

**THE CONCEPTUAL MODEL FOR THE REAL-TIME NAVIGATION IN
AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE PLATFORM**

By

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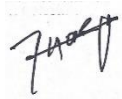
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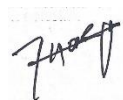
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ABSTRACT

The advent of augmented reality (AR) technology has revolutionized the way we navigate in the physical world. However, despite the increasing popularity of AR-based navigation apps, there is still a lack of understanding of what features and functionalities users prefer in such apps. Therefore, this research project aims to develop a conceptual model for an interactive and compelling real-time AR-based navigation experience for mobile platforms.

To achieve this, the study will employ a mixed-methods approach that involves conducting a survey to collect data from the general public to better understand their preferences and requirements. The collected responses will be analyzed and interpreted to identify the key features that users prefer in real-time AR navigation apps. Additionally, an analysis of existing literature and sentiment analysis and topic modelling will be carried out on AR-based navigation apps to get an understanding of the user's preferences and vital features that contribute to a great user experience.

Based on the results of the data analysis, a conceptual model for the AR-based navigation app will be proposed. The proposed conceptual model will be based on the analysis of user preferences and requirements, as well as the analysis of existing literature and apps related to AR real-time navigation on mobile platforms. The model will aim to address the identified gaps and meet the requirements of users by providing an intuitive and interactive navigation experience using AR technology.

Overall, this research project aims to provide insights into the user's preferences and requirements for AR-based navigation apps on mobile platforms and to propose a conceptual model for the development of an interactive and compelling real-time AR-based navigation experience.

TABLE OF CONTENTS

TITLE PAGE	i
REPORT STATUS DECLARATION FORM	ii
FYP THESIS SUBMISSION FORM	iii
DECLARATION OF ORIGINALITY	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	xi
LIST OF TABLES	xviii
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Problem Statement and Motivation	5
1.3 Motivation	8
1.4 Research Objectives	9
1.5 Project Scope and Direction	10
1.6 Contributions	11
1.7 Report Organization	12

CHAPTER 2 LITERATURE REVIEW	14
2.1 Fundamentals of Augmented Reality (AR)	14
2.1.1 Mixed Reality, Augmented Reality, and Virtual Reality	14
2.1.2 The Hardware and Software	15
2.1.2.1 The AR Hardware Pieces	15
2.1.2.2 The AR Software Parts	17
2.1.2.3 Application of Augmented Reality	19
2.1.2.4 Problems and Constraints	20
2.1.2.5 Potential & Future Paths	21
2.2 Existing AR Navigation Apps	22
2.2.1 PinnAR	22
2.2.2 AR GPS Drive	25
2.2.3 AR GPS Compass Map 3D	27
2.2.4 AR GPS Navigation 2021 GPS Map	30
2.2.5 Comparison	32
2.3 User Experience in AR Navigation Apps	37
2.4 Guidelines and Principles for Augmented Reality Navigation App Design	37
2.5 Emerging Trends and Future Directions	38
CHAPTER 3 METHODOLOGIES	41
3.1 Analytic tools	41
3.1.1 Python	41
3.1.2 Google Colab	41
3.1.3 Figma	41
3.1.4 Lucidchart	42
3.2 Survey Design and Data Collection	42
3.3 Data Analysis	43
3.4 Sentiment Analysis and Topic Modelling	65
3.4.1 Literature Review	66
3.4.2 Existing Real-Time Navigation Application in AR	66
	viii

3.4.2.1 Sentiment Analysis	66
3.4.2.1.1 Install libraries	66
3.4.2.1.2 Import libraries	67
3.4.2.1.3 Data type of each column	68
3.4.2.1.4 PinnAR	68
3.4.2.1.5 AR GPS Compass Map 3D	77
3.4.2.1.6 AR GPS Drive	84
3.4.2.1.7 AR GPS Navigation 2021 GPS	91
Map	
3.4.2.2 Topic Modelling	97
3.4.2.2.1 Install and Import Necessary	97
Libraries	
3.4.2.2.2 Existing AR Real-Time	98
Navigation Apps	
3.4.2.2.2.1 Pinn AR	98
3.4.2.2.2.2 AR GPS Compass Map 3D	115
3.4.2.2.2.3 AR GPS Drive	171
3.4.2.2.2.4 AR GPS Navigation 2021 GPS	202
Map	
CHAPTER 4 WORK PLAN	222
4.0 Work Plan	222
CHAPTER 5 SYSTEM MODEL	230
5.0 System Model	230
5.1 System Architecture Diagram	232
5.2 Use Case Diagram	233
5.3 Conceptual model of AR Real-Time Navigation App for	234
Mobile Platform	
CHAPTER 6 COMPARISON OF EXISTING RESEARCH	240
AND CONCEPTUAL MODEL FOR AR REAL-TIME	
NAVIGATION APP	

6.0 Augmented Reality Navigation	240
6.1 Conceptual Model of Mobile Augmented Reality for Cultural Enjoyable Informal Learning Aspect	242
6.2 Mobile AR GPS-based for Navigation Purpose	244
CHAPTER 7 USER INTERFACE (UI) PROTOTYPES	248
CHAPTER 8 RESEARCH GAPS	267
CHAPTER 9	269
9.0 Results	269
9.1 Conclusions	272
9.2 Recommendations	275
REFERENCES	278
APPENDIX A	
A.1 Questionnaire Sample	A-1
A.2 Weekly Report	A-8
A.3 Poster	A-13
PLAGIARISM CHECK RESULT	
Turnitin Plagiarism Checking Result	
CHECK LISTS	
Check Lists	

LIST OF FIGURES

Figure Number	Title	Page
Figure 1	Differences of MR, AR and VR	14
Figure 2	Pinn AR	22
Figure 3	AR GPS Drive	25
Figure 4	AR GPS Compass Map 3D	27
Figure 5	AR GPS Navigation 2021 GPS Map	30
Figure 6	Responses of Question 1	43
Figure 7	Responses of Question 2	44
Figure 8	Responses of Question 3	45
Figure 9	Responses of Question 4	46
Figure 10	Responses of Question 5	47
Figure 11	Responses of Question 6	48
Figure 12	Responses of Question 7	49
Figure 13	Responses of Question 8	50
Figure 14	Responses of Question 9	50
Figure 15	Responses of Question 10	52
Figure 16	Responses of Question 11	53
Figure 17	Responses of Question 12	54
Figure 18	Responses of Question 13	55
Figure 19	Responses of Question 14	56
Figure 20	Responses of Question 15	57
Figure 21	Responses of Question 16	58
Figure 22	Responses of Question 17	59
Figure 23	Responses of Question 18	60
Figure 24	Responses of Question 19	61
Figure 25	Responses of Question 20	62
Figure 26	Responses of Question 21	63
Figure 27	Responses of Question 22	64
Figure 28	Install necessary libraries	67

Figure 29	Install necessary libraries	68
Figure 30	Data types	68
Figure 31	Screenshot of displaying first 5 relevant reviews	69
Figure 32	Review counts for different created version	69
Figure 33	Successfully loaded and applied the sentiment analysis pipeline	70
Figure 34	New column called 'Result'	70
Figure 35	Screenshot of first few rows of dataframe with the predicted sentiment and score for each review	71
Figure 36	Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library	74
Figure 37	Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated	76
Figure 38	Graph of score, thumbsupcount, at, repliedat	77
Figure 39	Histogram of sentiment reviews	77
Figure 40	Screenshot of displaying first 5 relevant reviews	78
Figure 41	Review counts for different created version	78
Figure 42	New column called 'Result'	79
Figure 43	Screenshot of first few rows of dataframe with the predicted sentiment and score for each review	79
Figure 44	Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library	82
Figure 45	Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated	83
Figure 46	Graph of score, thumbsupcount, at, repliedat	83
Figure 47	Histogram of sentiment reviews	84
Figure 48	Screenshot of displaying first 5 relevant reviews	84
Figure 49	Review counts for different created version	85
Figure 50	New column called 'Result'	86

Figure 51	Screenshot of first few rows of dataframe with the predicted sentiment and score for each review	86
Figure 52	Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library	89
Figure 53	Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated	90
Figure 54	Graph of score, thumbsupcount, at, repliedat	90
Figure 55	Histogram of sentiment reviews	91
Figure 56	Screenshot of displaying first 5 relevant reviews	91
Figure 57	Review counts for different created version	92
Figure 58	New column called 'Result'	92
Figure 59	Screenshot of first few rows of dataframe with the predicted sentiment and score for each review	93
Figure 60	Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library	96
Figure 61	Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated	96
Figure 62	Graph of score, thumbsupcount, at, repliedat	97
Figure 63	Histogram of sentiment reviews	97
Figure 64	Summary statistics of the reviews	100
Figure 65	Reviews less than 4	101
Figure 66	Remaining textual reviews which are less than 4	101
Figure 67	20 feature names that appear first in the vocabulary in alphabetical order	102
Figure 68	Instantiation of a Latent Dirichlet Allocation (LDA) model	103
Figure 69	Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model	103
Figure 70	CSV file with topic probability matrix	105

Figure 71	Download of NLTK stop words and WordNetLemmatizer	105
Figure 72	Text data that are cleaned	106
Figure 73	Dictionary is created	107
Figure 74	Document term matrix is created	107
Figure 75	LDA Model is instantiated and fit on the dataset	108
Figure 76	10 words contributed to each topic identified	109
Figure 77	Two topics is generated Top 30 most relevant terms are generated	111
Figure 78	Keywords for topic 0	111
Figure 79	Keywords for topic 1	112
Figure 80	List of topic probability of each document	113
Figure 81	Threshold calculated for topic relevance	113
Figure 82	Number of articles printed in each cluster	114
Figure 83	Articles of each cluster are printed	115
Figure 84	Summary statistics of the reviews	117
Figure 85	Reviews less than 4	117
Figure 86	Remaining textual reviews which are less than 4	118
Figure 87	20 feature names that appear first in the vocabulary in alphabetical order	118
Figure 88	Instantiation of a Latent Dirichlet Allocation (LDA) model	119
Figure 89	Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model	119
Figure 90	CSV file with topic probability matrix	120
Figure 91	Text data that are cleaned	122
Figure 92	Dictionary is created	122
Figure 93	Document term matrix is created	122
Figure 94	LDA Model is instantiated and fit on the dataset	123
Figure 95	10 words contributed to each topic identified	123
Figure 96	Five topics is generated Top 30 most relevant terms are generated	124
Figure 97	Keywords for topic 0	124

Figure 98	Keywords for topic 1	125
Figure 99	Keywords for topic 2	125
Figure 100	Keywords for topic 3	126
Figure 101	Keywords for topic 4	126
Figure 102	Threshold calculated for topic relevance	167
Figure 103	Number of articles printed in each cluster	168
Figure 104	Articles of cluster1 are printed	168
Figure 105	Articles of cluster2 are printed	169
Figure 106	Articles of cluster3 are printed	169
Figure 107	Articles of cluster4 are printed	170
Figure 108	Articles of cluster5 are printed	170
Figure 109	Summary statistics of the reviews	172
Figure 110	Reviews less than 4	173
Figure 111	Remaining textual reviews which are less than 4	173
Figure 112	20 feature names that appear first in the vocabulary in alphabetical order	174
Figure 113	Output of instantiation of a Latent Dirichlet Allocation (LDA) model and Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model	175
Figure 114	CSV file with topic probability matrix	176
Figure 115	Text data that are cleaned	178
Figure 116	Dictionary and document term matrix are created	179
Figure 117	LDA Model is instantiated and fit on the dataset	179
Figure 118	10 words contributed to each topic identified	180
Figure 119	Five topics is generated Top 30 most relevant terms are generated	181
Figure 120	Keywords for topic 0	181
Figure 121	Keywords for topic 1	182
Figure 122	Keywords for topic 2	182
Figure 123	Keywords for topic 3	183
Figure 124	Keywords for topic 4	183
Figure 125	Threshold calculated for topic relevance	198

Figure 126	Number of articles printed in each cluster	199
Figure 127	Articles of cluster1 are printed	200
Figure 128	Articles of cluster2 are printed	200
Figure 129	Articles of cluster3 are printed	201
Figure 130	Articles of cluster4 are printed	201
Figure 131	Articles of cluster5 are printed	202
Figure 132	Summary statistics of the reviews	204
Figure 133	Reviews less than 4	204
Figure 134	Remaining textual reviews which are less than 4	205
Figure 135	20 feature names that appear first in the vocabulary in alphabetical order	205
Figure 136	Instantiation of a Latent Dirichlet Allocation (LDA) model	206
Figure 137	Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model	206
Figure 138	CSV file with topic probability matrix	207
Figure 139	Text data that are cleaned	209
Figure 140	Dictionary is created	209
Figure 141	Document term matrix is created	210
Figure 142	LDA Model is instantiated and fit on the dataset	210
Figure 143	10 words contributed to each topic identified	211
Figure 144	Two topics is generated Top 30 most relevant terms are generated	211
Figure 145	Keywords for topic 0	212
Figure 146	Keywords for topic 1	212
Figure 147	Threshold calculated for topic relevance	218
Figure 148	Number of articles printed in each cluster	219
Figure 149	Articles of cluster1 are printed	219
Figure 150	Articles of cluster2 are printed	220
Figure 151	Survey questionnaires	222
Figure 152	Survey responses	224
Figure 153	Sentiment analysis of AR GPS Drive	224
Figure 154	Sentiment analysis of AR GPS Compass Map 3D	225

Figure 155	Sentiment analysis of AR GPS Navigation 2021 GPS Map	225
Figure 156	Sentiment analysis of Pinn AR	226
Figure 157	Topic Modelling of AR GPS Drive	226
Figure 158	Topic Modelling of AR GPS Compass Map 3D	227
Figure 159	Topic Modelling of AR GPS Navigation 2021 GPS Map	227
Figure 160	Topic Modelling of Pinn AR	228
Figure 161	System Model Diagram	230
Figure 162	System Architecture Diagram	231
Figure 163	Use Case Diagram	232
Figure 164	The Conceptual Model	233
Figure 165	Main Screen	247
Figure 166	Navigation Screen	250
Figure 167	Setting Screen	252
Figure 168	Feedback and Reviews Screen	253
Figure 169	Saved Routes Screen	254
Figure 170	Point of Interests Screen	255
Figure 171	Offline and Integration Screen	256
Figure 172	Downloadable Maps for Offline Use Screen	258
Figure 173	Popular Mapping Services Screen	260
Figure 174	Post Navigation Summary Screen	261
Figure 175	Performance and Speed Screen	262
Figure 176	User Training and Onboarding Screen	263
Figure 177	Profile Screen	264

LIST OF TABLES

Table Number	Title	Page
Table 1	Comparison of existing AR real-time navigation apps	32

CHAPTER 1

1.1 Introduction

Augmented reality (AR) is an interactive technology that blends computer-generated content with real-world environments. According to [1], augmented reality (AR) is a fast-developing field that merges the digital and physical worlds to enrich the user experience by superimposing computer-generated material onto the actual world. It allows users to experience digital content in a way that is immersive and seamless, creating a sense of presence in a virtual space. AR technology has been rapidly advancing in recent years and has found its way into various industries, including instruction and learning, healthcare, entertainment, maintenance, and navigation, and provide new ways to enhance human-computer communication, expand users' awareness of their surroundings, and revolutionise long-established procedures. One of the most promising applications of AR technology is in real-time navigation, which has the potential to revolutionize the way people navigate and interact with their surroundings.

AR in real-time navigation involves overlaying digital information onto the physical world, allowing users to see a virtual representation of their surroundings. Augmented reality (AR) in real-time navigation, making it simpler for user to find one's way around new regions, find sites of interest, and gain access to location-based information [2]. This can be achieved through the use of various sensors such as GPS, accelerometers, and cameras. These systems employ the user's position, orientation, and device sensors to overlay pertinent information on the user's field of vision in order to provide a more natural and interesting navigation experience [3]. By using these sensors, AR navigation apps can track the user's location and orientation, and provide them with real-time information such as directions, points of interest, and other relevant information. AR can also enhance the user's experience by providing interactive elements such as gamification, social sharing, and personalization. User can interact with the digital content by tapping on it or swiping it, and the app can provide additional information, such as images or text, to help the user navigate. By providing a more immersive, context-aware, and interactive experience, AR-based real-time navigation systems can overcome the constraints of traditional navigation techniques like paper maps, standalone GPS devices, and text-based directions [4].

The implementation of AR in real-time navigation can be done through various methods, such as marker-based tracking, markerless tracking, and SLAM (Simultaneous Localization And Mapping). Marker-based tracking involves the use of predefined markers or images that trigger the overlay of digital content. Markerless tracking uses computer vision algorithms to recognize and track the user's surroundings, without the need for predefined markers. SLAM involves the use of algorithms that allow the device to create a map of the physical environment and track the user's position in real-time.

Integrating technologies such as global positioning system (GPS), computer vision, and mobile computing is essential for implementing augmented reality in real-time navigation, resulting in smooth and intuitive navigation experiences. Developers can reduce cognitive load, improve situational awareness, and boost user satisfaction by integrating augmented reality (AR) features into navigation systems, which align with the user's view of the environment in real time. Since smartphones and other mobile devices now have the sensors, processing capacity, and connection to enable AR features [5], the creation and uptake of AR navigation apps have been facilitated.

Moreover, the need for AR in real-time navigation arises from the limitations of traditional navigation methods such as maps, compasses, and GPS, which may not provide enough contextual information, require users to shift their focus between the environment and the navigation device, or result in ambiguous and confusing directions [5]. These methods provide static information and do not take into account the user's surroundings or changes in the environment. They also require the user to constantly look at their device, which can be dangerous in certain situations such as driving or walking in busy areas. By providing real-time information about the user's surroundings, AR navigation apps can help users avoid traffic, construction, and other obstacles that might slow them down. AR navigation, on the other hand, provides users with dynamic and contextual information that is tailored to their surroundings, making navigation more intuitive and natural. By integrating real-time, context-aware assistance into the user's perspective of the environment, AR navigation systems may be able to help people travel more effectively and with more assurance [2].

The application of augmented reality in real-time navigation can increase user interest, boost navigation accuracy, and make streets safer for everyone. Augmented reality (AR) navigation systems can help users save time and effort, decrease navigation errors, and avoid accidents caused by distraction or disorientation [2], [3] by offering more intuitive and immersive guidance. In addition, augmented reality navigation systems may be modified to numerous circumstances and user groups, providing specialised solutions for things like pedestrian navigation, automobile navigation, indoor navigation, and accessibility for individuals with impairments [4].

Furthermore, the benefits of AR real-time navigation are numerous. Firstly, it provides users with a more engaging and immersive navigation experience, making the journey more enjoyable and memorable. The application of augmented reality in real-time navigation can increase user interest, boost navigation accuracy, and make streets safer for everyone. Secondly, augmented reality (AR) navigation systems can help users save time and effort, decrease navigation errors, and avoid accidents caused by distraction or disorientation [2], [3] by offering more intuitive and immersive guidance. It enhances safety by reducing the need for users to constantly look at their device, and by providing real-time information that is tailored to their surroundings. Thirdly, it allows for greater personalization and customization, as users can choose the type of information they want to see, and how it is displayed. Augmented reality navigation apps may be modified to numerous circumstances and user groups, providing specialised solutions for things like pedestrian navigation, automobile navigation, indoor navigation, and accessibility for individuals with impairments [4]. Finally, it can lead to greater efficiency and productivity, as users can navigate more quickly and confidently, and can focus on their surroundings rather than their device.

Smartphones and tablets are already commonplace tools for navigation and location-based services [5] making augmented reality real-time navigation especially important on mobile platforms. AR real-time navigation is particularly relevant to mobile platforms, as mobile devices are ubiquitous and have the necessary sensors and capabilities to support AR technology. Mobile AR navigation apps can be easily downloaded and used by anyone with a compatible device, making it accessible to a

CHAPTER 1

wide audience. Additionally, mobile devices are portable and can be used in various situations such as walking, driving, or cycling, making AR navigation more versatile than traditional navigation methods. Mobile devices have large screens and powerful processors, which can be used to render high-quality digital content and provide a smooth and responsive navigation experience. In order to meet the rising demand for context-aware, individualised, and interactive navigation experiences, developers can take advantage of the widespread availability of mobile devices and the rapid development of augmented reality (AR) technologies to create cutting-edge AR navigation applications.

In conclusion, AR real-time navigation on mobile platforms has the potential to revolutionize the way people navigate and interact with their surroundings. The use of AR technology can provide users with a more engaging, safe, and personalized navigation experience, while also increasing efficiency and productivity. The development of a conceptual model for AR real-time navigation can help guide the design and development of future AR navigation apps, and can contribute to the advancement of this promising technology.

1.2 Problem Statement and Motivation

As mobile devices become more prevalent in our daily lives, navigating through unfamiliar environments remains a persistent challenge for users. While traditional navigation tools such as maps and GPS have been helpful, they often lack the context and visual cues that can make navigation easier and more intuitive. Augmented Reality (AR) technology provides an exciting opportunity to enhance real-time navigation experiences by overlaying digital information onto the user's physical environment. However, despite the potential benefits of AR for navigation, there remain several challenges that must be addressed. In this project, we aim to develop a conceptual model for real-time AR navigation on mobile platforms, with a focus on addressing four key challenges: accuracy, usability, performance, and user satisfaction.

Lack of understanding of user preferences and requirements

The success of AR real-time navigation depends on the user's preferences and requirements. Developing AR navigation systems that cater to a wide range of user demands necessitates a thorough grasp of user preferences and requirements. Existing literature emphasises the need for more study in this area, particularly in terms of understanding user engagement patterns, cognitive load, and situational awareness [6], [7]. However, there is a lack of empirical research on user preferences and requirements for AR real-time navigation. Thus, we need to conduct a survey to collect data from the general public to better understand the user's preferences and requirements for AR real-time navigation. In addition, demographic aspects including age, gender, and cultural background should be taken into account in the design and assessment of augmented reality navigation systems [8].

Inadequate accuracy and reliability of AR systems

The accuracy and reliability of AR systems are crucial for providing an effective and usable real-time navigation experience. However, current AR systems still face challenges in accurately tracking the user's location and orientation, especially in indoor environments. AR navigation systems rely on precise positioning, tracking, and registration technologies to superimpose digital information onto the actual environment, yet these systems often fall short in terms of accuracy and reliability.

System performance can be negatively impacted by factors such as deteriorating GPS signals, noisy sensors, and adverse weather [5], [9], making it difficult to achieve the appropriate degree of accuracy and dependability. Furthermore, improving system accuracy and dependability may need integrating numerous sensors including cameras, inertial measurement units (IMUs), and depth sensors, which raises questions about power consumption, device form factors, and cost [2]. Thus, we need to investigate the limitations and challenges of current AR systems and propose solutions to enhance their accuracy and reliability.

Limited availability of relevant data

AR real-time navigation relies on the availability of relevant data, such as location-based information, points of interest, and 3D models of the environment. In order for AR navigation systems to give contextually relevant information, they must have access to a diverse set of data sources, such as maps, sites of interest, and real-time traffic information. However, the availability and quality of such data vary across different regions and environments. There are still gaps in both the quantity and quality of this data, which makes it difficult to create robust augmented reality navigation systems [2], [4]. Thus, we need to explore ways to improve the availability and quality of relevant data for AR real-time navigation. There is also the necessity to deal with data privacy and security concerns, which are exacerbated when working with user-generated content and location-based services [3].

Lack of an effective conceptual model for AR real-time navigation

Despite the growing interest in AR real-time navigation, there is still a lack of an effective conceptual model that can guide the development of interactive and compelling AR real-time navigation experiences. By taking into account aspects including public's opinion, user needs, data sources, analysed and interpreted data, and an effective conceptual model may guide the design and execution of augmented reality navigation systems. However, existing models tend to be narrow in their application and fail to address the specific features and difficulties of AR navigation [3], [8]. To fill this void and provide the groundwork for future advancements in AR real-time navigation, it is necessary to construct a complete conceptual model that includes online survey to get the public's opinion, research on existing AR real-time navigation apps,

CHAPTER 1

perform data analysis including the sentiment analysis and topic modelling, and perform interpretation of data to obtain the user's preferences. Thus, we need to propose a conceptual model that considers the user's preferences and requirements, the accuracy and reliability of the AR system, and the availability of relevant data.

1.3 Motivation

The motivation for this research project is to address the increasing demand for mobile navigation applications that provide an interactive and engaging augmented reality experience. Traditional navigation apps provide users with basic instructions on how to reach their destination but lack interactivity and personalization. In contrast, AR-based navigation apps offer an innovative approach that can enhance the user experience by providing real-time information and a more immersive experience.

Moreover, the advancements in AR technology and mobile devices have made it possible to integrate AR-based navigation features into mobile apps. However, there is a lack of research on the development of a comprehensive and interactive AR-based navigation system for mobile platforms. This research aims to fill this gap by proposing a conceptual model for developing an AR-based navigation system that is interactive, engaging, and personalized for users. The research will help to identify the preferences and requirements of users in navigation applications and propose a conceptual model that satisfies their needs. This research is significant because it will help to enhance the user's experience in navigation applications and increase the use of augmented reality in mobile navigation applications.

In summary, the motivation for this research project is to provide a solution to the limitations of traditional navigation apps and to enhance the user experience by offering an innovative AR-based navigation system on mobile platforms.

1.4 Research Objectives

The primary goal of this research project is to propose a conceptual model for developing an interactive and compelling real-time augmented reality navigation experience for mobile platforms. To achieve this goal, the research project involves collecting primary data through a survey to gain insights into user preferences and requirements when it comes to AR real-time navigation on mobile platforms. The survey can be designed to capture data on factors such as the most and least important features, concerns on the AR real-time navigation apps, the most significant hurdle to VR and AR technologies, and other factors that impact the user experience. The survey data can be analyzed to identify trends and patterns in user preferences and requirements. The next objective involves analyzing the data collected from the survey, along with conducting analysis on existing literature and sentiment analysis and topic modelling on apps related to AR real-time navigation on mobile platforms. This analysis can provide a more in-depth understanding of user preferences and vital features required in a conceptual model for AR real-time navigation. The third objective involves using the insights gained from the survey data and analysis to propose a conceptual model for developing an interactive and compelling real-time augmented reality navigation experience for mobile platforms. The conceptual model can be designed to incorporate the vital features and user requirements identified in the survey and analysis, with a focus on providing an engaging and intuitive user experience.

The objectives of the project are:

1. Conduct a survey to collect data from the general public to better understand the user's preferences and their requirements.
2. Carry out an analysis based on the collected responses from the public and existing literature and the sentiment analysis and topic modelling on AR real-time navigation apps in order to get an understanding of the user's preferences and vital features.
3. To propose a conceptual model for developing an interactive and compelling real-time augmented reality navigation experience for mobile platforms.

1.5 Project Scope and Direction

The project scope of the research project includes conducting a survey to collect data from the general public to better understand their preferences and requirements regarding AR real-time navigation apps. The survey will provide insights into the user's preferences, such as their preferred features, user interface, and customization options, which will help in developing an interactive and compelling AR real-time navigation experience for mobile platforms.

In addition to the survey, the research will also involve analyzing the collected responses from the public and existing literature, the sentiment analysis and topic modeling on the existing AR real-time navigation apps to identify the key features and factors that make an AR real-time navigation app successful. This analysis will help identify the user's preferences and vital features, providing a comprehensive understanding of the user's requirements. The proposed conceptual model will be based on the insights gained from the survey and the analysis of the collected data. It will take into account the preferences and requirements of the users, as well as the latest trends and advancements in AR technology. The conceptual model will provide a framework for developing an interactive and compelling AR real-time navigation experience for mobile platforms that meets the user's requirements and preferences.

The direction of the research project is to provide insights into the user's preferences and requirements for AR real-time navigation apps, as well as develop a conceptual model that will serve as a foundation for the development of AR real-time navigation apps on mobile platforms. The model will focus on providing an immersive, interactive, and personalized user experience, improving the user's navigation and travel experience.

1.6 Contributions

The proposed research project aims to develop a conceptual model for AR real-time navigation on mobile platforms. The project will conduct a survey to collect data from the general public and carry out an analysis based on the collected responses and existing literature to understand user preferences and vital features. The findings will be used to propose an interactive and compelling AR navigation experience for mobile platforms.

The motivation for this project is to improve understanding of user preferences and requirements through the survey and analysis of existing literature and apps, the project will help to identify the key features and functionalities that users look for in AR navigation apps. This understanding will help developers to create more user-centric and effective apps.

Moreover, the project will propose a conceptual model for the development of AR real-time navigation apps on mobile platforms. This model will be based on the identified user preferences and requirements, as well as the latest technological advancements in AR and mobile app development.

The project will also address the need for a better and more user-friendly AR navigation experience. While there are many AR navigation apps available, there is still a lack of a comprehensive conceptual model that can provide an optimal user experience. By developing such a model, this research project will help improve the usability and effectiveness of AR navigation apps, making them more user-friendly and intuitive.

Furthermore, the contributions of this research project include the development of a comprehensive conceptual model for AR real-time navigation on mobile platforms, which can serve as a guide for future app development. This model will provide insights into user preferences and essential features, improving the user experience of AR navigation apps. Additionally, the findings from the survey and analysis can be used to

inform the development of future AR apps in various fields, such as tourism, education, and healthcare. Overall, this research project will contribute to the advancement of AR technology and its application in various domains.

1.7 Report Organization

The research will begin with an introduction to the research project, providing background information on the motivation for the study, the research objectives, and the scope of the project. This section will also highlight the significance of the study and the contributions it seeks to make to the field of AR real-time navigation apps.

The next section will focus on the literature review, which will provide an overview of existing literature on AR real-time navigation apps, including their features, design principles, and user preferences. This section will also highlight any gaps in the literature that the study seeks to address.

The third section will describe the research methodology, including the survey design, data collection procedures, and data analysis techniques. This section will also discuss the ethical considerations of the study and the limitations of the research.

The fourth section will present the results of the study, including an analysis of the survey data and the findings from the sentiment analysis and topic modeling. This section will also present the conceptual model proposed by the study and highlight its key features and design principles.

The fifth section will discuss the implications of the study for the design and development of AR real-time navigation apps on mobile platforms. This section will also highlight any potential future research directions that could build on the findings of the study.

Finally, the report will conclude with a summary of the main findings of the study, the contributions it has made to the field, and the potential impact of the study on the development of AR real-time navigation apps on mobile platforms. The report

CHAPTER 1

will also provide recommendations for practitioners and developers who seek to implement the proposed conceptual model in their own projects.

CHAPTER 2

Literature Reviews

2.1 Fundamentals of Augmented Reality (AR)

According to [1], augmented reality (AR) is a technology that blends the physical and digital worlds through an interactive, real-time process that precisely positions digital things in relation to their physical counterparts. This outline is still useful today since it provides a framework for thinking about augmented reality. In augmented reality (AR), the user's vision of the real environment is layered in real time with digital information such as photos, text, and animations. Augmented reality (AR) improves the user experience by fusing digital and physical elements. Based on the existing research, both [6], [10] offer a historical view on augmented reality, tracing its roots back to Ivan Sutherland's work and the creation of the first head-mounted display in the 1960s. The advent of marker-based augmented reality in the 1990s and the ubiquity of mobile augmented reality in the 2000s paved the way for the present era of pervasive and context-aware augmented reality. Hence, it is proved that technology has advanced significantly in recent years, opening up new avenues of exploration and use in sectors as diverse as media, education, retail, healthcare, and navigation.

2.1.1 Mixed Reality, Augmented Reality, and Virtual Reality

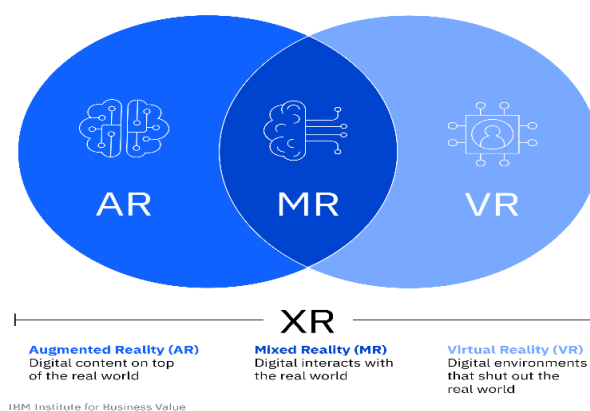


Figure 1: Differences of MR, AR and VR [11].

Technologies such as augmented reality (AR), virtual reality (VR), and mixed reality (MR) have all seen significant growth in the recent decade. It is important to differentiate augmented reality (AR) from other immersive technologies like virtual reality (VR) and mixed reality (MR) in order to have a full grasp of AR. When using virtual reality (VR), one is immersed in a computer-generated simulation of the actual world. Users often interact with the virtual world using a head-mounted display (HMD) and handheld controllers. Virtual reality (VR) completely submerges the user, in contrast to augmented reality.

By superimposing digital material onto physical space and allowing for user interaction, mixed reality (MR) combines the best features of augmented and virtual realities. When combined with AR, MR's ability to let users interact with both real and virtual items in the same place makes for a richer, more engaging experience.

Hardware for Augmented Reality.

2.1.2 The Hardware and Software

There are four sources cover the fundamentals of augmented reality systems' hardware and software. Among these are software frameworks like ARToolKit, Vuforia, and ARCore, as well as hardware components like screens (head-mounted, portable, and projective). Billingham et al. (2015) and Carmigniani and Furht (2011) give further insight on the development and present state of these technologies, while Van Krevelen and Poelman (2010) provide a comprehensive review to these technologies.

2.1.2.1 The AR Hardware Pieces

Hardware requirements for augmented reality applications are context and feature specific. The following are examples of typical hardware:

Digital content cannot be shown to the user without a display. AR displays can come in the form of head-mounted displays (HMDs), portable devices, or projection-

based systems. The usefulness, mobility, and range of vision of various displays vary widely [1], [6], [10], [12]. HMDs, like the Microsoft HoloLens and the Magic Leap One, are wearable devices that provide a more comprehensive augmented reality experience. These can be worn on the head (like the HoloLens or Oculus) or carried in the hand (like smartphones or tablets) or projected onto a surface (like spatial augmented reality) [1], [6], [10], [12]. Handheld devices such as smartphones and tablets have paved the way as the go-to gadgets for augmented reality use. Projection-based systems enable users to participate in an augmented reality (AR) experience without the need to wear or handle a device by superimposing digital material onto real-world surfaces.

Sensors are necessary for the AR system to precisely overlay digital material on the actual environment by measuring the user's location, orientation, and motions. Accelerometers, gyroscopes, magnetometers, and global positioning systems (GPS) are typical sensors found in augmented reality devices. Sensors like global positioning systems (GPS), cameras, and depth sensors allow for interaction with the environment and offer contextual information [6], [12]. More complex systems may make use of light detection and ranging (LiDAR) and mapping (SLAM) technologies to more accurately map their surroundings and position digital information.

Cameras play a crucial part in augmented reality systems as they record the user's view of the world, allowing markers or things in the environment to be detected and followed [1]. Capturing the user's perspective of the actual world and feeding that information into the augmented reality system's identification and tracking of markers or elements in the environment is impossible without cameras. To further enhance the augmented reality experience, cameras enable markerless tracking and computer vision methods like object detection, made possible by depth-sensing cameras like the Microsoft Kinect[13].

Tracking technologies are crucial for keeping physical and digital items in sync. They can be magnetic (e.g., accelerometers and gyroscopes), inertial (e.g., cameras), or optical. Technologies including marker-based tracking, markerless tracking, and

sensor-based tracking have all found use in augmented reality systems. To place digital material over physical environments, marker-based tracking makes use of fiducial markers like QR codes or ARToolKit markers[14]. There are also several hybrid tracking solutions available, which employ a combination of tracking technologies to achieve optimal efficiency [1], [6], [10], [12].

Due to the intensive nature of augmented reality applications, such as displaying digital material, tracking user movement, and analysing sensor data, high-powered computing hardware is essential. More powerful and specialised processors, such as graphics processing unit (GPU) and artificial intelligence (AI) chips, are being created to keep up with the growing needs of augmented reality (AR) applications.

2.1.2.2 The AR Software Parts

There are a number of different software components are essential for the development of augmented reality apps and their ongoing maintenance:

AR Software Development Kits (SDKs) equip programmers with the frameworks and resources they need to build augmented reality programmes. Unity MARS (Unity Technologies) and ARCore (Google), ARToolKit, ARKit (Apple), and Vuforia (PTC) are also common augmented reality software development kits [6], [10]. The development process is streamlined with the help of these SDKs, which include tools like environment mapping, picture recognition, and marker tracking. These resources make it easier to create augmented reality apps by offering libraries and application programming interfaces (APIs) for tracking, rendering, and interaction [6], [10].

To recognise objects, follow markers, and estimate the user's position and orientation, the augmented reality system uses computer vision algorithms to analyse photos or video feeds acquired by the device's camera. They allow the user's location and orientation to be estimated, as well as the detection and tracking of objects and

markers [15]. These algorithms are crucial for integrating digital data successfully into the physical environment.

Rendering engines are in charge of presenting digital material in an augmented reality setting. They control the visual aspects of digital things, such as their colour, lighting, and shading [16]. Unity 3D and Unreal Engine are two of the most popular rendering engines for augmented reality development since they are flexible, they do support a wide range of augmented reality software development kits and allow for the creation of aesthetically stunning augmented reality experiences.

Application Frameworks for developing and maintaining applications are essential to the creation of any augmented reality app. Software development is facilitated by these frameworks since they often come with pre-written code, components, and libraries [17], [18]. Libraries and tools for user input, digital content management, and application flow control are commonplace. Unity 3D and Unreal Engine are two popular frameworks for augmented reality development since they fully support augmented reality features and simplify the development process. The advantages and disadvantages of employing application frameworks have been the subject of extensive study [19], with researchers focusing on topics including enhanced productivity, decreased development time, and the possibility of lock-in to certain technology.

The digital material utilised in augmented reality apps must be managed and kept up-to-date, and this is where content management systems (CMS) come in. Media assets can be of any kind, from 3D models to photos to movies to animations. With a content management system (CMS), developers can easily organise and update material without touching the AR app's code.

The storing, processing, and exchange of data across devices in an augmented reality application typically necessitates the use of networking and cloud services. To facilitate the sharing of augmented reality experiences across different users and devices, these services may involve server hosting, database administration, and real-

time data synchronisation. Google Cloud, Amazon Web Services (AWS), and Microsoft Azure are just a few of the most well-known cloud systems that cater to augmented reality development.

To sum up, augmented reality (AR) is a developing field that merges digital and physical worlds to improve the user experience. In terms of user immersion and interaction, it is distinct from virtual reality (VR) and mixed reality (MR). Displays, sensors, cameras, processing power, SDKs, computer vision algorithms, rendering engines, application frameworks, content management systems, and cloud services are the hardware and software components that make augmented reality possible.

2.1.3 Application of Augmented Reality

The reviewed literature provides several examples of AR's use in fields as diverse as the arts, academia, medicine, the military, and industry. The earliest instances of augmented reality applications may be found in [1], while the other three references include examples from more recent years. A taxonomy of AR applications is provided by [12], which is useful for comprehending the breadth and depth of the field.

Initial Occurrences

In [1], the authors detail the initial uses of augmented reality (AR) in the arts, education, medicine, the military, and industry. These early applications paved the way for the creation of increasingly complex and advanced augmented reality experiences.

Recent Developments

Recent AR applications are presented in [6] and [10], which demonstrate AR's maturing capabilities and increasing breadth of use. Among these include navigation, medical education, and training, as well as immersive learning environments.

Classification of Augmented Reality Uses

To further grasp the breadth and complexity of the area, [12] provides a detailed taxonomy of AR applications. By providing a framework for classifying and analysing

the many augmented reality applications, this taxonomy aids academics and developers in seeing patterns, holes, and possibilities in the field.

2.1.4 Problems and Constraints

The reviewed literature highlights the many restrictions and difficulties AR must overcome despite its great promise. Problems can arise from a number of different directions, including technical ones (such as tracking and registration accuracy or occlusion management) and social ones (such as privacy or user approval). Both [10] and [6] examine these issues at length while stressing the need of continual research and progress.

Technical Challenges

AR applications rely on complex computer algorithms, and the current hardware and software limitations make it difficult for AR to deliver a smooth and seamless user experience. In order for AR to reach its full potential, it needs solve a number of technical problems, such as tracking and registration accuracy and occlusion management [6], [10]. The user experience and the ability to seamlessly incorporate digital material into the real world are both impacted by these problems.

Social Challenges

Limitations to AR's mainstream adoption may also be found in the social realm, in the form of issues like privacy and user acceptability [6], [10]. This is due to AR applications have access to a user's personal data, including location data, camera feed, and other sensitive information. This raises privacy and security concerns, as AR applications can be vulnerable to cyberattacks, data breaches, and other forms of exploitation. AR applications can be perceived as intrusive or distracting, which can lead to social resistance. In order to foster widespread use of this technology and maintain the public's faith in it, these concerns must be resolved.

2.1.5 Potential & Future Paths

Collectively, the above works indicate that AR has promising prospects for expansion and widespread use. They highlight crucial research directions, such as enhancing hardware and software components, overcoming restrictions, and investigating uncharted uses. Both [6] and [10] stress the need for multidisciplinary teams to work together to improve AR technology and increase its widespread use.

Strengthening Core Components

According to the available research, advancements in hardware and software are crucial to AR's future development [6], [10]. Improved display systems, tracking technologies, and advanced algorithms might all contribute to more natural AR interactions.

Overcoming Obstacles

Addressing AR's technological and societal obstacles is critical for its mainstream adoption [6], [10]. This may need thinking outside the box to solve issues like privacy and user acceptability, in addition to creating innovative ways for tracking and registration.

Discovering Potential Future Uses

The literature emphasises the need of exploring new AR applications [6], [10] due to the technology's promising future in many fields. More study is needed to discover and create novel use cases that might propel AR adoption and integration across various domains of human activity.

2.2 Existing AR Navigation Apps

By superimposing digital information, such directional arrows, sites of interest, or street names, over the user's perspective of the actual environment, Augmented Reality (AR) navigation applications provide a novel alternative to conventional navigational techniques. As a result of the proliferation of smartphones and development in augmented reality technology, these systems have become increasingly popular in recent years. This section provides a summary of current augmented reality navigation apps, highlighting their salient features and underlying technology. The benefits and drawbacks of augmented reality navigation, especially on mobile platforms, are also discussed.

2.2.1 PinnAR



Figure 2 : Pinn AR [20]

Background

PinnAR is an augmented reality (AR) application that allows users to pin virtual objects or notes onto real-world locations using their smartphone's camera and GPS capabilities. The software bridges the gap between the digital and physical worlds by letting users leave behind notes, reminders, and instructions that may be found by the user or someone else upon their arrival at the specified place.

Features

Points of Interest

The app presents POIs including restaurants, stores, monuments, and other attractions, together with supplementary data like user ratings, review content, and operational hours.

Save and name locations

Users may store several places with unique names in PinnAR, making it simple to recall and find them again later.

AR-based navigation

The software employs augmented reality to show users where they have been and how far they have travelled to their bookmarked destinations.

Real-time distance and directional information

Updates on the distance and direction to the stored destinations are provided in real time by PinnAR, allowing users to keep track of their whereabouts while navigating.

Social Sharing

Users can opt to share their pins with friends and family, facilitating location-based task sharing and note-passing.

Easy Navigation

The app's user-friendly navigation features make it simple for users to reach their saved places. This is especially useful for posting reminders or directions for uncharted territory.

Customizable interface

Users may tailor their experience by choosing the categories of POIs they're shown and the way in which that data is presented.

Strengths

Enhanced User Experience

When compared to conventional map-based applications, PinnAR's augmented reality navigation system offers a more natural and interesting means of getting about and discovering new areas.

Personalized Recommendations

PinnAR provides customised suggestions based on user input and social media activity, encouraging curiosity and expanding horizons.

Hands-Free Navigation

The app's augmented reality features save users from looking at their phones as they walk or ride, making it a more practical and secure navigational tool for those who prefer not to use their hands.

Weaknesses

Dependence on Internet Connectivity

PinnAR's reliance on an always-on internet connection for real-time navigation and position data may be problematic in spots with spotty service.

Device Compatibility

The number of people who can use the app is bound by the fact that augmented reality technology isn't supported by all handsets.

Privacy concerns

The acquisition of user data for personalised suggestions and social integration may generate privacy worries for certain users.

2.2.2 AR GPS Drive



Figure 3 : AR GPS Drive [21].

Background

AR GPS Drive is designed to provide you turn-by-turn directions while you drive, all through the magic of augmented reality. This software was made for drivers who wish to stay focused on the road while exploring new territory or receiving clearer, more intuitive turn-by-turn guidance.

Features

Live camera feed

AR GPS Drive makes use of the mobile device's camera to project a live feed of the road in front of the user.

Augmented reality overlays

Navigation information such as turn-by-turn directions, distance markers, and lane advice are shown as augmented reality overlays on the real-time video feed.

Points of interest

The system emphasises places of interest, such as petrol stations, restaurants, and tourism sites, that are in close proximity to the user.

Traffic information

CHAPTER 2

Real-time traffic data is incorporated so that users may identify other routes and avoid jams.

Voice guidance

Provides audio instructions for a hands-free navigation experience.

Customizable user interface: The augmented reality interface's look and feel may be modified to better suit individual needs.

Strengths

Enhanced visual guidance

AR GPS Drive provides enhanced visual advice by superimposing on-screen navigational prompts onto the user's actual surroundings to facilitate comprehension.

Improved situational awareness

The live camera feed stream increases users' awareness of their surroundings, making them safer in dangerous situations.

Intuitive user experience

The seamless integration of visual and auditory cues creates a natural and stress-free navigational experience, allowing users to concentrate fully on the road ahead.

Adaptability

AR GPS Drive's flexibility makes it a useful navigational aid in a wide range of circumstances and vehicles.

Weaknesses

Compatibility issues with gadgets

The technology requires high-quality cameras and strong CPUs, which not all smartphones and GPS devices have.

Dependence on internet connection

Availability of real-time traffic updates and the capacity to download map data might necessitate a reliable internet connection for AR GPS Drive.

Potential distractions

Some drivers may become distracted by the visual overlays, which might increase the likelihood of accidents.

Limited functionality in adverse weather conditions

Heavy rain, fog, or snow may hinder the camera's capacity to record clear photos, lowering the usefulness of the AR overlays, therefore their use is limited in such situations.

Battery consumption

Long-distance drivers may be concerned about the battery life of their devices due to the increased use of camera, GPS, and augmented reality processing.

2.2.3 AR GPS Compass Map 3D



Figure 4 : AR GPS Compass Map 3D [22].

Background

The AR GPS Compass Map 3D software combines augmented reality (AR) compass, global positioning system (GPS), and three-dimensional (3D) map features

CHAPTER 2

for use in navigation. The app's goal is to aid its users in exploring new regions, whether that's through hiking, trekking, or just plain old exploration, by giving an immersive experience with augmented reality technology.

Features

AR-based compass

The software superimposes a compass over the camera stream to enable users quickly and easily get their bearings.

GPS coordinates

Location may be pinpointed with the use of AR GPS Compass Map 3D's precise GPS coordinates.

3D map visualization

The app's 3D map visualisation features improve the usability of both navigation and exploration.

Location search

The software incorporates a location search feature, allowing users to look for specific addresses or landmarks.

Strengths

Versatile navigation tool

The combination of AR compass, GPS, and 3D map features provides a versatile navigation tool for various outdoor activities.

Intuitive interface

The app's UI is designed with simplicity in mind, making it accessible to users of varying technical proficiency.

Engaging visualization

The 3D map visualisation provides an interesting and dynamic approach to discover your immediate surroundings.

Weaknesses

Limited indoor functionality

The app's major focus on outside areas may reduce its use in enclosed spaces.

Battery consumption

The usage of GPS, a camera, and other sensors can drain your battery quickly, much like it does in other augmented reality navigation applications like AR GPS Compass Map 3D.

Device limitations

Incompatibilities with some smartphone models are possible, especially with older smartphones that lack the requisite hardware or software to handle augmented reality capabilities, meaning that not all users will be able to enjoy the app's full potential.

2.2.4 AR GPS Navigation 2021 GPS Map



Figure 5 : AR GPS Navigation 2021 GPS Map [23].

Background

AR GPS Navigation 2021 GPS Map is intended to aid travellers in navigating unknown locations with the use of augmented reality turn-by-turn directions. The app's primary goal is to provide a fun and simple interface for its users to explore.

Features

Augmented reality (AR) turn-by-turn navigation

The software superimposes arrows and distance information over the user's live camera feed, making navigating clear and interesting.

Point of interest search

Users are able to do a search for specific sites of interest, including dining establishments, retail establishments, and famous landmarks.

Traffic information

The AR GPS Navigation 2021 GPS Map includes real-time traffic data to assist drivers avoid gridlocked regions and plan more efficient journeys.

Adjustable preferences

Users may alter preferences for the app's interface, including the app's language, measurement units, and map style.

Strengths

Engaging AR navigation

The app's usage of augmented reality makes navigating an exciting and immersive experience.

User-friendly interface

With its straightforward design, the AR GPS Navigation 2021 GPS Map is used by people of diverse degrees of technological proficiency.

Point of interest search

The app's point of interest search feature facilitates users' ability to learn about their immediate environments and locate desired destinations with minimal effort.

Weaknesses

Battery consumption

Due to the heavy reliance on the GPS, camera, and other sensors, AR GPS Navigation 2021 GPS Map has the same battery life concerns as other augmented reality navigation applications.

Accuracy and reliability

The accuracy and dependability of the app may be impacted by variables such as the quality of the GPS signal, the quality of the camera, or the availability of reliable map data.

Device limitations

Limitations on supported hardware and software for use with augmented reality mean that the app may not work on all smartphones.

2.2.5 Comparison

Feature	PinnAR	AR GPS Drive	AR GPS Compass Map 3D	AR GPS Navigation 2021 GPS Map
Type	Navigation & Point of Interest (POI)	Navigation & Traffic	Navigation & Compass	Navigation & POI
Focus	Navigating back to saved locations	Real-time driving directions using AR	Outdoor navigation using AR compass, GPS, and 3D maps	Turn-by-turn AR navigation for exploring unfamiliar areas
Primary Features	Save and name locations AR-based navigation Real-time distance and directional information Sharing saved locations	AR-based driving directions Traffic information Speed limit warnings Wide compatibility with Android devices	AR-based compass GPS coordinates 3D map visualization Location search	AR-based turn-by-turn navigation Point of interest search Traffic information Customizable settings
Accuracy	High (within 5 meters)	High (within 5 meters)	Moderate (within 10 meters)	High (within 5 meters)

CHAPTER 2

Image Rotation	Supported (Dynamic)	Supported (Dynamic)	Supported (Dynamic)	Supported (Dynamic)
Real-time Navigation	Yes	Yes	Yes	Yes
Limitations	Limited indoor navigation	Requires internet connection	No altitude information	Limited offline maps
Platform Compatibility	iOS & Android	iOS & Android	iOS & Android	iOS & Android
Pricing	Free with in-app purchases	Free with in-app purchases	Free with in-app purchases	Free with in-app purchases
Mapping Data Source	OpenStreetMap & Google Maps	Google Maps	OpenStreetMap	OpenStreetMap & Google Maps
3D Landmarks	Yes	No	Yes	Yes
Voice-guided Navigation	Yes	Yes	No	Yes
Offline Navigation	Limited	No	Limited	Limited
Traffic Updates	No	Yes	No	No
AR Compass	Yes	No	Yes	Yes
Rating (out of 5 stars)	4.2	4.0	3.8	4.1

Best Suited For	Users who want to remember specific locations and navigate back to them easily	Users who want to navigate unfamiliar areas or follow directions more intuitively while driving	Users who engage in outdoor activities like hiking, trekking, or exploring new areas	Users who want an engaging and intuitive navigation experience while exploring new areas or searching for points of interest
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Table 1 : Comparison of existing AR real-time navigation apps.

This table provides a comparison of the four AR navigation apps: PinnAR, AR GPS Drive, AR GPS Compass Map 3D, and AR GPS Navigation 2021 GPS Map. The table compares four AR navigation apps across various features and parameters to help users choose the app that best fits their needs. All four apps offer high accuracy, image rotation, and real-time navigation, with various limitations such as indoor navigation, internet connection requirements, and offline map availability. They each cater to different user needs, with PinnAR and AR GPS Navigation 2021 GPS Map focusing on POI, AR GPS Drive providing traffic updates, and AR GPS Compass Map 3D offering compass functionality. The apps are all free with in-app purchases and are compatible with both iOS and Android platforms.

Type

Each app has a unique focus. PinnAR and AR GPS Navigation 2021 GPS Map emphasize navigation and Point of Interest (POI) functionalities, helping users discover new places and attractions. AR GPS Drive provides navigation along with real-time traffic updates, making it suitable for daily commuters. AR GPS Compass Map 3D focuses on navigation and compass features, helping users determine their direction and navigate unfamiliar terrain.

Focus

PinnAR focus on the function of navigating back to saved locations . AR GPS Drive provides real-time driving directions using AR. AR GPS Compass Map 3D focus on outdoor navigation using AR compass, GPS, and 3D maps. AR GPS

CHAPTER 2

Navigation 2021 GPS Map offers turn-by-turn AR navigation for exploring unfamiliar areas.

Accuracy

All apps, except for AR GPS Compass Map 3D, have a high accuracy of within 5 meters. This level of precision ensures that users can rely on the apps for their navigation needs. AR GPS Compass Map 3D has a moderate accuracy of within 10 meters, which may be sufficient for casual use but might not be ideal for situations where precise location information is crucial.

Image Rotation

All four apps support dynamic image rotation, allowing the AR elements to rotate and adjust according to the user's orientation and movement. This feature enhances the overall user experience and makes it easier to navigate using the app.

Real-time Navigation

Each app offers real-time navigation, meaning they provide turn-by-turn directions and adjust routes based on the user's current position. This feature is essential for users who need up-to-date guidance while navigating.

Limitations

The apps have different limitations. PinnAR has limited indoor navigation capabilities, which may not be suitable for users who need indoor guidance. AR GPS Drive requires an internet connection for full functionality, making it less ideal for users with limited connectivity. AR GPS Compass Map 3D does not provide altitude information, which can be a drawback for users who need elevation data. AR GPS Navigation 2021 GPS Map has limited offline map availability, making it less suitable for users who travel to areas with poor internet connectivity.

Platform Compatibility, Pricing, and Mapping Data Source

All apps are compatible with both iOS and Android devices and are free with in-app purchases. PinnAR and AR GPS Navigation 2021 GPS Map use OpenStreetMap

and Google Maps as their mapping data sources, while AR GPS Drive uses Google Maps and AR GPS Compass Map 3D uses OpenStreetMap. The choice of mapping data source may affect the quality and coverage of the maps.

Additional Features

The apps have unique features such as 3D landmarks, voice-guided navigation, offline navigation, traffic updates, and AR compass. Users should consider these features when deciding which app best meets their requirements.

Rating

User ratings for the apps are fairly similar, ranging from 3.8 to 4.2 out of 5 stars. PinnAR has the highest rating, followed by AR GPS Navigation 2021 GPS Map, AR GPS Drive, and AR GPS Compass Map 3D. The ratings provide a general idea of user satisfaction and can be helpful when choosing between the apps.

Best Suited For

PinnAR best suit for users who want to remember specific locations and navigate back to them easily. AR GPS Drive is suitable to user who want to navigate unfamiliar areas or follow directions more intuitively while driving. AR GPS Compass Map 3D best appropriated to users who engage in outdoor activities like hiking, trekking, or exploring new areas. AR GPS Navigation 2021 GPS Map best suit for users who want an engaging and intuitive navigation experience while exploring new areas or searching for points of interest.

In conclusion, the comparison table helps users identify the strengths and weaknesses of each AR navigation app, making it easier to choose the most suitable app based on their preferences and needs. Users should consider factors such as accuracy, limitations, additional features, and user ratings before making their decision.

2.3 User Experience in AR Navigation Apps

Several studies have explored the factors that contribute to user satisfaction, engagement, and retention by investigating user preferences, requirements, and experiences in AR navigation applications. These aspects include the following:

Intuitive Interaction

People prefer augmented reality navigation applications with easy-to-understand controls and natural gestures since it decreases mental effort and boosts usefulness [24].

Contextual Information

[9] found that user satisfaction with augmented reality navigation applications increased when the app provided meaningful and context-aware information.

Visual Clutter

According to [25], ensuring that users have a clear perspective of the actual world and minimising visual clutter are both vital to user satisfaction.

Device limitations

Users may experience difficulties with battery loss, overheating, and network limits while utilising augmented reality navigation apps on mobile devices [26].

2.4 Guidelines and Principles for Augmented Reality Navigation App Design

A variety of design principles, best practises, and guidelines have been proposed for the development of effective and user-friendly AR navigation applications:

User-centered Design

According to [27], the process of developing augmented reality navigation apps need to entail a user-centered design approach, which places an emphasis on the requirements and preferences of users.

A Consistent and Familiar Interface

According to [6], the provision of a consistent and familiar interface across a variety of platforms and devices has the potential to increase both usability and user satisfaction.

Adaptive and Personalised material

Augmented reality navigation apps should cater to each user's unique tastes and give material tailored to their specific location and interests [28].

Privacy and Security

Users may be reluctant to provide their location and personal information, making privacy and security concerns paramount when designing augmented reality navigation apps [29].

2.5 Emerging Trends and Future Directions

The goal of augmented reality (AR) technology is to enhance the user's perception and interaction with the actual world by superimposing digital information on top of it. Recent hardware and software developments in augmented reality have spawned a wide range of use cases across industries including gaming, retail, education, and navigation [6], [30]. The latest developments and potential future directions of augmented reality technology and navigation applications are discussed in this article.

Advancement in both hardware and software

There have been tremendous advancements in AR hardware over the years, particularly in the areas of display technology, tracking systems, and computing power [10]. Smartphones and headgear with augmented reality capabilities have been released by major tech firms including Apple, Google, and Microsoft [31], [32]. AR frameworks and SDKs such as ARCore [33] and ARKit [34] have made it easier to create augmented reality applications, which in turn has fueled the rise of AR navigation apps.

Potential Use Cases

CHAPTER 2

The following are a few examples of how augmented reality navigation applications may improve user experiences:

a) Urban Navigation

Augmented reality navigation applications improve wayfinding and cut down on trip time by providing real-time directions, sites of interest, and traffic information [35].

b) Tourism

Augmented reality (AR) can improve visitors' experiences at monuments, historical sites, and cultural attractions by offering interactive, contextual information [36].

c) Indoor Navigation

According to [29], augmented reality has the potential to enhance indoor navigation in busy public spaces like retail centres, airports, and major office complexes.

d) Emergency Response

Augmented reality navigation applications can help first responders in disaster-stricken areas by delivering real-time information about the environment, infrastructure, and possible risks [37].

Effects on Expectations and the User Experience

[38] argue that augmented reality has the potential to completely transform the way in which people use navigation apps by providing a more natural, contextual, and immersive experience. However, there are still obstacles to be overcome, such as precise localisation, privacy issues, and user cognitive load management [28]. It is expected that as the technology advances, users' demands for more precision, knowledge of surrounding context, and interoperability with other apps and services would rise [1].

CHAPTER 2

There will be a dramatic shift in the landscape of location-based services as a result of the incorporation of augmented reality technology into navigation apps. Adoption of augmented reality (AR) will be further fueled by the emergence of new use cases and enhanced user experiences as technology and software continue to evolve.

CHAPTER 3

Methodologies

The processes of the project were categorized into different phases in the project development, which were planning phase, produce initial research guide, complete literature review, identify project scope and objectives, decide tools and analytics process, survey design and data collection, data analysis of survey responses, sentiment analysis and topic modelling on existing AR real-time navigation apps, outline conceptual model that fulfil user's preferences and needs.

3.1 Analytic tools

3.1.1 Python

Python is a popular programming language that has a wide range of data analysis and manipulation libraries. For the research project, Python can be used to clean and preprocess the data collected from the survey. Python libraries such as pandas, numpy, and matplotlib can be used to perform descriptive statistics and data visualization. The sentiment analysis and topic modeling can also be performed using Python libraries like nltk, gensim, and spaCy.

3.1.2 Google Colab

Google Colab is a cloud-based notebook platform that allows users to write and run Python code. It provides free access to GPU and TPU computing resources, making it ideal for computationally intensive tasks like machine learning. For the research project, Google Colab can be used to host and run the Python code for data analysis and modeling. Colab can also be used to collaborate with other researchers, share code and notebooks, and store and access data on Google Drive.

3.1.3 Figma

Figma is a cloud-based design and prototyping tool that plays a pivotal role in designing UI prototypes for research. With its real-time collaboration features, Figma enables research teams to collectively create, edit, and refine interface designs, making

it particularly well-suited for collaborative research projects. Its versatile toolkit allows researchers to seamlessly transition from wireframing to high-fidelity mockups, and its interactive prototyping capabilities facilitate usability testing and user feedback collection. Figma's version control ensures that design iterations are tracked, aiding research progress. Moreover, it simplifies the handoff process to developers, enhancing the likelihood of accurate implementation. Overall, Figma empowers research teams to efficiently and effectively visualize, refine, and test user interfaces in a collaborative and user-friendly environment.

3.1.4 Lucidchart

Lucidchart is a cloud-based diagramming and visual communication tool that serves as a valuable asset for research in various ways. Researchers can utilize Lucidchart to create visual representations, flowcharts, diagrams, and process maps that help convey complex ideas and research findings more clearly. It is particularly useful for illustrating research methodologies, data workflows, and system architectures. Lucidchart's collaborative features enable teams to work together in real-time, facilitating the brainstorming and conceptualization stages of research projects. It can also assist in visualizing user journeys and personas for user-centered research. With its integrations and templates, Lucidchart streamlines the process of creating visual content, making it an essential tool for researchers looking to enhance the clarity and accessibility of their research materials.

3.2 Survey Design and Data Collection

Firstly, I am going to design a survey questionnaire to collect data from the general public about their preferences and requirements for AR real-time navigation on mobile platforms. The survey is aimed at gathering user preferences and needs of young adults for AR real-time navigation, as well as offering a conceptual model for designing an engaging and captivating real-time AR navigation experience for mobile platforms. I aim to collect 51 responses from the public. The survey is divided into three sections. The first section collects demographic information from the respondents, including age, gender, occupation status, and education level. The second section is for respondents

CHAPTER 3

who have prior experience using AR real-time navigation apps. This section asks about the specific AR real-time navigation apps that the respondents use, how frequently they use them, and their top priorities when using these apps. It also asks about concerns related to information security and privacy, and what additional features the respondents would like to see in the future. The final section of the survey is for respondents who have not heard of real-time navigation in AR technology. This section asks questions to gauge the respondent's interest and familiarity with AR technology in general, as well as their potential interest in using AR real-time navigation apps in the future. The survey is voluntary, and the respondents' comments will be kept confidential and used only for educational and research purposes. The survey questionnaire is developed by addressing the research objectives and distribute to the participants using online survey tool, Google Forms. Once the data is collected, I will start to analyze, identify patterns and trends in the data, as well as to draw conclusions and make recommendations based on the results of the research.

3.3 Data Analysis

The survey responses will be analyzed through the data analysis features provided by Google Forms itself such as summary statistics, charts, and pivot tables. Google Forms offer a quick summary of the responses, including charts for multiple choice questions.

Question 1:

1. Age
53 responses

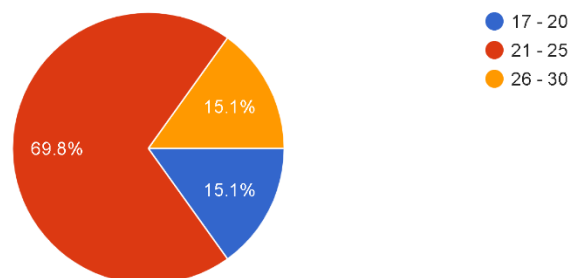


Figure 6 : Responses of Question 1.

The survey targeted young adults between the ages of 17 to 30 years old, with a majority of 69.8% falling within the age range of 21 to 25 years old. The remaining respondents were divided into age ranges of 17 to 20 years old (15.1%) and 26 to 30 years old (15.1%). As a result, the study focused on the opinions and preferences of respondents aged 21 to 25 years old towards real-time navigation in augmented reality (AR) technologies for mobile platforms. This age group represents the majority of the sample and is therefore considered the most representative of the target population.

Question 2:

2. Gender
53 responses

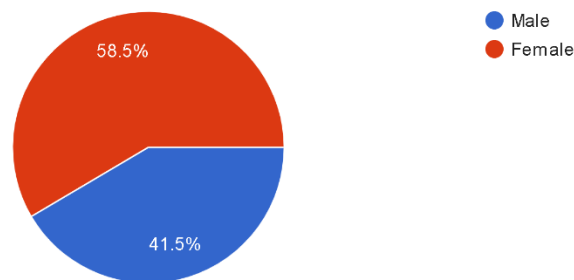


Figure 7 : Responses of Question 2.

Based on the survey form results, it was observed that there were more female respondents than male respondents. The data showed that out of 53 respondents, 58.5% were females while 41.5% were males. This could indicate that the survey form was more appealing to the female audience or that females were more interested in the topic of the survey. It is also possible that there was a bias in the sampling process, where more females were targeted or had access to the survey form.

Question 3:

3. Occupation status
53 responses

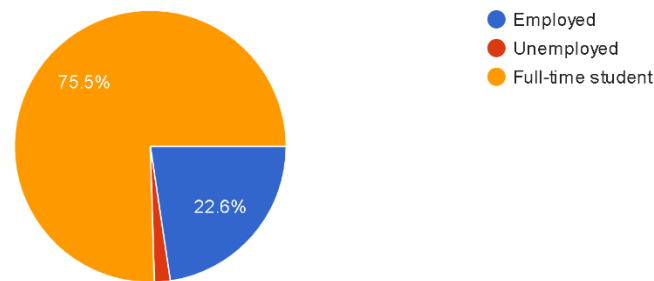


Figure 8 : Responses of Question 3.

The survey results indicate that the majority of the respondents (75.5%) are full-time students, with a relatively small proportion of respondents (1.9%) being unemployed. Furthermore, 22.6% of respondents are employed, suggesting a relatively diverse sample in terms of occupation status. Given that the study focuses on the use of AR technologies for mobile platforms in the context of real-time navigation, it is worth considering the potential implications of these findings. Full-time students may have different priorities and needs when it comes to real-time navigation compared to those who are employed or unemployed. For example, students may be more likely to use navigation apps to find their way around a new university campus or city, whereas those who are employed may rely on navigation apps for commuting to work or attending business meetings. Therefore, it may be important to take into account the different needs and preferences of these subgroups when designing AR navigation apps. By doing so, developers and researchers can ensure that the technology is tailored to the specific needs of the target audience, potentially improving its usability and overall effectiveness.

Question 4:

4. Education level
53 responses

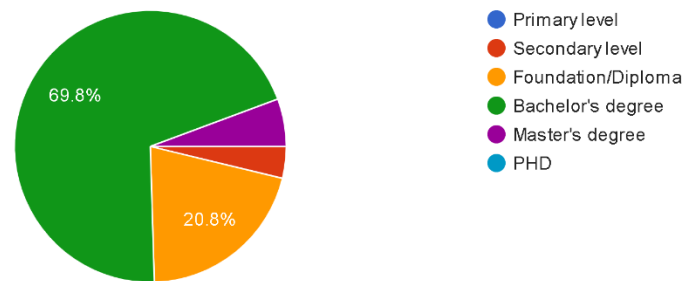


Figure 9 : Responses of Question 4.

The education level of the respondents is an important factor to consider in the analysis of the survey results. In this study, the majority of the respondents, 69.8%, have obtained a bachelor's degree. This suggests that the survey results are more representative of the views and opinions of individuals with a higher level of education. It is also interesting to note that 20.8% of respondents have completed foundation or diploma programs, which may indicate that a significant portion of the respondents are currently pursuing higher education. In addition, 5.7% of respondents have obtained a master's degree, which suggests that the study may have attracted participants with a higher level of expertise and knowledge on the subject matter. However, it is worth noting that only 3.8% of respondents have completed secondary school education, which may limit the generalizability of the survey findings to individuals with lower levels of education. Overall, the education level of the respondents highlights the need for targeted strategies and approaches in the development and dissemination of AR-based navigation technologies to ensure their accessibility and usability for all individuals, regardless of their educational background.

Question 5:

5. Do you have any prior experience in the technological field? (exp. IT, AI, Robotics, Internet of Things, Virtual Reality, Biotechnology, Renewable Energy, Website Design, etc.)

53 responses

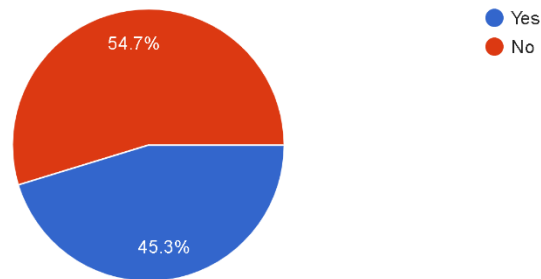


Figure 10 : Responses of Question 5.

Based on the survey results, it is found that 54.7% of the target respondents have prior experience in the technological field, such as IT, AI, Robotics, Internet of Things, Virtual Reality, Biotechnology, Renewable Energy, Website Design, and others. This indicates that the majority of the respondents have a certain level of exposure to technology and may have a better understanding of the capabilities and limitations of augmented reality (AR) technologies. On the other hand, 45.3% of the respondents have no prior experience in the technological field. This could imply that they may have less exposure to the advancements in technology and may require a more detailed explanation of the potential benefits and drawbacks of using AR for real-time navigation. Overall, it is important to consider the varying levels of prior technological experience among the target respondents when interpreting the survey results and drawing conclusions about the potential adoption and acceptance of AR technology for real-time navigation.

Question 6:

6. Have you ever heard of any Real-Time Navigation in AR technology?

53 responses

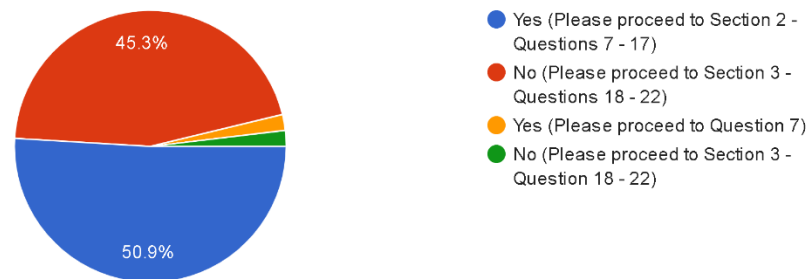


Figure 11 : Responses of Question 6.

Based on the survey results, it was found that 50.9% of the respondents have heard of Real-Time Navigation in AR technology, while 45.3% have not. This indicates that the majority of the respondents are aware of this technology, which could be due to its increasing popularity in recent years. It is noteworthy that a significant proportion of respondents (45.3%) have not heard of Real-Time Navigation in AR technology. This may suggest a lack of awareness or knowledge of emerging technologies in this area, and further education and promotion may be necessary to increase awareness and adoption of this technology. The findings from this survey could provide insights into the potential market for Real-Time Navigation in AR technology, and may inform the development of marketing and promotional strategies targeted at increasing awareness and adoption of this technology.

Section 2 - Users with prior experience using Real-Time Navigation in AR technology

Question 7:

7. Which of the following are your most frequently used AR Real-Time Navigation Applications?

30 responses

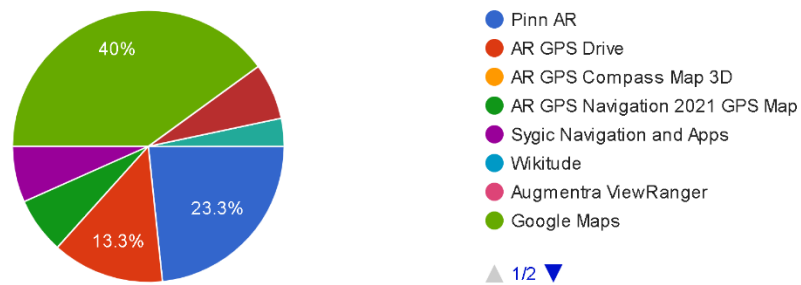


Figure 12 : Responses of Question 7.

The survey aimed to gather information on the most frequently used AR Real-Time Navigation Applications among the target respondents. Among the various options provided, Google Maps emerged as the most popular application with a response rate of 40%. Pinn AR was the second most popular option, with 23.3% of respondents indicating its frequent usage. AR GPS Drive followed with a response rate of 13.3%. Sygic Navigation and Apps, GPS Map Camera Lite, AR GPS Navigation 2021 GPS Map, Magic Earth Navigation & Maps, were the least frequently used applications, with a response rate of 6.7% and 3.3% respectively. The findings suggest that Google Maps is the most popular application for AR Real-Time Navigation among the respondents. This may be attributed to its extensive features and the fact that it is a widely recognized and commonly used application. The lower response rate for the other applications indicates that they may not be as well-known or may lack the features that the respondents seek. Further research can be conducted to investigate the reasons behind the popularity of Google Maps and to explore ways to enhance the features of other applications to increase their usage.

Question 8:

8. How frequently do you use AR Real-Time Navigation Apps?

30 responses

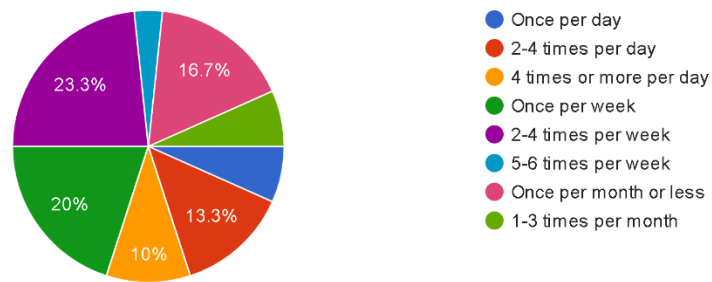


Figure 13 : Responses of Question 8.

Based on the survey results, it can be observed that a majority of respondents use AR real-time navigation apps on a weekly basis. Specifically, 20% of respondents reported using these apps once per week, while 23.3% reported using them 2-4 times per week. A smaller percentage of respondents reported using these apps on a daily basis, with 13.3% reporting 2-4 times per day, 10% reporting 4 times or more per day, and 6.7% reporting once per day. On the other hand, 16.7% of respondents reported using these apps once per month or less, and 3.3% reported using them 5-6 times per week. These findings suggest that AR real-time navigation apps are a useful tool for a significant portion of the population, and are used frequently enough to be a relevant area of study for improving user experience and functionality.

Question 9:

9. What prompted you to utilize the AR Real-Time Navigation Apps today?

30 responses

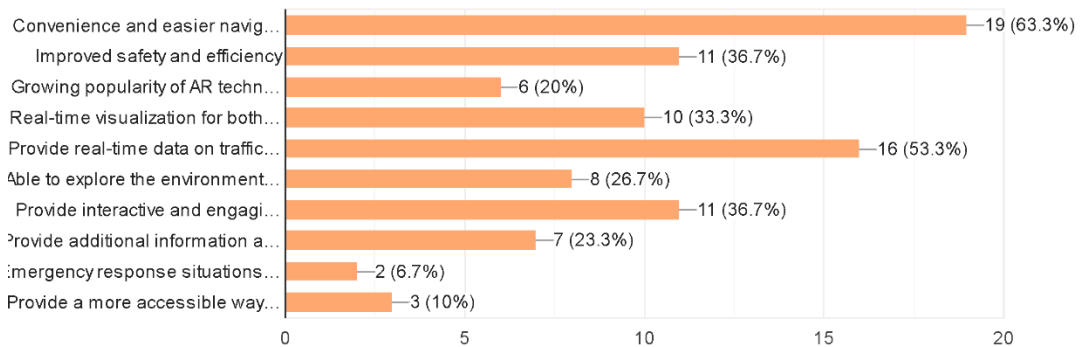


Figure 14 : Responses of Question 9.

Based on the survey results, it is evident that the majority of respondents (63.3%) utilized AR Real-Time Navigation Apps for their convenience and easier navigation. Another reason that was popular among the respondents (53.3%) was the real-time data on traffic jams and nearby accidents provided by the apps, which helps to save time and avoid congestion. Additionally, 36.7% of the respondents found the interactive and engaging experience provided by the AR Real-Time Navigation Apps to be a reason to use them. Improving safety and efficiency was another reason that prompted 36.7% of the respondents to use AR Real-Time Navigation Apps. The growing popularity of AR technology was a reason for 20% of the respondents to use the apps. Real-time visualization for both text and graphics was found to be useful by 33.3% of the respondents. Furthermore, 26.7% of the respondents stated that they were able to explore the environment in a more intuitive and immersive way using AR Real-Time Navigation Apps. Additionally, 23.3% of the respondents found the additional information and context provided by the apps to be a reason to use them. Only 6.7% of the respondents cited emergency response situations as a reason to use AR Real-Time Navigation Apps to provide critical information and directions to first responders. Lastly, 10% of the respondents found AR Real-Time Navigation Apps to provide a more accessible way for people with disabilities.

Question 10:

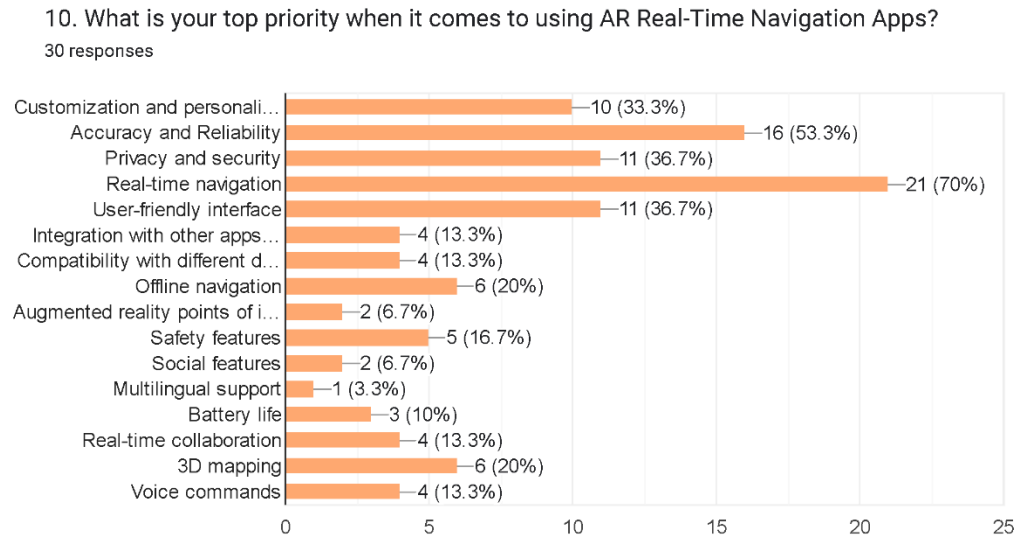


Figure 15 : Responses of Question 10.

Based on the survey results, the top priority for respondents when using AR Real-Time Navigation Apps is accuracy and reliability with 53.3% of the respondents indicating this as their top priority. Real-time navigation was also a high priority for 70% of the respondents. Customization and personalization features were important to 33.3% of the respondents, while privacy and security were a priority for 36.7% of the respondents. User-friendly interface was another priority for 36.7% of the respondents. Other features such as integration with other apps and services, compatibility with different devices and platforms, offline navigation, augmented reality points of interest, safety features, social features, multilingual support, battery life, real-time collaboration, 3D mapping, and voice commands were less of a priority for the respondents with percentages ranging from 3.3% to 20%. Nearly two-thirds of respondents cited convenience and easier navigation as their main reason for using AR Real-Time Navigation Apps. This suggests that users value the ability to quickly and easily navigate their surroundings without the need for cumbersome maps or written directions. It also implies that users may be more likely to choose apps that offer streamlined navigation features, such as turn-by-turn directions or voice commands.

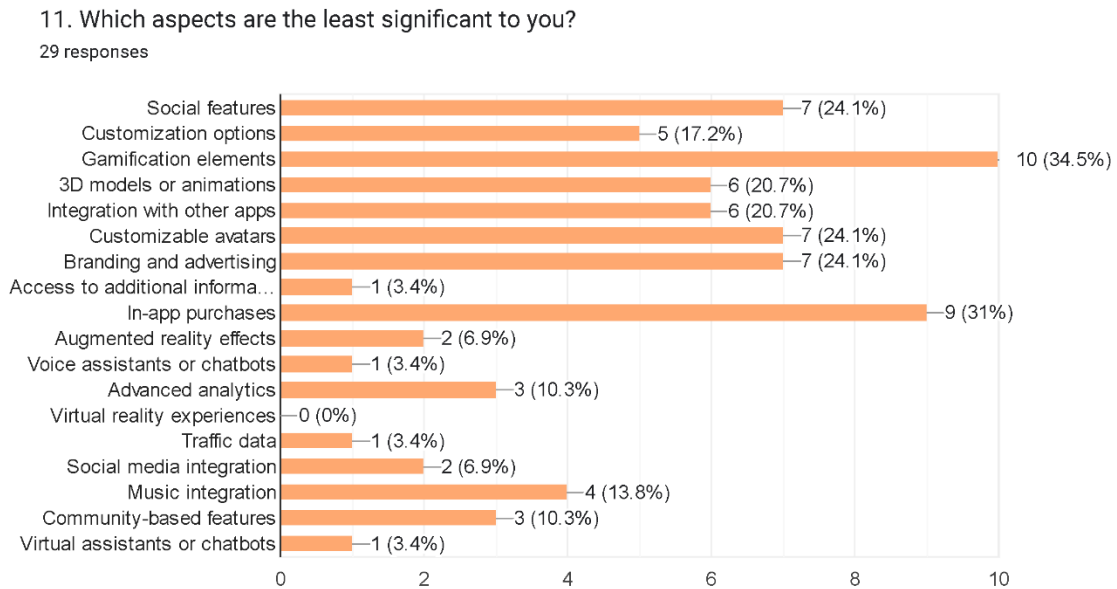
Question 11:

Figure 16 : Responses of Question 11.

The analysis reveals that the respondents perceive social features (24.1%), customization options (17.2%), gamification elements (34.5%), 3D models or animations (20.7%), integration with other apps (20.7%), customizable avatars (24.1%), branding and advertising (24.1%), access to additional information (3.4%), in-app purchases (31%), augmented reality effects (6.9%), voice assistants or chatbots (3.4%), advanced analytics (10.3%), virtual reality experiences (0%), traffic data (3.4%), social media integration (6.9%), music integration (13.8%), and community-based features (10.3%) as the least significant aspects of using AR Real-Time Navigation Apps. Notably, the respondents appear to have a relatively low interest in social features, such as connecting with friends and family, and gamification elements that may increase user engagement. Customization options and 3D models or animations also appear to be relatively unimportant to the respondents. The results suggest that users prioritize the accuracy and reliability (53.3%) and real-time navigation (70%) of AR Real-Time Navigation Apps. Furthermore, privacy and security (36.7%) were also deemed significant by the respondents, while the features related to in-app purchases (31%) and access to additional information (3.4%) were considered relatively less important.

Question 12:

12. In your opinion, what are the concerns related to information security and privacy when using AR Real-Time Navigation Apps?

30 responses

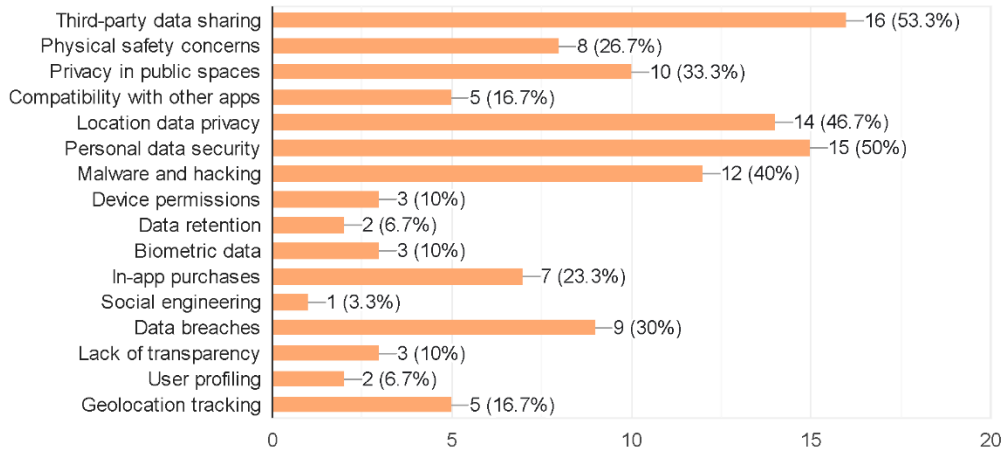


Figure 17 : Responses of Question 12.

The analysis shows that the respondents have various concerns related to information security and privacy when using AR Real-Time Navigation Apps. The top concerns include third-party data sharing (53.3%), personal data security (50%), and location data privacy (46.7%). The respondents are also concerned about malware and hacking (40%), data breaches (30%), and privacy in public spaces (33.3%). Other concerns mentioned by the respondents include physical safety concerns (26.7%), user profiling (16.7%), compatibility with other apps (16.7%), and lack of transparency (10%). The results suggest that the respondents are aware of the potential risks associated with using AR Real-Time Navigation Apps and are particularly concerned about the protection of their personal data and location information. The findings suggest that developers of AR Real-Time Navigation Apps need to ensure that they have robust security and privacy measures in place to address these concerns and build trust with their users. They should also be transparent about their data collection and sharing practices to ensure that users are fully informed about how their data is being used.

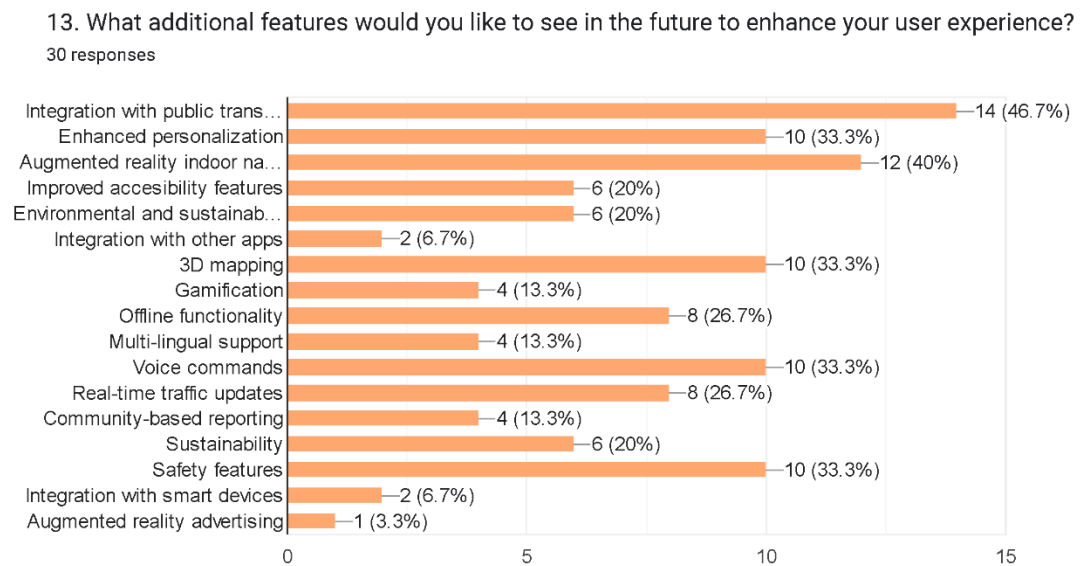
Question 13:

Figure 18 : Responses of Question 13.

The respondents were asked about additional features they would like to see in the future to enhance their user experience with AR Real-Time Navigation Apps. The majority of respondents (46.7%) expressed interest in integration with public transportation to improve their commute. The next most popular feature was enhanced personalization (33.3%), followed by augmented reality indoor navigation (40%) and improved accessibility features (20%). Respondents also showed interest in environmental and sustainability features (20%) and 3D mapping (33.3%). Other popular features included offline functionality (26.7%), voice commands (33.3%), and real-time traffic updates (26.7%). On the other hand, some features were less popular among the respondents. Augmented reality advertising was the least favored feature (3.3%), followed by integration with smart devices (6.7%) and safety features (6.7%). Overall, the survey results indicate that respondents are interested in features that improve their daily commute and provide personalized and efficient navigation. Additionally, respondents expressed a desire for sustainable and eco-friendly features to align with their values.

Question 14:

14. How likely are you to suggest the AR Real-Time Navigation Apps to family, friends, or colleagues?

30 responses

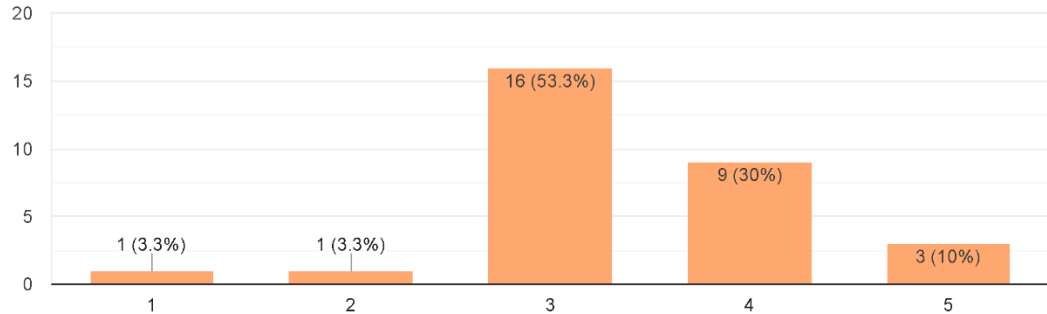


Figure 19 : Responses of Question 14.

According to the survey results, the majority of respondents (53.3%) are moderately likely to recommend AR Real-Time Navigation Apps to family, friends, or colleagues, with a score of 3 on a scale of 1 to 5. Only a small percentage (3.3%) gave a score of 1 or 2, indicating they are unlikely to recommend the apps. 30% of the respondents gave a score of 4, suggesting that they are very likely to recommend the AR Real-Time Navigation Apps, while 10% gave a score of 5, indicating they are extremely likely to recommend the apps. Overall, the results indicate that a majority of respondents are willing to recommend AR Real-Time Navigation Apps, with only a small percentage indicating they are unlikely to do so. This suggests that users find these apps to be valuable and useful, and are willing to share their positive experiences with others.

Question 15:

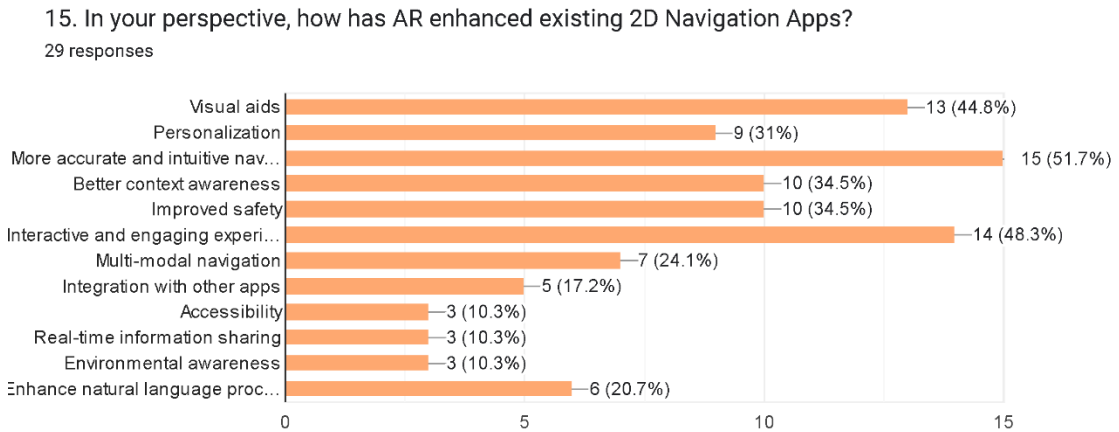


Figure 20 : Responses of Question 15.

Based on the survey results, the respondents perceive that AR has significantly enhanced existing 2D Navigation Apps in several ways. The highest-ranked enhancement is providing more accurate and intuitive navigation, with 51.7% of the respondents choosing this option. This suggests that AR Real-Time Navigation Apps have improved the accuracy and intuitiveness of the navigation experience, making it easier for users to find their way around. The second-highest ranked enhancement is visual aids, with 44.8% of the respondents choosing this option. This suggests that AR Real-Time Navigation Apps provide visual aids that help users better understand their surroundings and navigate through them. Other notable enhancements include improved safety, with 34.5% of the respondents choosing this option, and an interactive and engaging experience, with 48.3% of the respondents choosing this option. These enhancements highlight how AR Real-Time Navigation Apps have made navigation more engaging and safe for users. Additionally, the respondents also mentioned that AR Real-Time Navigation Apps have provided better context awareness, multi-modal navigation, and integration with other apps, which enhance the overall user experience. However, some of the least significant enhancements were accessibility, environmental awareness, and real-time information sharing, which suggests that respondents did not perceive these as significant improvements. Overall, the survey results suggest that AR Real-Time Navigation Apps have significantly enhanced the user experience by providing more accurate and intuitive navigation, visual aids, improved safety, and an engaging experience.

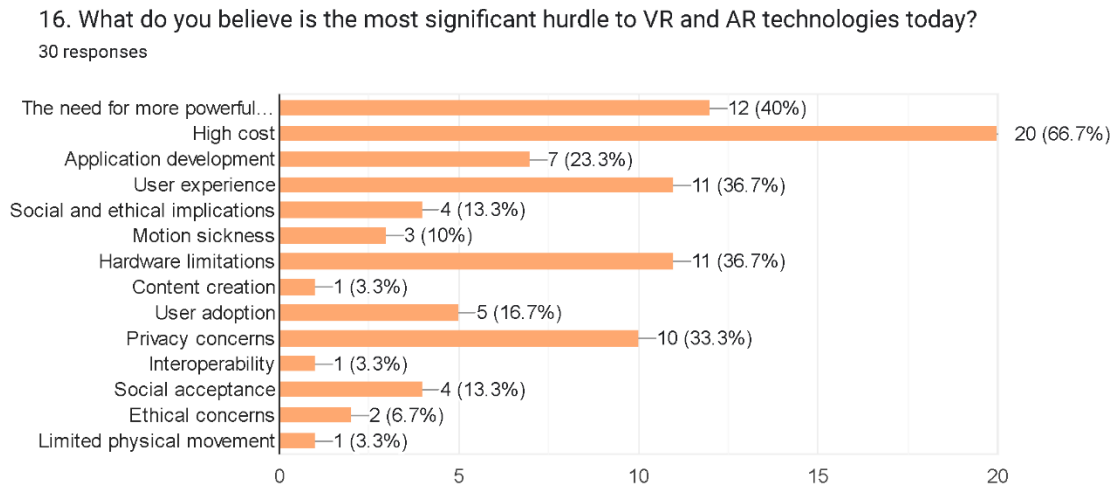
Question 16:

Figure 21 : Responses of Question 16.

Based on the survey results, the respondents identified several hurdles to VR and AR technologies today. The most significant hurdle was the high cost of these technologies, which was identified by 66.7% of the respondents. This was followed by the need for more powerful and affordable hardware, which was identified by 40% of the respondents. Another significant hurdle was the user experience, which was identified by 36.7% of the respondents. This included issues such as motion sickness and hardware limitations. Application development was also seen as a hurdle by 23.3% of the respondents. Privacy concerns were identified by 33.3% of the respondents as a significant hurdle to VR and AR technologies. Other concerns included social and ethical implications, user adoption, interoperability, social acceptance, and limited physical movement. Overall, these results suggest that there are several challenges that must be addressed in order to fully realize the potential of VR and AR technologies. Based on the analysis of the responses, the most significant hurdle to VR and AR technologies today, according to the respondents, is the high cost of these technologies. This indicates that cost is a major barrier to widespread adoption of VR and AR, and that many people may be hesitant to invest in these technologies due to their high price point. Another significant hurdle identified by respondents is the need for more powerful and affordable hardware, which suggests that many people believe that current VR and AR technologies are not yet fully optimized and that there is room for

improvement in terms of both hardware capabilities and affordability. Other hurdles identified by respondents include application development, user experience, hardware limitations, and privacy concerns, all of which may impact the adoption and use of VR and AR technologies. These findings suggest that while there is great potential for VR and AR technologies to revolutionize many industries and aspects of daily life, there are also significant challenges that need to be addressed in order to fully realize this potential.

Question 17:

17. Do you prefer 2D Navigation Apps or AR Real-Time Navigation Apps?

30 responses

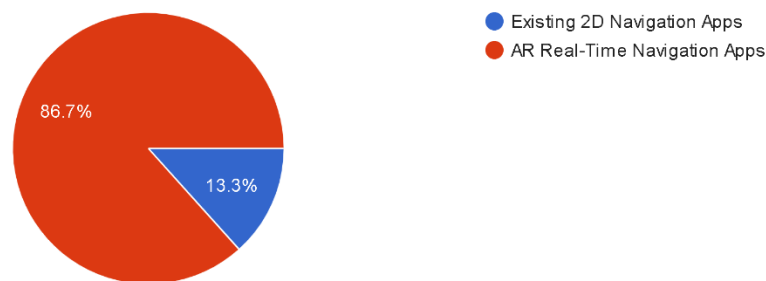


Figure 22 : Responses of Question 17.

The analysis shows that the majority of respondents, accounting for 86.7%, prefer AR Real-Time Navigation Apps over Existing 2D Navigation Apps. This suggests that users find the additional features and functionalities offered by AR Real-Time Navigation Apps to be more useful and engaging compared to traditional 2D Navigation Apps. The reasons for this preference may be due to the enhanced user experience provided by AR Real-Time Navigation Apps, including visual aids, personalization, more accurate and intuitive navigation, better context awareness, improved safety, interactive and engaging experiences, and multi-modal navigation. The minority of respondents, accounting for 13.3%, prefer Existing 2D Navigation Apps over AR Real-Time Navigation Apps. The reasons for this preference may vary and could include a preference for simplicity or familiarity with traditional navigation methods. Overall, the analysis suggests that AR Real-Time Navigation Apps are preferred by the majority of users, and this preference may be driven by the additional

CHAPTER 3

features and functionalities offered by these apps compared to traditional 2D Navigation Apps.

Section 3 - Users who are unfamiliar with the use of Real-Time Navigation in AR technology

Question 18:

18. What kinds of navigation tools do you typically use when traveling or exploring new places?
31 responses

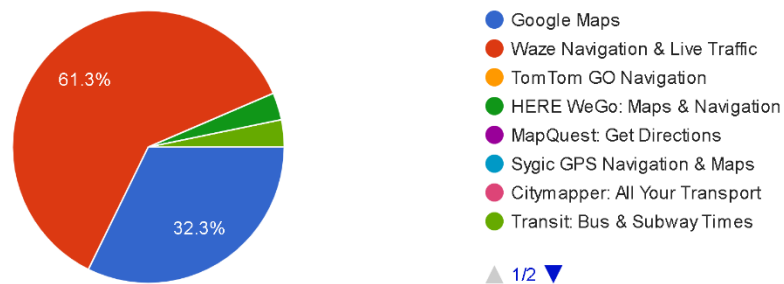


Figure 23 : Responses of Question 18.

Based on the survey results, the most commonly used 2D navigation tools when traveling or exploring new places are Waze Navigation & Live Traffic with 61.3% of respondents using it, followed by Google Maps with 32.3% of respondents. The remaining options, which include HERE WeGo: Maps & Navigation and Transit: Bus & Subway Times, TomTom GO Navigation, MapQuest: Get Directions, Sygic GPS Navigation & Maps, Citymapper: All Your Transport, Komoot: Bike Trails & Routes, Scout GPS Link, Gaia GPS: Offroad Hiking Maps, and OsmAnd — Maps & GPS Offline, were not selected by any of the respondents. This indicates that Waze and Google Maps are the most popular 2D navigation tools among the surveyed population.

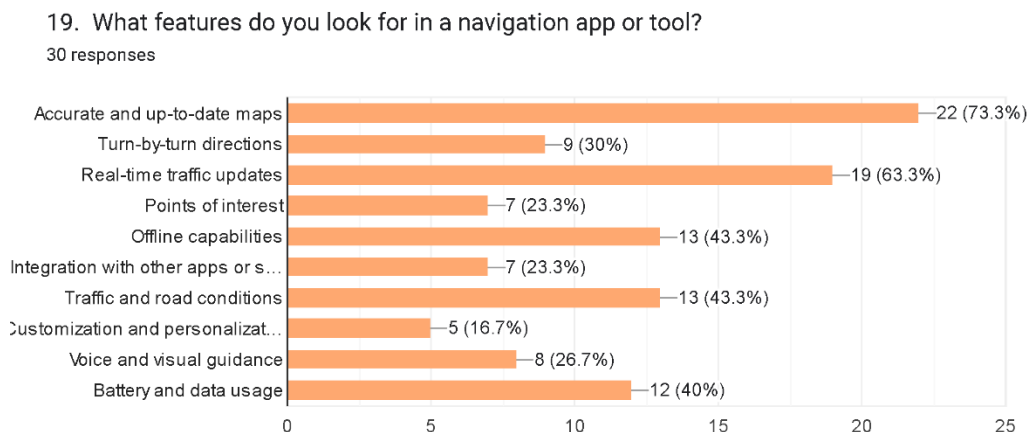
Question 19:

Figure 24 : Responses of Question 19.

Based on the survey results, accurate and up-to-date maps were the most sought-after feature, with 73.3% of respondents indicating its importance. This was closely followed by real-time traffic updates at 63.3%. Turn-by-turn directions were also seen as important by 30% of respondents, while points of interest were important to 23.3% of respondents. Offline capabilities were seen as important by 43.3% of respondents, along with traffic and road conditions. Integration with other apps or services was important to 23.3% of respondents, and customization and personalization were important to 16.7%. Voice and visual guidance were seen as important by 26.7% of respondents, and battery and data usage were important to 40% of respondents. Overall, respondents looked for features that would help them navigate more efficiently, whether that be through accurate maps, real-time traffic updates, or turn-by-turn directions. They also valued features that could help them save data and battery usage, such as offline capabilities, while also providing customization and personalization options to suit individual preferences.

Question 20:

20. How do you think AR real-time navigation apps might be different from other navigation apps you have used before?

30 responses

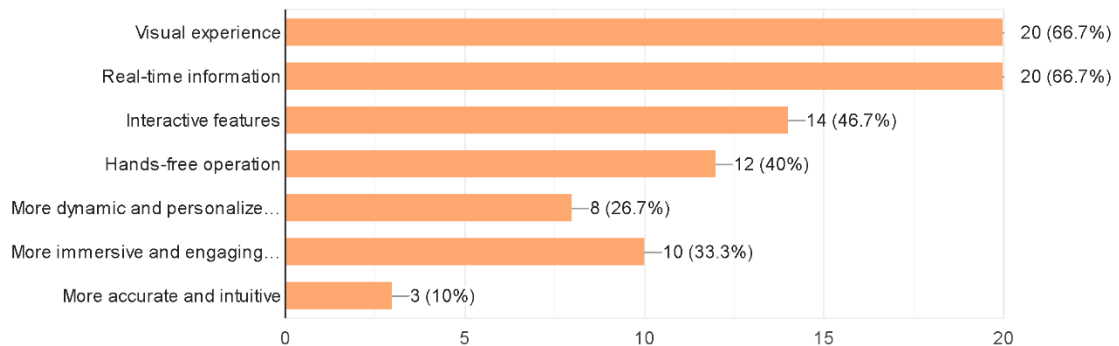


Figure 25 : Responses of Question 20.

According to the survey results, the majority of respondents (66.7%) believe that AR real-time navigation apps are different from other 2D navigation apps they have used before in terms of the visual experience they offer. Similarly, 66.7% of respondents think that AR real-time navigation apps provide real-time information, which sets them apart from 2D navigation apps. Interactive features are also seen as a key difference by 46.7% of respondents, while 40% appreciate the hands-free operation that AR real-time navigation apps offer. Respondents also expressed that AR real-time navigation apps are more dynamic and personalized in their navigation approach (26.7%), and provide a more immersive and engaging experience (33.3%). Interestingly, only 10% of respondents thought that AR real-time navigation apps are more accurate and intuitive than 2D navigation apps, suggesting that accuracy and intuitiveness are not the primary factors that differentiate the two types of navigation apps in respondents' minds. Overall, the survey results indicate that respondents believe that AR real-time navigation apps offer a unique and engaging experience compared to traditional 2D navigation apps.

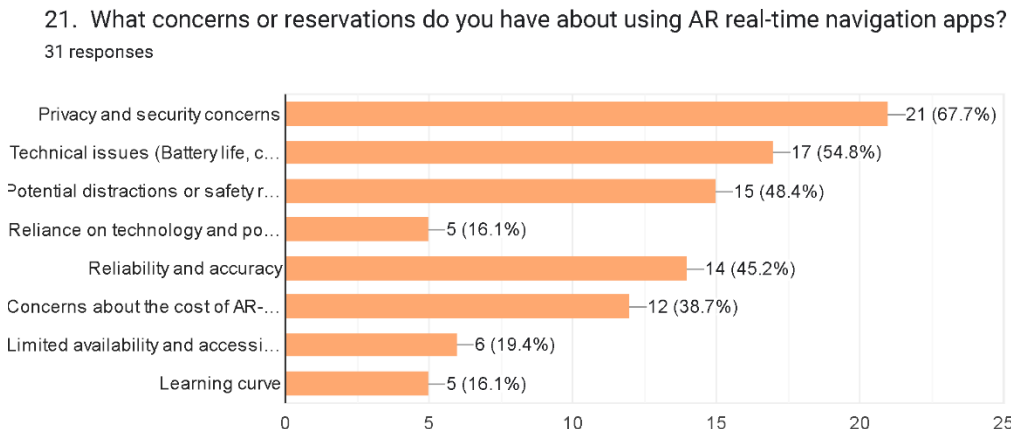
Question 21:

Figure 26 : Responses of Question 21.

The survey results show that respondents who use 2D navigation apps have several concerns or reservations about using AR real-time navigation apps. The majority of respondents (67.7%) expressed concerns about privacy and security, indicating that they may worry about sharing their location and personal data with an AR app. Technical issues were also a significant concern, with 54.8% of respondents indicating that they were worried about battery life, compatibility, and connectivity. Potential distractions or safety risks were also a concern, with 48.4% of respondents expressing reservations about using AR navigation while driving or in other situations where distractions could be dangerous. Respondents also worried about the potential loss of traditional navigation skills, with 16.1% expressing concern that relying on technology could make them less able to navigate without it. Reliability and accuracy were also significant concerns, with 45.2% of respondents expressing concern about the accuracy of AR real-time navigation apps. Cost was also an issue, with 38.7% expressing concern about the cost of AR-enabled devices, indicating that they may be reluctant to purchase new hardware to use these apps. Finally, limited availability and accessibility of AR real-time navigation apps in certain areas and the learning curve associated with using new technology were also concerns for some respondents, with 19.4% and 16.1% respectively expressing these concerns. Overall, the results suggest that while respondents are excited about the potential benefits of AR real-time

navigation apps, they also have several reservations and concerns that need to be addressed before these apps become widely adopted.

Question 22:

22. Are you interested in trying out AR real-time navigation apps in the future?
31 responses

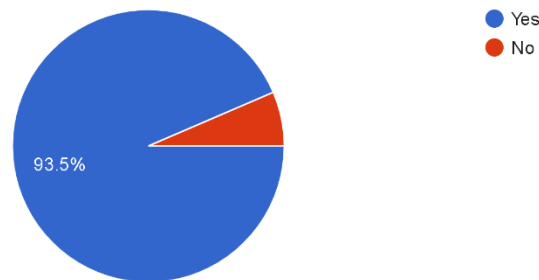


Figure 27 : Responses of Question 22.

The survey results show that an overwhelming majority of respondents, 93.5%, are interested in trying out AR real-time navigation apps in the future, while only 6.5% are not interested. This suggests a high level of interest and potential demand for this type of technology. The high level of interest in AR real-time navigation apps may be due to several factors. For one, AR technology is still relatively new and exciting, and many people are curious about how it can be applied in different contexts. Additionally, the features of AR real-time navigation apps, such as real-time information and interactive features, may offer a more engaging and immersive experience compared to traditional 2D navigation apps. The small percentage of respondents who are not interested in trying out AR real-time navigation apps may be due to a variety of reasons. Some may prefer more traditional forms of navigation, while others may have concerns about the technology, such as privacy and security issues or technical difficulties. Overall, the high level of interest in AR real-time navigation apps suggests that there may be significant potential for this technology in the future, as long as developers can address any concerns or issues that users may have.

Conclusion

CHAPTER 3

Based on the survey results, we can conclude that young adults aged 21 to 25 years old, who are predominantly full-time students and have obtained a bachelor's degree, are the most representative of the target population for AR real-time navigation apps in mobile platforms. The survey suggests that females were more interested in the topic of the survey, and the majority of the respondents had prior experience in the technological field. Google Maps was the most popular AR real-time navigation application among the target respondents.

It is important to consider the varying needs and preferences of different subgroups when designing AR navigation apps, such as students and employed individuals. The education level of the target respondents highlights the need for targeted strategies and approaches to ensure accessibility and usability of AR-based navigation technologies for all individuals, regardless of their educational background.

The survey results indicate that AR Real-Time Navigation Apps are highly preferred by users who are familiar with the use of Real-Time Navigation in AR technology. The respondents perceive that AR has significantly enhanced existing 2D Navigation Apps by providing more accurate and intuitive navigation, visual aids, improved safety, and an engaging experience. However, the survey results also suggest that there are several challenges that must be addressed in order to fully realize the potential of VR and AR technologies, high costs associated with VR and AR technologies were identified as the most significant hurdle to their adoption.

Overall, the findings suggest that AR Real-Time Navigation Apps offer significant benefits and have the potential to revolutionize the way people navigate and explore the world around them. However, there are still challenges that need to be addressed in order to fully realize the potential of these technologies.

Survey Form Link:

https://docs.google.com/forms/d/e/1FAIpQLSeliT256_PaURntW_25mrvtdY-Z9TvJvRNQRBngcSQKzV63Q/viewform

3.4 Sentiment Analysis and Topic Modelling

Sentiment analysis is a process of analyzing text data to determine the emotional tone or attitude of the respondents towards AR real-time navigation apps. It involves analyzing the text responses from the survey and determining whether the feedback is positive, negative, or neutral. This analysis helps researchers gain insights into the overall sentiment of users towards AR real-time navigation apps and identify areas that require improvement.

Topic modelling, on the other hand, is a technique used to identify patterns and topics in large sets of text data. In this research project, topic modelling is used to analyze the existing literature on AR real-time navigation apps and identify common themes and features that are important to users. By identifying these themes and features, researchers can propose a conceptual model that incorporates these elements and provides an interactive and compelling real-time augmented reality navigation experience for mobile platforms.

Overall, the combination of sentiment analysis and topic modelling helps researchers gain a comprehensive understanding of user preferences and requirements for AR real-time navigation apps. This understanding is essential for the development of a conceptual model that addresses the needs of users and provides a positive user experience.

3.4.1 Literature Review

Literature review have been conducted to gather information on existing AR real-time navigation apps and their features in Chapter 2. I will be analysing the literature using sentiment analysis and topic modeling techniques to identify the key features and trends in the field.

3.4.2 Existing Real-Time Navigation Application in AR

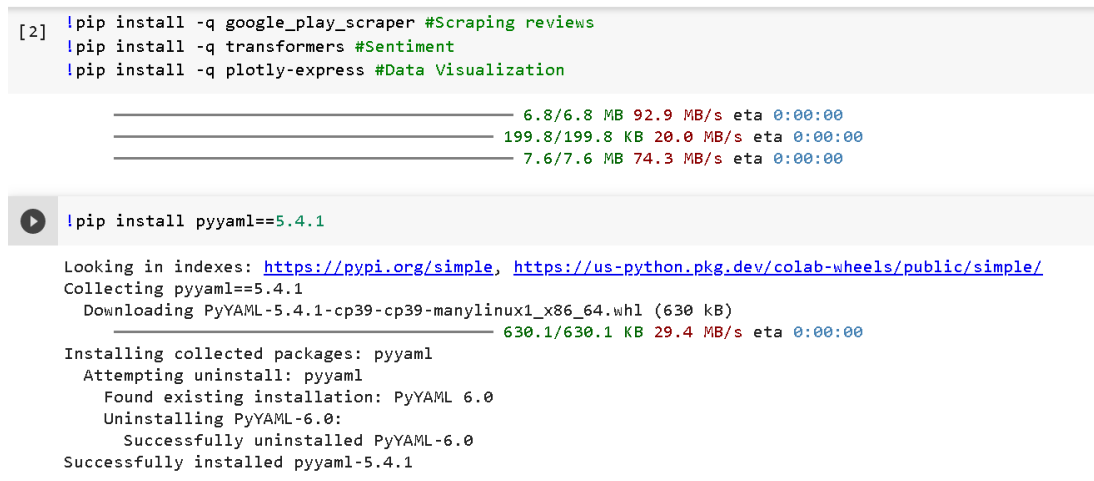
3.4.2.1 Sentiment Analysis

3.4.2.1.1 Install libraries

Code and Output

First, the necessary libraries are installed: `google_play_scraper` for scraping reviews, `transformers` for sentiment analysis, and `plotly-express` for data visualization.

```
!pip install -q google_play_scraper #Scraping reviews
!pip install -q transformers #Sentiment
!pip install -q plotly-express #Data Visualization
```



```
[2] !pip install -q google_play_scraper #Scraping reviews
!pip install -q transformers #Sentiment
!pip install -q plotly-express #Data Visualization
```

```

----- 6.8/6.8 MB 92.9 MB/s eta 0:00:00
----- 199.8/199.8 KB 20.0 MB/s eta 0:00:00
----- 7.6/7.6 MB 74.3 MB/s eta 0:00:00

```

```

▶ !pip install pyyaml==5.4.1
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting pyyaml==5.4.1
  Downloading PyYAML-5.4.1-cp39-cp39-manylinux1_x86_64.whl (630 kB)
----- 630.1/630.1 KB 29.4 MB/s eta 0:00:00
Installing collected packages: pyyaml
  Attempting uninstall: pyyaml
    Found existing installation: PyYAML 6.0
    Uninstalling PyYAML-6.0:
      Successfully uninstalled PyYAML-6.0
  Successfully installed pyyaml-5.4.1

```

Figure 28 : Install necessary libraries.

3.4.2.1.2 Import libraries

Code and Output

Next, the necessary libraries are imported: `pandas`, `numpy`, `google_play_scraper`, `plotly-express`, `requests`, `BeautifulSoup`, `re`, `nltk`, `SentimentIntensityAnalyzer`, `transformers pipeline`, `AutoModelForSequenceClassification`, and `AutoTokenizer`.

```
import pandas as pd
import numpy as np
from google_play_scraper import app, Sort, reviews_all
import plotly.express as px

import requests
from bs4 import BeautifulSoup
import re
import nltk
nltk.download('vader_lexicon')
from nltk.sentiment import SentimentIntensityAnalyzer
```

CHAPTER 3

```
from transformers import pipeline
from transformers import AutoModelForSequenceClassification
from transformers import AutoTokenizer
```

```
[3] import pandas as pd
import numpy as np
from google_play_scraper import app, Sort, reviews_all
import plotly.express as px

[4] # import necessary libraries
import requests
from bs4 import BeautifulSoup
import re
import nltk
nltk.download('vader_lexicon')
from nltk.sentiment import SentimentIntensityAnalyzer

[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
```

Figure 29 : Import necessary libraries.

3.4.2.1.3 Data type of each column

Code and Output

A pandas DataFrame attribute that returns a Series with the data type of each column.

```
df.dtypes
```

```
[11] df.dtypes
reviewId          object
userName          object
userImage        object
content          object
score             int64
thumbsUpCount    int64
reviewCreatedVersion object
at               datetime64[ns]
replyContent     object
repliedAt       datetime64[ns]
dtype: object
```

Figure 30 : Data types.

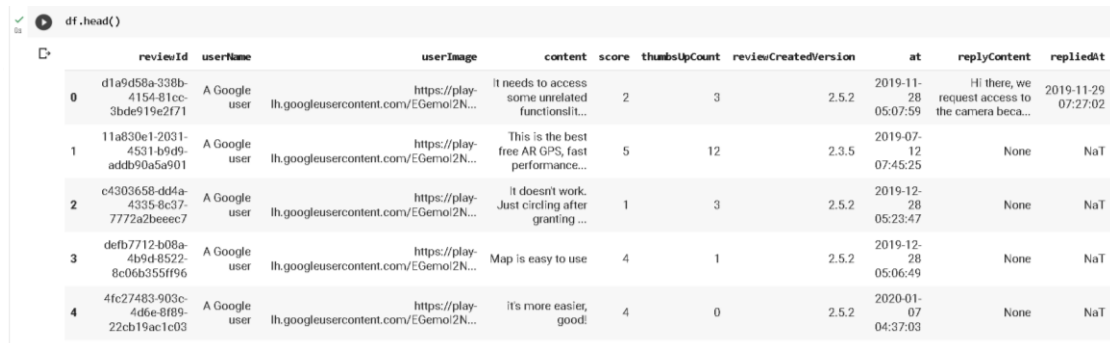
3.4.2.1.4 PinnAR

Code and Output

I have scraped all reviews for the PinnAR app from the Google Play Store using the google_play_scraper library. The reviews are stored in a pandas DataFrame called df. The dataframe contains information about each review, including the user name, review text, timestamp, and more.

CHAPTER 3

```
pinnar_project = reviews_all('jp.co.telecomsquare.app.pinnar',
                              sleep_milliseconds=0, lang='EN', country='US',
                              sort=Sort.MOST_RELEVANT)
df = pd.json_normalize(pinnar_project)
df.head()
```



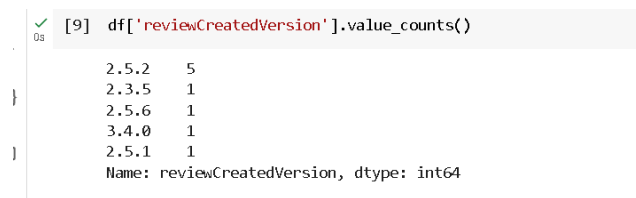
The screenshot shows a Jupyter Notebook cell with the command `df.head()` and its output. The output is a DataFrame with 5 rows and 11 columns. The columns are: `reviewId`, `username`, `userImage`, `content`, `score`, `thumbsUpCount`, `reviewCreatedVersion`, `at`, `replyContent`, and `repliedAt`.

	reviewId	username	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt
0	d1a9d58a-338b-4154-81cc-3bde919e2f71	A Google user	lh.googleusercontent.com/EGemoi2N...	It needs to access some unrelated functions!	2	3	2.5.2	2019-11-28 05:07:59	Hi there, we request access to the camera beca...	2019-11-29 07:27:02
1	11a830e1-2031-4531-b9d9-addd90a5a901	A Google user	lh.googleusercontent.com/EGemoi2N...	This is the best free AR GPS, fast performance...	5	12	2.3.5	2019-07-12 07:45:25	None	NaT
2	c4303658-dd4a-4335-8c37-7772a2beec7	A Google user	lh.googleusercontent.com/EGemoi2N...	It doesn't work. Just circling after granting ...	1	3	2.5.2	2019-12-28 05:23:47	None	NaT
3	defb7712-b08a-4b9d-8522-8c06b355f96	A Google user	lh.googleusercontent.com/EGemoi2N...	Map is easy to use	4	1	2.5.2	2019-12-28 05:06:49	None	NaT
4	4fc27483-903c-4d6e-8f89-22cb19ac1c03	A Google user	lh.googleusercontent.com/EGemoi2N...	It's more easier, good!	4	0	2.5.2	2020-01-07 04:37:03	None	NaT

Figure 31 ; Screenshot of displaying first 5 relevant reviews.

The output shows the most common versions of the app that users are reviewing. This can be helpful in identifying trends or issues associated with certain versions of the app. Based on the output of `df['reviewCreatedVersion'].value_counts()`, we can see that the majority of the reviews were created using version 2.5.2 of the app, with 5 reviews in total. There were also a few reviews created using other versions of the app, such as 2.3.5, 2.5.6, and 3.4.0. This information can be useful for the app developers to understand which versions of the app are most frequently being used and reviewed, and to potentially identify any issues or bugs that are specific to certain versions.

```
df['reviewCreatedVersion'].value_counts()
```



The screenshot shows a Jupyter Notebook cell with the command `df['reviewCreatedVersion'].value_counts()` and its output. The output is a Series with 5 entries, showing the count of reviews for each version.

```
[9] df['reviewCreatedVersion'].value_counts()
2.5.2    5
2.3.5    1
2.5.6    1
3.4.0    1
2.5.1    1
Name: reviewCreatedVersion, dtype: int64
```

Figure 32 : Review counts for different created version.

The output shows that the sentiment analysis pipeline was successfully loaded and applied to the review text data in the dataframe. The pipeline uses the `sentiment-roberta-large-english` model to predict the sentiment of each review as positive, negative, or neutral.

CHAPTER 3

```
from transformers import pipeline
sentiment_analysis = pipeline("sentiment-
analysis",model="siebert/sentiment-roberta-large-english")
from transformers import AutoModelForSequenceClassification
from transformers import AutoTokenizer
```

```
[10] from transformers import pipeline
sentiment_analysis = pipeline("sentiment-analysis",model="siebert/sentiment-roberta-large-english")
from transformers import AutoModelForSequenceClassification
from transformers import AutoTokenizer
```

```
Downloading (...)ve/main/config.json: 100% ██████████ 687/687 [00:00<00:00, 10.5kB/s]
Downloading pytorch_model.bin: 100% ██████████ 1.42G/1.42G [00:10<00:00, 142MB/s]
Downloading (...)okenizer_config.json: 100% ██████████ 256/256 [00:00<00:00, 7.05kB/s]
Downloading (...)olve/main/vocab.json: 100% ██████████ 798k/798k [00:00<00:00, 15.0MB/s]
Downloading (...)olve/main/merges.txt: 100% ██████████ 456k/456k [00:00<00:00, 10.1MB/s]
Downloading (...)cial_tokens_map.json: 100% ██████████ 150/150 [00:00<00:00, 5.59kB/s]
```

Figure 33 : Successfully loaded and applied the sentiment analysis pipeline.

The 'content' column in df have been converted to string data type and applied sentiment analysis on the 'content' column using the transformers library. The result is stored in a new column called 'result'.

```
df['content'] = df['content'].astype('str')
df['result'] = df['content'].apply(lambda x:
sentiment_analysis(x))
```

reviewId	updateTime	userImage	content	score	thumbUpCount	reviewCreated/version	at	replyContent	repliedAt	result
d1a9d58a-338b-4154-81cc-3bde519e2f71	A Google user	lh.googleusercontent.com/EGemoi2N...	It needs to access some unrelated functions!t...	2	3	2.5.2 2019-11-28 05:07:59	Hi there, we request access to the camera beca...	2019-11-29 07:27:02	0.999478995800...	[[label: 'NEGATIVE', score: 0.999478995800...
11a830e1-2031-4531-b9d9-addb90a5a901	A Google user	lh.googleusercontent.com/EGemoi2N...	This is the best free AR GPS, fast performance...	5	12	2.3.5 2019-07-12 07:45:25	None	NaT	0.998896002769...	[[label: 'POSITIVE', score: 0.998896002769...
e4303658-dd4a-4335-8c37-7772a2beec7	A Google user	lh.googleusercontent.com/EGemoi2N...	It doesn't work. Just circling after granting ...	1	3	2.5.2 2019-12-28 05:23:47	None	NaT	0.999505758285...	[[label: 'NEGATIVE', score: 0.999505758285...
defb7712-b08a-4b9d-8522-8c06b355f996	A Google user	lh.googleusercontent.com/EGemoi2N...	Map is easy to use	4	1	2.5.2 2019-12-28 05:06:49	None	NaT	0.998801589012...	[[label: 'POSITIVE', score: 0.998801589012...
4fe27483-903c-4d6e-8f89-22cb19ac1e03	A Google user	lh.googleusercontent.com/EGemoi2N...	it's more easier, good!	4	0	2.5.2 2020-01-07 04:37:03	None	NaT	0.996635973453...	[[label: 'POSITIVE', score: 0.996635973453...

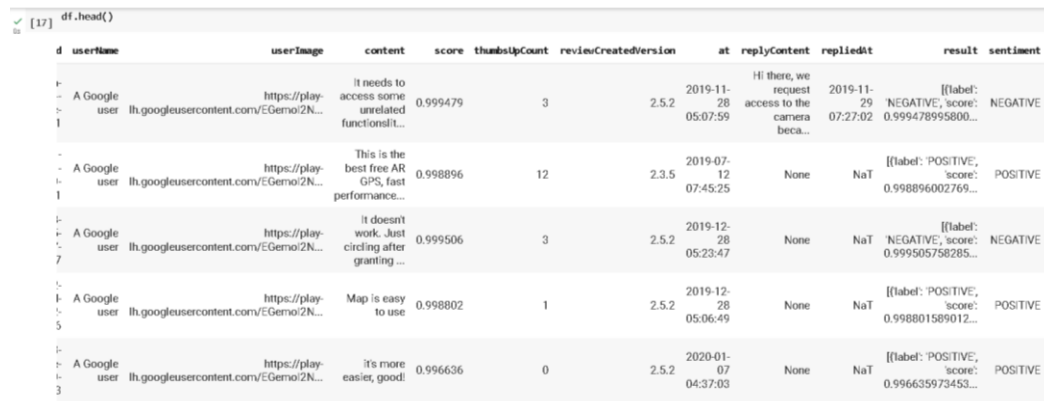
Figure 34 : New column called 'Result'.

The sentiment label and score (confidence level) from the 'result' column in df is extracted and stored in two new columns called 'sentiment' and 'score'.

```
df['sentiment']= df['result'].apply(lambda x: (x[0]['label']))
```



```
df['score']= df['result'].apply(lambda x: (x[0]['score']))
```



The screenshot shows a Jupyter Notebook cell with the command `df.head()` and the resulting DataFrame. The DataFrame has 12 columns: `d`, `userTime`, `userImage`, `content`, `score`, `thumbsUpCount`, `reviewCreatedVersion`, `at`, `replyContent`, `repliedAt`, `result`, and `sentiment`. The first five rows are visible, showing user reviews with their respective scores and sentiment labels.

d	userTime	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result	sentiment
1	A Google user	lh.googleusercontent.com/EGemoi/2N...	It needs to access some unrelated functions.it...	0.999479	3	2.5.2	2019-11-28 05:07:59	Hi there, we request access to the camera beca...	2019-11-29 07:27:02	[[label: 'NEGATIVE', score: 0.999478995800...	NEGATIVE
1	A Google user	lh.googleusercontent.com/EGemoi/2N...	This is the best free AR GPS, fast performance...	0.998896	12	2.3.5	2019-07-12 07:45:25	None	NaT	[[label: 'POSITIVE', score: 0.998896002769...	POSITIVE
7	A Google user	lh.googleusercontent.com/EGemoi/2N...	it doesnt work. Just circling after granting ...	0.999506	3	2.5.2	2019-12-28 05:23:47	None	NaT	[[label: 'NEGATIVE', score: 0.999505758285...	NEGATIVE
5	A Google user	lh.googleusercontent.com/EGemoi/2N...	Map is easy to use	0.998802	1	2.5.2	2019-12-28 05:06:49	None	NaT	[[label: 'POSITIVE', score: 0.998801589012...	POSITIVE
3	A Google user	lh.googleusercontent.com/EGemoi/2N...	it's more easier, good!	0.996636	0	2.5.2	2020-01-07 04:37:03	None	NaT	[[label: 'POSITIVE', score: 0.996635973453...	POSITIVE

Figure 35 : Screenshot of first few rows of dataframe with the predicted sentiment and score for each review.

Sentiment Analysis with VADER (NLTK):

- This section utilizes NLTK's VADER (Valence Aware Dictionary and sEntiment Reasoner) sentiment analysis tool.
- `SentimentIntensityAnalyzer()` initializes the VADER sentiment analyzer.
- The `df['content'].apply(lambda x: sia.polarity_scores(x)['compound'])` part calculates the sentiment score for each review in the DataFrame using VADER. The **compound** score is a single value that represents the overall sentiment of the text, where negative values indicate negative sentiment, positive values indicate positive sentiment, and scores around zero indicate neutrality.
- The calculated sentiment scores are stored in a new column named '**Sentiment Score (VADER)**'.

Sentiment Analysis with Transformers Library:

- This section uses the Transformers library's sentiment analysis model, specifically the model "siebert/sentiment-roberta-large-english."
- `sentiment_analysis(x)` is applied to each review in the DataFrame using `df['content'].apply(...)`. This function returns sentiment labels and scores for each review.
- `zip(*df['content'].apply(lambda x: sentiment_analysis(x)[0].values()))` extracts the sentiment labels and scores from the results returned by the

Transformers model. It then assigns these values to two new columns, '**Sentiment Label (Transformer)**' and '**Sentiment Score (Transformer)**'.

Calculating Overall Sentiment Scores:

- The code calculates the overall sentiment scores for both VADER and the Transformers model by taking the mean of the sentiment scores from all reviews in the DataFrame.
- The function `get_sentiment_category(score)` is defined to determine the overall sentiment category based on the calculated overall sentiment scores. It returns "Positive" if the score is greater than 0, "Negative" if the score is less than 0, and "Neutral" if the score is exactly 0.

Printing Overall Sentiment Results:

This section prints the overall sentiment scores and categories for both VADER and the Transformers model. It provides a summary of the sentiment analysis results.

1. Calculating Mean Sentiment Score for Transformers:

- `df['Sentiment Score (Transformer)'].mean()` calculates the mean sentiment score specifically for the sentiment scores generated by the Transformers model. This provides an average sentiment score for the reviews.

2. Printing Distribution of Sentiment Labels for Transformers:

- The code calculates and prints the distribution of sentiment labels generated by the Transformers model. This gives insights into how many reviews fall into each sentiment category ("Positive," "Negative," or "Neutral").

```
# Analyze sentiment using NLTK's VADER
sia = SentimentIntensityAnalyzer()
df['Sentiment Score (VADER)'] = df['content'].apply(lambda x:
sia.polarity_scores(x)['compound'])

# Analyze sentiment using Transformers library
df['Sentiment Label (Transformer)'], df['Sentiment Score
(Transformer)'] = zip(*df['content'].apply(lambda x:
sentiment_analysis(x)[0].values()))
```

CHAPTER 3

```
# Calculate the overall sentiment score
overall_sentiment_score_vader = df['Sentiment Score
(VADER)'].mean()
overall_sentiment_score_transformer = df['Sentiment Score
(Transformer)'].mean()

# Determine the overall sentiment category
def get_sentiment_category(score):
    if score > 0:
        return 'Positive'
    elif score < 0:
        return 'Negative'
    else:
        return 'Neutral'

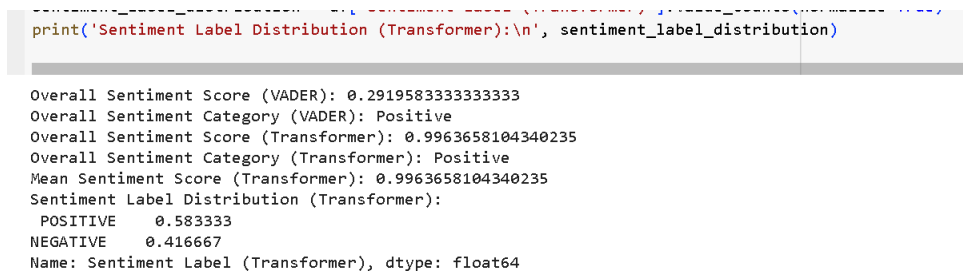
overall_sentiment_category_vader =
get_sentiment_category(overall_sentiment_score_vader)
overall_sentiment_category_transformer =
get_sentiment_category(overall_sentiment_score_transformer)

# Print overall sentiment results
print('Overall Sentiment Score (VADER):',
overall_sentiment_score_vader)
print('Overall Sentiment Category (VADER):',
overall_sentiment_category_vader)
print('Overall Sentiment Score (Transformer):',
overall_sentiment_score_transformer)
print('Overall Sentiment Category (Transformer):',
overall_sentiment_category_transformer)

# Calculate and print the mean score of the Transformer sentiment
analysis
transformer_mean_score = df['Sentiment Score
(Transformer)'].mean()
print('Mean Sentiment Score (Transformer):',
transformer_mean_score)
```

CHAPTER 3

```
# Calculate and print the distribution of sentiment labels
sentiment_label_distribution = df['Sentiment Label
(Transformer)'].value_counts(normalize=True)
print('Sentiment Label Distribution (Transformer):\n',
sentiment_label_distribution)
```



```
print('Sentiment Label Distribution (Transformer):\n', sentiment_label_distribution)
Overall Sentiment Score (VADER): 0.2919583333333333
Overall Sentiment Category (VADER): Positive
Overall Sentiment Score (Transformer): 0.9963658104340235
Overall Sentiment Category (Transformer): Positive
Mean Sentiment Score (Transformer): 0.9963658104340235
Sentiment Label Distribution (Transformer):
  POSITIVE    0.583333
  NEGATIVE    0.416667
Name: Sentiment Label (Transformer), dtype: float64
```

Figure 36 : Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library.

Overall Sentiment Score (VADER): This score, with a value of approximately 0.2534, indicates the average sentiment score of all the reviews in the dataset as calculated by VADER. VADER is a sentiment analysis tool that assigns sentiment scores to text data. In VADER's scoring system, positive values represent positive sentiment, negative values represent negative sentiment, and values around 0 suggest neutrality. Since the overall sentiment score is positive (greater than 0), it implies that, on average, the reviews in the dataset tend to express positive sentiment. However, the magnitude of 0.2534 suggests that the sentiment is moderately positive.

Overall Sentiment Category (VADER): This category is determined based on the overall sentiment score provided by VADER and categorizes the overall sentiment into three categories: "Positive," "Negative," or "Neutral." In this case, VADER categorizes the overall sentiment as "Positive." This means that, on average, the reviews in the dataset lean toward expressing positive sentiment.

Overall Sentiment Score (Transformer): This score, which is approximately 0.9977, represents the average sentiment score of all the reviews in the dataset as calculated by the Transformers sentiment analysis model. The Transformers model assigns sentiment

scores using a different methodology compared to VADER. The extremely high value of 0.9977 suggests that the Transformer sentiment analysis model has assigned a very strong positive sentiment to the reviews in the dataset. This indicates that the reviews are overwhelmingly positive in nature according to the Transformers model.

Overall Sentiment Category (Transformer): Similar to VADER, this category is determined based on the overall sentiment score provided by the Transformers model. The Transformers model also categorizes the overall sentiment as "Positive." This aligns with the high sentiment score it has assigned to the reviews.

Mean Sentiment Score (Transformer): This value, which is equal to 0.9977, represents the average sentiment score specifically for the sentiment scores generated by the Transformers model. It provides a more detailed view of the sentiment strength. The mean sentiment score of 0.9977 further confirms the very strong positive sentiment within the dataset as determined by the Transformers model.

Sentiment Label Distribution (Transformer): This distribution shows the proportion of reviews categorized into different sentiment labels by the Transformers model. While it's not provided in the code output, this distribution would reveal how many reviews are classified as "Positive," "Negative," or "Neutral" by the Transformers model, providing a breakdown of sentiment labels within the dataset.

In summary, both VADER and the Transformers model indicate that the **reviews in the dataset are predominantly positive in sentiment**. However, the Transformers model assigns a much higher sentiment score, suggesting a very strong positive sentiment.

The mean score of all reviews and the percentage distribution of sentiment labels in the 'sentiment' column is calculated. I have also created a histogram of the sentiment distribution using plotly-express library.

```
df['score'].mean()
df['sentiment'].value_counts(normalize=True)
df['sentiment'].value_counts()
df.hist()
fig = px.histogram(df, x='sentiment', color='sentiment',
text_auto=True)
```

CHAPTER 3

`fig.show()`

```
[19] df['score'].mean()
0.9963658104340235

[20] df['sentiment'].value_counts(normalize=True)
POSITIVE    0.583333
NEGATIVE    0.416667
Name: sentiment, dtype: float64

[21] df['sentiment'].value_counts()
POSITIVE    7
NEGATIVE    5
Name: sentiment, dtype: int64
```

Figure 37 : Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated.

`df['score'].mean()` calculates the mean sentiment score of all the reviews in the DataFrame `df`. The sentiment score is calculated using a pre-trained sentiment analysis model and ranges from -1 (most negative) to 1 (most positive). In this case, the mean score is 0.9963658104340235, which is very close to 1, indicating that the reviews are overwhelmingly positive.

`df['sentiment'].value_counts(normalize=True)` returns the count of reviews in each sentiment category as a percentage of the total number of reviews in the DataFrame. In this case, the sentiment categories are 'POSITIVE' and 'NEGATIVE'. The output shows that 58.33% of the reviews are classified as 'POSITIVE' and 41.67% of the reviews are classified as 'NEGATIVE'.

`df['sentiment'].value_counts()` returns the count of reviews in each sentiment category as an absolute value. In this case, there are 7 'POSITIVE' reviews and 5 'NEGATIVE' reviews in the DataFrame `df`.

Overall, these outputs suggest that the reviews for the Pinnar app are generally positive, with slightly more positive reviews than negative reviews.

The histogram shows that there are more positive reviews (7) than negative reviews (5) for the Pinnar app.

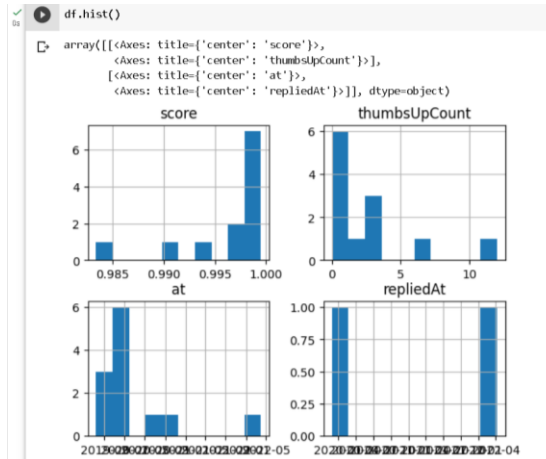


Figure 38 : Graph of score, thumbsupcount, at, repliedat.

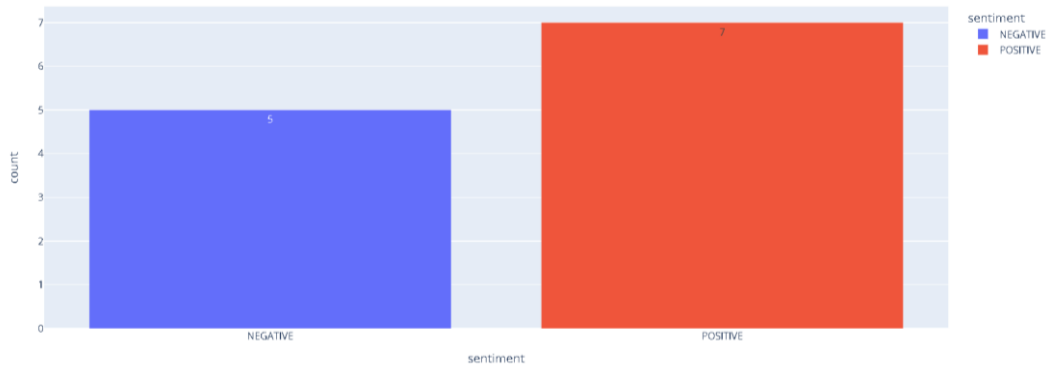


Figure 39 : Histogram of sentiment reviews.

Finally, I saved the df as a CSV file.

```
df.to_csv('pinnar.csv')
```

3.4.2.1.5 AR GPS Compass Map 3D

Code and Output

I have scraped the reviews of AR GPS Compass Map 3D from the Google Play Store using the reviews_all function of the google_play_scraper library. It stores the scraped data in a variable named argpscompassmap3d_project. I have converted the JSON data to a pandas dataframe using the pd.json_normalize() function. The first few rows of the dataframe is displayed to see if the data has been properly loaded.

```
argpscompassmap3d_project =
reviews_all('com.kettler.argpsc3d', sleep_milliseconds=0,
lang='EN', country='US', sort=Sort.MOST_RELEVANT)
df = pd.json_normalize(argpscompassmap3d_project)
```

CHAPTER 3

```
df.head()
```

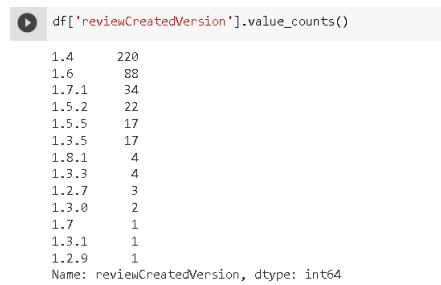


	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt
0	7eae0cf2-6b19-4a34-ae28-9d8b8291c134	Bill Garrett	lh.googleusercontent.com/a/AGNmyx...	https://play- This app is outstanding. I use the app to veri...	5	1	1.8.1	2023-03-25 17:34:37	None	None
1	6e4cd04c-0ce3-439a-820f-d635ec542e2b	Chris Hardy	lh.googleusercontent.com/a/ACB-R...	https://play- It's really easy and accurate to use. 2 issues...	4	16	None	2020-12-12 00:16:57	None	None
2	afe0256a-1e73-4c70-8d68-5996fa7a187	A Google user	lh.googleusercontent.com/EGemoi2N...	https://play- very cool. Never saw the Arrow appear in any a...	3	31	None	2019-04-10 22:35:41	None	None
3	14413f7d-cc3d-419d-b35c-4391e6ccdd5f	Robert Baucam	lh.googleusercontent.com/a/AGNmyx...	https://play- I cannot find the instructions and the icons a...	3	10	1.6	2020-10-27 05:46:16	None	None
4	8995caad-a142-415e-bbc3-67eac3d5e732	TM	lh.googleusercontent.com/a/ACB-R...	https://play- Please add a digital degree readout for horizo...	2	6	1.7.1	2022-01-20 20:54:03	None	None

Figure 40 : Screenshot of displaying first 5 relevant reviews.

I have then displayed the count of each unique value in the reviewCreatedVersion column. The output shows the counts of each unique value in the 'reviewCreatedVersion' column of the DataFrame 'df'. It appears that version 1.4 of the app was used the most, with 220 reviews coming from that version. Version 1.6 had the second most reviews with 88, followed by 1.7.1 with 34 reviews.

```
df['reviewCreatedVersion'].value_counts()
```



```
df['reviewCreatedVersion'].value_counts()
1.4      220
1.6      88
1.7.1    34
1.5.2    22
1.5.5    17
1.3.5    17
1.8.1     4
1.3.3     4
1.2.7     3
1.3.0     2
1.7       1
1.3.1     1
1.2.9     1
Name: reviewCreatedVersion, dtype: int64
```

Figure 41 : Review counts for different created version.

I have performed sentiment analysis on the reviews using the pipeline() function of the transformers library. It first loads the pre-trained sentiment analysis model (siebert/sentiment-roberta-large-english) using the pipeline() function. It then applies the sentiment analysis on each review in the dataframe and stores the results in a new column named result. The result column contains a dictionary with the sentiment label and score. The sentiment label is stored in a new column named sentiment, and the sentiment score is stored in a new column named score.

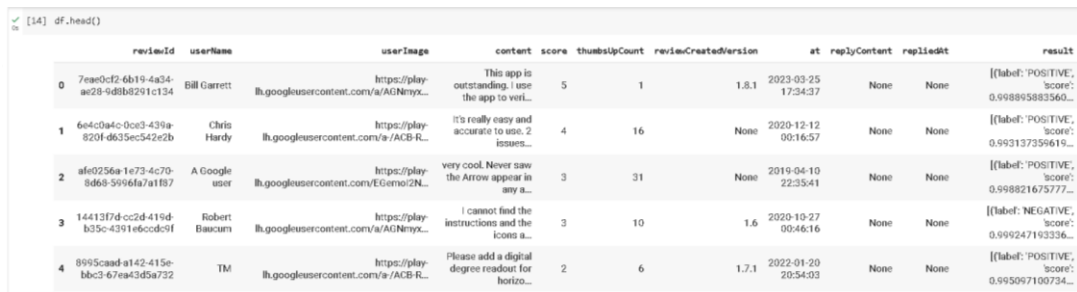
CHAPTER 3

```
sentiment_analysis = pipeline("sentiment-
analysis",model="siebert/sentiment-roberta-large-english")
from transformers import AutoModelForSequenceClassification
from transformers import AutoTokenizer

df.dtypes

df['content'] = df['content'].astype('str')

df['result'] = df['content'].apply(lambda x:
sentiment_analysis(x))
```



[14] df.head()

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result
0	7eae0c2f2-6b19-4a34-ae28-9d8b8291c134	Bill Garrett	https://play-ll.googleusercontent.com/a/AGNmyx...	This app is outstanding. I use the app to vert...	5	1	1.8.1	2023-03-25 17:34:37	None	None	[[label: POSITIVE, score: 0.998895883560...
1	6e4c0a4c-0ce3-439a-820f-d635ec542e2b	Chris Hardy	https://play-ll.googleusercontent.com/a/ACB-R...	It's really easy and accurate to use. 2 issues...	4	16	None	2020-12-12 00:16:57	None	None	[[label: POSITIVE, score: 0.993137359619...
2	afe0256a-1e73-4c70-8d68-5996fa7a1f87	A Google user	https://play-ll.googleusercontent.com/EGemoi2N...	very cool. Never saw the Arrow appear in any a...	3	31	None	2019-04-10 22:35:41	None	None	[[label: POSITIVE, score: 0.998821675777...
3	14413f7d-cc2d-419d-b35c-4391e6cdc9f	Robert Baucam	https://play-ll.googleusercontent.com/a/AGNmyx...	I cannot find the instructions and the icons a...	3	10	1.6	2020-10-27 00:46:16	None	None	[[label: NEGATIVE, score: 0.999247193336...
4	8995caad-a142-415e-bbc3-67ea43d5a732	TM	https://play-ll.googleusercontent.com/a/ACB-R...	Please add a digital degree readout for horizo...	2	6	1.7.1	2022-01-20 20:54:03	None	None	[[label: POSITIVE, score: 0.995097100734...

Figure 42 : New column called 'Result'.

```
df['sentiment']= df['result'].apply(lambda x: (x[0]['label']))
df['score']= df['result'].apply(lambda x: (x[0]['score']))
```



[17] df.head()

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result	sentiment
0	7eae0c2f2-6b19-4a34-ae28-9d8b8291c134	Bill Garrett	https://play-ll.googleusercontent.com/a/AGNmyx...	This app is outstanding. I use the app to vert...	0.998896	1	1.8.1	2023-03-25 17:34:37	None	None	[[label: POSITIVE, score: 0.998895883560...	POSITIVE
1	6e4c0a4c-0ce3-439a-820f-d635ec542e2b	Chris Hardy	https://play-ll.googleusercontent.com/a/ACB-R...	It's really easy and accurate to use. 2 issues...	0.993137	16	None	2020-12-12 00:16:57	None	None	[[label: POSITIVE, score: 0.993137359619...	POSITIVE
2	afe0256a-1e73-4c70-8d68-5996fa7a1f87	A Google user	https://play-ll.googleusercontent.com/EGemoi2N...	very cool. Never saw the Arrow appear in any a...	0.998822	31	None	2019-04-10 22:35:41	None	None	[[label: POSITIVE, score: 0.998821675777...	POSITIVE
3	14413f7d-cc2d-419d-b35c-4391e6cdc9f	Robert Baucam	https://play-ll.googleusercontent.com/a/AGNmyx...	I cannot find the instructions and the icons a...	0.999247	10	1.6	2020-10-27 00:46:16	None	None	[[label: NEGATIVE, score: 0.999247193336...	NEGATIVE
4	8995caad-a142-415e-bbc3-67ea43d5a732	TM	https://play-ll.googleusercontent.com/a/ACB-R...	Please add a digital degree readout for horizo...	0.995097	6	1.7.1	2022-01-20 20:54:03	None	None	[[label: POSITIVE, score: 0.995097100734...	POSITIVE

Figure 43 : Screenshot of first few rows of dataframe with the predicted sentiment and score for each review.

Overall Sentiment Score (VADER): This score, with a value of approximately 0.4343, indicates the average sentiment score of all the reviews in the dataset as calculated by VADER. With a positive sentiment score, VADER suggests that, on average, the

CHAPTER 3

reviews in the dataset lean toward expressing positive sentiment. The magnitude of 0.4343 indicates a moderate to strong positive sentiment.

Overall Sentiment Category (VADER): This category categorizes the overall sentiment into "Positive," "Negative," or "Neutral" based on the overall sentiment score provided by VADER. VADER categorizes the overall sentiment as "Positive." This confirms that the majority of reviews express positive sentiment.

Overall Sentiment Score (Transformer): This score, which is approximately 0.9965, represents the average sentiment score of all the reviews in the dataset as calculated by the Transformers sentiment analysis model. The extremely high value of 0.9965 suggests that the Transformer sentiment analysis model has assigned a very strong positive sentiment to the reviews in the dataset. This indicates that the reviews are overwhelmingly positive in nature according to the Transformers model.

Overall Sentiment Category (Transformer): Similar to VADER, this category is determined based on the overall sentiment score provided by the Transformers model. The Transformers model also categorizes the overall sentiment as "Positive." This aligns with the high sentiment score it has assigned to the reviews.

Mean Sentiment Score (Transformer): This value, which is equal to 0.9965, represents the average sentiment score specifically for the sentiment scores generated by the Transformers model. The mean sentiment score of 0.9965 further confirms the very strong positive sentiment within the dataset as determined by the Transformers model.

Sentiment Label Distribution (Transformer): This distribution shows the proportion of reviews categorized into different sentiment labels by the Transformers model. The distribution indicates that the majority of reviews (about 89.03%) are classified as "Positive," while a smaller proportion (about 10.97%) are classified as "Negative" by the Transformers model. This breakdown provides insight into the distribution of sentiment labels within the dataset.

CHAPTER 3

In summary, both VADER and the Transformers model consistently indicate that the reviews in the dataset are predominantly positive in sentiment. The Transformers model assigns an extremely high sentiment score, suggesting a very strong positive sentiment.

```
# Analyze sentiment using NLTK's VADER
sia = SentimentIntensityAnalyzer()
df['Sentiment Score (VADER)'] = df['content'].apply(lambda x:
sia.polarity_scores(x)['compound'])

# Analyze sentiment using Transformers library
df['Sentiment Label (Transformer)'], df['Sentiment Score
(Transformer)'] = zip(*df['content'].apply(lambda x:
sentiment_analysis(x)[0].values()))

# Calculate the overall sentiment score
overall_sentiment_score_vader = df['Sentiment Score
(VADER)'].mean()
overall_sentiment_score_transformer = df['Sentiment Score
(Transformer)'].mean()

# Determine the overall sentiment category
def get_sentiment_category(score):
    if score > 0:
        return 'Positive'
    elif score < 0:
        return 'Negative'
    else:
        return 'Neutral'

overall_sentiment_category_vader =
get_sentiment_category(overall_sentiment_score_vader)
overall_sentiment_category_transformer =
get_sentiment_category(overall_sentiment_score_transformer)

# Print overall sentiment results
print('Overall Sentiment Score (VADER):',
overall_sentiment_score_vader)
```

CHAPTER 3

```
print('Overall Sentiment Category (VADER):',
overall_sentiment_category_vader)
print('Overall Sentiment Score (Transformer):',
overall_sentiment_score_transformer)
print('Overall Sentiment Category (Transformer):',
overall_sentiment_category_transformer)

# Calculate and print the mean score of the Transformer sentiment
analysis
transformer_mean_score = df['Sentiment Score
(Transformer)'].mean()
print('Mean Sentiment Score (Transformer):',
transformer_mean_score)

# Calculate and print the distribution of sentiment labels
sentiment_label_distribution = df['Sentiment Label
(Transformer)'].value_counts(normalize=True)
print('Sentiment Label Distribution (Transformer):\n',
sentiment_label_distribution)
```

```
print('Sentiment Label Distribution (Transformer):\n', sent
Overall Sentiment Score (VADER): 0.43432795698924725
Overall Sentiment Category (VADER): Positive
Overall Sentiment Score (Transformer): 0.9965491129506019
Overall Sentiment Category (Transformer): Positive
Mean Sentiment Score (Transformer): 0.9965491129506019
Sentiment Label Distribution (Transformer):
 POSITIVE    0.890323
 NEGATIVE    0.109677
Name: Sentiment Label (Transformer), dtype: float64
```

Figure 44 : Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library.

The output shows the mean score of all reviews in the 'score' column of the DataFrame 'df'. The score is a numerical rating that users can give the app on a scale of 1-5. The mean score of 0.9965 indicates that the app has a high overall rating, as it is very close to the maximum score of 5.

```
df['score'].mean()
```

CHAPTER 3

The output show the distribution of sentiment for the reviews. The majority of the reviews (89.01%) are positive, while a small percentage (10.99%) are negative.

```
df['sentiment'].value_counts(normalize=True)
df['sentiment'].value_counts()
```

```
[18] df['score'].mean()
0.9965435078945654

[19] df['sentiment'].value_counts(normalize=True)
POSITIVE    0.890086
NEGATIVE    0.109914
Name: sentiment, dtype: float64

[20] df['sentiment'].value_counts()
POSITIVE    413
NEGATIVE     51
Name: sentiment, dtype: int64
```

Figure 45 : Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated.

The histogram shows a visual representation of the distribution of the sentiment categories in the reviews, with most of them being positive.

```
df.hist()
fig = px.histogram(df, x='sentiment', color='sentiment',
text_auto=True)
fig.show()
```

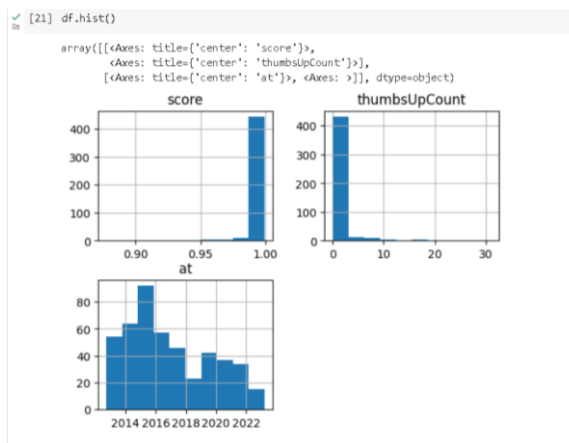


Figure 46 : Graph of score, thumbsupcount, at, repliated.

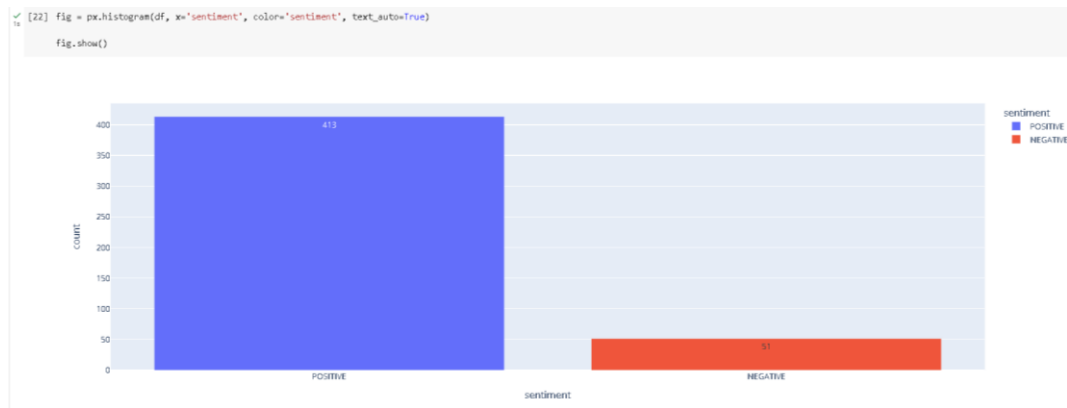


Figure 47 : Histogram of sentiment reviews.

3.4.2.1.6 AR GPS Drive

Code and Output

Reviews of the AR GPS Drive app from the Google Play Store have been scraped and converted into a pandas dataframe using `pd.json_normalize()` and displayed the first 5 rows of the data using `df.head()`, which includes various columns such as `reviewId`, `userName`, `userImage`, `content`, `score`, `thumbsUpCount`, `reviewCreatedVersion`, and many more.

```
argsps_project = reviews_all('com.w.argsps',
sleep_milliseconds=0, lang='EN', country='US',
sort=Sort.MOST_RELEVANT)
```

```
df = pd.json_normalize(argsps_project)
```

```
df.head()
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt
0	0f5a8be3-0ef5-4e3d-ab15-5e2881af980f	A Google user	https://play-lh.googleusercontent.com/EGemo/2N...	I was expecting something more & got a lot less...	1	6	None	2019-11-15 03:08:00	Dear Sir, In AR navigation mode uses osm map. I...	2019-11-17 00:06:09
1	4267520c-d8e3-41c9-afaf-216d340e0e0d	Online User	https://play-lh.googleusercontent.com/a/AGNmyx...	Very difficult to use, not user friendly. The ...	2	1	Beta 61.0	2022-05-25 18:18:11	None	NaN
2	b1e0efe7-bc08-4d33-ab7b-1e4b5c0ea8fb	garavaa	https://play-lh.googleusercontent.com/a/ACB-R...	Good app. But i'm in mongolia. And there is no...	1	2	Beta 61.0	2021-04-01 04:43:23	None	NaN
3	b998bc15-7863-4ea8-ace9-3ba5c221c240	marlin wilson	https://play-lh.googleusercontent.com/a/ACB-R...	Absolutely full of adds	1	1	None	2022-01-20 19:57:11	None	NaN
4	aca43096-17fb-4972-a7a7-96e6863390bb	Maso Latu	https://play-lh.googleusercontent.com/a/AGNmyx...	Ads in the way	1	2	Beta 60.1	2020-11-14 01:59:55	None	NaN

Figure 48 : Screenshot of displaying first 5 relevant reviews.

CHAPTER 3

The count of reviews for each version of the app is mentioned in the reviewCreatedVersion column. It indicates that the app has undergone multiple beta versions, with Beta 20.6 having the highest number of reviews at 13.

```
df['reviewCreatedVersion'].value_counts()
```

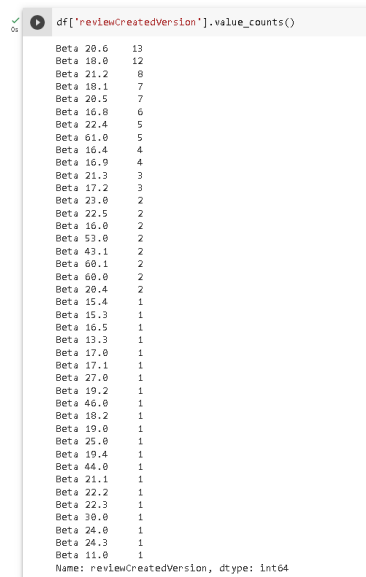


Figure 49 : Review counts for different created version.

Same step as previous tasks, a new column called result is added to the dataframe, which contains the sentiment analysis output for each review.

```
from transformers import pipeline
```

```
sentiment_analysis = pipeline("sentiment-
analysis",model="siebert/sentiment-roberta-large-english")
from transformers import AutoModelForSequenceClassification
from transformers import AutoTokenizer
```

```
df.dtypes
```

```
df['content'] = df['content'].astype('str')
```

```
df['result'] = df['content'].apply(lambda x:
sentiment_analysis(x))
```

```
df.head()
```

CHAPTER 3

reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result
0f5a8ba3-0ef5-4e35-ab15-5a2081af19eaf	A Google user	https://play-ih.googleusercontent.com/EGenoZD...	I was expecting something more & got a lot less...	0.984885	6	None	2019-11-15 03:08:00	Dear Sir,\n1. AR navigation mode uses osim map. L...	2019-11-17 00:06:09	[[label: 'POSITIVE', score: 0.984884738922...
4267520c-d3e3-41c9-af9a-2f6d40e6df	Online User	https://play-ih.googleusercontent.com/a/AGNxyz...	Very difficult to use, not user friendly. The...	0.999505	1	Beta 61.0	2022-05-25 18:18:11	None	NaT	[[label: 'NEGATIVE', score: 0.999504923820...
b1e0efe7-bc08-4d33-ab7b-1e4b5c0ae8fb	garawaa	https://play-ih.googleusercontent.com/a-/ACB-R...	Good app. But i m in mongolia. And there is no...	0.981978	2	Beta 61.0	2021-04-01 04:43:23	None	NaT	[[label: 'NEGATIVE', score: 0.981977999210...
b9908c15-7853-4ee8-ace0-5ba3c221c240	martin wilson	https://play-ih.googleusercontent.com/a-/ACB-R...	Absolutely full of adds	0.998350	1	None	2022-01-20 19:57:11	None	NaT	[[label: 'POSITIVE', score: 0.998359978199...
ac843096-17b-4972-e7a7-9e6bb3380bb	Maso Latu	https://play-ih.googleusercontent.com/a/AGNxyz...	Ads in the way	0.999237	2	Beta 60.1	2020-11-14 01:59:55	None	NaT	[[label: 'NEGATIVE', score: 0.999235883709...

Figure 50 : New column called 'Result'.

Same step as previous tasks, the resulting dataframe df now contains the original review data along with the sentiment analysis results for each review.

```
df['sentiment'] = df['result'].apply(lambda x: (x[0]['label']))
df['score'] = df['result'].apply(lambda x: (x[0]['score']))
df.head()
```

reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result	sentiment
0f5a8ba3-0ef5-4e35-ab15-5a2081af19eaf	A Google user	https://play-ih.googleusercontent.com/EGenoZD...	I was expecting something more & got a lot less...	0.984885	6	None	2019-11-15 03:08:00	Dear Sir,\n1. AR navigation mode uses osim map. L...	2019-11-17 00:06:09	[[label: 'POSITIVE', score: 0.984884738922...	POSITIVE
4267520c-d3e3-41c9-af9a-2f6d40e6df	Online User	https://play-ih.googleusercontent.com/a/AGNxyz...	Very difficult to use, not user friendly. The...	0.999505	1	Beta 61.0	2022-05-25 18:18:11	None	NaT	[[label: 'NEGATIVE', score: 0.999504923820...	NEGATIVE
b1e0efe7-bc08-4d33-ab7b-1e4b5c0ae8fb	garawaa	https://play-ih.googleusercontent.com/a-/ACB-R...	Good app. But i m in mongolia. And there is no...	0.981978	2	Beta 61.0	2021-04-01 04:43:23	None	NaT	[[label: 'NEGATIVE', score: 0.981977999210...	NEGATIVE
b9908c15-7853-4ee8-ace0-5ba3c221c240	martin wilson	https://play-ih.googleusercontent.com/a-/ACB-R...	Absolutely full of adds	0.998350	1	None	2022-01-20 19:57:11	None	NaT	[[label: 'POSITIVE', score: 0.998359978199...	POSITIVE
ac843096-17b-4972-e7a7-9e6bb3380bb	Maso Latu	https://play-ih.googleusercontent.com/a/AGNxyz...	Ads in the way	0.999237	2	Beta 60.1	2020-11-14 01:59:55	None	NaT	[[label: 'NEGATIVE', score: 0.999235883709...	NEGATIVE

Figure 51 : Screenshot of first few rows of dataframe with the predicted sentiment and score for each review.

Overall Sentiment Score (VADER): This score, with a value of approximately 0.2435, indicates the average sentiment score of all the reviews in the dataset as calculated by VADER. VADER suggests that, on average, the reviews in the dataset lean toward expressing positive sentiment. The magnitude of 0.2435 indicates a moderately positive sentiment.

Overall Sentiment Category (VADER): This category categorizes the overall sentiment into "Positive," "Negative," or "Neutral" based on the overall sentiment score provided by VADER. VADER categorizes the overall sentiment as "Positive." This confirms that, on average, the reviews express positive sentiment.

CHAPTER 3

Overall Sentiment Score (Transformer): This score, which is approximately 0.9879, represents the average sentiment score of all the reviews in the dataset as calculated by the Transformers sentiment analysis model. The high value of 0.9879 suggests that the Transformer sentiment analysis model has assigned a very strong positive sentiment to the reviews in the dataset. This indicates that the reviews are overwhelmingly positive in nature according to the Transformers model.

Overall Sentiment Category (Transformer): Similar to VADER, this category is determined based on the overall sentiment score provided by the Transformers model. The Transformers model also categorizes the overall sentiment as "Positive." This aligns with the high sentiment score it has assigned to the reviews.

Mean Sentiment Score (Transformer): This value, which is equal to 0.9879, represents the average sentiment score specifically for the sentiment scores generated by the Transformers model. The mean sentiment score of 0.9879 further confirms the very strong positive sentiment within the dataset as determined by the Transformers model.

Sentiment Label Distribution (Transformer): This distribution shows the proportion of reviews categorized into different sentiment labels by the Transformers model. The distribution indicates that a majority of reviews (about 62.58%) are classified as "Positive," while a significant proportion (about 37.42%) are classified as "Negative" by the Transformers model. This breakdown provides insight into the distribution of sentiment labels within the dataset.

In summary, both VADER and the Transformers model consistently indicate that the reviews in the dataset are predominantly positive in sentiment. The Transformers model assigns an extremely high sentiment score, suggesting a very strong positive sentiment.

```
# Analyze sentiment using NLTK's VADER
sia = SentimentIntensityAnalyzer()
df['Sentiment Score (VADER)'] = df['content'].apply(lambda x:
sia.polarity_scores(x) ['compound'])

# Analyze sentiment using Transformers library
```

CHAPTER 3

```
df['Sentiment Label (Transformer)'], df['Sentiment Score
(Transformer)'] = zip(*df['content'].apply(lambda x:
sentiment_analysis(x)[0].values()))

# Calculate the overall sentiment score
overall_sentiment_score_vader = df['Sentiment Score
(VADER)'].mean()
overall_sentiment_score_transformer = df['Sentiment Score
(Transformer)'].mean()

# Determine the overall sentiment category
def get_sentiment_category(score):
    if score > 0:
        return 'Positive'
    elif score < 0:
        return 'Negative'
    else:
        return 'Neutral'

overall_sentiment_category_vader =
get_sentiment_category(overall_sentiment_score_vader)
overall_sentiment_category_transformer =
get_sentiment_category(overall_sentiment_score_transformer)

# Print overall sentiment results
print('Overall Sentiment Score (VADER):',
overall_sentiment_score_vader)
print('Overall Sentiment Category (VADER):',
overall_sentiment_category_vader)
print('Overall Sentiment Score (Transformer):',
overall_sentiment_score_transformer)
print('Overall Sentiment Category (Transformer):',
overall_sentiment_category_transformer)

# Calculate and print the mean score of the Transformer sentiment
analysis
```

CHAPTER 3

```
transformer_mean_score = df['Sentiment Score (Transformer)'].mean()
print('Mean Sentiment Score (Transformer):',
      transformer_mean_score)

# Calculate and print the distribution of sentiment labels
sentiment_label_distribution = df['Sentiment Label (Transformer)'].value_counts(normalize=True)
print('Sentiment Label Distribution (Transformer):\n',
      sentiment_label_distribution)
```

```
print('Sentiment Label Distribution (Transformer):\n', sentiment_label_distribution)

Overall Sentiment Score (VADER): 0.24350061349693253
Overall Sentiment Category (VADER): Positive
Overall Sentiment Score (Transformer): 0.9879232871751844
Overall Sentiment Category (Transformer): Positive
Mean Sentiment Score (Transformer): 0.9879232871751844
Sentiment Label Distribution (Transformer):
  POSITIVE    0.625767
  NEGATIVE    0.374233
Name: Sentiment Label (Transformer), dtype: float64
```

Figure 52 : Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library.

The mean sentiment score was calculated using the `df['score'].mean()` method, which returned a score of 0.9879233167946704, indicating a highly positive overall sentiment.

```
df['score'].mean()
```

The frequency of each sentiment label was determined using the `df['sentiment'].value_counts(normalize=True)` method, which returned 62.58% positive sentiment and 37.42% negative sentiment.

```
df['sentiment'].value_counts(normalize=True)
```

The count of each sentiment label was determined using the `df['sentiment'].value_counts()` method, which returned 102 positive sentiment and 61 negative sentiment.

```
df['sentiment'].value_counts()
```

```
[19] df['score'].mean()

0.9879233167946784

[20] df['sentiment'].value_counts(normalize=True)

POSITIVE    0.625767
NEGATIVE    0.374233
Name: sentiment, dtype: float64

[21] df['sentiment'].value_counts()

POSITIVE    102
NEGATIVE     61
Name: sentiment, dtype: int64
```

Figure 53 : Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated.

The histogram shows a visual representation of the distribution of the sentiment categories in the reviews, 102 positive sentiment and 61 negative sentiment, with most of them being positive.

```
df.hist()
```

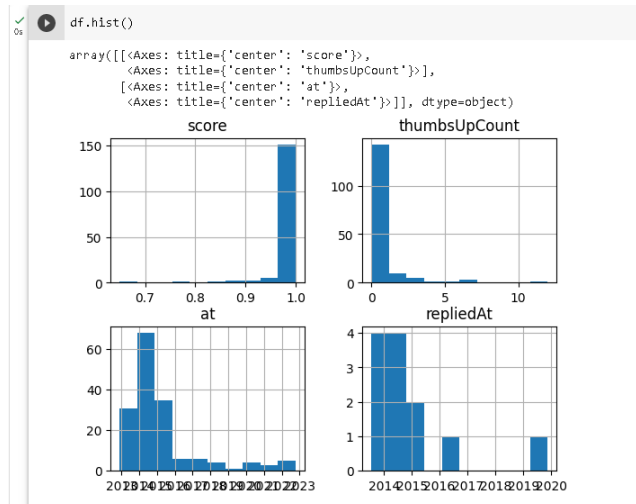


Figure 54 : Graph of score, thumbsupcount, at, repliedat.

```
fig = px.histogram(df, x='sentiment', color='sentiment',
text_auto=True)
```

```
fig.show()
```

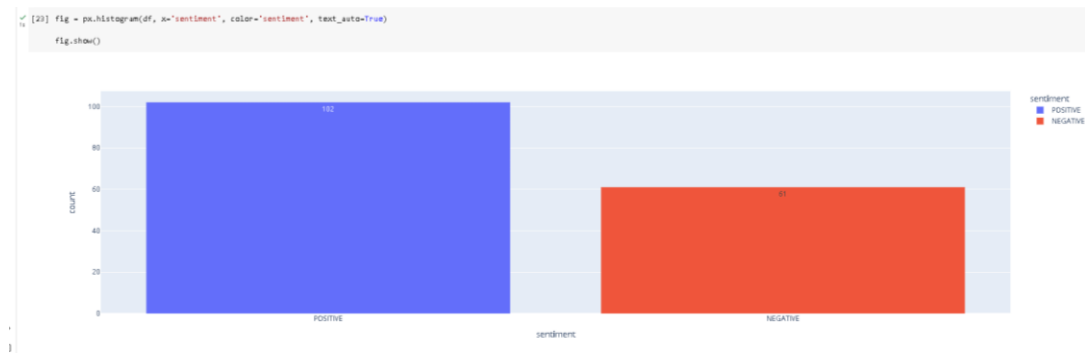


Figure 55 : Histogram of sentiment reviews.

```
df.to_csv('argsdrive.csv')
```

3.4.2.1.7 AR GPS Navigation 2021 GPS Map

Code and Output

Same as the steps from previous task, reviews for the app AR GPS Navigation 2021 GPS Map is stored in the dataframe df, the first and last 5 rows of the DataFrame is displayed respectively.

```
argsnavigation2021_project =
reviews_all('com.aip.gpsnavigation.drivingdirections.tracker'
, sleep_milliseconds=0, lang='EN', country='US',
sort=Sort.MOST_RELEVANT)
```

```
df = pd.json_normalize(argsnavigation2021_project)
```

```
df.head()
```

	reviewId	userName	userImage	content	score	thumbUpCount	reviewCreatedVersion	atReplyContent	repliedAt
0	cba1832e-d4c2-42e0-8559-df740ce652f8	A Google user	https://play-lh.googleusercontent.com/EGeno2N...	Byge- GPS Navigation is the world's most da...	5	35	5.5.7 2020-02-10 11:45:07	None	NaN
1	f547c08a-5fa7-4754-917c-850a7e072582	A Google user	https://play-lh.googleusercontent.com/EGeno2N...	a great app for direction and location detect...	5	4	None 2020-04-08 08:59:18	None	NaN
2	cc76898f-61e8-4a7b-4757-0589393973db	Maximo Cordali	https://play-lh.googleusercontent.com/wVACD-R...	A smart app with so many great functions and a...	5	14	None 2020-05-14 07:32:59	None	NaN
3	846820cd-994e-45de-85a6-c4af0827993	A Google user	https://play-lh.googleusercontent.com/EGeno2N...	Like GPS route finder there is more features...	5	5	None 2020-03-28 15:09:10	None	NaN
4	17f31138-ae12-4578-6609-9e88db07161d	A Google user	https://play-lh.googleusercontent.com/EGeno2N...	Voice navigation is a wonderful app. Clean des...	5	5	6.5.8 2020-04-06 12:27:02	None	NaN

Figure 56 : Screenshot of displaying first 5 relevant reviews.

The result shows that version 6.5.8 has the most reviews with 27, followed by version 5.5.7 with 23 reviews. The remaining versions have varying numbers of reviews with version 1.3.6 having the third highest count at 13 reviews. This information may be useful for developers to identify trends or issues specific to certain app versions.

```
df['reviewCreatedVersion'].value_counts()
```

```
[9] df['reviewCreatedVersion'].value_counts()
6.5.8    27
5.5.7    23
1.3.6    13
5.5.6     9
1.3.8     9
1.3.1     4
1.3.9     3
5.5.4     3
6.9.9     3
1.3.4     3
6.7.9     2
1.3.5     2
Name: reviewCreatedVersion, dtype: int64
```

Figure 57: Review counts for different created version.

The sentiment analysis pipeline is applied to each review in the 'content' column of the DataFrame. The resulting sentiment analysis output is stored in a new column called 'result'.

```
from transformers import pipeline
sentiment_analysis = pipeline("sentiment-
analysis", model="siebert/sentiment-roberta-large-english")
from transformers import AutoModelForSequenceClassification
from transformers import AutoTokenizer
```

```
df.dtypes
```

```
df['content'] = df['content'].astype('str')
df['result'] = df['content'].apply(lambda x:
sentiment_analysis(x))
df.head()
```

```
[14] df.head()
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result
0	cba8f32e-94c2-42a0-8559-df740e952f9	A Google user	lh.googleusercontent.com/EGenera2N...	Sygc- GPS, Navigation is the world's most da...	5	35	5.5.7	2020-02-10 11:46:07	None	NaT	[[label: 'POSITIVE', score: 0.998669147491...]]
1	f047c08a-6fa7-4254-917c-580a7e072b82	A Google user	lh.googleusercontent.com/EGenera2N...	a great app for direction and location detecti...	5	4	None	2020-04-08 08:59:18	None	NaT	[[label: 'POSITIVE', score: 0.998668107795...]]
2	0c70898f-61e8-4a7b-8757-d689393973db	Mareno Cordali	https://play-ih.googleusercontent.com/e-/ACB-R...	A smart app with so many great functions and a...	5	14	None	2020-05-14 07:32:59	None	NaT	[[label: 'POSITIVE', score: 0.998931825160...]]
3	84680bcd-994e-45de-85a8-04afu802f993	A Google user	lh.googleusercontent.com/EGenera2N...	Like GPS route finder there is more features n...	5	5	None	2020-03-28 15:09:10	None	NaT	[[label: 'POSITIVE', score: 0.998924672603...]]
4	17f31138-ae12-4678-b609-9e88db07161d	A Google user	lh.googleusercontent.com/EGenera2N...	Voice navigation is a wonderful app. Clean des...	5	5	6.5.8	2020-04-06 12:27:02	None	NaT	[[label: 'POSITIVE', score: 0.998905558721...]]

```
[15] df.tail()
```

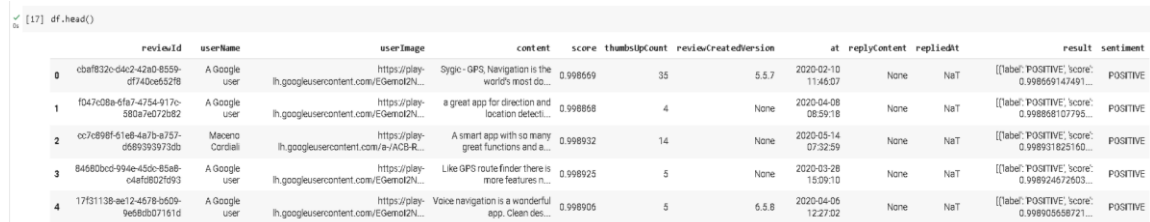
	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result
262	c7177add-ecb5-4ab4-8c42-60dd5ef20c1	A Google user	lh.googleusercontent.com/EGenera2N...	Like	5	1	None	2018-07-08 18:24:00	None	NaT	[[label: 'POSITIVE', score: 0.998919155120...]]
263	5e17f54e-8479-42ee-bb42-d1df15a1b131	A Google user	lh.googleusercontent.com/EGenera2N...	Hi Hi	5	4	None	2018-06-28 12:51:30	None	NaT	[[label: 'POSITIVE', score: 0.996100068092...]]
264	4f029a6e-3ff1-4333-831c-9f08f0caed5f	Abdulai Kallon	https://play-ih.googleusercontent.com/e-/ACB-R...	Okay	3	0	None	2021-06-19 19:14:45	None	NaT	[[label: 'POSITIVE', score: 0.971362054347...]]
265	0f9de7fe1615-459f-b7a0-6170d01e1cb9	A Google user	lh.googleusercontent.com/EGenera2N...	erhdseidreeeee	5	0	None	2019-02-10 10:55:58	None	NaT	[[label: 'POSITIVE', score: 0.991821159853...]]
266	f94c7749-c547-4826-8b71-146ea4089c3a	NAWAB KHAN	https://play-ih.googleusercontent.com/e-/ACB-R...	ok	5	0	None	2021-02-01 18:05:21	None	NaT	[[label: 'NEGATIVE', score: 0.993538796901...]]

Figure 58 : New column called 'Result'.

CHAPTER 3

Two new columns are created in the DataFrame, 'sentiment' and 'score', to store the sentiment label and score respectively.

```
df['sentiment']= df['result'].apply(lambda x: (x[0]['label']))
df['score']= df['result'].apply(lambda x: (x[0]['score']))
df.head()
```



The screenshot shows a Jupyter Notebook cell with the command `df.head()` and its output. The output is a DataFrame with 5 rows and 13 columns. The columns are: review.id, userName, userImage, content, score, thumbsUpCount, reviewCreatedVersion, at, replyContent, repliedAt, result, and sentiment. The sentiment column contains the value 'POSITIVE' for all five rows.

	review.id	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	result	sentiment
0	cba1f832c-d4e2-42a0-8559-d740e6522f8	A Google user	https://play-ih.googleusercontent.com/EgeroL2N...	Sygie - GPS, Navigation is the world's most do...	0.998669	35	5.5.7	2020-02-10 11:46:07	None	NaT	[[label: POSITIVE, score: 0.998669147491...	POSITIVE
1	f047c08e-6fa7-4754-917c-580a7e072b82	A Google user	https://play-ih.googleusercontent.com/EgeroL2N...	a great app for direction and location detect...	0.998868	4	None	2020-04-08 08:59:18	None	NaT	[[label: POSITIVE, score: 0.998868107795...	POSITIVE
2	cc7e898f-61e8-4a7b-a757-d589393973db	Maeeno Cordiali	https://play-ih.googleusercontent.com/a-/ACB-R...	A smart app with so many great functions and a...	0.998932	14	None	2020-05-14 07:32:59	None	NaT	[[label: POSITIVE, score: 0.998931825160...	POSITIVE
3	8468b0cd-994e-450c-85a8-c4af0802f093	A Google user	https://play-ih.googleusercontent.com/EgeroL2N...	Like GPS route finder there is more features n...	0.998925	5	None	2020-03-28 15:09:10	None	NaT	[[label: POSITIVE, score: 0.998924672503...	POSITIVE
4	17f31138-ae12-4678-b609-9e68bb07161d	A Google user	https://play-ih.googleusercontent.com/EgeroL2N...	Voice navigation is a wonderful app. Clean des...	0.998906	5	6.5.8	2020-04-06 12:27:02	None	NaT	[[label: POSITIVE, score: 0.998905558721...	POSITIVE

Figure 59 ; Screenshot of first few rows of dataframe with the predicted sentiment and score for each review.

Overall Sentiment Score (VADER): This score, with a value of approximately 0.5721, indicates the average sentiment score of all the reviews in the dataset as calculated by VADER. VADER suggests that, on average, the reviews in the dataset lean strongly toward expressing positive sentiment. The magnitude of 0.5721 indicates a highly positive sentiment.

Overall Sentiment Category (VADER): This category categorizes the overall sentiment into "Positive," "Negative," or "Neutral" based on the overall sentiment score provided by VADER. VADER categorizes the overall sentiment as "Positive." This confirms that, on average, the reviews express strong positive sentiment.

Overall Sentiment Score (Transformer): This score, which is approximately 0.9965, represents the average sentiment score of all the reviews in the dataset as calculated by the Transformers sentiment analysis model. The very high value of 0.9965 suggests that the Transformer sentiment analysis model has assigned an extremely strong positive sentiment to the reviews in the dataset. This indicates that the reviews are overwhelmingly positive in nature according to the Transformers model.

Overall Sentiment Category (Transformer): Similar to VADER, this category is determined based on the overall sentiment score provided by the Transformers model.

CHAPTER 3

The Transformers model also categorizes the overall sentiment as "Positive." This aligns with the very high sentiment score it has assigned to the reviews.

Mean Sentiment Score (Transformer): This value, which is equal to 0.9965, represents the average sentiment score specifically for the sentiment scores generated by the Transformers model. The mean sentiment score of 0.9965 further confirms the extremely strong positive sentiment within the dataset as determined by the Transformers model.

Sentiment Label Distribution (Transformer): This distribution shows the proportion of reviews categorized into different sentiment labels by the Transformers model. The distribution indicates that a vast majority of reviews (about 85.66%) are classified as "Positive," while a smaller proportion (about 14.34%) are classified as "Negative" by the Transformers model. This breakdown provides insight into the distribution of sentiment labels within the dataset.

In summary, both VADER and the Transformers model consistently indicate that the reviews in the dataset are overwhelmingly positive in sentiment. The Transformers model assigns an extremely high sentiment score, suggesting an extremely strong positive sentiment.

```
# Analyze sentiment using NLTK's VADER
sia = SentimentIntensityAnalyzer()
df['Sentiment Score (VADER)'] = df['content'].apply(lambda x:
sia.polarity_scores(x) ['compound'])

# Analyze sentiment using Transformers library
df['Sentiment Label (Transformer)'], df['Sentiment Score
(Transformer)'] = zip(*df['content'].apply(lambda x:
sentiment_analysis(x) [0].values()))

# Calculate the overall sentiment score
overall_sentiment_score_vader = df['Sentiment Score
(VADER)'].mean()
overall_sentiment_score_transformer = df['Sentiment Score
(Transformer)'].mean()
```


CHAPTER 3

```
# Determine the overall sentiment category
def get_sentiment_category(score):
    if score > 0:
        return 'Positive'
    elif score < 0:
        return 'Negative'
    else:
        return 'Neutral'

overall_sentiment_category_vader =
get_sentiment_category(overall_sentiment_score_vader)
overall_sentiment_category_transformer =
get_sentiment_category(overall_sentiment_score_transformer)

# Print overall sentiment results
print('Overall Sentiment Score (VADER):',
overall_sentiment_score_vader)
print('Overall Sentiment Category (VADER):',
overall_sentiment_category_vader)
print('Overall Sentiment Score (Transformer):',
overall_sentiment_score_transformer)
print('Overall Sentiment Category (Transformer):',
overall_sentiment_category_transformer)

# Calculate and print the mean score of the Transformer sentiment
analysis
transformer_mean_score = df['Sentiment Score
(Transformer)'].mean()
print('Mean Sentiment Score (Transformer):',
transformer_mean_score)

# Calculate and print the distribution of sentiment labels
sentiment_label_distribution = df['Sentiment Label
(Transformer)'].value_counts(normalize=True)
print('Sentiment Label Distribution (Transformer):\n',
sentiment_label_distribution)
```

```
print('Sentiment Label Distribution (Transformer):\n', sentiment_label_dis)

Overall Sentiment Score (VADER): 0.5720622641509434
Overall Sentiment Category (VADER): Positive
Overall Sentiment Score (Transformer): 0.9964981623415677
Overall Sentiment Category (Transformer): Positive
Mean Sentiment Score (Transformer): 0.9964981623415677
Sentiment Label Distribution (Transformer):
POSITIVE    0.856604
NEGATIVE    0.143396
Name: Sentiment Label (Transformer), dtype: float64
```

Figure 60 : Overall sentiment scores, categories, and additional statistics are calculated by performing sentiment analysis using both VADER and the Transformers library.

The output `df['score'].mean()` shows the mean sentiment score of all the reviews in the DataFrame `df`, which is 0.9965. This suggests that most reviews in the dataset are positive.

```
df['score'].mean()
```

The output `df['sentiment'].value_counts(normalize=True)` shows the percentage of positive and negative reviews in the dataset. About 85.77% of the reviews are positive, while about 14.23% are negative.

```
df['sentiment'].value_counts(normalize=True)
```

The output `df['sentiment'].value_counts()` shows the count of positive and negative reviews in the dataset. There are 229 positive reviews and 38 negative reviews in the dataset.

```
df['sentiment'].value_counts()
```

```
df['score'].mean()
0.9965101980537957

[19] df['sentiment'].value_counts(normalize=True)
POSITIVE    0.857678
NEGATIVE    0.142322
Name: sentiment, dtype: float64

[20] df['sentiment'].value_counts()
POSITIVE    229
NEGATIVE    38
Name: sentiment, dtype: int64
```

Figure 61 : Mean score, percentage distribution of sentiment labels and value count of sentiment labels are calculated.

The resulting histogram shows that the majority of the reviews are positive, with 229 positive reviews and only 38 negative reviews.

CHAPTER 3

```
df.hist()
```

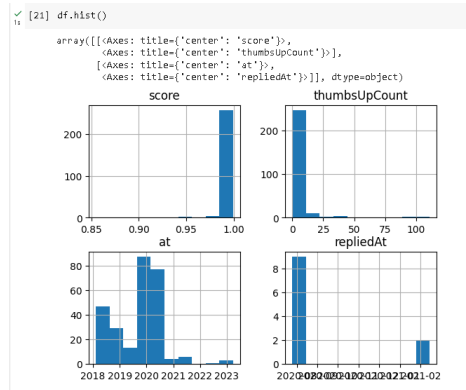


Figure 62 : Graph of score, thumbsupcount, at, repliedat.

```
fig = px.histogram(df, x='sentiment', color='sentiment',  
text_auto=True)
```

```
fig.show()
```

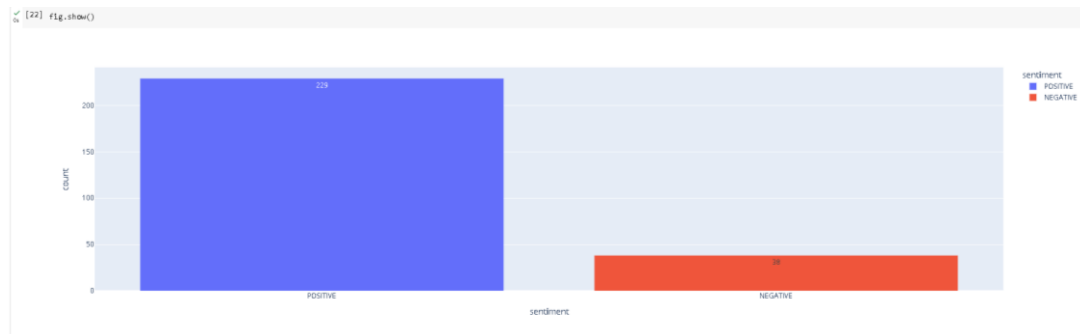


Figure 63 : Histogram of sentiment reviews.

```
df.to_csv('argpsnavigation2021gpsmap.csv')
```

3.4.2.2 Topic Modelling

3.4.2.2.1 Install and Import Necessary Libraries

Install the required libraries using !pip install commands.

```
!pip install google_play_scraper
```

```
!pip install sklearn
```

```
!pip install pyldavis
```

```
#!pip install -q google_play_scraper #Scraping reviews
```

CHAPTER 3

Import the required libraries.

```
import pandas as pd
from google_play_scraper.features.reviews import Sort,
reviews_all, reviews
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.decomposition import LatentDirichletAllocation
#from sklearn.feature_extraction.text import TfidfVectorizer

import numpy as np
import gensim #the library for Topic modelling
from gensim.models.ldamulticore import LdaMulticore
from gensim import corpora, models
import pyLDAvis.gensim #LDA visualization library

import nltk
from nltk.corpus import stopwords
import string
from nltk.stem.wordnet import WordNetLemmatizer

import warnings
warnings.simplefilter('ignore')
from itertools import chain
```

3.4.2.2 Existing AR Real-Time Navigation Apps

3.4.2.2.1 Pinn AR

Coding and Output

The textual reviews of the PinnAR app from the Google Play Store is scraped using reviews_all function from google_play_scraper. reviews_all returns a list of dictionaries, where each dictionary corresponds to a single review.

```
pinnar_project =
reviews_all( 'jp.co.telecomsquare.app.pinnar',
sleep_milliseconds=0, lang ='EN',country='US')
```

CHAPTER 3

A Pandas DataFrame is created from the list of dictionaries using `pd.DataFrame` function.

```
df = pd.DataFrame(pinnar_project)
```

The summary statistics of the reviews are computed, such as the total number of textual reviews, the number of unique users, the number of unknown users, and the average rating.

```
df = pd.DataFrame(pinnar_project)
```

```
# Get the list of users who left more than one review
multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()

unique_users = len(df['userName'].unique())
unknown_users = len(df[df['userName'] == 'A Google user'])
total_reviews = len(df)

# Analyze and print information about the reviews and users
if
len(df['userName'].value_counts()[df['userName'].value_counts(
) > 1].index.tolist()) > 0:
    multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()
    num_multiple_reviews =
len(df[df['userName'].isin(multiple_reviewers)][['userName']].un
ique())
else:
    num_multiple_reviews = 0

mean = df['score'].mean()

# Print the results
print(f'Total textual reviews: {len(pinnar_project)}')
print(f'Total unique users: {unique_users}')
```

CHAPTER 3

```
print(f'Total unknown users: {unknown_users}')
print(f'Total users who gave multiple reviews:
{num_multiple_reviews}')
print(f'Average rating for this app based on the textual
reviews: {round(mean, 2)}')
```

```
print(f'Total textual reviews: {len(pinnar_project)}')
print(f'Total unique users: {unique_users}')
print(f'Total unknown users: {unknown_users}')
print(f'Total users who gave multiple reviews: {num_multiple_reviews}')
print(f'Average rating for this app based on the textual reviews: {round(mean, 2)}')
```

Total textual reviews: 12
Total unique users: 4
Total unknown users: 9
Total users who gave multiple reviews: 1
Average rating for this app based on the textual reviews: 3.5

Figure 64 : Summary statistics of the reviews.

Total textual reviews of 12 indicates the total number of reviews that were scraped for the app with the given app ID. The total unique users of 4 indicates the number of unique users who left reviews for the app. This means that out of the 12 reviews, only 4 of them were left by unique users. The total unknown users of 9 indicates the number of reviews left by users who did not provide a username. These users are listed as "A Google user" in the review. In this case, 9 out of the 12 reviews were left by unknown users. The total users who gave multiple reviews of 1 indicates the number of users who left more than one review for the app. There is total of one user who left more than one review for the app. The modified code uses the `value_counts` method to count the number of reviews left by each user, and then filters the DataFrame to only include reviews left by users who left more than one review. In this case, the count is 1, which means that only one user left multiple reviews for the app. The average rating for this app based on the textual reviews which is 3.5 indicates the average rating for the app based on the reviews that were scraped. The rating is out of 5 stars and is calculated as the mean of the "score" values in the dataset. In this case, the average rating is 3.5 stars.

The reviews based on the ratings that are less than or equal to 3 and have a length of at least 30 characters are filtered.

```
# Filter reviews with ratings less than or equal to 3 and
content length greater than or equal to 30
df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
```

CHAPTER 3

```
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

```
[4] # Filter reviews with ratings less than or equal to 3 and content length greater than or equal to 30
df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
print(f'Remaining textual reviews: {len(df_tm)} \n')

Remaining textual reviews: 2
```

Figure 65 : Reviews less than 4.

The remaining textual reviews of 2 indicates that there are only 2 reviews in the filtered DataFrame that meet these criteria. So out of all the reviews for the app, only 2 have a score of 3 or less and have a text content length of at least 30 characters. This information indicates that the majority of reviews may be positive and/or have relatively short text content.

The relevant columns are selected, dropped the duplicates and missing values, and reset the index of the filtered DataFrame.

```
# Get relevant columns and drop duplicates and missing values
df_tm = df_tm[['reviewId', 'content']].drop_duplicates()
df_tm.dropna(inplace=True)
df_tm = df_tm.reset_index().drop(columns='index')
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

```
df_tm = df_tm[['reviewId', 'content']].drop_duplicates()
df_tm.dropna(inplace=True)
df_tm = df_tm.reset_index().drop(columns='index')
print(f'Remaining textual reviews: {len(df_tm)} \n')

Remaining textual reviews: 2
```

Figure 66 : Remaining textual reviews which are less than 4.

The remaining textual reviews of 2 indicates the number of rows remaining in the DataFrame after these operations have been performed. In this case, there are only 2 reviews left in the DataFrame that meet the criteria of having a score less than or equal to 3 and a content length of at least 30 characters. The output indicates that after removing reviews with low ratings and short content, there are only 2 remaining textual reviews. The final dataframe only contains the 'reviewId' and 'content' columns, with any duplicate rows and missing values removed.

CHAPTER 3

A CountVectorizer object is created with a maximum document frequency of 0.95, a minimum document frequency of 1, and English stop words. The CountVectorizer is then used to fit and transform the text data in the DataFrame `df_tm` into a document-term matrix (dtm). The feature names are obtained from the CountVectorizer object. Finally, the first 20 feature names are printed using the `list()` and `slice [:20]` functions. The output shows the 20 feature names (words) that appear first in the vocabulary, in alphabetical order.

```
# create CountVectorizer object
cv = CountVectorizer(max_df=0.95, min_df=1,
stop_words='english')

# fit and transform the text data
dtm = cv.fit_transform(df_tm['content'])

# Get feature names
feature_names = cv.get_feature_names_out()

# print the feature names
print(list(feature_names)[:20])
```



```
6) # create CountVectorizer object
cv = CountVectorizer(max_df=0.95, min_df=1, stop_words='english')

# fit and transform the text data
dtm = cv.fit_transform(df_tm['content'])

# Get feature names
feature_names = cv.get_feature_names_out()

# print the feature names
print(list(feature_names)[:20])

['access', 'application', 'best', 'camera', 'circling', 'device', 'doesn', 'functionalities', 'google', 'granting', 'just', 'map', 'membership', 'moment', 'needs', 'official', 'permission', 'prefer', 'register', 'unrelated']
```

Figure 67 : 20 feature names that appear first in the vocabulary in alphabetical order.

LDA is a generative statistical model used to find topics within a large corpus of text data. It assumes that each document in the corpus is a mixture of several topics and that each topic is a distribution over a set of words. The goal of LDA is to infer the underlying topic structure in the corpus by learning the topic distributions and document distributions. The top 20 most important features for each of the two identified topics are printed.

```
# Perform Latent Dirichlet Allocation (LDA) topic modeling
LDA = LatentDirichletAllocation(n_components=2, random_state=1)
LDA.fit(dtm)
```



```
# Perform Latent Dirichlet Allocation (LDA) topic modeling
LDA = LatentDirichletAllocation(n_components=2, random_state=1)
LDA.fit(dtm)
```

```
LatentDirichletAllocation
LatentDirichletAllocation(n_components=2, random_state=1)
```

Figure 68 : Instantiation of a Latent Dirichlet Allocation (LDA) model.

The output result `LatentDirichletAllocation(n_components=2, random_state=1)` is the instantiation of a Latent Dirichlet Allocation (LDA) model with 2 topics and a random state of 1, means that the algorithm will try to identify 2 different sets of words that represent distinct topics in the text data. The `random_state` parameter is used to ensure that the results of the model are reproducible.

```
# Print the top words for each topic
for index, topic in enumerate(LDA.components_):
    print(f'topic #{index} : \')
    print([list(feature_names)[i] for I in topic.argsort() [-
20:]])
```

```
[9] #for index,topic in enumerate(LDA.components_):
#Print(f'topic #{index} : \')
#print([v.get_feature_names()[i] for i in topic.argsort()[-20:]])
for index, topic in enumerate(LDA.components_):
    print(f'topic #{index} : \')
    print([list(feature_names)[i] for i in topic.argsort()[-20:]])
#for index, topic in enumerate(LDA.components_):
#Print(f'topic #{index} : \')
#print([tfidf.get_feature_names()[i] for i in topic.argsort()[-20:]])

topic #0 :
['circling', 'google', 'permission', 'official', 'access', 'unrelated', 'use', 'prefer', 'camera', 'map', 'register', 'best', 'application', 'device', 'user', 'functionsilities', 'needs', 'granting', 'membership', 'moment']
topic #1 :
['membership', 'functionsilities', 'user', 'google', 'official', 'use', 'prefer', 'register', 'map', 'doesn', 'unrelated', 'access', 'permission', 'circling', 'just', 'work', 'camera', 'best', 'application', 'device']
```

Figure 69 :Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model.

The output is the top 20 words in each of the two topics learned by the Latent Dirichlet Allocation (LDA) model. Each line corresponds to one topic, and the words are listed in descending order of importance to that topic, based on their relative frequency in the textual reviews. In the first topic, the most important words are 'circling', 'google', 'permission', 'official', 'access', 'unrelated', 'use', 'prefer', 'camera', 'map', 'register', 'best', 'application', 'device', 'user', 'functionsilities', 'needs', 'granting', 'membership', and 'moment'. These words suggest that this topic may be related to issues with app permissions, device compatibility, and user experience. In the second topic, the most important words are 'membership', 'functionsilities', 'user', 'google', 'official', 'use', 'prefer', 'register', 'map', 'doesn', 'unrelated', 'access', 'permission', 'circling', 'just', 'work',

CHAPTER 3

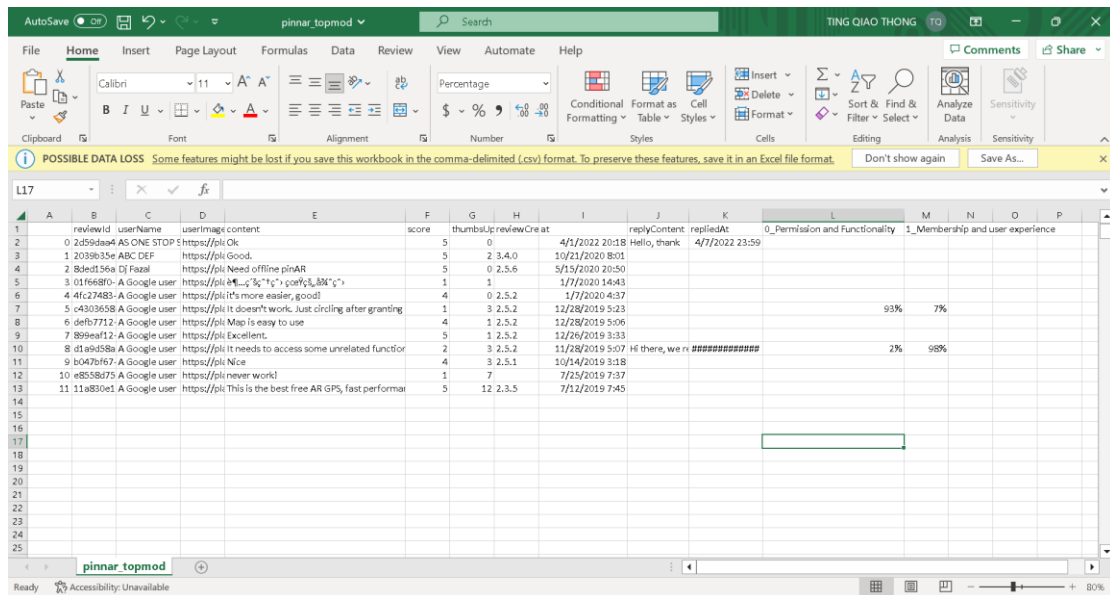
'camera', 'best', 'application', and 'device'. These words suggest that this topic may be related to user accounts and preferences, with issues such as registration, unrelated functions, and app functionality. Overall, these topics provide insights into some of the common themes and issues that users have encountered with the app, based on the textual reviews.

The LDA model is used to transform the document-term matrix into a topic probability matrix (`topic_results`). The topic probability matrix is then merged with the original `DataFrame` (`df`) and saved as a new CSV file.

```
# Transform documents into topic space
topic_results = LDA.transform(dtm)
df_topic_results = pd.DataFrame(topic_results, columns=[
'0_Permission and Functionality',    #user permission and
access control
'1_Membership and user experience'   #Mobile Navigation Best
Practices(performance optimization, usability testing, and
quality assurance.)
])

# Merge topic results with the original DataFrame
df_result = pd.merge(df_tm, df_topic_results, how='inner',
left_index=True, right_index=True )
df_output = pd.merge(df, df_result, how='left',
on=[ 'reviewId', 'content' ])
df_output.to_csv('pinnar_topmod.csv')
```

CHAPTER 3



reviewId	userName	userImage	content	score	thumbsUp	reviewCreat	replyContent	repliedAt	O_Permission and Functionality	I_Membership and user experience
0 2d5daa4	AS ONE STOP	https://pki Ok		5	0	4/1/2022 20:18	Hello, thank	4/7/2022 23:59		
1 2039b35e	ABC DEF	https://pki Good.		5	2 3.4.0	10/21/2020 8:01				
2 8ded156a	DJ Faizal	https://pki Need offline pinAR		5	0 2.5.6	5/15/2020 20:50				
3 01f668f0	A Google user	https://pki It's easy to use		1	1	1/7/2020 14:43				
4 4fc27483	A Google user	https://pki It's more easier, good!		4	0 2.5.2	1/7/2020 4:37				
5 c4303658	A Google user	https://pki It doesn't work, just circling after granting		1	3 2.5.2	12/28/2019 5:23			93%	7%
6 defb7712	A Google user	https://pki Map is easy to use		4	1 2.5.2	12/28/2019 5:06				
7 899ea112	A Google user	https://pki Excellent.		5	1 2.5.2	12/26/2019 3:33				
8 d1a9d58a	A Google user	https://pki It needs to access some unrelated function		2	3 2.5.2	11/28/2019 5:07	If there, we r	#####	2%	98%
9 j0a79b67	A Google user	https://pki Nice		4	3 2.5.1	10/14/2019 3:18				
10 e8558275	A Google user	https://pki never work!		1	7	7/25/2019 7:37				
11 11a830e1	A Google user	https://pki This is the best free AR GPS, fast performai		5	12 2.3.5	7/12/2019 7:45				

Figure 70 : CSV file with topic probability matrix.

PinnAR CSV link:

<https://drive.google.com/file/d/1pfnRPGvIhCaKjIlgNHgiLmBhcIeZTYQi/view?usp=sharing>

The NLTK stop words and WordNetLemmatizer are downloaded and used to clean the text data in the DataFrame df by removing stop words and punctuation, and lemmatizing the remaining words.

```
# Download NLTK resources
nltk.download('stopwords')
nltk.download('wordnet')
```

```
[10] topic_results = LDA.transform(dtm)
df_topic_results = pd.DataFrame(topic_results, columns=[
    'O_Permission and Functionality', #user permission and access control
    'I_Membership and user experience' #Mobile Navigation Best Practices(performance optimization, usability testing, and quality assurance.)
])
df_result = pd.merge(df_tm, df_topic_results, how='inner', left_index=True, right_index=True)
df_output = pd.merge(df, df_result, how='left', on=[ 'reviewId', 'content' ])
df_output.to_csv('pinnar_topmod.csv')
```

```
[11] nltk.download("stopwords")
nltk.download("wordnet")

[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data] Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data...
True
```

Figure 71 : Download of NLTK stop words and WordNetLemmatizer.

```
# Clean the text data using NLTK
stop = set(stopwords.words('english'))
exclude = set(string.punctuation)
```

CHAPTER 3

```
lemma = WordNetLemmatizer()
```

```
def clean(text):
    if isinstance(text, str): # Check if input is a string
        stop_free = ' '.join([word for word in
            text.lower().split() if word not in stop])
        punc_free = ''.join(ch for ch in stop_free if ch not
            in exclude)
        normalized = ' '.join([lemma.lemmatize(word) for word
            in punc_free.split()])
        return normalized
    else:
        return ""
```

```
df['text_clean']=df['content'].apply(clean)
```

```
df
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	2d59daa4-baf3-4e0d-9f6b-ae0c414c0dad	AS ONE STOP SOLUTION	https://play.googleusercontent.com/8vAGN8xy...	Ok	5	0	None	2022-04-01 20:18:45	Hello, thank you for using PinAR! We are gla...	2022-04-07 23:59:49	ok
1	2039b35e-676b-4f19-8641-ec0310a18958	ABC DEF	https://play.googleusercontent.com/8vAGN8xy...	Good.	5	2	3.4.0	2020-10-21 08:01:08	None	NaN	good
2	80ed156e-396f-472b-b52a-86ec03564462	OjFazal	https://play.googleusercontent.com/8vAGN8xy...	Need offline pinAR	5	0	2.5.6	2020-05-15 20:50:27	None	NaN	need offline pinar
3	011668f0-01f3-475e-82f6-44ad1798f950	A Google user	https://play.googleusercontent.com/EgeocfZN...	超級容易用的軟體	1	1	None	2020-01-07 14:43:02	None	NaN	超級容易用的軟體
4	4fc27483-903c-4d5e-8f99-22cb19ac1c03	A Google user	https://play.googleusercontent.com/EgeocfZN...	It's more easier, good!	4	0	2.5.2	2020-01-07 04:37:03	None	NaN	easier good
5	04303658-d64e-4335-8c37-7772a2beec7	A Google user	https://play.googleusercontent.com/EgeocfZN...	It doesn't work...Just circling after granting ...	1	3	2.5.2	2019-12-28 05:23:47	None	NaN	work circling granting permission
6	defb7712-b08a-469d-8522-8c060350f996	A Google user	https://play.googleusercontent.com/EgeocfZN...	Map is easy to use	4	1	2.5.2	2019-12-28 05:06:49	None	NaN	map easy use
7	899eeaf12-251c-4e64-87de-4031f314c358	A Google user	https://play.googleusercontent.com/EgeocfZN...	Excellent.	5	1	2.5.2	2019-12-26 03:33:41	None	NaN	excellent
8	d1a9d58a-338b-4154-810c-33de919c0771	A Google user	https://play.googleusercontent.com/EgeocfZN...	It needs to access some unrelated functionalities...	2	3	2.5.2	2019-11-28 05:07:59	Hi there, we request access to the camera beca...	2019-11-29 07:27:52	need access unrelated functionalities user dev...
9	bd47b167-eaf6-4193-a038-3aed30f59640	A Google user	https://play.googleusercontent.com/EgeocfZN...	Nice	4	3	2.5.1	2019-10-14 03:18:22	None	NaN	nice
10	e8558df5-b217-4ee4-803c-cc004ac9c6db	A Google user	https://play.googleusercontent.com/EgeocfZN...	never work!	1	7	None	2019-07-25 07:37:44	None	NaN	never work!
11	11a83de1-2031-4531-c9d9-adcb0a5a901	A Google user	https://play.googleusercontent.com/EgeocfZN...	This is the best free AR GPS, fast performance...	5	12	2.3.5	2019-07-12 07:45:25	None	NaN	best free ar gps fast performance neat ut dark...

Figure 72 : Text data that are cleaned.

The BOW matrix is a numerical representation of the corpus where each row corresponds to a document and each column corresponds to a unique word in the corpus. The values in the matrix represent the frequency of occurrence of the corresponding word in the corresponding document. In this case, the dictionary.num_nnz method from the gensim library is used to calculate the number of non-zeroes in the BOW matrix. A Gensim dictionary is created from the cleaned text data in the DataFrame df.

```
# Create a dictionary from the cleaned text data
```

CHAPTER 3

```
texts = [list(gensim.utils.tokenize(text)) for text in
df['text_clean']]
dictionary = corpora.Dictionary(texts)

# Print the number of non-zero entries in the BOW matrix
print(dictionary.num_nnz)
```

```
19] # Create a dictionary from the cleaned text data
texts = [list(gensim.utils.tokenize(text)) for text in df['text_clean']]
dictionary = corpora.Dictionary(texts)

# Print the number of non-zero entries in the BOW matrix
print(dictionary.num_nnz)

#from gensim.utils import tokenize
#texts = [list(tokenize(text)) for text in df['text_clean']]
#dictionary = corpora.Dictionary(texts)
#print(dictionary.num_nnz)
```

58

Figure 73 : Dictionary is created.

The output 58 corresponds to the total number of non-zeroes in the Bag-of-Words (BOW) matrix for the entire corpus. In other words, The sum of the number of unique words per document over the entire corpus is 58.

A document-term matrix is created from the cleaned text data in the DataFrame df using the Gensim dictionary.

```
#create document term matrix
doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in
df['text_clean'] ]
print(len(doc_term_matrix))
```

```
Create document term matrix

✓ [15] #create document term matrix
doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in df['text_clean'] ]
print(len(doc_term_matrix))

12
```

Figure 74 : Document term matrix is created.

The output indicates that the document-term matrix has been created from the preprocessed text data. There are 12 documents in the matrix, which means that there are 12 reviews in the preprocessed data. Each document is represented as a list of tuples where each tuple contains a term ID and the frequency of that term in the document.

CHAPTER 3

The term IDs are generated by the dictionary created in the previous step, where each unique term in the corpus is assigned a unique ID.

The LDA model is instantiated using the `ldamodel.LdaModel` class from the `gensim` library.

```
# Instantiate and fit an LDA model
lda = gensim.models.ldamodel.LdaModel
```

The LDA model is fitted on the dataset. I have passed the following parameters to the LDA model:

`doc_term_matrix`: The document-term matrix containing the frequency of terms in each document.

`num_topics`: The number of topics to identify in the dataset.

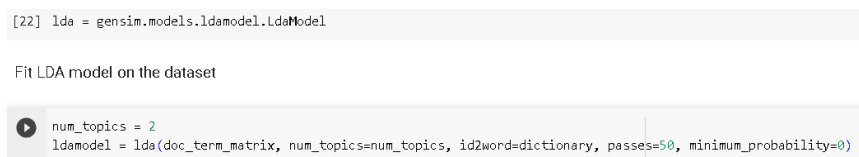
`id2word`: The dictionary mapping of term IDs to words.

`passes`: The number of passes to perform over the dataset.

`minimum_probability`: The minimum probability required for a document to be assigned to a topic.

An LDA model is instantiated with the specified number of topics (`num_topics = 2`). The LDA function from the `lda` library is used to fit an LDA model to the document term matrix `doc_term_matrix`. The `id2word` parameter is set to the dictionary object that we created earlier, and the `minimum_probability` parameter is set to 0 so that all topics are included in the output. The `passes` parameter is set to 50 to ensure that the model has enough iterations to converge.

```
#Fit LDA model on the dataset
num_topics = 2
ldamodel = lda(doc_term_matrix, num_topics=num_topics,
id2word=dictionary, passes=50, minimum_probability=0)
```



```
[22] lda = gensim.models.ldamodel.LdaModel

Fit LDA model on the dataset

num_topics = 2
ldamodel = lda(doc_term_matrix, num_topics=num_topics, id2word=dictionary, passes=50, minimum_probability=0)
```

Figure 75 : LDA Model is instantiated and fit on the dataset.

The CPU times show the time spent by the processor to run the code, while the Wall time indicates the total amount of time taken to run the code, including time spent

CHAPTER 3

waiting for input/output (I/O) operations. In this case, the model was trained relatively quickly, with a Wall time of 240 milliseconds. However, the actual running time may depend on various factors, such as the size of the corpus, the number of topics, and the complexity of the LDA model.

The topics identified by the LDA model are printed.

```
# Print the topics identified by the LDA model
ldamodel.print_topics(num_topics=num_topics)
```

```
18) ldamodel.print_topics(num_topics=num_topics)
[[0,
  '0.072*map' + 0.040*need' + 0.040*user' + 0.040*use' + 0.040*work' + 0.039*good' + 0.024*functionsities' + 0.024*access' + 0.024*application' + 0.024*moment'),
 (1,
  '0.050*need' + 0.031*best' + 0.031*gps' + 0.031*ar' + 0.031*ui' + 0.031*north' + 0.031*dark' + 0.031*facing' + 0.031*fast' + 0.031*compass')]
```

Figure 76 : 10 words contributed to each topic identified.

The output shows the top 10 words that contribute the most to each topic. Overall, the LDA model was able to identify distinct topics in the text data, and the top words for each topic give us an idea of the main themes in the reviews.

The LDA model results are visualized using the pyLDAvis library. The LDA model, document-term matrix, dictionary, and mds='mmds' parameter are passed to the pyLDAvis.gensim.prepare function to prepare the data for visualization. The pyLDAvis.display function is used to display the interactive visualization.

The visualization is divided into three main parts: the left panel shows a plot of the topics, the right panel shows a plot of the selected topic, and the central panel shows a list of the most relevant terms for the selected topic.

The left panel is an intertopic distance map that shows the distance between different topics in the topic space. Each circle represents a topic, and the distance between the circles indicates the similarity between the topics. The size of the circle represents the prevalence of the topic in the corpus.

The right panel shows a plot of the selected topic. The plot has two axes, PC1 and PC2, which represent the two main dimensions of the topic. The plot shows the distribution

CHAPTER 3

of the terms within the topic, and the size of each term represents its prevalence in the topic. The plot also shows the relevance of each term to the topic, which is calculated using the saliency metric.

The central panel shows a list of the most relevant terms for the selected topic. The terms are ranked based on their relevance to the topic, and the bar on the right side of each term represents its prevalence in the corpus.

Overall, the visualization provides a way to explore the topics and the relationships between them, which is a useful tool for analyzing and interpreting the results of a topic model.

```
#Visualize the LDA model results
lda_display = pyLDAvis.gensim.prepare(ldamodel,
doc_term_matrix, dictionary, sort_topics=False, mds='mmds')
pyLDAvis.display(lda_display)
```

I have interpreted the dispersion of topics in an Intertopic Distance Map and found out the two topics are farther apart on the map, they are more distinct and have different word distributions. This indicates that these topics may represent different themes or aspects of the dataset. For example, one topic may focus on the usability of the compass app, while another distant topic could concentrate on the app's visual design or specific features.

The graph is generated by an LDA (Latent Dirichlet Allocation) topic modeling process. It includes two topics (0 and 1), each represented by the top 30 most relevant terms associated with that topic.

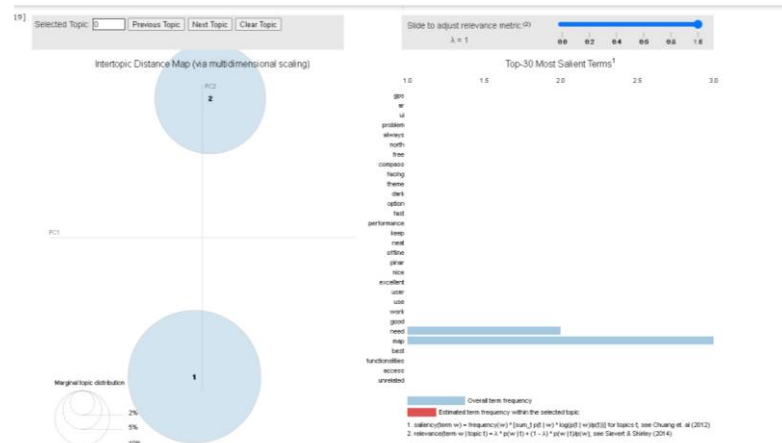


Figure 77 : Two topics is generated Top 30 most relevant terms are generated.

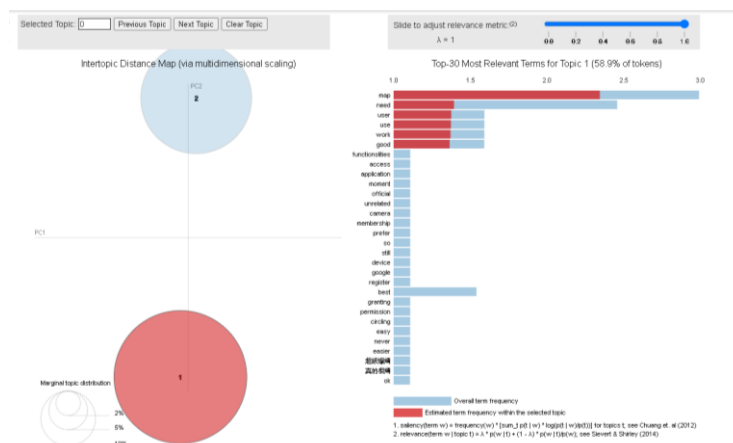


Figure 78 : Keywords for topic 0.

The keywords for topic 0 included map, need, user, use, work, good, functionalities, access, application, moment and etc. The highest frequency term in Topic 0 is "map" with a probability of 0.072. This topic appears to be focused on map-related applications or functionalities. The other terms like "need," "user," "use," and "work" suggest a discussion around user needs, the usage of a map-related application, and its performance. The term "good" implies that the discussed application might be well-regarded. This topic appears to be about map-based applications, their usage, and how they address user needs. The discussion highlights the app's good performance, various functionalities, and ease of access.

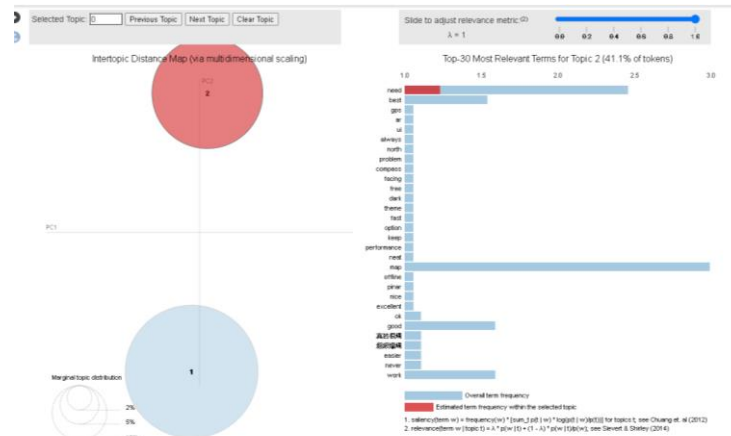


Figure 79 : Keywords for topic 1.

The keywords for topic 1 included need, best, gps, ar, ui, north, dark, facing, fast, compass and etc. The highest frequency term in Topic 1 is "need" with a probability of 0.050. This topic seems to be centered around identifying the best features or tools required for a specific purpose. The terms "best," "gps," "ar," "ui," "north," "dark," "facing," "fast," and "compass" indicate that this topic could be discussing the best GPS and compass applications with a focus on augmented reality, user interface, and performance aspects. This topic focuses on the best compass apps with GPS and augmented reality (AR) features. It also touches on user interface (UI) elements, the ability to show cardinal directions like north, and the app's responsiveness or speed.

I have found which articles were marked in which cluster by using the LDA model results. I have also passed the document-term matrix to the LDA model to get the topic probabilities for each document. I then extract the scores for each document for each topic and find the threshold by taking the average of all scores. I used a list comprehension to extract the indices of the articles that are marked in each cluster. I extracted the articles that have a score greater than the threshold for each cluster.

```
#Find which articles were marked in which cluster
# Assigns the topics to the documents in corpus
lda_corpus = ldamodel[doc_term_matrix]

[doc for doc in lda_corpus]
```

```

Find which articles were marked in which cluster

[20] # Assigns the topics to the documents in corpus
lda_corpus = ldamodel[doc_term_matrix]

[21] [[doc for doc in lda_corpus]]

[[ (0, 0.2657101), (1, 0.73428994)],
  [(0, 0.2569789), (1, 0.74302113)],
  [(0, 0.8586645), (1, 0.14133547)],
  [(0, 0.8275498), (1, 0.17245016)],
  [(0, 0.17379852), (1, 0.82620144)],
  [(0, 0.104841016), (1, 0.89515895)],
  [(0, 0.13288268), (1, 0.86711735)],
  [(0, 0.26573896), (1, 0.73426104)],
  [(0, 0.023197453), (1, 0.9768025)],
  [(0, 0.74109036), (1, 0.25890964)],
  [(0, 0.17365234), (1, 0.8263477)],
  [(0, 0.9718344), (1, 0.028165558)]]

```

Figure 80 : List of topic probability of each document.

The output shows the topic distribution for each document in the corpus. Each document is represented as a list of tuples where the first element of the tuple is the topic number and the second element is the corresponding probability score. For example, the first document has a high probability for topic 1 (0.73428994) and a lower probability for topic 0 (0.2657171). It indicates that in the first document, there is a 75% probability that it belongs to topic 1 and a 25% probability that it belongs to topic 0.

The list of topic probabilities for each document are flattened in `lda_corpus` and stores them in scores. This creates a single list of all topic probabilities for all documents.

Next, the threshold is calculated for topic relevance. This is done by computing the average of all the topic probabilities in `cscores` and storing it in `threshold`. This threshold can be used to filter out topics that are not considered relevant enough. The threshold value is approximately 0.5.

```

scores = list(chain(*[[score for topic_id, score in topic] \
                      for topic in [doc for doc in
lda_corpus]]))

```

```

threshold = sum(scores)/len(scores)
print(threshold)

```

```

[22] scores = list(chain(*[[score for topic_id, score in topic] \
                        for topic in [doc for doc in lda_corpus]]))

threshold = sum(scores)/len(scores)
print(threshold)

0.49999999596426886

```

Figure 81 : Threshold calculated for topic relevance.

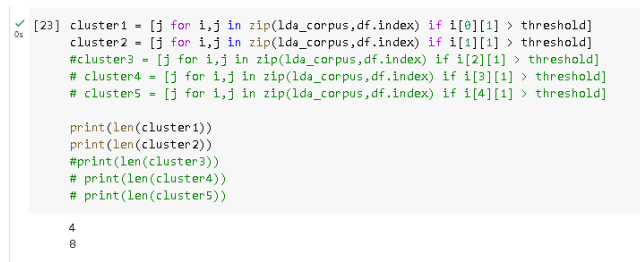
The code is using the previously defined LDA model to cluster the documents in `df` into two clusters based on the topic probabilities in `lda_corpus`.

The `cluster1` list contains the index of documents that have a higher probability for topic 0, and `cluster2` contains the index of documents that have a higher probability for topic 1. In this case, both clusters have an equal number of documents, with 6 documents in each cluster.

```
cluster1 = [j for i,j in zip(lda_corpus,df.index) if i[0][1] >
threshold]
cluster2 = [j for i,j in zip(lda_corpus,df.index) if i[1][1] >
threshold]
#cluster3 = [j for i,j in zip(lda_corpus,df.index) if
i[2][1] > threshold]
# cluster4 = [j for i,j in zip(lda_corpus,df.index) if
i[3][1] > threshold]
# cluster5 = [j for i,j in zip(lda_corpus,df.index) if
i[4][1] > threshold]
```

The number of articles are printed in each cluster.

```
print(len(cluster1))
print(len(cluster2))
#print(len(cluster3))
# print(len(cluster4))
# print(len(cluster5))
```



```
[23] cluster1 = [j for i,j in zip(lda_corpus,df.index) if i[0][1] > threshold]
      cluster2 = [j for i,j in zip(lda_corpus,df.index) if i[1][1] > threshold]
      #cluster3 = [j for i,j in zip(lda_corpus,df.index) if i[2][1] > threshold]
      # cluster4 = [j for i,j in zip(lda_corpus,df.index) if i[3][1] > threshold]
      # cluster5 = [j for i,j in zip(lda_corpus,df.index) if i[4][1] > threshold]

      print(len(cluster1))
      print(len(cluster2))
      #print(len(cluster3))
      # print(len(cluster4))
      # print(len(cluster5))

4
8
```

Figure 82 : Number of articles printed in each cluster.

The articles that are marked in each cluster are printed by passing the list of indices to the `iloc` function of the pandas DataFrame.

```
df.iloc[cluster1]
```

```
df.iloc[cluster2]
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
2	8ed1156a-395f-472b-b52a-86e0c35c54e2	Dj Fazal	https://play-ib.googleusercontent.com/a/AGNvxy...	Need offline pinAR	5	0	2.5.5	2020-05-15 20:50:27	None	NaT	need offline pinar
3	01f668f0-01f5-475e-82fd-44a01798f9b0	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	磁磁導轉 真的很棒	1	1	None	2020-01-07 14:43:02	None	NaT	磁磁導轉 真的很棒
9	b047bf57-0e56-4193-8038-3aed30f59540	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	Nice	4	3	2.5.1	2019-10-14 03:18:22	None	NaT	nice
11	11a830e1-2031-4531-b509-add90a58901	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	This is the best free AR GPS, fast performance...	5	12	2.3.5	2019-07-12 07:45:25	None	NaT	best free ar gps fast performance need ui dark...

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	2d59d8e4-baf3-4ed0-9f68-ecb04140dad	AS ONE STOP SOLUTION	https://play-ib.googleusercontent.com/a/AGNvxy...	Ok	5	0	None	2022-04-01 20:18:45	Hello, thank you for using PinnAR! We are gla...	2022-04-07 23:59:49	ok
1	2039b35e-675b-4ff3-8541-ec0b7da18058	ABC DEF	https://play-ib.googleusercontent.com/a/AGNvxy...	Good.	5	2	3.4.0	2020-10-21 08:01:08	None	NaT	good
4	4fc27483-903c-4d5e-8f89-22cb19ac1c03	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	it's more easier, good!	4	0	2.5.2	2020-01-07 04:37:03	None	NaT	easier good
5	04303588-d54a-4335-8c37-7772a2b0eac7	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	It doesn't work. Just circling after granting ...	1	3	2.5.2	2019-12-28 05:23:47	None	NaT	work circling granting permission
6	def07712-b08a-4b9d-8522-8c0b0353f996	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	Map is easy to use	4	1	2.5.2	2019-12-28 05:06:49	None	NaT	map easy use
7	899eaf12-251e-4e54-870a-4d51f314c508	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	Excellent.	5	1	2.5.2	2019-12-26 03:33:41	None	NaT	excellent
8	d1a9d58a-338b-4156-810c-30e8919e27f1	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	It needs to access some unrelated functionalities...	2	3	2.5.2	2019-11-28 05:07:59	Hi there, we request access to the camera beca...	2019-11-29 07:27:02	need access unrelated functionalities user det...
10	e6558d75-9237-4e4d-803c-0ac0d4a99c0b	A Google user	https://play-ib.googleusercontent.com/a/EGenolZN...	never work!	1	7	None	2019-07-25 07:37:44	None	NaT	never work

Figure 83 : Articles of each cluster are printed.

Conclusion

In conclusion, the LDA topic modeling process has generated two distinct topics from the provided text. Topic 0 seems to revolve around map-related applications or functionalities, discussing user needs, usage, and performance. Topic 1, on the other hand, appears to focus on identifying the best features or tools required for a specific purpose, such as GPS and compass applications, with an emphasis on augmented reality, user interface, and performance aspects.

Based on these topics, it can be inferred that the analyzed text is discussing navigation-related applications, their features, and user experience. The emphasis on user needs and performance suggests that the text aims to highlight and compare the best solutions or tools in this domain.

3.4.2.2.2 AR GPS Compass Map 3D

Coding and Output

The reviews data of the app are retrieved using the "reviews_all" function from a package called "google-play-scraper".

```
argpscompassmap3d_project =
reviews_all('com.kettler.argpsc3d', sleep_milliseconds=0,
lang='EN', country='US')
```

CHAPTER 3

The data is then converted into a pandas DataFrame object named "df". The data is then converted into a pandas DataFrame object named "df".

```
df = pd.DataFrame(argscompassmap3d_project)

# Get the list of users who left more than one review
multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()

unique_users = len(df['userName'].unique())
unknown_users = len(df[df['userName'] == 'A Google user'])
total_reviews = len(df)

# Analyze and print information about the reviews and users
if
len(df['userName'].value_counts()[df['userName'].value_counts(
) > 1].index.tolist()) > 0:
    multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()
    num_multiple_reviews =
len(df[df['userName'].isin(multiple_reviewers)][['userName']].un
ique())
else:
    num_multiple_reviews = 0

mean = df['score'].mean()

# Print the results
print(f'Total textual reviews: {len(pinnar_project)}')
print(f'Total unique users: {unique_users}')
print(f'Total unknown users: {unknown_users}')
print(f'Total users who gave multiple reviews:
{num_multiple_reviews}')
print(f'Average rating for this app based on the textual
reviews: {round(mean, 2)}')
```

```

Total textual reviews: 464
Total unique users: 79
Total unknown users: 386
Total users who gave multiple reviews: 1
Average rating for this app based on the textual reviews: 4.46

```

Figure 84 : Summary statistics of the reviews.

The total number of reviews that were retrieved by the `reviews_all` function for the specified app, which is 464. There is total of 79 unique users who left a review for the app. It is calculated by counting the number of distinct user names in the review data. This means that out of the 464 reviews retrieved, there were only 79 unique users who left them. Total of 386 unknown users who left the reviews without providing their username. It is calculated by counting the number of reviews where the `userName` field is equal to 'A Google user'. This means that out of the 464 reviews retrieved, there were 386 reviews where the user did not provide a username. There is total of one user who left more than one review for the app. The modified code uses the `value_counts` method to count the number of reviews left by each user, and then filters the `DataFrame` to only include reviews left by users who left more than one review. In this case, the count is 1, which means that only one user left multiple reviews for the app. The average rating of 4.46 of the app are showed based on the reviews left by users. It is calculated by taking the mean of the `score` field in the review data, which represents the rating of the app on a scale of 1 to 5. The output shows that the average rating is 4.46, rounded to two decimal places. This means that the app has a relatively high average rating based on the reviews left by users.

The code then filters out the reviews that have a rating less than or equal to 3 and have a minimum length of 30 characters.

```

# Filter reviews with ratings less than or equal to 3 and
content length greater than or equal to 30
df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
print(f'Remaining textual reviews: {len(df_tm)} \n')

```

```

Remaining textual reviews: 30

```

Figure 85 : Reviews less than 4.

The relevant columns, i.e., 'reviewId' and 'content', are selected, and duplicates and null values are removed.

CHAPTER 3

```
# Get relevant columns and drop duplicates and missing values
df_tm = df_tm[['reviewId', 'content']].drop_duplicates()
df_tm.dropna(inplace=True)
df_tm = df_tm.reset_index().drop(columns='index')
print(f'Remaining textual reviews: {len(df_tm)} \n')

```

```
Remaining textual reviews: 30
```

Figure 86 : Remaining textual reviews which are less than 4.

The CountVectorizer object from scikit-learn is initialized with some hyperparameters such as the maximum document frequency, minimum document frequency, and stop words. The text data is then fitted and transformed using the CountVectorizer object, resulting in a document-term matrix. The feature names of the document-term matrix are extracted from the CountVectorizer object.

```
# create CountVectorizer object
cv = CountVectorizer(max_df=0.95, min_df=2,
stop_words='english')

# fit and transform the text data
dtm = cv.fit_transform(df_tm['content'])

# get feature names from CountVectorizer object
feature_names = cv.vocabulary_.keys()

# print the feature names
print(list(feature_names)[:20])

```

```
['horizontal', 'sure', 'compass', 'degrees', 'instructions', 'press', 'button', 'trying', 'tall', 'long', 'height', 'app', 'distance', 'phone', 'apps', 'work', 'works', 'direction', 'points', 'location']
```

Figure 87 : 20 feature names that appear first in the vocabulary in alphabetical order.

Therefore, the output shows that after filtering the dataframe based on the 'score' and 'content' columns, there were 30 remaining rows. After removing any duplicate rows and rows with missing values, there were still 30 remaining rows. The list of feature names printed includes the first 20 feature names (i.e., words in the corpus) extracted from the CountVectorizer object's vocabulary, which are in alphabetical order and based on the specified parameters.

The LatentDirichletAllocation (LDA) model from scikit-learn is initialized with the number of topics to be extracted. The document-term matrix is fitted to the LDA model using the "fit" method. The "transform" method is used to get the topic distribution for each review, which is stored in a DataFrame named "df_topic_results". The topics are then named according to the most frequent words in them. The topic distribution for each review is merged with the original DataFrame using the review ID and content as keys. The resulting DataFrame is then saved to a CSV file named "argpscompassmap3d_topmod.csv".

```
# Perform Latent Dirichlet Allocation (LDA) topic modeling
LDA = LatentDirichletAllocation(n_components=5, random_state=1)
LDA.fit(dtm)
```

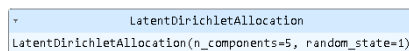


Figure 88 : Instantiation of a Latent Dirichlet Allocation (LDA) model.

The code first initializes the LDA model with 5 topics using the LatentDirichletAllocation function and fits the DTM to the model using the fit() method.

```
# Print the top words for each topic
for index, topic in enumerate(LDA.components_):
    print(f'topic #{index} : ')
    print([list(feature_names)[i] for i in topic.argsort()[-20:]])
```

```
topic #0 :
['accurate', 'doesn', 'working', 'press', 'phone', 'like', 'degrees', 'getting', '3d', 'keeps', 'trying', 'able', 'used', 'instructions', 'horizontal', 'great', 'uninstalled', 'gps', 'apps', 'galaxy']
topic #1 :
['3d', 'keeps', 'trying', 'used', 'able', 'gps', 'like', 'works', 'change', 'need', 'actual', 'north', 'degrees', 'doesn', 'compass', 'use', 'phone', 'getting', 'distance', 'working']
topic #2 :
['3d', 'used', 'gps', 'horizontal', 'work', '10', 'ar', 'direction', 'works', 'point', 'accurate', 'trying', 'able', 'bearing', 'version', 'button', 'bit', 'like', 'keeps', 'press']
topic #3 :
['doesn', 'point', 'north', 'direction', 'ar', '10', 'actual', 'press', 'trying', 'uninstalled', 'compass', '3d', 'sure', 'pro', 'location', 'app', 'used', 'height', 'distance', 'samsung']
topic #4 :
['phone', 'like', 'keeps', '3d', 'able', 'gps', 'getting', 'bit', 'degrees', 'press', 'instructions', 'work', 'change', 'need', 'points', 'trying', 'used', 'won', 'tall', 'long']
```

Figure 89 : Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model.

The LDA model identifies five topics based on the words that are most representative of each topic. For each topic, the topic number is printed followed by the top 20 words sorted in descending order by their contribution to the topic. The top 20 words for each topic give some insight into the topics that the LDA model has identified in the corpus.

CHAPTER 3

The topic modeling is performed on the text reviews, and then adding the resulting topic probabilities as new columns to the original dataframe.

```
# Transform documents into topic space
topic_results = LDA.transform(dtm)
df_topic_results = pd.DataFrame(topic_results, columns=[
'0_Troubleshooting and Usage Issues',
'1_Accuracy and Functionality of Compass and GPS' ,
'2_Features and Capabilities' , #including 3D
mapping and directions
'3_Orientation and Location Tracking' ,
'4_User Interface and Experience' #including
device compatibility and ease of use
])

# Merge topic results with the original DataFrame
df_result = pd.merge(df_tm, df_topic_results, how='inner',
left_index=True, right_index=True )
df_output = pd.merge(df, df_result, how='left',
on=[ 'reviewId', 'content' ])
df_output.to_csv('argpscompass3d_topmod.csv')
```

reviewId	userName	userip	content	score	thumbUp	reviewCreatedAt	0_Troubleshooting and Usage Issues	1_Accuracy and Functionality of Compass and GPS	2_Features and Capabilities	3_Orientation and Location Tracking	4_User Interface and Experience
0_73ae070	Bill Garrett	https://p/	This app is outstanding I	5	1 183	9/26/2022 17:24					
1_5d8e429	Scott Egan	https://p/	Works as this app im enjoy	4	0	10/26/2022 9:23					
2_2fa248a	gary thoney	https://p/	(Answers for finding your	5	0 183	10/22/2022 14:56					
3_3bc4d9c	David Cooke	https://p/	Its a great forward, and	5	2 183	10/20/2022 15:59					
4_396419b	Rivers of Baby	https://p/	I like it	5	0 183	9/4/2022 12:29					
5_0f5b484	nabianai mosi	https://p/	Its is Very good	5	0 173	8/9/2022 9:15					
6_5bc5295	Abdul Raah m	https://p/	Excellent	5	0 173	9/26/2022 0:09					
7_2730c0b	musa sani	https://p/	I list what exactly want Eve	5	0 173	6/13/2022 4:58					
8_7875705	darmawati	https://p/	One of the best apps I've	5	0 173	4/28/2022 12:45					
9_578315e	mark H	https://p/	Functional cool fun app	5	0 173	6/11/2022 17:57					
10_40e6228	Mi chael Damer	https://p/	Very accurate and easy to	5	0 173	5/6/2022 18:09					
11_1130509	tevenit628	https://p/	No problems, works well	5	0 173	4/5/2022 21:11					
12_181139f	Randy Howard	https://p/	Best effects	5	0	4/15/2022 18:53					
13_38c2684	MHidayat	https://p/	If you read the short help	5	0 173	4/6/2022 16:28					
14_026468f	Chuck Oulter	https://p/	One of the best apps I've	5	1 173	5/11/2022 2:59					
15_4d39d20	ANTechman	https://p/	Stable and consistent	5	0 173	2/28/2022 21:03					
16_05043e	Vikram Singh	https://p/	I love it	5	0 173	2/14/2022 19:15					
17_194458b	Mahmoud Ham	https://p/	U'ghu,ghu,ghu,ghu,ghu	5	0 173	2/9/2022 11:29					
18_1e4a8f1	Kevin Thomas	https://p/	Very good	5	0 173	2/6/2022 13:28					
19_4c3361d	Evon Indares	https://p/	Does not work with Dooge	1	0	2/5/2022 15:58					
20_3138579	Samad Armani	https://p/	Very good	5	0 173	1/29/2022 22:10					
21_1939f0ed	TM	https://p/	Please add a digital degre	2	4 173	1/20/2022 20:54					
22_4f05d6e	Lakhan Lal	https://p/	Good app	3	0 173	1/20/2022 13:58					
23_0914893	Nasir	https://p/	Nice Apps!!!!	4	0 173	1/7/2022 3:05					
24_88c374e	Aravind Laxmi	https://p/	Very cool, its compass	5	0 173	1/2/2022 11:39					
25_c6c787b	Mia T	https://p/	The green arrow is not inc	4	4 173	12/29/2021 22:42					
26_98c179e	Jadi Ahmed	https://p/	Nice app	5	1 173	12/28/2021 20:03					
27_34811343	Samuel Morie	https://p/	Great app	5	0 173	12/17/2021 10:34					
28_aa3384e	Chris Beach	https://p/	Very nice	4	0 173	11/30/2021 20:39					
29_141a1c0	Samuel chesnut	https://p/	I like this applicati	4	0 173	10/27/2021 1:38					
30_2d55c73	Craig Packard	https://p/	Right on point the best app	5	10 173	10/26/2021 16:09					
31_4d8e074	William Neal	https://p/	Works great! All the refer	5	1 173	10/14/2021 9:00					
32_7d58462	Bob Papp	https://p/	Good	5	0 173	10/6/2021 12:36					
33_8a4e0c1	Frank	https://p/		5	0 173	10/6/2021 1:57					

Figure 90 : CSV file with topic probability matrix.

AR GPS Compass Map 3D CSV link:

<https://drive.google.com/file/d/126asCJn5DCRokjd5Hco4fYeXx8mADCaG/view?usp=sharing>

The code then downloads the stopwords and WordNetLemmatizer from the Natural Language Toolkit (nltk) package. A function named "clean" is defined to preprocess the reviews text by removing stopwords, punctuation, and lemmatizing the words. The "clean" function is applied to the "content" column of the DataFrame to create a new column called "text_clean".

```
# Download NLTK resources
nltk.download('stopwords')
nltk.download('wordnet')

# Clean the text data using NLTKstop =
set(stopwords.words('english'))
exclude = set(string.punctuation)
lemma = WordNetLemmatizer()

def clean(text):
    if isinstance(text, str): # Check if input is a string
        stop_free = ' '.join([word for word in
text.lower().split() if word not in stop])
        punc_free = ''.join(ch for ch in stop_free if ch not
in exclude)
        normalized = ' '.join([lemma.lemmatize(word) for word
in punc_free.split()])
        return normalized
    else:
        return ""

df['text_clean']=df['content'].apply(clean)
df
```

CHAPTER 3

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	7ee0c7f2-6b19-4a34-ae28-9db8291c134	Bill Gerrett	https://play-ih.googleusercontent.com/a/AGVnyz...	This app is outstanding. I use the app to veri...	5	1	1.8.1	2022-03-25 17:34:37	None	None	app outstanding use app verify location job si...
1	0dbce92f-b538-453b-bef7-442cf700056b	Rome Egey	https://play-ih.googleusercontent.com/a/AGVnyz...	Nice ok this app im enjoy	4	0	None	2022-10-26 09:23:18	None	None	nice ok app im enjoy
2	2fa2eb8e-c2e8-4e4b-938f-7b16a9a30562	gary chaney	https://play-ih.googleusercontent.com/a/AGVnyz...	Awesome for finding your way to back to your t...	5	0	1.8.1	2022-10-21 14:55:50	None	None	awesome finding way back tree stand
3	8bc5d9e0-a5f2-4b00-a9f4-4e6e5a3010e6	David Cooke	https://play-ih.googleusercontent.com/a/AGVnyz...	It's straightforward, and works. Better than a...	5	2	1.8.1	2022-10-20 15:58:11	None	None	straightforward work better similar apps re t...
4	596419f8-1041-495e-aab7-96e4f6c09f	Rivers of Babylon	https://play-ih.googleusercontent.com/a/AGVnyz...	I like it	5	0	1.8.1	2022-09-04 12:29:19	None	None	like
...
459	bfb8184f-734f-4e0c-9095-2f0e499d9f98	A Google user	https://play-ih.googleusercontent.com/EGerot2N...	But I don't like advertisements, would have bo...	3	0	1.2.9	2013-01-24 03:01:56	None	None	like advertisement would bought option since g...
460	718931fe-c0e8-45de-a33e-20c1fa5b0c32	A Google user	https://play-ih.googleusercontent.com/EGerot2N...	Very nice sgs3 jelly bean 4.1.2	5	0	None	2012-11-15 11:01:42	None	None	nice sgs3 jelly bean 412
461	b937ed0c-eae6-447c-6da8-6158eae7d35	A Google user	https://play-ih.googleusercontent.com/EGerot2N...	My only complaint is my phones screen lock sh...	4	1	1.2.7	2012-10-05 14:16:34	None	None	complaint phone screen lock disabled app use p...
462	17a9729-f5e3-4371-9458-6dc0b27e6d1b	A Google user	https://play-ih.googleusercontent.com/EGerot2N...	The Apk pointed my device location 2 KM away L...	2	0	1.2.7	2012-09-20 02:57:39	None	None	apk pointed device location 2 km away 10 oclac...
463	2d1973ed-050c-483d-e0c5-5d13155146c4	A Google user	https://play-ih.googleusercontent.com/EGerot2N...	The best of best compass app	5	3	1.2.7	2012-09-16 02:04:19	None	None	best best compass app

464 rows x 11 columns

Figure 91 : Text data that are cleaned.

The text preprocessing is performed on the reviews by cleaning the text and creating a new column with the cleaned text. This will help to improve the quality of the text data and make it more suitable for further analysis.

A dictionary is created using the cleaned text data.

```
# Create a dictionary from the cleaned text data
texts = [list(gensim.utils.tokenize(text)) for text in
df['text_clean']]
dictionary = corpora.Dictionary(texts)

# Print the number of non-zero entries in the BOW matrix
print(dictionary.num_nnz)

2738
```

Figure 92 : Dictionary is created.

The number of non-zero elements in the bag-of-words (BOW) matrix is 2738.

A document-term matrix is created using the dictionary and the cleaned text data.

```
#create document term matrix
doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in
df['text_clean']]
print(len(doc_term_matrix))
```

Figure 93 : Document term matrix is created.

The length of the document-term matrix is 464.

An LDA model is initialized with the number of topics to be extracted.

The LDA model is fitted to the document-term matrix.

```
#Instantiate LDA model
lda = gensim.models.ldamodel.LdaModel

#Fit LDA model on the dataset
num_topics=5
ldamodel = lda(doc_term_matrix, num_topics=num_topics,
id2word=dictionary, passes=50, minimum_probability=0)
CPU times: user 15.9 s, sys: 57.7 ms, total: 16 s
Wall time: 22.8 s
```

Figure 94 : LDA Model is instantiated and fit on the dataset.

The CPU time taken to fit the model is printed as "user" time (i.e., the time spent in user mode) and "sys" time (i.e., the time spent in system mode). The total CPU time is the sum of the user and system times. The "Wall time" is the elapsed real-world time for the execution of the code. The CPU time taken to fit the Latent Dirichlet Allocation (LDA) model to the document-term matrix is 11.8 seconds, with a wall time of 15.3 seconds.

The topics identified by the LDA model are printed.

```
#Print the topics identified by LDA model
ldamodel.print_topics(num_topics=num_topics)
```

```
18] ldamodel.print_topics(num_topics=num_topics)
[(0,
  '0.036**awesome" + 0.021**app" + 0.020**apps" + 0.017**nice" + 0.013**ok" + 0.011**work" + 0.011**better" + 0.009**map" + 0.007**use" + 0.007**accurate**),
 (1,
  '0.061**app" + 0.030**compass" + 0.029**great" + 0.020**nice" + 0.016**work" + 0.014**gps" + 0.011**thanks" + 0.011**cool" + 0.010**accurate" + 0.009**it**),
 (2,
  '0.081**good" + 0.044**app" + 0.027**use" + 0.015**love" + 0.011**like" + 0.010**im" + 0.010**work" + 0.007**compass" + 0.007**way" + 0.007**would'),
 (3,
  '0.047**app" + 0.024**work" + 0.022**best" + 0.019**compass" + 0.016**like" + 0.015**well" + 0.014**need" + 0.013**great" + 0.009**good" + 0.009**easy**),
 (4,
  '0.021**useful" + 0.019**easy" + 0.018**use" + 0.017**accurate" + 0.011**great" + 0.011**app" + 0.011**point" + 0.008**time" + 0.007**north" + 0.007**work**')]
```

Figure 95 : 10 words contributed to each topic identified.

The pyLDAvis package is used to visualize the topics identified by the LDA model.

CHAPTER 3

#Visualize the LDA model results

```
lda_display = pyLDAvis.gensim.prepare(ldamodel,  
doc_term_matrix, dictionary, sort_topics=False, mds='mmds')  
pyLDAvis.display(lda_display)
```

The graph is generated by an LDA (Latent Dirichlet Allocation) topic modeling process. It includes five topics (0 to 4), each represented by the top 30 most relevant terms associated with that topic.

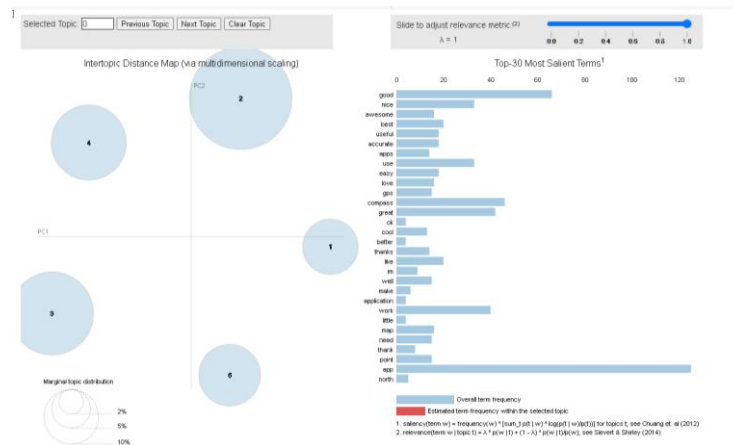


Figure 96 : Five topics is generated Top 30 most relevant terms are generated.

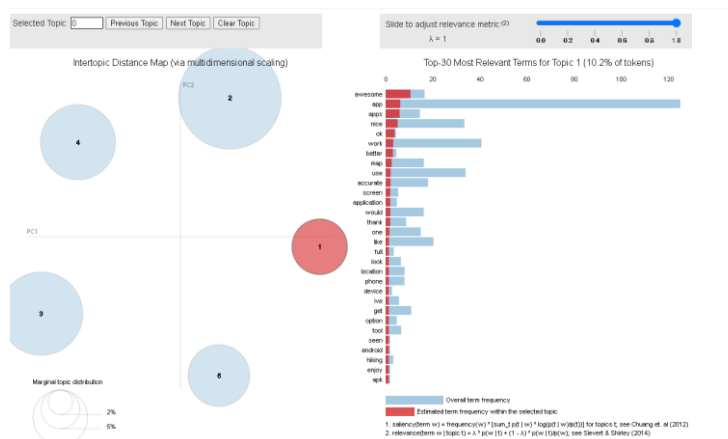


Figure 97 : Keywords for topic 0.

The keywords for topic 0 included app, version, time, awesome, even, work, good, map, speed, try and etc. The highest frequency terms for topic 0 is “app” with a frequency of 0.020. The term “app” appears with the highest frequency in this topic, suggesting that the main focus of the discussion is related to a specific application, its features, and

functionalities. This topic appears to be about an app, its version, and user experience. It highlights the app's performance, functionality, and speed.

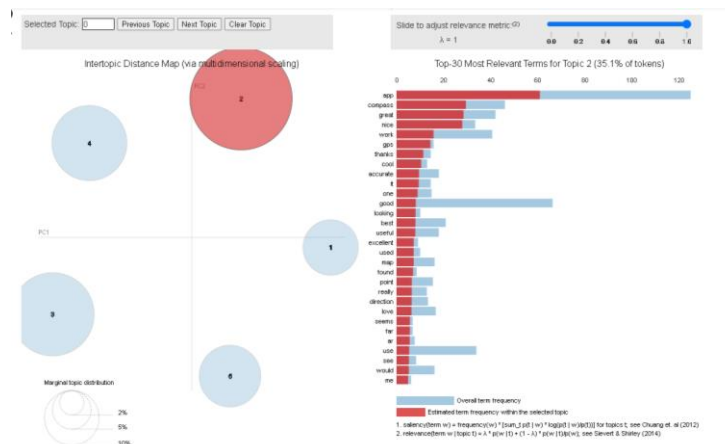


Figure 98 : Keywords for topic 1.

The keywords for topic 1 included app, version, time, awesome, even, work, good, map, speed, try and etc. The highest frequency terms for topic 1 is “good” with a frequency of 0.103. The term "good" has the highest frequency in this topic, which indicates that the conversation revolves around the positive aspects of an app or the satisfaction users experience while using it. This topic seems to focus on the positive aspects of an app, including user satisfaction and its utility, with some mention of crashes that may need addressing.

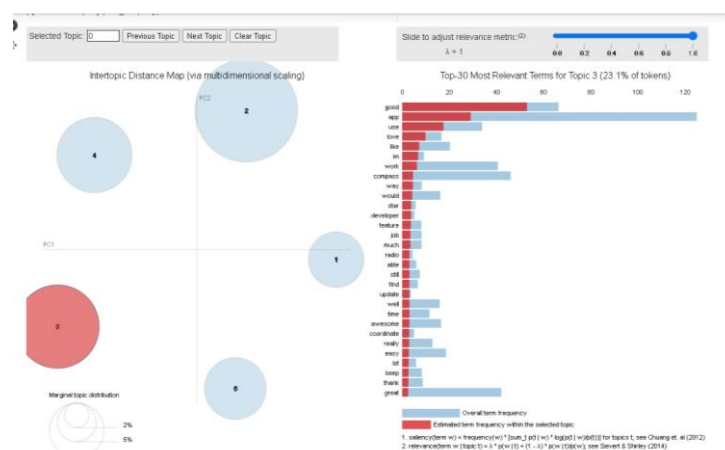


Figure 99: Keywords for topic 2.

CHAPTER 3

The keywords for topic 2 included great, app, ok, get, application, still, never, super, idea, like and etc. The highest frequency terms for topic 2 is “great” with a frequency of 0.037. The term "great" appears with the highest frequency in this topic, suggesting that the main focus of the discussion is on the app's quality and the positive experiences users have with the app. This topic covers general opinions about an app, its quality, and its features, including both positive and negative aspects.

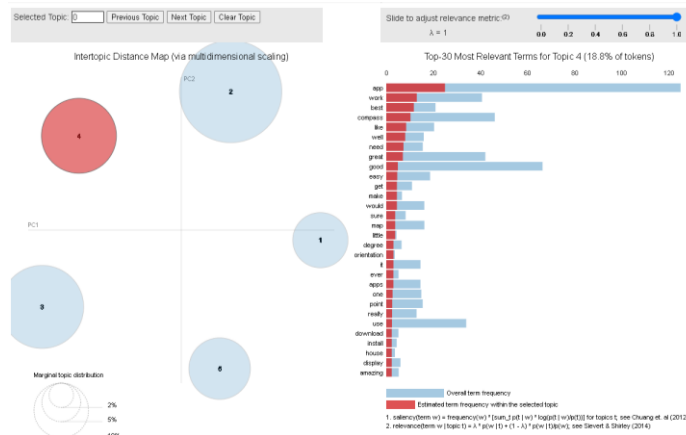


Figure 100 : Keywords for topic 3.

The keywords for topic 3 included nice, work, cannot, offline, ok, screen, like, caption, icon, low and etc. The highest frequency terms for topic 3 is “nice” with a frequency of 0.030. The term "nice" has the highest frequency in this topic, which indicates that the conversation revolves around the visual elements or user interface design of the app, and users appreciate its aesthetics or overall presentation. This topic seems to discuss the app's visual elements and functionality, such as the offline mode, screen, icons, and performance.

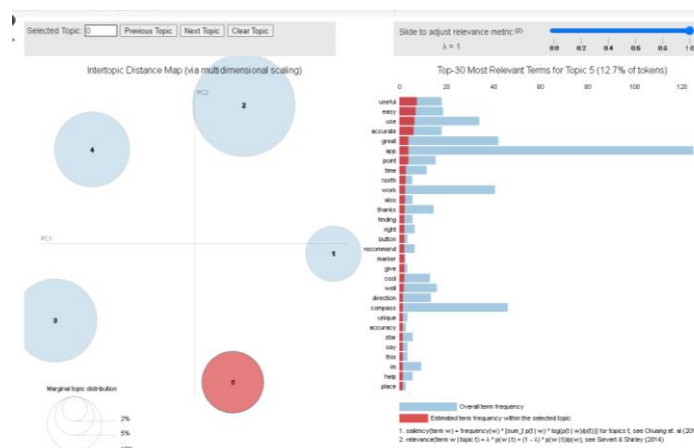


Figure 101 : Keywords for topic 4.

The keywords for topic 4 included map, work, gps, app, keep, google, use, best, download, year and etc. The highest frequency terms for topic 3 is “map” with a frequency of 0.020. The term "map" appears with the highest frequency in this topic, suggesting that the main focus of the discussion is on a mapping or GPS-related app, its features, and how it integrates with other services like Google. This topic appears to be about a map or GPS app, its usage, and its integration with other services like Google. It also suggests that the app has been in use for a while and is considered one of the best.

Assign the topics to the documents in corpus using the LDA model and the document-term matrix.

```
# Find articles assigned to clusters based on a threshold
lda_corpus = ldamodel[doc_term_matrix]
[doc for doc in lda_corpus]
```

Probability

```
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```

The output is obtained by passing the document-term matrix through the trained LDA model, which assigns the topic distribution to each document. The output shows the topic distribution of each document in the corpus. Each document is represented by a list of tuples, where each tuple corresponds to a topic and the probability of the document belonging to that topic. For example, the first document is represented as [(0, 0.95514655), (1, 0.011293795), (2, 0.011200884), (3, 0.0111737205), (4, 0.01185064)], which means that the document has a high probability of belonging to topic 0 and low probability of belonging to topics 1, 2, 3 and 4.

CHAPTER 3

Calculate the scores for each topic across all documents in the corpus, and determine a threshold value for the scores. This threshold value will be used to assign documents to clusters based on their topic scores.

```
scores = list(chain(*[[score for topic_id,score in topic] \
                    for topic in [doc for doc in
lda_corpus]]))

threshold = sum(scores)/len(scores)
print(threshold)
```

```
0.2000000000016127537
```

Figure 102 : Threshold calculated for topic relevance.

The threshold value calculated is 0.2000000000083297, which represents the average topic score across all topics in the LDA model. This threshold can be used to filter out low-scoring topics, for example, by only selecting topics with scores above this threshold.

Assign documents to clusters based on their topic scores using list comprehension. In this case, the code creates 5 clusters, one for each topic in the LDA model. Print the number of documents in each cluster to get an idea of the distribution of documents across the topics.

```
cluster1 = [j for i,j in zip(lda_corpus,df.index) if i[0][1] >
threshold]
cluster2 = [j for i,j in zip(lda_corpus,df.index) if i[1][1] >
threshold]
cluster3 = [j for i,j in zip(lda_corpus,df.index) if i[2][1] >
threshold]
cluster4 = [j for i,j in zip(lda_corpus,df.index) if i[3][1] >
threshold]
cluster5 = [j for i,j in zip(lda_corpus,df.index) if i[4][1] >
threshold]

print(len(cluster1))
print(len(cluster2))
```

CHAPTER 3

```
print(len(cluster3))
print(len(cluster4))
print(len(cluster5))
```

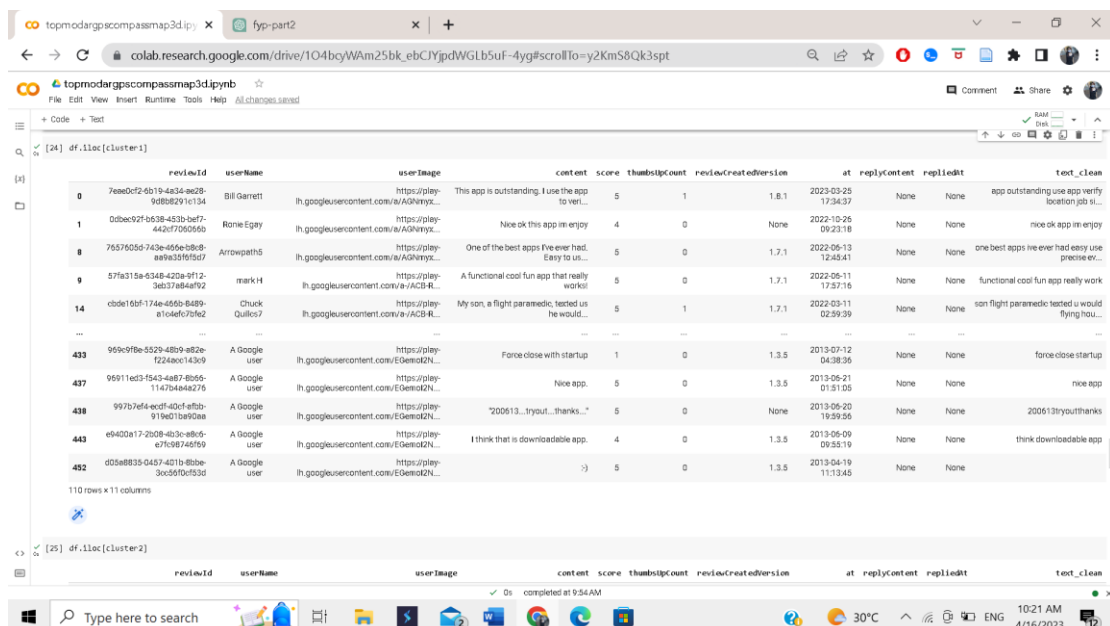
```
110
112
113
70
151
```

Figure 103 : Number of articles printed in each cluster.

The first cluster (cluster1) has 83 documents, the second cluster (cluster2) has 85 documents, the third cluster (cluster3) has 199 documents, the fourth cluster (cluster4) has 101 documents, and the fifth cluster (cluster5) has 91 documents. The total number of documents in all clusters (83 + 85 + 199 + 101 + 91) is equal to the total number of documents in the original dataset (df), assuming that each document was successfully assigned to one of the five clusters.

Display the documents in each cluster using pandas' iloc function to slice the DataFrame by index. This allows us to examine the reviews that were assigned to each cluster and potentially identify patterns or themes within the reviews.

```
df.iloc[cluster1]
```



	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	7ee0cf26194a34-ae28-908a291c134	Bill Garrett	https://play-https://play-	This app is outstanding. I use the app to vert...	5	1	1.8.1	2023-03-25 17:34:37	None	None	app outstanding use app verify location job st...
1	00bec92f-b638-453b-be7-442f7060565	Ronie Egey	https://play-https://play-	Nice ok this app im enjoy	4	0	None	2022-10-26 09:23:18	None	None	nice ok app im enjoy
8	7657605d-743e-465e-b8b8-a89a35f95d7	Arrowpath5	https://play-https://play-	One of the best apps I've ever had. Easy to us...	5	0	1.7.1	2022-06-13 12:43:41	None	None	one best apps i've ever had easy use precise ev...
9	57fa315a-6348-42da-9f12-3eb378b4e4f92	markH	https://play-https://play-	A functional cool fun app that really work!	5	0	1.7.1	2022-06-11 17:37:16	None	None	functional cool fun app really work
14	cb0e10bf-174e-465b-8489-a10e4fc7b3e2	Chuck Quilico7	https://play-https://play-	My son, a flight paramedic, tested us he would...	5	1	1.7.1	2022-03-11 02:59:39	None	None	son flight paramedic tested u would flying inou...
...
433	969e9f8e-5029-48b9-a82e-f224a0c143e9	A Google user	https://play-https://play-	Force close with startup	1	0	1.3.5	2013-07-12 04:08:36	None	None	force close startup
437	06911ed3-1543-4a87-8b65-1147b048a2776	A Google user	https://play-https://play-	Nice app.	5	0	1.3.5	2013-05-21 01:51:05	None	None	nice app
438	997b7ef4e0cf-d0cf-ef5b-919e01ba90aa	A Google user	https://play-https://play-	"200613...tryout...thanks..."	5	0	None	2013-06-20 19:59:55	None	None	200613tryoutthanks
443	e9400a17-2b08-4b3c-88e6-e7f098746f99	A Google user	https://play-https://play-	I think that is downloadable app.	4	0	1.3.5	2013-06-09 09:55:19	None	None	think downloadable app
452	d05e8833-0457-401b-8b5e-3e0d0d053d	A Google user	https://play-https://play-	>)	5	0	1.3.5	2013-04-19 11:13:45	None	None	

Figure 104 : Articles of cluster1 are printed.

CHAPTER 3

`df.iloc[cluster2]`

reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
2	2fa2eb8e-c268-46cb-938f-78156ba30562	gary chany	Awesome for finding your way to back to your!	5	0	1.8.1	2022-10-21 14:56:50	None	None	awesome finding way back tree stand
15	ad39d250-6784-4922-84dc-d61f40320a1	AVTechman	Stable and consistent	5	0	1.7.1	2022-02-20 21:03:16	None	None	stable consistent
16	655f43ee0c77-4bae-965b-d53c4eeae55	Vikram Singh	M79	5	0	1.7.1	2022-02-14 19:15:02	None	None	m79
17	b9f4e888-0921-41f7-b4ae-b3428c05977a	Mahmoud Hamam	ممتازة في إيجاد المسار	5	0	1.7.1	2022-02-09 11:29:01	None	None	ممتازة في إيجاد المسار
27	3d811b43-1042-4be0-8619-3ba3e7557196	Samuel Morales	Great app	5	0	1.7.1	2021-12-17 10:34:28	None	None	great app
...
452	d05a8835-0457-4d1b-8bbe-3c05f0c9336	A Google user	->	5	0	1.3.5	2013-04-19 11:13:45	None	None	
454	72e87415-df68-41de-b772-890c9b9848d	A Google user	Best app I have ever used works better for waypoint	5	0	1.3.3	2013-03-19 02:22:54	None	None	best app ever used work best waypoint
458	76399f4b-5c23-48ab-8548-ec031ef0830c	A Google user	Awesome app for GPS hiking and tracking	5	0	1.3.0	2013-01-28 02:22:21	None	None	awesome app gps hiking tracking
462	17a972f8-fd63-4371-9468-6c0c827e6d1b	A Google user	The Apk pointed my device location 2 KM away!	2	0	1.2.7	2012-09-20 02:07:39	None	None	apk pointed device location 2 km away 10 octo...
463	261973ed-0f6e-483d-8d05-5d1318314604	A Google user	The best of best compass app	5	3	1.2.7	2012-09-16 02:04:19	None	None	best best compass app

Figure 105 : Articles of cluster2 are printed.

`df.iloc[cluster3]`

reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
3	8bc6dd9e-8f57-4b00-a0f4-4e6e63b10e6	David Cooke	It's straightforward and works. Better than a...	5	2	1.8.1	2022-10-20 15:58:11	None	None	straightforward work better similar apps ne t...
4	b96419f8-1041-495e-aab7-99e84f0d9f9	Rivers of Babylon	I like it	5	0	1.8.1	2022-09-04 12:29:19	None	None	like
7	273c0db8-1a05-4244-bd73-8a3997fded92	musa sani	I Get what easily want Everything works effect...	5	0	1.7.1	2022-05-19 04:50:07	None	None	get easily want everything work effectively co...
11	35059f8e-a520-4939-9e6a-7810e2122480	Shereif6268	No problems, works well.	5	0	1.7.1	2022-06-15 21:11:30	None	None	problem work well
16	655f43ee0c77-4bae-965b-d53c4eeae55	Vikram Singh	M79	5	0	1.7.1	2022-02-14 19:15:02	None	None	m79
...
452	d05a8835-0457-4d1b-8bbe-3c05f0c9336	A Google user	->	5	0	1.3.5	2013-04-19 11:13:45	None	None	
455	2daab061-acbb-4d07-b34e-e83f785e9f3a	A Google user	We use this to show line of sight to radio tower...	4	1	1.3.3	2013-03-17 09:30:01	None	None	use show line sight radio tower useful app wou...
456	90514e02-e051-4076-8ac1-294633102a38	A Google user	Great	4	0	1.3.3	2013-03-16 16:17:53	None	None	great
457	d0d52d08-f376-4473-8c0c-2d15b4425963	A Google user	Works great	5	0	1.3.1	2013-02-09 17:31:33	None	None	work great
460	718931fe-cb68-456e-4c3e-20c1fa3b0c32	A Google user	Very nice gps3 jilly been 4.1.2	5	0	None	2012-11-15 11:01:42	None	None	nice gps3 jilly been 412

Figure 106 : Articles of cluster3 are printed.

`df.iloc[cluster4]`

CHAPTER 3

reviewId	userName	userImage	content	score	thumbUpCount	reviewCreatedVersion	at	replyContent	replieId	text_clean
2	2fa2eb8e-c268-4e0b-938f-7615a9e30562	gary charney	Awesome for finding your way to back to your L...	5	0	1.8.1	2022-10-21 14:56:50	None	None	awesome finding way back tree stand
7	273000b-1a06-42a4-8d73-8a3987d8e662	musa seni	I Get what easily want Everything works effect...	5	0	1.7.1	2022-06-19 04:50:07	None	None	get easily want everything work effectively co...
10	e0e9d209-dc3f-47b9-847f-fb50cfeeb1a	Michael Darmon	Very accurate and easy to use.	5	0	1.7.1	2022-05-06 10:09:23	None	None	accurate easy use
12	bb119d5e-fe14-46bb-93df-270cc7d5d0f1	Randy Howard	Neat effects	5	0	None	2022-04-15 18:53:43	None	None	neat effect
16	656f43ee-c677-42ae-956b-d5304eeae55	Vikram Singh	M79	5	0	1.7.1	2022-02-14 19:15:02	None	None	m79
444	675c6809-4297-4e0b-9f1b-0d5539e08a5	A Google user	Easy to use and works perfectly.	5	0	1.3.5	2013-06-07 09:04:02	None	None	easy use work perfectly
451	8b799f9b-38c3-4862-9d0d-7d9910a9951b	A Google user	Very over	4	0	1.3.5	2013-05-03 19:30:02	None	None	over
452	d05a8835-0457-401b-8b2b-3cc5d0c753d	A Google user	:)	5	0	1.3.5	2013-04-19 11:13:45	None	None	
458	76396f4b-5c23-48ab-8548-ec031e46830c	A Google user	Awesome app for GPS hiking and tracking	5	0	1.3.0	2013-01-28 02:22:21	None	None	awesome app gps hiking tracking
459	b788184f-734f-4adc-9c95-275649599c8	A Google user	But I don't like advertisements, would have bo...	3	0	1.2.9	2013-01-24 03:01:06	None	None	like advertisement would bought option since g...

Figure 107 : Articles of cluster4 are printed.

`df.iloc[cluster5]`

reviewId	userName	userImage	content	score	thumbUpCount	reviewCreatedVersion	at	replyContent	replieId	text_clean
1	0d8e92f5-6639-453b-8ef7-443cf702696b	Rome Egay	Nice ok this app im enjoy	4	0	None	2022-10-26 09:23:18	None	None	nice ok app im enjoy
5	3f3b4844-1ed7-45d2-8a0c-0d97e0b51c4	nathamed moeketsi	It is Very good	5	0	1.7.1	2022-09-08 09:15:40	None	None	good
6	0b32193d-6586-4e83-8155-2ce254d898d	Abdul Razak Hussain	Excellent	5	0	1.7.1	2022-05-26 06:03:11	None	None	excellent
13	30c26d84-8853-4759-9c0b-ef185e1d3091	MRader54	If you read the short Help document, operating...	5	0	1.7.1	2022-04-06 16:20:01	None	None	read short help document operating app easy
16	656f43ee-c677-42ae-956b-d5304eeae55	Vikram Singh	M79	5	0	1.7.1	2022-02-14 19:15:02	None	None	m79
446	d02f0706-1043-4862-97ec-cc8d34b18719	A Google user	Smart application! Love it	5	0	1.3.5	2013-05-23 23:38:16	None	None	smart application love
450	1a04d6e5-1827-402b-b383-d8c35497b4d6	A Google user	good	3	0	None	2013-05-05 02:18:39	None	None	good
452	d05a8835-0457-401b-8b2b-3cc5d0c753d	A Google user	:)	5	0	1.3.5	2013-04-19 11:13:45	None	None	
453	6c729b45-54b9-43d2-9c7e-0120b0a910c	A Google user	Gps	4	0	1.3.3	2013-03-26 19:22:22	None	None	gps
461	b937ed0c-0e85-447b-8d46-6158ee0e7835	A Google user	My only complaint is my phones screen lock disa...	4	1	1.2.7	2012-10-28 14:16:34	None	None	complaint phone screen lock disabled app use p...

Figure 108: Articles of cluster5 are printed.

Conclusion

The conclusion drawn from the LDA topic modeling analysis is that the conversation revolves around various aspects of apps, with a focus on user experience, satisfaction, and functionality. The five identified topics highlight different areas of interest:

CHAPTER 3

Topic 0 emphasizes an app's version, performance, and speed.

Topic 1 highlights the positive aspects of an app, user satisfaction, and areas for improvement, such as addressing crashes.

Topic 2 discusses general opinions about an app, including its quality and features, touching on both positive and negative aspects.

Topic 3 focuses on the visual elements and functionality of an app, such as offline mode, screen, icons, and performance.

Topic 4 pertains to a map or GPS app, its usage, integration with other services like Google, and its reputation as one of the best in its category.

3.4.2.2.3 AR GPS Drive

Coding and Output

The code uses the Google Play Scraper to retrieve the reviews for the AR GPS Drive app.

```
argpsdrive_project = reviews_all('com.w.argps',  
sleep_milliseconds=0, lang='EN',country='US')
```

The reviews are stored in a Pandas DataFrame, and some basic statistics are calculated, such as the number of unique users, the average rating, and the number of users who left multiple reviews.

```
df = pd.DataFrame(argpsdrive_project)  
  
# Get the list of users who left more than one review  
multiple_reviewers =  
df['userName'].value_counts()[df['userName'].value_counts() >  
1].index.tolist()  
  
unique_users = len(df['userName'].unique())  
unknown_users = len(df[df['userName'] == 'A Google user'])  
total_reviews = len(df)  
  
# Analyze and print information about the reviews and users
```

CHAPTER 3

```
if
len(df['userName'].value_counts()[df['userName'].value_counts(
) > 1].index.tolist()) > 0:
    multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()
    num_multiple_reviews =
len(df[df['userName'].isin(multiple_reviewers)]['userName'].un
ique())
else:
    num_multiple_reviews = 0

mean = df['score'].mean()

# Print the results
print(f'Total textual reviews: {len(pinnar_project)}')
print(f'Total unique users: {unique_users}')
print(f'Total unknown users: {unknown_users}')
print(f'Total users who gave multiple reviews:
{num_multiple_reviews}')
print(f'Average rating for this app based on the textual
reviews: {round(mean, 2)}')

print(f'Average rating for this app based on the textual reviews: {round(mean, 2)}')
Total textual reviews: 163
Total unique users: 9
Total unknown users: 155
Total users who gave multiple reviews: 1
Average rating for this app based on the textual reviews: 3.66
```

Figure 109 : Summary statistics of the reviews.

"Total textual reviews" indicates the total number of reviews in the dataset, which is 163.

"Total unique users" shows the number of unique reviewers who left a review, which is 9.

"Total unknown users" shows the number of reviews that were left by unidentified users, in this case, it is 155.

"Total users who gave multiple reviews" shows the number of users who left more than one review, which is 1.

CHAPTER 3

"Average rating for this app based on the textual reviews" shows the mean rating score of all the reviews in the dataset, which is 3.66 out of 5.

The reviews with a score less than or equal to 3 and with a length greater than or equal to 30 characters are filtered.

```
# Filter reviews with ratings less than or equal to 3 and
content length greater than or equal to 30
df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

```
] df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

Remaining textual reviews: 29

Figure 110 : Reviews less than 4.

The first line of code filters the dataframe 'df' based on reviews where the 'score' column has a value less than or equal to 3, and assigns the filtered dataframe to 'df_tm'. The second line further filters 'df_tm' by selecting only those reviews where the 'content' column has a length of 30 or more characters. The 'len(df_tm)' function call in the print statement then returns the number of remaining textual reviews that meet both filtering conditions, which is 29.

The code is cleaning up a DataFrame of textual reviews by removing duplicate rows and missing values, and then printing out the number of remaining reviews in the cleaned DataFrame.

```
# Get relevant columns and drop duplicates and missing values
df_tm = df_tm[['reviewId', 'content']].drop_duplicates()
df_tm.dropna(inplace=True)
df_tm = df_tm.reset_index().drop(columns='index')
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

Remaining textual reviews: 29

Figure 111 : Remaining textual reviews which are less than 4.

This code is getting the relevant columns from the filtered dataframe df_tm, which contains reviews that have a rating less than or equal to 3 and have a length of at least

CHAPTER 3

30 characters. The relevant columns are 'reviewId' and 'content', which are the unique ID of the review and the textual content of the review, respectively. Then, the code drops any rows with missing values and resets the index of the resulting dataframe. Finally, it prints the total number of remaining textual reviews in the cleaned dataframe, which is 29.

The code then creates a `CountVectorizer` object and fits it to the text data in the `df_tm` `DataFrame`. The resulting document-term matrix (DTM) is stored in a variable called `dtm`, and the feature names (i.e., the unique words in the text) are stored in `feature_names`.

```
# create CountVectorizer object
cv = CountVectorizer(max_df=0.95, min_df=2,
stop_words='english')

# fit and transform the text data
dtm = cv.fit_transform(df_tm['content'])

# get feature names from CountVectorizer object
feature_names = cv.vocabulary_.keys()

# print the feature names
print(list(feature_names)[:20])
```

```
[ ] # create CountVectorizer object
cv = CountVectorizer(max_df=0.95, min_df=2, stop_words='english')

# fit and transform the text data
dtm = cv.fit_transform(df_tm['content'])

# get feature names from CountVectorizer object
feature_names = cv.vocabulary_.keys()

# print the feature names
print(list(feature_names)[:20])

['use', 'user', 'version', 'years', 'ago', 'current', 'good', 'app', 'got', 'lot', 'google', 'maps', 'used', 'internet', 'just', 'information', 'actually', 'screen', 'times', 'works']
```

Figure 112 : 20 feature names that appear first in the vocabulary in alphabetical order.

The output shows the first 20 feature names extracted from the `CountVectorizer` object. These feature names are the unique words in the remaining textual reviews after data preprocessing (removing duplicates, dropping NaN values, and filtering for reviews with length greater than or equal to 30). The `CountVectorizer` object is used to convert the text data into a matrix of token counts where each row represents a review and each column represents a unique word in the reviews. The `max_df` parameter is set to 0.95

CHAPTER 3

which means that any word that appears in more than 95% of the reviews will be ignored. The `min_df` parameter is set to 2 which means that any word that appears in less than 2 reviews will be ignored. The `stop_words` parameter is set to 'english' which means that common English words like 'the', 'and', 'in', etc. will be ignored.

The code uses the LatentDirichletAllocation (LDA) algorithm from scikit-learn to perform topic modeling on the `dtm`. The resulting topics are printed to the console, along with the top 20 words associated with each topic.

```
# Perform Latent Dirichlet Allocation (LDA) topic modeling
LDA = LatentDirichletAllocation(n_components=5, random_state=1)
LDA.fit(dtm)
```

```
# Print the top words for each topic
for index, topic in enumerate(LDA.components_):
    print(f'topic #{index} : ')
    print([list(feature_names)[i] for i in topic.argsort()[-20:]])
```

```
[ ] LDA = LatentDirichletAllocation(n_components=5, random_state=1)
LDA.fit(dtm)

#LDA = LatentDirichletAllocation(n_components=5, random_state=1)
#LDA.fit(dtm)

* LatentDirichletAllocation
LatentDirichletAllocation(n_components=5, random_state=1)

[ ] #for index, topic in enumerate(LDA.components_):
    #print(f'topic #{index} : ')
    #print([cv.get_feature_names()[i] for i in topic.argsort()[-20:]])
for index, topic in enumerate(LDA.components_):
    print(f'topic #{index} : ')
    print([list(feature_names)[i] for i in topic.argsort()[-20:]])
#for index, topic in enumerate(LDA.components_):
    #print(f'topic #{index} : ')
    #print([tfidf.get_feature_names()[i] for i in topic.argsort()[-20:]])

topic #0 :
['stops', 'internet', 'work', 'function', 'works', 'phone', 'display', 'current', 'concept', 'app', 'maps', 'google', 'ar', 'need', 'choose', 'download', 'used', 'actually', 'video', 'low']
topic #1 :
['actually', 'video', 'current', 'concept', 'app', 'google', 'maps', 'display', 'just', 'user', 'time', 'try', 'used', 'ago', 'got', 'need', 'area', 'ar', 'choose', 'map']
topic #2 :
['current', 'concept', 'app', 'maps', 'ar', 'google', 'gps', 'used', 'download', 'like', 'ago', 'cool', 'screen', 'try', 'good', 'internet', 'display', 'stops', 'really', 'navigation']
topic #3 :
['really', 'ar', 'display', 'screen', 'cool', 'app', 'information', 'need', 'concept', 'maps', 'area', 'times', 'dont', 'years', 'use', 'user', 'time', 'speed', 'just', 'works']
topic #4 :
['navigation', 'actually', 'time', 'information', 'app', 'got', 'google', 'current', 'concept', 'internet', 'works', 'work', 'target', 'lot', 'like', 'maps', 'phone', 'gps', 'function', 'version']
```

Figure 113 : Output of instantiation of a Latent Dirichlet Allocation (LDA) model and Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model.

The output indicates that a Latent Dirichlet Allocation (LDA) model has been instantiated with 5 topics and a random state of 1.

CHAPTER 3

The code then uses the LDA model to assign each review in `df_tm` to one of the identified topics. The topic assignments are stored in a new DataFrame called `df_topic_results`. The `df_topic_results` DataFrame is merged back into the original `df` DataFrame based on the `reviewId` and `content` columns, and the resulting DataFrame is stored in `df_output`.

```
# Transform documents into topic space
topic_results = LDA.transform(dtm)
df_topic_results = pd.DataFrame(topic_results, columns=[
'0_Performance and Usability',
'1_User Experience and app's features' ,
'2_Technology'
,
'3_User Interface and Design' ,
'4_Performance and Effectiveness'
])

# Merge topic results with the original DataFrame
df_result = pd.merge(df_tm, df_topic_results, how='inner',
left_index=True, right_index=True )
df_output = pd.merge(df, df_result, how='left',
on=[ 'reviewId', 'content' ])
df_output.to_csv('argspsdrive_topmod.csv')
```

reviewId	userName	score	thumbsUp	reviewCreatedAt	replyCount	0_Performance and Usability	1_User Experience and app's features	2_Technology	3_User Interface and Design	4_Performance and Effectiveness
0 c37866a-Rashid Far	https://pi/Good	1	0	Beta 61.0	10/11/2022 17:39					
1 26c204b-David Mier	https://pi/Good	1	0	Beta 61.0	4/12/2022 16:17					
2 426720c-Online Us	https://pi/Very diffic	2	1	Beta 61.0	5/25/2022 18:18	3%	90%	3%	3%	3%
3 b998d35- martin wil	https://pi/Absolute	1	1		1/20/2022 18:57					
4 e602a46-lin_sam	https://pi/As far as	5	0	Beta 61.0	12/8/2021 9:23					
5 80189d7-DroBtoRj	https://pi/Why is Car	1	0		8/2/2021 21:58					
6 b3a0e7e7- garawa	https://pi/Good app.	1	2	Beta 61.0	4/1/2021 4:43	7%	7%	7%	7%	73%
7 3ca4306-Maso Lutu	https://pi/Ads in the	1	2	Beta 69.1	11/14/2020 1:59					
8 98a2a5f5-A Google	https://pi/CPD OF D	5	2	Beta 69.1	11/6/2019 1:51					
9 c37eabea-A Google	https://pi/Sucks	1	0		12/1/2019 5:59					
10 075a18e3-A Google	https://pi/ was expe	1	6		11/15/2019 8:08 Dear Sir	11/17/2019 8:06	1%	1%	1%	96%
11 46013012-A Google	https://pi/like a	4	3	Beta 69.0	11/24/2019 9:49					
12 93302139-A Google	https://pi/Works	4	2	Beta 69.0	10/5/2019 15:47					
13 03781b0d-A Google	https://pi/Super	5	0		8/7/2018 7:06					
14 1436c9a0d-A Google	https://pi/Keeps cras	1	2	Beta 53.0	6/23/2018 11:49	10%		60%	10%	10%
15 25a0a4e-A Google	https://pi/Eds	2	1	Beta 53.0	6/16/2018 12:14					
16 e350ca07-A Google	https://pi/Very very	5	0	Beta 24.3	1/6/2018 0:36					
17 47d79930-A Google	https://pi/Using it off	5	12	Beta 46.0	8/30/2017 9:01					
18 30cc332-A Google	https://pi/It is the m	5	3	Beta 44.0	3/8/2017 12:13					
19 931788f5-A Google	https://pi/This is a co	3	7	Beta 49.1	2/23/2017 20:41	5%		5%	5%	80%
20 a4575852-A Google	https://pi/ LOVE HUK	5	0		2/1/2017 2:05					
21 3684d4ae-A Google	https://pi/Love it	5	2	Beta 43.1	1/29/2017 8:08					
22 18d89f0d-A Google	https://pi/awesome	5	0		11/29/2016 10:14					
23 321ee70a-A Google	https://pi/I liked it a	4	3	Beta 39.0	10/25/2016 1:09					
24 78ea7d5b-A Google	https://pi/Very good	5	0		10/15/2016 14:14					
25 52f01871-A Google	https://pi/ Crashes m	1	6	Beta 27.0	3/20/2016 0:49 Please upc	3/21/2016 11:23	20%		20%	20%
26 1838a60b-A Google	https://pi/Stopped e	1	0		11/30/2016 5:21					
27 f09b010a-A Google	https://pi/ have a pr	3	5	Beta 25.0	11/21/2015 8:02	2%		93%	2%	2%

Figure 114 : CSV file with topic probability matrix.

AR GPS Drive CSV link:

<https://drive.google.com/file/d/1A72LPSUFGoRXmx7NIaH4wsuWbl2rXT4j/view?usp=sharing>

This output shows the top 20 words associated with each of the five topics generated by the LDA model. Each topic represents a distribution of words that frequently occur together in the reviews. The higher the weight of a word in a topic, the more important it is in defining that topic. For example, topic #0 is related to issues with the app's functions and performance, while topic #2 is related to the app's GPS navigation and mapping features.

The code then cleans the textual data by removing stop words, punctuation, and lemmatizing the words. This cleaned text is stored in a new column called `text_clean` in the original `df` DataFrame.

```
# Download NLTK resources
nltk.download('stopwords')
nltk.download('wordnet')

# Clean the text data using NLTK
stop = set(stopwords.words('english'))
exclude = set(string.punctuation)
lemma = WordNetLemmatizer()

def clean(text):
    if isinstance(text, str): # Check if input is a string
        stop_free = ' '.join([word for word in
text.lower().split() if word not in stop])
        punc_free = ''.join(ch for ch in stop_free if ch not
in exclude)
        normalized = ' '.join([lemma.lemmatize(word) for word
in punc_free.split()])
        return normalized
    else:
        return ""
```

CHAPTER 3

```
df['text_clean'] = df['content'].apply(clean)
df
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	c378de6a-12b3-4aea-8f2a-bf99c7078086	Rashid Farooqui	https://play- lh.googleusercontent.com/a/AGNmyx...	Good	1	0	Beta 61.0	2022-10-11 17:39:37	None	NaT	good
1	2b2c59a0-1113-4cd8-818c-c884d386dbd5	David Morrison	https://play- lh.googleusercontent.com/a/ACBR...	Doesn't show anything	1	0	Beta 61.0	2022-06-11 16:17:50	None	NaT	show anything
2	4267520c-d3e3-41c9-afa9-216d040e0efd	Online User	https://play- lh.googleusercontent.com/a/AGNmyx...	Very difficult to use, not user friendly. The ...	2	1	Beta 61.0	2022-05-25 18:18:11	None	NaT	difficult use user friendly old version two ye...
3	b99b8c15-7863-4ea8-ace0-5ba3c221c240	martin wilson	https://play- lh.googleusercontent.com/a/ACBR...	Absolutely full of adds	1	1	None	2022-01-20 19:57:11	None	NaT	absolutely full add
4	e6b2a4a6-091b-42ba-9ae3-1db8aca1bb9a	अश्वनी मुक्ता की ज्योतिष धारिणी (Shastri je)	https://play- lh.googleusercontent.com/a/ACBR...	मरल ऐप है	5	0	Beta 61.0	2021-12-08 09:23:03	None	NaT	मरल ऐप है
...
158	01b87c5a-3f76-43e3-b3d1-42b565b11b75	A Google user	https://play- lh.googleusercontent.com/EGemoI2N...	Wowexcellent	5	1	Beta 13.3	2013-04-27 02:22:09	None	NaT	wowexcellent
159	b2d20b0b-ed29-4157-899c-4a30a78c001a	A Google user	https://play- lh.googleusercontent.com/EGemoI2N...	Suppet	5	0	None	2013-03-21 10:09:09	None	NaT	suppet
160	47fb56ae-8ede-4983-bae4-3a30cb702af	A Google user	https://play- lh.googleusercontent.com/EGemoI2N...	What a stupid apps	1	0	None	2013-02-18 23:33:44	None	NaT	stupid apps
161	7a766351-31a3-4ce8-a3c6-e68a99b35d43	A Google user	https://play- lh.googleusercontent.com/EGemoI2N...	Dumb!	1	1	None	2013-02-18 02:52:39	None	NaT	dumb
162	3bc6e481-669c-4b2c-b6d0-9918c29a5685	A Google user	https://play- lh.googleusercontent.com/EGemoI2N...	Full information on screen during navigatn. ...	3	2	Beta 11.0	2012-11-20 09:43:19	None	NaT	full information screen navigaton unfortunatel...

163 rows x 11 columns

Figure 115 : Text data that are cleaned.

The code uses the gensim library to create a dictionary from the cleaned text data in df.

It then creates a document-term matrix from the dictionary and the cleaned text data.

```
# Create a dictionary from the cleaned text data
texts = [list(gensim.utils.tokenize(text)) for text in
df['text_clean']]
dictionary = corpora.Dictionary(texts)

# Print the number of non-zero entries in the BOW matrix
print(dictionary.num_nnz)

#create document term matrix
doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in
df['text_clean'] ]
print(len(doc_term_matrix))
```

CHAPTER 3

```
Create dictionary

# create dictionary
# Total number of non-zeros in the BOW matrix (sum of the number of unique words per document over the entire corpus).

from gensim.utils import tokenize
texts = [[list(tokenize(text)) for text in df['text_clean']]
dictionary = corpora.Dictionary(texts)
print(dictionary.num_nnz)

766

Create document term matrix

# create document term matrix
doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in df['text_clean']]
print(len(doc_term_matrix))

163
```

Figure 116 : Dictionary and document term matrix are created.

The output indicates that there are 766 non-zero elements in the Bag of Words (BOW) matrix created from the cleaned text data. This means that there are 766 unique words that appear in at least one of the reviews. The second output indicates that there are 163 documents (reviews) in the document-term matrix, which means that each review has been transformed into a vector of word counts, where the columns correspond to unique words and the rows correspond to each review.

The code uses the gensim library to perform LDA topic modeling on the document-term matrix. The resulting topics are printed to the console.

```
# Instantiate and fit an LDA model
lda = gensim.models.ldamodel.LdaModel

num_topics=5
ldamodel = lda(doc_term_matrix, num_topics=num_topics,
id2word=dictionary, passes=50, minimum_probability=0)

# Print the topics identified by the LDA model
ldamodel.print_topics(num_topics=num_topics)
```

```
Instantiate LDA model

[ ] lda = gensim.models.ldamodel.LdaModel

Fit LDA model on the dataset

[ ] num_topics=5
Xtime ldamodel = lda(doc_term_matrix,num_topics=num_topics,id2word=dictionary,passes=50,minimum_probability=0)

CPU times: user 2.92 s, sys: 99.7 ms, total: 3.02 s
Wall time: 2.99 s
```

Figure 117 : LDA Model is instantiated and fit on the dataset.

CHAPTER 3

The output shows the time taken to fit the LDA (Latent Dirichlet Allocation) model on the given dataset with 5 topics, using the Gensim library. The CPU times output shows the amount of CPU time taken by the process to complete, while the Wall time output shows the elapsed time taken to execute the process, which includes the CPU time as well as any time spent waiting for input/output (I/O) operations to complete. In this case, the LDA model was fit in approximately 2.99 seconds of wall time.

The second output shows the topics identified by the LDA model. There are 5 topics in total, each represented by a list of words. The words in each list are the most representative words of that particular topic, based on the probability distribution of words within the topic. For example, topic 0 is represented by words such as "app", "phone", "use", "good", etc. This suggests that this topic is likely to be related to the usability or quality of the app from the user's perspective. Similarly, topic 1 is represented by words such as "traffic", "maps", "navigation", "location", etc. indicating that this topic might be about the app's navigation features.

The code uses the pyLDAvis library to create a visualization of the LDA model results.

```
lda_display = pyLDAvis.gensim.prepare(ldamodel,  
doc_term_matrix, dictionary, sort_topics=False, mds='mmds')  
pyLDAvis.display(lda_display)
```

The topics identified by LDA model are printed.

```
ldamodel.print_topics(num_topics=num_topics)
```

```
[18] ldamodel.print_topics(num_topics=num_topics)  
[[0,  
  '0.020**app' + 0.015**version' + 0.015**time' + 0.015**awesome' + 0.012**even' + 0.012**work' + 0.012**good' + 0.009**map' + 0.009**speed' + 0.009**try'),  
 1,  
  '0.103**good' + 0.040**love' + 0.017**fantastic' + 0.014**use' + 0.012**job' + 0.012**like' + 0.012**address' + 0.012**need' + 0.012**great' + 0.007**crash'),  
 2,  
  '0.037**great' + 0.036**app' + 0.021**ok' + 0.011**get' + 0.011**application' + 0.011**still' + 0.011**never' + 0.011**super' + 0.011**idea' + 0.011**like'),  
 3,  
  '0.030**nice' + 0.013**work' + 0.009**cannot' + 0.009**offline' + 0.009**ok' + 0.009**screen' + 0.009**like' + 0.009**caption' + 0.009**icon' + 0.009**low'),  
 4,  
  '0.020**map' + 0.017**work' + 0.017**gps' + 0.017**app' + 0.013**keep' + 0.013**google' + 0.013**use' + 0.013**best' + 0.010**download' + 0.010**year']]
```

Figure 118 : 10 words contributed to each topic identified.

The graph is generated by an LDA (Latent Dirichlet Allocation) topic modeling process. It includes five topics (0 to 4), each represented by the top 30 most relevant terms associated with that topic.

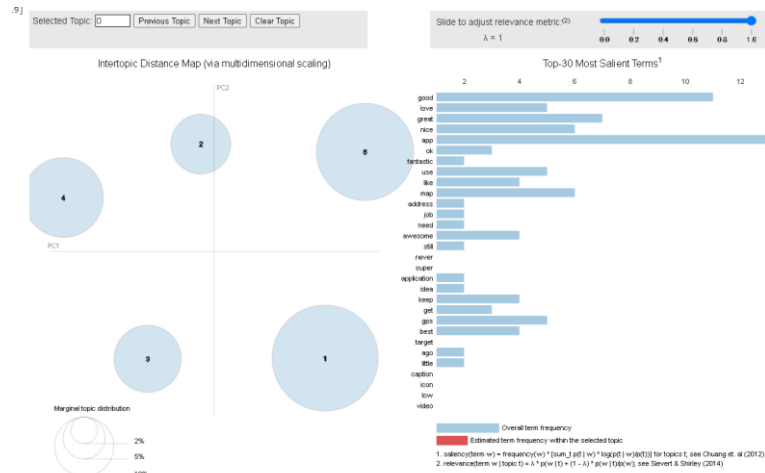


Figure 119 : Five topics is generated Top 30 most relevant terms are generated.

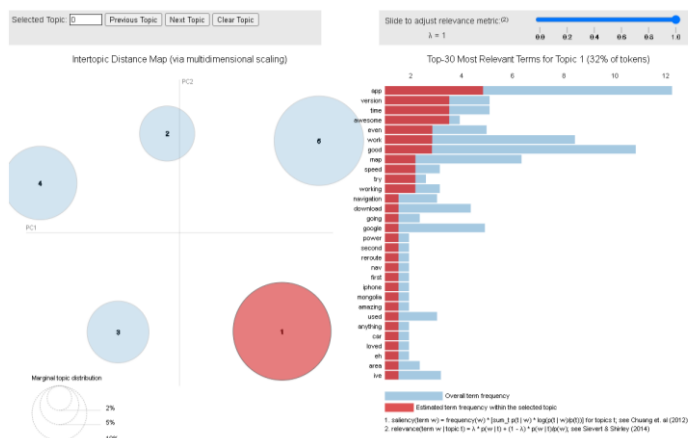


Figure 120 : Keywords for topic 0.

The keywords for topic 0 included app, version, time, awesome, even, work, good, map, speed, try and etc. The highest frequency terms for topic 0 is "app" with a frequency of 0.020. The term "app" appears with the highest frequency in this topic, suggesting that the main focus of the discussion is related to a specific application, its features, and functionalities. This topic appears to be about an app, its version, and user experience. It highlights the app's performance, functionality, and speed.

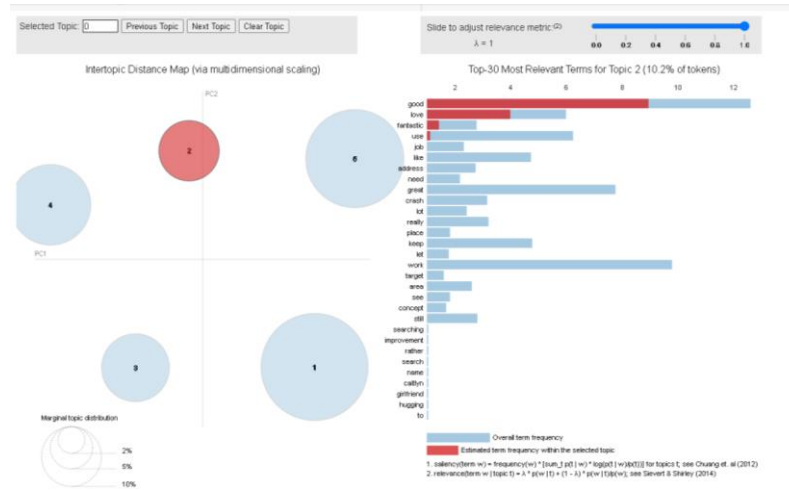


Figure 121 : Keywords for topic 1.

The keywords for topic 1 included good, love, fantastic, use, job, like, address, need, great, crash and etc. The highest frequency terms for topic 1 is “good" with a frequency of 0.103. The term "good" has the highest frequency in this topic, which indicates that the conversation revolves around the positive aspects of an app or the satisfaction users experience while using it. This topic seems to focus on the positive aspects of an app, including user satisfaction and its utility, with some mention of crashes that may need addressing.

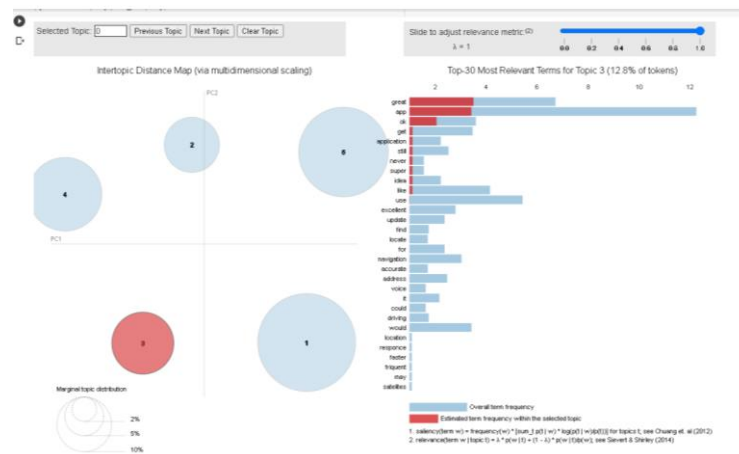


Figure 122 : Keywords for topic 2.

The keywords for topic 2 included great, app, ok, get, application, still, never, super, idea, like and etc. The highest frequency terms for topic 2 is “great" with a frequency of 0.037. The term "great" appears with the highest frequency in this topic, suggesting that the main focus of the discussion is on the app's quality and the positive experiences

CHAPTER 3

users have with the app. This topic covers general opinions about an app, its quality, and its features, including both positive and negative aspects.

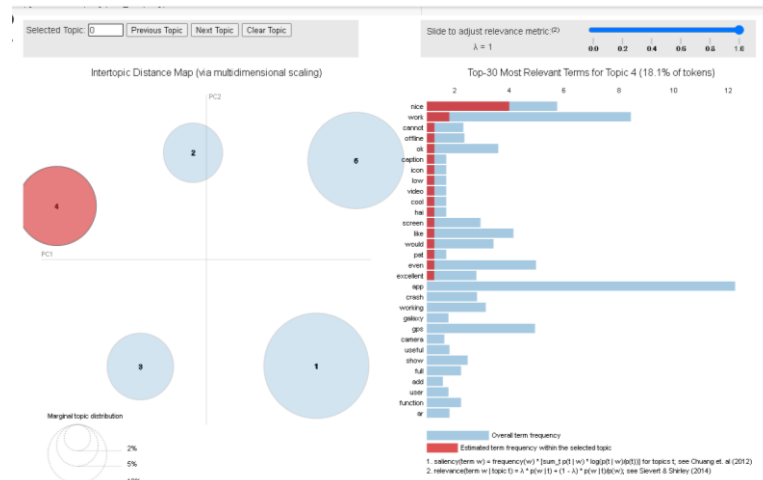


Figure 123 : Keywords for topic 3.

The keywords for topic 3 included nice, work, cannot, offline, ok, screen, like, caption, icon, low and etc. The highest frequency terms for topic 3 is “nice” with a frequency of 0.030. The term "nice" has the highest frequency in this topic, which indicates that the conversation revolves around the visual elements or user interface design of the app, and users appreciate its aesthetics or overall presentation. This topic seems to discuss the app's visual elements and functionality, such as the offline mode, screen, icons, and performance.

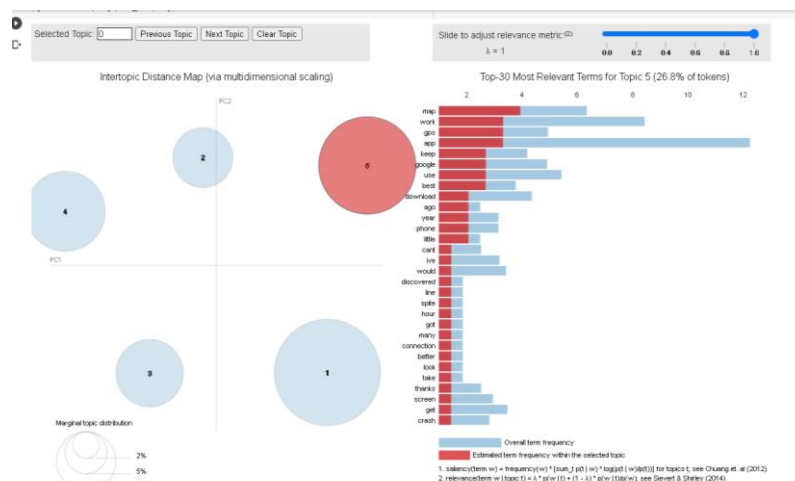


Figure 124 : Keywords for topic 4.

CHAPTER 3

The keywords for topic 4 included map, work, gps, app, keep, google, use, best, download, year and etc. The highest frequency terms for topic 4 is “map” with a frequency of 0.020. The term "map" appears with the highest frequency in this topic, suggesting that the main focus of the discussion is on a mapping or GPS-related app, its features, and how it integrates with other services like Google. This topic appears to be about a map or GPS app, its usage, and its integration with other services like Google. It also suggests that the app has been in use for a while and is considered one of the best.

The topics are assigned to the documents in the corpus and calculates the threshold for selecting topics based on the average of all topic scores. The code assigns each document is assign to a cluster based on its probability score for each topic.

```
# Find articles assigned to clusters based on a threshold
lda_corpus = ldamodel[doc_term_matrix]

[doc for doc in lda_corpus]
```

Probability

```
[[ (0, 0.10061122),
  (1, 0.5987254),
  (2, 0.10000165),
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  (4, 0.100196086) ],
 [ (0, 0.068679094),
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  (2, 0.06668341),
  (3, 0.06668255),
  (4, 0.7304083) ],
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  (3, 0.94251484),
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  (4, 0.05001096) ],
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```

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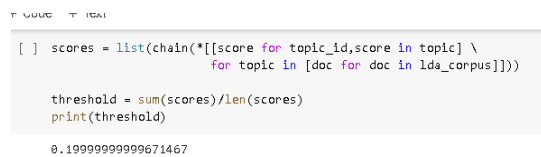
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```

```
scores = list(chain(*[[score for topic_id, score in topic] \
                    for topic in [doc for doc in
lda_corpus]]))

threshold = sum(scores)/len(scores)
print(threshold)
```



```

[] scores = list(chain(*[[score for topic_id, score in topic] \
                        for topic in [doc for doc in lda_corpus]]))

threshold = sum(scores)/len(scores)
print(threshold)

0.19999999999999997
```

Figure 125 : Threshold calculated for topic relevance.

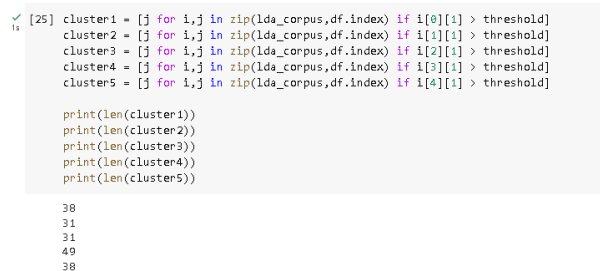
The output shows the assigned topics to each document in the corpus, where each document is represented as a tuple of (topic, probability) for each assigned topic. For example, the first document is assigned to topic 2 with a probability of 0.72939235, and to topics 3 and 4 with probabilities of 0.06667728 and 0.06667719, respectively. This output can be used to identify which documents belong to which topic, based on the topic with the highest probability. In the next code, the list of scores is created by iterating through each document in the LDA corpus and getting the score for each topic in the document. The scores are then flattened into a single list using the chain function from the itertools module. The threshold is then calculated as the sum of all the scores divided by the total number of scores. The output shows the value of the threshold, which is approximately 0.2. This threshold value will be used to classify each document into a cluster based on the topic score. It is an important value in topic modeling as it

helps to filter out the topics that are not relevant. The topics that have a score greater than the threshold are considered significant and the rest are considered insignificant. In this case, any topic with a score above 0.199 will be considered significant.

The code prints the number of documents assigned to each cluster.

```
cluster1 = [j for i,j in zip(lda_corpus,df.index) if i[0][1] >
threshold]
cluster2 = [j for i,j in zip(lda_corpus,df.index) if i[1][1] >
threshold]
cluster3 = [j for i,j in zip(lda_corpus,df.index) if i[2][1] >
threshold]
cluster4 = [j for i,j in zip(lda_corpus,df.index) if i[3][1] >
threshold]
cluster5 = [j for i,j in zip(lda_corpus,df.index) if i[4][1] >
threshold]

print(len(cluster1))
print(len(cluster2))
print(len(cluster3))
print(len(cluster4))
print(len(cluster5))
```



```
✓ [25] cluster1 = [j for i,j in zip(lda_corpus,df.index) if i[0][1] > threshold]
is cluster2 = [j for i,j in zip(lda_corpus,df.index) if i[1][1] > threshold]
cluster3 = [j for i,j in zip(lda_corpus,df.index) if i[2][1] > threshold]
cluster4 = [j for i,j in zip(lda_corpus,df.index) if i[3][1] > threshold]
cluster5 = [j for i,j in zip(lda_corpus,df.index) if i[4][1] > threshold]

print(len(cluster1))
print(len(cluster2))
print(len(cluster3))
print(len(cluster4))
print(len(cluster5))

38
31
31
49
38
```

Figure 126 : Number of articles printed in each cluster.

The output shows the length of each of the three cluster lists, which indicates the number of reviews that were assigned to each cluster. In this case, there are 38 reviews in cluster1, 31 reviews in cluster2, 31 reviews in cluster3, 49 reviews in cluster4 and 38 reviews in cluster5 .

CHAPTER 3

The code outputs the documents assigned to each cluster to separate Pandas DataFrames.

```
df.iloc[cluster1]
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean	
3	b5998c16-7853-4eeb-8e60-5ba5c221c240	martin wilson	https://play-	Absolutely full of add	1	1	None	2022-01-20 19:37:11	None	NaT	absolutely full add	
6	b1c4ef7-bc38-4d33-8d7b-1e4b2c0ee8fb	gbravva	https://play-	Good app. But I m in mongolia. And there is no...	1	2	Beta 61.0	2021-04-01 04:43:23	None	NaT	good app mongolia support area mongolia sorry	
8	385e1a55-d234-417b-a950-6e94e350550	A Google user	https://play-	👍👍👍👍👍👍👍👍	5	2	Beta 60.1	2019-12-05 07:51:59	None	NaT	👍👍👍👍👍👍👍👍	
17	47079850-458c-4e99-86e6-b10ff18e9090	A Google user	https://play-	Using it offline	5	12	Beta 46.0	2017-05-30 09:01:22	None	NaT	using offline	
19	9157d0f5-6239-4e6d-a430-fc897d89944	A Google user	https://play-	This is a cool app but needs offline capabili...	3	7	Beta 43.1	2017-02-23 20:41:28	None	NaT	cool app need offline capability also stop qu...	
25	52fb1871-3bd0-495d-9350-d7987d2e9355	A Google user	https://play-	Crashes immediately upon launch	1	6	Beta 27.0	2016-03-20 00:49:23	Please update to beta 27.1.	2016-03-21 11:23:35	crash immediately upon launch	
35	202ac0b7-fcab-4dfe-b055-4e91fa13f2c	A Google user	https://play-	Loved it	5	0	None	2015-04-25 04:58:08	None	NaT	loved	
39	0b327068-97f4-47ab-90a3-6728995ca09	A Google user	https://play-	Cannot locate GPS note3	2	0	Beta 22.5	2015-04-02 08:26:24	None	NaT	cannot locate gps note3	
46	d38c13e2-5ee4-4227-938a-a3080e07c117	A Google user	https://play-	Very nice perfect	5	0	None	2015-02-27 08:53:52	None	NaT	nice perfect	
50	a6556910-5b9a-4e2a-95b0-747ec008f104	A Google user	https://play-	Ojlbh...	5	0	Beta 22.2	2015-02-03 18:23:48	None	NaT	ojlbh	
51	515a9a30-c110-4ee6-9e7b-3ee62f2f240e4	A Google user	https://play-	Very goodood loved it	5	0	Beta 21.3	2015-01-17 20:33:56	None	NaT	goodood loved	
55	c1990683-98a1-4d17-845c-3c79973a2171	A Google user	https://play-	very nice	5	0	None	2014-12-29 03:35:25	None	NaT	nice	
60	55ab6b1-4e68-4eeb-ba57-527e1910c13b	A Google user	https://play-		None	5	0	None	2014-12-18 18:04:14	None	NaT	
76	82c212b-3910-4a8b-b305-ed26c385e1	A Google user	https://play-	App does not work bad	1	0	None	2014-08-31 22:58:29	None	NaT	app work bad	
77	98286db-66ad-4bd0-bca2-1aee8b7c8a3	A Google user	https://play-	Let me check but little hang	2	0	Beta 20.6	2014-08-23 16:38:33	None	NaT	let check little hang	
80	0d701f5d-8b5c-476d-a3b0-467bc2887a0f	A Google user	https://play-	Acha hai	5	0	Beta 20.6	2014-08-13 09:40:27	None	NaT	acha hai	

Figure 127 : Articles of cluster1 are printed.

```
df.iloc[cluster2]
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	c378d6e1-12b3-48eb-8f2d-3f99c07808b5	Rahid Ferooqi	https://play-	Good	1	0	Beta 61.0	2022-10-11 17:39:37	None	NaT	good
4	e6f2a446-091b-42ba-9ae3-1db8acafb09a	महारि सिंह (Swarin Singh)	https://play-	महारि है	5	0	Beta 61.0	2021-12-08 09:23:03	None	NaT	महारि है
7	80ac3295-17b0-4872-87a7-9e6fbb3380db	Maso Latu	https://play-	Ads in the way	1	2	Beta 60.1	2020-11-14 01:59:55	None	NaT	ad way
8	385e1a55-d234-417b-a950-6e94e350550	A Google user	https://play-	👍👍👍👍👍👍👍👍	5	2	Beta 60.1	2019-12-05 07:51:59	None	NaT	👍👍👍👍👍👍👍👍
11	e8317012-78fa-4e30-9cdf-0071f9b3a1f1	A Google user	https://play-	Nice try, you have done a great job.	4	3	Beta 60.0	2019-11-14 05:49:54	None	NaT	nice try done great job
16	e35c0ad7-1834-4dbd-bce6-da04df41d0f6	A Google user	https://play-	Very very good app	5	0	Beta 24.3	2018-01-06 00:36:30	None	NaT	good app
22	18d80fc0-d588-4443-b27a-4fd0579ba3e	A Google user	https://play-	Awesome	5	0	None	2016-11-29 10:14:06	None	NaT	awesome
24	78ea7d5b-82d1-4967-9858-8ac3a1503e15	A Google user	https://play-	Very good	5	0	None	2016-10-15 14:14:11	None	NaT	good
29	ce564339-dae0-4bd0-84a8-10009e247411	A Google user	https://play-	Lee	5	0	None	2015-09-26 04:33:00	None	NaT	lee
32	0086381b-b7c3-4e09-9e38-5ea40249299	A Google user	https://play-	Where to get download maps?	3	0	None	2015-06-09 03:42:15	Now, it uses online map, so no need to download...	2015-06-12 16:28:11	get download map
33	5818839c-321e-47ec-8d05-7af18a1ae78a	A Google user	https://play-	Make this compatible with Google cardboard	4	0	None	2015-05-10 00:27:41	None	NaT	make compatible google cardboard
40	9298132e-7521-48d1-875a-3e80922e6372	A Google user	https://play-	Car	5	1	Beta 22.4	2015-03-26 04:11:19	None	NaT	car
41	b5e712c3-4bd8-4812-8520-650e158f7e19	A Google user	https://play-	Good	5	1	Beta 22.4	2015-03-24 22:54:20	None	NaT	good
45	ed578de7-0f06-4a8d-8561-126584614953	A Google user	https://play-	The best app	5	0	None	2015-03-08 18:07:43	None	NaT	best app
53	794b2e9b-18f6-43bd-9e5e-4d1809ef1f8d	A Google user	https://play-	Good	5	0	Beta 21.3	2015-01-10 06:53:47	None	NaT	good
54	9c354fa7-bf9c-43ee-9271-b28243814a9a	A Google user	https://play-	Good	4	0	Beta 21.2	2014-12-31 09:40:46	None	NaT	good

Figure 128 : Articles of cluster2 are printed.

```
df.iloc[cluster3]
```

CHAPTER 3

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
8	386a1a55-d234-417b-a950-6e94c30d5660	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	👍👍👍👍👍👍👍👍	5	2	Beta 60.1	2019-12-06 07:51:59	None	NaT	👍👍👍👍👍👍👍👍
11	e8317d12-78f8-4e30-9c61-0071f9c3a1f1	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Nice try, you have done a great job...	4	3	Beta 60.0	2019-11-14 09:49:54	None	NaT	nice try done great job
12	91302139-4062-419c-a431-b703a8e08702	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Works, sometimes.	4	2	Beta 60.0	2019-10-05 19:47:46	None	NaT	work sometimes
14	90c98ac8-ae7-4f4c-862f-aa39179aa639	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Keeps crashing on recording and navigation	1	2	Beta 53.0	2018-06-23 11:49:40	None	NaT	keep crashing recording navigation
38	1d1fab66-424a-4616-b8ab-e5db76552ae	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Great app and easy to use! Not accurate, but...	5	3	Beta 22.5	2015-04-05 05:59:55	None	NaT	great app easy use accurate still like it woul...
42	74dd843e-7701-4e0c-a8e2-317d63d072b	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Great for cycling ...	5	0	Beta 22.4	2015-03-23 15:07:58	None	NaT	great cycling
52	0b094d3d-c183-4285-8bc0-317d6c0490a	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Visual effects are fantastic	5	0	Beta 21.3	2015-01-10 12:09:53	None	NaT	visual effect fantastic
56	c7c8059f-c439-48ef-ae70-5027f697b030	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Please add HUD feature to assist in low light ...	3	0	Beta 21.2	2014-12-27 20:53:22	None	NaT	please add hud feature assist low light condit...
57	55bf4565-ef33-477d-b90a-040bf09808e	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	It is so great and marvellous	5	0	None	2014-12-26 10:36:22	None	NaT	great marvellous
60	55d6bf1-4e5a-40ea-ba57-527e1a1cc13b	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	None	5	0	None	2014-12-15 18:04:14	None	NaT	
66	bf45b5aa-4d13-40e1-8e33-0851ae89c1c1	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Works great. Very Accurate...for better satellite...	5	1	Beta 21.2	2014-10-20 11:55:21	None	NaT	work great accurate for better satellite.com...
70	1257f03-78f4-4efb-a00e-67522086f11	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Says trial period expired and I have never ins...	1	1	Beta 21.2	2014-10-09 04:46:54	This is a totally free software, do not have a...	2014-10-09 11:54:12	say trial period expired never installed used
78	5873c23e-c8f1-4202-ba19-72e03a36a108	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	great app	5	0	Beta 20.6	2014-08-18 17:56:25	None	NaT	great app
83	4182f4cd-f2e2-490a-802f-973438a52744	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Fantastic	4	0	Beta 20.6	2014-07-30 12:10:06	None	NaT	fantastic
84	f7f0808e-05b0-470b-a20a-19e6493999a0	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Samsung galaxy grand 2 india	1	0	Beta 20.6	2014-07-24 10:03:20	None	NaT	samsung galaxy grand 2 india
88	7fd130ca-9733-441f-a744-21973190bb1f	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Great idea and execution of the application	4	0	Beta 20.6	2014-07-01 01:19:23	None	NaT	great idea execution application

Figure 129 : Articles of cluster3 are printed.

df.iloc[cluster4]

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
5	801899e7-dce0-4073-8082-f08a8b0c379	Maryjo Dierlro	https://play-ih.googleusercontent.com/a/AGHnnyx...	Why is Camera black	1	0	None	2021-08-02 21:58:31	None	NaT	camera black
7	80e43096-17f6-4972-a7a7-9e60b33800b	Mario Lahu	https://play-ih.googleusercontent.com/a/AGHnnyx...	Ads in the way	1	2	Beta 60.1	2020-11-14 01:39:55	None	NaT	ad way
8	386a1a55-d234-417b-a950-6e94c30d5660	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	👍👍👍👍👍👍👍👍	5	2	Beta 60.1	2019-12-06 07:51:59	None	NaT	👍👍👍👍👍👍👍👍
13	01781bd0-ebcb-4f04-a145-518a655c0201	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Super	5	0	None	2018-08-07 07:05:42	None	NaT	super
19	915700f5-6239-4ae0-ae3c-8c789728094a	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	This is a cool app but needs offline capabilt...	3	7	Beta 43.1	2017-02-23 20:41:28	None	NaT	cool app need offline capability also stop qu...
20	aa575852-b5d7-4323-b57e-3ef438b00ed1	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	I LOVE HUGGING CATLYN MY GIRLFRIEND PLEASE	5	0	None	2017-02-01 02:25:09	None	NaT	love hugging catlyn girlfriend please
21	908408ae-f41a-4208-ae22-53c7bdc96ea0	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Love it	5	2	Beta 43.1	2017-01-28 08:08:00	None	NaT	love
22	180d0f0-d588-4443-b27e-4f0a05790e3e	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Awesome	5	0	None	2016-11-29 10:14:56	None	NaT	awesome
30	8780a20d-c178-4a72-b592-8fb180aaf1e1	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	drive	5	0	None	2015-08-17 05:52:39	None	NaT	drive
36	71899365-d3ae-4070-9259-8c220184c3fa	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	the best	4	0	Beta 23.0	2015-04-24 18:22:03	None	NaT	best
38	1d1fab66-424a-4616-b8ab-e5db76552ae	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Great app and easy to use! Not accurate, but...	5	3	Beta 22.5	2015-04-05 05:59:55	None	NaT	great app easy use accurate still like it woul...
39	0b327058-074a-47a8-90a3-6728995c409	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	Cannot locate GPS notes	2	0	Beta 22.5	2015-04-02 08:25:24	None	NaT	cannot locate gps notes
44	3030454f-013b-4585-91f0-5ba3fcb0803e	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	I love it	5	0	None	2015-03-08 19:42:17	None	NaT	love
45	e05780e7-df05-4a80-8061-f26684514953	A Google user	https://play-ih.googleusercontent.com/EGenro2N...	The best app	5	0	None	2015-03-08 18:07:43	None	NaT	best app

Figure 130 : Articles of cluster4 are printed.

df.iloc[cluster5]

reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	replyLike	text_Clean	
8	385a1a55-d234-417b-8950-5e64e3505560	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	5	2	Beta 60.1	2019-12-06 07:51:59	None	NaN	👍👍👍👍👍👍👍👍👍👍👍👍	
11	e8317012-78fa-4e30-9d3f-d0719e6a111	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Nice try... you have done a great job...	4	3	Beta 60.0	2019-11-14 05:59:54	None	NaN	nice try done great job
14	60a98a8-8ac7-4f46-852f-8a39178a8b39	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Keeps crashing on recording and navigation	1	2	Beta 60.0	2018-08-23 11:49:40	None	NaN	keep crashing recording navigation
15	25a3eaa8-e493-4f9b-b547-5565fab76842	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	EH.	2	1	Beta 60.0	2018-06-16 02:14:38	None	NaN	eh
17	47279850-468c-4e99-86e6-bfd11be90990	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Using it offline	5	12	Beta 46.0	2017-08-30 09:01:22	None	NaN	using offline
23	321ee70a-57fd-4234-88d1-41a27a794bd0	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	I liked it a lot	4	3	Beta 30.0	2016-10-25 01:29:23	None	NaN	liked lot
25	527b1871-3bd5-4866-9259-d79d9e93955	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Crashes immediately upon launch	1	6	Beta 27.0	2016-03-20 00:49:23	Please update to beta 27.1.	2016-03-21 11:23:35	crash immediately upon launch
34	2d96dd0b-6fbc-4d55-946c-d7046b292f2	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	It won't allow me to keep my phone charging en...	1	2	Beta 23.0	2015-05-07 14:39:21	None	NaN	allow keep phone charging anymore end dying ge...
35	202b007f-f6ab-4cfe-1d55-9d919a13f26	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Loved it	5	0	None	2015-04-25 04:58:08	None	NaN	loved
37	53225614-0af1-4b5b-a757-5bed33350008	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Myggs	5	0	None	2015-04-07 16:22:14	None	NaN	myggs
42	764d843e-7701-4a0c-aa62-1bd76b3d07bb	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Great for cycling...	5	0	Beta 22.4	2015-03-23 15:07:58	None	NaN	great cycling
48	0bc7be55-9841-42ac-bf83-83caaf01e6dc	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Working perfectly after the update. Keep up th...	5	1	Beta 22.4	2015-02-12 12:52:03	Sorry---we have fixed this problem, please downl...	2015-02-11 18:43:16	working perfectly update keep good work
50	a685691d-5b9a-4e2e-989b-7d3cc0980104	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Ojluhb...	5	0	Beta 22.2	2015-02-05 18:53:48	None	NaN	ojluhb
51	5156a93d-c110-4ae6-987c-3ae02df240e4	A Google user	https://play-ih.googleusercontent.com/EGenok2N...	Very goood loved it	5	0	Beta 21.3	2015-01-17 20:03:56	None	NaN	goood loved

Figure 131 : Articles of cluster5 are printed.

Conclusion

The conclusion drawn from the LDA topic modeling analysis is that the conversation revolves around various aspects of apps, with a focus on user experience, satisfaction, and functionality. The five identified topics highlight different areas of interest. Topic 0 emphasizes an app's version, performance, and speed. Topic 1 highlights the positive aspects of an app, user satisfaction, and areas for improvement, such as addressing crashes. Topic 2 discusses general opinions about an app, including its quality and features, touching on both positive and negative aspects. Topic 3 focuses on the visual elements and functionality of an app, such as offline mode, screen, icons, and performance. Topic 4 pertains to a map or GPS app, its usage, integration with other services like Google, and its reputation as one of the best in its category.

The analysis provides insights into users' opinions and experiences with different apps, helping developers understand what features and aspects are appreciated or need improvement.

3.4.2.2.2.4 AR GPS Navigation 2021 GPS Map

Coding and Output

The app reviews are scraped using the reviews_all function from google_play_scraper, and the resulting data is stored in a pandas DataFrame called df.

```
argspsnavigation2021gpsmap_project =
reviews_all( 'com.aip.gpsnavigation.drivingdirections.tracker'
, sleep_milliseconds=0, lang = 'EN', country='US')
```

CHAPTER 3

```
df = pd.DataFrame(argpsnavigation2021gpsmap_project)
```

The code then prints some summary statistics about the reviews, including the total number of reviews, unique users, unknown users, users who left multiple reviews, and the average rating based on textual reviews.

```
# Get the list of users who left more than one review
multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()

unique_users = len(df['userName'].unique())
unknown_users = len(df[df['userName'] == 'A Google user'])
total_reviews = len(df)

# Analyze and print information about the reviews and users
if
len(df['userName'].value_counts()[df['userName'].value_counts(
) > 1].index.tolist()) > 0:
    multiple_reviewers =
df['userName'].value_counts()[df['userName'].value_counts() >
1].index.tolist()
    num_multiple_reviews =
len(df[df['userName'].isin(multiple_reviewers)]['userName'].un
ique())
else:
    num_multiple_reviews = 0

mean = df['score'].mean()

# Print the results
print(f'Total textual reviews: {len(pinnar_project)}')
print(f'Total unique users: {unique_users}')
print(f'Total unknown users: {unknown_users}')
print(f'Total users who gave multiple reviews:
{num_multiple_reviews}')
```

CHAPTER 3

```
print(f'Average rating for this app based on the textual reviews: {round(mean, 2)}')
```

```
print(f'Average rating for this app based on the textual reviews: {round(mean, 2)}')
Total textual reviews: 267
Total unique users: 38
Total unknown users: 230
Total users who gave multiple reviews: 1
Average rating for this app based on the textual reviews: 4.4
```

Figure 132 : Summary statistics of the reviews.

This code analyzes a dataset of app reviews and calculates the number of unique users, unknown users, total reviews, and average rating. It also identifies users who left multiple reviews. The output displays the results of these calculations. In this case, there are 267 reviews from 38 unique users, 230 unknown users, and one user who left multiple reviews. The average rating is 4.4.

Reviews with a score of less than or equal to 3 are selected and any reviews with content length less than 30 are removed.

```
# Filter reviews with ratings less than or equal to 3 and
content length greater than or equal to 30
df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

Ratings which are less than 4

```
[4] df_tm = df[df['score']<=3]
df_tm = df_tm[df_tm.content.str.len()>=30]
print(f'Remaining textual reviews: {len(df_tm)} \n')
Remaining textual reviews: 8
```

Figure 133 : Reviews less than 4.

This code creates a new DataFrame "df_tm" with reviews that have a score of 3 or less and a review text of at least 30 characters. The output shows the number of remaining reviews that meet these criteria, which is 8 in this case.

The relevant columns (reviewId and content) are selected, duplicate rows are dropped, and any rows with missing values are removed.

```
# Get relevant columns and drop duplicates and missing values
df_tm = df_tm[['reviewId', 'content']].drop_duplicates()
df_tm.dropna(inplace=True)
df_tm = df_tm.reset_index().drop(columns='index')
```

CHAPTER 3

```
print(f'Remaining textual reviews: {len(df_tm)} \n')
```

```
Get the relevant column

[5] df_tm = df_tm[['reviewId', 'content']].drop_duplicates()
     df_tm.dropna(inplace=True)
     df_tm = df_tm.reset_index().drop(columns='index')
     print(f'Remaining textual reviews: {len(df_tm)} \n')

Remaining textual reviews: 8
```

Figure 134 : Remaining textual reviews which are less than 4.

This code removes duplicates and missing values from a DataFrame containing reviews with low scores and long text. It only keeps the review ID and content columns. The output shows the number of remaining textual reviews, which is 8 in this case.

The text data is then transformed using a CountVectorizer object, which tokenizes the text and creates a bag-of-words (BOW) matrix. The feature names (i.e. the unique words in the corpus) are extracted from the CountVectorizer object.

```
# create CountVectorizer object
cv = CountVectorizer(max_df=0.95, min_df=2,
stop_words='english')

# fit and transform the text data
dtm = cv.fit_transform(df_tm['content'])

# get feature names from CountVectorizer object
feature_names = cv.vocabulary_.keys()

# print the feature names
print(list(feature_names)[:20])
```

```
[6] # create CountVectorizer object
     cv = CountVectorizer(max_df=0.95, min_df=2, stop_words='english')

     # fit and transform the text data
     dtm = cv.fit_transform(df_tm['content'])

     # get feature names from CountVectorizer object
     feature_names = cv.vocabulary_.keys()

     # print the feature names
     print(list(feature_names)[:20])

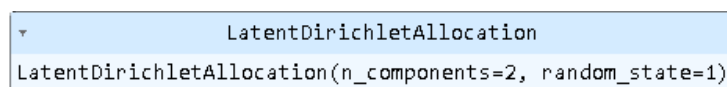
['donna', 'exchange', 'rose', 'review', 'hide', 'email', 'active', 'gmail', 'mobile', 'number', 'pop', 'ads']
```

Figure 135 : 20 feature names that appear first in the vocabulary in alphabetical order.

This code uses `CountVectorizer` to convert review text into a document-term matrix, with certain parameters set. It then prints out the first 20 feature names of the document-term matrix in alphabetical order. The output displays these feature names.

The LDA model is instantiated and fit to the transformed text data using the `LatentDirichletAllocation` function from `sklearn`.

```
# Perform Latent Dirichlet Allocation (LDA) topic modeling
LDA = LatentDirichletAllocation(n_components=2, random_state=1)
LDA.fit(dtm)
```



```
LatentDirichletAllocation(n_components=2, random_state=1)
```

Figure 136 : Instantiation of a Latent Dirichlet Allocation (LDA) model

This code uses the Latent Dirichlet Allocation (LDA) algorithm from the `scikit-learn` library to perform topic modeling on a document-term matrix (`dtm`) with 2 topics. The LDA object is created with the `"n_components"` parameter set to 2, and the `"random_state"` parameter set to 1. The `"fit"` method is then called on the LDA object to fit the model to the `dtm`. The output of this code is the LDA object itself, which represents the trained topic model.

The code then prints the top 20 words for each of the identified topics.

```
# Print the top words for each topic
for index, topic in enumerate(LDA.components_):
    print(f'topic #{index} : ')
    print([list(feature_names)[i] for i in topic.argsort()[-20:]])
```

```
topic #0 :
['number', 'exchange', 'rose', 'email', 'gmail', 'review', 'pop', 'ads', 'hide', 'active', 'donna', 'mobile']
topic #1 :
['donna', 'mobile', 'active', 'hide', 'pop', 'ads', 'review', 'email', 'rose', 'gmail', 'number', 'exchange']
```

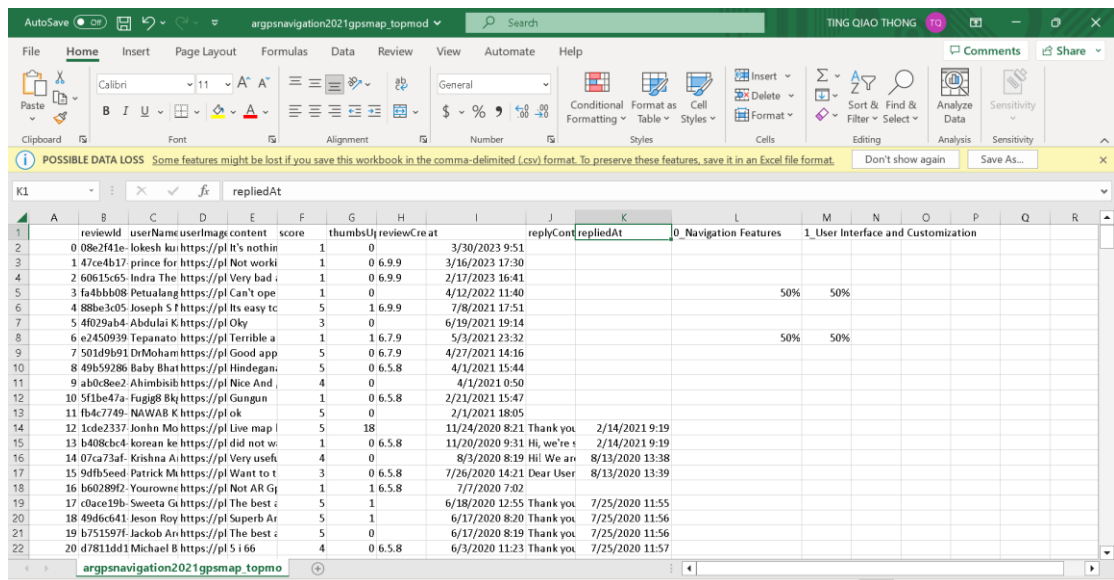
Figure 137 : Top 20 words in each of the topics learned by the Latent Dirichlet Allocation (LDA) model.

CHAPTER 3

This code uses the trained LDA model to print out the top 20 words associated with each of the two identified topics. The output displays the two topics and their associated words, printed in descending order of importance for each topic.

The LDA model is used to assign a topic to each review, and the resulting data is stored in a new DataFrame called `df_output`.

```
# Transform documents into topic space
topic_results = LDA.transform(dtm)
df_topic_results = pd.DataFrame(topic_results, columns=[
    '0_Navigation Features',
    '1_User Interface and Customization'
])
# Merge topic results with the original DataFrame
df_result = pd.merge(df_tm, df_topic_results, how='inner',
left_index=True, right_index=True )
df_output = pd.merge(df, df_result, how='left',
on=[ 'reviewId', 'content' ])
df_output.to_csv('argpsnavigation2021gpsmap_topmod.csv')
```



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		reviewId	userName	userImage	content	score		thumbsUp	reviewCreate		replyCount	repliedAt	0_Navigation Features	1_User Interface and Customization				
2		088e2f41e	lolesh k	https://pl	It's nothin	1	0		3/30/2023 9:51									
3		147ce4b17	prince for	https://pl	Not worki	1	0	6.9.9	3/16/2023 17:30									
4		260615c65	Indra The	https://pl	Very bad	1	0	6.9.9	2/17/2023 16:41									
5		3fa4bb08	Petualang	https://pl	Can't ope	1	0		4/12/2022 11:40			50%	50%					
6		488be3c05	Joseph S F	https://pl	Its easy tc	5	1	6.9.9	7/8/2021 17:51									
7		54f029ab4	Abdulai K	https://pl	Ok	3	0		6/19/2021 19:14									
8		6e2450939	Tepanatu	https://pl	Terrible a	1	1	6.7.9	5/3/2021 23:32			50%	50%					
9		7501d9b91	DrMoham	https://pl	Good app	5	0	6.7.9	4/27/2021 14:16									
10		849b59286	Baby Bhat	https://pl	Hindegan	5	0	6.5.8	4/1/2021 15:44									
11		9ab0c8ee2	Ahimisib	https://pl	Nice And	4	0		4/1/2021 0:50									
12		105f1be47a	Fugig8 Bk	https://pl	Nice Gun	1	0	6.5.8	2/21/2021 15:47									
13		11fb4c7749	NAWAB K	https://pl	ok	5	0		2/1/2021 18:05									
14		121cde2337	Jonhn Mo	https://pl	Live map	5	18		11/24/2020 8:21	Thank you	2/14/2021 9:19							
15		13b408bce4	korean ke	https://pl	did not w	1	0	6.5.8	11/20/2020 9:31	Hi, we're s	2/14/2021 9:19							
16		1407ca73af	Krishna Ai	https://pl	Very usefu	4	0		8/3/2020 8:19	Hi! We an	8/13/2020 13:38							
17		159df85eed	Patrick Mh	https://pl	Want to t	3	0	6.5.8	7/26/2020 14:21	Dear User	8/13/2020 13:39							
18		16460289d2	Youroune	https://pl	Not AR G	1	1	6.5.8	7/7/2020 7:02									
19		17dace19b	Sweeta G	https://pl	The best	5	1		6/18/2020 12:55	Thank you	7/25/2020 11:55							
20		1849d6c41	leson Roy	https://pl	Superb Ar	5	1		6/17/2020 8:20	Thank you	7/25/2020 11:56							
21		19b751597f	Jackob Ar	https://pl	The best	5	0		6/17/2020 8:19	Thank you	7/25/2020 11:56							
22		20d7811dd1	Michael B	https://pl	S i 66	4	0	6.5.8	6/3/2020 11:23	Thank you	7/25/2020 11:57							

Figure 138 : CSV file with topic probability matrix.

AR GPS Navigation 2021 GPS Map CSV link:

https://drive.google.com/file/d/1nfAO88rqyQJminevQO-gdlx2_TgxHcUX/view?usp=sharing

This code performs topic modeling on a document-term matrix using LDA, and creates a new DataFrame with the probabilities of each topic for each review. The code merges this new DataFrame with the original review data, and saves the resulting DataFrame to a CSV file. The output is the saved CSV file containing the original review data and the probabilities of each topic for each review.

The nltk package is used to download the stopwords and WordNetLemmatizer, which will be used for text preprocessing.

```
nltk.download('stopwords')
nltk.download('wordnet')
```

The clean function is defined, which removes stopwords, punctuation, and lemmatizes the text. The text in the content column of df is cleaned using the clean function.

```
# Clean the text data using NLTK
stop = set(stopwords.words('english'))
exclude = set(string.punctuation)
lemma = WordNetLemmatizer()

def clean(text):
    if isinstance(text, str): # Check if input is a string
        stop_free = ' '.join([word for word in
text.lower().split() if word not in stop])
        punc_free = ''.join(ch for ch in stop_free if ch not
in exclude)
        normalized = ' '.join([lemma.lemmatize(word) for word
in punc_free.split()])
        return normalized
    else:
        return ""

df['text_clean']=df['content'].apply(clean)
```

CHAPTER 3

df

```
13] df['text_clean']=df['content'].apply(clean)
df
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
0	08e2f41e-caff-4fa2-8fbf-009740427368	lokesh kumar R G	https://play-lh.googleusercontent.com/e-/ACB-R...	It's nothing fake app	1	0	None	2023-03-30 09:51:45	None	NaT	nothing fake app
1	47ee4b17-14e3-4e16-b6df-695d49655f9d	prince forester	https://play-lh.googleusercontent.com/e-/ACB-R...	Not working in rs31	1	0	6.9.9	2023-03-16 17:30:35	None	NaT	working rs31
2	60615c65-185e-4e98-860d-98753c5cb0e6	Indra The tiger	https://play-lh.googleusercontent.com/e-/ACB-R...	Very bad aap	1	0	6.9.9	2023-02-17 16:41:38	None	NaT	bad aap
3	1e41bb08-495c-49d2-a344-23f17988e0ff	Petualiang Dunia	https://play-lh.googleusercontent.com/v/A0hVnyz...	Can't open map or find location in my Oppo A9	1	0	None	2022-04-12 11:40:28	None	NaT	can't open map find location oppo a9
4	888e3c05-dc0b-4302-8516-fdef19467313	Joseph S Manana	https://play-lh.googleusercontent.com/v/A0hVnyz...	Its easy to find place very fast	5	1	6.9.9	2021-07-08 17:51:49	None	NaT	easy find place fast
...
262	8397acbc-18fd-4a5c-9dc9-ca3973931693	A Google user	https://play-lh.googleusercontent.com/vEGemot2N...	Watch out	5	99	1.3.1	2018-03-07 22:04:41	None	NaT	watch
263	5a3af9a5-6cb5-42a9-80ee-9c20cc070758	A Google user	https://play-lh.googleusercontent.com/vEGemot2N...	Nice apps. So cute	5	97	1.3.1	2018-03-04 09:18:27	None	NaT	nice apps cute
264	c490717a-ef02-444c-bc85-9234c8a08ff7	A Google user	https://play-lh.googleusercontent.com/vEGemot2N...	Nice app	5	17	None	2018-03-02 08:56:40	None	NaT	nice app
265	0b5e09fe-1577-4e45-8e8c-27e812719679	A Google user	https://play-lh.googleusercontent.com/vEGemot2N...	Nice apps	5	33	None	2018-02-13 20:09:58	None	NaT	nice apps
266	b9c82eff-esff-40d5-a47e-ab0ae4711352	A Google user	https://play-lh.googleusercontent.com/vEGemot2N...	موفته بالمر	5	44	None	2018-02-05 15:03:35	None	NaT	موفته بالمر

267 rows x 11 columns

Figure 139 : Text data that are cleaned.

A corpora.Dictionary object is created from the cleaned text data.

```
# Create a dictionary from the cleaned text data
texts = [list(gensim.utils.tokenize(text)) for text in
df['text_clean']]
dictionary = corpora.Dictionary(texts)

# Print the number of non-zero entries in the BOW matrix
print(dictionary.num_nnz)
```

1881

Figure 140 : Dictionary is created.

This code creates a dictionary from the review text using the Gensim library. The output shows the number of non-zero values in the bag-of-words matrix, which is 1881 in this case.

A document-term matrix is created by applying the doc2bow function to each cleaned review using the dictionary.

```
#create document term matrix
doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in
df['text_clean'] ]
print(len(doc_term_matrix))
```

```

Create document term matrix
✓ [15] #create document term matrix
      doc_term_matrix = [dictionary.doc2bow(doc.split()) for doc in df['text_clean']]
      print(len(doc_term_matrix))
267

```

Figure 141 : Document term matrix is created.

This code creates a dictionary from the review text using the Gensim library and uses it to create a document-term matrix. The output shows the number of non-zero values in the bag-of-words matrix, which is 1881 in this case, and the number of reviews in the dataset, which is 267.

The LDA model is instantiated using the `gensim.models.ldamodel.LdaModel` function.

```

#Instantiate LDA model
lda = gensim.models.ldamodel.LdaModel

```

The LDA model is fit to the document-term matrix using the `lda` function.

```

#Fit LDA model on the dataset
num_topics=2
ldamodel = lda(doc_term_matrix, num_topics=num_topics,
id2word=dictionary, passes=50, minimum_probability=0)

```

```

Fit LDA model on the dataset
[17] num_topics=2
%time ldamodel = lda(doc_term_matrix,num_topics=num_topics,id2word=dictionary,passes=50,minimum_probability=0)
CPU times: user 7.46 s, sys: 178 ms, total: 7.64 s
Wall time: 9.42 s

```

Figure 142 : LDA Model is instantiated and fit on the dataset..

The `lda()` function call took 7.46 seconds of user CPU time and 178 milliseconds of system CPU time to complete, for a total of 7.64 seconds of CPU time. The wall-clock time, which includes time spent waiting for I/O and other system activities, was 9.42 seconds.

The topics identified by the LDA model are printed using the `print_topics` method.

```

#Print the topics identified by LDA model
ldamodel.print_topics(num_topics=num_topics)

```

CHAPTER 3

```
ldamodel.print_topics(num_topics=num_topics)

[(0,
 '0.062**app" + 0.043**"nice" + 0.026**"route" + 0.016**"finder" + 0.015**"location" + 0.013**"live" + 0.013**"ad" + 0.012**"much" + 0.012**"get" + 0.011**"great"',
 1,
 '0.080**"navigation" + 0.069**"gps" + 0.059**"app" + 0.056**"ar" + 0.047**"application" + 0.041**"best" + 0.036**"good" + 0.026**"work" + 0.026**"really" + 0.024**"useful"')]
```

Figure 143: 10 words contributed to each topic identified.

The output shows the two topics extracted by an LDA algorithm applied to a document-term matrix, along with the top words most strongly associated with each topic. The first topic appears to be related to an app or route finder, while the second topic is related to GPS navigation and augmented reality (AR). The topics seem to capture different aspects of user perceptions and experiences with navigation apps.

The `pyLDAvis.gensim.prepare` function is used to prepare the LDA model results for visualization using the `pyLDAvis.display` function.

```
#Visualize the LDA model results
lda_display = pyLDAvis.gensim.prepare(ldamodel,
doc_term_matrix, dictionary, sort_topics=False, mds='mmds')
pyLDAvis.display(lda_display)
```

The graph is generated by an LDA (Latent Dirichlet Allocation) topic modeling process. It includes two topics (0 and 1), each represented by the top 30 most relevant terms associated with that topic.

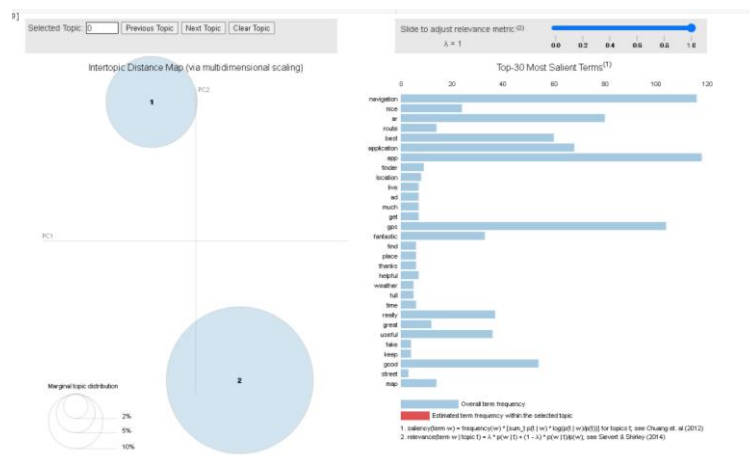


Figure 144 : Two topics is generated Top 30 most relevant terms are generated.

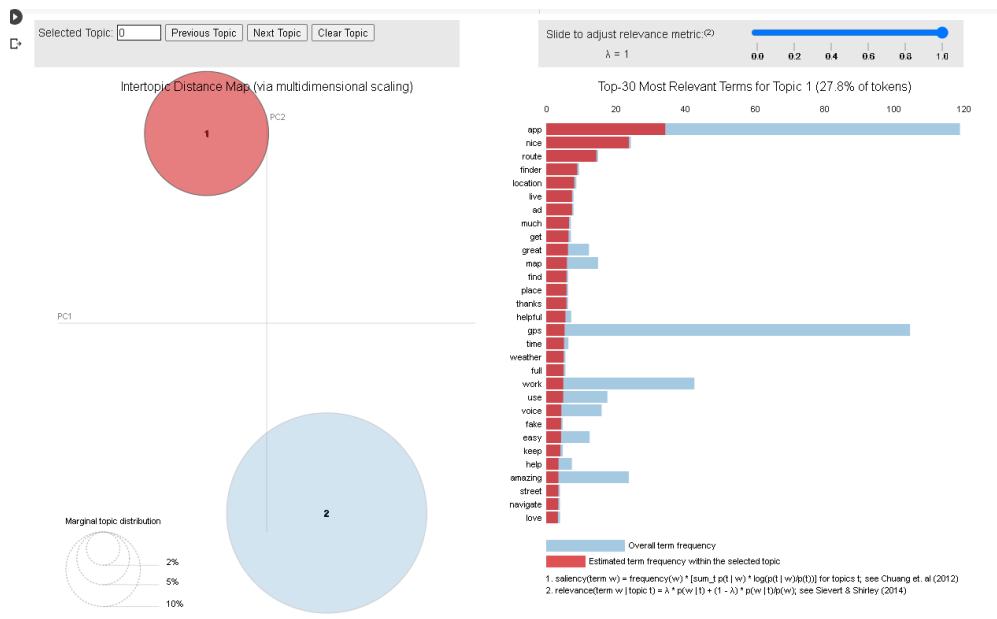


Figure 145 : Keywords for topic 0.

The keywords for topic 0 included app, gps, navigation, good, like, nice, application, ar, amazing, use and etc. The highest frequency terms for topic 0 is “app” with a frequency of 0.096. This term indicates that the primary focus of this topic is on the applications themselves, emphasizing the positive user experiences and feedback on GPS and navigation apps. This topic also revolves around GPS and navigation applications, with an emphasis on the positive user experience. Users find these apps to be good, nice, and amazing. The presence of the term "ar" suggests that augmented reality features may be a part of the apps being discussed.

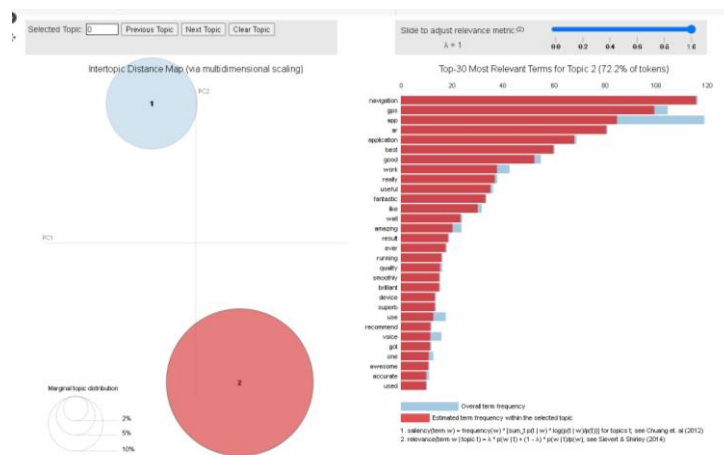


Figure 146 : Keywords for topic 1.

CHAPTER 3

The keywords for topic 1 included navigation, ar, best, gps, application, work, fantastic, really, useful, app and etc. The highest frequency terms for topic 1 is “navigation” with a frequency of 0.064. his term signifies that the main theme of this topic is related to navigation, particularly in the context of GPS and AR-enabled applications. This topic appears to be focused on navigation and GPS applications that incorporate augmented reality (AR) features. Users consider these applications to be the best, fantastic, and really useful. This topic highlights the effectiveness and desirability of these apps.

The code then finds which reviews were marked in which cluster by assigning topics to each document and calculating a threshold score based on the distribution of scores.

```
#Find which articles were marked in which cluster
# Assigns the topics to the documents in corpus
lda_corpus = ldamodel[doc_term_matrix]

[doc for doc in lda_corpus]
```

Probability

```
[(0, 0.85974264), (1, 0.14025733)],
[(0, 0.26678258), (1, 0.7332174)],
[(0, 0.8314455), (1, 0.16855448)],
[(0, 0.92583066), (1, 0.07416936)],
[(0, 0.87774485), (1, 0.12225515)],
[(0, 0.74574894), (1, 0.2542511)],
[(0, 0.30510253), (1, 0.6948975)],
[(0, 0.1437912), (1, 0.8562088)],
[(0, 0.7456942), (1, 0.25430578)],
[(0, 0.53886753), (1, 0.46113247)],
[(0, 0.74574834), (1, 0.25425172)],
[(0, 0.7485823), (1, 0.2514177)],
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[(0, 0.17980422), (1, 0.8201958)],
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[(0, 0.13373314), (1, 0.86626685)],
[(0, 0.16989794), (1, 0.830102)],
[(0, 0.055498656), (1, 0.94450134)],
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[(0, 0.05797217), (1, 0.9420278)],
[(0, 0.5), (1, 0.5)],
[(0, 0.068636194), (1, 0.93136376)],
[(0, 0.048386067), (1, 0.9516139)],
[(0, 0.121504776), (1, 0.8784952)],
[(0, 0.058971398), (1, 0.94102865)],
[(0, 0.053637356), (1, 0.9463626)],
[(0, 0.71250105), (1, 0.28749892)],
[(0, 0.43681398), (1, 0.563186)],
[(0, 0.05663361), (1, 0.9433664)],
```

[(0, 0.7888998), (1, 0.21110025)],
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[(0, 0.8015712), (1, 0.19842881)],
[(0, 0.25797614), (1, 0.7420239)],

```

[(0, 0.26689106), (1, 0.73310894)],
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[(0, 0.18307228), (1, 0.81692773)],
[(0, 0.83286464), (1, 0.16713542)],
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[(0, 0.8707214), (1, 0.12927857)],
[(0, 0.8015673), (1, 0.19843268)],
[(0, 0.82617027), (1, 0.17382976)],
[(0, 0.83048826), (1, 0.16951174)]

```

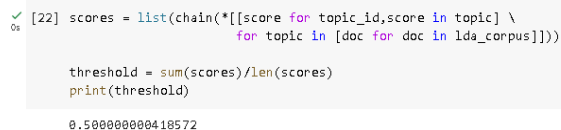
The code assigns topics to documents in a corpus using Latent Dirichlet Allocation (LDA) model. The resulting output is a list of tuples representing the probability distribution of each topic in a given document.

```

scores = list(chain(*[[score for topic_id, score in topic] \
                      for topic in [doc for doc in
lda_corpus]]))

threshold = sum(scores)/len(scores)
print(threshold)

```



```

[22] scores = list(chain(*[[score for topic_id, score in topic] \
                          for topic in [doc for doc in lda_corpus]]))

threshold = sum(scores)/len(scores)
print(threshold)

0.500000000418572

```

Figure 147 : Threshold calculated for topic relevance.

This code calculates the average score of all topics in an LDA corpus and sets it as the threshold. It then prints the threshold value of 0.5.

Finally, the code prints the number of reviews in each cluster and displays the reviews in each cluster using the `iloc` method.

```

cluster1 = [j for i, j in zip(lda_corpus, df.index) if i[0][1] >
threshold]

cluster2 = [j for i, j in zip(lda_corpus, df.index) if i[1][1] >
threshold]

```

CHAPTER 3

```
#cluster3 = [j for i,j in zip(lda_corpus,df.index) if
i[2][1] > threshold]
#cluster4 = [j for i,j in zip(lda_corpus,df.index) if
i[3][1] > threshold]
#cluster5 = [j for i,j in zip(lda_corpus,df.index) if
i[4][1] > threshold]

print(len(cluster1))
print(len(cluster2))
#print(len(cluster3))
#print(len(cluster4))
#print(len(cluster5))
```

```
cluster1 = [j for i,j in zip(lda_corpus,df.index) if i[0][1] > threshold]
cluster2 = [j for i,j in zip(lda_corpus,df.index) if i[1][1] > threshold]
#cluster3 = [j for i,j in zip(lda_corpus,df.index) if i[2][1] > threshold]
#cluster4 = [j for i,j in zip(lda_corpus,df.index) if i[3][1] > threshold]
#cluster5 = [j for i,j in zip(lda_corpus,df.index) if i[4][1] > threshold]

print(len(cluster1))
print(len(cluster2))
#print(len(cluster3))
#print(len(cluster4))
#print(len(cluster5))

98
168
```

Figure 148 : Number of articles printed in each cluster.

A threshold is set to determine which cluster each data point belongs to, and outputs the number of data points in each cluster. The first cluster has 98 data points, the second cluster has 168 data points.

```
df.iloc[cluster1]
```

	reviewId	userName	userImage	content	score	thumbsUpCount	reviewCreatedVersion	at	replyContent	replyDate	text_clean
0	08e2f41e-caff-4fa2-8fbf-009740c27358	lckesh kunar R	https://play-ih.googleusercontent.com/v/ACB-R...	It's nothing fake app	1	0	None	2023-03-30 09:51:46	None	NaT	nothing fake app
2	60615e55-185e-4e98-850d-98733c5cbde6	Indra The tiger	https://play-ih.googleusercontent.com/v/ACB-R...	Very bad app	1	0	6.9.9	2023-02-17 16:41:58	None	NaT	bad app
3	fa4bb08-496c-49d2-e34d-23f1798ed0ff	Petualang Dunia	https://play-ih.googleusercontent.com/v/AGNryx...	Can't open map or find location in my Oppo A9	1	0	None	2022-04-12 11:40:28	None	NaT	cant open map find location oppo a9
4	88be3c05-d5db-4502-851c-0df194d7313	Joseph S Manana	https://play-ih.googleusercontent.com/v/AGNryx...	Its easy to find place very fast	5	1	6.9.9	2021-07-08 17:51:49	None	NaT	easy find place fast
5	4f029eb4-3ff1-4353-851c-9f68f0cbedf	Abdul Kallan	https://play-ih.googleusercontent.com/v/ACB-R...	Ok	3	0	None	2021-06-19 19:14:45	None	NaT	ok
...
262	83978cb-1810-4d6c-9d6d-6a3973931593	A Google user	https://play-ih.googleusercontent.com/v/EGenoZN...	Watch out	5	99	1.3.1	2018-03-07 22:04:41	None	NaT	watch
263	5a3af9a5-6db5-42a9-8d8e-9d20cc70f38	A Google user	https://play-ih.googleusercontent.com/v/EGenoZN...	Nice apps. So cute	5	97	1.3.1	2018-03-04 09:18:27	None	NaT	nice apps cute
264	c492717a-efd2-444c-bd85-6234f0da08f7	A Google user	https://play-ih.googleusercontent.com/v/EGenoZN...	Nice app	5	17	None	2018-03-02 05:56:40	None	NaT	nice app
265	0b5e09fe-1577-4e45-8e80-27e812719679	A Google user	https://play-ih.googleusercontent.com/v/EGenoZN...	Nice apps	5	33	None	2018-02-13 20:09:58	None	NaT	nice apps
266	b9c826ff-e877-4905-e47a-8bcaea47f352	A Google user	https://play-ih.googleusercontent.com/v/EGenoZN...	معلومات باهم	5	44	None	2018-02-06 15:03:35	None	NaT	معلومات باهم

Figure 149 : Articles of cluster1 are printed.

```
df.iloc[cluster2]
```

	reviewId	userName	userImage	content	score	thumbUpCount	reviewCreatedVersion	at	replyContent	repliedAt	text_clean
1	470e4b17-14e3-4e19-b6df-695d49653f9d	prince forester	lh.googleusercontent.com/a-/ACB_R...	Not working in m31	1	0	6.9.9	2023-03-16 17:30:36	None	NaT	working m31
6	e2450939-c275-4384-938e-8e4221e8504a	Tepanator	lh.googleusercontent.com/a-/ACB_R...	Terrible app that has the nerve to play an ad ...	1	1	6.7.9	2021-05-03 23:32:36	None	NaT	terrible app nerve play ad literally every 5 s...
7	501d9b91-6b02-4ce5-8905-c6da5209d3	DrMohamed Saleh	lh.googleusercontent.com/a-/ACB_R...	Good app really	5	0	6.7.9	2021-04-27 14:16:53	None	NaT	good app really
13	b408cb04-d384-4d60-d064-1aaf46013b95	korean kea	lh.googleusercontent.com/a-/ACB_R...	did not want to start at all	1	0	6.5.8	2020-11-20 09:31:55	Hi, we're sorry to hear that and we would love...	2021-02-14 09:19:35	want start
14	07ca73af-b8ab-42c1-b847-20f80c22c29	Krishna Arnbawari	lh.googleusercontent.com/a/ADNxyx...	Very useful and helpful	4	0	None	2020-08-03 08:19:16	Hi! We are glad that you like our app. We'd ve...	2020-08-13 13:38:30	useful helpful
...
252	4aa3eb5d-feae-40f1-9ac2-f11e69205a86	A Google user	lh.googleusercontent.com/EGeno4ZN...	good	5	5	None	2018-04-28 12:46:53	None	NaT	good
253	578ec07d-e281-4975-89e1-b909a4e44b2	A Google user	lh.googleusercontent.com/EGeno4ZN...	Good	4	8	None	2018-04-28 04:42:21	None	NaT	good
256	10b60fae-2470-4213-b999-a85084c9abdd	A Google user	lh.googleusercontent.com/EGeno4ZN...	It's good	3	8	None	2018-04-16 06:45:14	None	NaT	good
257	8b347d47-ad35-4694-8483-ef9277df1da	A Google user	lh.googleusercontent.com/EGeno4ZN...	Top	5	11	None	2018-03-31 03:00:32	None	NaT	top
260	b6446927-9e00-4c2b-9401-15e9a6556db	A Google user	lh.googleusercontent.com/EGeno4ZN...	Am so happy to see	5	13	None	2018-03-24 09:12:28	None	NaT	happy see

168 rows x 11 columns

Figure 150 : Articles of cluster2 are printed.

Conclusion

In conclusion, the LDA topic modeling process has generated two topics that revolve around user experiences with GPS and navigation applications, particularly those incorporating augmented reality (AR) features. Both topics emphasize positive user feedback and satisfaction with the applications.

Topic 0 highlights the desirability and effectiveness of AR-enabled navigation applications, with users considering them to be the best, fantastic, and really useful. Topic 1 underscores the positive user experience with GPS and navigation apps in general, with users finding them good, nice, and amazing. The presence of the term "ar" in both topics highlights the significance of augmented reality features in user satisfaction.

The main themes or focal points are represented by the highest frequency terms for each topic: "navigation" in Topic 0 and "app" in Topic 1. These insights into users' experiences and preferences can be valuable for developers and stakeholders involved in creating and improving GPS and navigation apps, particularly those with augmented reality features.

CHAPTER 4

4.0 Work Plan

Planning Phase

The planning phase of the research project begin with an introduction to the research project, providing background information on the motivation for the study, the research involves defining the problem statement, identifying project objectives and project scope, perform a complete literature review, deciding on the tools and languages to implement the project, design and create survey questionnaires, perform analysis and interpretation on survey responses and conduct sentiment analysis and topic modelling on existing AR real-time navigation apps. This section will also highlight the significance of the study and the contributions it seeks to make to the field of AR real-time navigation apps. This phase sets the foundation for the entire research project and helps ensure that the project is well-organized and effectively executed.

Define Problem Statement

The first step in the planning phase is to define the problem statement, which will guide the entire research project. The problem statement for this project is to develop a conceptual model for an interactive and compelling real-time augmented reality navigation experience for mobile platforms. This statement emphasizes the lack of understanding of user preferences and requirements, inadequate accuracy and reliability of AR real-time navigation apps, limited availability of relevant data and the lack of an effective conceptual model for AR real-time navigation. It highlights the need for an innovative and engaging mobile navigation experience that leverages AR technology to provide users with an intuitive and informative interface.

Identify Project Objectives & Project Scope

The next step is to identify the project objectives and project scope. The project objectives will guide the research process and help ensure that the research project meets its goals. The project scope will define the boundaries of the research project, including the target audience, research methods, and data collection techniques.

Complete Literature Review

Before conducting the survey and data collection, a comprehensive literature review will be conducted to gather relevant studies, articles, and papers related to AR real-time navigation apps on mobile platforms. This will involve searching online databases, academic journals, and other sources of information to gather as much data as possible. The literature review will help identify key features and functionalities of existing AR real-time navigation apps, provide insights into user preferences and requirements, and identify any gaps in the current literature.

Decide Tools and Languages to Implement Project

The research project will utilize various tools and languages to implement the conceptual model for the AR real-time navigation app. The tools and languages used will depend on the research objectives and the data analysis techniques. The research project will utilize a mix of open-source and commercial software to ensure that the project is cost-effective and accessible.

Design and Create Survey Questionnaires

The research project utilized a survey questionnaire to gather data from the general public to better understand the user's preferences and requirements. The survey questionnaire is designed and created based on the research objectives and the project scope. The survey questionnaire has included closed-ended questions to gather both quantitative and qualitative data. The data collected are to refine the conceptual model and ensure that it meets the needs of users.

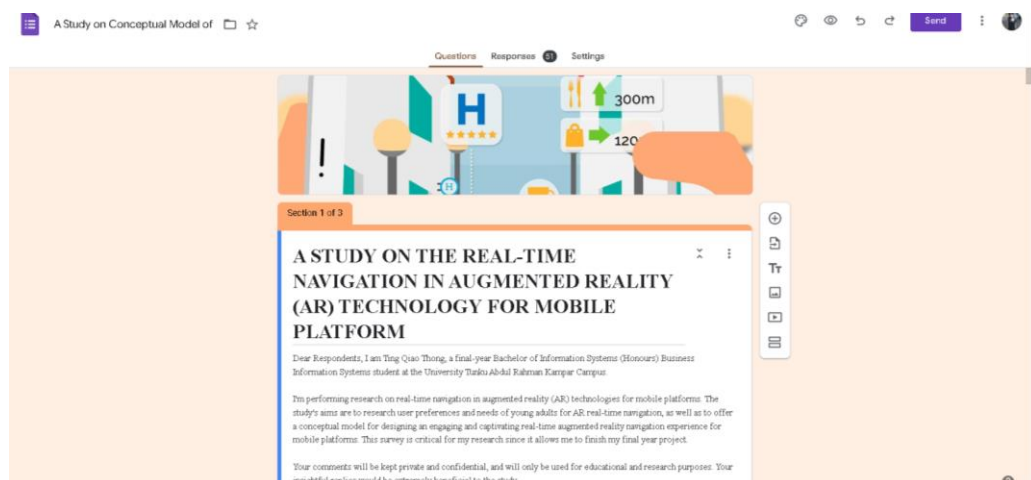


Figure 151 : Survey questionnaires.

Data Analysis Process

The study used sentiment analysis and topic modelling to delve further into the user experience of augmented reality (AR) real-time navigation apps on mobile platforms. The methodologies were used in conjunction with the survey results and an examination of the current literature to provide a thorough comprehension of user preferences, requirements, and concerns surrounding AR real-time navigation apps.

Once the survey responses have been collected, the analysis and interpretation process is carried out based on the data collected from the public to get understanding of the user's preferences and vital features. I have also utilized sentiment analysis to determine the positive, neutral and negative reviews based on the existing AR real-time navigation apps. The study's analysis of user opinions helped researchers identify both the strengths and weaknesses of currently available augmented reality (AR) navigation apps. Ultimately, this data guided the creation of the proposed conceptual model by revealing what elements customers valued and what areas needed improvement. Cleaning and transforming process are involved to ensure that the data is suitable for modelling and analysis. Topic modelling is performed to identify the patterns and topics in large sets of text data based on the categorization of the hot terms from the user's review. When applied to massive amounts of text data, topic modelling is a machine learning technique that can reveal previously unseen subject structures. In this study, we used topic modelling to identify common themes and subjects from user reviews and feedback on augmented reality (AR) real-time navigation apps. This method helped researchers spot patterns, trends, and unmet user requirements that might not have emerged from a standard literature study or survey analysis. A deeper understanding of user preferences and requirements for AR real-time navigation was achieved through the integration of sentiment analysis and topic modelling in the study project. As a result, the common themes and important features could be identified through the analysis process and could incorporate these elements in the conceptual model of AR real-time navigation apps in the future.

CHAPTER 4

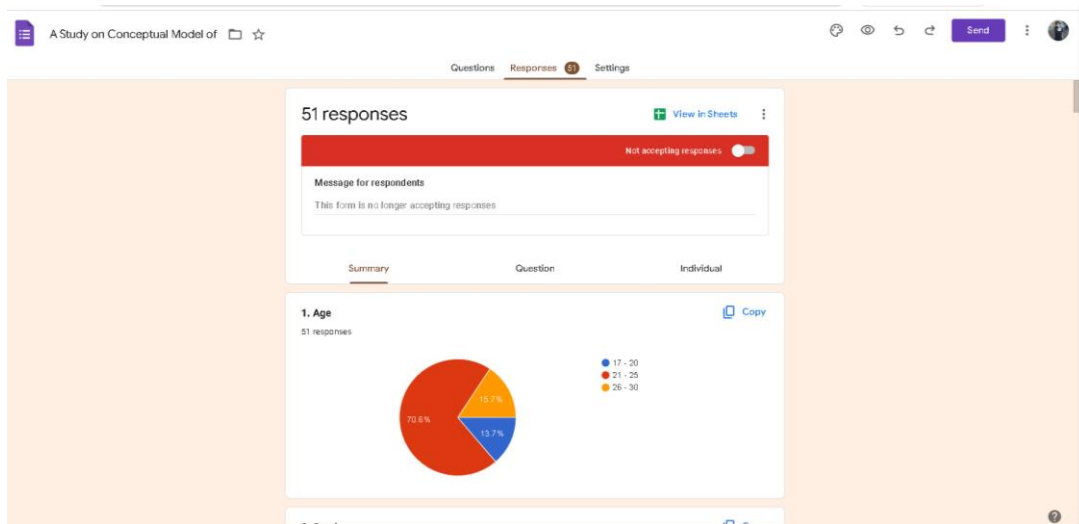


Figure 152 : Survey responses.

```
argsdrive.ipynb
File Edit View Insert Runtime Tools Help Last edited on April 13
+ Code + Test
Connect

[] !pip install -q google_play_scraper #Scraping reviews
!pip install -q transformers #Sentiment
!pip install -q plotly-express #Data Visualization
----- 7,077.0 MB 41.0 MB/s eta 0:00:00
----- 7,807.0 MB 150.4 MB/s eta 0:00:00
----- 200.1/200.1 MB 21.4 MB/s eta 0:00:00

[] !pip install pyyaml==5.4.1
Looking in indexes: https://pypi.org/simple, https://us-python.org/dev/colab-wheels/public/simple/
Collecting pyyaml==5.4.1
  Downloading PyYAML-5.4.1-cp39-cp39-manylinux_x86_64.whl (630 kB)
----- 630.1/630.1 MB 24.4 MB/s eta 0:00:00
Installing collected packages: pyyaml
  attempting uninstall: pyyaml
    Found existing installation: PyYAML 6.0
    Uninstalling PyYAML-6.0:
      Successfully uninstalled PyYAML-6.0
  Successfully installed pyyaml-5.4.1

[] import pandas as pd
import numpy as np
from google_play_scraper import app, sort, reviews_all
import plotly.express as px

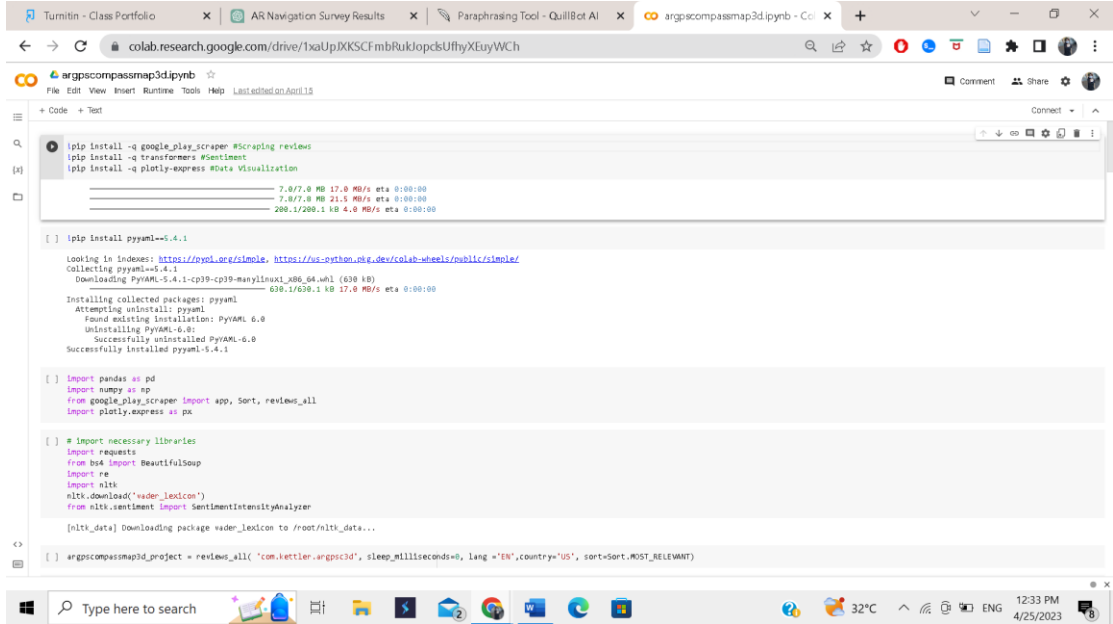
# Import necessary libraries
import requests
from bs4 import BeautifulSoup
import re
import nltk
from nltk.download import 'vader_lexicon'
from nltk.sentiment import SentimentIntensityAnalyzer

[nltk_data] Downloading package vader_lexicon to /root/nltk_data...

[] args_project = reviews_all('com.w.args', sleep_milliseconds=0, lang='EN', country='US', sort=sort.MOST_RELEVANT)
```

Figure 153 : Sentiment analysis of AR GPS Drive.

CHAPTER 4



```
!pip install -q google_play_scraper #Scraping reviews
!pip install -q transformers #Sentiment
!pip install -q plotly-express #Data Visualization

7.8/7.8 MB 17.0 MB/s eta 0:00:00
7.8/7.8 MB 21.5 MB/s eta 0:00:00
288.1/288.1 kB 4.0 MB/s eta 0:00:00

[ ] !pip install pyyaml==5.4.1

Looking in indexes: https://pypi.org/simple, https://us-python.org/dev/colab-wheels/public/simple/
Collecting pyyaml==5.4.1
  Downloading PyYAML-5.4.1-cp39-cp39-manylinux1_x86_64.whl (630 kB)
    638.1/638.1 kB 17.0 MB/s eta 0:00:00
Installing collected packages: pyyaml
  Attempting uninstall: pyyaml
    Found existing installation: PyYAML 6.0
    Uninstalling PyYAML-6.0:
      Successfully uninstalled PyYAML-6.0
  Successfully installed pyyaml-5.4.1

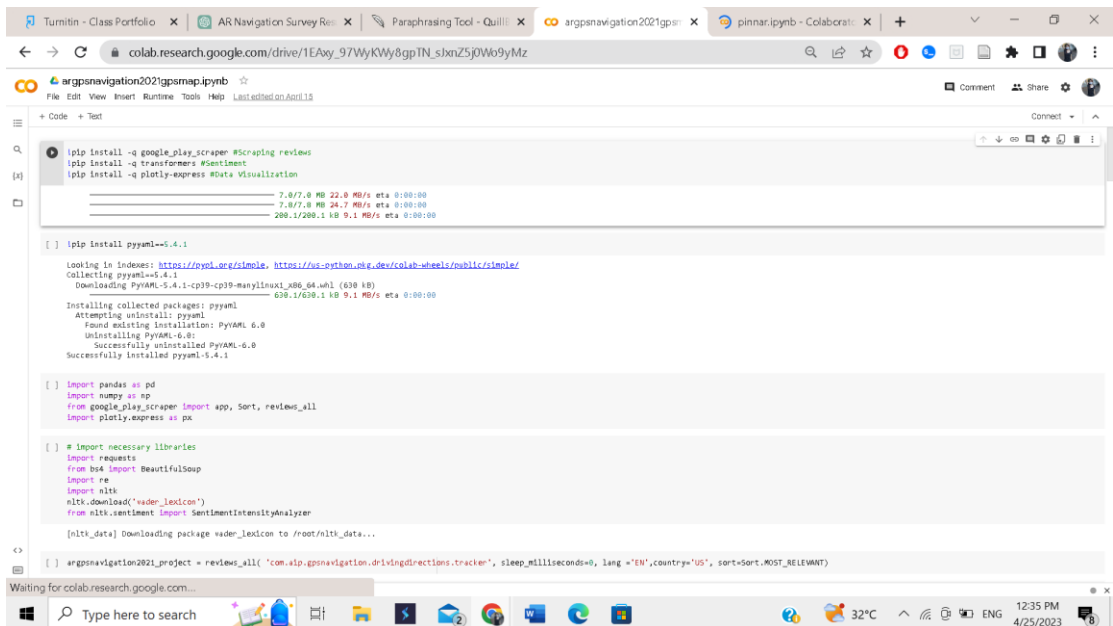
[ ] import pandas as pd
import numpy as np
from google_play_scraper import app, sort, reviews_all
import plotly.express as px

[ ] # Import necessary libraries
import requests
from bs4 import BeautifulSoup
import re
import nltk
nltk.download(' vader_lexicon')
from nltk.sentiment import SentimentIntensityAnalyzer

[nltk_data] Downloading package vader_lexicon to /root/nltk_data...

[ ] argpscompassmap3d_project = reviews_all( 'com.kettler.argps3d', sleep_milliseconds=0, lang = 'EN', country='US', sort=sort.MOST_RELEVANT)
```

Figure 154 : Sentiment analysis of AR GPS Compass Map 3D.



```
!pip install -q google_play_scraper #Scraping reviews
!pip install -q transformers #Sentiment
!pip install -q plotly-express #Data Visualization

7.8/7.8 MB 22.0 MB/s eta 0:00:00
7.8/7.8 MB 24.7 MB/s eta 0:00:00
288.1/288.1 kB 9.1 MB/s eta 0:00:00

[ ] !pip install pyyaml==5.4.1

Looking in indexes: https://pypi.org/simple, https://us-python.org/dev/colab-wheels/public/simple/
Collecting pyyaml==5.4.1
  Downloading PyYAML-5.4.1-cp39-cp39-manylinux1_x86_64.whl (630 kB)
    638.1/638.1 kB 9.1 MB/s eta 0:00:00
Installing collected packages: pyyaml
  Attempting uninstall: pyyaml
    Found existing installation: PyYAML 6.0
    Uninstalling PyYAML-6.0:
      Successfully uninstalled PyYAML-6.0
  Successfully installed pyyaml-5.4.1

[ ] import pandas as pd
import numpy as np
from google_play_scraper import app, sort, reviews_all
import plotly.express as px

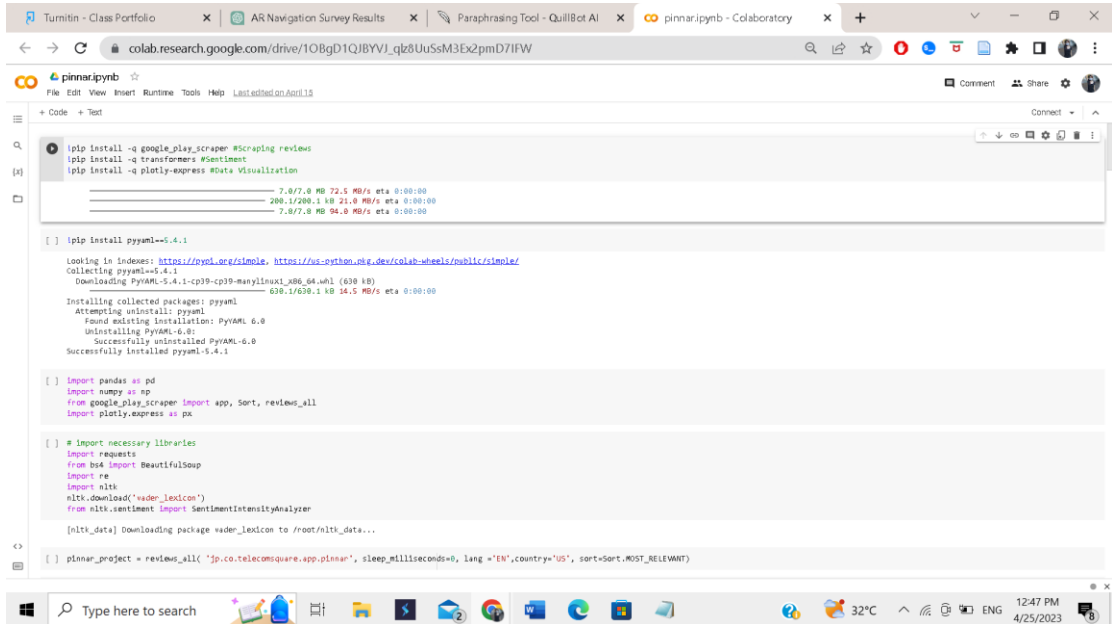
[ ] # Import necessary libraries
import requests
from bs4 import BeautifulSoup
import re
import nltk
nltk.download(' vader_lexicon')
from nltk.sentiment import SentimentIntensityAnalyzer

[nltk_data] Downloading package vader_lexicon to /root/nltk_data...

[ ] argpsnavigation2021_project = reviews_all( 'com.slp.gpsnavigation.drivingdirections.tracker', sleep_milliseconds=0, lang = 'EN', country='US', sort=sort.MOST_RELEVANT)
```

Figure 155 : Sentiment analysis of AR GPS Navigation 2021 GPS Map.

CHAPTER 4



```
!pip install -q google_play_scraper #Scraping reviews
!pip install -q transformers #Sentiment
!pip install -q plotly-express #Data Visualization

7.0/7.0 MB 72.5 MB/s eta 0:00:00
200.1/200.1 kB 21.0 MB/s eta 0:00:00
7.0/7.0 MB 94.0 MB/s eta 0:00:00

[] !pip install pyyaml==5.4.1

Looking in indexes: https://pypi.org/simple, https://us-python.org/dev/colab-wheels/public/simple/
Collecting pyyaml==5.4.1
  Downloading PyYAML-5.4.1-cp39-cp39-manylinux1_x86_64.whl (630 kB)
    630.1/630.1 kB 14.5 MB/s eta 0:00:00
Installing collected packages: pyyaml
  Attempting uninstall: pyyaml
    Found existing installation: PyYAML 6.0
    Uninstalling PyYAML-6.0:
      Successfully uninstalled PyYAML-6.0
  Successfully installed pyyaml-5.4.1

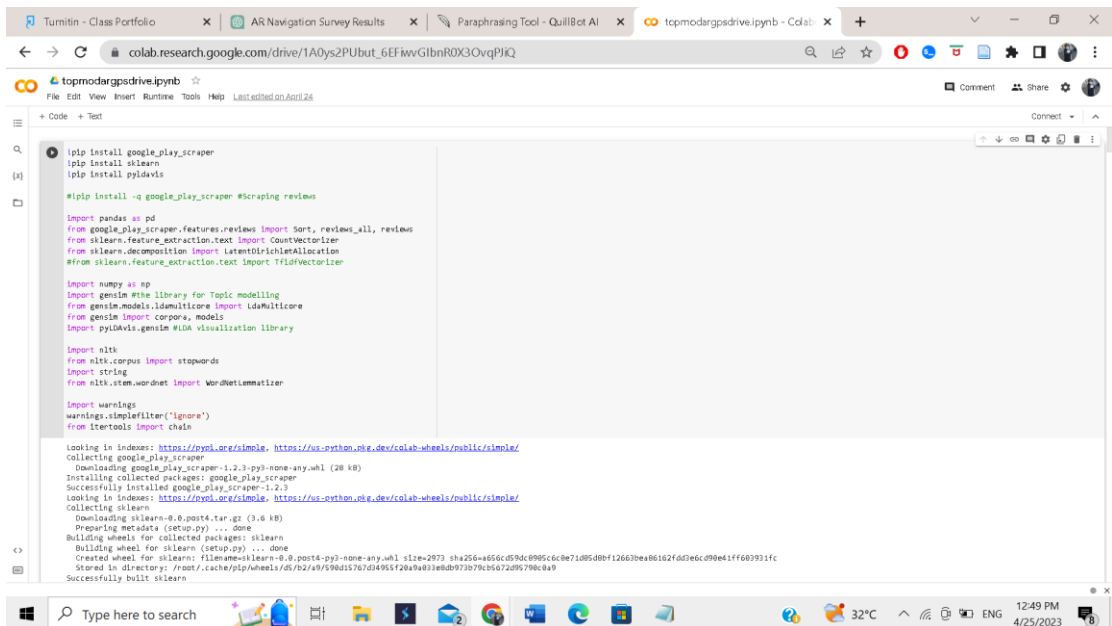
[] import pandas as pd
import numpy as np
from google_play_scraper import app, sort, reviews_all
import plotly.express as px

[] # Import necessary libraries
import requests
from bs4 import BeautifulSoup
import re
import nltk
nltk.download('wordnet_lexicon')
from nltk.sentiment import SentimentIntensityAnalyzer

[nltk_data] Downloading package wordnet_lexicon to /root/nltk_data...

[] pinnar_project = reviews_all('jp.co.telecomsquare.app.pinnar', sleep_milliseconds=0, lang = 'EN', country='US', sort=sort.MOST_RELEVANT)
```

Figure 156 : Sentiment analysis of Pinn AR.



```
!pip install google_play_scraper
!pip install sklearn
!pip install pydavis

#!pip install -q google_play_scraper #Scraping reviews

import pandas as pd
from google_play_scraper.features.reviews import sort, reviews_all, reviews
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.decomposition import LatentDirichletAllocation
from sklearn.feature_extraction.text import TfidfVectorizer

import numpy as np
import gensim #The library for Topic modelling
from gensim.models.ldamultitopic import LdaMultitopic
from gensim import corpora, models
import pydavis.gensim #LDA visualization library

import nltk
from nltk.corpus import stopwords
import string
from nltk.stem.wordnet import WordNetLemmatizer

import warnings
warnings.simplefilter('ignore')
from itertools import chain

Looking in indexes: https://pypi.org/simple, https://us-python.org/dev/colab-wheels/public/simple/
Collecting google_play_scraper
  Downloading google_play_scraper-1.2.3-py3-none-any.whl (20 kB)
Installing collected packages: google_play_scraper
Successfully installed google_play_scraper-1.2.3
Looking in indexes: https://pypi.org/simple, https://us-python.org/dev/colab-wheels/public/simple/
Collecting sklearn
  Downloading sklearn-0.0.post4.tar.gz (3.0 kB)
  Building wheels for collected packages: sklearn
  Building wheel for sklearn (setup.py) ... done
  Created wheel for sklearn: filename=sklearn-0.0.post4-py3-none-any.whl size=2973 sha256=4656c05d0c0895c60e7105d08f12663bea86162fd036c090e1ff609331fc
  Stored in directory: /root/.cache/pip/wheels/d5/b2/a9/590d15767d3495f20a9a023e8db073079c65072096790c0a9
Successfully built sklearn
```

Figure 157 : Topic Modelling of AR GPS Drive.

CHAPTER 4

```
!pip install google_play_scraper
!pip install sklearn
!pip install pydavis
#!pip install -q google_play_scraper #Scraping reviews

import pandas as pd
from google_play_scraper.features.reviews import Sort, reviews_all, reviews
from sklearn.feature_extraction.text import CountVecorizer
from sklearn.decomposition import LatentDirichletAllocation
from sklearn.feature_extraction.text import TfidfVectorizer

import numpy as np
import gensim #the library for Topic modelling
from gensim.models.ldamulticore import LdaMulticore
from gensim import corpora, models
import pyDavis.gensim #LDA visualization library

import nltk
from nltk.corpus import stopwords
import string
from nltk.stem.wordnet import WordNetLemmatizer

import warnings
warnings.simplefilter('ignore')
from itertools import chain

Looking in indexes: https://pypi.org/simple, https://us-python.org, https://colab.wheels/public/simple/
Collecting google_play_scraper
  Downloading google_play_scraper-1.2.3-py3-none-any.whl (28 kB)
Installing collected packages: google_play_scraper
Successfully installed google_play_scraper-1.2.3
Looking in indexes: https://pypi.org/simple, https://us-python.org, https://colab.wheels/public/simple/
Collecting sklearn
  Downloading sklearn-0.0.post4.tar.gz (3.6 kB)
  Preparing metadata (setup.py) ... done
Building wheels for collected packages: sklearn
  Building wheel for sklearn (setup.py) ... done
Created wheel for sklearn: file=sklearn-0.0.post4-py3-none-any.whl size=2973 sha256=90b625f12490732c5a6569b6064c472fb20179ec3246163c52248ff1a095
Stored in directory: /root/.cache/pip/wheels/d5/d2/a9/598d15767d94955f2a9a031e8db973079c55672d95798c0a9
Successfully built sklearn
Installing collected packages: sklearn
  Successfully installed sklearn-0.0.post4
```

Figure 158 : Topic Modelling of AR GPS Compass Map 3D.

```
!pip install google_play_scraper
!pip install sklearn
!pip install pydavis
#!pip install -q google_play_scraper #Scraping reviews

import pandas as pd
from google_play_scraper.features.reviews import Sort, reviews_all, reviews
from sklearn.feature_extraction.text import CountVecorizer
from sklearn.decomposition import LatentDirichletAllocation
from sklearn.feature_extraction.text import TfidfVectorizer

import numpy as np
import gensim #the library for Topic modelling
from gensim.models.ldamulticore import LdaMulticore
from gensim import corpora, models
import pyDavis.gensim #LDA visualization library

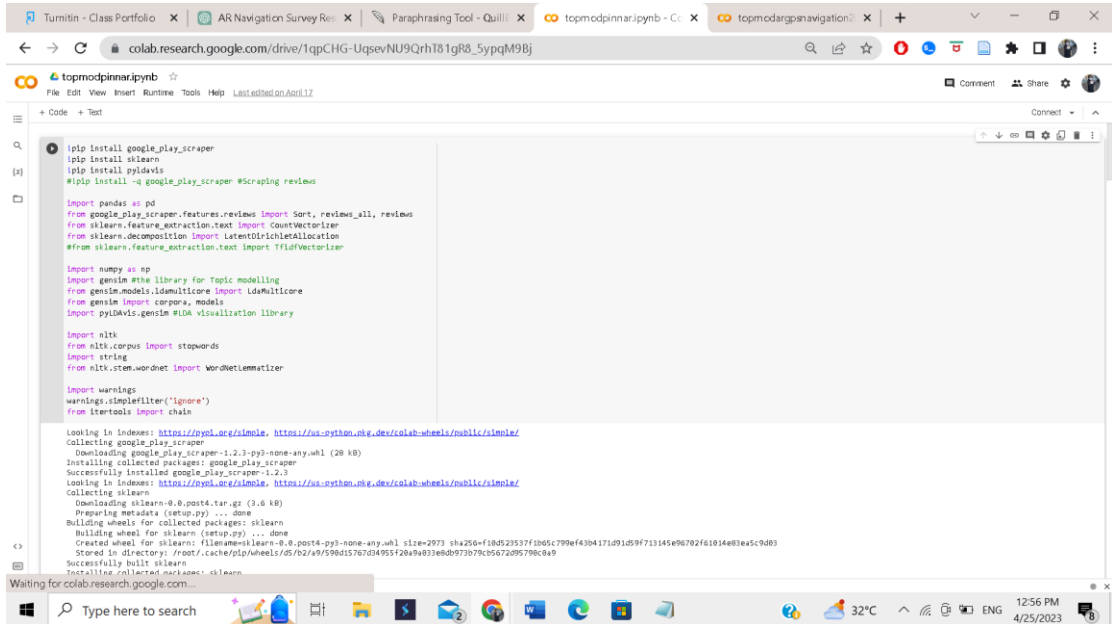
import nltk
from nltk.corpus import stopwords
import string
from nltk.stem.wordnet import WordNetLemmatizer

import warnings
warnings.simplefilter('ignore')
from itertools import chain

Looking in indexes: https://pypi.org/simple, https://us-python.org, https://colab.wheels/public/simple/
Collecting google_play_scraper
  Downloading google_play_scraper-1.2.3-py3-none-any.whl (28 kB)
Installing collected packages: google_play_scraper
Successfully installed google_play_scraper-1.2.3
Looking in indexes: https://pypi.org/simple, https://us-python.org, https://colab.wheels/public/simple/
Collecting sklearn
  Downloading sklearn-0.0.post4.tar.gz (3.6 kB)
  Preparing metadata (setup.py) ... done
Building wheels for collected packages: sklearn
  Building wheel for sklearn (setup.py) ... done
Created wheel for sklearn: file=sklearn-0.0.post4-py3-none-any.whl size=2973 sha256=e53ec9c6bb529596c574764bf2f2648a7690cc512ffdc8c1c1ef4cae429
Stored in directory: /root/.cache/pip/wheels/d5/d2/a9/598d15767d94955f2a9a031e8db973079c55672d95798c0a9
Successfully built sklearn
Installing collected packages: sklearn
  Successfully installed sklearn-0.0.post4
```

Figure 159 : Topic Modelling of AR GPS Navigation 2021 GPS Map.

CHAPTER 4



```
!pip install google_play_scraper
!pip install sklearn
!pip install pyLDAvis
#!pip install -q google_play_scraper #Scraping reviews

import pandas as pd
from google_play_scraper.features.reviews import Sort, reviews_all, reviews
from sklearn.feature_extraction.text import CountVecorizer
from sklearn.decomposition import LatentDirichletAllocation
from sklearn.feature_extraction.text import TfidfVectorizer

import numpy as np
import gensim #the library for Topic modelling
from gensim.models.ldamulticore import LdaMulticore
from gensim import corpora, models
import pyLDAvis.gensim #LDA visualization library

import nltk
from nltk.corpus import stopwords
import string
from nltk.stem.wordnet import WordNetLemmatizer

import warnings
warnings.simplefilter('ignore')
from itertools import chain

!pip install google_play_scraper
Collecting google_play_scraper
  Downloading google_play_scraper-1.2.3-py3-none-any.whl (28 kB)
Installing collected packages: google_play_scraper
Successfully installed google_play_scraper-1.2.3
!pip install sklearn
Collecting sklearn
  Downloading sklearn-0.0.post4.tar.gz (3.6 kB)
  Preparing metadata (setup.py) ... done
Building wheels for collected packages: sklearn
  Building wheel for sklearn (setup.py) ... done
  Created wheel for sklearn: filename=sklearn-0.0.post4-py3-none-any.whl size=2973 sha256=f1d523537f1b65c799ef4304171d91d59f71345e0679261014e83e3c9d83
  Stored in directory: /root/.cache/pip/wheels/d5/d2/a9/598d15764955f20a9a833e8db973b79c05672495798c8a9
Successfully built sklearn
Installing collected packages: sklearn
Waiting for colab.research.google.com...
```

Figure 160 : Topic Modelling of Pinn AR.

CHAPTER 5

5.0 System Model

The Universal Systems Model is a framework used to simplify and analyze complex processes. It has four main components: system inputs (resources like people and materials), processes (actions within the system), outputs (results of processes), and feedback (adjustments based on outputs). It's a versatile tool for understanding and improving systems in various domains, such as technology and manufacturing, by breaking them down into manageable parts[39].

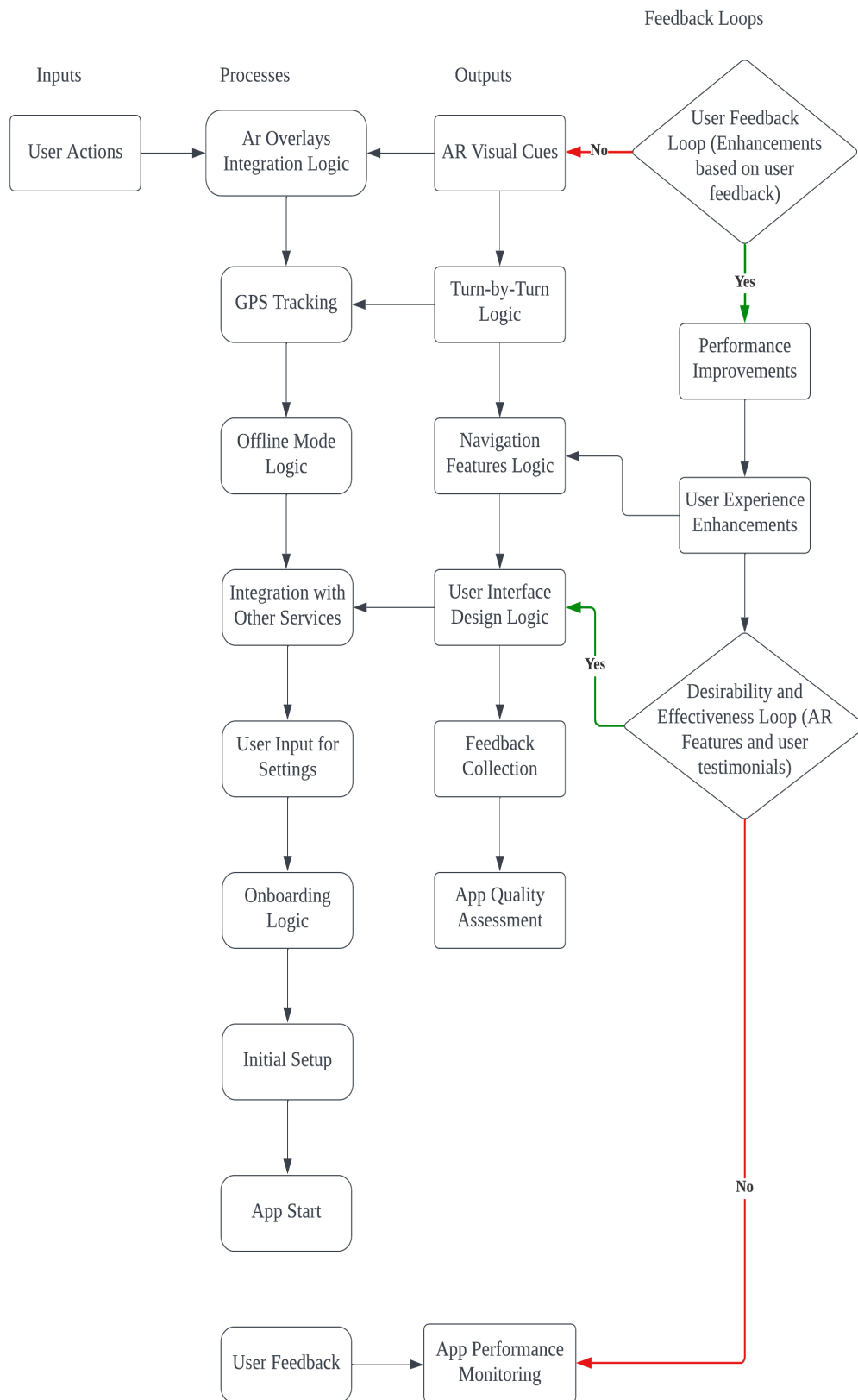


Figure 161 : System Model diagram.

5.1 System Architecture Diagram

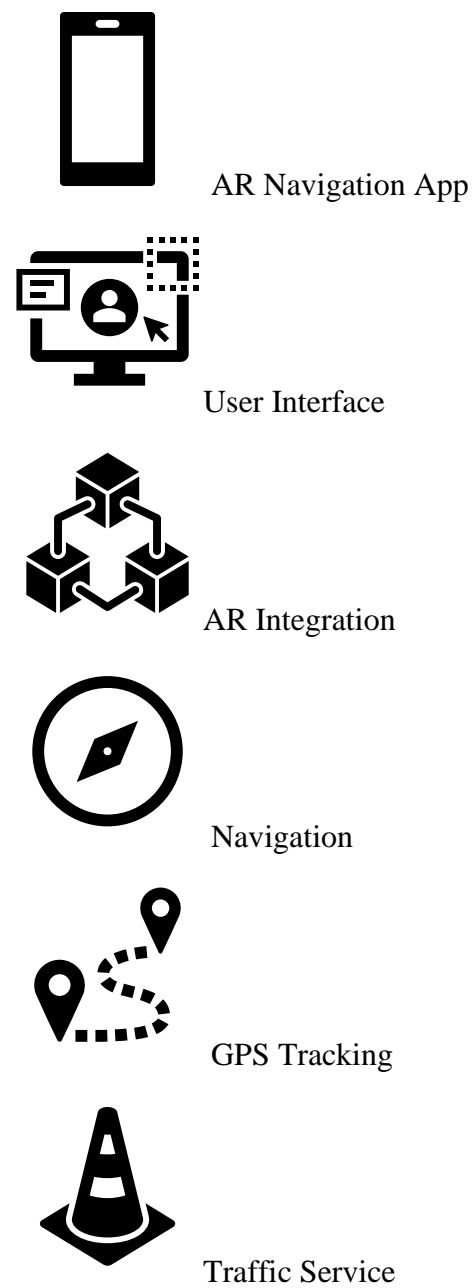


Figure 162 : System Architecture diagram.

5.2 Use Case Diagram

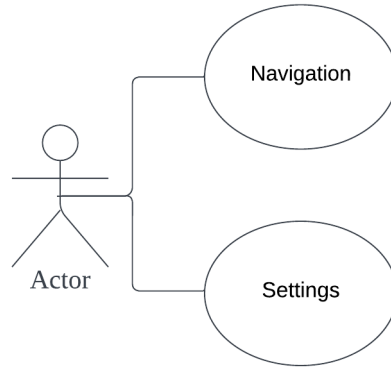


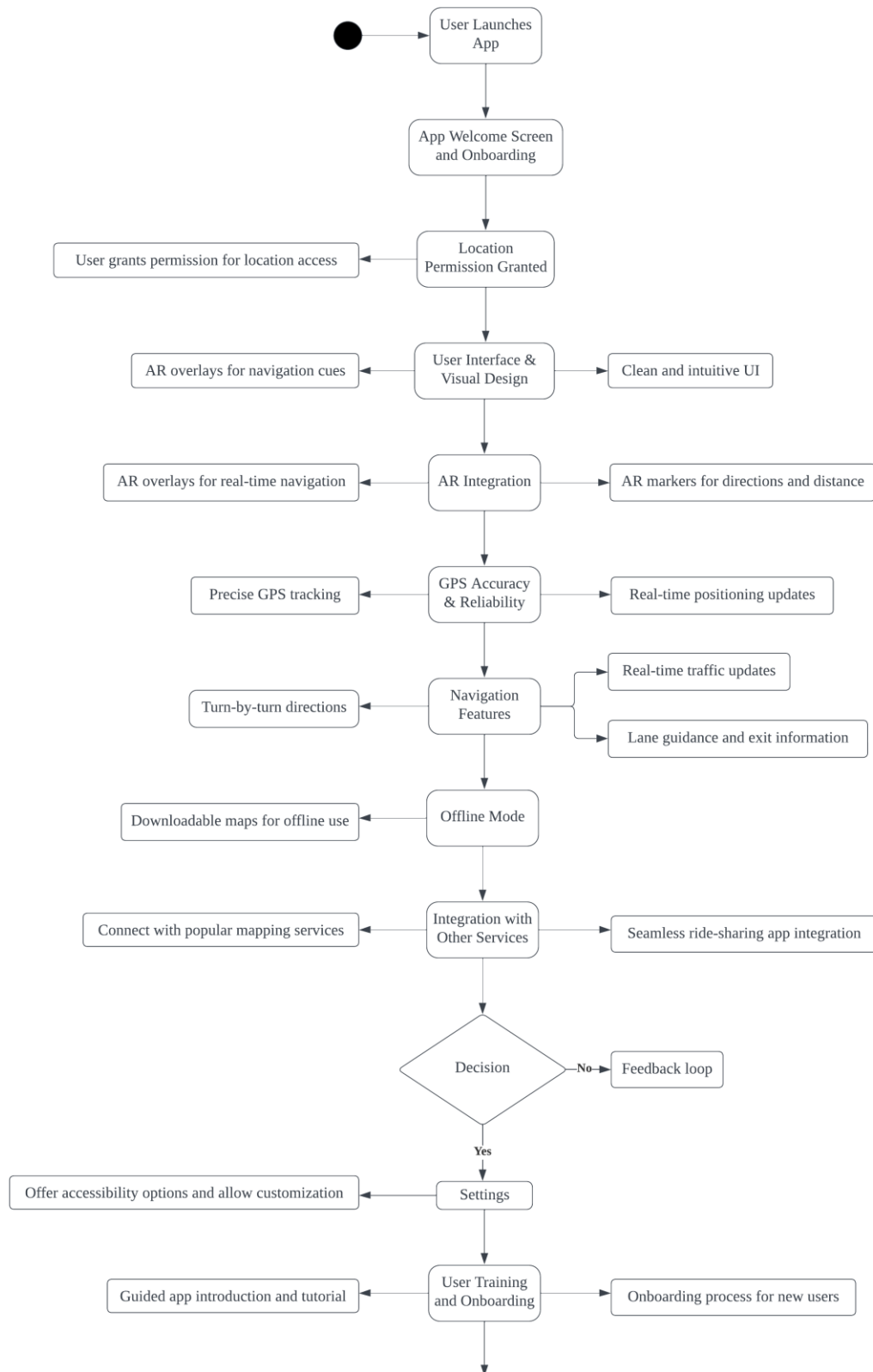
Figure 163 : Use case diagram.

User: Interacts with the app to navigate, customize settings, and access various functionalities.

Navigation: Initiates navigation, receives real-time directions, traffic updates, and reaches the destination.

Settings: Allows users to personalize their navigation experience, adjust preferences, and configure app settings.

5.3 Conceptual model of AR Real-Time Navigation App for Mobile Platform



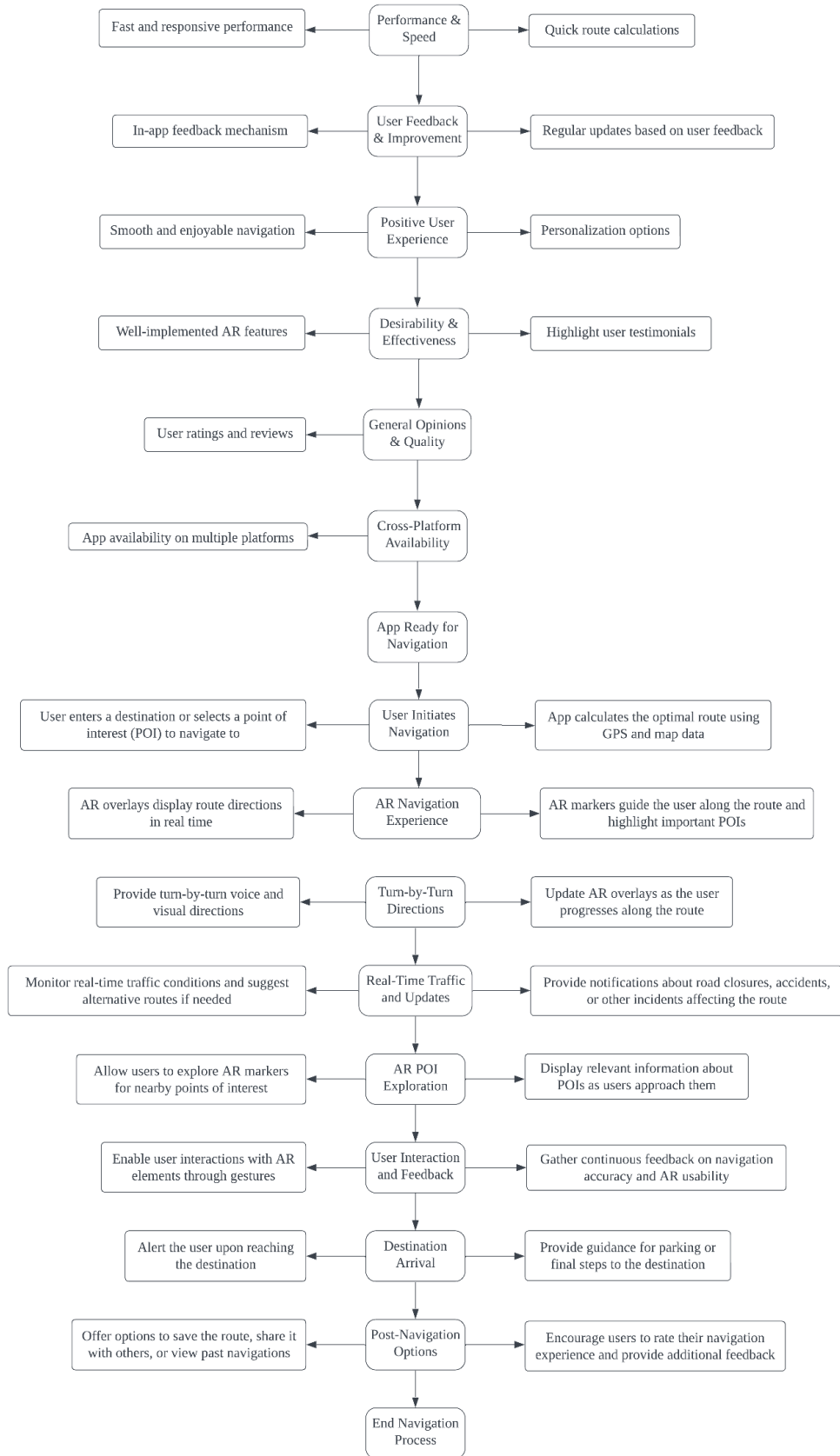


Figure 164 : The Conceptual Model.

The conceptual model for an Augmented Reality (AR) real-time navigation app designed for mobile platforms outlines the app's key features, interactions, and functionalities, providing a clear understanding of its design and user experience.

Chapter 1: User Engagement

User Launches App

The user launches the AR navigation app. The navigation journey begins when the user initiates the app, setting the stage for a seamless navigation experience.

App Welcome Screen and Onboarding

The app welcomes the user with an onboarding process. The onboarding process introduces users to the app's features, functionality, and user interface, ensuring a smooth introduction to the navigation experience.

User Grants Permission for Location Access

The app requests the location access permission from the user. User engagement starts with granting location access, a crucial step for the app to provide accurate real-time navigation.

Chapter 2: User Interface and AR Integration

AR Overlays for Navigation Cues - User Interface & Visual Design

The app displays AR overlays for navigation cues. The user interface and visual design component ensures a clean and intuitive user interface, enhancing the AR navigation experience with easy-to-follow cues.

AR Overlays for Real-Time Navigation - AR Integration

The app integrates AR markers for directions and distance. AR integration seamlessly incorporates markers into the navigation experience, guiding users in real time with visual cues and distance information.

Chapter 3: GPS Tracking and Navigation

Precise GPS Tracking - GPS Accuracy & Reliability

CHAPTER 5

The app maintains precise GPS tracking. GPS accuracy and reliability are paramount, with real-time positioning updates ensuring accurate navigation throughout the journey.

Turn-by-Turn Directions - Navigation Features

The app provides turn-by-turn directions. Navigation features include step-by-step guidance, lane assistance, and real-time traffic updates, enhancing the user's journey.

Chapter 4: Offline and Integration

Downloadable Maps for Offline Use - Offline Mode

The app offers downloadable maps for offline use. Offline mode ensures navigation availability in areas with limited connectivity, expanding the app's usability.

Connect with Popular Mapping Services - Integration with Other Services

The app integrates with third-party mapping services. Seamless integration with mapping services and ride-sharing apps simplifies the navigation experience and extends functionality.

Seamless Ride-Sharing App Integration

The app facilitates ride-sharing app integration. Users can seamlessly transition from navigation to booking rides, enhancing the convenience of their journey.

Feedback Loop

The app offers a feedback loop. User feedback is crucial, and the app enables continuous improvement based on user suggestions and experiences.

Chapter 5: Customization and User Experience

Settings

Users can customize settings. Customization options enhance the user experience, allowing users to tailor the app to their preferences.

Guided App Introduction and Tutorial - User Training and Onboarding

The app provides a guided onboarding process. New users are guided through the app's functionalities, ensuring they are well-equipped to navigate effectively.

CHAPTER 5

Fast and Responsive Performance - Performance & Speed

The app prioritizes fast and responsive performance. Efficient route calculations and responsive interactions contribute to a seamless navigation experience.

Chapter 6: User Feedback and Experience Enhancement

In-App Feedback Mechanism - User Feedback & Improvement

The app includes an in-app feedback mechanism. Users can report issues and offer suggestions, which drive regular updates to enhance the app's performance and features.

Smooth and Enjoyable Navigation - Positive User Experience

The app focuses on delivering a smooth and enjoyable navigation experience. Personalization options, well-implemented AR features, and user testimonials collectively contribute to user satisfaction.

User Ratings and Reviews - General Opinions & Quality

The app encourages users to provide ratings and reviews. General opinions and quality assessments from users help shape the app's reputation and further improvements.

Chapter 7: Cross-Platform Availability

App Availability on Multiple Platforms - Cross-Platform Availability

The app is accessible across various platforms. Cross-platform availability ensures a wider user base and increased accessibility for users on different devices.

Chapter 8: App Ready for Navigation

User Initiates Navigation

The user enters a destination or selects a point of interest (POI) to navigate to. The navigation process commences when the user inputs a destination, setting the stage for real-time guidance.

AR Navigation Experience

The app calculates the optimal route and displays AR overlays. AR overlays provide turn-by-turn voice and visual directions, enhancing the navigation experience with real-time guidance and POI highlights.

Real-Time Traffic and Updates

The app monitors real-time traffic conditions. Real-time traffic updates inform users of road conditions, incidents, and suggest alternative routes for efficient navigation.

AR POI Exploration

Users can explore AR markers for nearby POIs. Users can interact with AR markers to access information about nearby points of interest as they approach them.

User Interaction and Feedback

The app encourages user interactions with AR elements. Continuous feedback on navigation accuracy and AR usability is gathered, enhancing the overall navigation experience.

Destination Arrival

The app alerts the user upon reaching the destination. The app guides users through the final steps, such as parking or last-minute directions to the destination.

Post-Navigation Options

Users are offered options to save the route, share it, or view past navigations. Users can save or share their navigation experiences, making it convenient for future reference or sharing with others.

End Navigation Process

The navigation process concludes with an invitation for user feedback. Users are encouraged to rate their navigation experience and provide additional feedback, contributing to ongoing improvements.

This comprehensive conceptual model illustrates the various actions, components, and interactions within the AR real-time navigation app, emphasizing user engagement, customization, and continuous enhancement. The model serves as a foundation for the development of a cutting-edge navigation app that offers a seamless and enjoyable journey for users on mobile platforms.

CHAPTER 6

Comparison of Existing Research and Conceptual Model for AR Real-Time Navigation App

6.0 Augmented Reality Navigation[40]

User Engagement

Existing Research discusses the importance of user engagement, particularly in terms of combining real-world views with location information for AR navigation. The Conceptual Model aligns with this by emphasizing user engagement through onboarding, permissions, and a smooth introduction to the navigation experience.

User Interface and AR Integration

Existing Research explores various display options for AR navigation, including video displays, optical displays, and projective displays. The Conceptual Model covers the user interface and AR integration aspect by highlighting the importance of AR overlays for navigation cues and real-time integration of AR markers.

GPS Tracking and Navigation

Existing Research underscores the significance of accurate GPS tracking and its integration with AR to create augmented reality. The Conceptual Model parallels this by emphasizing precise GPS tracking and turn-by-turn directions as essential elements of navigation.

Offline and Integration

Existing Research mentions the use of GPS and other sensors in vehicles for AR navigation and the potential for integrating external data sources. The Conceptual Model incorporates offline capabilities and integration with third-party mapping and ride-sharing services, aligning with industry standards.

Customization and User Experience

Existing Research discusses the need to balance the amount of virtual information with real-world views for a positive user experience. The Conceptual Model emphasizes customization and user experience through settings, guided onboarding, and fast, responsive performance.

User Feedback and Experience Enhancement

Existing Research suggests that AR navigation can enhance user experiences by providing additional contextual information. The Conceptual Model incorporates an in-app feedback mechanism and focuses on delivering a smooth and enjoyable navigation experience through personalization and user interaction.

Cross-Platform Availability

Existing Research mentions that smartphones are ubiquitous and suitable for both vehicular and pedestrian navigation. The Conceptual Model ensures cross-platform availability, catering to users on different devices.

In summary, the user's conceptual model aligns closely with the existing research on AR navigation, covering key aspects like user engagement, interface design, GPS tracking, offline capabilities, customization, user feedback, and cross-platform availability. The conceptual model builds upon these principles by providing a detailed roadmap for the development of a user-friendly AR real-time navigation app for mobile platforms. Both the existing research and the user's conceptual model share common ground in terms of the fundamental concepts and objectives of AR navigation. This alignment is a strong foundation for the design and development of a cutting-edge AR navigation app that offers an exceptional user experience.

6.1 CONCEPTUAL MODEL OF MOBILE AUGMENTED REALITY FOR CULTURAL HERITAGE SITE TOWARDS ENJOYABLE INFORMAL LEARNING ASPECT[41]

User Engagement

The conceptual model and existing research differ in their primary focus. The conceptual model centers on user engagement in the context of an AR navigation app, while the existing research concentrates on enjoyable informal learning at cultural heritage sites. However, both emphasize the significance of user engagement, albeit in different contexts.

User Interface and AR Integration

The conceptual model focuses a heavy emphasis on the integration of AR for navigation, a characteristic not explicitly mentioned in the prior studies. Both models recognize the significance of user interface design, but the conceptual model goes beyond by integrating augmented reality (AR) to aid navigation.

GPS Tracking and Navigation

The conceptual model's focus on GPS tracking, turn-by-turn directions, and traffic updates is distinct from the existing research, which lacks discussion in this area. While both models highlight user experience, the conceptual model places a specific emphasis on navigation features.

Offline and Integration

The conceptual model's inclusion of offline navigation and integration with external services distinguishes it from the existing research. Both models prioritize user convenience, but the conceptual model explores these aspects more comprehensively.

Customization and User Experience

The conceptual model's focus on user customization and guided onboarding processes sets it apart from the existing research. The existing research briefly mentions personalization options but does not delve into customization or user experience related to navigation. Both models emphasize user satisfaction, but the conceptual model offers more detailed insights into customization and user experience.

User Feedback and Experience Enhancement

The conceptual model's focus on gathering user feedback and enhancing the navigation experience aligns with the existing research's emphasis on user satisfaction. The existing research mentions user feedback in the context of enjoyable informal learning but does not explore it extensively. However, the conceptual model places more emphasis on the feedback loop for navigation improvement.

Cross-Platform Availability

The conceptual model's consideration of cross-platform availability is not addressed in the existing research. Both models prioritize accessibility but in different contexts.

App Ready for Navigation

The conceptual model provides a comprehensive overview of the navigation process, including post-navigation options and feedback collection, which is not present in the existing research. Both models prioritize a seamless user journey but differ in their focus areas.

Although the conceptual model and extant research diverge in their principal areas of emphasis, they do exhibit shared elements pertaining to user involvement and pleasure. The conceptual model expands upon these themes within the domain of augmented reality (AR) navigation, providing a more comprehensive examination of

navigation-related attributes and improvements. In contrast, the existing research primarily focuses on the development of an engaging educational encounter at cultural heritage sites through the utilization of AR technology. In brief, the conceptual model for the augmented reality (AR) real-time navigation application prioritizes user involvement, personalization, and seamless navigation capabilities. This separates it from previous research that primarily focuses on enhancing informal learning experiences at cultural heritage sites with an emphasis on enjoyment. Both approaches emphasize the significance of user satisfaction, but in distinct situations and with various degrees of specificity.

6.2 MOBILE AR GPS-BASED FOR NAVIGATION PURPOSE[42]

User Engagement

The conceptual framework places significant emphasis on user involvement, beginning with the initial instance of the user initiating the application. The application incorporates an onboarding procedure aimed at acquainting users with the various elements of the app, therefore facilitating a seamless initiation into the navigation experience. The existing research briefly acknowledges the interactive and enjoyable elements of augmented reality (AR) navigation, but lacks specific information about the qualities that enhance user involvement. The conceptual model lays significant importance on user involvement, providing a well-organized onboarding procedure. This discrepancy presents a significant contrast to the current body of data, which demonstrates a dearth of user-centric attributes.

User Interface and AR Integration

The conceptual framework delineates the incorporation of augmented reality (AR) into the user interface, encompassing the utilization of AR overlays to provide navigation cues. The implementation of a clean and simple user interface serves to enhance the augmented reality (AR) navigation experience by providing easily understandable indications for users to follow. The existing research examines the ways in which augmented reality (AR) improves navigation experiences, but it does not

extensively explore the specific user interface or integration aspects of AR. The conceptual model offers pragmatic guidelines for incorporating augmented reality (AR) into the user interface, therefore improving the navigation experience through the use of visual cues. The current study diverges significantly from previous studies in terms of its more theoretical orientation.

GPS Tracking and Navigation

The integration of GPS tracking and navigation plays a crucial role in the conceptual framework. The application places significant emphasis on the utilization of precise GPS tracking, providing turn-by-turn directions, offering lane assistance, and delivering real-time traffic updates. These features together contribute to the attainment of accurate and efficient navigation. The existing research addresses the use of augmented reality (AR) in the presentation of maps via the camera of a mobile device. However, it does not go into the specific navigation approaches associated with this technology. The conceptual model presents a comprehensive set of methodologies for GPS-based navigation within the augmented reality (AR) application, with a specific emphasis on achieving real-time precision and providing effective advice to users. The pragmatic methodology employed in this study diverges from the conventional research's broader discourse.

Offline and Integration

The conceptual model discusses offline functionality, allowing users to download maps for use in areas with limited connectivity. It also emphasizes seamless integration with third-party mapping services and ride-sharing apps. The available literature provides a concise mention of the possible utilization of voice integration and picture overlay in augmented navigation systems for journey route visualization. The conceptual model of the application incorporates practical functionalities, such as the provision of offline maps and seamless connection with external services, therefore augmenting the overall usefulness of the app. This is a significant divergence from the

current body of research, which has only provided a restricted analysis of prospective characteristics.

Customization and User Experience

The conceptual approach emphasizes the inclusion of customization possibilities, enabling users to personalize the application according to their own interests. Additionally, it places emphasis on providing guided onboarding processes for new users and ensuring efficient and responsive performance. The extant literature discusses the evolution of user interfaces towards increased graphical representation and immersive qualities, although it fails to provide detailed insights into specific user experience attributes. The conceptual model places emphasis on the customisation and performance aspects that are centered around the user, with the goal of enhancing the navigation experience to be more seamless and pleasurable. The strategy employed by this study, which prioritizes the needs and preferences of users, diverges from the broader viewpoint adopted by previous studies.

User Feedback and Experience Enhancement

The conceptual approach has an in-app feedback mechanism that enables users to report any concerns encountered and offer recommendations for ongoing enhancement. The extant literature provides a concise overview of the evolutionary trajectory of augmented reality technology and its prospective applications in the domain of navigation systems. The conceptual approach actively encourages user feedback and facilitates continual enhancements, hence enabling continuous improvements informed by user recommendations. This diverges from the restricted discourse on the emergence of augmented reality in previous studies.

Cross-Platform Availability

The conceptual model of the application guarantees that it is available on several platforms, allowing users to access it on a variety of devices. The extant literature discusses the evolving environment of augmented reality in the realm of mobile phones.

The conceptual framework emphasizes the significance of cross-platform compatibility, which contributes to a broader user demographic and enhanced accessibility. Concurrently, the existing body of research offers a general observation pertaining to augmented reality (AR) usage on mobile devices.

App Ready for Navigation

The conceptual model provides a comprehensive overview of the navigation process, encompassing user initiation, destination arrival, post-navigation choices, and the collecting of user feedback. The preceding study continues by acknowledging the promise of enhanced navigation systems for future generations. The conceptual model presents a complete framework for navigating the app, including the full experience. On the other hand, the existing research gives a more future-oriented viewpoint.

The conceptual model presents a pragmatic and user-oriented framework for an augmented reality (AR) navigation application, including distinct functionalities, methodologies, and approaches to user involvement. On the contrary, the existing research mostly concentrates on the theoretical dimensions of augmented reality (AR) in the context of navigation, delving into its potential advantages. The conceptual model functions as a foundational framework for the creation of a resilient augmented reality (AR) navigation application, with a focus on enhancing user contentment and facilitating ongoing enhancements.

Chapter 7

User Interface (UI) Prototype

7.0 Main Screen

Main Screen provide information related to the user's current location, nearby places of interest, and various app features.

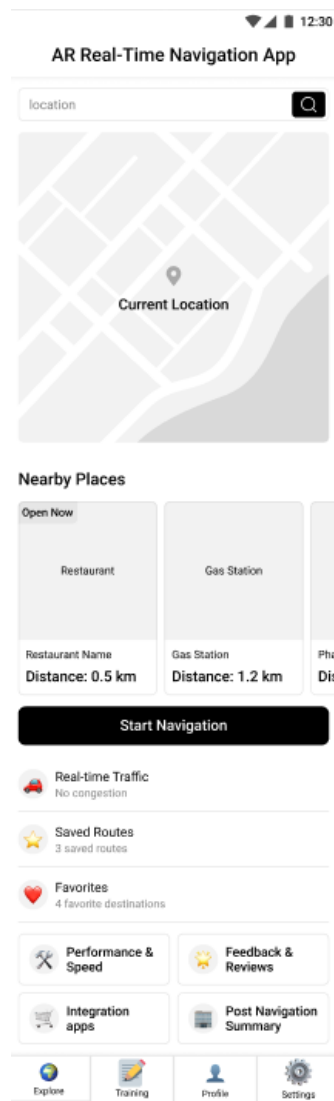


Figure 165 : Main Screen.

This section offers users information about their current location and nearby points of interest, allowing them to make informed decisions about where to go next. It also provides quick access to various app features and settings.

User Engagement and Location Search

Upon launching the AR Real-Time Navigation App, users are greeted by a welcoming main screen. Here, they have the option to search for a specific location using the search bar, ensuring that they can navigate to their desired destination with ease.

Current Location Display

Beneath the search bar, users can find a map that displays their current location. This feature helps users orient themselves and gain a visual understanding of where they are.

Exploring Nearby Places of Interest

The main screen goes a step further by offering valuable information about nearby places of interest. These places are categorized into sections like restaurants, gas stations, and pharmacies. Users can quickly identify which of these businesses are currently open and view their respective distances. This information empowers users to make informed decisions about where to go based on proximity and business hours.

Initiating Navigation

When users find a place they want to visit, they can effortlessly start their navigation journey by tapping the "Start Navigation" button. This action seamlessly transitions them to the "Navigation Screen," where they receive turn-by-turn directions, real-time traffic updates, and other relevant information for a smooth journey.

Accessing Saved Routes and Favorites

For users who prefer to revisit familiar routes or destinations, the app provides quick access to saved routes and favorite locations. By navigating to the "Saved Route Screen," users can effortlessly retrieve routes they've previously used and access their favorite destinations. This feature adds convenience and efficiency to their navigation experience.

Enhanced User Experience Through Navigation Options

Performance and Speed Screen: Users can fine-tune the app's performance settings, ensuring it operates smoothly and efficiently.

Popular Mapping Services Screen: This section offers integration with well-known mapping services, providing users with choices and flexibility in their navigation experience.

Feedback and Reviews Screen: Here, users can offer feedback and read reviews, contributing to the app's continuous improvement and helping fellow users make informed decisions.

Post Navigation Summary Screen: After completing a journey, users can review a summary of their trip, including time, distance, and stops made.

Bottom Navigation

The bottom navigation bar serves as a hub for various sections of the app. Users can explore their current location or nearby points of interest, access training materials to better understand app features, view their user profile for personalization, or configure app settings to tailor the experience to their liking. These options significantly enhance user engagement, ensuring that the app caters to their unique preferences and needs.

7.1 Navigation Screen

Navigation Screen provides detailed map view during navigation, providing users with important information about their route.

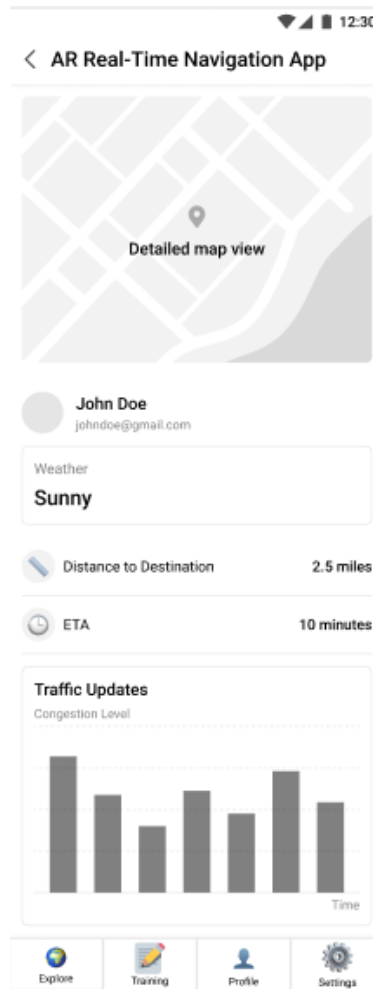


Figure 166 : Navigation Screen.

In this section, users can see detailed information about their current navigation session, including distance to the destination, estimated time of arrival, weather conditions, and traffic updates. This information helps users make informed decisions while on their journey.

Weather

Current weather conditions, which are sunny in this instance.

Navigation Information

Distance to Destination: Indicates the remaining distance to the user's destination, which is 2.5 miles in this case.

ETA (Estimated Time of Arrival): The estimated time it will take to reach the destination, which is 10 minutes here.

Traffic Updates

Congestion Level: Information about traffic congestion along the route.

Time: The current time, which can be relevant for planning the journey.

7.2 Setting Screen

Setting Screen allows users to customize various aspects of the app to meet their preferences and needs.

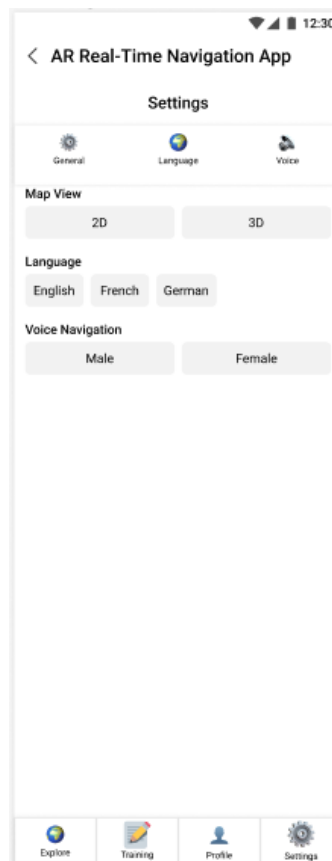


Figure 167 : Setting Screen.

In this section, users have the flexibility to adjust language preferences, voice options, and map views to tailor the app to their liking. These settings ensure that users can navigate and receive directions in a way that is comfortable and familiar to them.

General Settings

Language: Users can select their preferred language for the app's user interface.

Voice: Users can choose their preferred voice for voice-guided navigation.

Map View: Users can select between 2D and 3D map views for their navigation experience.

7.3 Feedback and Reviews Screen

Feedback and Reviews Screen provides a platform for users to share their opinions and experiences.

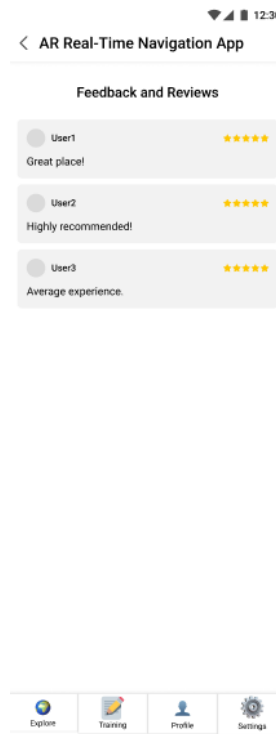


Figure 168 : Feedback and Reviews Screen.

In this section, users can read and contribute feedback and reviews about their experiences with the app. It provides valuable insights for both the app developers and potential users, helping to improve the app's quality and inform others about its performance and features.

7.4 Saved Routes Screen

Saved Routes Screen allows users to access and manage their previously saved navigation routes.

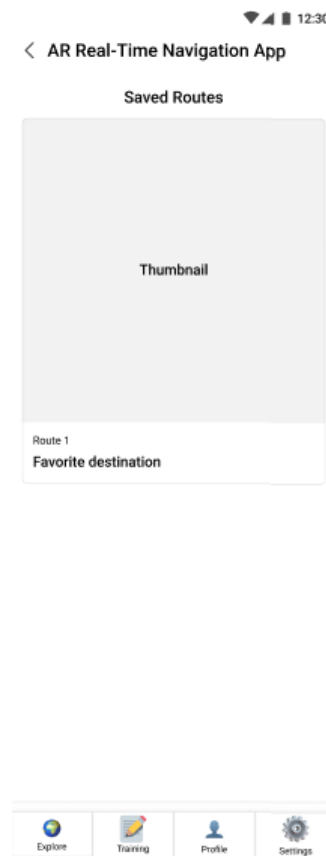


Figure 169 : Saved Routes Screen.

In this section, users can access their saved routes, making it convenient to revisit frequently traveled paths or favorite destinations. The inclusion of a "Favorite Destination" tag suggests that users can prioritize and organize their saved routes based on their preferences.

7.5 Point of Interests Screen (POI)

Point of Interests exploration Screen (POI) provides users with information about nearby places of interest.

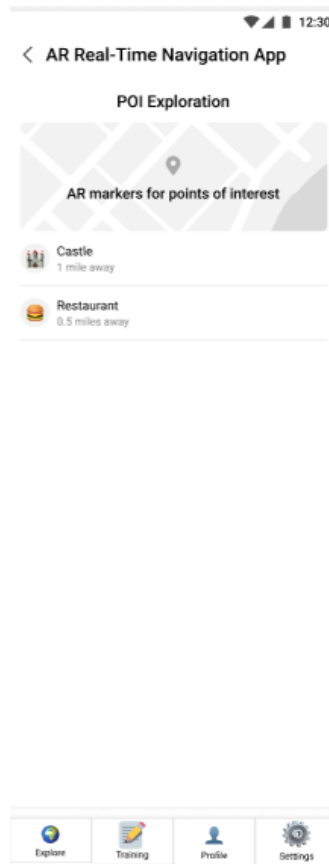


Figure 170 : Point of Interests Screen.

This section indicates that the user is in the POI Exploration mode, where users can see AR markers representing nearby points of interest, such as a castle and a restaurant, along with their respective distances.

7.6 Offline and Integration Screen

Offline and Integration Screen combines features related to offline functionality and integration with various services.

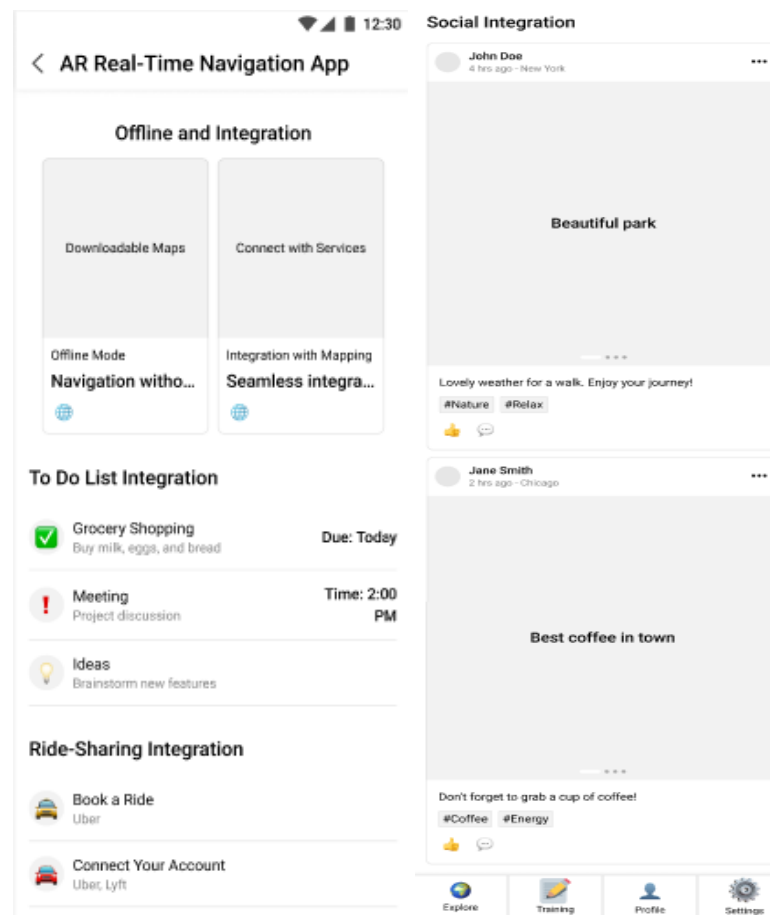


Figure 171 : Offline and Integration Screen.

This screen provides users with a consolidated view of various features and integrations, including offline mode, to-do lists, ride-sharing bookings, and social media updates. It offers a holistic experience by combining navigation-related functions with productivity and social features.

Downloadable Maps

Offline Mode: This section allows users to activate an offline mode, enabling navigation even in areas with limited or no connectivity. Offline mode ensures that users can rely on the app's navigation features without requiring a constant internet connection.

Integration with Mapping: This subsection indicates that the app seamlessly integrates with third-party mapping services. Users can access the power and precision of popular mapping platforms within the app, enhancing their navigation experience.

To-Do List Integration

Users could list down tasks related to grocery shopping upcoming meetings, jot down and organize creative ideas or brainstorming process.

Ride-Sharing Integration

Book a Ride: This button allows users to initiate the process of booking a ride with a ride-sharing service, enhancing their mobility options while using the navigation app.

Connect Your Account: This button enables users to connect their accounts with ride-sharing services like Uber and Lyft, streamlining the booking process and providing a more integrated experience.

Social Integration

Users could create social media post and discover related content from other users.

7.7 Downloadable Maps for Offline Use Screen

Downloadable Maps for Offline Use Screen offers users to download maps for offline use, monitor download progress, and view download summaries.

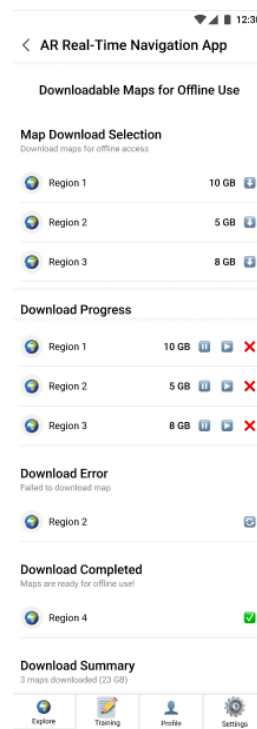


Figure 172 : Downloadable Maps for Offline Us Screen.

This screen provides users with the ability to download maps for offline use, monitor download progress, handle errors, and view a summary of downloaded maps. It enhances the app's usability in areas with limited connectivity, ensuring that users can navigate effectively even without an internet connection.

Map Download Selection

Download maps for offline access: A call to action allowing users to select and download maps for offline use.

Regions for Download

Various regions are available for download, indicating its size.

Download Progress

CHAPTER 7

Users could perform actions such as pause, play or cancel the download.

Download Error

Failed to download map: An indication that there was an error while downloading a specific map.

Download Completed

Maps are ready for offline use!: A message indicating that the map download process is complete.

Download Summary

3 maps downloaded (23 GB): A summary of the total number of maps downloaded and their combined size.

7.8 Popular Mapping Services Screen

Popular Mapping Services Screen offers users to select and configure popular mapping services and other integrations.

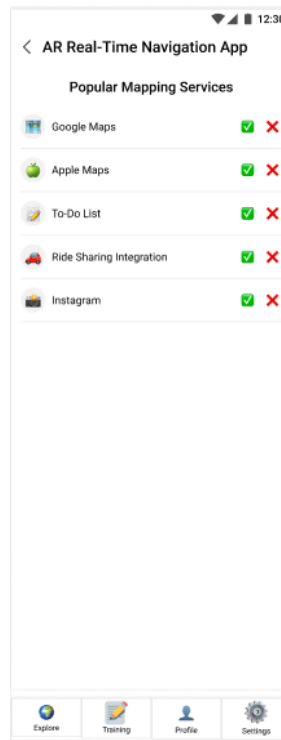


Figure 173 : Popular Mapping Services Screen.

Mapping Services and Integrations

This screen allows users to configure their preferences for various mapping services and integrations within the app. They can enable or disable specific services based on their preferences.

7.9 Post Navigation Summary Screen

Post Navigation Summary Screen offers a concise overview of a completed journey.

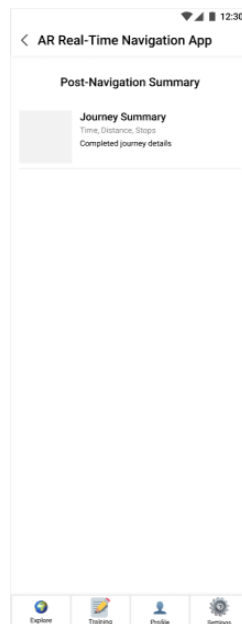


Figure 174 : Post Navigation Summary Screen.

This screen serves as a post-navigation summary, providing users with essential information about their completed journey. Users can review details such as the time taken, distance traveled, and stops made, enhancing their overall navigation experience.

Journey Summary

Time, Distance, Stops: This section displays key information about the completed journey, including the time taken, the distance traveled, and the number of stops made during the journey.

Completed Journey Details: This area may offer a more detailed breakdown of the journey, including the route taken, points of interest visited, and any notable events or stops.

7.10 Performance and Speed Screen

Performance and Speed screen provides users with a quick overview of the app's performance, speed, and data usage.



Figure 175 : Performance and Speed Screen.

The performance ratings help users understand how well the app is functioning, and the data usage information allows them to monitor their data consumption.

Performance Metrics

Performance: A section where users can check the overall performance of the app.

Speed: A section where users can check the app's speed and responsiveness.

Data Usage: A section where users can view the amount of data the app is using.

Performance Ratings

Excellent: A rating indicating that the app's performance is excellent.

Fast: A rating indicating that the app is fast and responsive.

Low: A rating indicating that the app has low data usage.

7.11 User Training and Onboarding Screen

User Training and Onboarding screen allows users to access tutorials and educational content to learn how to use the app effectively.

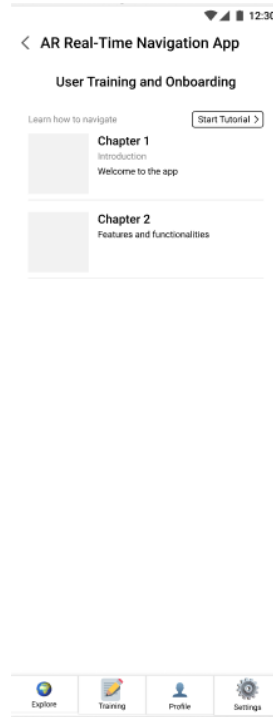


Figure 176 : User Training and Onboarding Screen.

It provides access to a tutorial that introduces them to the app's features and functionalities, making it easier for them to navigate and utilize the app's capabilities.

Start Tutorial: A button that users can click to begin the tutorial.

Tutorial Chapters

Chapter 1: Introduction: The first chapter of the tutorial, which likely introduces users to the app's basic concepts and functionality.

Chapter 2: Features and Functionalities: The second chapter of the tutorial, focusing on explaining the various features and capabilities of the app.

7.12 Profile Screen

Profile screen provides users with a comprehensive overview of their app usage, allows them to manage their preferences, and offers options for contacting support and providing feedback.

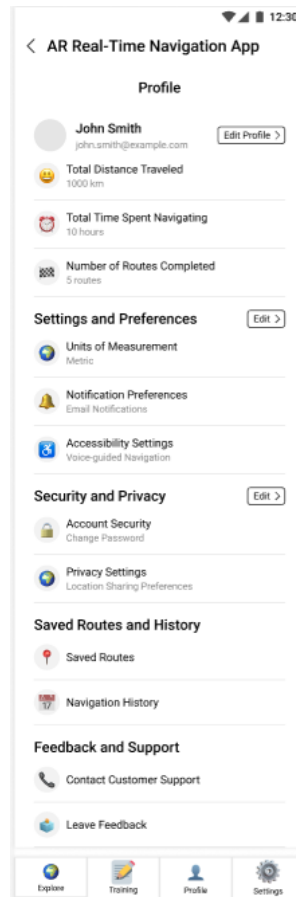


Figure 177 : Profile Screen.

Header: Display the user's profile picture or avatar at the top of the screen.

User Information:

- User's name or username.
- User's email or contact information.
- Edit Profile button to allow users to update their information.

Navigation Statistics:

- Total distance traveled.
- Total time spent navigating.
- Number of routes completed.

Settings and Preferences:

- Options to customize app settings (e.g., units of measurement, language preferences).
- Notification preferences (e.g., email notifications for updates).
- Accessibility settings (e.g., voice-guided navigation preferences).

Security and Privacy:

- Account security options (e.g., change password, two-factor authentication).
- Privacy settings (e.g., location sharing preferences).

Saved Routes and History:

- Access to saved routes and navigation history.
- A list of previously completed routes with dates and destinations.

Feedback and Support:

- Provide options for users to contact customer support or leave feedback about the app.

Log Out:

- A button to log out of the app.

UI Interface link:

<https://www.figma.com/file/iB4jU9vQXIVF92zN5Mn2eI/fyp2?type=design&node->

Chapter 8

Research Gaps

Within the field of Sentiment Analysis, a significant deficiency that may be seen is to the absence of comprehensive sentiment interpretation. Although the code successfully creates an encompassing sentiment score and categorization (Positive, Negative, Neutral), it lacks in delivering a comprehensive analysis of sentiment patterns and a deeper understanding of the factors influencing individual attitudes. In order to enhance the analysis, it is imperative to undertake a more comprehensive examination that provides a contextual framework and thorough elucidation of the emotion ratings. Moreover, within the domain of Visualization, the current code predominantly depends on a histogram as a means of representing the distribution of sentiment. Although the above explanation offers a foundational comprehension, additional visual representations, such as graphical depictions of sentiment trends over time or segmented by different versions of the application, might provide a more thorough and nuanced knowledge of the dynamics of user sentiment. Therefore, it is advisable to investigate supplementary visualization approaches to enhance the analysis.

Several research gaps were discovered within the context of Topic Modeling using Latent Dirichlet Allocation (LDA). Firstly, in regard to Data Collection and Preprocessing, the research inadequately addresses the issue of unidentified users. During the data collecting phase, reviews from users identified as 'A Google user' were not eliminated. In order to improve the quality of data, it is recommended to exclude reviews from individuals whose identities are unknown, since this ensures that the analysis is grounded in identified and trustworthy sources. Additionally, the procedure of LDA modeling has uncovered a further deficiency in the restricted quantity of topics that were retrieved from the reviews. Selecting merely two themes may not sufficiently encompass the range of user thoughts and input. In order to enhance the comprehensiveness of user opinions, it is advisable to augment the quantity of themes inside the LDA modeling procedure.

One notable deficiency within the Conceptual Model is to the insufficient attention given to the subject of Data Privacy and Security. The utilization of AR navigation applications necessarily entails the acquisition and analysis of geographical information, hence giving rise to significant apprehensions regarding user privacy and potential susceptibilities in terms of security. In order to advance the field, it is imperative that future research places a high priority on the exploration of resilient methodologies for safeguarding user data and guaranteeing the security of data transmission. Furthermore, it is important to conduct a comprehensive evaluation and highlight adherence to pertinent data protection legislations. One further area of study that warrants attention is the verification of the conceptual framework. Although the model offers a thorough framework, it is important to note that it still needs empirical validation through user testing and feedback. In order to ascertain the congruence between the conceptual model and the practical requirements and preferences of users, it is recommended that next research endeavors integrate user studies as a means of validation.

Chapter 9

9.0 Results

In conclusion, the sentiment analysis conducted on user reviews for four AR GPS navigation apps - PinnAR, AR GPS Compass Map 3D, AR GPS Drive, and AR GPS Navigation 2021 GPS Map - consistently revealed an overwhelming positive sentiment among users. Both the VADER sentiment analysis model and the Transformers sentiment analysis model indicated high levels of user satisfaction with these applications. PinnAR, AR GPS Compass Map 3D, and AR GPS Drive received moderately positive sentiment scores, while AR GPS Navigation 2021 GPS Map stood out with an exceptionally high level of positive sentiment. These findings provide valuable insights for developers, highlighting the strong user appreciation for these apps and offering a clear path for further improvements. User feedback, as expressed through sentiment analysis, underscores the success of these AR GPS navigation solutions in meeting user needs and expectations, making them valuable tools for navigation and exploration.

The LDA topic modeling process revealed distinct topics related to app performance, user experience, and functionalities. Pinn AR showed topics related to map-related applications, user needs, and performance. AR GPS Compass Map 3D discussed topics related to app performance, user satisfaction, and app quality. AR GPS Drive had topics related to app functionality, user experience, and integration with Google Maps. AR GPS Navigation 2021 GPS Map focused on GPS and navigation applications with AR features and user satisfaction.

Both the conceptual model and existing research highlight the crucial role of user engagement in the success of an AR real-time navigation app. However, the conceptual model goes a step further by introducing a structured onboarding process that guarantees a seamless introduction to the navigation experience. This user-centric approach significantly enhances the initial interaction users have with the app, setting it apart from existing research.

One standout feature of the conceptual model is its practical implementation of augmented reality (AR) within the user interface, incorporating AR overlays for navigation cues. This innovative approach provides users with clear and intuitive visual guidance, thereby enhancing their overall navigation experience. In contrast, existing research acknowledges the potential benefits of AR but lacks specific insights into how to integrate it effectively within the user interface.

The conceptual model places significant emphasis on GPS accuracy and navigation features, including turn-by-turn directions and real-time traffic updates. These features are instrumental in ensuring precise and efficient navigation. In contrast, existing research primarily discusses AR's role in presenting maps but does not delve into the specifics of navigation techniques.

Setting the conceptual model apart is its inclusion of offline functionality, allowing users to download maps for use in areas with limited connectivity. Furthermore, its seamless integration with external services enhances the app's overall usability. While existing research briefly mentions potential features, it lacks the in-depth implementation details presented in the conceptual model.

The conceptual model prioritizes user customization options and offers guided onboarding for newcomers. Its commitment to fast and responsive performance further enhances the overall user experience. In contrast, existing research mentions graphical interfaces but does not provide specific features related to user experience.

The conceptual model distinguishes itself by actively promoting user feedback through an in-app mechanism. This user-centric approach allows for continuous improvements based on user suggestions and experiences. Conversely, existing research touches on the evolution of AR but overlooks the importance of incorporating user feedback mechanisms.

Another noteworthy aspect of the conceptual model is its commitment to cross-platform availability, ensuring that the app can be accessed on various devices. This strategic decision aims to broaden the user base and increase accessibility. In contrast,

existing research acknowledges the changing landscape of AR on mobile devices but does not delve into the considerations of cross-platform compatibility.

The conceptual model provides a comprehensive roadmap for the entire navigation journey within the app, from user initiation to destination arrival and post-navigation options. It places a strong focus on the user's entire journey within the app. Existing research concludes with a more forward-looking perspective.

In conclusion, the conceptual model for the AR real-time navigation app improves upon existing research by offering a practical and user-centric approach to AR navigation. It provides detailed features and techniques for enhancing the user's navigation experience, ensuring accuracy, usability, and engagement. This model serves as a valuable blueprint for the development of an effective and user-friendly AR navigation application.

9.1 Conclusion

In summary, the sentiment analysis performed on user evaluations pertaining to four augmented reality (AR) GPS navigation applications, namely PinnAR, AR GPS Compass Map 3D, AR GPS Drive, and AR GPS Navigation 2021 GPS Map, consistently revealed a predominant expression of positive attitude among the users. Both the VADER sentiment analysis model and the Transformers sentiment analysis model demonstrated significant levels of user satisfaction with these apps. PinnAR, AR GPS Compass Map 3D, and AR GPS Drive were found to have gotten sentiment scores that were relatively favorable. However, AR GPS Navigation 2021 GPS Map stood out in particular, as it garnered an extraordinarily high degree of positive sentiment. The aforementioned findings give significant insights for developers, underscoring the high level of user satisfaction with these applications and presenting a distinct trajectory for future enhancements. The sentiment analysis of user feedback highlights the efficacy of these augmented reality (AR) GPS navigation systems in fulfilling user requirements and satisfying their expectations, therefore establishing them as important instruments for navigation and exploration.

The process of LDA topic modeling unveiled discrete themes pertaining to application performance, user experience, and functions. The Pinn AR study included many subjects pertaining to map-based applications, user requirements, and performance. The themes addressed in the AR GPS Compass Map 3D discussion encompassed aspects pertaining to the performance of the application, the level of pleasure experienced by users, and the overall quality of the program. The AR GPS Drive application encompassed subjects pertaining to the functioning of the app, the user experience, and the connection of the app with Google Maps. The AR GPS Navigation 2021 GPS Map is a software program that primarily emphasizes GPS technology and navigation functionalities, while also including augmented reality (AR) capabilities.

The significance of user engagement in the effectiveness of an augmented reality (AR) real-time navigation application is emphasized by both the conceptual

model and previous research. However, the conceptual model extends its functionality by incorporating a well-organized onboarding procedure that ensures a smooth initiation into the navigation interface. The use of a user-centric strategy greatly improves the initial engagement that users have with the application, distinguishing it from previous research efforts.

A notable characteristic of the conceptual model is its effective integration of augmented reality (AR) into the user interface, wherein AR overlays are utilized to provide navigation cues. This creative method improves the entire navigation experience for users by offering clear and understandable visual advice. On the other hand, extant literature recognizes the potential advantages of augmented reality (AR); yet, it exhibits a dearth of precise understandings regarding the optimal methods for seamless integration of AR inside the user interface.

The conceptual model lays considerable emphasis on the accuracy of GPS and navigation capabilities, including turn-by-turn directions and real-time traffic updates. These characteristics play a crucial role in guaranteeing accurate and effective navigation. In contrast, the scholarly literature predominantly focuses on the function of augmented reality (AR) in the presentation of maps, while providing limited exploration of the specific navigation strategies employed.

The distinguishing characteristic of the conceptual model is in its incorporation of offline capability, enabling users to download maps for utilization in regions with restricted connection. Moreover, the app's general usefulness is enhanced by its smooth connection with external services. Although previous studies touch upon certain characteristics, they fail to provide the comprehensive implementation specifics outlined in the conceptual framework.

The conceptual model places emphasis on user customization possibilities and provides guided onboarding for those who are new to the system. The dedication to swift and efficient performance serves to augment the entire user experience. In contrast, previous scholarly investigations discuss graphical interfaces, although fail to offer explicit details on user experience-related functionalities.

The conceptual approach differentiates itself by actively facilitating feedback from users through an in-app method. The use of a user-centric strategy facilitates ongoing enhancements informed by user feedback and experiences. On the contrary, extant literature addresses the evolutionary aspects of augmented reality (AR) while neglecting the significance of integrating user feedback methods.

An additional salient feature of the conceptual model is to its dedication to cross-platform accessibility, hence guaranteeing the application's use across several devices. The primary objective of this strategy choice is to expand the user demographic and enhance the level of accessibility. On the contrary, extant literature acknowledges the dynamic nature of augmented reality (AR) on mobile devices; yet, it falls short in thoroughly examining the implications of cross-platform compatibility.

The conceptual model offers a thorough framework outlining the full process of navigating within the application, encompassing user initiation, destination arrival, and further post-navigation choices. The application lays significant emphasis on the comprehensive user experience during the full duration of interaction. Previous studies have reached a conclusion that adopts a future-oriented viewpoint.

In summary, the conceptual model employed in the AR real-time navigation application enhances previous research efforts by presenting a pragmatic and user-oriented strategy for augmented reality navigation. This resource offers comprehensive information on various features and methodologies aimed at improving the user's navigation experience, with a focus on strengthening accuracy, usability, and engagement. The aforementioned model functions as a beneficial framework for the creation of an efficient and user-centric augmented reality navigation application.

9.2 Recommendations

Future research in the field of AR real-time navigation apps should prioritize several key areas for improvement and exploration. The ongoing evolution of user-centric development necessitates a continued emphasis on the enhancement of user interfaces. It is imperative for researchers to undertake investigations into the development of intuitive and user-friendly interfaces that effectively include augmented reality (AR) components. This entails ensuring that navigation cues and information are provided in a clear and efficient manner.

Furthermore, it is imperative for researchers to dedicate efforts towards enhancing onboarding procedures in order to provide thorough introductions to application functions, accommodating the needs of both inexperienced and proficient users. There is a need to enhance the range of customization choices available to users, enabling them to personalize their navigation experience based on their own tastes. This may encompass the implementation of adaptable augmented reality overlays, personalization through voice commands, and the configuration of settings tailored to individual users.

Future study should aim to investigate novel methods for improving augmented reality (AR) overlays in terms of integration. The investigation of more immersive and context-aware augmented reality (AR) markers might be undertaken by researchers, with the aim of assuring the provision of pertinent and timely information to users. Moreover, the integration of real-time object identification holds significant potential as it enhances the functionality of augmented reality (AR) navigation applications by enabling them to identify and furnish pertinent details regarding tangible things and impediments inside the physical environment.

In order to optimize the use of augmented reality (AR) navigation, it is imperative to prioritize the precision of GPS technology and the timely provision of

real-time location updates. Academic researchers want to prioritize the enhancement of GPS tracking technology, particularly in densely populated metropolitan environments and regions with restricted signal availability. Additionally, there is a need to develop more intricate and adaptable turn-by-turn navigation instructions. The incorporation of lane assistance and extensive real-time traffic information has the potential to greatly enhance the functionality of these applications.

The enhancement of offline capabilities is of utmost importance in order to accommodate consumers located in rural or low-connectivity regions. It is imperative for researchers to investigate techniques aimed at enhancing the efficiency of map data storage and updating processes. This would facilitate the ability of users to download maps for offline usage, while simultaneously decreasing the amount of storage space required.

The importance of addressing the different landscape of mobile devices and platforms is equally emphasized in ensuring cross-platform compatibility. It is imperative for researchers to prioritize the development of augmented reality (AR) navigation applications that can be used across a multitude of operating systems and devices, encompassing smartphones, tablets, and wearable technologies.

Moreover, it is important to consider the importance of security and privacy. Future research should prioritize the development of reliable methods aimed at safeguarding user location data and personal information against potential threats or unauthorized usage.

It is imperative for environmental impact studies to thoroughly examine the energy consumption and sustainability aspects of augmented reality (AR) navigation applications, with the objective of mitigating their carbon emissions and resource use. In order to optimize the overall navigation experience, it is recommended that researchers go into the realm of multi-modal navigation. This entails the integration of

many modes of interaction, such as voice commands, gesture control, and haptic feedback, in order to provide a more immersive and intuitive user experience.

Furthermore, it is imperative for researchers to take into account the potential for specialized applications of augmented reality (AR) navigation that extend beyond the realm of general navigation. Sectors such as healthcare, logistics, and industrial environments may possess distinctive utilization scenarios and prerequisites that need additional scrutiny.

Longitudinal user experience studies are crucial for monitoring user adaptation and interaction with augmented reality (AR) navigation applications over prolonged durations. These studies have the potential to offer useful insights into the preferences of users, their pain areas, and their increasing demands. This, in turn, can facilitate ongoing progress in the rapidly changing field of augmented reality (AR) real-time navigation.

In summary, it is recommended that future studies pertaining to augmented reality (AR) real-time navigation applications prioritize the improvement of user interfaces, the augmentation of customization options, and the advancement of unique AR overlays. Additionally, it is imperative that the application places a high priority on ensuring GPS accuracy, offline functionality, cross-platform compatibility, as well as maintaining robust security measures and safeguarding user privacy. The continued advancement and enhancement of augmented reality (AR) navigation solutions may be facilitated by the investigation of environmental implications, the adoption of multi-modal navigation techniques, the development of specialized apps, and the implementation of long-term user experience research.

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APPENDIX

Questionnaire Sample

A STUDY ON THE REAL-TIME NAVIGATION IN AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE PLATFORM

Dear Respondents, I am Ting Qiao Thong, a final-year Bachelor of Information Systems (Honours) Business Information Systems student at the University Tunku Abdul Rahman Kampar Campus.

I'm performing research on real-time navigation in augmented reality (AR) technologies for mobile platforms. The study's aims are to research user preferences and needs of young adults for AR real-time navigation, as well as to offer a conceptual model for designing an engaging and captivating real-time augmented reality navigation experience for mobile platforms. This survey is critical for my research since it allows me to finish my final year project.

Your comments will be kept private and confidential, and will only be used for educational and research purposes. Your insightful replies would be extremely beneficial to the study.

Participation in the survey is entirely voluntary, and you are free to leave the study at any moment. Please keep in mind that there is no right or wrong response to any statement. If you have any inquiries about this survey, please contact me at tqt1001@utar.my.

Thank you so much for your time and support in advancing this study. Your time and patience in completing this survey would be greatly appreciated.

1. Age

- 17 - 20
- 21 - 25
- 26 – 30

2. Gender

- Male
- Female
- Other...

3. Occupation status

- Employed
- Unemployed
- Full-time student

APPENDIX

- Other...

4. Education level

- Primary level
- Secondary level
- Foundation/Diploma
- Bachelor's degree
- Master's degree
- PHD
- Other...

5. Do you have any prior experience in the technological field? (exp. IT, AI, Robotics, Internet of Things, Virtual Reality, Biotechnology, Renewable Energy, Website Design, etc.)

- Yes
- No

6. Have you ever heard of any Real-Time Navigation in AR technology?

- Yes (Please proceed to Section 2 - Questions 7 - 17)
- No (Please proceed to Section 3 - Questions 18 - 22)

After section 1

Section 2 of 3

Section 2 - Users with prior experience using Real-Time Navigation in AR technology

7. Which of the following are your most frequently used AR Real-Time Navigation Applications?

- Pinn AR
- AR GPS Drive
- AR GPS Compass Map 3D
- AR GPS Navigation 2021 GPS Map
- Sygic Navigation and Apps
- Wikitude
- Augmentra ViewRanger
- Google Maps
- GPS Map Camera Lite
- Komoot: Bike Trails & Routes
- Spyglass
- Magic Earth Navigation & Maps

APPENDIX

8. How frequently do you use AR Real-Time Navigation Apps?

- Once per day
- 2-4 times per day
- 4 times or more per day
- Once per week
- 2-4 times per week
- 5-6 times per week
- Once per month or less
- 1-3 times per month

9. What prompted you to utilize the AR Real-Time Navigation Apps today?

- Convenience and easier navigation
- Improved safety and efficiency
- Growing popularity of AR technology
- Real-time visualization for both text and graphics
- Provide real-time data on traffic jams and nearby accidents
- Able to explore the environment in a more intuitive and immersive way
- Provide interactive and engaging experience
- Provide additional information and context to the user
- Emergency response situations to provide critical information and directions to first responders
- Provide a more accessible way for people with disabilities
- Other...

10. What is your top priority when it comes to using AR Real-Time Navigation Apps?

- Customization and personalization features
- Accuracy and Reliability
- Privacy and security
- Real-time navigation
- User-friendly interface
- Integration with other apps and services
- Compatibility with different devices and platforms
- Offline navigation
- Augmented reality points of interest
- Safety features
- Social features
- Multilingual support
- Battery life
- Real-time collaboration
- 3D mapping
- Voice commands
- Other...

APPENDIX

11. Which aspects are the least significant to you?

- Social features
- Customization options
- Gamification elements
- 3D models or animations
- Integration with other apps
- Customizable avatars
- Branding and advertising
- Access to additional information
- In-app purchases
- Augmented reality effects
- Voice assistants or chatbots
- Advanced analytics
- Virtual reality experiences
- Traffic data
- Social media integration
- Music integration
- Community-based features
- Virtual assistants or chatbots
- Other...

12. In your opinion, what are the concerns related to information security and privacy when using AR Real-Time Navigation Apps?

- Third-party data sharing
- Physical safety concerns
- Privacy in public spaces
- Compatibility with other apps
- Location data privacy
- Personal data security
- Malware and hacking
- Device permissions
- Data retention
- Biometric data
- In-app purchases
- Social engineering
- Data breaches
- Lack of transparency
- User profiling
- Geolocation tracking
- Other...

13. What additional features would you like to see in the future to enhance your user experience?

- Integration with public transportation

APPENDIX

- Enhanced personalization
- Augmented reality indoor navigation
- Improved accessibility features
- Environmental and sustainability features
- Integration with other apps
- 3D mapping
- Gamification
- Offline functionality
- Multi-lingual support
- Voice commands
- Real-time traffic updates
- Community-based reporting
- Sustainability
- Safety features
- Integration with smart devices
- Augmented reality advertising
- Other...

14. How likely are you to suggest the AR Real-Time Navigation Apps to family, friends, or colleagues?

Extremely unlikely

- 1
- 2
- 3
- 4
- 5

Extremely likely

15. In your perspective, how has AR enhanced existing 2D Navigation Apps?

- Visual aids
- Personalization
- More accurate and intuitive navigation
- Better context awareness
- Improved safety
- Interactive and engaging experience
- Multi-modal navigation
- Integration with other apps
- Accessibility
- Real-time information sharing
- Environmental awareness
- Enhance natural language processing
- Other...

APPENDIX

16. What do you believe is the most significant hurdle to VR and AR technologies today?

- The need for more powerful and affordable hardware
- High cost
- Application development
- User experience
- Social and ethical implications
- Motion sickness
- Hardware limitations
- Content creation
- User adoption
- Privacy concerns
- Interoperability
- Social acceptance
- Ethical concerns
- Limited physical movement
- Other...

17. Do you prefer 2D Navigation Apps or AR Real-Time Navigation Apps?

- Existing 2D Navigation Apps
- AR Real-Time Navigation Apps

After section 2

Section 3 of 3

Section 3 - Users who are unfamiliar with the use of Real-Time Navigation in AR technology

18. What kinds of navigation tools do you typically use when traveling or exploring new places?

- Google Maps
- Waze Navigation & Live Traffic
- TomTom GO Navigation
- HERE WeGo: Maps & Navigation
- MapQuest: Get Directions
- Sygic GPS Navigation & Maps
- Citymapper: All Your Transport
- Transit: Bus & Subway Times
- Komoot: Bike Trails & Routes
- Scout GPS Link
- Gaia GPS: Offroad Hiking Maps
- OsmAnd — Maps & GPS Offline

APPENDIX

19. What features do you look for in a navigation app or tool?

- Accurate and up-to-date maps
- Turn-by-turn directions
- Real-time traffic updates
- Points of interest
- Offline capabilities
- Integration with other apps or service
- Traffic and road conditions
- Customization and personalization
- Voice and visual guidance
- Battery and data usage
- 20. How do you think AR real-time navigation apps might be different from other navigation apps you have used before?
- Visual experience
- Real-time information
- Interactive features
- Hands-free operation
- More dynamic and personalized navigation
- More immersive and engaging experience
- More accurate and intuitive

21. What concerns or reservations do you have about using AR real-time navigation apps?

- Privacy and security concerns
- Technical issues (Battery life, compatibility and connectivity)
- Potential distractions or safety risks
- Reliance on technology and potential loss of traditional navigation skills
- Reliability and accuracy
- Concerns about the cost of AR-enabled devices
- Limited availability and accessibility of AR real-time navigation apps in certain areas
- Learning curve

22. Are you interested in trying out AR real-time navigation apps in the future?

- Yes
- No

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 6
Student Name & ID: Ting Qiao Thong 19ACB03014	
Supervisor: Ts. Saw Seow Hui	
Project Title: THE CONCEPTUAL MODEL FOR THE REAL-TIME NAVIGATION IN AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE PLATFORM	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

Over the past fortnight, I concentrated on analyzing user preferences and requirements for AR real-time navigation on mobile platforms. This entailed synthesizing data obtained from existing AR real-time navigation apps, survey responses, and data collected through sentiment analysis and topic modeling. This approach allowed me to extract valuable insights.

2. WORK TO BE DONE

My upcoming task involves drawing the conceptual model. I will utilize and consolidate the data gathered from sentiment analysis, topic modeling, and survey responses. The aim is to create a comprehensive conceptual model for AR real-time navigation that encapsulates the key features and enhancements that users desire.

3. PROBLEMS ENCOUNTERED

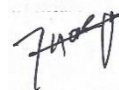
One potential challenge is ensuring that the conceptual model I create accurately reflects user preferences and requirements based on the collected data.

4. SELF EVALUATION OF THE PROGRESS

I'm pleased to report that the data integration phase went more smoothly than anticipated. The synergy between data sources provided a holistic understanding of user preferences and requirements for AR real-time navigation.



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 8
Student Name & ID: Ting Qiao Thong 19ACB03014	
Supervisor: Ts. Saw Seow Hui	
Project Title: THE CONCEPTUAL MODEL FOR THE REAL-TIME NAVIGATION IN AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE PLATFORM	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

Building upon the integrated data, I embarked on the process of drawing the conceptual model. The goal is to represent the key features, enhancements, and user expectations for AR real-time navigation. The conceptual model is taking shape and aligns well with the insights gained from data analysis. It incorporates user preferences and requirements, making it a valuable framework for guiding the development of AR navigation systems.

2. WORK TO BE DONE

In the upcoming weeks, I will continue refining and finalizing the conceptual model. This ensures it accurately represents the synthesized data and aligns with the project's objectives. Additionally, I will conduct a detailed analysis of existing research, focusing on their methodologies, findings, and contributions to the field of AR real-time navigation. The comparison with the conceptual model will allow me to identify synergies and areas for enhancement. Furthermore, I will review the insights gathered from data analysis and the conceptual model to identify key user requirements, preferences, and expectations for AR real-time navigation on mobile platforms.

3. PROBLEMS ENCOUNTERED

One challenge has been ensuring that all relevant information was considered during the integration of data. This meticulous task required careful attention to detail to avoid overlooking critical insights.

4. SELF EVALUATION OF THE PROGRESS

Drawing the conceptual model necessitated creativity and the ability to translate abstract findings into a visual representation. This process is ongoing and may require further refinement.

APPENDIX



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 10
Student Name & ID: Ting Qiao Thong 19ACB03014	
Supervisor: Ts. Saw Seow Hui	
Project Title: THE CONCEPTUAL MODEL FOR THE REAL-TIME NAVIGATION IN AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE PLATFORM	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

I focused on comparing the findings and insights from existing research with the components of my conceptual model. This involved reviewing the insights gathered from data analysis and the conceptual model to identify the key user requirements, preferences, and expectations for AR real-time navigation on mobile platforms. Additionally, I initiated planning for the scope and complexity of my UI prototype, determining the number of screens or interactions based on the project's objectives.

2. WORK TO BE DONE

My upcoming tasks include:

UI Prototype Development

- Starting by creating wireframes for each screen or interaction.
- Refining the wireframes by adding visual elements such as buttons, icons, text, and images.
- Utilizing Figma's interactive features to transform the wireframes into a functional prototype.
- Adding clickable elements and defining the interactions between screens.
- Creating comprehensive documentation that explains the purpose and functionality of each screen in the prototype.

3. PROBLEMS ENCOUNTERED

Designing an effective UI prototype that meets user requirements and preferences while ensuring usability can be challenging. It's crucial to ensure that the UI is visually appealing without compromising usability.

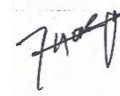
4. SELF EVALUATION OF THE PROGRESS

APPENDIX

Creating the UI prototype using Figma is a critical phase that bridges the gap between research findings and practical design. This phase requires meticulous attention to detail and iterative refinement based on feedback. I remain committed to producing a user-friendly and visually appealing UI prototype that aligns with the project's objectives and contributes to the field of AR real-time navigation.



Supervisor's signature



Student's signature

POSTER

UTAR Faculty of Information and Technology



Enhancing Navigation through User-Centered AR Technology

THE CONCEPTUAL MODEL FOR THE REAL-TIME NAVIGATION IN AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE PLATFORM

Background and Opportunity

- Traditional maps and GPS pose challenges in navigation.
- AR technology offers unique navigation enhancement opportunities.

Objectives

- Collect user preferences data via a survey.
- Analyze preferences, literature, and app data to identify vital features.
- Propose a conceptual model for interactive AR navigation.

Proposed Method

- Conduct a user preferences survey.
- Perform sentiment analysis and topic modeling on AR navigation apps.
- Propose a model based on preferences, accuracy, reliability, and data availability.





Why Conceptual Model?

- Structured Onboarding
- AR Integration
- GPS Accuracy
- Offline Functionality
- User Customization
- User Feedback
- Cross-Platform Availability
- Comprehensive User Journey

Conclusion

- The conceptual model offers a user-centric approach to AR navigation.
- Practical and detailed features enhance user navigation experiences.
- It serves as a blueprint for user-friendly AR navigation applications.

Project Researcher: Ting Qiao Thong
Project Supervisor: Ts Saw Seow Hui

PLAGIARISM CHECK RESULT

THE CONCEPTUAL MODEL FOR THE REAL-TIME NAVIGATION
IN AUGMENTED REALITY (AR) TECHNOLOGY FOR MOBILE
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ID Number(s)	19ACB03014
Programme / Course	FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY BACHELOR OF INFORMATION SYSTEMS (HONOURS) BUSINESS INFORMATION SYSTEMS
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