

**MUSIC BY ACTIONS: A MUSIC RECOMMENDER BASED ON ACTIVITY
RECOGNITION
BY
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FACULTY/INSTITUTE* OF INFORMATION AND COMMUNICATION TECHNOLOGY

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ABSTRACT

Recommendation systems are widely used for personalized movies, music and product suggestions using collaborative filtering methods. Currently, music recommender suggests music based on listening history and similar genres, which are not ambient and actor aware. This project proposes HitMe; a music recommendation system that suggests songs based on the users' real-time activities. For example, HitMe recommends high tempo songs to a user running on a treadmill while a slow pace song for a user who is relaxing on a couch. Firstly, we build a CNN-LSTM for indoor activity recognition using a custom activity dataset. The dataset contains pre-processed activity videos from "HMDB51", "UCF-101", "STAIR Actions", and "kinetics-downloader" datasets. We train the CNN-LSTM for multiclass classifications to identify nine actions; that includes: "Biking", "ComputerWork", "Driving", "Eat&Drink", "PlayInstrument", "Sport", "Studying", "Walking", "Writing". Before that, we use VGG16 to extract video features useful for the CNN-LSTM. The early results showed that HitMe model score 0.6507 in accuracy for indoor activity recognition. Besides activity recognition model, we also implement a content-based music recommender system by using the Spotify API, where this recommender is to recommend users a list of tracks based on the user preferences such as favourite artist, song, and activity predicted from the activity recognition model. In a nutshell, the final result showed that HitMe able to get user context information and make a recommended playlist in Spotify.

Keywords: Music Recommendation System, Human Activity Recognition, Content-based Filtering, Spotify API, Contextual Awareness.

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LIST OF ABBREVIATIONS

<i>API</i>	Application Programming Interface
<i>AVI</i>	Audio Video Interleave
<i>CNN</i>	Convolutional Neural Network
<i>CNN-LSTM</i>	CNN Long Short-Term Memory Network
<i>GPS</i>	Global Positioning System
<i>HAR</i>	Human Activity Recognition
<i>IoT</i>	Internet of Things
<i>JSON</i>	JavaScript Object Notation
<i>LSTM</i>	Long Short-Term Memory
<i>MRS</i>	Music Recommender System
<i>REST</i>	Representational State Transfer
<i>URL</i>	Uniform Resource Locator

Chapter 1 Introduction

1.1. Problem Statement and Motivation

Music is a popular entertainment media element in this digital world, but it is not only for the entertainment purpose, it also has value on the many different field with the appropriate music. For example, we can play the music or a song in any kind of event like a wedding, a sport competition, etc. Moreover, the music can be categorized into few genres such as bass, pop, jazz, rock, folk, etc. Therefore, with the help of the music recommender the users can get a better user experience when using the music streaming or any music player or playlist, this can be achieved when the music recommender collects the users' data and then analyse the taste of the user. Thus, users will easily get the song recommend and no need spend a lot of time to search for the music that meet their taste. But there is a problem that face by this music recommendation system.

The **problem statement** of this music recommendation system as the below:

- (i) Lack of real time updates or multiple variable types in recommendation systems.

Existing music recommendation is not contextual-aware, i.e. currently, the recommendation algorithm only recommend music based on listening history. Consider a case where user x is reading a book at leisure pace but his playlist is made up of electro music. In this case, the recommender would suggest electro-pop that might not be suitable for reading.

Usually, most of today's recommender systems are based on the users' feedback history towards a specific group of items to make prediction. It is like a service that perform to the users with a number of the recommendations but actually they are giving the same recommendations to the users and without considered users' current mood, location, or activities. [1]

1.2. Project Scope

This project aims to build a Music Recommendation System (MRS) that come out with the music recommendation based on users' current activities. By having these recommendation systems, the system would need the users to provide their contextual information, Human Activity Recognition (HAR) and user's music preference, so that all these metadata and information can be process through the recommendation engine. Hence, it will be generating the recommended playlists based on users' information given. Finally, the users can go thought the recommended playlists that the system recommend to the users.

1.3. Project Objectives

Main Objective:

The Project aims to provide a Music Recommendations System that can based on users' action or activities to recommend them the most suitable music.

By propose this objective, it is mainly to solve the problem of the users faced which is the music recommended by the playlists is not so suitable for the users' current activities. So in this project, it will build up a Music Recommender by improving the contextual aware of the recommend system towards users, so that it can provide the most suitable songs to the users.

Sub-Objective 1:

To design a Music Recommendation Architecture based on activity context using Content-Based filtering method.

Although there are plenty of the music streaming services are using the Collaborative Filtering as their main filtering approach while apply for their recommendation system. But content-based filtering approach is more suitable for this project, this is due to the recommendation is based on user's activity and then store a list of recommended songs into the new playlist, at this time there will be a problem for Collaborative Filtering to apply in this project where it will have the "Cold Start" issue in the beginning.

Sub-Objective 2:

To deploy the Human Activities Recognition (HAR) system using Recurrent Neural Network (RNN).

In this recommender system the one of the inputs is using the Human Activities Recognition (HAR) that means the system will predict the movement of the users based on the sensor data and then make a prediction that which songs will be more suit to the users' music listening taste.

1.4. Impact, Significance and Contribution

The outcome of this project is a music recommender system that provides users a list of recommend songs which may suitable for their current activity. By using this music recommender system, it may help the users to improve their motivation and also the productivity especially for those who like to listen to the music when they are studying, working, sporting, and other human activity. Moreover, this system also helps users to save time on searching for their favorite songs, for instance when the user who wish to listen some high tempo songs during sporting, by recognize their current activity the music recommender will recommend the songs based on the high tempo and also the song's type that users like.

Furthermore, since this project is a combination of the human activity recognition and the hybrid filtering system, hence it can be a recommend system which much closer to the human and also understand us compared to the traditional recommender system.

Besides that, as this project is to recommend the music based on user's current activity, but it also having many different possibilities to work with others application such as IoT, custom gaming BGM, and etc. Hence, this project could contribute as a foundation or base model for the future enhancement.

1.5. Background Information

1.5.1. Contextual Aware

Contextual Aware is an information which recognize from the human or computer system to provide the information relevant to the characteristic of a human or an object and also the current environment. The context information includes the information such as location, identity, location, activity, task and etc.

Furthermore, this context information can be collected by using the current technology that we have, for instance the camera, GPS, microphone and the sensors from our smart devices, and also the resources from the web browser. By having this context information, we can use them to provide a more personalized application or suggestion/recommendations for different types of user's demand. The usage for this context information has been applied in our daily life, for example, the news in Facebook, the recommended songs in Spotify, the suggestion of item in amazon, and etc. [2]

1.5.2. Human Activity Recognition (HAR)

Human activity recognition is a kind of wide area of study that help us to identify a person's specific action or task from the sensor data. Usually, the actions that will be identify in this area such as walking, jumping, talking, standing, and also sitting. Moreover, there are other human activities will also be recognized, for example studying, cooking, driving and etc. [3]

For the collection of the sensor data will be taking using the smart devices like video record the action in few seconds or minutes of frames or images, the alternative way is using the wearable sensors or accelerometer. By using this information that we could apply into many different areas such as medical, military, smart home environment (IoT), driving activities and etc. [4]

In the past decade, this kind of sensor data or information is very difficult and expensive to be collect due to the immature technology. But in these few years, because of the rise of information era, we are able to get much more of the data from the web browser or library since some of them are free for commercial use.

Currently, there are many developers and also data analyzers which work with this kind of research and come out with the classification of these actions. The purpose of this research or work is to use the sensor data and then fit/train them into a model and come out with the model that able to classify the activity of new unseen subjects from the sensor data.

1.5.3. Content Based Filtering Approach

A content-based filtering approach is defined as a recommend method that based on the users or items' additional information. In specifically means that it extracts the user or item's features to recommend the user with other things which slightly similar with the user's preference and also based on their previous actions or explicit feedback. [5] To have a better understanding of this approach, the better example instead of music recommender, the movie recommender system is considered as one of the most suitable examples for this approach. The movie recommender can be based on the user's preference like which movie they like to watch and then recommend then the almost similar movie to the user as the figure 1-1. [6]

In simple words, this approach using the object's characteristic to make prediction for the similar or related items. While apply in this project is that it does not have the "cold-start" issue at the beginning while using this system, means that it just has to base on users' preference and then make the recommendations to the users.

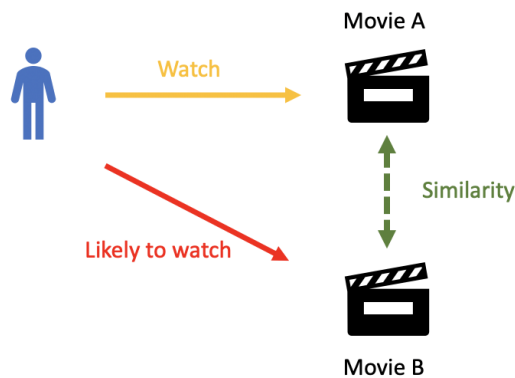


Figure 1-1 Content-Based Approach Example

1.5.4. Convolutional Neural Network (CNN)

In the area of image recognition task, the most popular deep learning algorithm that we use is the convolution neural network. It is one of the neural networks that commonly used for processing image, classification, and also recognition. This is because of its structure to train the model by several layers of perceptron to filter over the input. The layers that consist in CNN which are input / output layers and also a hidden layer. For the hidden layer it includes the layers like convolutional layer, pooling layer, and also fully connected layer. Moreover, for the convolutional layer it is used to abstract the input data or images and then adjust them into a learnable weight from the learning process, after that the final output will based on the multiplication of the input data and the weight which adjusted from the learning process. By having these powerful layers, it is much simpler and also efficient to handle image processing task. [7]

For better understanding of this CNN, the figure below shows an overview of the CNN architecture:

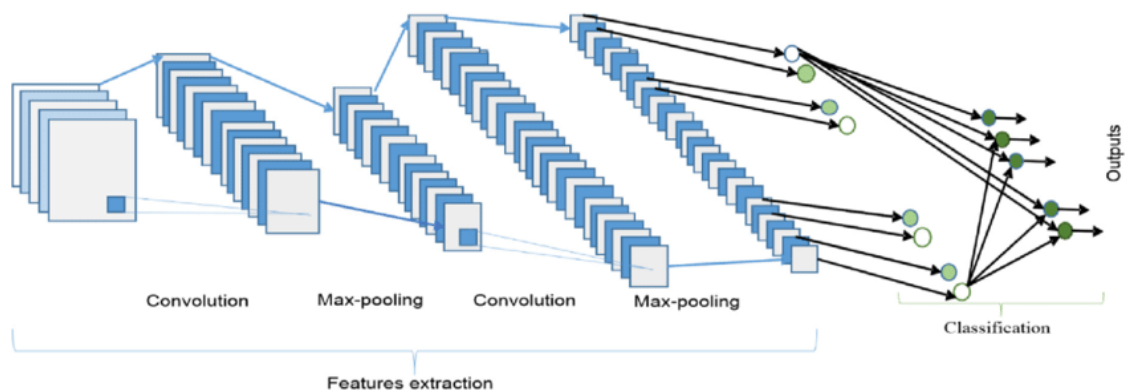


Figure 1-2 CNN's architecture

1.5.5. Recurrent Neural Network (RNN)

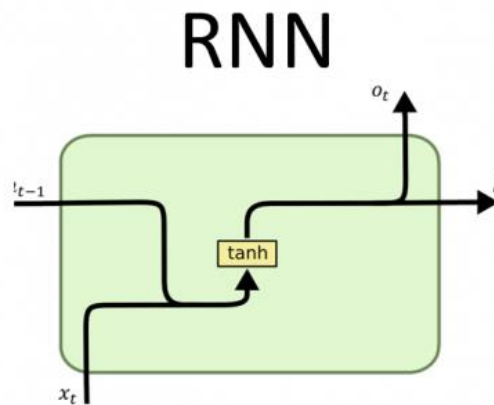


Figure 1-3 RNN's architecture

Recurrent neural network is also one of the popular deep learning algorithms that its main focus is to process the data in a sequence way. Which means that it will keep the previous learning output and then keep learning the new things or data so that the output will be much more accuracy than others algorithm. It is commonly used in the area such as text prediction and also text translation. We take the text translation as an example, usually the normal translator is just translating the words one by one and does not care about the previous words so this is the problem because in our human language it can have many different meanings of the sentences. Hence the machine should know the overall sentences meaning instead of splitting the sentences into words and translate it. [8]

Furthermore, although this RNN is much more efficient in the processing images videos by keeping the memories of previous output, but it also has one major issue when the things getting lagger the output will be not that accurate. This is because of the memories of previous output that it keeps consist of some unnecessary data. In order to solve this issue, the researcher come out with a solution by using the Long Short-Term Memory (LSTM) method.

1.5.6. Long Short-Term Memory (LSTM)

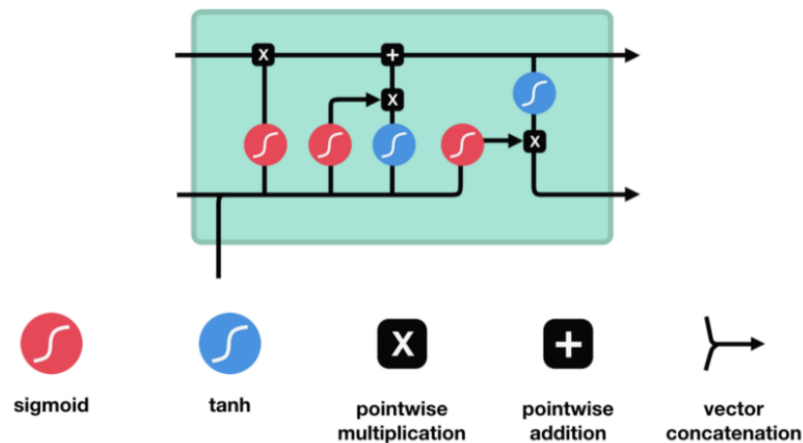


Figure 1-4 LSTM's architecture

As the previous introduce the RNN which having a shortage of short-term memory. This long short-term memory (LSTM) is an improved version of RNN, which it added some layer so that the RNN could only keep those useful data or previous output to get a better accuracy. Moreover, the structure for this LSTM is added the forget gate, input gate, and also output gate.

To have a better understand how they LSTM works, let's start from the forget gate. The forget gate is the gate that filter out those useful information from the previous output, it can be done by marking the information between 0 and 1. For the value 0 means that the information may not useful to us and it will be forget or remove, while for the value 1 it will get the permission to proceed to next stage. [9]

The input gate, in this stage it will filter out the information based on its importance and then update to the cell state. While for the output gate, it is to come out with a new output result by combining with the previous useful information and then pass the new information to the next process.

1.6. Report Organization

The details of this report will follow the sequences as the following chapters respectively. Firstly, chapter 2 will discuss about the literature review for few music streaming providers and the music genre for each activity. Secondly, the methodologies and the overall system design is discussing in chapter 3 while for the chapter 4 will go through the system implementation process which how the step of this system is implemented. Next the evaluation of this system will be discussed here the chapter 5. Finally, the conclusion will be covered in chapter 6 for this project.

Chapter 2 Literature Review

In this section will discuss about the few similar music streaming applications where to find out their music filtering approach, and the next will be figure out the most suitable music genre types for each activity as proposed.

2.1. Music Streaming Application

2.1.1. Spotify

Spotify is one of the popular music streaming applications in nowadays. In this application, users can find millions of songs from many different artists and genres, and it also have a system that contain with the complex algorithm that based on the users' listening history data and then make recommendation to the users. [10] Currently, they are using 3 main approach which are the natural language processing (NLP), collaborative filtering, and audio analysis. Moreover, in-order to match the music to the users' personal testes, these models can be used by compared the users' profile with the systems. [11]

Strength

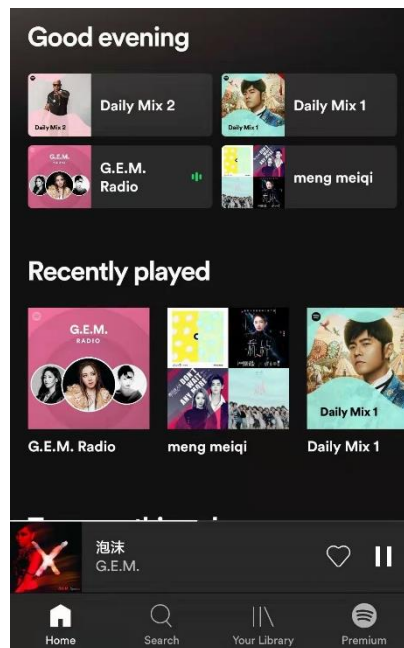


Figure 2-1 Spotify's Interface

As the figure 2-1 showed above is the interface of the Spotify, from there we can see that there are few recommended playlists provided for users to choose based on their preference of the recommended songs.

Weakness

There is one issue the faced by Spotify that it used the collaborative filtering which it is hard to be recommended the new and unpopular songs. Since this filtering is based on the users' usage of the application, so that the system will recommend more about the popular songs. [12]

2.1.2. Apple Music

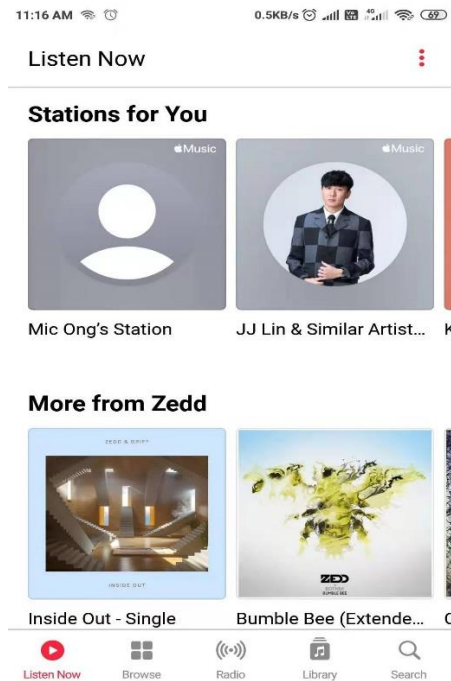


Figure 2-2 Apple Music “Station for You”

Apple Music is an alternative music streaming application that have the potential to replace the Spotify. It provided streaming service to the users but also having the services as well as the music recommendation features in this application. As the figure 2-2 showed above, it is the interface for the Apple music, and it is containing one session there which is the “Stations for You”. This session is the way Apple Music recommend the personalize selection of music to the users based on their listening habits. [13]

Strength

Apple Music applied the Human Curation filter to its recommendation system, so that the users can curate their playlists based on specific genres or moods. Moreover, it also allows the users to have their friends’ playlist or recent listening artist or song so that it makes it more suit for the users. [14]

Weakness

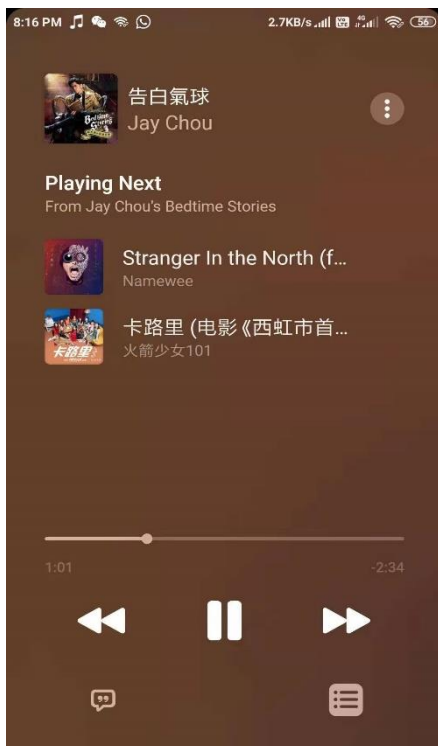


Figure 2-3 Music Playing

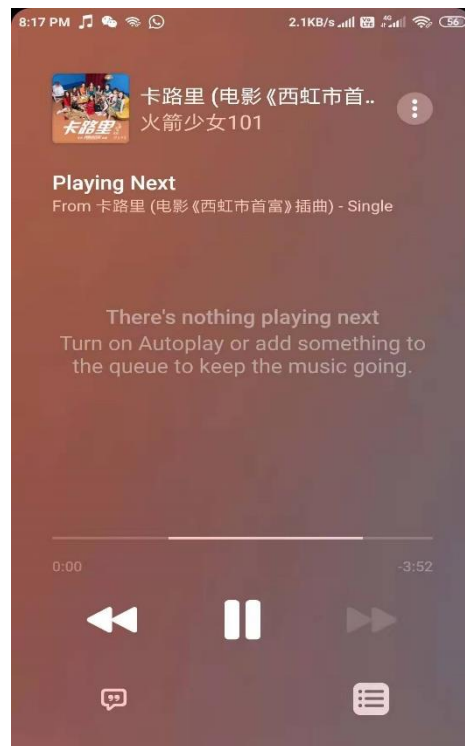


Figure 2-4 Recommend Slow

The weakness will be the recommend system is a little bit slow compared to other music streaming application as the figure 2-4 showed above. As we can see that from figure 2-3 it is recommend only 2 songs while waiting next songs suggest.

2.1.3. YouTube Music

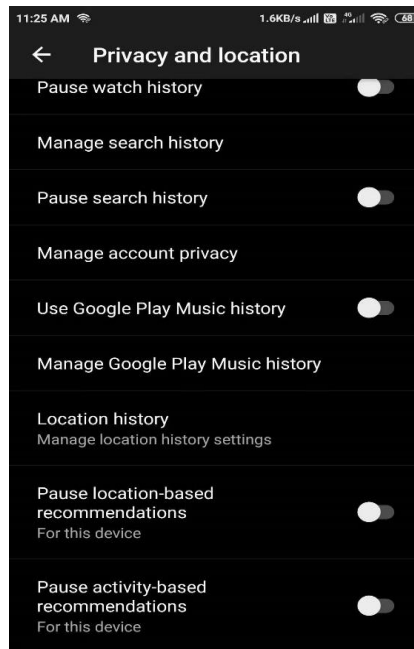


Figure 2-5 YouTube Music “Location-Based Recommendation”

YouTube Music is also a music streaming player that it is to replace the Google Play Music and having some similarity features as the Spotify. Its recommendation system is slightly different from the others recommender system, meanwhile it is executed by using the Google Brain which contain a lot of the data and algorithm, and neural networks so that it can easily provide the recommendation to the users. (Kumar, 2020) It also provided a recommendations option for users which is the location-based recommendations, that this recommendation could provide users the music suggestion based on where their location is. [15]

Strength

Its location-based recommendation is a good way to perform as the contextual information data, so that the google can know where the is the users' location. This is an advantage for the YouTube Music, since other music streaming application does not provide this kind of function to the users.

Weakness

The weakness of the location-based recommendation is that most of the users does not know about this function and some of them may not interesting about it.

2.1.4. Deezer

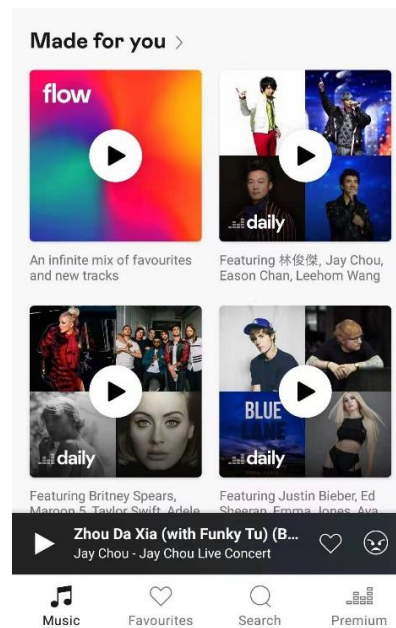


Figure 2-6 Deezer's Flow Recommendation

Deezer music application has the function that can personalized the recommendations that are as individual as users' preference. In this application, it is provided the recommended songs in a session called "FLOW" as the figure 2-6 showed above. In this session its music recommend process is based on the users' liked or banned to the songs, playlists, and album to form a recommend personal playlists for the users. Although its "FLOW" recommend is nothing special, but for the performance it is considered as normal that can perform the task well. [16]

Strength

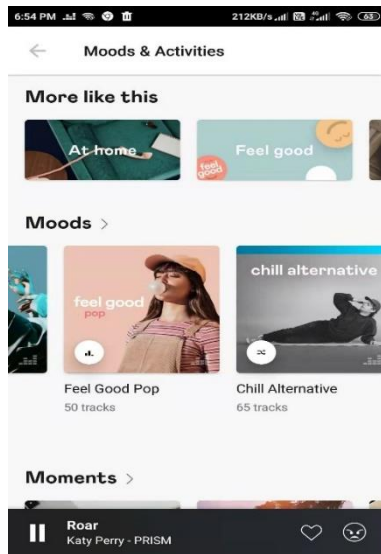


Figure 2-7 Recommend by mood

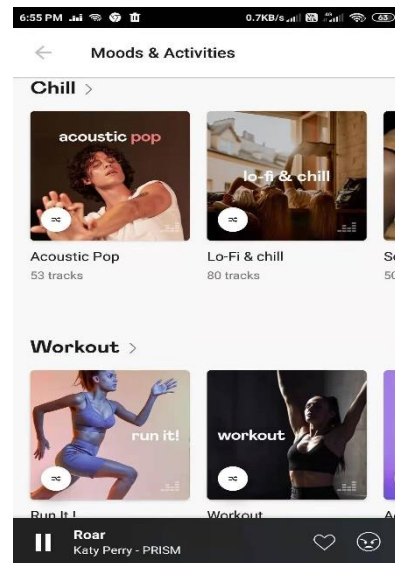


Figure 2-8 Example of mood

As the figures 2-7 and 2-8 showed above, it has a special recommend playlist for users based on their mood and activities, which can be categorized in few types such as Moods, Moments, Flashback, Party, Romance, Chill, and Workout.

Weakness

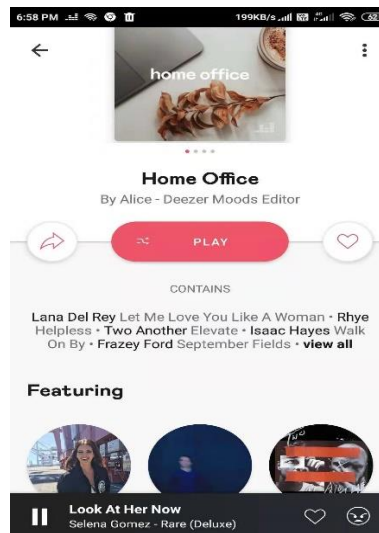


Figure 2-9 Suggested Songs

In the suggested mode, some of the song does not suite to the user's taste. As the figure 2-9 showed above that having some of the song is not really suitable for Asian users' taste.

2.1.5. Tidal

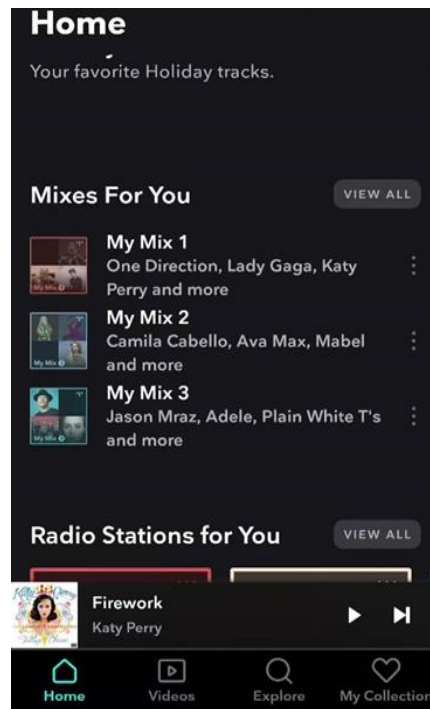


Figure 2-10 Tidal Interface

Although this Tidal is a music streaming application that focus on the value of the sound quality for its users, but similarly it also provides the personalized playlists for users. In its recommendation system the users will get the similar playlists and recommendations, and also they may more focus on the music culture. (PCMag Asia Nov, 2020) As the figure 2-10 showed above, it is the Tidal interface and it also contain the “Mixes for You” session which is a personalized playlist that recommend to the users based on their listening habits such as the music saved in the “My Collection” and also the most recent listening patterns. [17]

Strength

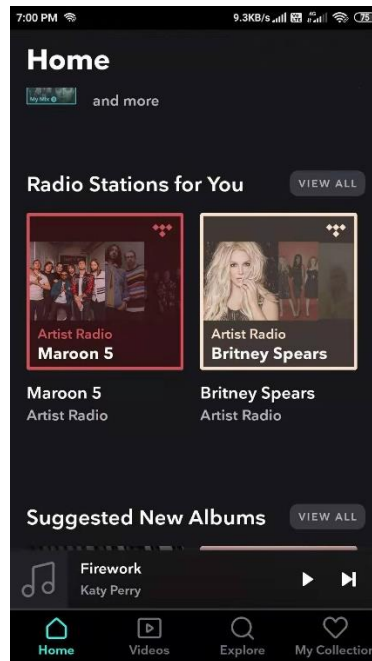


Figure 2-11 Radio Station

The strength of this Tidal is that it takes an advantage on the discovery of new music that suit to its users. By doing this, it just needs a few weeks to collect the users' listening habits. Moreover, it also has its personalized playlists for recommend songs to the users through the Radio Stations as the figure 2-11 showed above. [18]

Weakness

Unlike the Spotify, they are having personalize features like Discovery Weekly, Daily Mix, etc. Tidal only have one personalized playlist to recommend the music to its users, so this may its weakness compared to other music streaming application. [19]

Table 2-1 Comparison Table for Proposed Solution of Reviewed Application

Music Streaming\ Approach Used	Collaborative Filtering	Content-Based Recommendation	Hybrid Recommender Engines
Spotify [23]	✓		
Apple Music [20]	✓		
YouTube Music [22]	✓		
Deezer [21]			✓
Tidal [17]	✓		

2.2. Custom Genre For Each Activity

As for the music itself having many different kinds of component where all of this components combine as a one will produce a music, and this components are also considered as a characteristics of the music where it may consist of sound, melody, expression, genre, audio signal, and etc. [study.com] Since there are so many characteristic for the music, then when it comes to a person who listen to a songs will also have their requirements or preferences where what kinds of songs they like to listen to. So in this project, it is necessary to study and find out the most suitable music genre for each different activity. [24]

Below is the analysis for what kind of music genre will be more appropriate to be listen for each activity:

2.2.1. Biking

Biking activity is considered as a sport activity but in specific action manner. In this activity the some of the cyclist may like to have a music while they are cycling in the road, and this actually could help them to have a better motivation that let them to continue this activity. But at the same time listen to music while cycling is also a risk for them where they may not be able to aware the environment surrounding them like a car suddenly pop up from any direction. [25] So while cycling and listening to the music is not totally a bad thing, as we just have to select those songs with motivated but in the type should be in a moderate tempo and not too loud then the issue will be solved. Based on the research, this activity mostly is based on the Pop, Rock, Hip-Hop. [26]

2.2.2. Computer Work

Nowadays, most of the people who mostly work with their computer will more prefer to listen to the music as their assistant whether to help them relax, getting new idea or even help them to motivate themselves to complete the assigned tasks. For example, the people who will often listen to the music while working mostly are universities student and also those workers who work in office or freelancer. These kinds of people they will face to the computer most of the time, so that they may need to listen to some music to get them relax and this also could help them to get motivated while working. But sometimes who work in the office may also need

to respond to others, so the music type should not be too loud so that they are still able to hear what is going on in the outside world. Hence the recommended genres are Classic Rock, Pop. []

2.2.3. Driving

As the driving activity is consider as a critical activity where the driver have to maintain their emotion in a correct manner, and listening to music while driving is a benefits for the driver to relax themselves for a long drive, but there is also a limitation if the music genre, or tempo is not appropriate which may cause the driver unable to control their emotions and worst is happen the accident where they not able to concentrate to drive. So it is important to have an appropriate music genre for the driver to relax but not to make them high and forgot that they are driving at the moment. The most recommended music genres for driving activity such as the pop music, folk, classic, and country. [35]

2.2.4. Eating and Drinking

According to the study of the [27], that is when performing the eating activity, it is important to listen to the right music where it can help to enhance positive experience during a meal. Where the recommended music genre while doing the eating action is about listen to the Jazz, R&B, Pop type of genre. [28]

2.2.5. Playing Instrument

Mostly when we talk about the instrument the most popular instrument will be the piano, guitar. Actually playing instrument activity is consider as a sub-domain of the musical activity, where it is just part of the musical activity. [31] But when it comes to the activity like we are playing a piano and then what kind of the music genre should we refer to? And also the listen to the music while playing instrument can be become an assistant for the user that they may have more idea for creating their new song or any other activity. While for the most recommended genre for this activity such as Classic, and Jazz. [32]

2.2.6. Sport

Listen to music while sporting is a very common behavior compared to others activity that most of the people would like to listen to the high tempo music when they perform sporting activity. Based on the research study shows that listen to music while sporting able to influence people to become more excited and having more energy to continue their activity, but the tempo should be in a high level instead of a low tempo song. [36] Hence the suggested music genre for this sporting activity is Hip-Hop, heavy metal, dance music. [37]

2.2.7. Studying

There are a lot of style for the user preference in terms of this studying activity, it is because some of the people may like to listen to their favourite songs while some may need a quiet space to study. However, based on the study for the benefits for listen to music while studying is that it able to help people to relax their mind, improve the concentration, also improve the performance during the peak moment like having test, and completing their assignments. [33] So for the recommended genre for this activity will be the pop, instrument, classical music, and jazz. [34]

2.2.8. Walking

Sometimes people will go out from their house and go to somewhere else which could let them relax or they go to work by walking, in this kind of situation some people will more prefer to bring up their earphone and listen to the songs they like while walking to the destination, because this could help them to keep relaxing and also to not feel bored while walking alone in the street. [29] But in this situation, it is also a consideration for them to choose what type of songs they should listen to is the best to help them to relax themselves while walking. As the research study shows that there most popular music genre for this activity such as folk, country, classic rock. [30]

2.2.9. Writing

When it comes to the writing activity, the user group for this activity would be students, author. Where they may need to write article, report for their work, so some of the people may need to have a music environment to let them keep motivated to finish the writing. Hence, the recommended genre for this activity is jazz, classical. [38]

Table 2-2 Table of Custom Music Genre for each Activity

No.	Activity	Music Genre	Intensity
1.	Biking	Pop, Rock, Hip-Hop	Moderate
2.	Computer work	Classic Rock, Pop	Chill, Moderate
3.	Driving	Folk, Pop, Classic, Country	Moderate
4.	Eating & Drinking	Jazz, R&B, Pop	Chill
5.	Playing Instrument	Classic, Jazz	Chill, Moderate
6.	Sport/Work out	Hip-Hop, Heavy Metal, Dance Music	High Pace, Moderate
7.	Studying	Pop, Instrument, Classic, Jazz	Chill, Moderate
8.	Walking	Folk, Country, Classic Rock	Chill, Moderate
9.	Writing	Jazz, Classical	Chill, Moderate

The table above shows that the most suitable custom music genre type for each activity.

Chapter 3 System Methodology

3.1. Methodologies

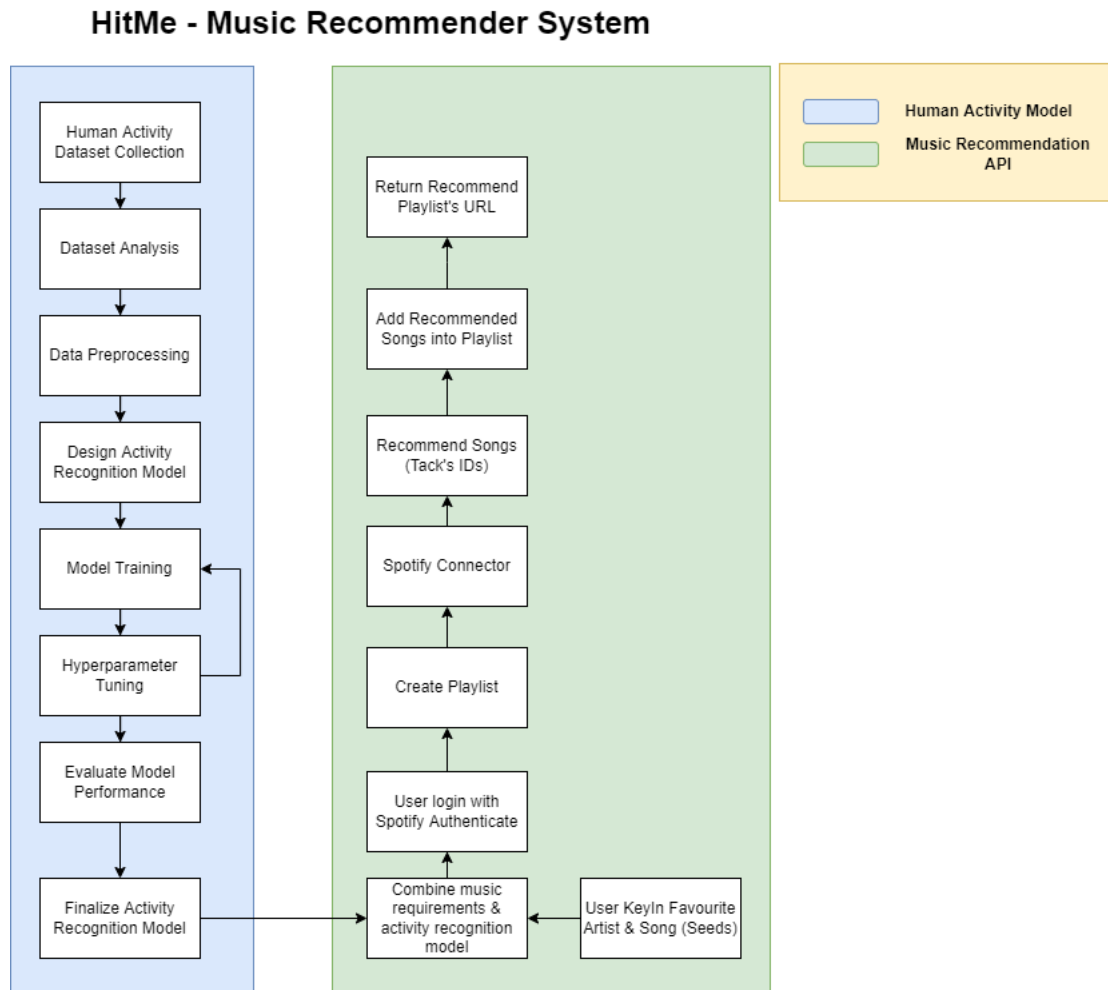


Figure 3-1 Overall Methodologies

The above figure 3-1 shows that the proposed methodology of this music recommender by actions. Project 1 has covered until the end of human activity recognition model, where the work is complete all the work from collecting the dataset, data preprocessing, model training, parameter tuning and evaluate the model trained. While for Project 2 is continue from the previous progress where to finalize the HAR model and then start for the music recommender system implementation.

3.1.1. Human Activity Recognition Model Explanation:

For the first stage of this proposed methodology, there are multiple human activity datasets available to collect from different websites. After that, the next steps are to analyze the collected dataset, and only those datasets with the format of .mp4 and also .avi will be kept for the model training.

Furthermore, the preprocessing steps is a much more important steps before going to the model training part. This is because preprocessing data is to clean up and also perform feature selection so that it won't affect the accuracy of the output. In this stage, first the dataset will be labelled and then proceed with the splitting task which split the whole dataset into training set and also testing set. The further steps are to extract the frame of the video from the dataset, after that proceed with the data formatting and also transforming.

After that, the next stage is about the design of activity recognition model is to determine the model to be used for training. Once the model has been selected then will proceed with the model training phase. During the training phase it may face some issues such as overfitting and also underfitting, so in order to avoid or deal with this kind of issues, usually it is needed for adjustment of the model's hyperparameter and also adjust the size of training dataset.

After the hyperparameter tuning, the next step is to evaluate the activity recognition model performance. In can be done by using the testing dataset to test the performance and then compared with the training output. The reason we use this testing dataset to test again the model is to check how the trained model deal with the unseen data before we deploy it. Once the performance is the expected result then the model will be finalized.

3.1.2. Music Recommender System Explanation:

After completing the HAR model, then the next step is to implement the music recommender system (MRS). This MRS is proposed to use the Spotify API where this API having a lot of the libraries and reference for us to build a custom recommender based on our design.

Based on the second part of the proposed design in figure 3.1, the very first step before using the Spotify API, it may require the user to authenticate their Spotify account with the system. If the user accepts the scope agreement that may modify their Spotify account's playlist, then the user will get an access token that allow them to request the services from Spotify API. There are a few steps after user get the access to the API is that the system will create a new playlist and then proceed with the Spotify Connector to get the recommended songs based on the user's current activity.

After that, a list of recommended songs will be return as a list of tracks' ID, then those recommended songs will be added to the new added playlist by using the Spotify API with the list of track's ID. Finally, the user will get an URL of the new created playlist in the Spotify, where the user can just copy and search for the URL link to direct access to the playlist.

3.2. Tools and Technologies Used

The common language used in this project would be the Python language and the below list are the libraries that will be applied for both HAR model and MRS to build the project. While for the MRS libraries there is one extra technology used is the web framework. (Flask)

Table 3-1 Libraries for HAR Model

Libraries	Version
Python	3.8.5
Numpy	1.19.2
Pandas	1.2.3
Keras	2.4.3
Scikit-Learn	0.24.1
TensorFlow	2.4.1
OpenCV	4.5.1.48
tqdm	4.50.2
h5py	2.10.0

Table 3-2 Libraries for MRS System

Libraries	Version
flask	2.1.1
Jinja2	3.1.1
Werkzeug	2.1.1
Spotipy	2.19.0
requests	2.27.1
requests-html	0.10.0
requests-oauthlib	1.3.1
pyngrok	5.1.0
click	8.1.2
itsdangerous	2.1.2

Besides the libraries used, there is also the platforms and tools apply in this project such as the **Jupyter Notebook** using for the training of HAR model, **Visual Studio Code** and also

Windows Command Prompt Interface while implement the MRS where these platforms able to let us to have more flexibility while debugging the code. Finally, the **Web Browsers** where it able to let us to test out the presentation of the system result.

3.3. HAR Model

3.3.1. Overall Architecture Flow

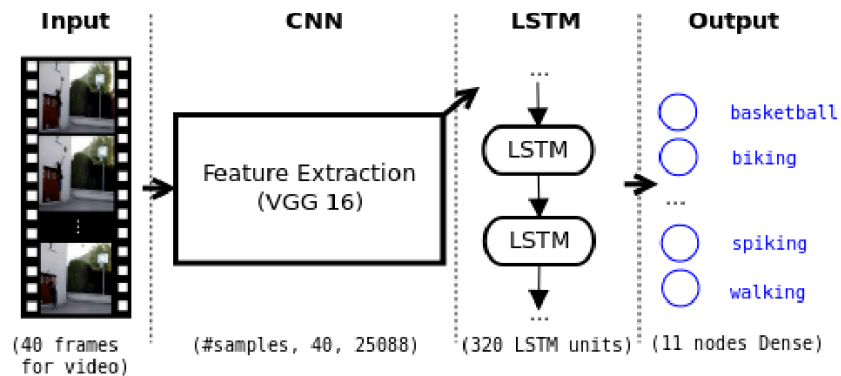


Figure 3-2 Overall CNN-LSTM's architecture

The figure 3-2 above shows that the overview of the selected architecture for this human activity recognition model by using the CNN-LSTM network. Firstly, it starting from the input images that has been split the frame of the video, then it will proceed with the CNN for the feature extraction by using the VGG 16. After the feature extraction from CNN, it will pass the data through the LSTM approach which use for sequential training. Finally, the output node will be classify based on the LSTM. [39]

For more information about the VGG16, the VGG stands for Visual Geometry Group and the 16 means that it has 13 convolutional and 3 fully-connected layers. It is one of the commonly used vision model architecture in this trend. The difference between this architecture with others is that it having larger number of hyperparameter which consist about 138 million parameters. [40]

3.3.2. Standard Evaluation Metrics for Model Performance

After building the model, the evaluation of the model is a must so that we can prove that the accuracy of the trained model. In this project, for the activity recognition model it is to come out with the classification output, so we will evaluate the performance of the model by using the evaluation metrics which cover few types of scores such as accuracy, precision, recall, confusion matrix, and also f1 scores. Although the accuracy score is to show us how accurate the model is but it is still the first consideration, this is because one of the limitations is the imbalanced class of output. The higher accuracy score does not mean it is the best result, so in this case the precision, recall, confusion matrix, and the f1 scores will be much promising scores to evaluate this project.

3.3.3. Dataset Collection

Before starting the training process, the dataset is needed for the entire training process, so there are several datasets that can be found from the Internet. Below table are the datasets from different websites which will be used to build the Human activity recognition model:

Table 3-3 Download Links for HAR model Dataset

Websites	Download Link
UCF-101	https://www.crcv.ucf.edu/research/data-sets/ucf101/
HMDB51	https://serre-lab.clps.brown.edu/resource/hmdb-a-large-human-motion-database/#Downloads
STAIR Actions	https://stair-lab-cit.github.io/STAIR-actions-web/
Kinetics-downloader (from GitHub)	https://github.com/Showmax/kinetics-downloader

For more information, the UCF-101 and HMDB51 can directly downloaded from the website given, while STAIR Actions and Kinetics-downloader need to use external method to download the video datasets. For the STAIR Actions, since we only need certain activity/action so we can modify the action lists file which in the format of csv, and then we can run the download.sh file to download the dataset that we want to avoid wasting time. Moreover, for the kinetics-downloader it is available from GitHub and we need to focus on 2 files which is the list_classes.py for us to check which classes that we want, and also download.py which allow us to download the video. In this case, we would only need certain classes so based on the documentation given in the GitHub, we may use this format of code “python download.py --classes 'pole vault' 'blowing glass” to download the videos dataset.

Once the dataset has completely downloaded, then it is needed to label and split them into training and testing set before proceeding to the preprocessing steps. The below figure 3-3 shows that the training dataset which has been labelling.

Video	Label
./dataset_converted_avi1/Walking/W73.avi	Walking
./dataset_converted_avi1/Walking/W62.avi	Walking
./dataset_converted_avi1/Walking/W55.avi	Walking
./dataset_converted_avi1/Eating & Drinking/D133.avi	Eating & Drinking
./dataset_converted_avi1/Playing Piano, Guita/P79.avi	Playing Piano, Guita
./dataset_converted_avi1/Playing Piano, Guita/P68.avi	Playing Piano, Guita
./dataset_converted_avi1/Playing Piano, Guita/P69.avi	Playing Piano, Guita
./dataset_converted_avi1/Walking/W76.avi	Walking
./dataset_converted_avi1/Eating & Drinking/D108.avi	Eating & Drinking

Figure 3-3 Training Dataset's Labeling

3.3.4. Data Pre-processing

First of all, the labelling the dataset the next step is to perform frame extraction for all the video clips by using the OpenCV. Moreover, the extracted frames are different from each other based on their video duration and also the video frame rate. To have a better understanding, let's say currently one of the video clips having a frame rate of 30 and the duration is about 5 seconds, then the frame extraction for this video will be 150 frames. The further steps are to resize the data into appropriate image resolution, and they need to be normalized between value of 0 and 1. In this case the image resolution we will keep in within 0 to 100 and in order to speed up the training time that is why the normalization of data is needed in this phase.

3.4. Music Recommender System

3.4.1. Overall Architecture Flow

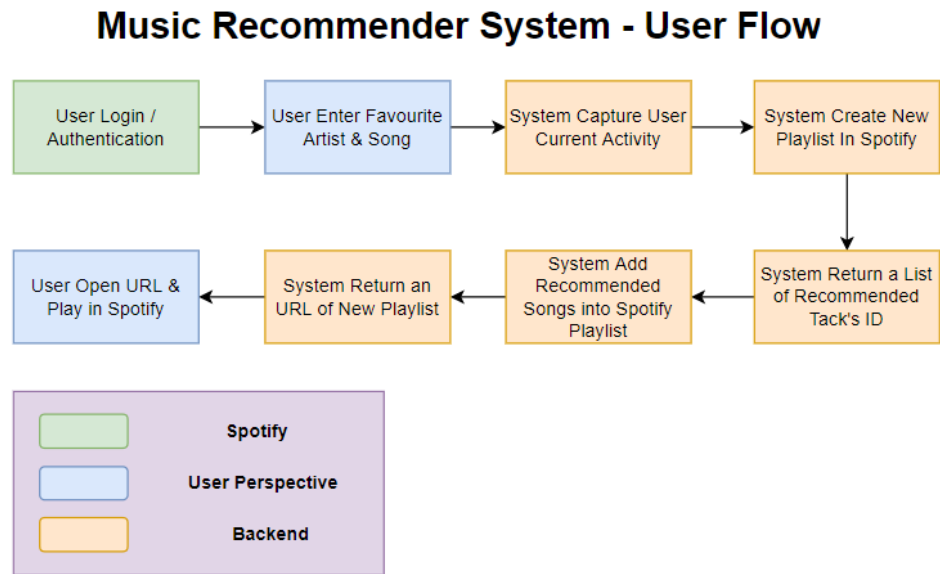


Figure 3-4 User Flow for the MRS

The figure above shows that the overall flow for the user who will be using this Music Recommender System is that they have to go through this flow so that they will get the experience for this system.

For the first stage is that the user will need to authenticate with the Spotify whether they are sign in or sign up, it means that they have to get authority from the user to access to the Spotify app with the developer. While in the second stage is that the user will prompt with a web page that require user to enter their personal preference which is their favourite artist and song, since this project is using the content-based filtering recommendation method then this information is to let the system to recommend the similar songs based on user preferences about the song, in specifically it can be said that the user can control whether they want to listen to Mandarin songs or English songs, and also what kind of artist style they like.

Furthermore, after user enter their preference then the next stage is to about the system work perform in the background that is the system capture the user's current activity by using their device camera, then pass the captured frames to the HAR model to forecast the current activity. While for the music recommender system will then called out the Spotify API for create a new playlist in user's

Spotify library and then process and extract the recommended songs' ID. Next is to use the list of the recommended songs' ID and add them into the new created playlist, then the system will return the URL of the new created playlist to the user, and they can just direct copy and paste to any web browser and open the playlist.

3.4.2. Spotify API

The Spotify API is considered as a REST API, where their Web API endpoints will return the result of metadata by using the JSON format, and the information includes the tracks, albums, and artists from the Spotify Data Catalogue. Its application is not only for the web API but also for able to apply in many platforms such as Mobile App (iOS, Android), Embeds platforms, and Commercial Hardware, Web SDK. [41]

Although Spotify provided plenty of the options for us to choose, but in this project, we only choose the Web API (figure 3-5) as the solution since we can use the Flask the python web framework to connect with this solution, so that we don't have to implement an additional mobile application to use this system.

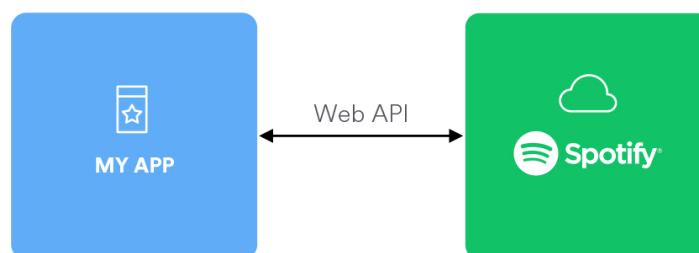


Figure 3-5 Spotify API Connection with Application

3.4.3. A/B Testing

For the evaluation of this music recommender may differ from the HAR model since this system is not trained by ourselves so it may not be suitable to use the same method in the section 3.3.2 the standard evaluation metrics for model performance. So, the A/B Testing is introduced to solve this issue, where it able to let us to test out the confidence of the null hypothesis compared to the new hypothesis and see whether which one having the higher hypothesis value we then decide to reject or accept the null hypothesis or new hypothesis.

3.5. Implement Issues and Challenges

There are several difficulties during the implementation of this project. First of all, in the collection of the dataset stage it requires a lot of time due to the format of the dataset we needed is the video file like .mp4 or .avi but not the csv file which means that most of the dataset found would be the pre-processed data. Moreover, the classes of the video dataset is also an issue which means that it is hard to find that one dataset contain all the custom classes that we want to build in this human activity recognition model.

Furthermore, is the training accuracy for this human activity recognition model is not in a good accuracy, which means that it may require more time to find tune the hyperparameters or make adjustment of the training dataset. Nevertheless, there is also a possibility that the size of the dataset since in this activity recognition model will be classify more than two classes so that it may require more sample data to avoid the imbalanced class issue.

Furthermore, there is also having some of the challenges while implement the Music Recommender System. Since this music recommender system is implemented using the Spotify API, hence for those who implement this part may need to have strong knowledge about the REST API, so that it will be easier for understand how the Spotify API works and then design a better solution throughout the architecture diagram. Take this project as an example, the architecture design for this music recommender system still has a big improvement to be done in the future which in terms of the reliability and also flexibility of the system design.

3.6. Timeline

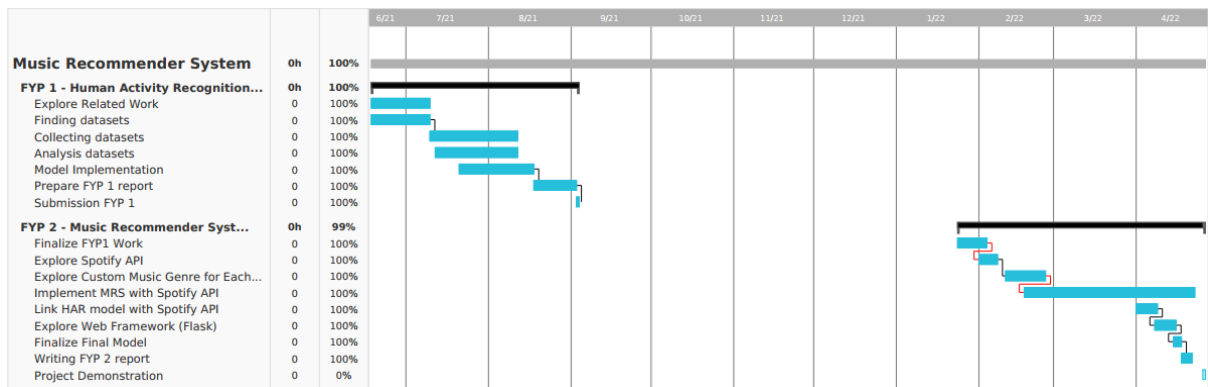


Figure 3-6 Timeline for Entire Project

The figure 3-6 above shows that the overall timeline for this project 1 and project 2. In overall, it takes 2 semesters to implement this project and in the middle of the period is because of the duration time in that semester has only 7 weeks so it may not enough time to complete the remaining part of the project so it will be started in the next semester. Moreover, in the project 2 there are several tasks which are not on the track which is the task of “Finalize FYP1 Work” and also the task of “Explore Custom Music Genre for Each Activity”. Where both of these tasks are due to the limited time and also difficult to explore the article of the study of custom music genre suitable for which activity respectively.

Chapter 4 System Implementation

4.1. Steps to Setup and Build the Project

4.1.1. Human Activity Model

Step 1: Finding Datasets

Since this human activity recognition model needed video datasets to train the model, so we have to find and collect the datasets that have the classes we need in this model training. First of all, there are few datasets have found but after the exploration of the data inside the dataset, there are only 4 datasets that suit for the model training which are “UCD-101”, “HMDB51”, “STAIR Actions”, and “kinetics-downloader”.

To collect these datasets, as introduced in the chapter 3 under the “Dataset” section there are 2 datasets which are the “UCD-101” and “HMDB51” able to directly download from the website, while for the remaining 2 datasets which are “STAIR Actions”, and “kinetics-downloader” are needed to download in a different way.

For the “STAIR Actions” which require to use the command prompt (for windows user) or terminal (for Linux user) to download the YouTube video datasets by typing this command “\$ bash download.sh” to run the download script. Moreover, it is required to install the ffmpeg and also jq before run the download script, but there is one thing need to be highlight is that the action classes from the provided actionlist.csv need to keep only those classes that we want which are “Studying”, “using_computer”, otherwise the download script will download all the action in the file and it may take a long time to process.

Furthermore, for the “kinetics-downloader” it can be found a lot of files from its website, but the only things that we need is the “download.py” and “list_categories.py”, and the requirement for this dataset which are “Python version after 3.4”, “youtube-dl”, “ffmpeg”, and “gzip”. Next, the steps to download the dataset is very easy just open the command prompt (for windows user) or terminal (for Linux user) and then use this command “python download.py --classes 'pole vault' 'blowing glass””. This command is to let us download the specific classes that we need, in this dataset we only download the classes of “driving”, “jogging”, and “writing”.

In summary of this section, in this project there are 9 classes that we used for the human activity recognition model which are “Biking”, “ComputerWork”, “Driving”, “Eat&Drink”, “PlayInstrument”, “Sport”, “Studying”, “Walking”, “Writing”.

Step 2: Labelling Datasets

Before proceeding to the extraction frame, it is needed to be label the datasets so that they can be clearly stated the path of the video clips, and also which classes they belong to just like the figure shows below, the “Video” column shows the video path while for the “Label” represent their belong classes.

	Video	Label
0	./dataset_converted_avi1/Playing Piano,Guita/P...	Playing Piano,Guita
1	./dataset_converted_avi1/Playing Piano,Guita/P...	Playing Piano,Guita
2	./dataset_converted_avi1/Playing Piano,Guita/P...	Playing Piano,Guita
3	./dataset_converted_avi1/Playing Piano,Guita/P...	Playing Piano,Guita
4	./dataset_converted_avi1/Playing Piano,Guita/P...	Playing Piano,Guita
...
765	./dataset_converted_avi1/Walking/W62.avi	Walking
766	./dataset_converted_avi1/Walking/W73.avi	Walking
767	./dataset_converted_avi1/Walking/W118.avi	Walking
768	./dataset_converted_avi1/Walking/W69.avi	Walking
769	./dataset_converted_avi1/Walking/W214.avi	Walking

Figure 4-1 Labelled Datasets

After the labelling, there is one thing needed which is split them into training set, testing set and also a validation set.

Step 3: Extract Frame from Datasets

As followed the introduce from chapter 3 data pre-processing part, it is to extract the frame from the video clips which use to multiply their duration and also the frame rate, which means that if the video clip consists of 5 seconds of duration and 30 frame rates then the extracted frame will be 150 frames. After extract the frame then the images will be store into a file, for the training set will store in a file called “train2” while for the validation set will store into another file called “validation”. After that, the sorting of the frame will be performed and finally pass the sorted frame into a new csv named “sortedTrainFrames.csv” and “sortedTestingFrames.csv”.

Step 4: Preprocessing

There are few things need to process before proceeding to the model training phase which are load the images and then keep them into target size which is (100,100,3), and then the normalize the pixel value of the images by divided by 255 so that they can fit into the CNN model (VGG16).

Step 5: Training Human Activity Recognition Model

As the proposed architecture for this human activity recognition model in chapter 3 is by using the CNN-LSTM network. In this architecture it has 2 parts for the training, for the first part which is belongs to the CNN also known as VGG16, it is used to extract the feature. Moreover, for the second part is the LSTM which is our main focus that it is used to train the model by keep the useful memory and help us get the higher accuracy. Besides that, there is a highlight that the training datasets only include 4 actions which are “Biking”, “Eating&Drinking”, “PlayingInstrument”, and “Walking”. This is because the remaining datasets was found in the last period of the development so that it is not enough development time to proceed, and the full actions classes will be completely trained in the future work.

The figures 4-2 and 4-3 below shows that the summary of the VGG 16 layer and also RNN which to be trained.

CNN – VGG16

```
Model: "vgg16"
-----
Layer (type)                Output Shape                Param #
-----
input_2 (InputLayer)        [(None, None, None, 3)]    0
block1_conv1 (Conv2D)        (None, None, None, 64)     1792
block1_conv2 (Conv2D)        (None, None, None, 64)     36928
block1_pool (MaxPooling2D)   (None, None, None, 64)     0
block2_conv1 (Conv2D)        (None, None, None, 128)    73856
block2_conv2 (Conv2D)        (None, None, None, 128)    147584
block2_pool (MaxPooling2D)   (None, None, None, 128)    0
block3_conv1 (Conv2D)        (None, None, None, 256)    295168
block3_conv2 (Conv2D)        (None, None, None, 256)    590080
block3_conv3 (Conv2D)        (None, None, None, 256)    590080
block3_pool (MaxPooling2D)   (None, None, None, 256)    0
block4_conv1 (Conv2D)        (None, None, None, 512)    1180160
block4_conv2 (Conv2D)        (None, None, None, 512)    2359808
block4_conv3 (Conv2D)        (None, None, None, 512)    2359808
block4_pool (MaxPooling2D)   (None, None, None, 512)    0
block5_conv1 (Conv2D)        (None, None, None, 512)    2359808
block5_conv2 (Conv2D)        (None, None, None, 512)    2359808
block5_conv3 (Conv2D)        (None, None, None, 512)    2359808
block5_pool (MaxPooling2D)   (None, None, None, 512)    0
-----
Total params: 14,714,688
Trainable params: 0
Non-trainable params: 14,714,688
```

Figure 4.2 CNN-VGG16 Model Summary

Recurrent Neural Network (RNN)

layer (type)	Output Shape	Param #
lstm (LSTM)	(None, 10)	20920
dense (Dense)	(None, 4)	44
lstm_2 (LSTM)	(None, 10)	20920
dense_2 (Dense)	(None, 4)	44
lstm_3 (LSTM)	(None, 10)	20920
dense_3 (Dense)	(None, 4)	44
lstm_4 (LSTM)	(None, 10)	20920
dense_4 (Dense)	(None, 4)	44
lstm_5 (LSTM)	(None, 10)	20920
dense_5 (Dense)	(None, 4)	44
lstm_6 (LSTM)	(None, 10)	20920
dense_6 (Dense)	(None, 4)	44
lstm_7 (LSTM)	(None, 10)	20920
dense_7 (Dense)	(None, 4)	44
lstm_8 (LSTM)	(None, 10)	20920
dense_8 (Dense)	(None, 4)	44
lstm_9 (LSTM)	(None, 10)	20920
dense_9 (Dense)	(None, 4)	44
lstm_10 (LSTM)	(None, 10)	20920
dense_10 (Dense)	(None, 4)	44
lstm_11 (LSTM)	(None, 10)	20920
dense_11 (Dense)	(None, 4)	44
lstm_12 (LSTM)	(None, 10)	20920
dense_12 (Dense)	(None, 4)	44
lstm_13 (LSTM)	(None, 10)	20920
dense_13 (Dense)	(None, 4)	44
lstm_14 (LSTM)	(None, 10)	20920
dense_14 (Dense)	(None, 4)	44
lstm_15 (LSTM)	(None, 10)	20920
dense_15 (Dense)	(None, 4)	44
lstm_16 (LSTM)	(None, 10)	20920
dense_16 (Dense)	(None, 4)	44
lstm_17 (LSTM)	(None, 5)	10360
dense_17 (Dense)	(None, 4)	24
lstm_18 (LSTM)	(None, 10)	20920
dense_18 (Dense)	(None, 4)	44
lstm_19 (LSTM)	(None, 10)	20920
dense_19 (Dense)	(None, 4)	44

Figure 4-3 RNN Model Summary

Step 6: Result of Trained Human Activity Recognition Model

After completed the training phase for this activity recognition model, here is to discuss about the result of the trained model. The figure 4-2 below shows that the result after the training process. As observed that its accuracy score and validation accuracy has getting a higher scoring from this training, but unfortunately the validation loss was a bit far from the loss score.

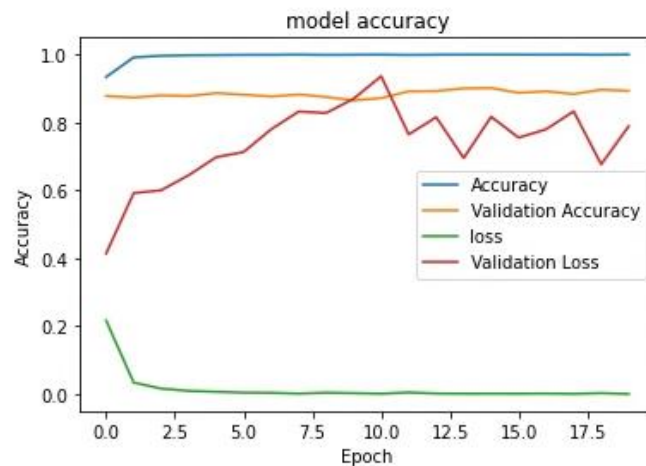


Figure 4-4 Activity Recognition Model Accuracy

In order to improve the accuracy of the model trained, it is needed to perform grid search for the optimization of the hyperparameter. After performing this grid search, we can get the best parameters which is the figure 4-3 show below, and the best accuracy for this model is 0.6507 which is still considered at a satisfied score, but it still needs to be improved.

```
best_parameters = grid_search.best_params_  
best_accuracy = grid_search.best_score_  
  
best_parameters  
{'batch_size': 128, 'epochs': 1, 'optimizer': 'adam'}  
  
best_accuracy  
0.6507009714841843
```

Figure 4-5 Fine Tuned Accuracy and Parameter

After the fine-tuned of the model trained, in order to know how the model work well it is needed to perform some prediction based on unseen data. The unseen data which is

store into a file named “ActionTest”, the test item can be a video or images which has been extracted from the video, both ways can be get the result for the prediction.

For example, the figure 4-4 below shows the video that will going to predict with the model.



Figure 4-6 Sample Video for Prediction Test

```
predict = model.predict_classes(X_test_rnn)
#print(predict)

if(predict==0):
    print("Biking")
elif(predict==1):
    print("Eating&Drinking")
elif(predict==2):
    print("Playing Instrument")
elif(predict==3):
    print("Walking")
else:
    print("Nothing")

files = glob('ActionTest/*.jpg')
for f in files:
    os.remove(f)
if cv2.waitKey(1) & 0xFF == ord('q'):
    break

# When everything done, release the capture
cap.release()
cv2.destroyAllWindows()
```

Eating&Drinking

Figure 4-7 Conditions and Predicted Result

The figure 4-5 above shows that the result and how the condition for the prediction.

Since in this work only trained 4 actions so there were only 5 conditions for the

prediction which are the “Biking”, “Eating&Drinking”, “PlayingInstrument”, and “Walking”, while for the “Nothing” means that the prediction does not belongs to the above 4 actions provided. Finally, the result is predicted correctly based on the video given which is belongs to the “Eating&Drinking” class.

4.1.2. Music Recommendation System

Step 1: Spotify Developer Account

- At the beginning of implementing the MRS, we need to have a Spotify Developer account and also an application as a minimum requirement so that we are able to request access for their services. As for reference, the figure below shows that the account for this project has been created as well as the application named "HitMe". There is another important thing which is the "Client ID" and "Client Secret" (Label A) where both of these keys will be needed for the entire process of this MRS. But one thing needs to be noticed is that the "Client Secret" is very important in terms of personal security where it is not recommended to be shared with others. Moreover, the figure x is to control the users who will access and try your application.

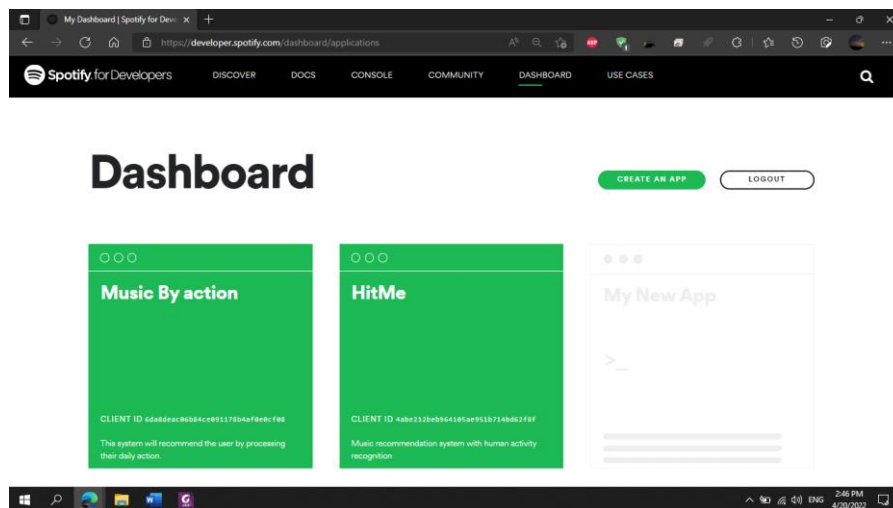


Figure 4-8 Spotify Developer Website

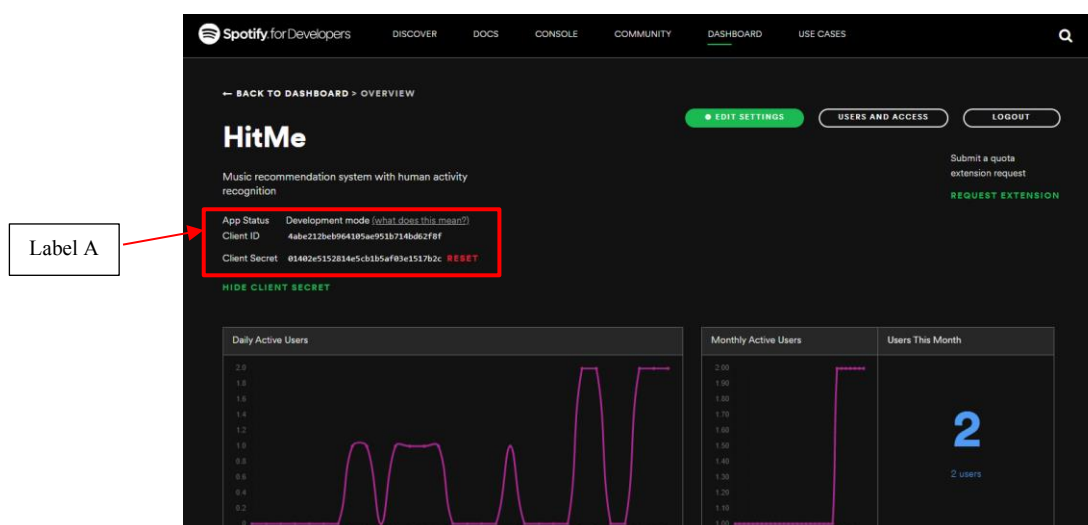


Figure 4-9 HitMe Client Keys

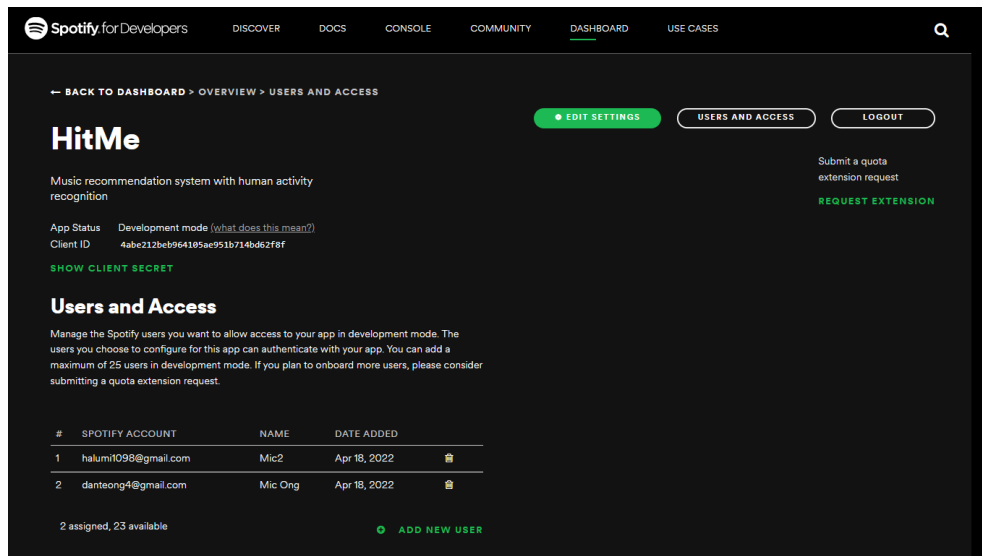


Figure 4-10 User Access Management

Step 2: Spotify Authorization

There are few options for us to choose for the authentication method whether we want to direct access for the services (Client Credentials) or authenticate before getting to use the services (Implicit Grant). The difference is that the Client Credentials will only get the simple services where it unable to modify users' playlist (e.g. Search Function), but Implicit Grant do.

While in this project we will using the combination for both of this authentication, this is because we need to access the services for the recommendation service and also modify the user's playlist. As the figure x below shows that the Client Credentials Flow which the user direct request for the access token without authenticate with their Spotify account. For the figure x below shows that the Implicit Grant Flow that for the user will be prompted for authenticate in order to get access token permission to request for the Spotify services.

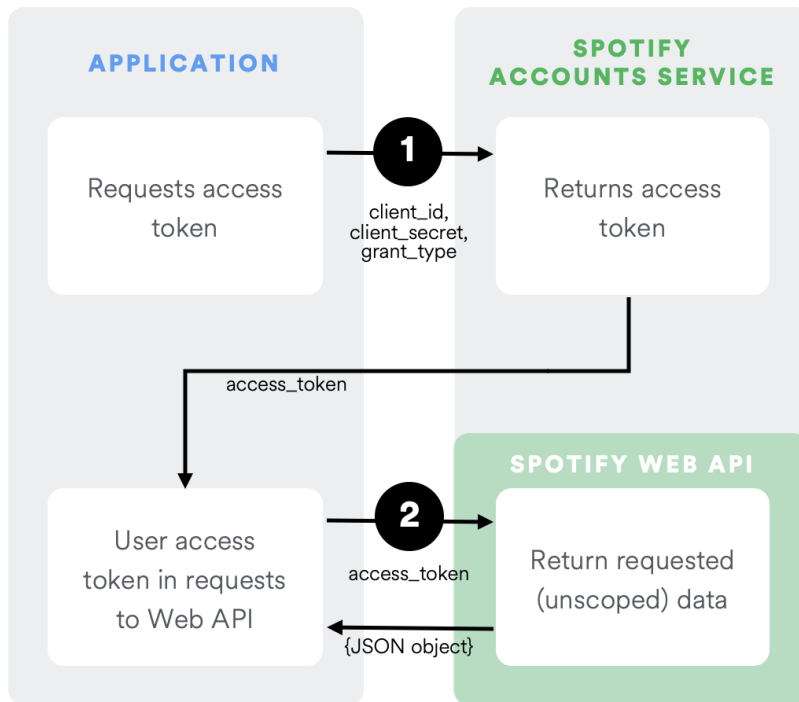


Figure 4-11 Spotify Client Credentials Flow

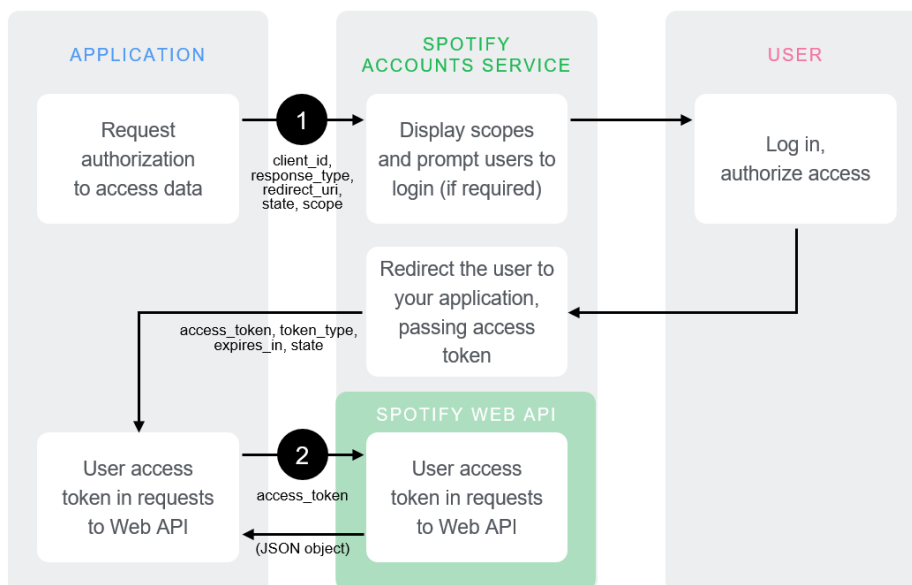


Figure 4-12 Spotify Implicit Grant Flow

Step 3: Spotify Refences

After getting access permission to request for the Spotify services, then it is time to play with its services. In this project the services that we will need include in this few categories:

Table 4-1 Spotify Category with Services

Category	Services
Artist	- Get Artist [GET]
Tracks	- Get Recommendations [GET] - Get Track [GET]
Search	- Search for Item [GET]
Users	- Get Current User's Profile [GET]
Playlists	- Create Playlist [POST] - Add Item to Playlist [POST]
Genres	- Get Available Genre Seeds [GET]

```
app.py MusicRecommend.py x
Final_Output > MusicRecommend.py > SpotifyAPI
6
7 class SpotifyAPI(object):
8     access_token = None
9     access_token_expires = datetime.datetime.now()
10    access_token_did_expire = True
11    client_id = None
12    client_secret = None
13    token_url = "https://accounts.spotify.com/api/token"
14
15 > def __init__(self, client_id, client_secret, *args, **kwargs): ...
19
20 > def get_client_credentials(self): ...
31
32 > def get_token_headers(self): ...
37
38 > def get_token_data(self): ...
42
43 > def perform_auth(self): ...
60
61 > def get_access_token(self): ...
72
73 > def get_resource_header(self): ...
79
80 > def get_resource(self, lookup_id, resource_type='albums', version='v1'):
87
88 > def getUserPlist(self, u_id): ...
96
97 > def get_genre(self): ...
106
107 > def recommend_track(self, artists, genres, tracks): ...
118
119 > def get_album(self, _id): ...
```

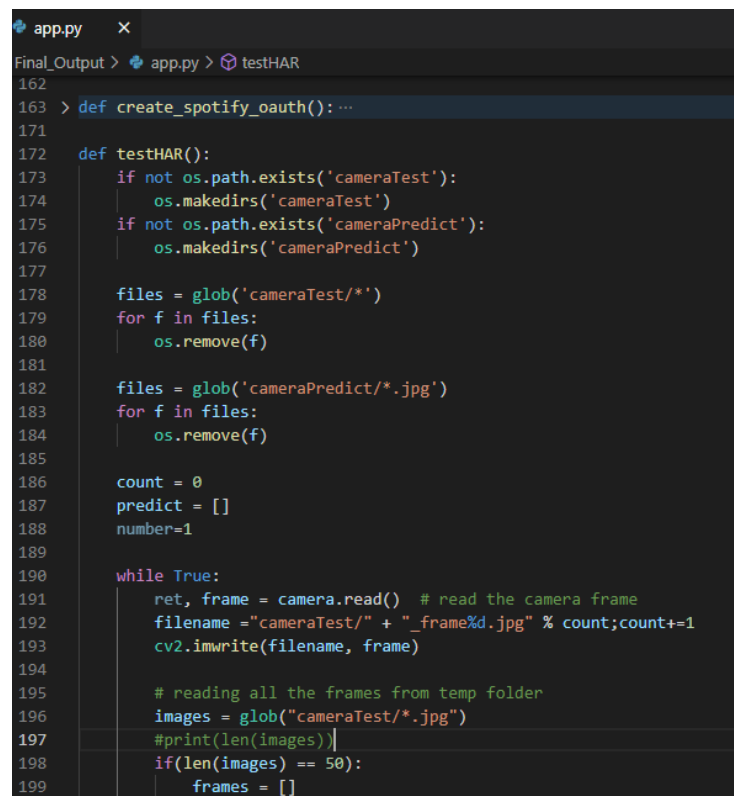
Figure 4-13 Sample Snippet for Spotify API

4.1.3. Fully Connected Both Module

After successfully implement the HAR model and MRS, then the next thing to do will be combine both modules to make it into one single workable system.

Step 1: Export HAR model into Python File

In order for us to use the methods that we have created and trained in the previous steps; we then need to convert it into a python file so that we able to use it in an efficient way instead of calling those methods from the Jupyter Notebook. We just need to export those important methods and libraries into a single python file and then we are able to proceed by using the Visual Studio Code.



```
app.py X
Final_Output > app.py testHAR
162
163 > def create_spotify_oauth():...
171
172 def testHAR():
173     if not os.path.exists('cameraTest'):
174         os.makedirs('cameraTest')
175     if not os.path.exists('cameraPredict'):
176         os.makedirs('cameraPredict')
177
178     files = glob('cameraTest/*')
179     for f in files:
180         os.remove(f)
181
182     files = glob('cameraPredict/*.jpg')
183     for f in files:
184         os.remove(f)
185
186     count = 0
187     predict = []
188     number=1
189
190     while True:
191         ret, frame = camera.read() # read the camera frame
192         filename = "cameraTest/" + "_frame%d.jpg" % count;count+=1
193         cv2.imwrite(filename, frame)
194
195         # reading all the frames from temp folder
196         images = glob("cameraTest/*.jpg")
197         #print(len(images))
198         if(len(images) == 50):
199             frames = []
```

Figure 4-14 Sample Snippet for Export HAR model

Step 2: Import and Connect HAR model and MRS

The figure 4-13 below shows that the MRS have been import and apply to the main system. Where this will be easy for us to run the entire flow start from the HAR model until the user get a list of recommended songs.

```
import MusicRecommend as mr
def recommend():
    action_result = testHAR()

    #main app - spotify developer
    client_id = '4abe212beb964105ae951b714bd62f8f'
    client_secret = '01402e5152814e5cb1b5af03e1517b2c'
    #client_id = client_id1
    #client_secret = client_secret1

    # Test whether the spotify API is connect?
    spotify = mr.SpotifyAPI(client_id, client_secret)
    print("The API Authentication Status is : ",spotify.perform_auth())

    #Check Access Token
    access_token = spotify.access_token
    print("The Access Token : ",access_token)

    art = fav_artist
    tra = fav_song
    artist = spotify.search_art(artist)
    track = spotify.search_track(tra)

    # Parameter
    global activity_class
    activity_class = action_result
    genre = mr.genre_type(activity_class)
    print("Genres for '{act}': is {gen} :\n".format(act = action_result, gen = genre))
    list_id = spotify.get_recommended_songs(seed_artists= artist, seed_tracks= track, seed_genres = genre, access
    new_list_id = dict(enumerate(list_id))
    return new_list_id
```

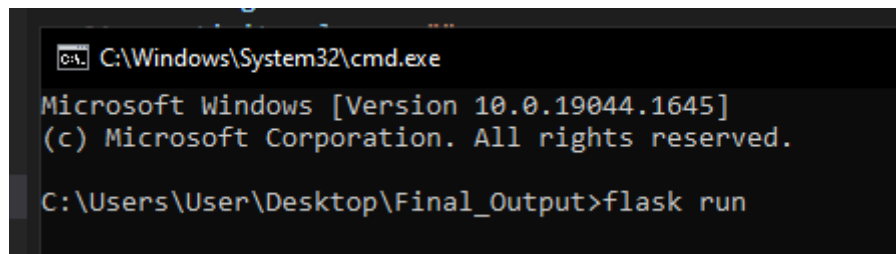
Figure 4-15 Sample Snippet for Import MRS

Step 3: Flask App

As previously we only using the command line to display the result and it not able to let the user to clearly know what is going on. Hence, we will need to apply a web framework to have a better presentation and also let the user easier to use the system. But before applying this Flask as the web framework it is having few requirements for us to perform before use it. It is we need to have libraries installed in our PC or also in an alternative way is to create a virtual environment to install all the package and libraries needed before start. But in this project, it just used the laptop to perform all the setup and able to run in a smooth way.

After the installation of the required libraries, then we can proceed to setup the routing direction where the flow is based on the user flow in the Chapter 3, figure 3-4. Finally, we able to test the result for this project, it can be done by go to the directory of the python files by using the command prompt and then type the command “flask run” (figure 4-14) so that the system will be run. Next, the system will provide us the URL to access the system by using our PC localhost IP address (as the figure 4-15).

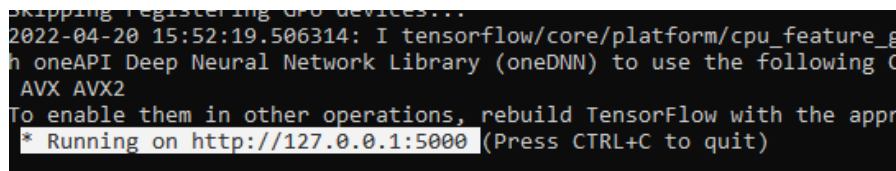
After search and access to the URL link provided in any web browser, then the user will get into the Spotify Authentication Page as the figure 4-16 below shows, only the users who have authenticate will get to the next page which is the main page to get user's favourite artist and favourite song (as the figure 4-17). When the user press submit button then the system will using the camera to capture user's current activity around 5 seconds (which takes about 50 frame in the backend) and the system will return the result as the URL link to the new created playlist (figure 4-18) which based on the user's input (Favourite Artist, Song, and Current Activity) and user can directly copy and paste the URL link to any web browser to open the playlist then result will display like the figure 4-19, while get a confirmation may refer to the figure 4-20 to check that the "New Recommended Songs" is in the user's library.



```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.19044.1645]
(c) Microsoft Corporation. All rights reserved.

C:\Users\User\Desktop\Final_Output>flask run
```

Figure 4-16 Run Python File on Command Prompt



```
Skipping registering GPU devices...
2022-04-20 15:52:19.506314: I tensorflow/core/platform/cpu_feature_g...
h oneAPI Deep Neural Network Library (oneDNN) to use the following C...
AVX AVX2
To enable them in other operations, rebuild TensorFlow with the appro...
* Running on http://127.0.0.1:5000 (Press CTRL+C to quit)
```

Figure 4-17 LocalHost IP Address

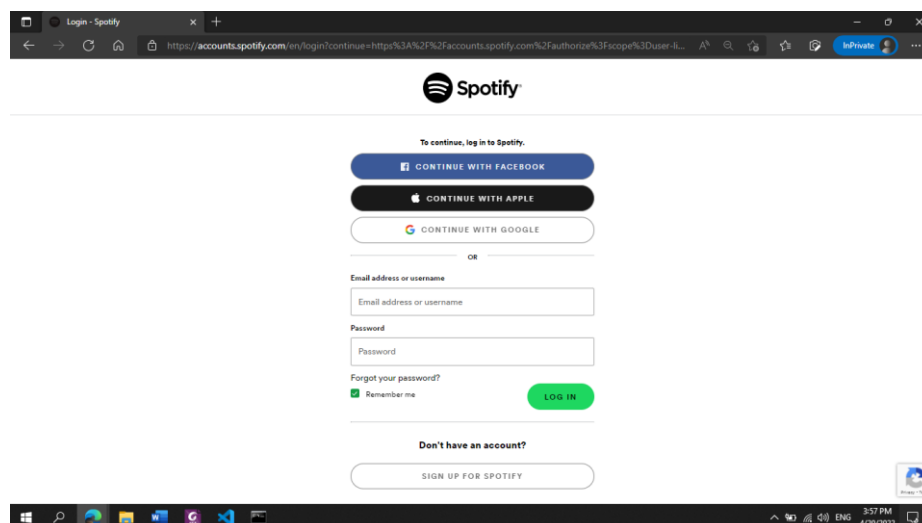


Figure 4-18 Spotify Authentication Page

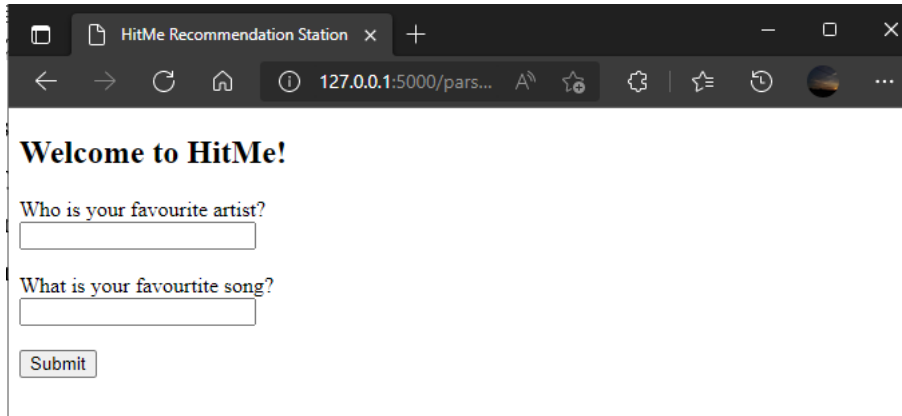


Figure 4-19 Enter User's Favourite Artist & Song

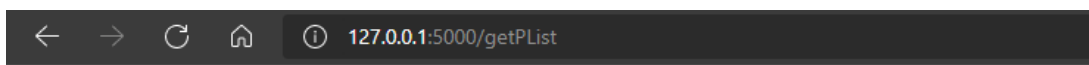


Figure 4-20 System Return New Playlist URL

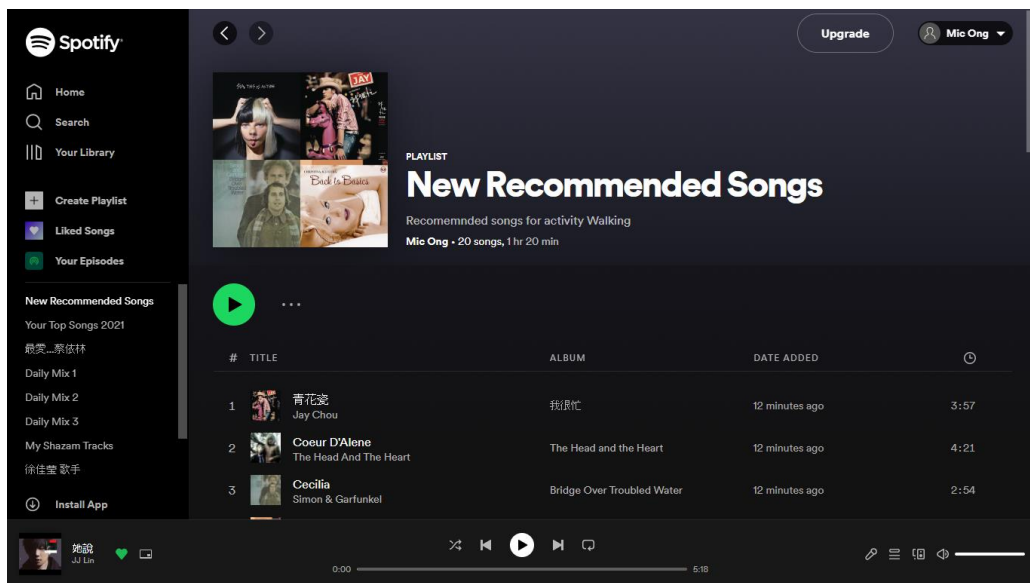


Figure 4-21 New Created Playlist

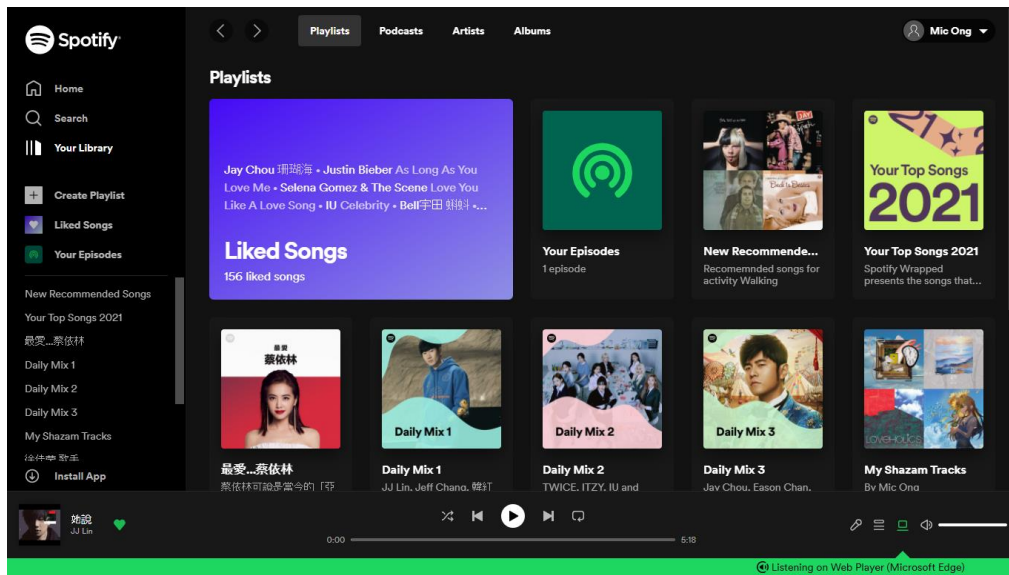


Figure 4-22 New Playlist Added in Spotify Library

Table 4-2 Different Input with Different Recommend Songs

Test	Input	Result
1	<p>Welcome to HitMe!</p> <p>Who is your favourite artist? <input type="text" value="Jay Chou"/></p> <p>What is your favourite song? <input type="text" value="她说"/></p> <p><input type="button" value="Submit"/></p>	<p>Recommended songs:</p> <ol style="list-style-type: none"> "[REDACTED]" by Eric Chou "[REDACTED]" by Leslie Cheung "BECAUSE OF YOU - Piano" by BY2 "[REDACTED]" by Hebe Tien "[REDACTED]" by David Tao "[REDACTED]" by Leehom Wang "[REDACTED]" by Ronghao Li "[REDACTED]" by Fish Leong "[REDACTED]" by A-Mei Chang "Honegger: Un grand sommeil noir" by Arthur Honegger "Fur Alina" by Arvo Pärt "[REDACTED]" by Jay Chou "Songs My Mother Taught Me (from "Gypsy Songs", Op. 5 "[REDACTED]" by Eason Chan "[REDACTED]" by Juno Mak "[REDACTED] - [REDACTED]" by Leslie Cheung "[REDACTED]" by Silence Wang "Der Freischütz, J. 277, 3. Akt: Was gleicht wohl auf "[REDACTED]" by BY2 "Beethoven: Symphony No. 9 in D Minor, Op. 125 "Chora
2	<p>Welcome to HitMe!</p> <p>Who is your favourite artist? <input type="text" value="Justin Bieber"/></p> <p>What is your favourite song? <input type="text" value="As long as you love me"/></p> <p><input type="button" value="Submit"/></p>	<p>Recommended songs:</p> <ol style="list-style-type: none"> "Look What You Made Me Do" by Taylor Swift "The Dreamer" by The Tallest Man On Earth "Pictures of Stone" by Milk Maid "All My Life" by K-Ci & JoJo "If Tomorrow Never Comes" by Ronan Keating "Like the Dawn" by The Oh Hellos "He Doesn't Know Why" by Fleet Foxes "Eternal Flame - Single Version" by Atomic Kitten "Marry Me" by Train "psychofreak (feat. WILLOW)" by Camila Cabello "Home" by The Falls "The First Time I Ran Away" by M. Ward "Flightless Bird, American Mouth" by Iron & Wine "Getaway Car" by Taylor Swift "I Want You Back - Radio Edit" by *NSYNC "Don't Say You Love Me" by M2M "Don't Carry It All" by The Decemberists "Creature Fear" by Bon Iver "Truth" by Amos Lee "august" by Taylor Swift

3	<p>Welcome to HitMe!</p> <p>Who is your favourite artist? <input type="text" value="JJ Lin"/></p> <p>What is your favourite song? <input type="text" value="Bedroom"/></p> <p><input type="button" value="Submit"/></p>	<p>Recommended songs:</p> <ol style="list-style-type: none"> 1) "Violin Sonata in D Minor, Op. 9: II. Andantino tranquillo e dolce" by Karol S 2) "Offenbach: Les Contes d'Hoffmann, Act 4: "Belle nuit, ô nuit d'amour" (Barcarol 3) "Sleepy Eyes" by Elohim 4) "Bad To Worse" by Ra Ra Riot 5) "Wild Girl" by Kito 6) "So Hot You're Hurting My Feelings" by Caroline Polachek 7) "ㄟ ㄟ ㄟ ㄟ ㄟ ㄟ ㄟ ㄟ" by Jay Chou 8) "Woman Is a Word" by Empress Of 9) "Whispering" by Einojuhani Rautavaara 10) "Swing Swing" by ayokay 11) "Look What You're Doing To Me" by BANKS 12) "ㄟ ㄟ ㄟ ㄟ ㄟ ㄟ" by Ren Ran 13) "Peach" by BROODS 14) "Seventeen" by Sjowgren 15) "ㄟ ㄟ" by Stefania Sun 16) "ㄟ ㄟ" by Jay Chou 17) "ㄟ ㄟ ㄟ ㄟ ㄟ" by Rachel Liang 18) "No Exit" by Tennis 19) "Monteverdi: L'incoronazione di Poppea, SV 388, Act 3: "Pur ti miro" (Neron, 20) "I giorni (Arr. For Violin, Piano And String Orchestra)" by Ludovico Einaudi
4	<p>Welcome to HitMe!</p> <p>Who is your favourite artist? <input type="text" value="IU"/></p> <p>What is your favourite song? <input type="text" value="Celebrity"/></p> <p><input type="button" value="Submit"/></p>	<p>Recommended songs:</p> <ol style="list-style-type: none"> 1) "People I Don't Like" by UPSAHL 2) "4 Walls" by f(x) 3) "Treat Me Like A Slut" by Kim Petras 4) "Le nozze di Figaro, K. 492, Act I: "Non più andrai"" by V 5) "LALALAY ㄟ ㄟ ㄟ" by SUNMI 6) "SAD GIRLZ LUV MONEY Remix (feat. Kali Uchis and Moliy)" B 7) "Whispering" by Einojuhani Rautavaara 8) "Tonight" by BIGBANG 9) "Love poem" by IU 10) "Cigarettes out the Window" by TV Girl 11) "Your Teeth In My Neck" by Kali Uchis 12) "Suite for Violin, Clarinet and Piano, Op. 157b: II. Dive 13) "Nail Tech" by Jack Harlow 14) "Grow A Pear" by Kesha 15) "LILAC" by IU 16) "Without You (Feat. ROSE)" by G-DRAGON 17) "FLOWER SHOWER" by Hyuna 18) "Deal With It (feat. Kelis)" by Ashnikko 19) "Teacher's Pet" by Melanie Martinez 20) "Bills, Bills, Bills" by Destiny's Child

As the table above shows that if the user enter different combination of their favourite artist and song, then they will get a totally different recommended playlist based on their preference. User's input will influence them music recommend result whether their favourite songs is more towards the English songs or the Mandarin songs and etc.

Chapter 5 System Evaluation And Discussion

5.

5.1. Simple Prediction for each Activity Class

As the human activity recognition have been successfully build with a moderate accuracy, but it also able to detect the object where to make a prediction for the each of the classes. The predict classes include Biking”, “ComputerWork”, “Driving”, “Eat&Drink”, “PlayInstrument”, “Sport”, “Studying”, “Walking”, and “Writing”, where the below are the images of sample detection for each of the classes.

5.1.1. Biking Activity



Figure 5-1 Sample Detection 1 of Biking Class



Figure 5-2 Sample Detection 2 of Biking Class

5.1.2. Computer Work



Figure 5-3 Sample Detection 1 of Computer Work Class



Figure 5-4 Sample Detection 2 of Computer Work Class

5.1.3. Driving



Figure 5-5 Sample Detection 1 of Driving Class

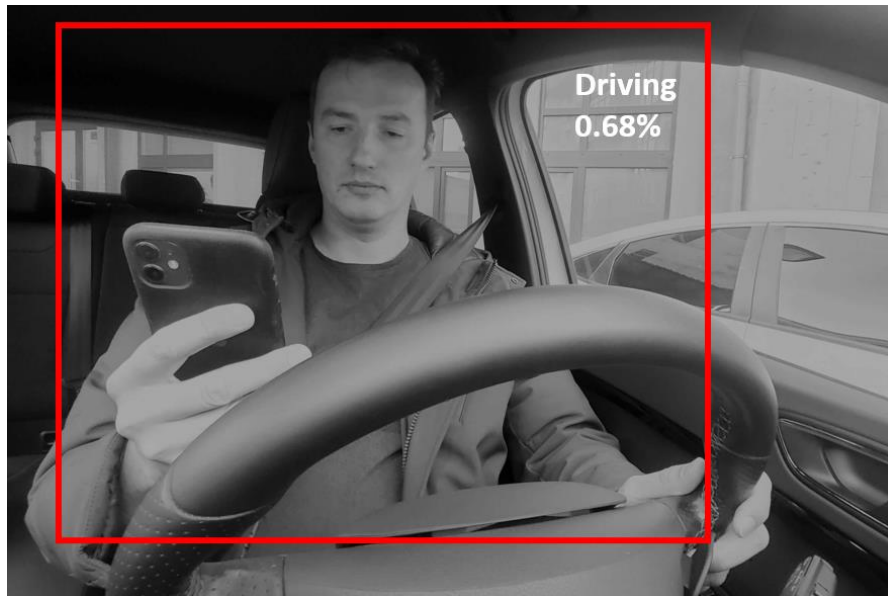


Figure 5-6 Sample Detection 2 of Driving Class

5.1.4. Eating and Drinking



Figure 5-7 Sample Detection 1 of Eating and Drinking Class



Figure 5-8 Sample Detection 2 of Eating and Drinking Class

5.1.5. Playing Instrument

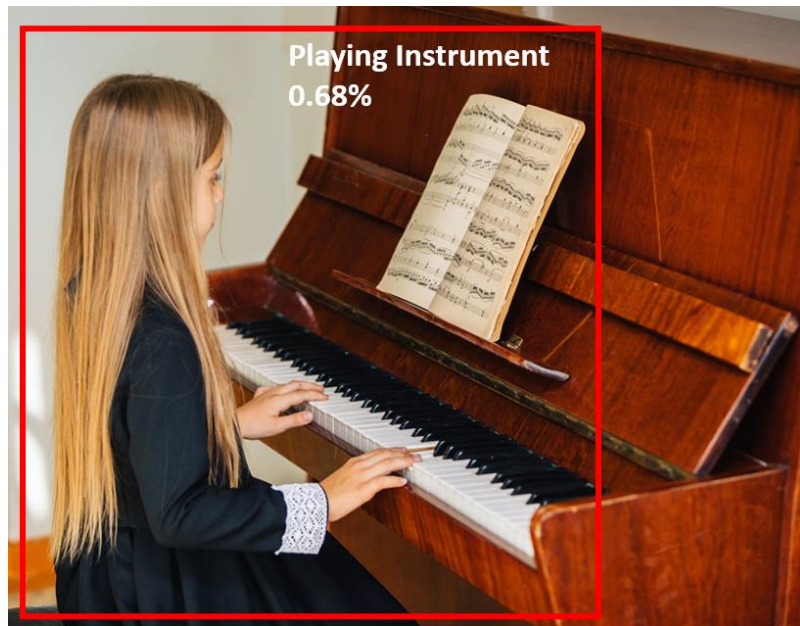


Figure 5-9 Sample Detection 1 of Playing Instrument Class

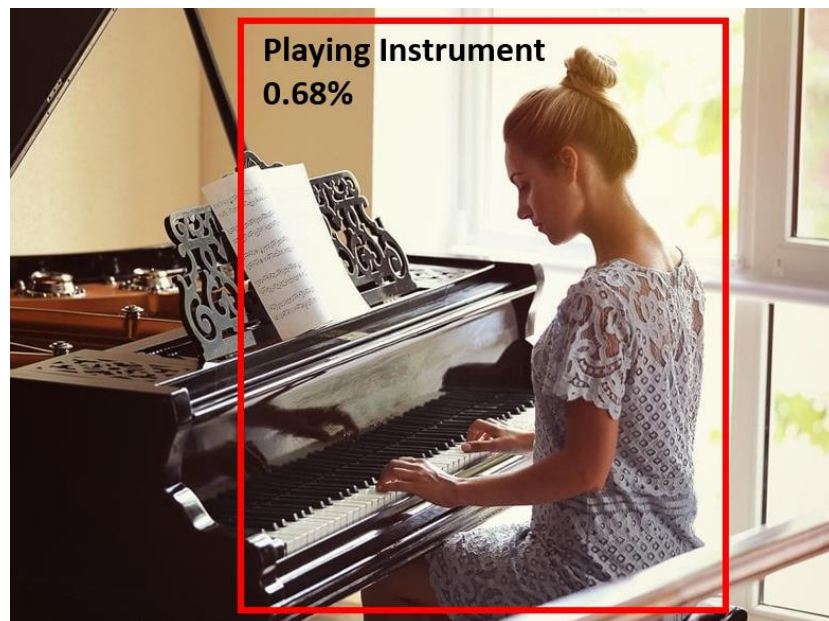


Figure 5-10 Sample Detection 2 of Playing Instrument Class

5.1.6. Sport



Figure 5-11 Sample Detection 1 of Sport Class

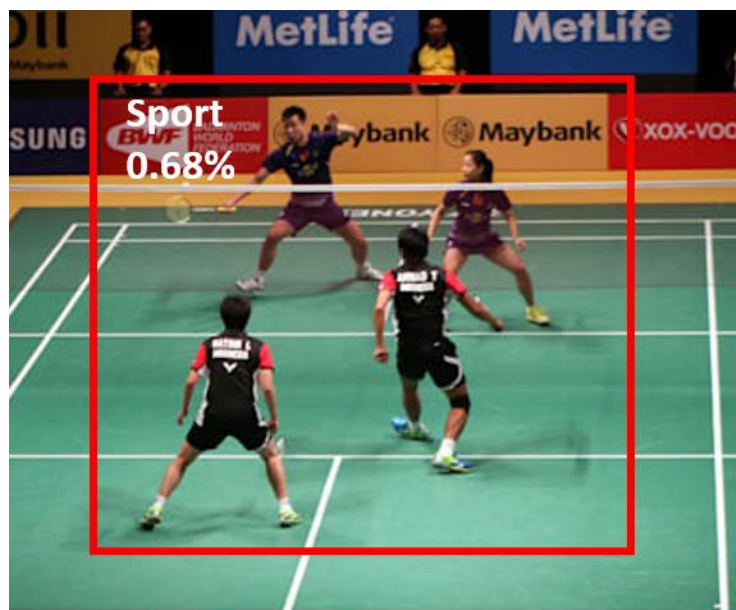


Figure 5-11 Sample Detection 1 of Sport Class

5.1.7. Studying

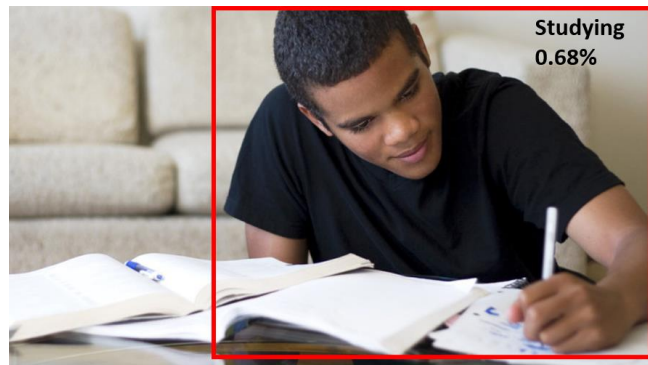


Figure 5-13 Sample Detection 1 of Studying Class

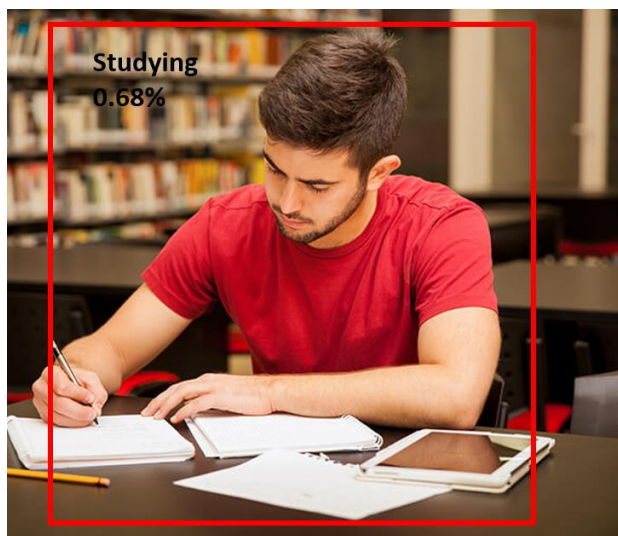


Figure 5-14 Sample Detection 2 of Studying Class

5.1.8. Walking



Figure 5-15 Sample Detection 1 of Walking Class

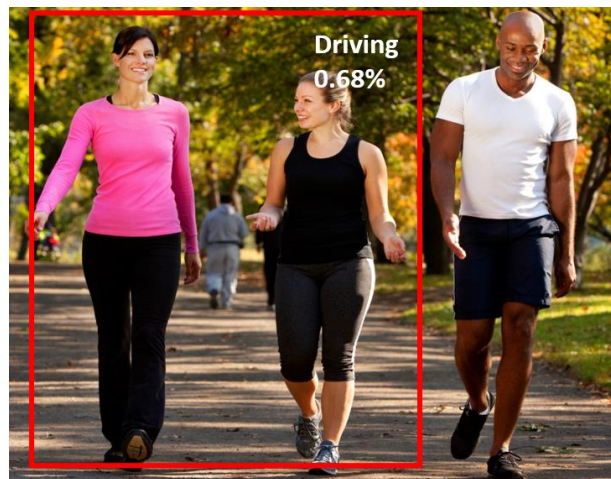


Figure 5-16 Sample Detection 2 of Walking Class

5.1.9. Writing



Figure 5-17 Sample Detection 1 of Writing Class

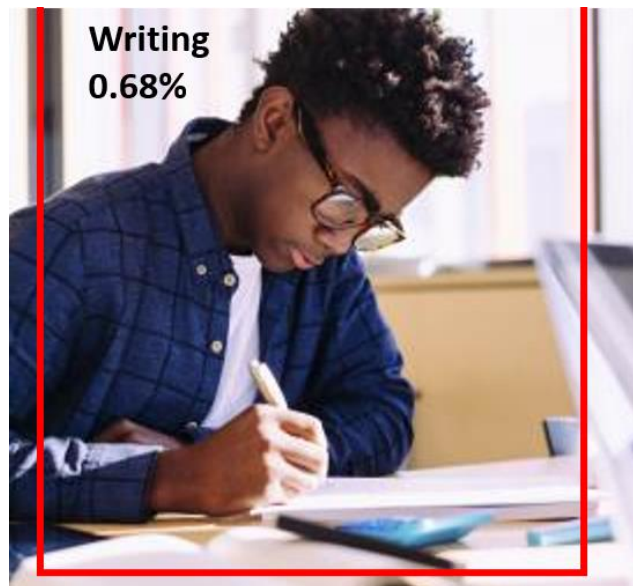


Figure 5-18 Sample Detection 2 of Writing Class

5.2. HitMe vs Original Spotify Recommended Songs

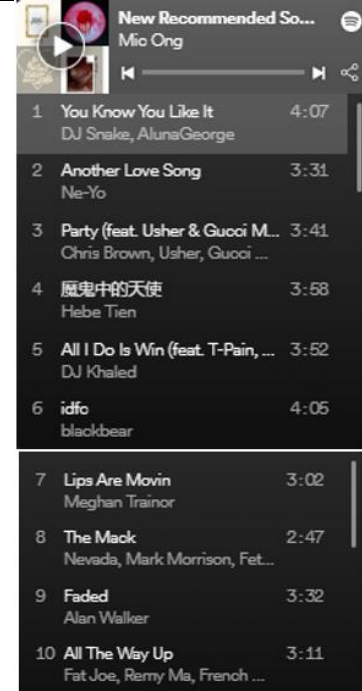
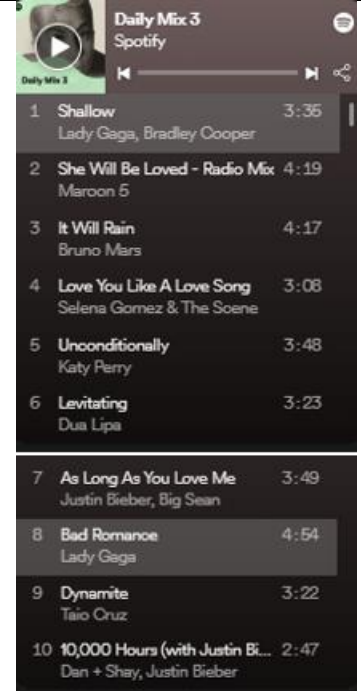


Table 5-1 Comparison Table of HitMe & Original Spotify Recommended Songs


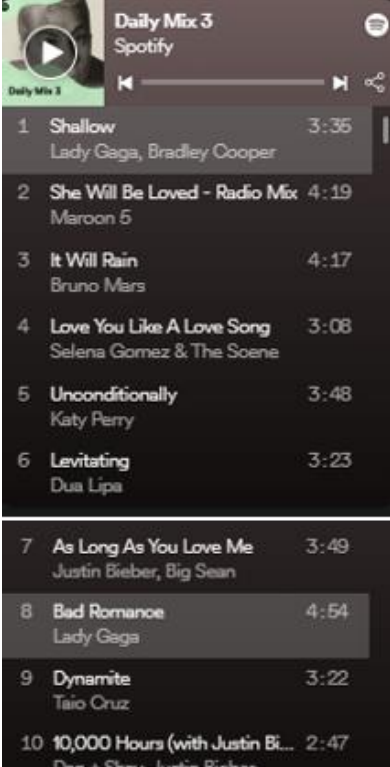

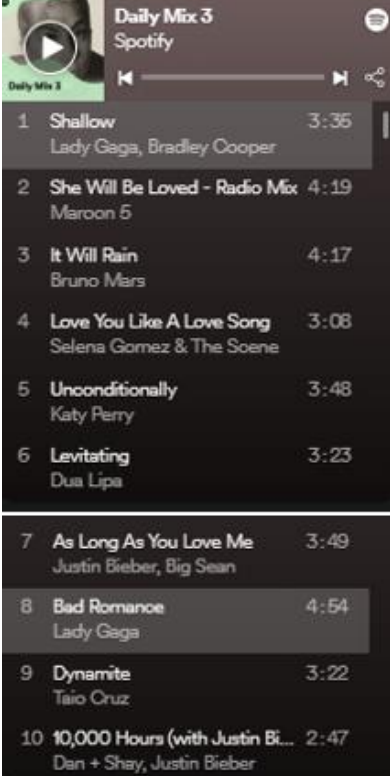
No.	HitMe + Spotify API	Original Spotify
1.	"Look What You Made Me Do" by Taylor Swift	"Shallow" By Lady Gaga, Bradley Cooper
2.	"The Dreamer" by The Tallest Man On Earth	"She Will Be Loved" By Maroon 5
3.	"psychofreak (feat. WILLOW)" by Camila Cabello	"It Will Rain" By Bruno Mars
4.	"Don't Say You Love Me" by M2M	"Love You Like A Love Song" By Selena Gomez & The Scene
5.	"august" by Taylor Swift	"Unconditionally" By Katy Perry
6.	"The Dreamer" by The Tallest Man On Earth	"Dynamite" By Taio Cruz
7.	"If Tomorrow Never Comes" by Ronan Keating	"Levitating" By Dua Lipa
8.	"All My Life" by K-Ci & JoJo	"Bad Romance" By Lady Gaga
9.	"Marry Me" by Train	"As Long As You Love Me" By Justin Bieber, Big Sean
10.	"The First Time I Ran Away" by M. Ward	"10,000 Hours (with Justin Bieber)" By Dan + Shay, Justin Bieber

The table above shows that the comparison for both recommenders, where the HitMe recommended songs is totally different from the Spotify's recommended songs, where the differences is based on the music genre and user's preference which consists of their favourite artist and song.

5.3. Diversity Rate

Table 5-2 Table of Diversity Rate for Both Music Recommender

Activity	HitMe + Spotify API	Original Spotify
Biking	 <p>New Recommended So... Mio Ong</p> <ol style="list-style-type: none"> You Know You Like It 4:07 DJ Snake, AlunaGeorge Another Love Song 3:31 Ne-Yo Party (feat. Usher & Gucci M... 3:41 Chris Brown, Usher, Gucci ... 魔鬼中的天使 3:58 Hebe Tien All I Do Is Win (feat. T-Pain, ... 3:52 DJ Khaled idfo 4:06 blackbear Lips Are Movin 3:02 Meghan Trainor The Mack 2:47 Nevada, Mark Morrison, Fet... Faded 3:32 Alan Walker All The Way Up 3:11 Fat Joe, Remy Ma, French ... 	 <p>Daily Mix 3 Spotify</p> <ol style="list-style-type: none"> Shallow 3:35 Lady Gaga, Bradley Cooper She Will Be Loved - Radio Mix 4:19 Maroon 5 It Will Rain 4:17 Bruno Mars Love You Like A Love Song 3:08 Selena Gomez & The Soenae Unconditionally 3:48 Katy Perry Levitating 3:23 Dua Lipa As Long As You Love Me 3:49 Justin Bieber, Big Sean Bad Romance 4:54 Lady Gaga Dynamite 3:22 Taio Cruz 10,000 Hours (with Justin Bi... 2:47 Dan + Shay, Justin Bieber
Eating & Drinking	 <p>New Recommended So... Mio Ong</p> <ol style="list-style-type: none"> 我難過 4:44 6666 At Least I Had You (with JJ ... 3:23 Gentle Bones, JJ Lin Black and Tan Fantasy - Live 6:20 Duke Ellington Drive' Man 5:16 Abbey Lincoln 我知道 4:10 BY2 Are You Real - Remastered 4:47 Art Blakey One Note Samba (Samba D... 6:01 Coleman Hawkins 你還要我怎樣 5:10 Joker Xue 我不願讓你一個人 4:25 Mayday I Know You Know 3:45 Esperanza Spalding 	 <p>Daily Mix 1 Spotify</p> <ol style="list-style-type: none"> 晴天 4:29 Jay Chou 我的秘密 (MySecret) 4:08 G.E.M. 說愛你 3:46 Jolin Tsai 當你 4:09 JJ Lin 匿名的好友 4:21 Rainie Yang 月牙灣 5:08 F.I.R. 另一個天堂 4:26 Leehom Wang 逆光 4:54 Stefanie Sun 你不是真正的快樂 5:11 G.E.M. 驢公 2:52 Jolin Tsai

<p>Playing Instrument</p>	 <p>New Recommended Songs Mio Ong</p> <ol style="list-style-type: none"> Songs My Mother Taught Me... 1:56 Antonín Dvořák, Yo-Yo Ma, ... Power Power (feat. Shaun R... 3:08 Duckwrth, Shaun Ross Grilling Niggas 2:55 cupcaldKe 當你 3:23 Cyndi Wang Your Teeth In My Neck 3:06 Kali Uchis XS 3:21 Rina Sawayama 每天愛你多一些 4:39 Jacky Cheung 手心的舞臺 4:40 JJ Lin, G.E.M. Unlock it (Look It) - feat. Kim... 3:52 Charli XCX, Kim Petras, Jay ... Le Concert royal de la Nuit, ... 2:38 Anonymous, Ensemble Corr... 	 <p>Daily Mix 3 Spotify</p> <ol style="list-style-type: none"> Shallow 3:35 Lady Gaga, Bradley Cooper She Will Be Loved - Radio Mix 4:19 Maroon 5 It Will Rain 4:17 Bruno Mars Love You Like A Love Song 3:08 Selena Gomez & The Scene Unconditionally 3:48 Katy Perry Levitating 3:23 Dua Lipa As Long As You Love Me 3:49 Justin Bieber, Big Sean Bad Romance 4:54 Lady Gaga Dynamite 3:22 Taio Cruz 10,000 Hours (with Justin Bi... 2:47 Dan + Shay, Justin Bieber
<p>Walking</p>	 <p>New Recommended Songs Mio Ong</p> <ol style="list-style-type: none"> Tip Toe (feat. French Monta... 3:07 Jason Derulo, French Monta... Wandering Me 3:19 Sui Zhen 原來你什麼都不要 4:48 A-Mei Chang 最近 4:03 Sam Lee 當你孤單你會想起誰 4:16 Nicholas Teo 這世界那麼多人 - 電影《我... 4:45 Karen Mok 這世界那麼多人 - 電影《我... 4:45 Karen Mok Bedroom (feat. Anne-Marie) 3:23 JJ Lin, Anne-Marie I'm Writing a Novel 3:35 Father John Misty 簡單愛 4:30 Jay Chou Dynamite 3:22 Taio Cruz 	 <p>Daily Mix 3 Spotify</p> <ol style="list-style-type: none"> Shallow 3:35 Lady Gaga, Bradley Cooper She Will Be Loved - Radio Mix 4:19 Maroon 5 It Will Rain 4:17 Bruno Mars Love You Like A Love Song 3:08 Selena Gomez & The Scene Unconditionally 3:48 Katy Perry Levitating 3:23 Dua Lipa As Long As You Love Me 3:49 Justin Bieber, Big Sean Bad Romance 4:54 Lady Gaga Dynamite 3:22 Taio Cruz 10,000 Hours (with Justin Bi... 2:47 Dan + Shay, Justin Bieber

The table above shows that the ten sample tracks for both recommended tracks, where the purpose of this test is to count the number of the unique tracks from the proposed music recommend compared to the original Spotify recommended tracks. But due to the tracks from the “HitMe + Spotify API” (the proposed solution) is totally different from the Original Spotify recommended tracks, and in each of the activity HitMe able to recommend different genres of songs. Meanwhile, for the original Spotify recommended songs playlist is that it not always change, or update based on user’s real time context. As the figures below shows that the proof / references of the recommended songs for each class.

Table 5-3 Table of Reference for Each Activity Class

<p>Genres for 'Eating' is jazz, r-n-b, pop :</p> <p>Recommended songs:</p> <ol style="list-style-type: none"> 1) " " by 5566 2) "At Least I Had You (with JJ Lin)" by Gentle Bones 3) "Black and Tan Fantasy - Live" by Duke Ellington 4) "Driva'man" by Max Roach 5) " " by BV2 6) "Are You Real - Remastered" by Art Blakey 7) "One Note Samba (Samba De Uma Nota So)" by Coleman Hawkins 8) " " by Joker Xue 9) " " by Mayday 10) "I Know You Know" by Esperanza Spalding 11) "On my way" by Hins Cheung 12) "Home" by Kit Chan 13) " " by Cyndi Wang 14) " ()" by Mayday 15) "You Make Me Feel so Young" by Michael Bublé 16) "He's My Guy" by Sarah Vaughan 17) "Journey Into Melody - 2007 Digital Remaster/Rudy Van Gelder 18) "Gloomy Sunday (with Teddy Wilson & His Orchestra) - Take 19) " ()" by Jay Chou 20) " " by JC 	<p>Genres for 'Playing Instrument' is classical, jazz, piano :</p> <p>Recommended songs:</p> <ol style="list-style-type: none"> 1) "Songs My Mother Taught Me (from "Gypsy Songs", Op. 55, No. 4)" 2) "Power Power (feat. Shaun Ross)" by Duckwrth 3) "Grilling Niggas" by cupcakke 4) " " by Cyndi Wang 5) "Your Teeth In My Neck" by Kali Uchis 6) "XS" by Rina Sawayama 7) " " by Jacky Cheung 8) " " by JJ Lin 9) "Unlock it (Lock It) - feat. Kim Petras and Jay Park" by Charli 10) "Le Concert royal de la Nuit, Grand Ballet, Le Soleil: Les Pla Entrée des Génies" by Anonymous 11) "Ain't Shit" by Doja Cat 12) "Fur Alina" by Arvo Part 13) " " by Jay Chou 14) " " by Karen Mok 15) "COMPLETE MESS" by 5 Seconds of Summer 16) " " by JJ Lin 17) "Hush" by The Marías 18) " " by Sodagreen 19) "BOOGIE" by BROCKHAMPTON 20) "Violin Sonata in F Minor, Op. 5: I. Allegro appassionato" by
<p>Genres for 'Walking' is folk, country, techno :</p> <p>Recommended songs:</p> <ol style="list-style-type: none"> 1) "Tip Toe (feat. French Montana)" by Jason Derulo 2) "Wandering Me" by Sui Zhen 3) " " by A-Mei Chang 4) " " by Sam Lee 5) " " by Nicholas Teo 6) " " by Karen Mok 7) "Bedroom (feat. Anne-Marie)" by JJ Lin 8) "I'm Writing a Novel" by Father John Misty 9) " " by Jay Chou 10) "Dynamite" by Taio Cruz 11) "Another Love Song" by Me-Yo 12) " " by Karen Mok 13) " " by Leehom Wang 14) "In The Midnight" by Langhorne Slim 15) "People Help the People" by Birdy 16) "On my way" by Hins Cheung 17) "Attention" by Charlie Puth 18) "What Lovers Do" by Maroon 5 19) "Creature Fear" by Bon Iver 20) " " by Jay Chou 	<p>Genres for 'Biking' is pop, rock, hip-hop :</p> <p>Recommended songs:</p> <ol style="list-style-type: none"> 1) "You Know You Like It" by DJ Snake 2) "Another Love Song" by Me-Yo 3) "Party (feat. Usher & Gucci Mane)" by Chris Brown 4) " " by Hebe Tien 5) "All I Do Is Win (feat. T-Pain, Ludacris, Snoop Dogg 6) "idfc" by blackbear 7) "Lips Are Movin" by Meghan Trainor 8) "The Mack" by Nevada 9) "Faded" by Alan Walker 10) "All The Way Up" by Fat Joe 11) "In My Blood" by Shawn Mendes 12) "Uptown Funk (feat. Bruno Mars)" by Mark Ronson 13) "Back Together" by Robin Thicke 14) " #MaydayBlue20th - feat. " by Mayday 15) " " by A-Mei Chang 16) "If It Ain't Love" by Jason Derulo 17) "Shining (feat. Beyoncé & Jay-Z)" by DJ Khaled 18) "Work" by Rihanna 19) "Yeah! (feat. Lil Jon & Ludacris)" by Usher 20) " " by A-Mei Chang

5.4. Average Duration

Table 5-4 Activities Average Duration with Different Playlist

Activity	Average Duration (minutes)		
	Ground Truth	Existing Playlist	Proposed Playlist
Biking	38 minutes	36 minutes	50 minutes
Eating	8 minutes	10 minutes	12 minutes
Walking	60 minutes	64 minutes	68 minutes
Playing Instrument	60 minutes	62 minutes	70 minutes

Ground Truth is measured using 20 participants data.

When using the proposed music recommender system, it is necessary to test out the difference between the existing playlist in terms of the user's average duration when they listen to the playlist. The table above shows that the comparison between the existing playlist and the proposed playlist, which the purpose of this testing is to compare which playlist will be influence the users' activity durations. Take the biking activity as an example, if a user X is using the existing playlist and he/she bike for around 36 minutes, but when they are using the proposed playlist and he/she able to bike around 50 minutes which the duration is longer than the existing playlist. In addition, the ground truth column is to represent the common duration that normal people take to perform the activity and it is measured using 20 participants data.

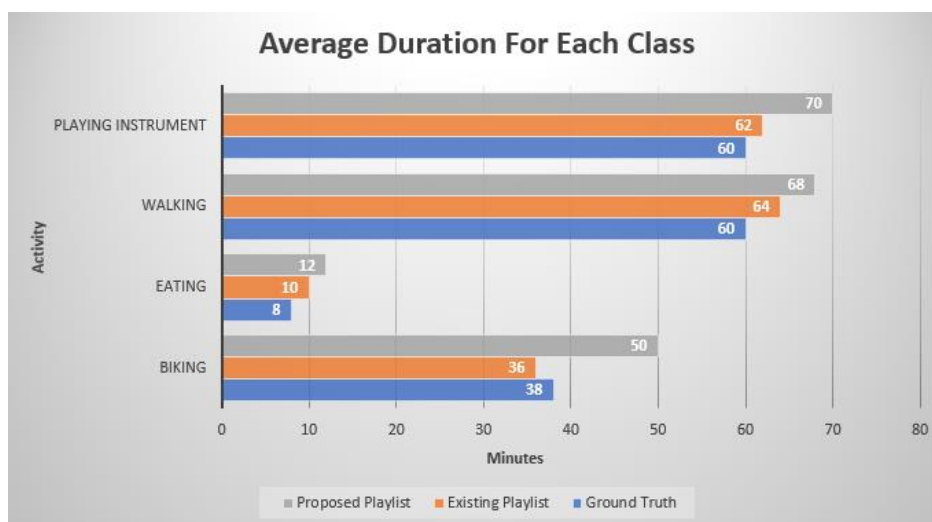


Figure 5-19 Average Duration for Each Classes

As observed the bar chart above it shows that the Proposed Playlist always let user stay for the activity longer than other activity, that means it able to let the users to have more

concentration, relaxing, and energetic to conduct the activity. Since nothing is better than doing the right thing, same goes to this music recommendation if the user listen to the most suitable music genres type then they may have more motivation to continue the activity.

5.5. A/B Testing

The A/B Testing is also known as “Split Testing” where it is used to compare the performance for both versions of the object or content and observe that which object will have more votes or prefer by others. [42] Before conducting this evaluation, it should split the user group into two group that is “Control Group” and “Test Group”, where the “Control Group” is represent as the original version of the test object, while for the “Test Group” is the user group that represent those users who more like the new version of the object in a controlled environment. There are few steps where we need to follow to get the result for this testing, that is the to collect and study the sample data, review, and compare the statistical results. [43]

Step1: Form Hypothesis

Null Hypothesis (H0): Original Spotify Recommended Playlist is more suitable for the user’s current activity.

Alternative Hypothesis (H1): New playlist with user activity is more suitable for the user’s current activity.

Step2: Create Control Group and Test Group

Control Group : Old design (Original Spotify)

Test Group : New design (New playlist)

In this testing, the total number of the participants is 30 participants, and we will randomly select from these 30 participants as our sample data to perform statistical analysis. For the control group will be assign to the user prefer using the original Spotify recommended playlist, while for the test group will be the user who prefer to use the new generated playlist which recommend based on their current activity with music preference.

Step3: Data Collection and Perform A/B Testing

The table below shows that the 10 random selected sample data from the 30 sample data:

Table 5-5 Ten Sample Participant Data of Rating on New Playlist with User Activity

Participants	New playlist with user activity (Rate out of 5)	Original Spotify Recommended Playlist (Rate out of 5)
Participant 1	3	5
Participant 2	4	3
Participant 3	5	2
Participant 4	3	4
Participant 5	3	2
Participant 6	4	5
Participant 7	5	2
Participant 8	2	5
Participant 9	5	2
Participant 10	4	3

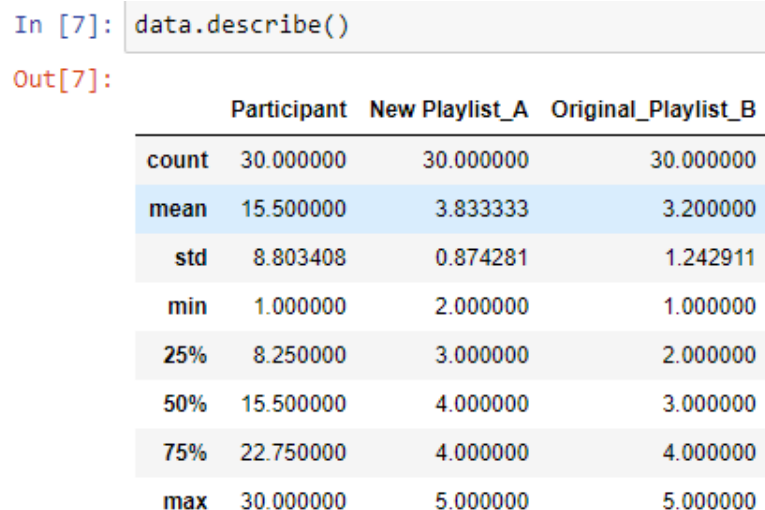


Figure 5-20 Mean Value for Control and Test Group

Mean rating of Control Group : 3.20 over 5

Mean rating of Test Group : 3.83 over 5

Step4: Statistical Significance of the A/B Test

While test the data collected, it has been separated in to 2 group which is the “*New Playlist_A*” and “*Original Playlist_B*”. The “*New Playlist_A*” is represent the new generated playlist which based on the user’s current activity, while for the “*Original Playlist_B*” is represent the original playlist recommend by Spotify itself.

```
In [4]: sns.distplot(data['New Playlist_A'])  
Out[4]: <AxesSubplot:xlabel='New Playlist_A', ylabel='Density'>
```

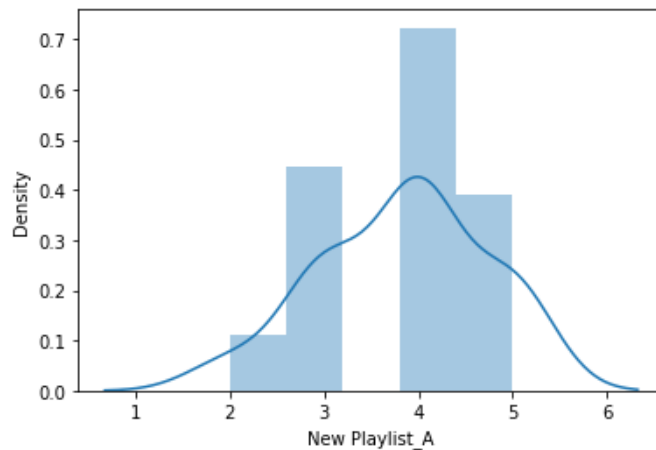


Figure 5-2 Test Group’s Distribution (*New Playlist_A*)

```
In [5]: sns.distplot(data['Original_Playlist_B'])  
Out[5]: <AxesSubplot:xlabel='Original_Playlist_B', ylabel='Density'>
```

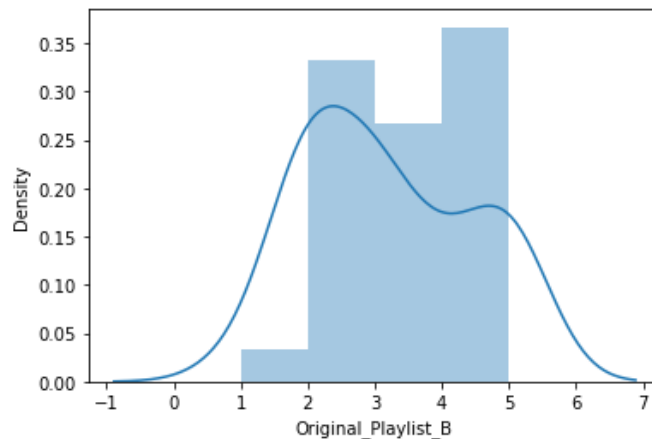


Figure 5-3 Control Group’s Distribution (*Original Playlist_B*)

```
In [6]: t_stat, p_val= ss.ttest_ind(data['New Playlist_A'], data['Original_Playlist_B'])  
t_stat , p_val  
Out[6]: (2.282772497155168, 0.02612733217299642)
```

Figure 5-4 Values of *t*-score and *p*-value

As observed from the above figure 5-2 and figure 5-3, it shows that the result of distribution for the statistical testing for this A/B Testing. First of all, the mean rating in step 3 shows that the control having mean rate of 3.20 over 5 while the test group mean rate is 3.83 over 5. Moreover, the figure 5-4 above shows the t-score value is 2.2828 and also the p-value is 0.0261. To conclude this testing result, we can be said that the alternative hypothesis (H1) is accepted while the null hypothesis will be rejected due to the p-value is less than the significant level which is 0.05. In a nutshell, the new created playlist with user context will be more suitable for the user's current activity.

Summary of the Evaluation and Discussion:

Poor performance on the HAR model where the accuracy is not at the higher accuracy level.

Possible reasons to cause the poor performance of the model trained:

- Lack of proper processing the quality of the datasets (video), since the datasets is come from different sources, so it might be different from each other, and also the video/image resolution is also a bigger issue need to be handled in a proper way.
- Parameters of current CRNN model is not suitable for the current training datasets, need to be adjust and select the most suitable parameters before trained the model, so that the model able to train in an efficient way.

Chapter 6 Conclusion

6.1. Project Review

As nowadays, music streaming is considered as one of the popular trends, and also due to the enhancement of the internet most of the people would more prefer to listen music in real time instead of offline mode. But the problems come in that there are lesser music recommender system or application which provides the recommendation based on the context aware. Although it is still considered difficult to get the user's context with the current technology, but it is also a motivation to have this kind of project to contribute the work in terms of the context awareness.

Based on this issue, this project has proposed a solution which to build a music recommender system that able to recommend a list of songs based on user's current activity that also suit to their favourite taste of the music genre type. The solutions which consist of two parts, the first part is to build a Human Activity Recognition model to capture user's current activity by using the CRNN architecture to train the model, while the second part is to build a content-based music recommender system by using the Spotify API.

As a result, after implementing this project, although the human activity recognition model is not considering a good model at the moment, but at least it can be a "Proof of Concept" that shows us the feasibility by apply this kind of contextual awareness concept into the traditional music recommendation system.

6.2. Future Work

Throughout this project, it can be said that this project having a high potential to be extended and apply into many different fields of study which may require the concept of the contextual awareness with the recommendation. Take an example, by applying this recommendation system to any other IoT solution where the IoT is one of the best solutions to capture user's context in order to achieve the contextual awareness.

Apart from the other possibilities to be extended, there is also having some improvement need to apply in this project so that it could be more reliable and robust

for the long run. First is to enhance the HAR model accuracy, whereas discussed in the previous section the model trained in this project is not good and accurate enough to achieve the industrial level. Moreover, the extension of the HAR model activity recognition, where it can be further extending the activities with many other activities instead of the proposed activities. Finally, the MRS design's code structure can be enhanced to make it more consistent where only use one of the authentication methods instead of combination for both the "Client Credentials" and "Implicit Grant" methods.

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 1
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- No Task

2. WORK TO BE DONE

- Revision work done in FYP 1 and get refresh all the things.
- Finalize the Human Activity Recognition model.
- Explore how to build the Music Recommender System.
- Find Dataset for Music Recommender System.

3. PROBLEMS ENCOUNTERED

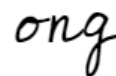
- No

4. SELF EVALUATION OF THE PROGRESS

- Still on track



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 4
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Get refresh all the work in Project 1
- Found all the dataset needed for Music Recommender System

2. WORK TO BE DONE

- Finalize the Human Activity Recognition model.
- Explore how to build the Music Recommender System.
- Explore Spotify API
- Explore Spotify Connector

3. PROBLEMS ENCOUNTERED

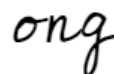
- **No**

4. SELF EVALUATION OF THE PROGRESS

- Still on track for the progress



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 6
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Finalize the Human Activity Recognition model.
-

2. WORK TO BE DONE

- Explore how to build the Music Recommender System.
- Explore Spotify API
- Explore Spotify Connector

3. PROBLEMS ENCOUNTERED

- Limited time to retrain the Human Activity Recognition model for the improvement of the accuracy, hence will remain the accuracy on Project 1

4. SELF EVALUATION OF THE PROGRESS

- Still on track for the progress



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 8
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Explore Spotify Connector
- Explore Spotify API
- Explore how to build the Music Recommender System

2. WORK TO BE DONE

- Start building Music Recommender System using Spotify API

3. PROBLEMS ENCOUNTERED

- No

4. SELF EVALUATION OF THE PROGRESS

- Still on track for the progress



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 10
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Half way on implement the Music Recommender System using Spotify API

2. WORK TO BE DONE

- Explore Flask web framework

3. PROBLEMS ENCOUNTERED

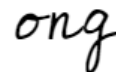
- Stuck at the Spotify API link with Human activity recognition model

4. SELF EVALUATION OF THE PROGRESS

- Still on track for the progress



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 12
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Fully implement the Music Recommender System using Spotify API
- Explore Flask web framework

2. WORK TO BE DONE

- Connect Music Recommender System with Flask

3. PROBLEMS ENCOUNTERED

- No

4. SELF EVALUATION OF THE PROGRESS

- Still on track for the progress



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	Study week no.: 13
Student Name & ID: Ong Kian Shon & 18ACB02258	
Supervisor: Dr. Aun Yichiet	
Project Title: Music By Actions: A Music Recommender Based on Activity Recognition	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Fully implement the Music Recommender System

2. WORK TO BE DONE

- Complete report

3. PROBLEMS ENCOUNTERED

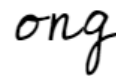
- No

4. SELF EVALUATION OF THE PROGRESS

- Still on track for the progress



Supervisor's signature



Student's signature

Music By Actions - HITME

A Music Recommender Based on Activity Recognition

Introduction

Music is a popular entertainment media element in this digital world, but it is not only for entertainment purposes. Therefore, with the help of the music recommender the users can get a better user experience when using the music streaming or any music player or playlist, this can be achieved when the music recommender collects the users' data and then analyze the taste of the user. Thus, users will easily get the song to recommend, and no need to spend a lot of time searching for the music that meets their taste.

Methodology

1. CRNN network:
 - Combination of VGG16 as extractor with LSTM network to implement Human Activity Recognition.
2. Content-based Filtering:
 - Method for music recommender to recommend similar songs based on user's preferences.
3. Spotify API:
 - Request services from Spotify to modify the user's playlist with features of "Create Playlist", "Add Item to Playlist", and "Search Function".

Objectives

- 1 Provide a Music Recommendation System that can based on users' activities to recommend the most suitable music.
- 2 To design a Music Recommendation Architecture based on activity context using Content-based Filtering
- 3 To deploy the Human Activity Recognition (HAR) system using Recurrent Neural Network (RNN).

Conclusion

In conclusion, this project has successfully implemented a prototype to present the idea of "Proof of Concept" where the final result of the CRNN model score is 0.0657 in accuracy for indoor activity recognition. Besides that, the Music Recommender System is able to get user context information and make a recommended playlist on Spotify.

Present By Ong Kian Shon

Supervisor: Dr. Aun Yichiet

PLAGIARISM CHECK RESULT

Music by Action - A Music Recommender Based on Activity Recognition

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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	ONG KIAN SHON
ID Number(s)	18ACB02258
Programme / Course	Bachelor of Information Systems (HONOURS) Information Systems Engineering
Title of Final Year Project	Music by Actions: A Music Recommender Based on Activity Recognition

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Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.



Signature of Supervisor

Signature of Co-Supervisor

Name: Dr Aun Yichiet

Name: _____

Date: 22 April 2022

Date: _____



UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

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Student Id	18ACB02258
Student Name	Ong Kian Shon
Supervisor Name	Dr. Aun Yichiet

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I, the author, have checked and confirmed all the items listed in the table are included in my report.

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Date: 22 April 2022