SMART REFRIGERATOR

BY

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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

UNIVERSITI TUNKU ABDUL RAHMAN

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It is hereby certified that Ng Zhen Hong (ID No: 20ACB05788) has completed this final year project entitled "SMART REFRIGERATOR" under the supervision of Dr Cheng Wai Khuen (Supervisor) from the Department of Computer Science, Faculty of Information and Communication Technology.

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ABSTRACT

This project focuses on developing a semi-automated smart refrigerator system designed to enhance food management and user convenience. The system targets a wide audience, including homemakers, professional chefs, elderly individuals, and casual refrigerator users, by addressing key issues such as manual item input, food overstocking, and the lack of real-time refrigerator status transparency. This project has integrated computer vision, deep learning, and IoT technologies to automate the detection of food items inside the refrigerator, using a Raspberry Pi and a webcam to simulate a smart environment. Users will be able to access real-time information about the contents of their fridge, receive reminders about food expiry, and manage their inventory through an intuitive platform. This development will be of particular interest to technology enthusiasts, IoT developers, and manufacturers looking to innovate in the smart home appliance market. Additionally, it serves as a valuable simulation model for testing new concepts in smart refrigerator design, with a focus on reducing food waste, improving convenience, and enhancing sustainability practices.

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LIST OF ABBREVIATIONS

AI:	Artificial Intelligence
ANN:	Artificial Neural Network
CNN:	Convolutional Neural Network
R-CNN:	Region-based Convolutional Neural Network
Faster R-CNN:	Faster Region-based Convolutional Neural Network
YOLO:	You Only Look Once
IoT:	Internet of Things
UI:	User Interface
API:	Application Programming Interface
VNC:	Virtual Network Computing
IP:	Internet Protocol
SSH:	Secure Shell

CHAPTER 1: INTRODUCTION

1.1 Background Information

In this decade, the advancements in technology have elevated people living standards to unprecedented heights. Accompany the rise of the Internet, we have entered a more intelligent and interconnected era. The Internet has not only transformed the way information is transmitted and exchanged but has also spurred numerous innovative technologies and applications. One of the mainstream technologies derived from the Internet is the Internet of Things (IoT), a phenomenon that has garnered significant attention in recent years.

Which the emergence of IoT signifies the dawn of an era where everything is interconnected. Devices can communicate with each other through the Internet, bringing numerous conveniences and possibilities to our lives. Whether it's smart homes, smart cities, smart healthcare, or industrial automation, IoT technology is omnipresent. Through sensors and data analytics, IoT can enhances the efficiency and performance of devices and provides greater security and comfort in people daily lives.

Interestingly, technological advancements have also accelerated the pace of social operations, increasing the rhythm of people's lives as they strive to earn more money for a more comfortable existence. Then the refrigerator, as a necessity for modern people, was originally manufactured to facilitate food storage and extend the lifespan of food. However, at some point, refrigerators have turned into cabinets for storing spoiled food. This might sound absurd, but it is indeed the reality. According Blichfeldt and his research team in 2015 were proposed to "consider the fridge as a site of ‘procrastination’: somewhere to put food and wait for it to go off before disposing of it" [1].

The reason behind this phenomenon is that busy lives leave people with no time to pay attention to the food left in the refrigerator. Besides, today youth more prefer to dining out or ordering takeout food to avoid the hassle of cooking and washing dishes. Consequently, the importance of refrigerators in modern life has diminished. Even the most advanced smart refrigerators with various modern functions do not make a significant difference, as most users are neither full-time homemakers nor professional chefs and thus do not give proper attention to the food stored in their refrigerators. According to research, the actual consumption of planned food is only half of what was initially intended [2]. The author also urges people to make a shopping list before purchasing groceries to avoid buying duplicates, which leads to food piling up and eventually spoiling and being discarded.

Furthermore, the advancement of smart refrigerators reflects the integration of various modern technologies, such as AI and blockchain, but has brought minimal improvement to daily life. The cumbersome operating procedures, complex menus, and instructional materials are often off-putting. Next is the issue of today's aging society. Modern fertility rates are increasingly lower than in the past, as young people prefer the freedom of single life. The result of an aging society is a growing unfamiliarity with technology, and an increasing desire to disengage from it due to the tediousness of a fast-paced and unfulfilling lifestyle. Therefore, the majority of smart refrigerator users are those born in the 90s, who have witnessed the transition from the old era to the new one.

These phenomena highlight a disconnect between technological advancements and user needs. While smart refrigerators continue to evolve technologically, if these advancements do not address user's actual problems or improve their experience but will struggle to gain widespread acceptance and application. This is particularly true for the elderly, who often find it difficult to adapt to rapidly changing technological environments, making them more likely to maintain the status quo rather than actively embrace new technologies. Therefore, when developing new products, tech companies need to consider not only the feasibility of the technology but also the practical needs and habits of users, to truly achieve the goal of enhancing quality of life through technology.

Consequently, this proposed project aims to develop an innovative and minimalist smart refrigerator model designed to be user-friendly for all demographic groups, including minority groups. By focusing on simplicity and practicality, this new smart refrigerator prototype will address the disconnect between technological advancements and user needs. It will feature intuitive interfaces, streamlined functionalities, and user-centric design to ensure that everyone, regardless of their familiarity with technology, can easily benefit from its features. This approach not only promises to enhance the quality of life for users but also sets a new standard for the integration of technology in daily living. By prioritizing usability and accessibility, we can create a smart refrigerator that truly meets the needs of modern society and bridges the gap between innovation and everyday practicality.

1.2 Problem statement

According to the prerequisite's investigation, we identified several noteworthy issues or gaps. After detailed analysis and rigorous comparison, we discovered the following interesting problems that are worth mentioning:

The inconvenience of needing to manually input items in an otherwise automated system:
For the new generation of smart refrigerators, their functionality must be comprehensive yet reasonable. However, due to some manufacturers' immature technology and insufficient research funding, smart refrigerators have emerged with user-unfriendly designs, especially in internal recognition systems. One such design flaw includes the need for manual item scanning. This means that after shopping, users must manually input or identify each item one by one. Examples include infrared barcode scanning, manual clicking, and single-camera recognition. Therefore, this unreasonable issue will be a key focus of this research. We will propose and test hypothetical solutions to address this problem.

The accumulation of items due to over-purchasing and the resulting issue of not consuming items in time:

In today's fast-paced society that prioritizes of speed, refrigerators are almost optional for many modern young people. Since as most of them rely on takeout and dining out. The minority who does use refrigerators, such as homemakers, professional chefs, and market vendors, have a certain understanding and control over their refrigerator contents. But the main things are that casual users, apart from those who need refrigerators for their professions, do not pay much attention to restocking and managing their fridge. According to certain theories, people today tend to buy more food than necessary to give themselves more leisure time or due to forgetfulness, leading to stockpiling. Some of this stockpiled food even spoils before it can be consumed. [2] Those who discover this in time may be considered lucky, but those who do not can face a serious problem as the spoiled food continues to contaminate other items in the refrigerator, ultimately creating a food safety crisis.

The lack of transparency regarding refrigerator abnormal behaviour and notifications:

Another challenge is the lack of transparency in refrigerator data. This issue mainly arises from two factors. First, the device data and design of refrigerators are not easily disclosed, as this could impact their commercial value. Second, for non-professionals, understanding the various data points of a refrigerator is almost impossible, rendering error reporting meaningless. Most users simply believe that as long as the refrigerator is functioning, there is no problem, and thus, they do not manage it actively. However, this transparency could lead to better maintenance and timely intervention, ultimately prolonging the lifespan of the refrigerator and enhancing user satisfaction.

To address these challenges, this proposal introduces a semi-automated smart refrigerator component, using minimalistic design to simulate and enhance the feasibility of a smart refrigerator. This includes a training scheme capable of analysing food items, a simulator as the receiving end, and a communication medium between the user and the refrigerator. The completion of this proposed project will depend on the successful development of the device and the upgrade of the recognition engine. Therefore, its enhancement version will rely on more advanced equipment and technologies in the future.

1.3 Motivation

This development project aims to integrate innovation and technology to address specific groups and real-world issues, exploring and expressing the latest technology in computer vision, deep learning, and the Internet of Things (IoT). The final goal is for the results to serve as a simulation test for new refrigerator models and to become fundamental for mainstream future development.[3]

Firstly, this development project is aimed to all ages. Therefore, the invention must be arranged and designed with simplicity and clarity in mind. The goal is to provide these groups with a service model that can adapt to their lifestyles, and the simplified design should make it easier for them to use the invention fully and effectively. Nevertheless, this project is also to validate and test whether the new refrigerator concept developed can potentially help reduce food waste. Included in this is the use of language modules and real-time feedback scripts, which will serve as the refrigerator's AI for internal management and provide users with relevant information.

Furthermore, this development aims to include the feasibility and capabilities of the latest computer vision model and object detection technical into Internet of Things (IoT) domain. This includes analysing food in photos, videos, and real-time images, as well as simulating physical equipment setups to achieve testing in real-world scenarios. In fact, the accuracy of recognition will depend on how the training dataset is processed and injected [3]. Therefore, this development will involve investing heavily in training dataset preparation to achieve optimal performance, followed by rigorous testing.

The next motivation is to learn adaptability between different hardware and software. Not all hardware and software versions are suitable for optimal use. This project analyses and identifies the hardware and software versions feasibility for smart refrigerator control management. The project aims to achieve hardware compatibility and optimal hardware performance levels, as well as software adaptation to that hardware version. Certain software versions may become overly complex and frequently updated, requiring more value from the hardware and causing adaptation issues. On the other hand, outdated versions may lack the features needed to fully operate the hardware. Therefore, this project required in-depth research and tuning of hardware and software.

In conclusion, the motivation behind this project is driven by a commitment to integrating advanced technology to address real-world challenges in smart refrigerator design. The primary goal is to cater to specific user groups, such as homemakers, chefs, and vulnerable populations, by providing intuitive and effective solutions that enhance food management and potentially reduce waste. Through the implementation of cutting-edge computer vision, machine learning, and IoT technologies, the project aims to pioneer innovations that not only improve daily living but also contribute to sustainable practices in the kitchen. Consequently, the project hopes to set a precedent for future developments in smart appliance technology, fostering greater efficiency, accessibility, and environmental responsibility in households worldwide.

1.4 Project Objectives

To establish an easily familiar conversation and manipulate medium:

The main objective of this project is to establish an interactive medium that facilitates direct interaction between users and refrigerators, which providing real-time data support. This system is aims to revolutionize the way individuals interact with their refrigerators by offering features such as monitoring and control management in real time. Users will be able to access the information about the contents of their refrigerators, including expiration dates and other information.

To develop an automated recognition system:

This proposed project aims to develop an automated detection system to physically simulate and monitor the storage of food inside a refrigerator and perform detection and analysis. Using a simplified circuit and a webcam to simulate internal detection in the refrigerator, the system will automatically capture food samples for analysis purpose. Then, the results will be stored in the system terminal for users to access and consult.

To proposed smart reminders script and mention way to improve users' food handling awareness:

This proposed project attempt to utilize a language engine to interact with users for both routine and non-routine operations. Various language models and training datasets will be used to analyse user language then providing feedback through a connected medium. The system will offer prompts, suggestions, warnings, and more. This objective is purpose to generate a more vivid and adequate language responses in a mode or module that approach such the people express in non-fluent, unformal words and sentences.

1.5 Project scope

This project purposed to develop and simulate a smart refrigerator environment, integrated with an intuitive interactive platform that enables users to familiar and easily participate. The platform will empower users with the flexibility and practicality to remotely access their refrigerator contents using their personal devices such as smart phone, smart home, laptop, desktop and more. The main point of this project is based on the refrigerator simulation be main leading to entire processing tasks, which include a simple framework to provide the minimum interactivity, food detection and analysis and language engine support.

To complete the refrigerator simulation, we will first develop a refrigerator simulator aimed at displaying basic values, managing content storage, and central management. Following this, we will utilize enhance object recognition and detection model to predict the items inside the refrigerator. As this development is still in the experimental phase, significant time will not be spent on processing extensive training datasets. Instead, this project focus on recognizing basic and commonly found items such as bananas, apples, and oranges. Conversely, this project will actively use limited resources to conduct practical tests and assess its usability effectively.

Next, a Raspberry Pi will serve as the central processor to control and process the information captured by the webcam, which will be transmitted to the terminal for analysis and management.

Additionally, a enhance language module will be utilized to design scripts for analysing and processing users' language input then providing relevant responses.

1.5.1 Out of the project scope:

No matter what, smart refrigerator still belongs to the smart home automation system field, so the security caution is inevitable. One crucial reason is to protect the user profile and preferences from anonymous intrusions via the internet, as internet connection is a necessity for IoT development. Thus, database breaches are a common occurrence in IoT [4]. However, for the purpose of focusing on minimalistic development, security system management will be temporarily put on hold to concentrate on optimizing the existing system integration.

Additionally, due to the limited performance of the Raspberry Pi, adding extra databases and programs will severely affect its usable resources. Therefore, this project assumes that the final production will use better equipment, including the core processor, circuit design, stable power supply, and other necessities. This will support better and faster responses and feedback.

Nevertheless, developing a comprehensive recognition system database requires a significant amount of time and effort for a single developer. Therefore, this development is approached from an experimental perspective to test its feasibility. Consequently, the development process assumes that a large and complete training dataset might be added in the future.

1.6 Impact, Significance and Contributions

This development will integrate innovation and technology, actively utilizing modern mainstream technologies such as computer vision and deep learning. It about of use enhance learning techniques to implement an active object recognition feature, providing users with real-time and accurate information about the items in their refrigerator. Furthermore, to simulate its feasibility and practicality, the development includes the use of tangible hardware for real-world operations. This ensures that the project can be tested and validated in realistic scenarios. Consequently, this development will propose a novel concept for smart refrigerators, aiming to establish a foundational model that could lead the way for mainstream smart refrigerators in the future.

Firstly, this development project is optimized for all generation, which to enhance its practicality and ease of understanding, which provide them with the most simplified and efficient service. It is designed to ensure that users can adapt to the basic operations of the new smart refrigerator with minimal time and a comfortable learning curve, thereby enhancing convenience in their daily lives. This is especially beneficial for elderly individuals and homemakers, who often find complex procedures and instructions unappealing. By focusing on user-friendly interfaces and straightforward functionality, the project ensures that these groups can enjoy the benefits of advanced technology without the frustration of complicated systems.

Secondly, this development plan also aims to achieve transparency and accessibility of refrigerator data, enabling users to monitor their refrigerator status in real-time. This real-time access is designed to help tackle the issue of food waste. To address this issue, the development will provide users with the most direct and effective methods to remind, inform, and assist them in managing their refrigerators. This proactive approach aims to significantly reduce food waste by helping users keep track of their food inventory and make better consumption decisions.

In fact, this development project had integrated innovative and modern technologies, is both meaningful and necessary. I believe it has the potential to serve as a cornerstone in the field of IoT development, paving the way for more advanced technologies in the future. I also hope that this technology will fulfil its practicality, operating at its full potential to serve society by continuous upgrades and improvements, it can further enhance the quality of life and convenience for people in the modern world.

1.7 Report Organization

Based on the standard requirements of a final year project report, Chapter 1 identifies the project background, problem statements, motivations, objectives, scope, and contributions. These sections aim to provide a general and basic overview of the study, allowing readers to quickly grasp the significance and purpose of the report.

Next, Chapter 2 introduces previous research on food detection and recognition technologies, comparing their performance in terms of advantages, disadvantages, practicality, and reliability.

Following this, Chapter 3 provides a detailed analysis of the technologies adopted and the deployment methods used in this development.

In Chapter 4, the report details the hardware and software utilized in this project, along with a thorough description of the development process.

Then, Chapter 5 explains the various functions of the developed system and how it operates.

Subsequently, Chapter 6 objectively evaluates the completion level of the development and discusses related future development issues.

Finally, Chapter 7 offers a summary of the report and provides additional explanations and supplementary information.

CHAPTER 2: LITERATURE REVIEW/TECHNICAL REVIEW

2.1 Existing System Review

2.1.1 RFID Refrigerator

Figure 2.1.1: Example RFID Smart Refrigerators

The background of RFID can be traced back to the early 20th century with the development of wireless communication and radar technology state. Its application to radar technology paved the way for its evolution into commercial tagging, supply chain management, and various domains. With the rise of the Internet of Things (IoT), RFID has assumed a pivotal role as a connecting link that enables the interaction among diverse devices and sensors. This allows for seamless data collection, exchange and updating between objects, helping to enhance the functionality of modern appliances such as smart refrigerators. [4]

The RFID Fridge main goal is implementing a refrigerator to maintain an updated list of the items stored in the fridge. To achieve this goal, every item that is willing to be stored must be tagged with an RFID tag, then when the user places it in the fridge, the RFID reader will be able to identify the product's RFID tag and register the detailing data in the database. It's important to note that this process is digital and not a physical tagging process. Then the refrigerator autonomously reads all the internal RFID tags and gathers information, subsequently updating a centralized database. This information includes details such as consumption dates, item conditions, quantities, temperatures, and more.

Strength:

The incorporation of RFID technology into the iFridge system brings forth a range of significant advantages. By utilizing RFID tags for each item within the refrigerator, users can experience a revolutionized approach to inventory management. The system offers real-time insights into the fridge's contents, enabling users to effortlessly monitor quantities, expiry dates, and even temperatures. This translates to reduced food wastage as users are promptly alerted to impending expirations and encouraged to use items efficiently. The automated data collection and integration with the database provide users with a streamlined method for generating shopping lists and planning meals, ultimately saving valuable time and effort. The iFridge's adoption of RFID technology promises to elevate convenience, reduce wastefulness, and offer a seamless user experience.

Limitation:

While the integration of RFID technology into the iFridge holds the promise of a more efficient and organized approach to food management, there are notable disadvantages to consider. The initial setup of the RFID system can be complex, requiring users to navigate through technical aspects such as tagging items and configuring the system. Additionally, the costs associated with implementing RFID, including the acquisition of RFID tags and any required infrastructure upgrades, can be substantial. This financial aspect might dissuade some users from adopting the technology. Moreover, reliance on technology brings the risk of system malfunctions or connectivity issues, potentially disrupting users' access to accurate information. Balancing the benefits against the technical intricacies and financial investment will be crucial in determining the feasibility of the iFridge's RFID-based approach.

2.1.2 IoT Refrigerator

Figure 2.1.2: IoT Smart Refrigerator Preview

The rise of the Internet of Things (IoT) stands as a testament to the relentless progress of technology, fundamentally altering how we interact with everyday appliances. Among the most transformative innovations is the evolution of refrigeration systems. These modern refrigerators are no longer passive storage units; instead, they function as proactive, communicative devices that seamlessly synchronize with other smart systems, exchange critical data online, and provide users with unprecedented control and convenience. Through IoT advancements, refrigerators have evolved into sophisticated, precision-driven systems capable of real-time monitoring, task automation, and enhanced user experiences. This is made possible by IoT's exceptional connectivity, enabling devices within the same network to communicate and share information effortlessly. [5]

Strength:

Incorporating IoT technology into smart refrigerators enhances their functionality and value significantly. One of the most notable benefits is remote monitoring and control, allowing users to access and manage their refrigerator's functions through a mobile app from virtually anywhere at any time. Additionally, IoT's cloud-based infrastructure offers scalable solutions, meaning that as demand for internet traffic grows, hardware upgrades or software enhancements can be seamlessly deployed to handle increased workloads without significant disruption. Another critical advantage is IoT's ability to optimize resource utilization. By reducing energy consumption, minimizing food wastage, and improving overall operations, IoT-driven refrigerators contribute to efficiency and cost savings.

Limitation:

Despite their benefits, IoT-enabled smart refrigerators face several limitations. One of the primary challenges is the need for regular maintenance and technical support. IoT devices require frequent updates to ensure proper functionality, but many consumers, particularly busy adults, may lack the time or technical knowledge to perform these updates consistently. Another significant issue is the reliance on stable internet connectivity. IoT systems depend heavily on a reliable network, and users in areas with poor or inconsistent internet service may experience difficulties with setup and performance. Lastly, the current app ecosystem for controlling IoT smart refrigerators is somewhat limited. The quality and functionality of smartphone apps can vary significantly, with some applications offering restricted features or suffering from poor user interface design, which can diminish the overall user experience.

2.1.3 AI Refrigerator (Machine learning Based)

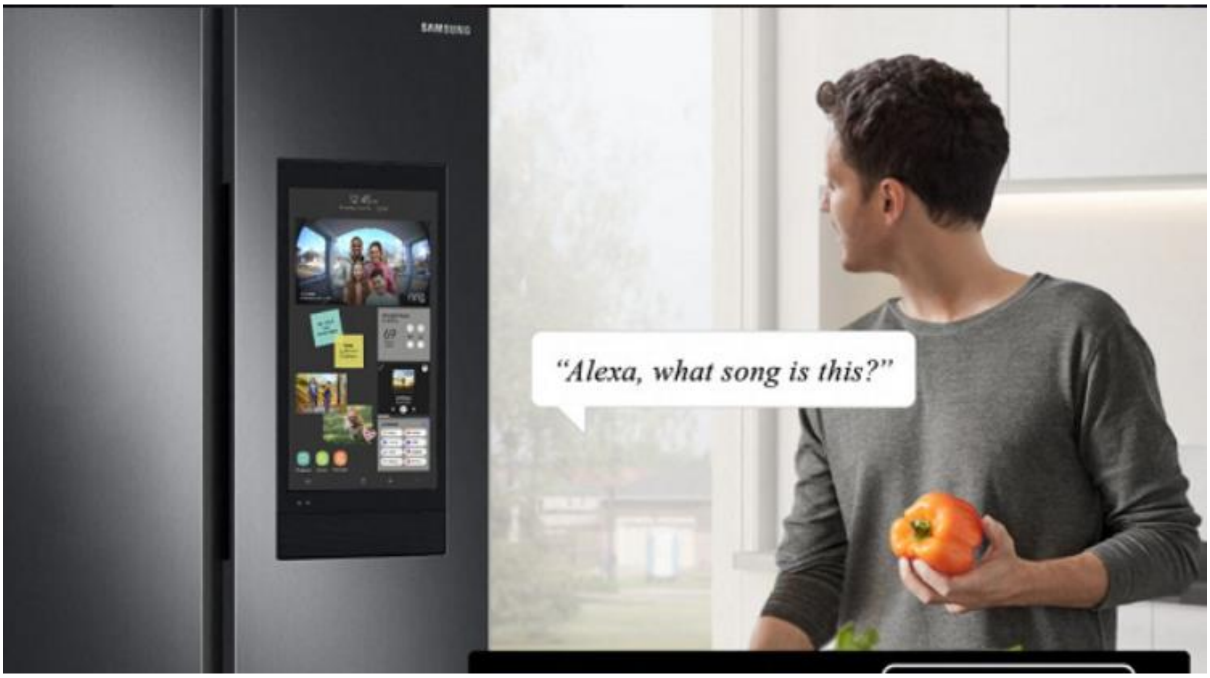


Figure 2.1.3: AI Concept Demo

The most exciting and captivating topic of the 21st century is undoubtedly the development of Artificial Intelligence (AI). Representing the pinnacle of advanced technology, AI's versatility spans multiple domains, including the creation of smart refrigerators. This commentary explores the use of one of the most popular AI models, Artificial Neural Networks (ANNs), as the core for information processing in smart refrigerator systems. [6]

The value of ANNs lies in their ability to be trained to recognize and identify various food items stored in a refrigerator using images captured by built-in cameras. This feature supports automated inventory management, tracking expiration dates, and even generating recipe suggestions based on available ingredients. In addition, ANNs enable a range of human-machine interaction functionalities, such as voice and gesture control, user behavior analysis and prediction, and forecasting energy consumption. By integrating ANN technology, smart refrigerators have the potential to transform kitchen management, offering a seamless and AI-driven approach that enhances daily convenience and efficiency. [7]

Strength:

The advantages of AI-powered smart refrigerators are clear. First, with the support of ANNs, the system can accurately identify and categorize different types of food items using image recognition. This enables users to automate their inventory management, keeping track of food, quantities, and expiration dates with ease. The system can automatically update itself, enhancing user-friendliness. Additionally, through continuous learning, the AI adapts to user behaviours and preferences, tailoring the refrigerator's settings and recommendations to individual needs. The system also offers predictive maintenance, autonomously monitoring component performance and reminding users to conduct timely checkups, which can extend the lifespan of the refrigerator.

Limitation:

However, these advanced capabilities come with certain limitations. High performance requires high costs. Training AI models, such as ANNs, on large datasets is both time-consuming and expensive, resulting in a higher price point for AI-powered refrigerators, limiting their accessibility to some consumers. Additionally, the complexity of AI systems can lead to prolonged maintenance and testing phases, posing challenges during development. Another key concern is that AI technology is still evolving. AI systems may make incorrect decisions based on incomplete or inaccurate data, which could lead to unintended outcomes. For instance, if an AI system misinterprets a visual cue, it could incorrectly classify expired food as fresh or vice versa. Lastly, a significant limitation of ANNs is their susceptibility to overfitting. When an ANN becomes too specialized in learning from the training data, it may perform exceptionally well on that data but fail to generalize to new, unseen data, leading to poor predictions and reduced effectiveness in real-world scenarios.

2.1.4 Cloud Refrigerator

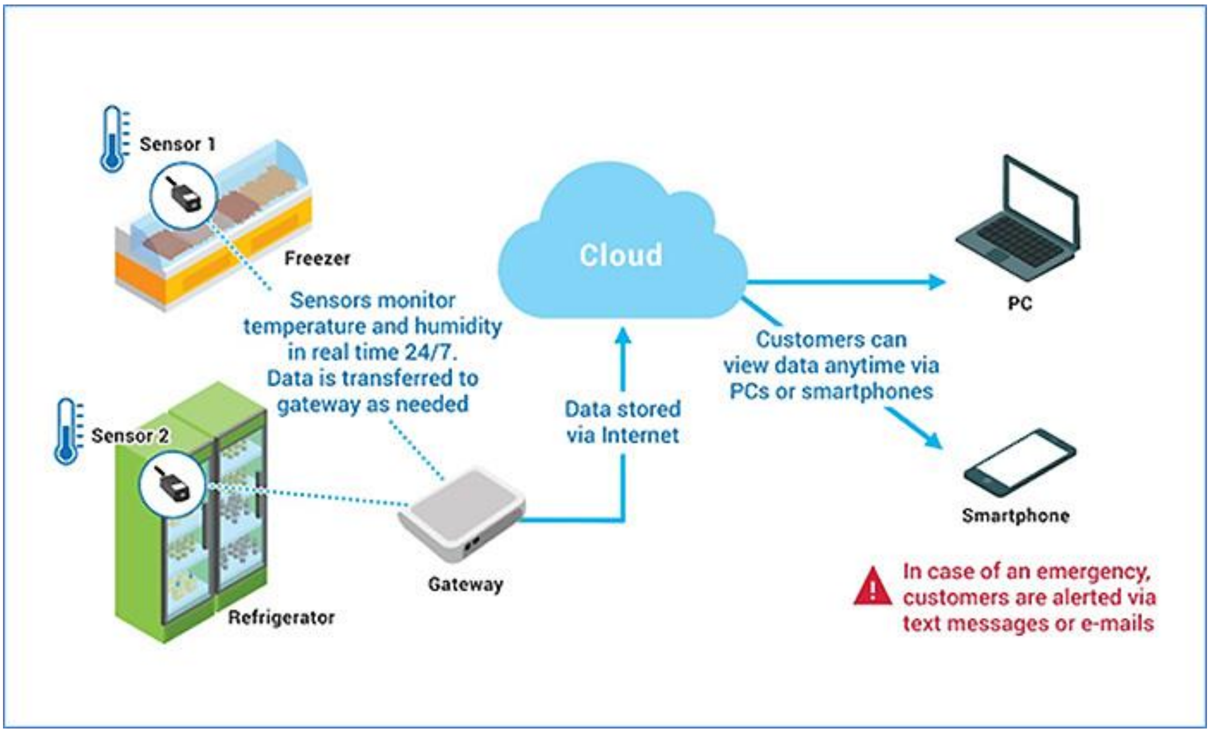


Figure 2.1.4: Cloud Based Architectural preview.

Cloud storage has become increasingly familiar to modern consumers, but when applied to refrigeration systems, its integration with IoT (Internet of Things) brings new dimensions of functionality. In IoT-enabled refrigerators, sensors are embedded to monitor various factors such as temperature, humidity, door status, and food inventory. These sensors collect data, which is then transmitted to cloud storage for processing and analysis. The integration of cloud services and IoT allows for features such as remote temperature control, real-time alerts for open doors, and inventory checks via mobile apps.

On a deeper level, cloud services offer more than just data storage—they provide remote computing power to enhance the functionality of the refrigerator. For example, the cloud can store historical data like temperature trends and usage patterns, which helps in providing predictive maintenance and energy efficiency insights. Cloud services also enable manufacturers to remotely deploy software updates to the refrigerator, offering new features or improvements without the need for physical repairs or upgrades.

According to research, a new hardware and software architecture has been proposed, enabling the cost-effective development, testing, and deployment of advanced control algorithms specifically for commercial refrigerators. The primary objective of this cloud-based control framework is to optimize energy consumption by leveraging cloud computing's cost-efficient resources for software-based energy management solutions. [8]

Strength:

The foremost strength of cloud-based architecture in smart refrigerators is the cost-effective framework it offers through the use of cloud technology. This not only reduces production costs but also leads to more affordable smart refrigerators for consumers. Additionally, it presents an economical solution for developing and testing advanced control algorithms, which are especially useful for appliances like refrigerators. Moreover, cloud-based architecture significantly enhances energy management, addressing the growing need for environmentally conscious technologies. By treating energy optimization as a software-driven task, the framework reduces energy usage in refrigeration systems, contributing to overall sustainability.

Limitation:

Despite its advantages, the cloud-based architecture is not without limitations. One major drawback is its dependency on external cloud resources. While cloud computing can offer cost and scalability benefits, it raises concerns about data privacy, security, and latency. The reliance on external resources might affect the reliability of control algorithms and increase the vulnerability of sensitive data related to refrigeration systems. Additionally, transitioning to this new architecture may present challenges for operators and developers, as they might face a learning curve during the initial stages of implementation. The specificity of this cloud-based control framework to commercial refrigerators and energy optimization may also limit its broader adoption across different industries and applications, reducing its versatility and scalability.

Additionally, transitioning to a new hardware and software architecture might entail a certain level of complexity during the initial stages. Operators and developers could encounter challenges in adapting to this innovative approach, potentially resulting in a learning curve and initial implementation difficulties. Moreover, the architecture's applicability is specific to commercial refrigerators and energy optimization. This specificity could limit its broader adoption across different industries and applications, hindering its versatility and scalability.

2.1.5 Blockchain Refrigerator

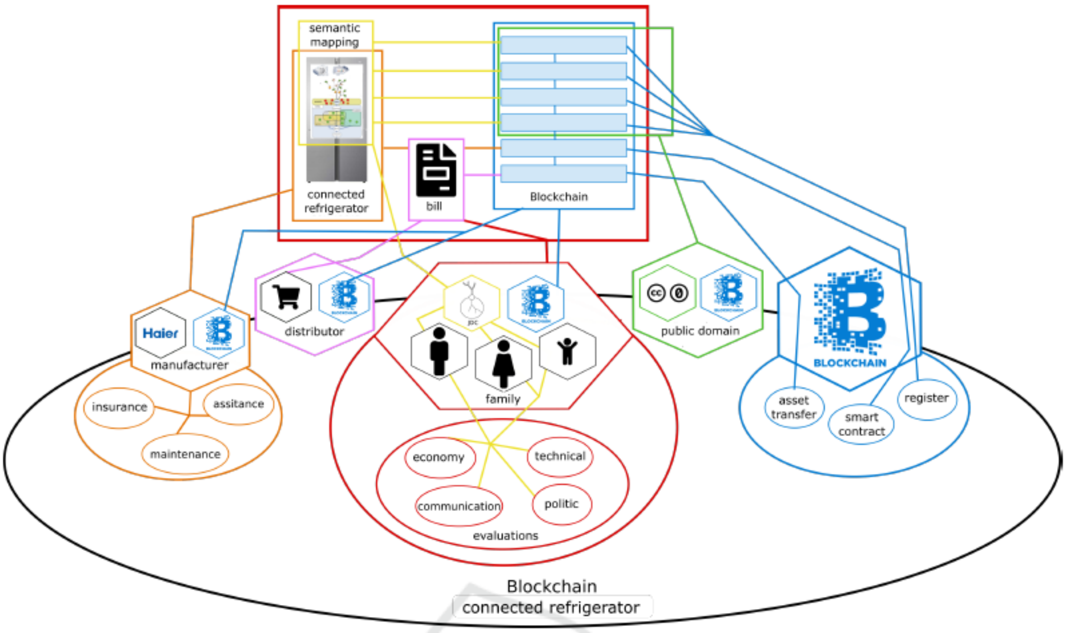


Figure 2.1.5: Ecosystem of the Blockchain for a connected refrigerator.

Over the past nearly five years, blockchain has emerged as a groundbreaking technology that has rapidly captured significant attention and witnessed widespread development. In this relatively short timeframe, there has been a remarkable surge in both interest and active exploration of blockchain's capabilities. In essence, blockchain represents a revolutionary technological advancement with the potential to reshape various industries and systems. Notably, the concept of the smart refrigerator has also been influenced by this wave of innovation.

According to a past online report, the fundamental aspects of a smart refrigerator, they introduced some promising features that offer blockchain transparency and secure energy consumption data for user reference. It also mentions about that the unique recording characteristics of blockchain treat every user as a participant in the energy market. This means that there is an accurate transaction history on the blockchain network for the electricity used by each device, providing proof of consumption. [9]

Furthermore, subsequent articles have also indicated the application of blockchain in the smart refrigerator ecosystem. They emphasize the potential to leverage blockchain's capabilities for secure data storage and real-time updates, aiming to enhance both practicality and traceability. Incorporating these technologies into smart refrigerators represents a revolutionary innovation. The robust traceability it provides ensures the comprehensive preservation and sharing of pertinent food information, encompassing details like processing procedures, production origins, and more. This empowers users with a clear understanding of ingredient sources and better control over freshness, even extending to the seamless integration of purchasing processes within the blockchain network.

Strength:

As mentioned above, one of the key characteristics of blockchain is its traits, including high transparency, traceability, and autonomy, which contribute to the real-time immutability of blockchain data. This holds significant value in the realms of food and supply chains. Not only limited to the domain of food, but even refrigerator technology, refrigerator origin, and internal identification can also be tokenized and leveraged through blockchain.

Returning to the context of food and supply chains, blockchain can provide comprehensive information about food sources, production methods, and handling procedures, thereby enhancing food safety. In the event of recalls or quality issues, this technology can rapidly identify affected batches, thus reducing the risk of foodborne diseases. Furthermore, Blockchain's decentralized structure removes the need for intermediaries or central authorities.

This means it can eliminate middlemen in food supply chains and empower users to directly engage with producers and suppliers.

Limitation:

Although blockchain technology has potential it does have some limitations that can hinder its progress. First and foremost, scalability is a concern. Dealing with a volume of real time transactions or events can present challenges, in scaling the data. May require time to adapt to increased traffic. Secondly there is the issue of energy consumption. Blockchain networks, those that utilize proof of work consensus mechanisms like Bitcoin can consume an amount of energy. This goes against the goal of energy devices and could potentially undermine the benefits of reduced energy consumption achieved through improved management. Lastly data privacy is a factor to consider. The inherent transparency of blockchain is both advantageous and disadvantageous. While it ensures data integrity it also has the potential to expose information to parties. Striking the balance, between transparency and privacy is crucial.

2.2 Comparison Existing System with Proposed System:

Refrigerator / Feature	RFID Smart Refrigerator	IoT Smart Refrigerator	AI Based Smart Refrigerator (ANN)	Cloud Based Refrigerator	Blockchain Smart Refrigerator
Basic smart refrigerator feature	**YES**	**YES**	**YES**	**YES**	**YES**
Proactive management	**NO**	**YES**	**YES**	**NO**	**NO**

Management initialization	YES	NO	NO	NO	NO
Information sharing	Partially YES	YES	YES	YES	YES
Independent management	YES	YES	YES	NO	NO
Autonomously diagnoses errors	NO	NO	YES	NO	NO
Real-time recording	YES	YES	YES	YES	YES
Network dependency	NO	YES	YES/NO	YES	YES
Energy control	NO	YES	YES	NO	YES
Reduce pollution levels	YES	YES	YES	YES	YES
Price guarantee	YES	NO	NO	YES	NO

Table 2.2: System Review and Comparison with proposed system.

2.3 Recommendations:

According to several existing technical reviews, it is currently known that smart refrigerators tend to lean towards technical differentiation. This means that manufacturers are more focused on incorporating various new or popular technologies into the smart refrigerator domain, rather than strengthening the basic functionalities. While this may seem like a positive development because it results in the introduction of refrigerators with new technologies, it can be detrimental. Being overly fixated on innovation can cause people to lose sight of the true purpose of refrigerators and may lead to a saturation of novelty in innovations. This excessive emphasis on technical differentiation may lead of compromise the core refrigerators characteristics, which making them less focusing on their primary task. It's important to strike a balance between innovation and maintaining the fundamental utility of these appliances to ensure they continue to serve their primary purpose effectively. Indeed, the situation with smart refrigerators shares similarities with the smartphone industry. In the world of smartphones today, the physical appearance and form factor of most devices have become remarkably similar, with variations mainly in Performance comparison. Consequently, the key differentiator for consumers has shifted from the novelty of new features to a strong preference for specific brands.

In hence, this proposed system will develop a smart environment that closely simulates the value provided by smart refrigerators as an alternative to traditional ones. The system will employ with hybrid development approach that incorporating a combination of cloud and AI technologies. The features will encompass smart functionalities that augment the basic functions of a refrigerator, including real-time reporting, monitoring, and remote control. Users will interact with this platform to simulate the functions of smart refrigerators in real life and provide feedback accordingly.

CHAPTER 3: System Methodology/Approach

3.1 System Design Diagram/Equation

3.1.1 Project Workflow in Phased Development:

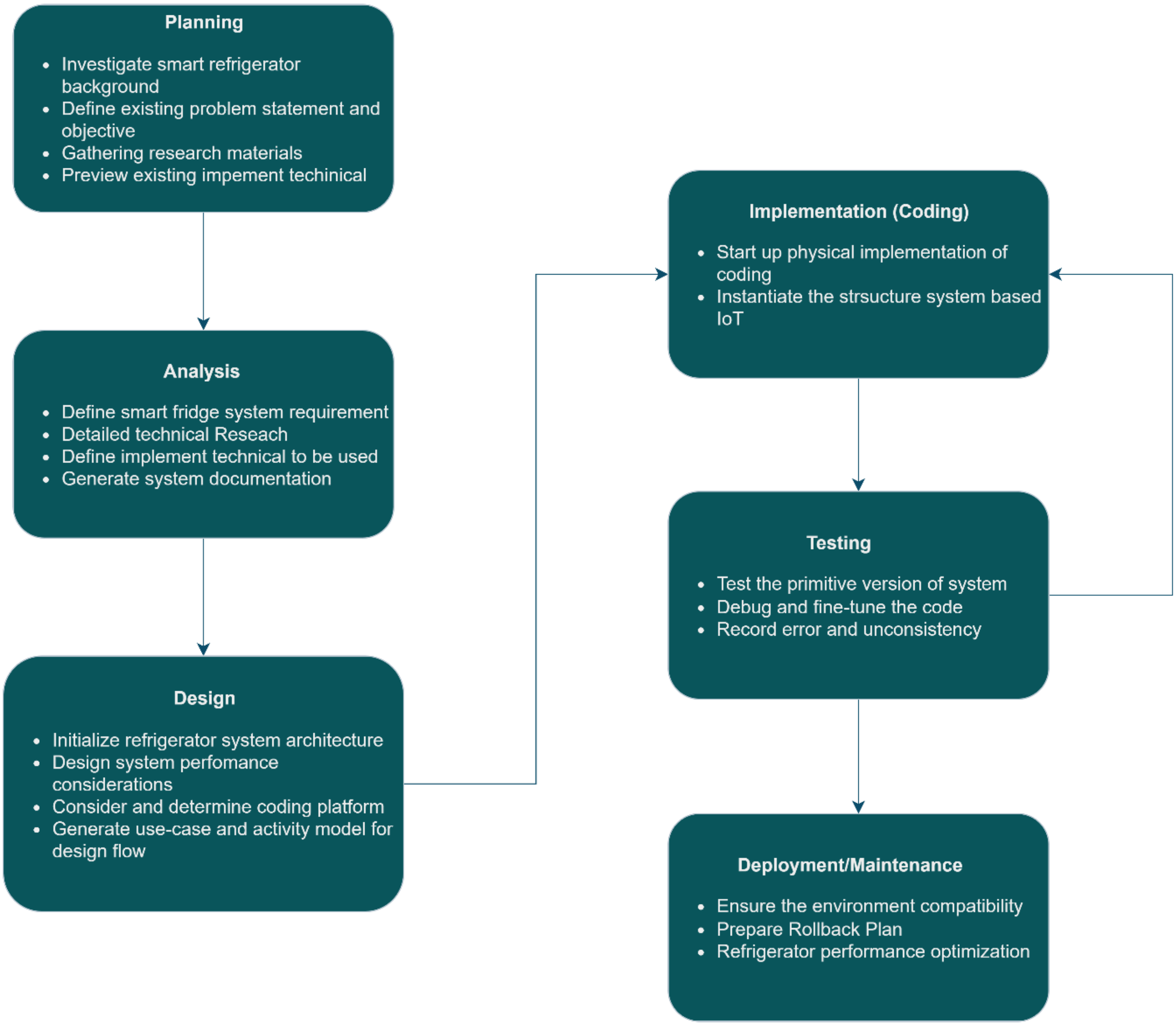


Figure 3.1.1: Proposed Project Workflow Diagram

Planning:

In the planning phase, an investigation into the smart refrigerator's background will be conducted. This includes exploring its history, evolution, and operational workflow. The problem statement and project objectives will be defined based on the gathered insights. Research materials, such as data, academic papers, and technical documentation, will be collected to support the project. The phase will conclude with a review of existing implementation technologies in the smart refrigerator domain to gain insights into technical solutions and emerging trends.

Analysis:

During the analysis phase, specific system requirements for the smart fridge will be defined, focusing on functionality, performance, and user interface needs. Detailed technical research will be conducted on the implementation technologies, such as sensors and communication protocols, to ensure alignment with the system requirements. Based on this research, specific technologies for the project's implementation will be selected. The system documentation will then be created, outlining the architecture, components, and technical specifications, ensuring all findings and decisions are clearly recorded.

Design:

This phase involves initializing the system architecture, which includes defining the system structure, key components, interaction models, and the user interface architecture. Decisions will be made regarding the coding platform, ensuring compatibility with IoT technologies and scalability considerations. Use-case and activity models will also be generated to outline the design flow, serving as a reference and guiding blueprint for the project's progression.

Implementation:

The coding and physical implementation begin during this phase. The design and architecture plans are translated into executable software, creating the foundation for the smart refrigerator simulation. The system will be visually presented, acting as a terminal connected to local devices and supporting interaction.

Testing:

In the testing phase, the prototype will undergo initial testing to evaluate its basic functionality and ensure the system operates as intended. Following this, a thorough code review will be conducted, with debugging and fine-tuning taking place to address any identified issues. The process ensures that errors and inconsistencies are resolved, improving the manageability and scalability of the system.

Deployment/Maintenance:

The final phase involves the deployment of the system in a practical environment. A rollback plan will also be prepared to ensure the system can revert to a previous stable state in the event of disruptions during future updates. Ongoing performance optimizations and maintenance will ensure the refrigerator system remains functional and efficient.

3.1.2 Architecture Design

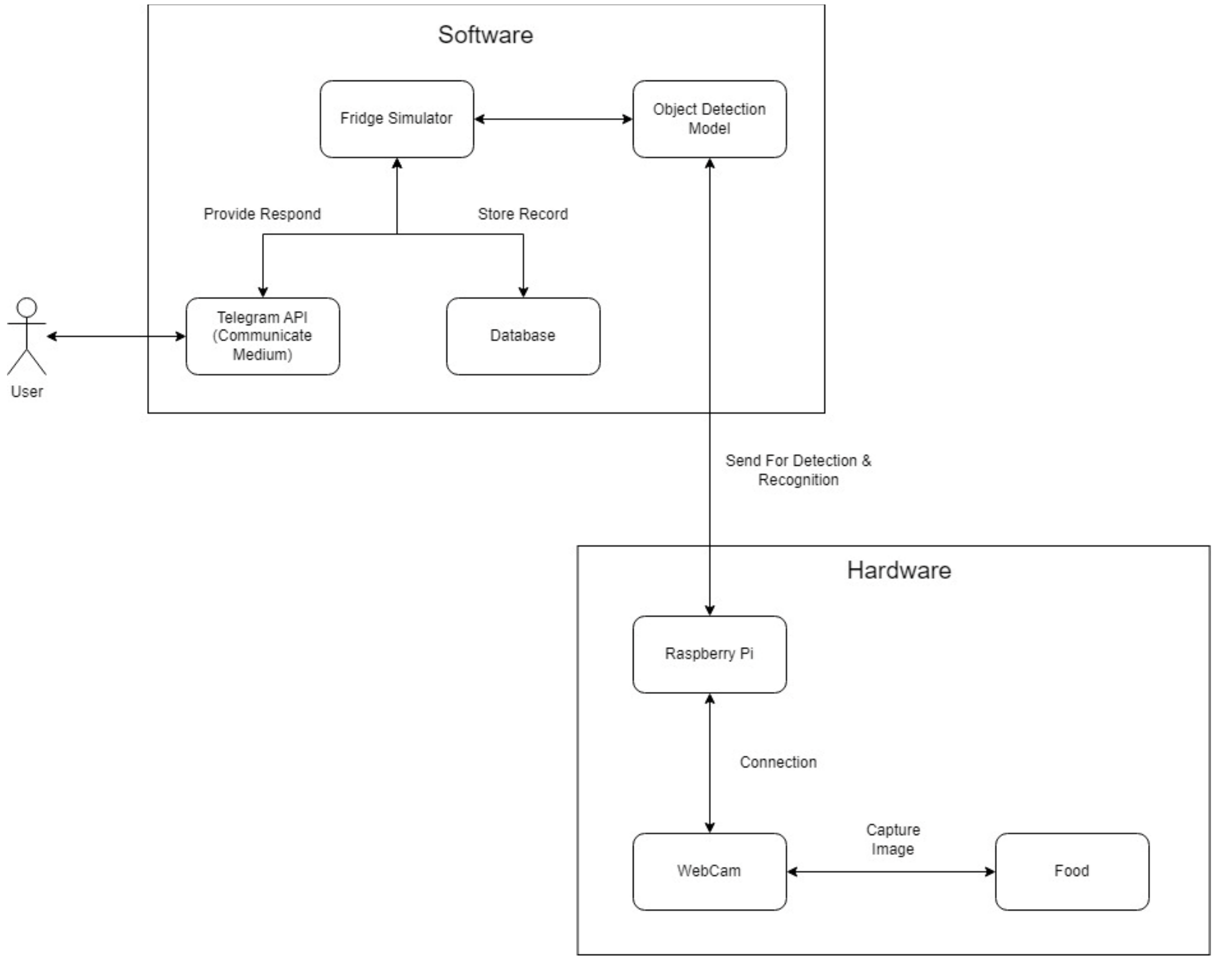


Figure 3.1.2: Smart Refrigerator Architecture Diagram

The architecture diagram shows the general interaction of the smart refrigerator system and identifies the roles of the hardware and software sub-systems. There is several elements that constitute the software section. Secondly, most of the execution commands are processed in the simulator, as well as most of the data generation. They link to the object detection and recognition module of the system. The latter serves as a communication channel, the API of the Telegram messenger is used for this purpose, enabling the user to receive information about the contents of the fridge. The detection results from the object detection model are then used in the fridge simulator which acts as a smart fridge and provides detection results.

On the hardware side, there is a fake recognition part implemented on Raspberry Pi. It interfaces with a webcam that takes photos as soon as it is connected. The Raspberry Pi partially analyses these images and then passes them to the object detection and recognition module. Last but not the least, the score obtained is shown on the fridge simulator and the score is added to the database.

3.1.3 Use Case Diagram

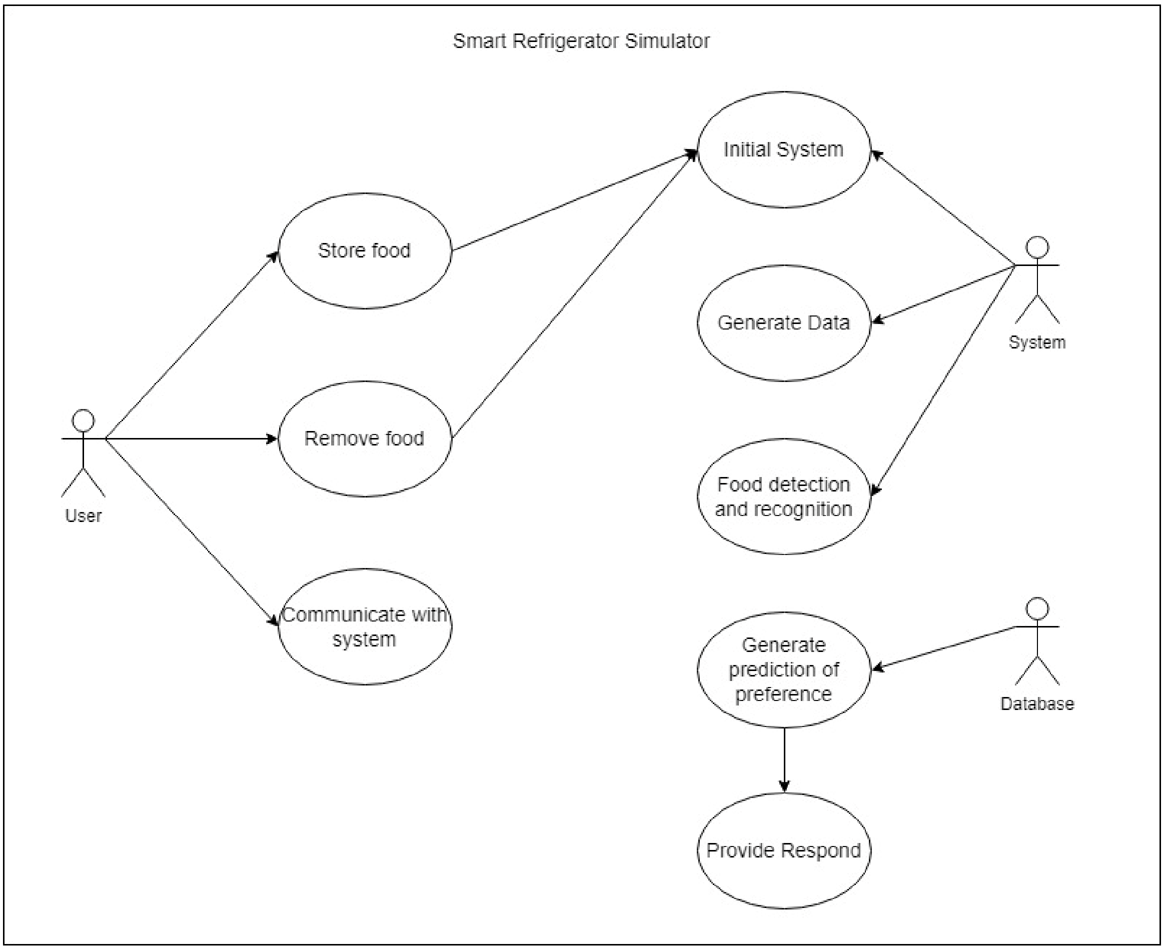


Figure 3.1.3: Smart Refrigerator Use Case Diagram

The use case diagram shows the relationships between the smart refrigerator simulator system and the interactions between the users and the components within the system to achieve various goals. The major components of the system are the user, the system and the database. Customers can put and take food products into the fridge and give orders to the system to get the information about the products in the fridge.

The system handles several key functions: it starts up, creates data from user engagement and food identification procedures, identifies food, and recognizes food, and makes predictions about the user's food preferences. This database becomes important in storing data and helping the system in coming up with these predictions.

It also changes its status when the user stores or removes food. By means of the communication channel, the user can get answers concerning the contents of the fridge, which the system generates and processes using the data accumulated. The function of predicting the preferences of users is made possible by the data stored in the system, and thus, the smart refrigerator can provide appropriate recommendations and keep track of the food's efficiency. In general, this diagram shows that there is a clear integration between the hardware and software aspects in order to form a smart refrigerator system.

3.1.4 Activity Diagram

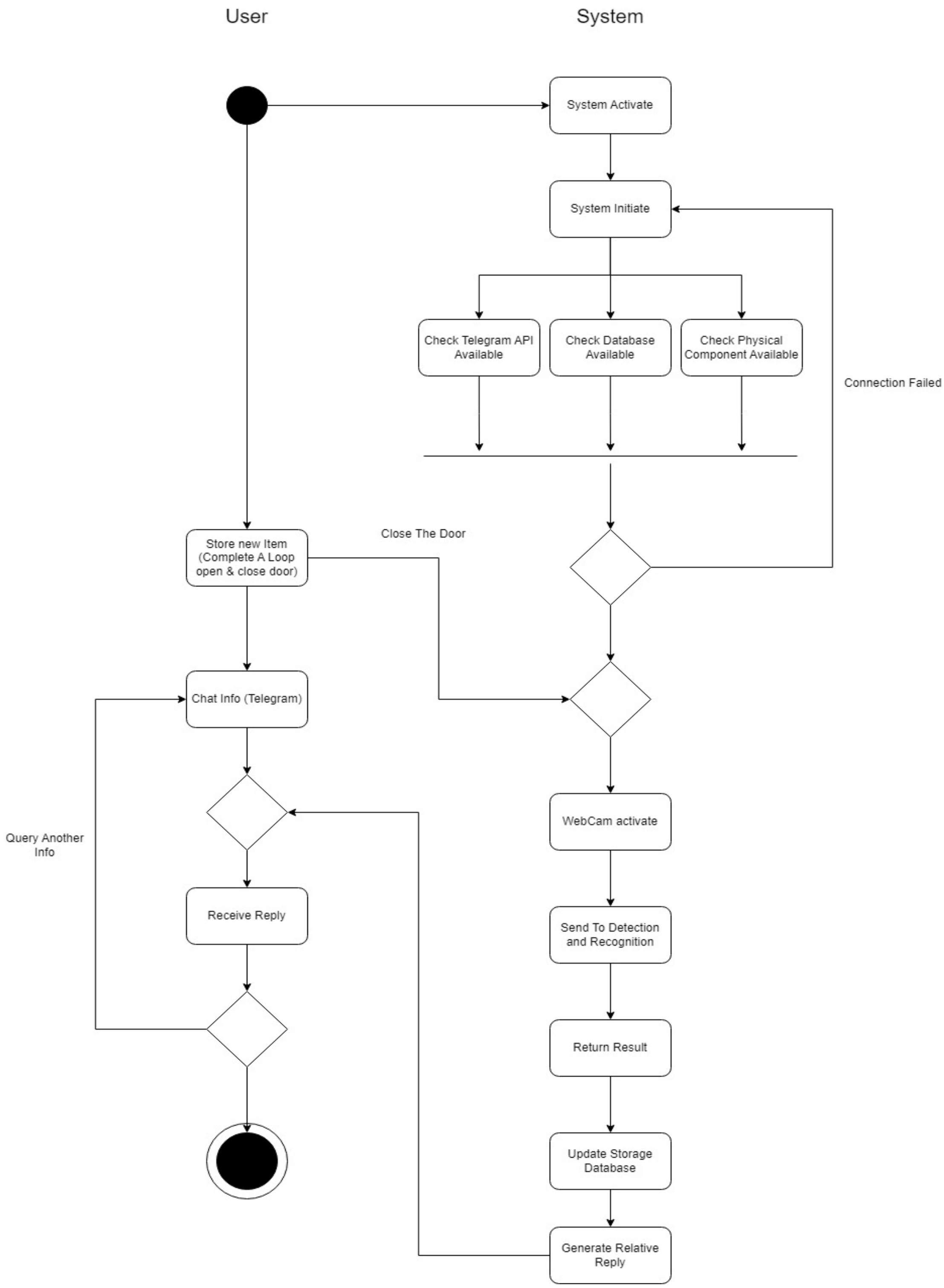


Figure 3.1.4: Smart Refrigerator Activity Diagram

The activity diagram shows the workflow of the smart refrigerator system and outlines the steps to be taken. The process starts when the user switches on the system and this leads to the beginning of the internal process of the system. The system checks the availability of key components: the Telegram API for the communication, the database for data storage and the physical components. If any of these checks fail, the system determines that there is a connection failure and stops the operations.

After success of connection, when a user opens and closes the fridge door to store a new item or remove an item will be completed loop, then the system turns will on the webcam to take pictures of the stored items. The images are passed to the detection and recognition module where they are processed, and the outcome is given. Furthermore, the new prediction is then stored in the storage database to keep a record of the fridge's contents in the system.

Additionally, Telegram API is used to become a conversation medium between user with fridge simulator, where users can ask about the contents of the fridge, or something related to it. These queries are then handled by the system and the required answers are produced considering the new data from the detection outcomes. This interaction creates a feedback loop in which the user receives timely and accurate information about the refrigerator's contents.

3.2 Food Detection Approach & Solution

3.2.1 Object Detection Method (R-CNN Model)

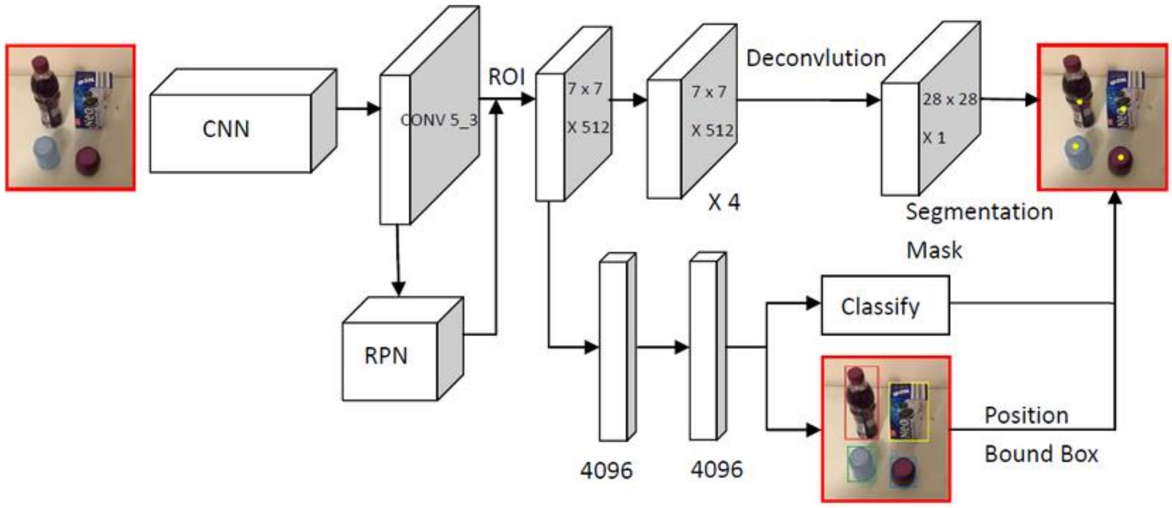


Figure 3.2.1: R-CNN Model

R-CNN or Region-based Convolutional Neural Network is one of the earliest methods used in object detection, which is an extension of CNNs, not limited to image classification. Thus, the key advancement of R-CNN is the detection of objects within an image and, at the same time, assigning them into different categories. This is done by first obtaining the regions that are likely to contain the objects, then classifying these regions using a CNN and lastly, adjusting the bounding boxes around the objects. The process involves three key steps: selective search for creating region proposals, feature extraction with a CNN, and classification and bounding box regression with SVMs and linear regression. [10]

In this project case of the application of R-CNN for the detection of food items, it can be specifically helpful in the classification of various foods in an image. The first step involves the generation of region proposals that could possibly contain foods using selective search. Each of the proposed regions is passed through a CNN to extract features that describe foods based on their colour, texture, and shape. These features are vital for categorizing the foods in different groups for instance fruits, vegetables and beverages.

For example, in a smart fridge application, R-CNN can be used for identifying objects such as apples, bananas and soda cans. Following the generation of region proposals, the CNN extracts feature from each region and feeds them to the SVM classifiers to decide on the existence and type of food. The bounding box regressor then refines the detection by moving the bounding boxes to better fit the detected food items. This enables the smart fridge to monitor the stock, inform the user of the availability of certain foods and it can recommend recipes based on the foods that are in stock.

Despite its effectiveness, the computational demands of R-CNN can be a bottleneck, especially when dealing with many images or real-time detection requirements. However, its robust framework for object detection has paved the way for more advanced and efficient methods like Fast R-CNN and Faster R-CNN, which address these limitations while retaining high detection accuracy.

3.2.2 Faster R-CNN Model

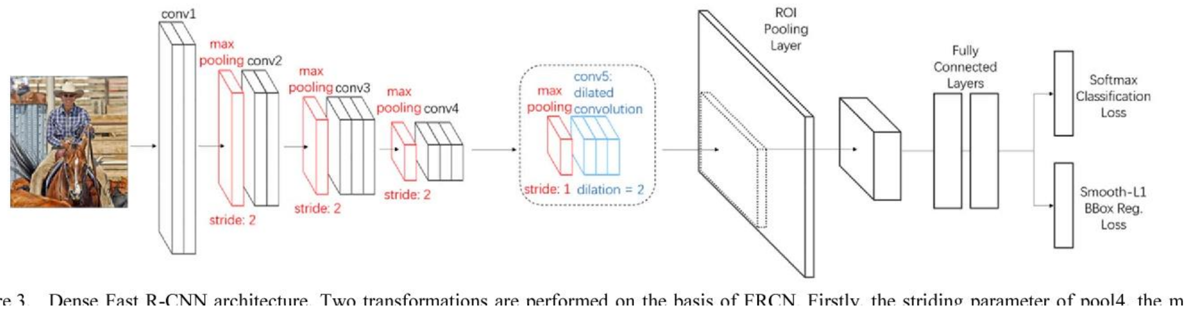


Figure 3.2.2: Faster R-CNN Model

The Faster R-CNN model is a better development of object detection over R-CNN and Fast R-CNN. It incorporates the region proposal generation into the architecture of the neural network which makes the detection process more streamlined and less complex [11]. The major enhancement in Faster R-CNN is the Region Proposal Network (RPN), which eliminates the dependence on external region proposal methods as seen in the previous models and instead uses a fully convolutional network to generate the region proposals from the feature maps.

In Faster R-CNN, the process starts with a convolutional neural network (such as VGG or ResNet) to obtain feature maps of the entire input image. These feature maps are then passed to the Region Proposal Network (RPN), which is a small network that is shifted over the feature map to produce region proposals. For each sliding window location, the RPN generates multiple region proposals along with the objectness scores which is the probability of the region containing an object [12]. Non-Maximum Suppression (NMS) is then used to eliminate the proposals that are heavily overlapping with each other.

Due to the improved speed and accuracy of Faster R-CNN, it is ideal for use in food detection especially where quick and efficient identification of food items is necessary. For example, in smart fridge scenario, Faster R-CNN can be used for detecting and recognizing different types of food products like fruits, vegetables, packed foods etc with very less of rate missing.

In this project cases, the process starts with the feeding of the entire image of the fridge's contents into a CNN to obtain feature maps of all the contents. The Region Proposal Network (RPN) then scans these feature maps to produce possible regions of interest (RoIs) that may contain the food items. These proposals are then passed through Non-Maximum Suppression (NMS) to keep the most probable regions without redundancy. The other proposals are then fed through the RoI pooling layer to make them uniform before being classified into the particular food categories and having their bounding boxes adjusted for better localization.

3.3 FYP 1 Development Timeline

Project Activities	Week 1	Week2	Week 3	Week 4	Week 5	Week 6
Chapter 1: Introduction						
Background Investigation	**12/2/2024**					
Problem Statement		**16/2/2024**				
Project Motivation		**17/2/2024**				
Project Objectives		**18/2/2024**				
Project Scope		**18/2/2024**				
Report Organization						
Chapter 2: Literature Review						
Resources Study			**20/2/2024**			
Review of Existing Technologies			**24/2/2024**			
Pros and Cons Review				**29/2/2024**		
Technical Evaluation				**2/3/2024**		
Comparative Technical Analysis (Table)				**4/3/2024**		
Chapter 3: System Methodology / Approach						
System Modeling Sketching				**7/3/2024**		
Application Design (Diagram)					**9/3/2024**	
System Architecture Design (Diagram)					**11/3/2024**	
System Flowchart					**11/3/2024**	
Chapter 4: System Design						
System Block Diagram					**13/3/2024**	
System Components Specification					**14/3/2024**	
Circuits and Components Design						**15/3/2024**
System Components Interaction Operations						**17/3/2024**

	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Chapter 5: Preliminary Implmentation						
Generate terminal system framework	**18/3/2024**					
Software Setup (Function Setup)	**22/3/2024**					
Components Integration		**26/3/2024**				
Develop Terminal User Interface		**29/3/2024**				
Develop User Communication Medium		**31/3/2024**				
Code Refinement			**3/4/2024**			
Establish Synchronization			**5/4/2024**			
Record Documentation						
Refine Draft Report				**10/4/2024**		
Draft Checking						**22/4/2024**

3.4 FYP 2 Development Timeline

FYP 2						
Project Activities	**Project Weeks**					
	Week 1	Week2	Week 3	Week 4	Week 5	Week 6
Enhance Development						
Upgrade Fridge Terminal	**21/6/2024**					
Dataset Preparation		**25/6/2024**				
Object Detection Model Training		**29/6/2024**				
Model Deployment			**3/7/2024**			
Physical Components Preparation			**6/7/2024**			
Components Integration				**9/7/2024**		
Database Environment Preparation				**11/7/2024**		
Record Deloyment				**13/7/2024**		
Develop Respond Generator					**17/7/2024**	
Test Session						
System Testing and Performance metrics					**20/7/2024**	
Validate and Compare the Result					**22/7/2024**	
System Refinement and Roll Back Checking						**24/7/2024**
Retest						**28/7/2024**
Objective Evaluation						**1/8/2024**

	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
Report Documentation							
Challenges Documentation	**6/8/2024**						
Report Complement		**12/8/2024**					
Project Summary & Conclusion		**13/8/2024**					
Final Checking			**17/8/2024**				
Report Checking							
Draft Checking							**5/9/2024**
Final Version Submission							**6/9/2024**

Chapter 4: System Design

4.1 System Block Diagram

4.1.1 Food Detection & Recognition System

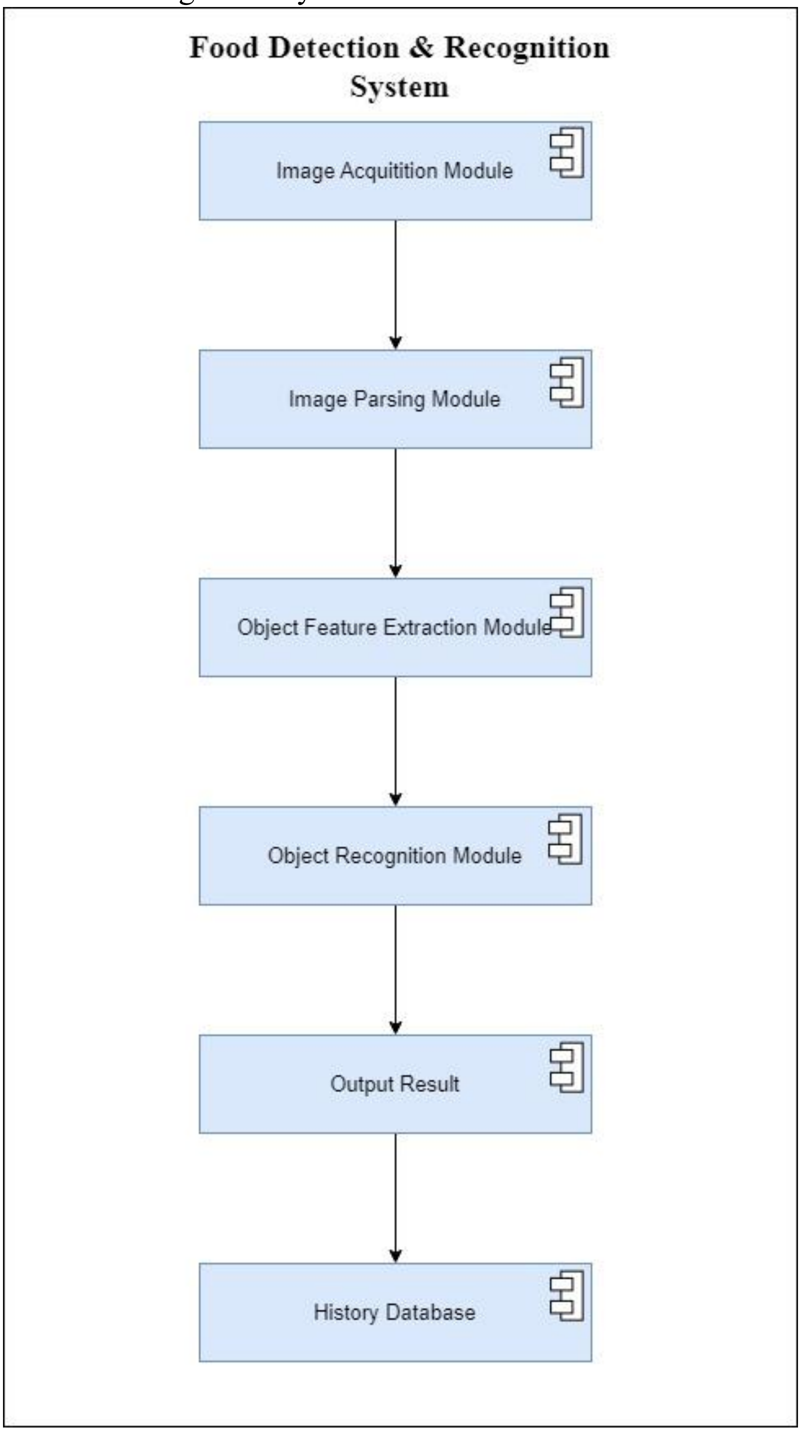


Figure 4.1.1: Food Detection & Recognition System Block Diagram

This figure 4.1.1 has shown a complete system for real-time identification, as well as tracking of the food items in a virtual refrigerator. It starts with the Image Acquisition Module where images of the refrigerator's content are taken using a webcam and trigger by the user action. This module is important as it gives the system the data that is required to enable the other modules to perform objects detection and recognition tasks.

After the images have been taken, the acquired images are forwarded to the Image Parsing Module. The preprocessing step in this module involves resizing, normalization, and format changes to ready the images for the subsequent analysis. This makes the images to be in the best condition for the next process thus making the subsequent processes to be accurate and fast.

After that, the processed images are then passed through the Object Feature Extraction Module in which shapes, colour and texture features are extracted. This step is purpose to defining the specific features that are unique to different foods. These extracted features are then used in the Object Recognition Module in trained deep learning module to identify and classifying the food items.

The Output Result module is responsible for presenting the recognized food items and it gives a result of the contents of the refrigerator after the recognition has been made. Nevertheless, this information will represent through the fridge simulator interface and saved in the history database which to represent user storage and remove behaviour of food. This database keeps a record of all the items that have been recognized over time that helps in tracking of inventory and usage. This makes the system modular and thus highly efficient and easily expandable depending on the needs of the organization.

4.1.2 Fridge Terminal System

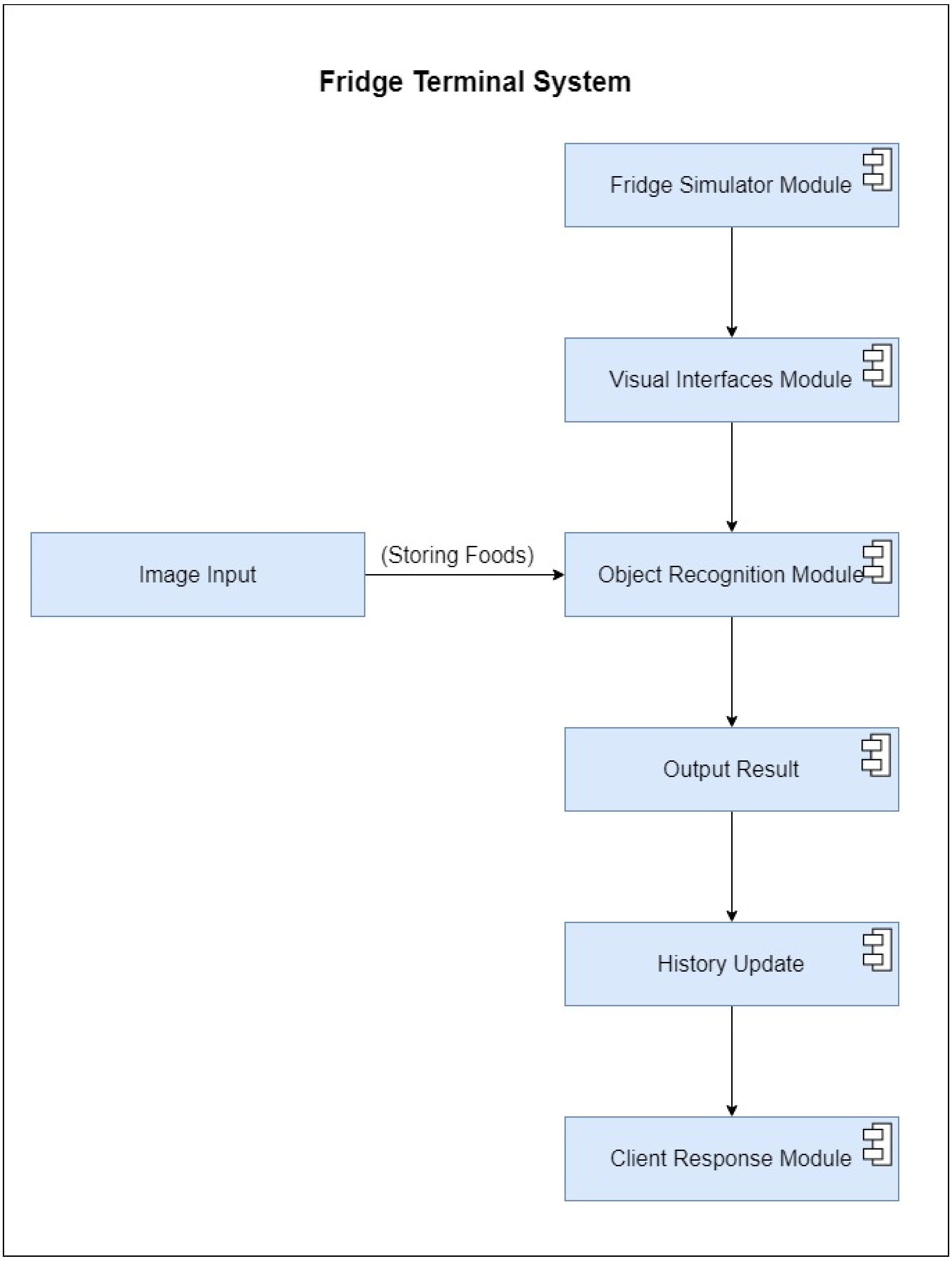


Figure 4.1.2: Fridge Terminal System

In figure 4. 1. 2 describes a Fridge Terminal System that combines simulation, recognition, and management of stored food in a virtual environment. The system is intended to be at the centre of the entire system works, which mimic the refrigerator functionality, identify the stored items, keep record of these items for inventory purposes and compute the user response for different scenarios.

This is done by the Fridge Simulator Module that involves the creation of a virtual fridge that simulates a real one. This module is crucial for the purpose of the storage and retrieval of food items in an environment that is controlled, and as such the users get to engage with a fridge like environment. The simulation data is then passed to the Visual Interfaces Module which has the graphical representation of the fridge and its contents. This module also guarantees that the users have a clear and intuitive vision of the items stored, thus making the interaction more attractive and informative.

At the same time, the Image Input module records images that are related to storage actions, for instance, placing or taking food items. These images are important for the system's ability to recognize objects and are sent to the Object Recognition Module. This module employs the use of complex image analysis and artificial neural networks to detect and classify foods. It is important to maintain an organized inventory and for this reason, it analyses the visual characteristics of the items to guarantee proper recognition.

Once the objects are recognised, the results are presented through the Output Result module. This module gives the users a list of the items that have been stored or retrieved so that they can have an overview of what has been done. This information is then updated in the History Update module which records all the activities such as adding, deleting and the current status of the items. This history is useful in monitoring how the usage of the inventory has been over a given period.

Finally, the Client Response Module processes the updated history data to generate appropriate responses or actions based on user interactions or system status. This could include notifying users of low-stock items, suggesting restocking, or providing summaries of recent activities.

By combining simulation, recognition, and responsive feedback, the Fridge Terminal System offers a comprehensive solution for managing food storage in a simulated environment, enhancing user experience and ensuring efficient inventory control.

4.2 System Components Specification

4.2.1 Hardware Platform

4.2.1.1 Asus TUF-gaming A15

Description	Specifications
Model	Asus TUF-gaming A15
Processor	AMD 5600
Operating System	Windows 10
Graphic	NVIDIA GeForce GTX 1650 ti
Memory	DirectX11 8GB DDR4 RAM
Display	1920 * 1080 Landscape

Table 4.2.1.1: Main Development Tool

The Asus TUF Gaming A15 is a robust gaming laptop equipped with an AMD Ryzen 5 5600 processor and runs on Windows 10. It features an NVIDIA GeForce GTX 1650 Ti graphics card, 8GB of DDR4 RAM, and supports DirectX 11. The display is a Full HD 1920x1080 resolution, providing a high-quality visual experience suitable for gaming and multimedia tasks.

4.2.1.2 Raspberry Pi 4 Model B

Description	**Specifications**
Model	Raspberry Pi 4 Model B
Release Date	June 2019
Processor	Broadcom BCM2711, Quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
Memory	2 GB
Graphics	OpenGL ES 3.0 Graphics

Table 4.2.1.2: Raspberry Pi Details

The Raspberry Pi 4 Model B is a powerful, compact single-board computer released in June 2019. It features a Broadcom BCM2711 quad-core Cortex-A72 64-bit processor running at 1.5GHz and comes with 2GB memory and OpenGL ES 3.0 Graphics

4.2.1.3 USB Webcam

Description	Specifications
Model	USB Webcam
Image Senser	CMOS
USB Interface	Dirverless USB 2.0
Image focus	5 cm to infinity

Table 4.2.1.3: USB Webcam Details

The Webcam that connected with raspberry pi is simulation of real-time photos capturing of food stored and generating digital images, and then transferring them to the host computer for storage.

4.2.2 Firmware/OS

4.2.2.1 Windows 10 Home

Description	Specifications
Edition	Windows 10 Home
Release Date	July 29, 2015
Version	22H2
OS build	19045.4651
Experience	Windows Feature Experience Pack 1000.19060.1000.0

Table 4.2.2.1: Window System Details

This table provides an overview of the key features and specifications of Windows 10 across different aspects such as system requirements, security, productivity, networking, compatibility, system management, enterprise features, developer tools, gaming, and accessibility.

4.2.3 Program Language

4.2.3.1 Java/JavaFX

Description	Specifications
Language	Java / JavaFX
Version	1.8.0_411

Table 4.2.3.1: Jave / JavaFX language Details

For designing and simulating the fridge terminal of this project, making it the core of the entire project, and then deriving objective solutions and deploy management.

4.2.3.2 Python

Description	Specifications
Language	Python

Version	3.12

Table 4.2.3.2: Python language Details

Python is used for training the object detection model to recognize items inside the fridge, as well as for upgrading and predicting responses in the smart alert system.

4.2.3.3 OpenCV

Description	**Specifications**
Language	OpenCV
Version	4.10

Table 4.2.3.3: OpenCV Details

OpenCV is utilized for object detection by identifying and classifying items inside the fridge from the captured images. OpenCV also handles image processing tasks, such as resizing and noise reduction, to enhance the quality of the images and ensure accurate detection.

4.2.3.4 JSON

Description	Specifications
Language	JSON
Version	20240303

Table 4.2.3.4: JSON Version Details

JSON is used as a medium for goods, serving as a package for information exchange and transmission between systems. This includes object detection and recognition results, script execution comments, and communication between the system and Raspberry Pi.

4.3 Circuits and Components Design

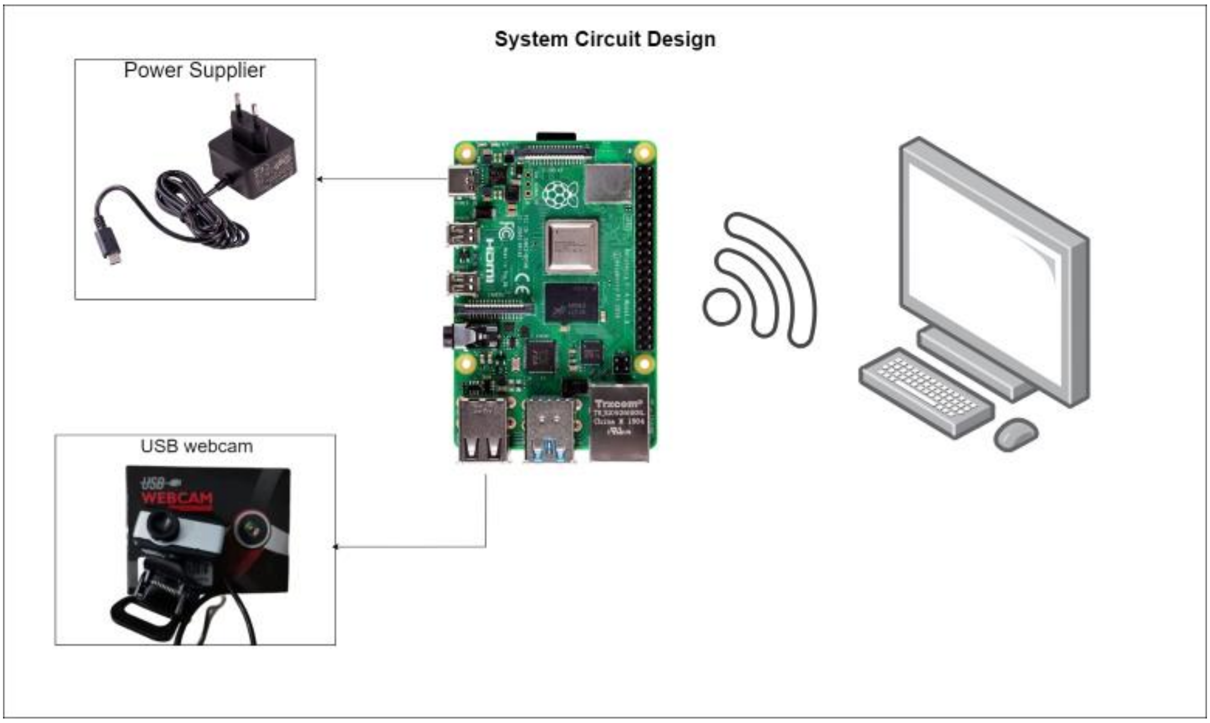


Figure 4.3: Circuits and Components Design

This developed circuit design mentioned does not include soldering or circuit connection processes involved in the production. However, it optimizes the utilization of the versatile option available in the Raspberry Pi 4B model for development. As it can be observed from figure 4.3, is about required is a stable power supply and a USB webcam connection. Following that, through the technical aspect, the system works wirelessly using a network connection to establish interaction between circuit with terminal platform.

4.4 System Components Interaction Operations

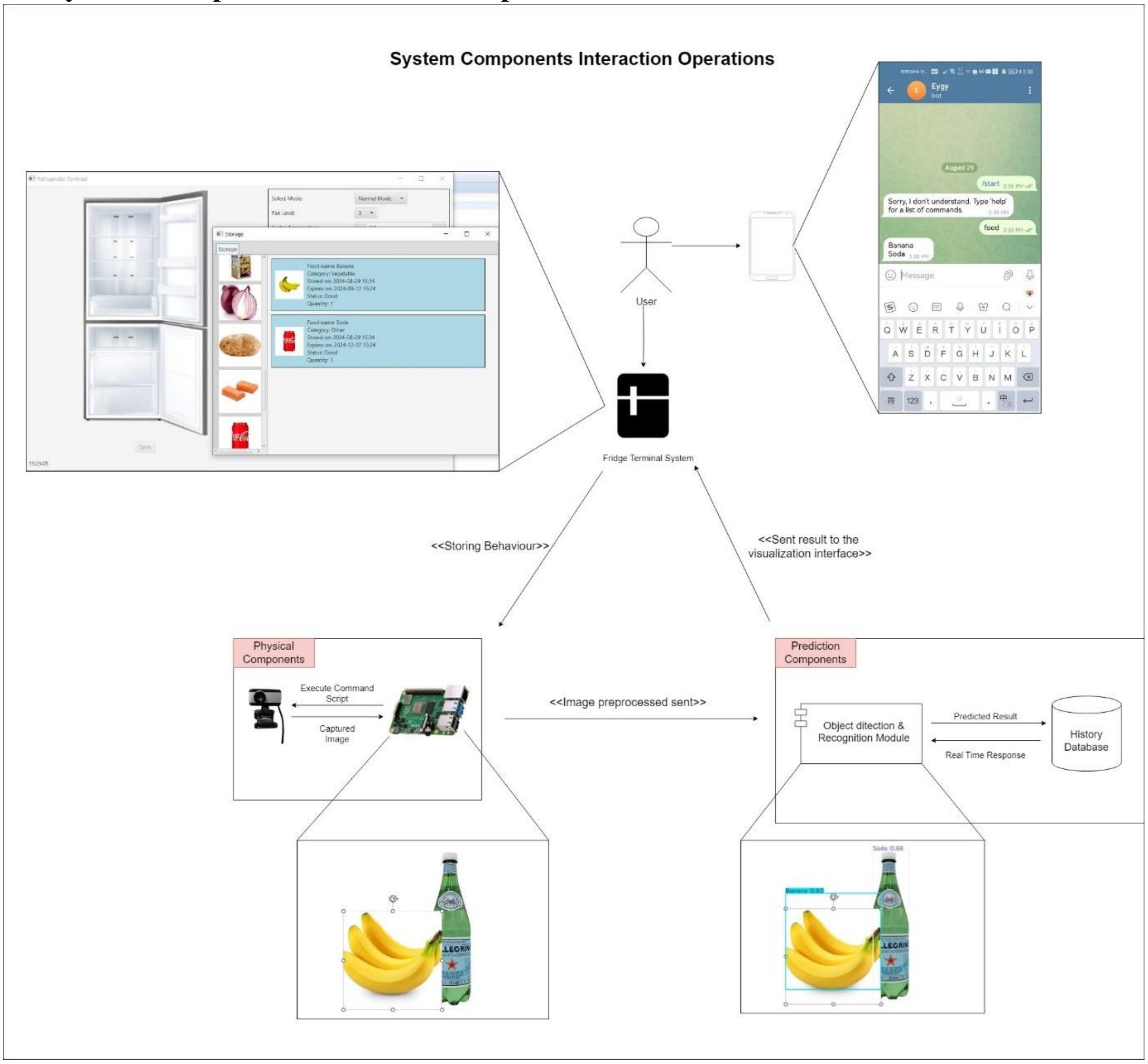


Figure 4.4: System Components Interaction Operations

The figure 4.4 demonstrate the Whole Smart Fridge Terminal System in a systematic solution that combines different elements to control and monitor food and its stocks. It is equipped with a user interface which offers a menu that displays the fridge content in pictures and other details such as name of the food, type of food, date and time of addition, and the quantity. This interface helps users to be able to control and check on the status of storage of the food items conveniently.

At the part of the system's physical components are include a camera and a Raspberry Pi. The camera which is attached to the Raspberry Pi takes pictures of the items inside the fridge either when the door is opened or at some predefined time. These images are pre-processed by the Raspberry Pi and then forwarded to the system's Prediction Components. The Prediction Components consist of an Object Detection and Recognition Module that involves the use of artificial intelligence to detect and categorize the objects that appear in the images. The module described above identifies and recognizes different foods in images and stores the outcomes in the history database.

The history database enabling the system to keep a record of all identified items and produce the reports on the food intake and the food storage. This data is also used for updating storage section of the fridge terminal system so that the user interface always contains up-to-date information about the fridge's contents.

Last, the system has a mobile visualization interface which is invoked through a messaging API, for instance, Telegram. This interface enables the user to communicate with the fridge through sending commands or questions to get the status of the fridge. They can request for information such as what is being stored now or be alerted when a certain item's stock is low or when some items are expiring.

Chapter 5: System Implementation

5.1 Hardware Setup

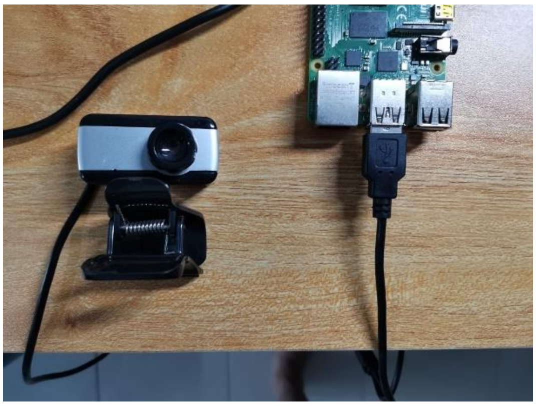
	Connect the Raspberry Pi 4B to an adapter via the USB Type-C interface to provide power, which will output a constant 5.1V.
	Connect the Micro HDMI to HDMI interface to a laptop or external display (for initial setup only). After the initial setup, this step will no longer be necessary to complete the tasks.
	Connect the webcam to the USB interface for standby, and then use a script or commands to access it.

Table 5.1: Hardware Setup Step

5.2 Software Setup

Before launching the initialization, the Raspberry Pi needs a series of system installations and configurations, as well as some adjustments on the host machine, to ensure the proposed system can run properly.

5.2.1 Raspberry Pi System Installation Sequences:

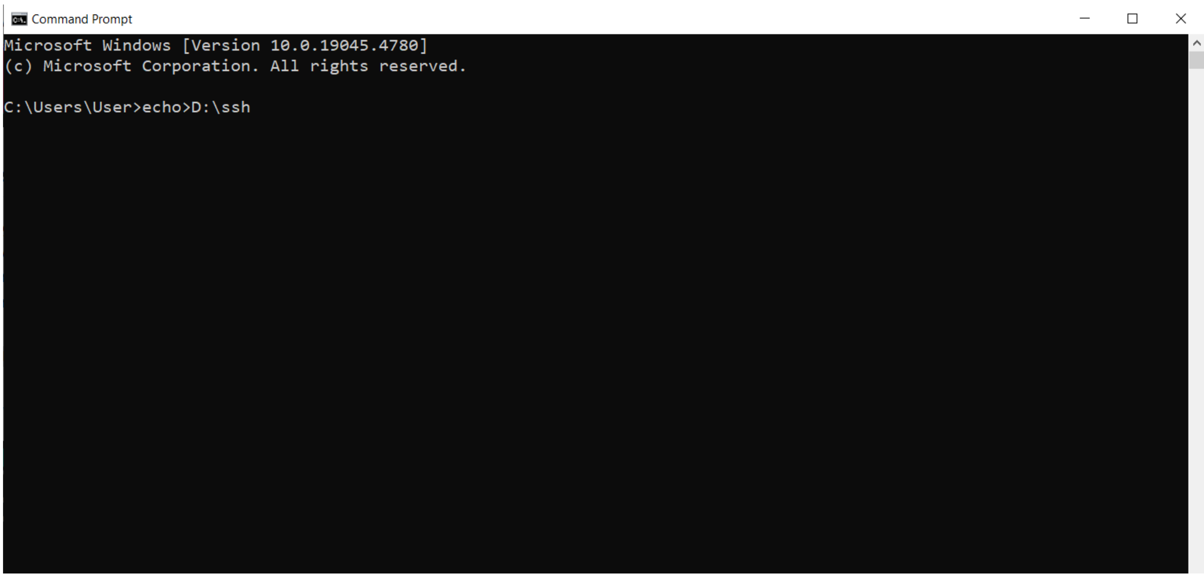
I.

Prepare a microSD card for to store the operating system and data, making it essential for booting, running applications, and saving files. At least 16GB is recommended, but 32GB or higher is ideal for more extensive usage.

II.

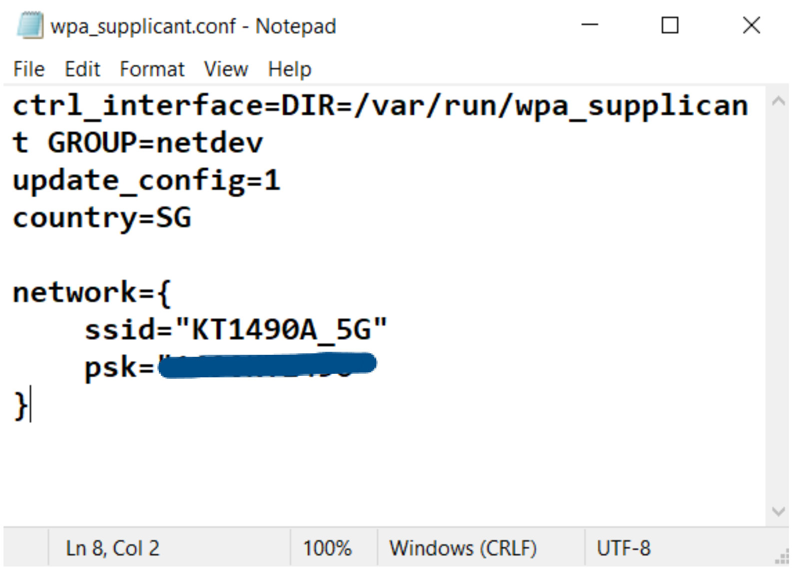
After inserting the card into the host machine, start the Raspberry Pi Imager and follow the settings shown in the figure. The reason for using the OS (32-bit) system is because this development uses a 4B Pi with 2GB RAM and is limited to command-line operations.

III.



To prepare for incoming wireless operation, we need to copy an empty ssh file onto the microSD card. Which using the ‘echo’ command to achieve it.

IV.



Last, create a notebook and write the configuration as shown as figure. This file is used for internal network setup to facilitate wireless connections. Input the **SSID** as the network name, and the **PSK** as the network password. Then, attach this note to the microSD card and name it as “wpa_supplicant.conf”.

V.

Download PuTTY and VNC Viewer. PuTTY is an SSH client for remote command-line access to Raspberry Pi, which allowing to execute commands and manage user device without a direct monitor or keyboard. VNC Viewer provides remote desktop access, enabling user to interact with the Raspberry Pi's graphical interface without any physical connection.

5.2.2 Java setup (SHH Connection with Raspberry Pi)

The following Java code setup an SSH connection with a Raspberry Pi using the JSch library that facilitates secure shell. The program starts with creating an SSH connection to Raspberry Pi by using the given username, IP address, and password. On connection, it sends a command to the Raspberry Pi using a terminal application known as fswebcam that is used to take images from the webcam. The captured image is stored with the Raspberry Pi at the given path. The program then downloads this image using SFTP (Secure File Transfer Protocol) and stores it in the path indicated by the user in his/her laptop. The image is then transferred and the SSH and SFTP connections are terminated afterwards. This automation allows the image capture and transfer from Raspberry Pi to a laptop from a distance.

```
    private final String piUser = "____";
    private final String piHost = "____";
    private final String piPassword = "____";
    private final String remoteImagePath = "_____";
    private final String localImagePath = "____";
```

This part of the code declares several class-level variables that contain login information and the paths to the Raspberry Pi and files. The piUser variable stores the username needed to log in to the Raspberry Pi. The piHost variable is the IP address of the Raspberry Pi on the local network. The piPassword variable holds the password that is required for authentication to access the pi. The remoteImagePath variable holds the path on the Raspberry Pi in which the captured image will be stored and the localImagePath variable holds the path where the image will be downloaded in the laptop. These paths are important in the control of the image capturing and transfer between Raspberry Pi and the laptop.

```
private void captureImage() {
        try {
            // Setup JSch for SSH connection
            JSch jsch = new JSch();
            Session session = jsch.getSession(piUser, piHost, 22);
            session.setPassword(piPassword);

            java.util.Properties config = new java.util.Properties();
            config.put("StrictHostKeyChecking", "no");
            session.setConfig(config);
            session.connect();
```

```
// Run fswebcam command on Raspberry Pi
ChannelExec channelExec = (ChannelExec) session.openChannel("exec");
channelExec.setCommand("fswebcam --verbose image.jpg");

// Capture output and error streams for debugging
InputStream in = channelExec.getInputStream();
InputStream err = channelExec.getErrStream();
channelExec.connect();

// Read command output
byte[] tmp = new byte[1024];
while (true) {
   while (in.available() > 0) {
      int i = in.read(tmp, 0, 1024);
      if (i < 0) break;
      System.out.print(new String(tmp, 0, i));
   }
   while (err.available() > 0) {
      int i = err.read(tmp, 0, 1024);
      if (i < 0) break;
      System.err.print(new String(tmp, 0, i));
   }
   if (channelExec.isClosed()) {
      if (in.available() > 0) continue;
      System.out.println("Exit status: " + channelExec.getExitStatus());
      break;
   }
   try {
      Thread.sleep(1000);
```

```
            } catch (Exception ee) {
                ee.printStackTrace();
            }
        }

        channelExec.disconnect();

        // Transfer the image back to the laptop
        downloadFile(session, remoteImagePath, localImagePath);

        session.disconnect();

    } catch (Exception e) {
        e.printStackTrace();
    }
}
```

The captureImage() method establishes an SSH connection to the Raspberry Pi using the JSch library and executes a command to capture an image with the Pi's webcam using fswebcam. It first sets up the SSH session with the provided credentials, bypassing strict host key checking for convenience. After connecting, it opens an execution channel to run the image capture command, monitors the command's output and errors for debugging, and waits for the process to complete.

```
private void downloadFile(Session session, String remotePath, String localPath) {
    try {
        ChannelSftp channelSftp = (ChannelSftp) session.openChannel("sftp");
        channelSftp.connect();
```

```
        try (OutputStream outputStream = Files.newOutputStream(Paths.get(localPath))) {
            channelSftp.get(remotePath, outputStream);
        }

        channelSftp.disconnect();
    } catch (Exception e) {
        e.printStackTrace();
    }
}
```

The downloadFile() method transfers a file from the Raspberry Pi to the local laptop using the SFTP protocol. It begins by opening an SFTP channel (ChannelSftp) over the existing SSH session (session). After connecting the SFTP channel, it sets up a file output stream to the specified local path (localPath) on the laptop. The channelSftp.get() method is then used to download the file from the Raspberry Pi's path (remotePath) to the local output stream. This effectively transfers the file from the Raspberry Pi to the laptop. After the transfer is complete, the SFTP channel is disconnected to close the connection, and any exceptions during the process are caught and printed to the console for debugging.

5.3 Setting and Configuration

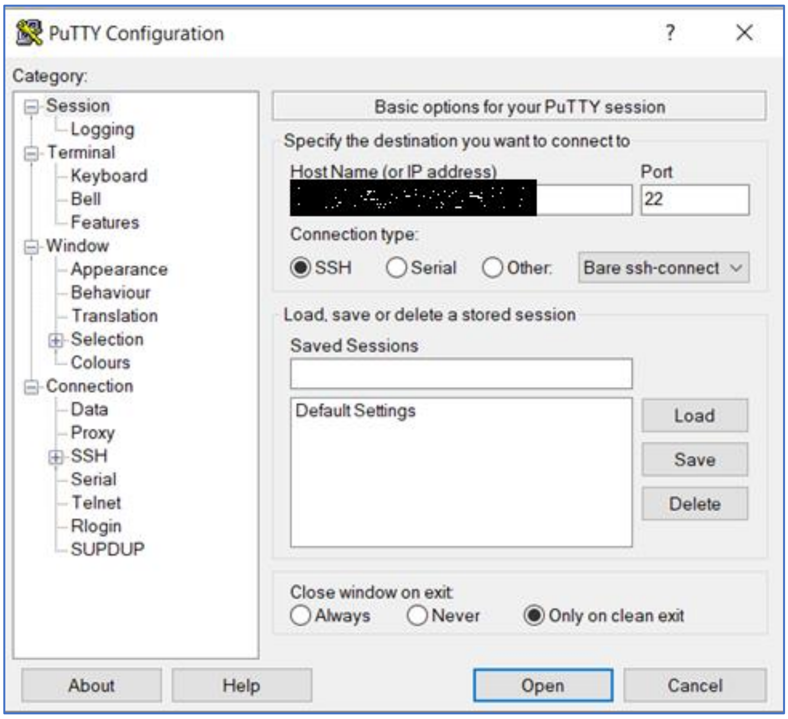


Figure 5.3.1: Putty Configuration

PuTTY, enter the IP address or hostname of the device that wanted to connect and ensure the "Port" is set to 22, which is the default for SSH. Under "Connection type", select "SSH" to specify that this is an SSH connection. Once everything is set up, clicking "Open" initiates the SSH connection to the remote device.

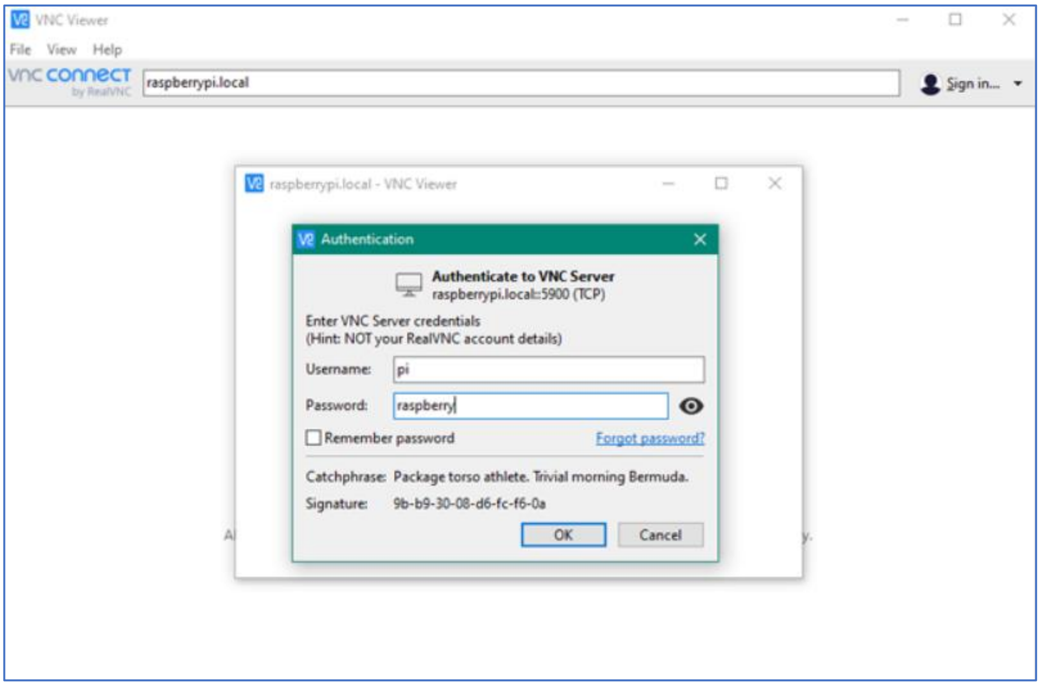


Figure 5.3.2: VNC Login Configuration

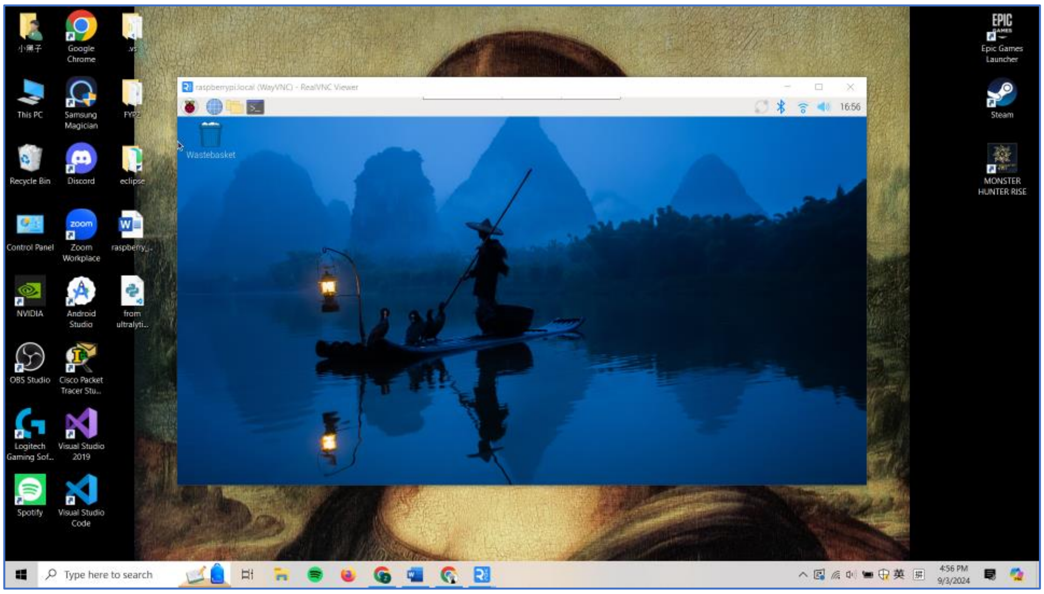


Figure 5.3.3: Raspberry Pi Interfaces

Once successfully connected, use VNC to enter the Raspberry Pi's hostname and password again. This will enable secure remote-control access to the Pi, allowing you to perform tasks inside it.

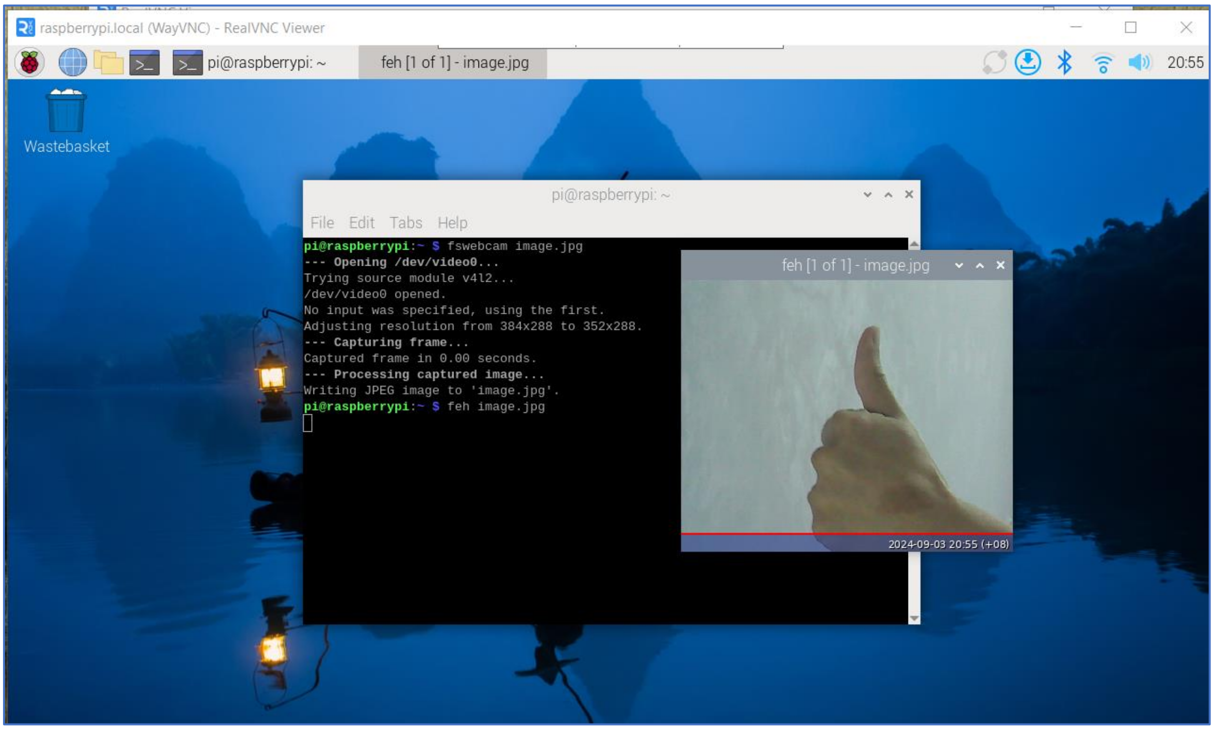


Figure 5.3.4: Webcam configuration and testing

To verify the connection and compatibility between the webcam and the Raspberry Pi, we ran the commands 'sudo apt update' and 'sudo apt install fswebcam feh' to install the necessary software. Then tested the webcam's performance by capturing an image with the command 'fswebcam image.jpg' and displaying the captured image using 'feh image.jpg'.

5.4 System Operation

Figure 5.4.1: Predicted result

Once all preparations are completed, the system will be able to perform object recognition across different contexts. By using a trained model and a webcam, the captured images are processed through the model, which, based on the quality of the training set and the host's GPU capabilities, identifies parts of the image that represent food items. This effectively simulates a camera inside a refrigerator scanning and identifying its contents.

5.5 Implementation Issues and Challenges

When trying to establish the first connection, many connection errors happened, which resulted in failure and system crash. Because of the high level of error sensitivity in this configuration, the advancement was very slow. Moreover, the instability of the network led to frequent disconnection and other unexpected errors most of the time.

To be more specific, these issues stem from various causes such as wrong settings in the SSH, different IP address, and network fluctuation. SSH configuration is the process of creating keys, configuring access to the key, and checking the SSH daemon on Raspberry Pi. The failure in any of these steps may result to non-establishment of the connection or crashes. Besides, an incorrect IP address, for example, due to a typo or an outdated assignment in a dynamic network environment, can lead to the Raspberry Pi becoming unreachable.

Network instability brings another dimension into the equation. A variable connection may lead to the termination of the SSH session and the failure of the command or complete disconnection. This is especially so where Wi-Fi connection is weak or patchy as any disruption means having to reconnect which spend more time.

5.6 Concluding Remark

In conclusion, setting up a reliable connection between a Raspberry Pi and external devices, such as webcams, requires careful configuration and attention to detail. Addressing hardware compatibility, ensuring stable network conditions, and correctly setting up SSH and IP addresses are all crucial steps. While challenges such as connection errors and network instability can hinder progress, thorough preparation and troubleshooting can significantly enhance the effectiveness and reliability of the system.

Chapter 6: System Evaluation and Discussion

6.1 System Testing and Performance Metrics

6.1.1 Food detection and recognition model testing and performance metrics

In this experiment focused on food detection and recognition, the objective was to train models on common, everyday food items such as soda, banana, and apple. Given the time constraints, the precision of the models fluctuated range between 91.08% and 95.19%, showing stable performance across multiple iterations. The training process incorporated various models, including convolutional neural networks (CNNs) and neural networks (NNs), while key metrics like the F1 score, precision, recall, and precision-recall curves were used to evaluate the results.

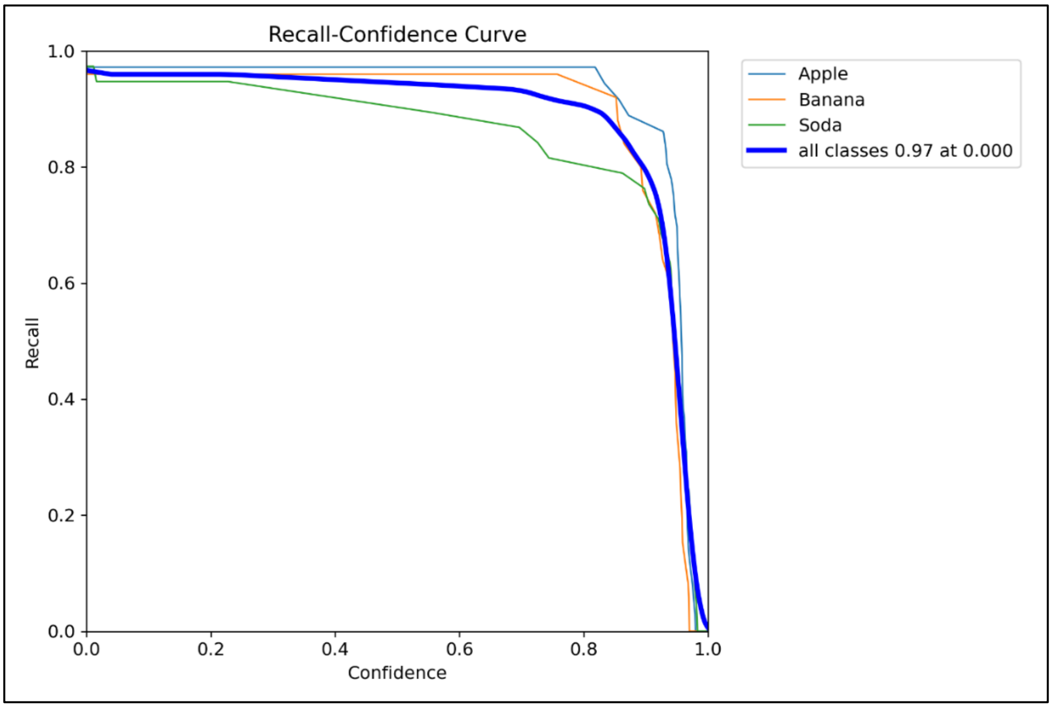


Figure 6.1.1.1: Recall-Confidence Curve

The Recall-Confidence Curve illustrates the relationship between recall (the true positive rate) and prediction confidence. The Recall-Confidence Curve illustrates the relationship between recall (the true positive rate) and prediction confidence. Recall stays consistently high across various confidence levels but starts to drop around the 0.8 mark for individual categories. Notably, for all classes combined, the recall remains at approximately 0.97, even when confidence is set to a very low threshold of 0.0. This suggests that the model can confidently detect most items, though individual class performance may vary.

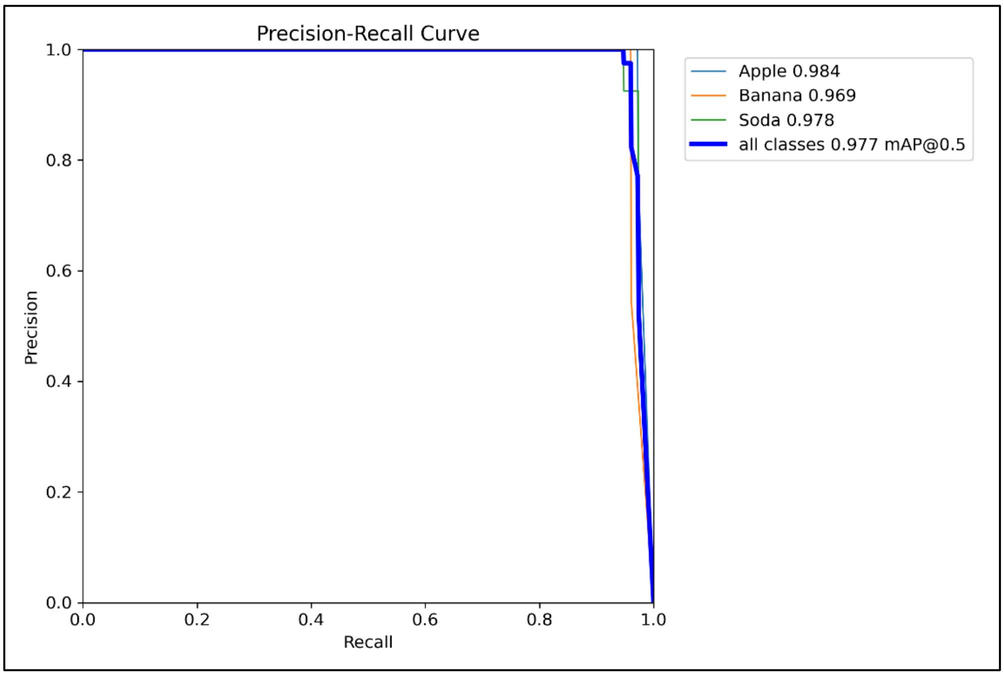


Figure 6.1.1.2: Precision-Recall Curve

The Precision-Recall Curve highlights the balance between precision and recall across the categories. Here, the model performs strongly, with precision and recall values ranging from 0.97 to 0.98 for all classes. The mean average precision (mAP) stands at 0.977 when the threshold is set at 0.5, reflecting a robust trade-off between precision and recall across the dataset.

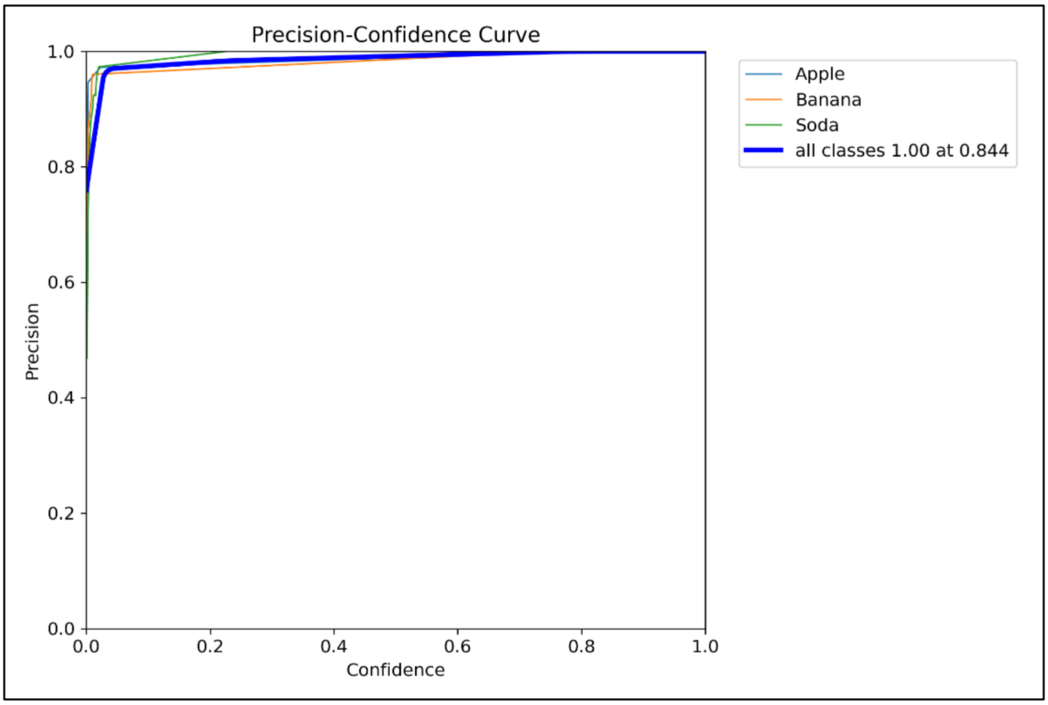


Figure 6.1.1.3: Precision-Recall Curve

The **Precision-Confidence Curve** shows how precision changes as the model's confidence in its predictions increases. Precision hits near-perfect levels (1.00) at a confidence threshold of 0.844, indicating that the model is highly reliable when it makes high-confidence predictions. This is an encouraging sign, especially in applications where accuracy is critical.

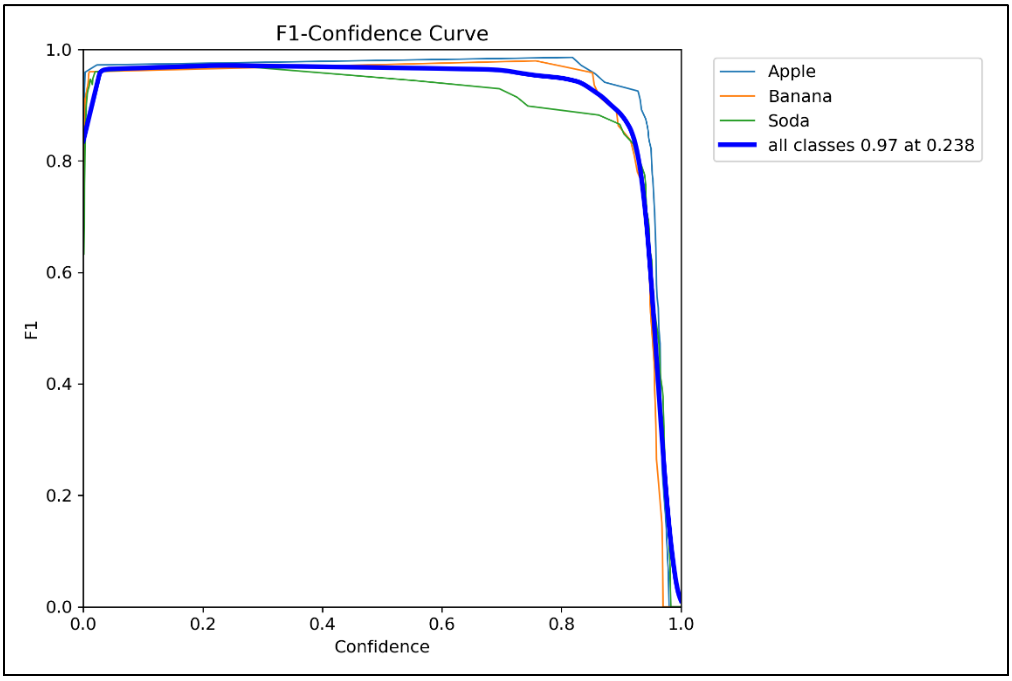


Figure 6.1.1.4: F1-Confidence Curve

Additionally, the **F1 score**, which balances precision and recall, is a critical metric in this experiment. For all classes, the F1 score reaches 0.97 at a confidence threshold of 0.238. This demonstrates that the model maintains a strong balance between precision and recall, even at moderate confidence levels, making it highly effective across a wide range of prediction thresholds. The F1 score is especially important in cases where both false positives and false negatives have serious consequences, as it provides a more holistic view of the model's performance.

In expanding on these results, it's important to note that the model's ability to maintain a high recall across low confidence levels (as shown in the recall-confidence curve) indicates that the system is effective in detecting objects without missing too many relevant items, even when it is uncertain about the prediction. The high precision at confidence levels above 0.844 suggests that when the model does make confident predictions, it is extremely reliable, which is essential for practical applications like food recognition where false positives could lead to confusion or errors. Finally, the strong F1 score at 0.238 suggests that the model performs well even in scenarios where predictions may be less certain, providing a robust all-around performance across multiple metrics.

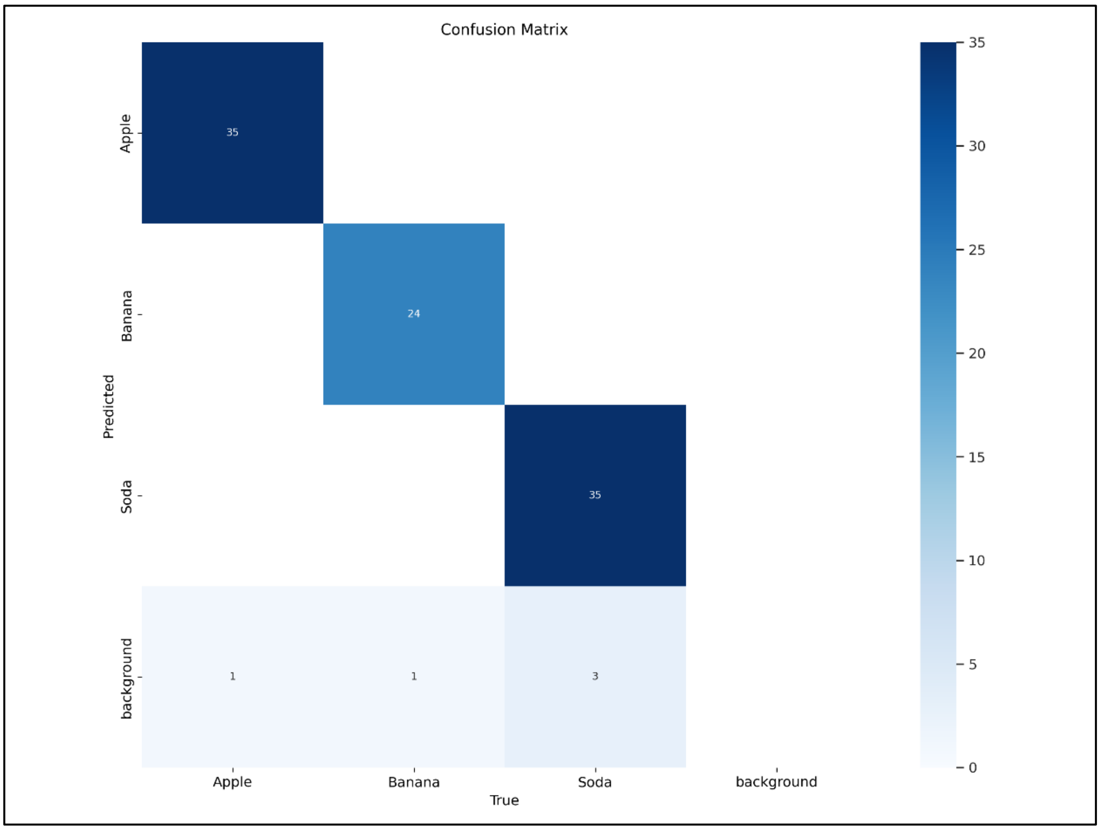


Figure 6.1.1.5: Confusion Matrix

The confusion matrices for your fridge food detection model demonstrate a solid performance overall, with high accuracy across most classes. In the standard confusion matrix, the model correctly identifies apples and soda without any misclassification, with 35 correct predictions for each. Bananas are also detected accurately, albeit with some minor confusion, reflected in the slightly lower count of 24 correct predictions. The background class shows marginal misclassifications, with 1 instance each for apple and banana, and 3 for soda being incorrectly categorized as background. This indicates that while the model performs well in detecting food items, there is some sensitivity when distinguishing between objects and the background.

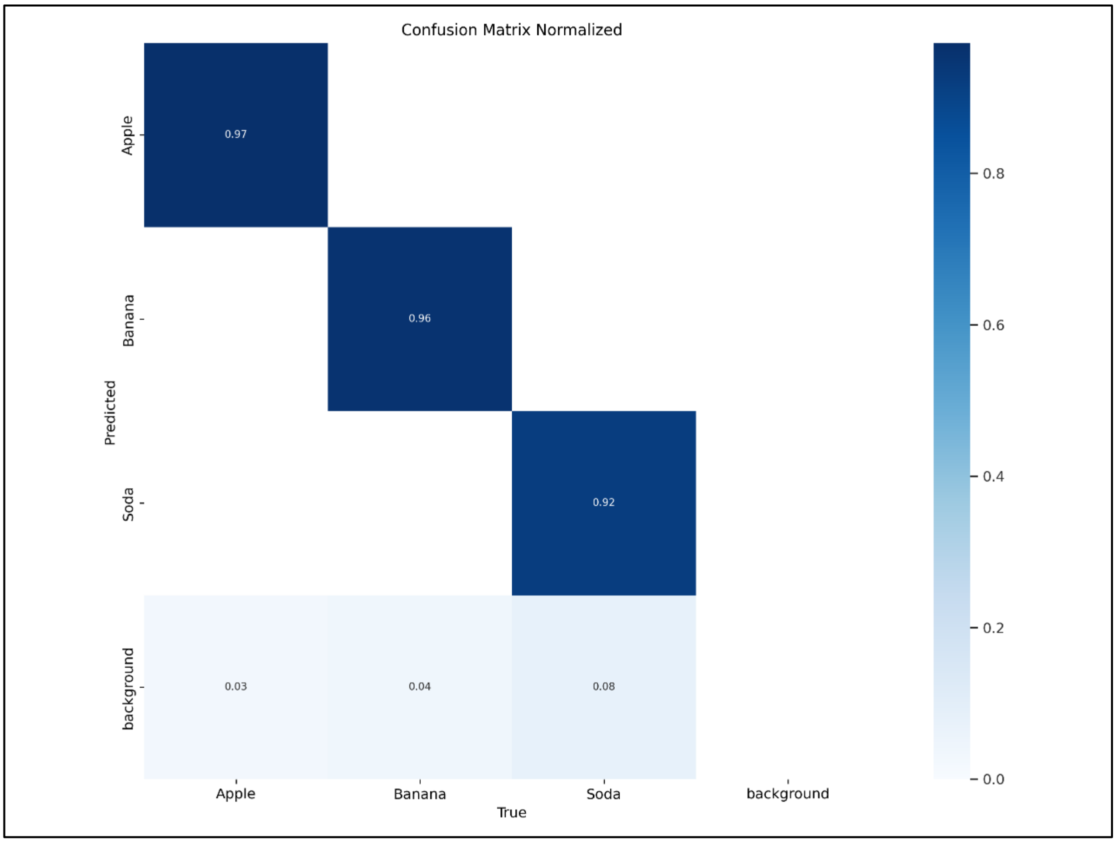


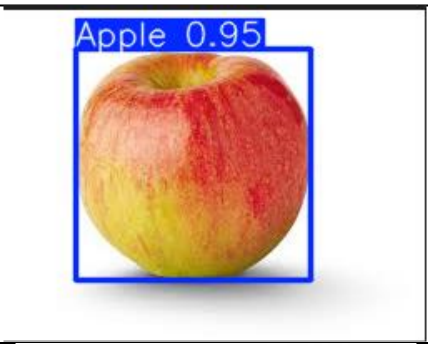
Figure 6.1.1.6: Confusion Matrix Normalized

The normalized confusion matrix highlights the accuracy of predictions across all classes, with apples achieving a near-perfect accuracy of 97%, bananas at 96%, and soda at 92%. These metrics showcase the robustness of the model in identifying distinct food categories. However, there is a minor but notable confusion in the background classification, where 3% of apples, 4% of bananas, and 8% of sodas are incorrectly classified as background. This suggests that while the model excels at recognizing primary food items, there is room for improvement in discriminating between food and non-food (background) elements.

6.2 Testing Setup and Result

6.2.1 Object Detection & Recognition Test

The first test to be conducted is the accuracy of the object detection training set. The experimental items include apples, bananas, and various styles of soda. This test aims to ensure that the system not only accurately identifies these items but also correctly reads and records them after detection. This involves verifying that the training set's performance aligns with the expected results and that each item is properly logged for future reference or actions. The process includes checking for any discrepancies in the detection results, ensuring that the items are categorized correctly, and confirming that the data is accurately captured and stored.

	Apple detected with 95%
	Banana detected with 95%
	Soda Can detected with 97%

	Soda Bottle detected with 96%

Table 6.2.1: Object Recognition Accuracy

The test results, under unobstructed conditions, have shown promising outcomes with high accuracy. The recognition accuracy for apples and bananas reached 95%, while aluminium can sodas achieved an impressive 97%. Bottled sodas followed closely with a 96% recognition accuracy. Given the permissible conditions, the training set demonstrates its ability to perform normal detection capabilities effectively

6.2.2 Object Detected Synchronization

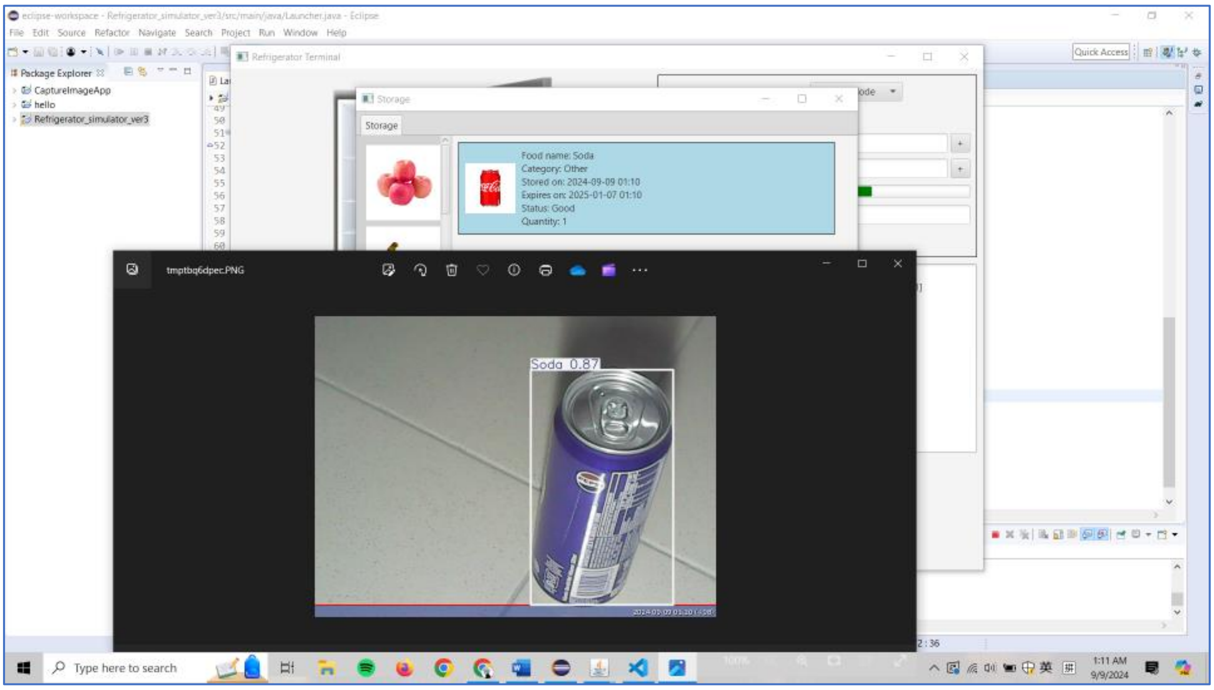


Figure 6.2.2.1: 1 Soda Detected

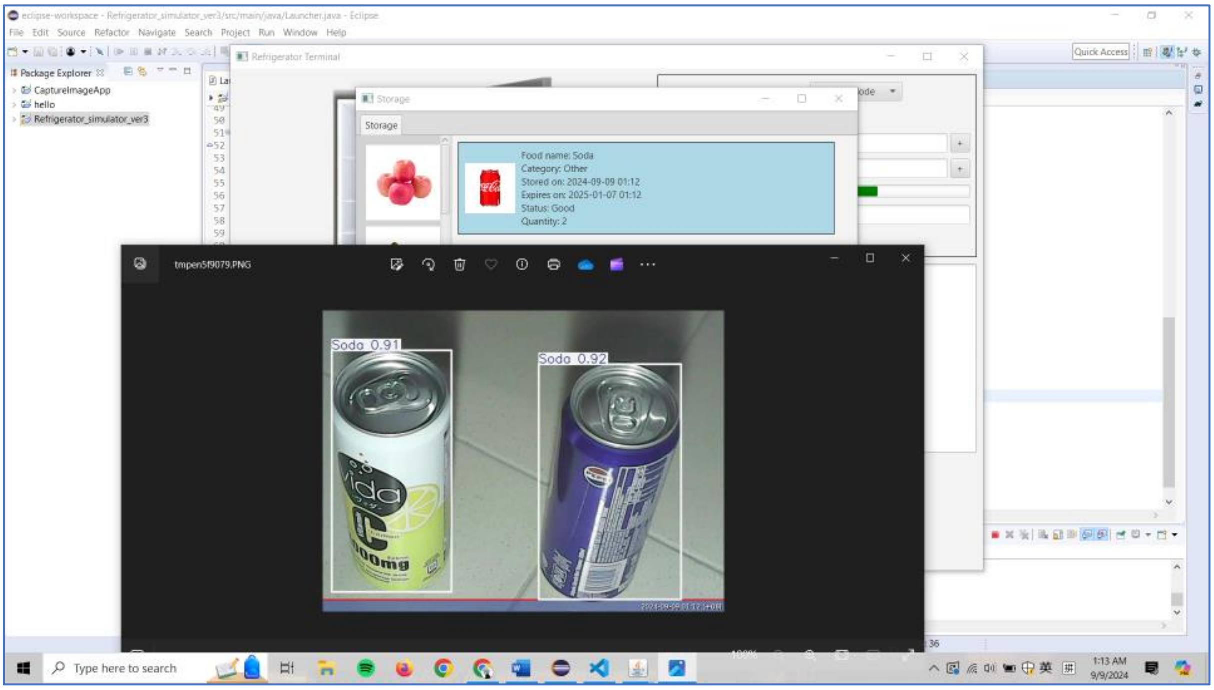


Figure 6.2.2.2: 2 Soda Detected

6.2.3 Client Respond services

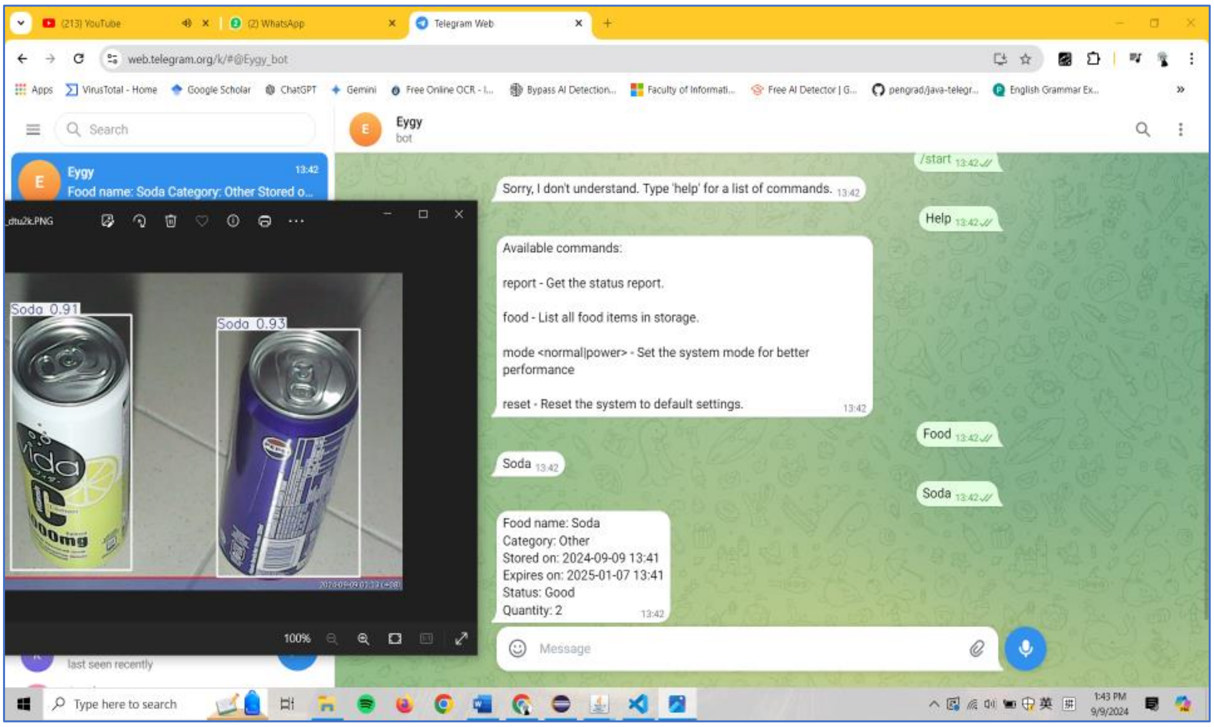


Figure 6.2.3: Telegram API Response

6.3 Project Challenges & Technical Issues

First of all, this proposed project objectively faces a crucial and challenging issue, which the security threats that may prevail in the creation of bridge to exchange information between the different modules. Although this may not be a big issue for experimental purposes, but it exists as potential issue that require secure transfer of data. For instance, the users' behaviour and preferences in the fridge will be monitored and adjusted to the daily habits and preferences. Also, APIs used in mobile location tracking also need to be properly managed. Due to the risks of malicious intrusions and data theft, the security of the system must be enhanced and closely regulated. Besides, the proposed project must consider the security risks associated with data privacy breaches particularly with the growing use of IoT devices.

It should be noted that the security of the system should be maintained by the proper encryption of the data and the constant security audits.

The second challenge is about possibility of the camera to capture wrong images due of the angle or the conditions of the environment. For instance, there are problems such as fogging or condensation that may happen because of the low temperatures and the contact with the warm air when the door of the fridge is opened. This fog or condensation can form on the lens of the camera, and this hinders the vision of the camera and thus produces blurred images. Furthermore, inadequate lighting, wrong positioning of the camera or wrong orientation may lead to the camera not being able to recognize the objects or capture the whole scene. Therefore, this could lead to either poor data or failure of the detection system that compromises the fridge's capacity to keep track of its content.

Therefore, the improvement should explore the solutions such as using advanced cameras with anti-fogging coatings or built-in defogging mechanisms. Another potential solution would be to incorporate external sensors to monitor temperature and humidity inside the fridge, which could trigger automatic defogging actions when needed. Either install a protective covers or regular cleaning mechanisms could be employed to ensure the camera lens remains clear from moisture or debris. These enhancements would ensure clearer and more accurate image capturing, thereby improving the overall reliability of the system.

Finally, given that the main purpose of a refrigerator is to cool, any other technologies should ultimately be aimed at improving the user experience and their comfort. Placing specialized computing devices or CPUs within the fridge goes against the concept of this development. Although this could in fact offer enhanced control and analysis of data and enhanced efficiency of linked outputs it would heavily tax the refrigerator's power source. Even more importantly, it would increase the general cost of the fridge since the price of the material would be incorporated in the final price.

In fact, this project is aimed at addressing the needs of smaller and underserved communities, so it's essential to find alternative methods for physical deployment that can further reduce development costs. Additionally, integrating such complex technology could also increase maintenance challenges, requiring frequent technical support and updates. To remain practical and accessible, a balance must be struck between innovation and functionality, ensuring that the final product is both affordable and energy-efficient for the target demographic.

6.4 Objectives Evaluation

Reflecting to the proposed project's results, that is observed that the first two objectives have been largely achieved with significant progress. The system successfully implements a user-friendly interface that allows for intuitive interaction, fulfilling the first objective. Users can engage with the system effortlessly, establishing a solid foundation for further enhancements. This progress paves the way for the expansion of conversational AI and interaction mediums in smart appliance systems.

The second objective, the development of an automated recognition system, has also been accomplished. Through the integration of object detection technologies, the system is capable of recognizing items inside the fridge and updating its inventory automati cally. This breakthrough will mark as a significant advancement but also establishes a vital technological base for future iterations. The system's ability to autonomously track items represents a transformative step toward reducing manual intervention and improving fridge management efficiency.

However, the third objective is proposing a smart reminders script and enhancing users' food handling awareness, and it requires further work and real-world evaluation. While technical solutions can be developed, this objective hinges heavily on user engagement and behavioural patterns. The effectiveness of smart reminders and their impact on users' food handling habits must be carefully assessed over time. Since refrigerators cater to a broad and diverse audience, achieving success in this area demands collaboration with the users themselves. It is essential to consider their needs, preferences, and interaction patterns when designing the smart reminders, ensuring that the system aligns with their expectations and daily routines.

Thus, the evaluation of this objective is ongoing, and it is expected that real-world testing and user feedback will play a crucial role in shaping its success. The reminders system needs to balance technical sophistication with practical usability, providing value to users by offering actionable insights into food management while raising awareness about food storage, expiration dates, and waste reduction. By involving users in the evaluation and improvement process, the system can evolve to better meet the goal of enhancing food handling awareness and ultimately drive user satisfaction.

In conclusion, while the first two objectives have been successfully met, the third objective will require continuous refinement, collaboration with users, and iterative improvements to ensure it meets both the technical and practical demands of the end-users.

6.5 Concluding Remark

Consequently, there are several questions that remain unanswered in this project, especially the difficulties encountered during the development process. These issues that must be addressed before proceeding with further enhancements and cause another issue. Some of the issues include system insecurity and possible rise in costs due to incorporation of new technology. Upon the analysis of the given options, one of the most effective strategies is to outsource the computing system and security to an external cloud computing provider.

The primary advantage of using cloud computing is its vast computational power, scalability, and nearly limitless storage capacity. With cloud infrastructure, the project free from offloading the heavy processing tasks, allowing for more efficient data analysis and real-time monitoring without burdening the physical fridge. This benefit can reduce the need for powerful in-built CPUs, lowering energy consumption and ensures constant system updates and security patches managed by the cloud provider. Besides, cloud services typically include enhanced of security measures such as encryption, data backups, and automated maintenance, which available for protecting sensitive user data from malicious intrusion.

Furthermore, the flexibility of cloud solutions allows for easy scalability, which means the system can grow with extensive requirements without the need for new and costly hardware investments. The only drawback which can be quite serious is the need to maintain a stable and reliable connection to the network to keep the system running. however, the advantages of this approach, such as the ability in terms of cost reduction, enhanced security, and performance far outweigh the drawback.

Nevertheless, the camera issue could be addressed by adopting hydrophilic-coated glass lenses, which reduce fogging and condensation in low-temperature environments, improving the accuracy of the fridge's image capturing. By balancing cloud integration with practical cost-saving solutions like this, the project can remain accessible to underserved communities while delivering innovative, efficient, and secure performance.

Chapter 7: Conclusion & Recommendations

7.1 Conclusion

In this technologically advanced era, the development of the IoT is inevitable. Recently, there is a trend to integrate smart systems into our daily lives, which aiming to create fully automatic smart home systems like those seen in science fiction movies. This has led to many interesting inventions, such as smartwatches that can connect to household appliances, monitors that can identify pet's moods, voice-controlled home appliances and more. These advancements are essential for technological progress. Although the process may be challenging, the results of these inventions will become pioneers of future technology and an important part of human development history.

In summary, this project aims to utilize technologies such as computer vision and deep learning algorithm to develop a smart refrigerator that can identify and manage food automatically and provide relevant respond-based user's need. It also incorporates popular social media API interfaces for remote communication and operation medium. However, the current progress is only a semi-fidelity product, it has successfully achieved its functional and experimental objectives. Through this project, a brand-new smart refrigerator prototype and strategy have been created, aiming to reduce food waste and promote intelligent technology.

The development of this smart refrigerator solution has the potential to meet modern needs and provide an effective solution to food waste issues. Besides, this research has significant prospects for transforming smart homes and ensuring their long-term viability. No matter what, the efforts must continue to refine and expand these innovative solutions, promote collaboration among stakeholders, and facilitate the widespread adoption of IoT technology.

By the way, this proposed project had contained of two known issues. Firstly, the accuracy of intelligent recognition depends on the completeness of its training set. Integrating and managing a large training set directly on the refrigerator itself is counterproductive because the databases and algorithms used for computation and feedback would consume a significant amount of the refrigerator's resources, leading to inefficiency. Additionally, it is impractical to sell a refrigerator with an entire server built into it. Secondly, the cost and energy consumption associated with maintaining such a complex system could be prohibitive for widespread consumer adoption.

Despite these challenges, the development results are satisfactory. Although many unexpected errors and difficulties were encountered along the way, persistent research efforts have led to significant breakthroughs. Nevertheless, continuous improvement and collaboration with industry experts will be crucial to overcoming the remaining problem and ensuring the successful implementation of this smart refrigerator technology. Which the ongoing evolution of IoT promises a future where technology seamlessly integrates into our daily lives, enhancing convenience and sustainability.

7.2 Future Recommendations

With the rise of cloud computing, many of companies have adopted with cloud-based solutions to enhance their development capabilities. This is because, cloud computing has offers significant advantages in terms of processing speed, read/write speed, and storage capacity, surpassing the limitations of physical hardware. Essentially, it functions like a virtual server, which has garnered widespread popularity. Moreover, cloud users do not need a specialized team for maintenance and upgrades, as these tasks are handled by third-party cloud providers. Users only need to ensure their products remain online to enjoy a wide range of services.

Therefore, incorporating cloud computing into the development of smart refrigerators is both feasible and beneficial for future projects. The primary function of a refrigerator is cooling, with all other features considered secondary, designed to assist in achieving better cooling efficiency. As a result, it does not require, nor can it accommodate, high-performance specialized equipment without increasing costs and leading to a counterproductive outcome.

Additionally, not all users may be suited for or fully understand the high-tech features of a smart refrigerator.

In fact, when cloud computing is integrated into smart fridge development, it revolutionizes both functionality and user experience. With the enhanced computational power and storage capacity of the cloud, smart fridges can leverage advanced machine learning and artificial intelligence algorithms to analyze vast amounts of data and without suppression of local hardware.

Besides, cloud computing also allows for real-time inventory tracking, generate notification based on script triggers. Additionally, cloud computing will make predictive maintenance becomes feasible, as the fridge can diagnose potential issues before they become problems, reducing downtime and repair costs and ensures software updates and new features can be pushed to the appliance seamlessly, thus provide a better user experience environment.

APPENDICES

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WEEKLY REPORTS

FINAL YEAR PROJECT WEEKLY REPORT (WEEK 1)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 1**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Upgrade fridge terminal
2. WORK TO BE DONE **-**Database preparation
3. PROBLEMS ENCOUNTERED -Nope
4. SELF EVALUATION OF THE PROGRESS **-**So far so good

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT (WEEK 2)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 2**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE

-Database built up and fine-tune

-Research of the object detection & recognition techniques

-Prototype built

2. WORK TO BE DONE

-Model deployment on terminal

-Physical components preparation

3. PROBLEMS ENCOUNTERED

-Nope

4. SELF EVALUATION OF THE PROGRESS

-So far so good

Supervisor's signature Student's signature

FINAL YEAR PROJECT WEEKLY REPORT (WEEK 3)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 3**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE
-Model deployment test -Fine-tune Model -Physical components preparation
2. WORK TO BE DONE
-Components setup & research
3. PROBLEMS ENCOUNTERED
-Nope
4. SELF EVALUATION OF THE PROGRESS
-So far so good

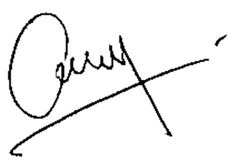
Supervisor's signature Student's signature

FINAL YEAR PROJECT WEEKLY REPORT (WEEK 4)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 4**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Component integration -Object detection & recognition training
2. WORK TO BE DONE -Client site model refinement
3. PROBLEMS ENCOUNTERED -Wasting some time to deal with huge datasets and training
4. SELF EVALUATION OF THE PROGRESS -So far so good



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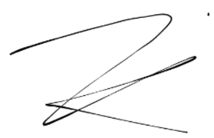

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FINAL YEAR PROJECT WEEKLY REPORT (WEEK 5)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 5**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Deal with client site interface
2. WORK TO BE DONE **-**System compatibility test
3. PROBLEMS ENCOUNTERED -Nope
4. SELF EVALUATION OF THE PROGRESS **-**So far so good

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FINAL YEAR PROJECT WEEKLY REPORT (WEEK 6)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 6**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE
2. WORK TO BE DONE -Rebuilt the model
3. PROBLEMS ENCOUNTERED -System crash due of Gradle setting error
4. SELF EVALUATION OF THE PROGRESS -Keeping effort

Supervisor's signature

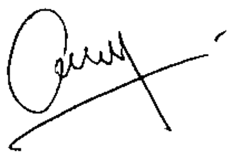
Student's signature

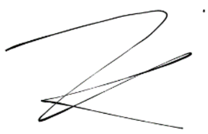
FINAL YEAR PROJECT WEEKLY REPORT (WEEK 7)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 7**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Rebuilt and refine the new system
2. WORK TO BE DONE
3. PROBLEMS ENCOUNTERED **-**No problems encountered
4. SELF EVALUATION OF THE PROGRESS **-**So far so good





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FINAL YEAR PROJECT WEEKLY REPORT (WEEK 8)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 8**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Complete almost the testing and fix some of the defect
2. WORK TO BE DONE -Refactor the coding -Report Writing
3. PROBLEMS ENCOUNTERED -Nope
4. SELF EVALUATION OF THE PROGRESS -So far so good

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FINAL YEAR PROJECT WEEKLY REPORT (WEEK 9)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 9**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Report writing 40%
2. WORK TO BE DONE
3. PROBLEMS ENCOUNTERED **-**Nope
4. SELF EVALUATION OF THE PROGRESS **-**So far so good

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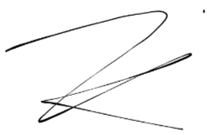
FINAL YEAR PROJECT WEEKLY REPORT (WEEK 10)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 10**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -System validation and performance testing
2. WORK TO BE DONE
3. PROBLEMS ENCOUNTERED **-**Nope
4. SELF EVALUATION OF THE PROGRESS **-**So far so good



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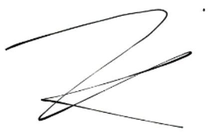
FINAL YEAR PROJECT WEEKLY REPORT (WEEK 11)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 11**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Complete the report
2. WORK TO BE DONE -System refinement -Retest -Objective evaluation -Challenges documentation
3. PROBLEMS ENCOUNTERED -Nope
4. SELF EVALUATION OF THE PROGRESS -So far so good



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FINAL YEAR PROJECT WEEKLY REPORT (WEEK 12)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 12**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE
-System refinement -Retest -Objective evaluation -Challenges documentation
2. WORK TO BE DONE
-
3. PROBLEMS ENCOUNTERED
-Nope
4. SELF EVALUATION OF THE PROGRESS
-So far so good

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FINAL YEAR PROJECT WEEKLY REPORT (WEEK 13)

(Project II)

Trimester, Year: Y3S3	**Study week no.: 13**
Student Name & ID: Ng Zhen Hong	
Supervisor: Ts Dr Cheng Wai Khuen	
Project Title: Smart Refrigerator	

1. WORK DONE -Report draft checking
2. WORK TO BE DONE **-** Project presentation prepare
3. PROBLEMS ENCOUNTERED **-**Nope
4. SELF EVALUATION OF THE PROGRESS **-**So far so good

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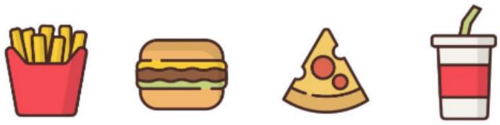
POSTER DESIGN

GENIUS FRIDGE A+Z

New Generation Smart Refrigerator

INTRODUCTION

Refrigerator that can be automatically managed and possesses "intelligence" to provide users with real-time feedback and assistance. These include specialization in security, expandability, or simply embedding a tablet for the sake of adding intelligence.



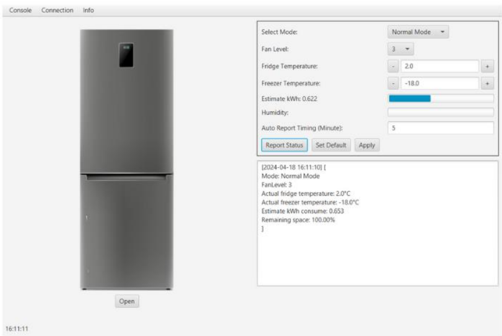
PROPOSED METHOD

-Users can remotely monitor, control, and receive information using their phones.

- With this feature, users can connect to the refrigerator for various operations at any time and from anywhere.

-An advanced AI support system provides users with the most efficient assistance.

- The AI's backup system enables users to handle food-related issues more efficiently.



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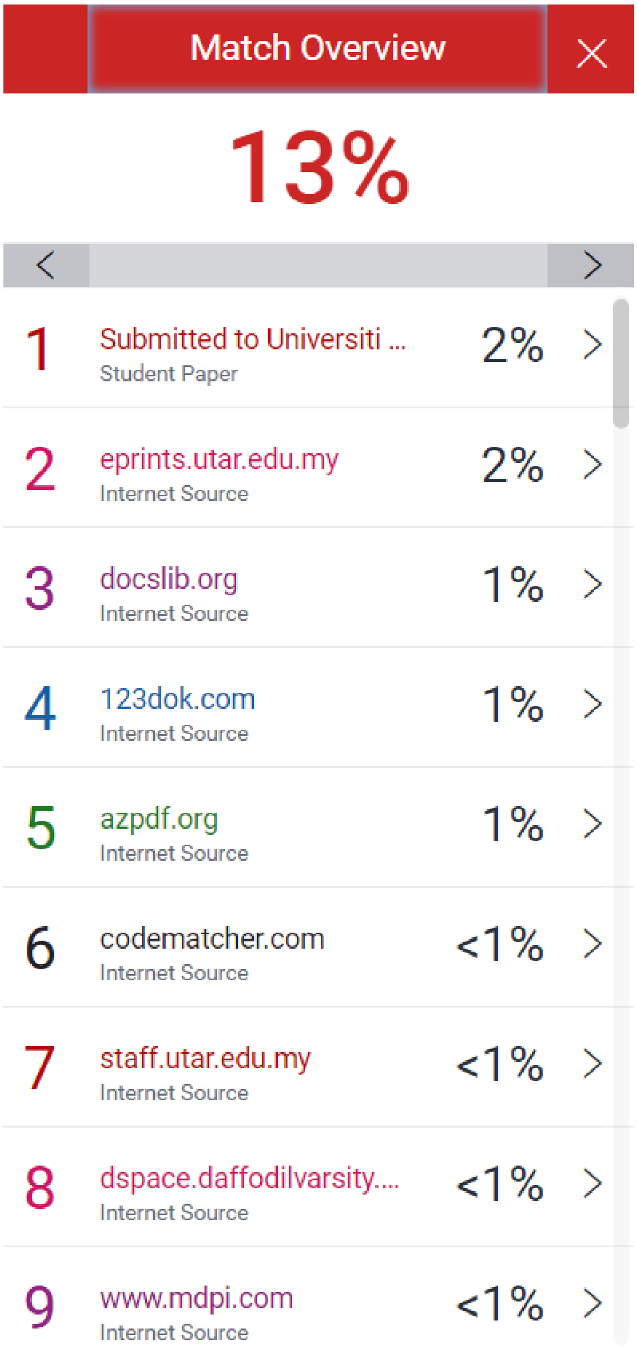

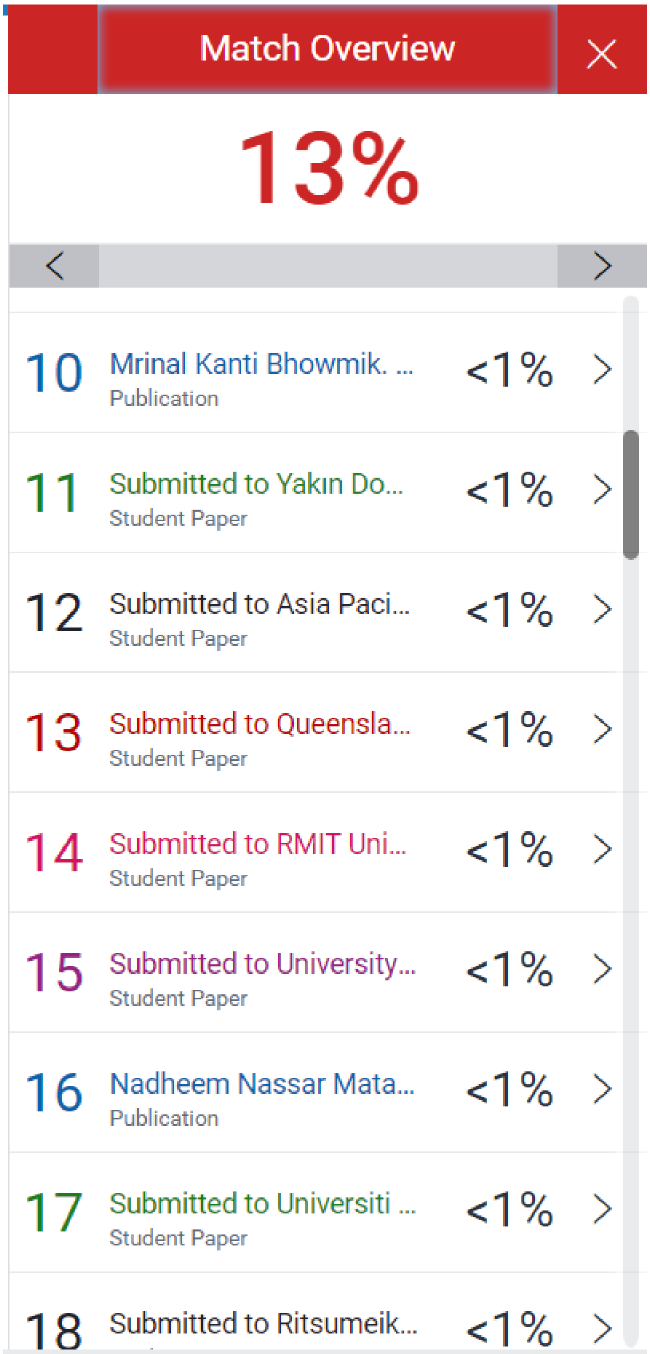
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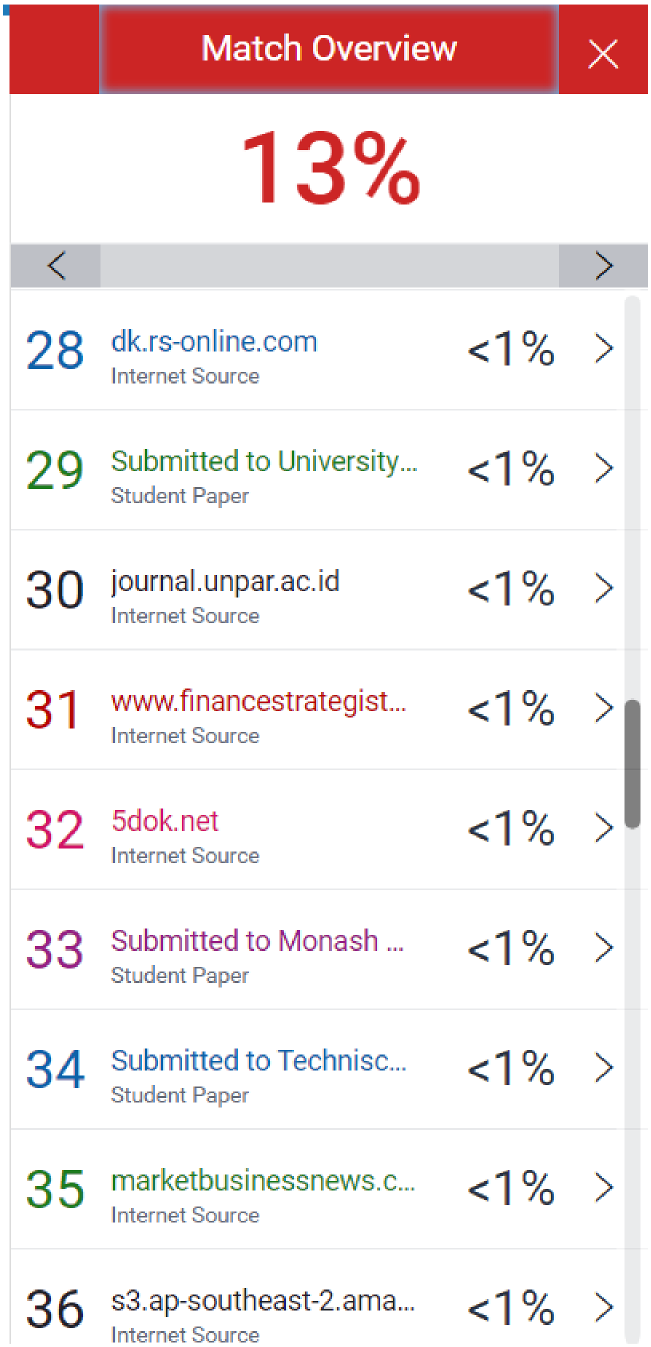
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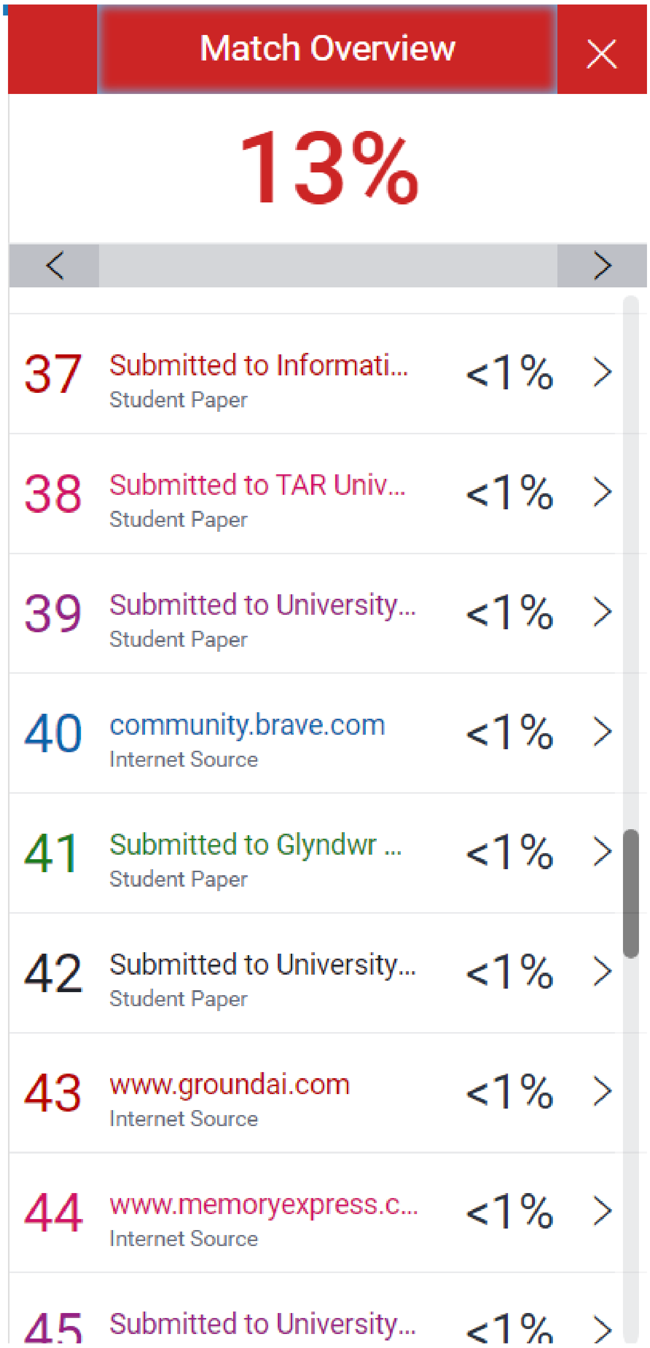
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