Traffic Monitoring System with Emergency Support using SOM

By

Tan Hoai Thang

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirement

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

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(Kampar Campus)

JAN 2020

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Date : _____20/04/2020____________

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ABSTRACT

With the advance of science and technology, everyone will buy a car for convenience. With more cars on the road, emergency vehicles such as ambulances are having a hard time bypassing busy lane. Therefore, with the help of the vehicle emergency alarm system, the driver can stay alert and move sideways, enabling the emergency vehicle to reach the destination as soon as possible.

This paper proposed a system of emergency notification to alert the driver. By using Self-Organizing Map technique, the ambulance siren can be localized based on the detected ambulance siren. Also, Support vector machines were used to classify the presence of ambulance siren and further support self-organizing maps. Next, A mobile app has been developed and installed on a smartphone to forward the results to drivers on the other side of the road. Several processes will implement such pre-processing, as well as feature extraction, for better classification and localization process. In the classification section, all the processed parameters are input into the classification algorithm to classify the groups to which the input parameters belong. Lastly, the classification results are divided into two groups: whether there is an ambulance siren or not. If there is an ambulance, siren localization will be carried out and output the distance of the ambulance siren. In addition, the results are uploaded to an online database and notified to drivers on the road.

To examine the reliability of the system, the system was tested on the St. John ambulance siren dataset, which is the real-world ambulance siren collected at outdoors. Based on the test results, the application was able to perform localization on the St. John ambulance dataset with an average accuracy of 98.0%. Lastly, to test the performance of the system to detect the presence of ambulance sirens, the Kaggle online dataset was used for testing and with an average accuracy of 96%.

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
CCTV	Closed-Circuit Television
ECU	Electronic Control Unit
ESR	Ear Spectrum Ratio
FFT	Fourier Fast Transformation
GPRS	General Packet Radio Service
GPS	Global Positioning Satellite
GSOM	Growing Self-Organizing Map
ITD	Interaural Time Difference
IVC	Inter-Vehicle Communication
MFCC	Mel Frequency Cepstral Coefficient
PDM	Pheromone-Density Measure
R2V	Responder-to-Vehicle
RMS	Root Mean Square
SOM	Self-Organizing Map
STE	Short Time Energy
V2I	Vehicle-To-Infrastructure
V2V	Inter-Vehicle Communication
WLAN	Wireless Local Area Networks
ZCR	Zero Crossing Rate

Chapter 1 Introduction

1.1 Problem Statement

Life is precious, whenever there is a life emergency happened, high chances of the ambulances have to speed up their operations as well as travelling to the nearby hospitals when they are sending casualties as soon as possible. In the modern days, the vehicle technology has evolved into a mature stage, sound insulation of vehicle is one of the good examples. When people are driving, it might be difficult to hear the sound from external environment, as good isolation of sound from external environment has been implemented. For instance, siren sound is usually difficult to be transmitted into the vehicles when coming from far, as the siren sound generated by the ambulance is blocked by the car soundproof rubber. Besides, other factors that distract driver's attention such as mobile phones, global positioning satellite (GPS) devices or communication between the passengers, these will cause the driver unaware of the presence of emergency vehicles.

On the other hand, when an ambulance gets near the vehicle in certain range. Drivers are able to sense the ambulance nearby. Yet, they might have ambiguity on the actual location of the ambulance. According to The Nation Thailand, as many as 20 percent of patients who need emergency treatment fail to reach the hospital in time due to traffic jam and died on the way. This shows the relationship between time and life-saving missions. It is important to alert drivers especially for vehicles where sirens are hard to hear due to good sound insulation or loud interior noise.

Since the beginning of this century, our government has provided a lot of infrastructure for traffic monitoring. Jalanow.com (2019) is a Malaysian real-time traffic surveillance system that monitors traffic through multiple roadside surveillance cameras. Users need to visit the website www.jalanow.com to check the traffic flow status. However, for this system, each CCTV data is collected from different nodes on the road, newly collected road status requires 10-15 minutes to update on the monitoring system. In addition, this type of monitoring system is not reliable because it may affect the quality of data when the weather is bad, such as heavy rain. Traffic accidents can also cause cameras to down because traffic camera can be damaged. Besides that, Bitcarrier (2019) is a real-time traffic flow monitoring system, multiple sensor placed at different location in the city street to collect the traffic information. System will receive the data from sensor to perform analyse of traffic flow. Nevertheless, neither system provides emergency alerts when there are emergency vehicles in the lane.

1.2 Project Background

The progression of human civilization in this new age, technology is more and more developed, and better vehicle technology has been developed. To enjoy these new things, many people will buy a vehicle and let them have better driving experience. As rapidly increasing traffic volume on the road, traffic monitoring is needed to monitor road conditions. Traffic monitoring system refers to the systematic process of collecting, analysing, summarizing and preserving the traffic data of vehicle which describe the characteristic of vehicles and how it moves on-road (Ekwonwune, et al., 2018). Vehicles that cross the streets and highways every day have a lot of useful information. Through subsequent traffic data, it can be used to detect anomalies, accidents, and congestion on the road.

According to Definitions.net, traffic congestion is a condition on the road that occurs when road usage increases. Traffic congestion is when traffic either stops completely or slows down. Unfortunately, this can cause drivers to wait longer in long traffic queues to reach their destinations. Therefore, traffic congestion is a common and most annoying thing for every driver. Traffic congestion is always happening on road especially commuter time, a road full of cars, buses, varies the type of vehicle that causes traffic to become busy. Traffic congestion has led to increased travel time brought social cost drivers, including inconsistency, economic loss, driving experiences. There are multiple possibilities to causing traffic congestion the most common one accident. According to TEE (2019) the number of accidents in Malaysia rose from 533,875 cases to 548,598 cases in 2017 and 2018, this is more or less due to the increase in traffic on the roads. When a traffic accident happens, it impedes the flow of cars. This is because other cars cannot pass through and stop over there. Next, rubbernecking also slow down the traffic, which driver slow down their car to see the situation of the accident. Other reasons such as construct, which also will slow down the traffic because part of the lane is unable to use.

Traffic monitoring system can help users in travel. It reduces the chances of road users sitting in traffic jams for too long, it can inform what is happening in front of them, what is the current traffic condition, and help users to decide whether to change the route, to avoid congestion. Highway traffic status board is a type of infrastructure which placed along a highway that tells the driver current traffic status and how long it will take to reach a particular destination. It can help drivers estimate their time and make decisions about routes. Traffic monitoring system with emergency alert is a very useful system. When that is an ambulance is coming from behind. It is important to aware drivers need to be more careful and prepare to clear the way for the ambulance. So that the ambulance can get the patient to the hospital as soon as possible. This can prevent treatment delays and lead to death. In this case, the emergency notification system plays an important role. According to Windle (2002), an emergency notification system was developed using car stereos cut technique, to alert the driver of an emergency vehicle when it was approaching. The emergency vehicle will broadcast a warning message in certain range of radio frequencies. The vehicle's radio system will scan for radio signals and will be interrupts radio music when detected the emergency signal and alert drivers with a voice message. MEVAS (2019) is an emergency product that install a device on both normal and emergency vehicle. When the emergency vehicle's device is turned on, it emits a radio signal and other vehicles receive a pulse of signals, simultaneously use audio to notify the driver.

Also, in this day and age, most drivers would choose a smartphone navigation application to navigation and view the road conditions, such as Waze, Google maps, etc. These apps provide up-to-date traffic conditions in different ways, such as red colour lanes mean slow traffic and stops and green colour for smooth driving conditions. Most of these navigation applications are update the traffic condition by collecting data from user's smartphone GPS, after obtaining the user's GPS information, the traffic flow status is obtained through a series of calculations. Counts (2016) stated that HAAS is a type Responder-to-Vehicle (R2V) technology, which installs an application on driver’s smartphone. The app notifies the driver when upcoming emergency vehicles.

Self- Organizing Map (SOM) is an Artificial Neural Network (ANN) which invented by a professor of Finland named Teuvo Kohonen in the 1980s, that uses unsupervised learning for training which no human intervention and generate low dimension space (Normally 2D dimension) from N dimension input vector (Ralhan, 2018). SOM also one type of competitive learning algorithm. Firstly, for the SOM algorithm, the value of the weight vector for each neuron will be randomly initialized. A row of datasets is selected and place them in the SOM topology. There are two phases in the SOM algorithm, the competition phase, and the learning phase. For the competition phase, the input vector is computing with all the weight of the neuron in SOM topology and the closest is the winning neuron (the active neuron), the distance between the input vector and neuron is calculated by using Euclidean distance. Each input vector that has similar features will be assigned to the same cluster in the SOM topology’s algorithm cause neighbouring neurons in the SOM topology respond similarly to some input patterns. Therefore, the next step learning stage which to solve the problem. In every iteration of the learning stage, the neuron will adjust closer to the input vector for Keep the neighbourhood relationships that exist with the input vector and the neuron.

Dressler et al. (2014) stated that Inter-Vehicle Communication (IVC) is an important research area, which is developing rapidly due to the great advances in mobile and wireless communication technologies and the growth in the internal micro processing capabilities of today's automobiles and other mobile vehicles. IVC can increase road traffic capacity through platooning vehicles. Meanwhile, reports and alert functions of IVC support real-time warning information to avoid collisions. This improves driver safety and comfort. Also, communication is divided into two types of Inter-Vehicle Communication (V2V) and Vehicle-To-Infrastructure (V2I). V2V communication is used for driver assistance or traffic monitoring. V2I is communication between vehicles, and its infrastructure is located along roads, providing services such as Internet access, intervehicle calls or advertising.

1.3 Motivation

This project will provide convenience for drivers of cars, trucks, buses, etc. As the monitoring system will help the road users understand the road condition and it is efficient for them to plan their road trips, it can save them time from waiting in traffic jam. In addition, it helps patients who are involved in emergencies, such as severe bleeding from serious injuries or heart attacks. According to The Star (2016), Two people were killed in two motorcycle accidents on the 228km North-South Expressway. The accident has caused a traffic jam near Simpang Ampat in Alor Gajah. An ambulance was rushing to the scene to rescue the victims, but the emergency lane was blocked by the vehicles. This shows the importance of informing the drivers to allow a crossable lane, when an ambulance has arrived nearby. If the driver realised the importance of this issue, the ambulance will be able to rush to the hospital on time, the two victims may have a chance to survive. The development of the system is designed to help people to reach their destination without the delaying of time so as to reduce the chance of being late and prevent unintended consequences. especially in the emergency case.

1.4 Objective

The objectives of proposed system which is Traffic Monitoring System with Emergency Support using SOM are:

1. **To implement unsupervised learning Self-Organizing Map (SOM) to localized the ambulance siren and to infer the traffic condition.**

   In order to perform localization on the ambulance siren, Self-Organizing Map was studies and a topology map was trained. he distances of the ambulance can be determined by the topology map. If most users in the same location receive the result of the system that an ambulance was detected in a particular area, then the user will infer what happened there, such as a car accident that caused the traffic to slow down.

2. **To identify the ambulances' emergency siren collected using microphone accurately and indicates the presence of nearby ambulances**

   It is to verify between normal traffic conditions and special traffic conditions especially with the presence of ambulance A classifier was trained to identify whether there were ambulances in that environment. Also, different samples collected by microphones and online datasets were used to test the trained classifier.

3. **To provide monitoring status for road users and trigger alerts whenever ambulances' siren was found.**

   The system is association of Self-Organizing Map and classifier. The system will detect the presence of the ambulance, as well as the distance of the ambulance, if the ambulance siren is detected. Therefore, the system allows the user to be notified when an ambulance siren is detected.

4. **To provide monitoring based on results collected from other road users at different locations and shared with other road users.**

   To allow users to receive notification results from road users in other locations. A mobile application was developed that works on sharing information whenever an ambulance is presence. Therefore, users are allowed to receive notifications as soon as an ambulance is detected in another location. Besides receive notification, the application allows users to view the ambulances detected on the application map.

1.5 Proposed Approach/Study

The proposed system applied Self- Organizing Map to perform localization of ambulance siren based on the inputted siren sound. Before localization process, Support vector machine (SVM) is used to classify the pre-processed sound to identify the presence of ambulance siren. The system also applied band-pass filtering and trimming technic to pre-processed the inputted sound. Features extracted were two major category features of audio which is temporal, and spectral features. The final phase of the system is result sharing, which is developed on a mobile platform. The real-time database use was provided by Google Firebase. The information is shared from the system to the online cloud and forwarded to mobile applications on smartphones.

1.6 Highlight of the Project

The siren localization system can be used on the real-world ambulance siren sound. Also, the siren classification stage involved before the localization stage helps in save time and computing power, avoid unnecessary waste of resources. After the presence of ambulance siren was confirmed, the localization system will more likely to return an accurate and reliable result. Next, the process of sharing emergency alert time is faster than an ambulance on the road, the user can be notified more quickly of the arrival of an ambulance and perform the necessary actions. Lastly, the platform for sharing results is mobile devices, because almost everyone now has a smartphone and doesn't need to buy extra hardware to receive the results. The users only need to install the application in the smartphone to receive the result.

1.7 Report Organization

This report consists of six chapters, chapter one to chapter six. Chapter one mainly consists of the introduction of this project which includes the problem statement, objectives and so on. Chapter two consists of the literature review that various studies related to the project. The relevant previous works were reviewed and comparison was done among them. Next, chapter 3 is describing the system design of the project. Chapter 4 describes on the system implementation process while chapter 5 records on several verification testing plans. Last but not the least, the conclusion has been written in chapter 6 in this report.

Chapter 2 Literature Review

A siren system is often used as a notification of an emergency, especially suitable for emergency vehicles, because it can easily attract people's attention. Stokoe (2016) studies show that 75% of people choose siren as notifications for something. According to Kuligowski & Wakeman (2017), siren is an important tool to alert peoples, and peoples can easily react. Despite, sirens are not suitable for hearing impaired people because they cannot hear. Terry Caellp & David Porter (1980) claimed that when the ambulance approached the driver, it was difficult for the driver to localize the ambulance siren. As results, sirens can be used to alert people, but not everyone. Therefore, when there is any emergency, notification needs to be sent into the car to inform the driver more clearly. According to the research of Zhang, et al. (2019) longer notification in-vehicle have better driver response ability, more reliable and safety benefit. Drivers need to receive messages to be notified. Vehicles can receive shared emergency notifications in a number of ways.

Vehicle-to-infrastructure (V2I) communication is the most common form of communication, in which the vehicle receives messages sent by the roadside or fixed location infrastructure. The infrastructure act as a base station, equipped with network equipment, which allowing communication in the same network. FLEXMod FM211 is an emergency alert system which adopted the V2I technique Technoroll (n.d.). The device placed in a fixed position will transmit an alert message to the vehicle. But there are some difficulties with this technique. The network connection between the vehicle and the network equipment is limited, and the distance between the network equipment can be problematic. If the distance between the two network devices is too far, the driver may not be immediately notified when an emergency vehicle arrives. This is because vehicle device can lose connection with road side infrastructure when there is too big gap.

Second, Vehicle-to-Vehicle (V2V) communication allows the use of Wireless Local Area Networks (WLAN) to forward data from one vehicle to another until the destination node, without the need for communication through a base station. According to research of Liu & Guo (2018), in the vehicle collision warning system should aware when using V2V communication. Transmission latency is a major concern. This can make a difference between the actual distance and the distance sent to another car. In this case, it can be dangerous, if the system processing wrong distance information, and identify as the safe distance. No warning will be given to the driver, which may result in an accident. Furthermore, security is a V2V issue, because V2V communicates through WLAN, anyone in the network can send messages, and if someone intentionally misleads, there may be unpredictable consequences.

Technique Review

In order to better understand Self-Organizing Map (SOM) and emergency notification technology, several research papers are studied as follows. The first part discusses several types of self-organizing maps and their related researches. The second part is the method of feature extraction and sound location of siren. The last part is about method of Inter-Vehicle Communication.

2.1 Self-Organizing Map

2.1.1 Conventional Self-Organizing Map

Self-Organizing Map (SOM) is one type of unsupervised artificial Neural Network. SOM identify patterns embedded in training data and classified it without supervision. SOM is an artificial neural network inspired by the human brain (Jantvik, 2009). The input from different sensors to the human body is mapped to the corresponding regions of the cerebral cortex. SOM does the same thing, mapping inputs with the same characteristics to the same cluster. The mapping process is through competitive learning. Before that, every neuron weight is initialized. The input vector is chosen and computed the weight different with all neurons weight, neuron with the have the less different known as Best Matching Unit (BMU). After complete of competitive process will go for learning process, the winning neuron (BMU) will update its weight based on the learning rate (α), and become more likely with input vector. Also, the neighbour neuron of BMU will learn more similar to input vector but the rate is less compared to BMU neuron. The neighbour of BMU neuron is based on sigma (s), which is the neuron within the radius (s) will become neighbour of BMU neuron. Alpha and sigma are time series parameter, they have inversely relationship with time which decrease as the number of iteration increase. (t) is the number of iterations and (T) is the time constant. Use equation 1 to calculate the learning rate.

$$\alpha(t) = \alpha_0 \, exp\left(\frac{-t}{T}\right) \; (\mathbf{1})$$

Therefore, the process of adaption of weight of BMU and neighbour neuron cause the orientation of neurons become so order and meaningful. Self-Organizing Map form from the topologic map that make up according to input vector. **Figure 2.1** is the simulation of self-organizing map.

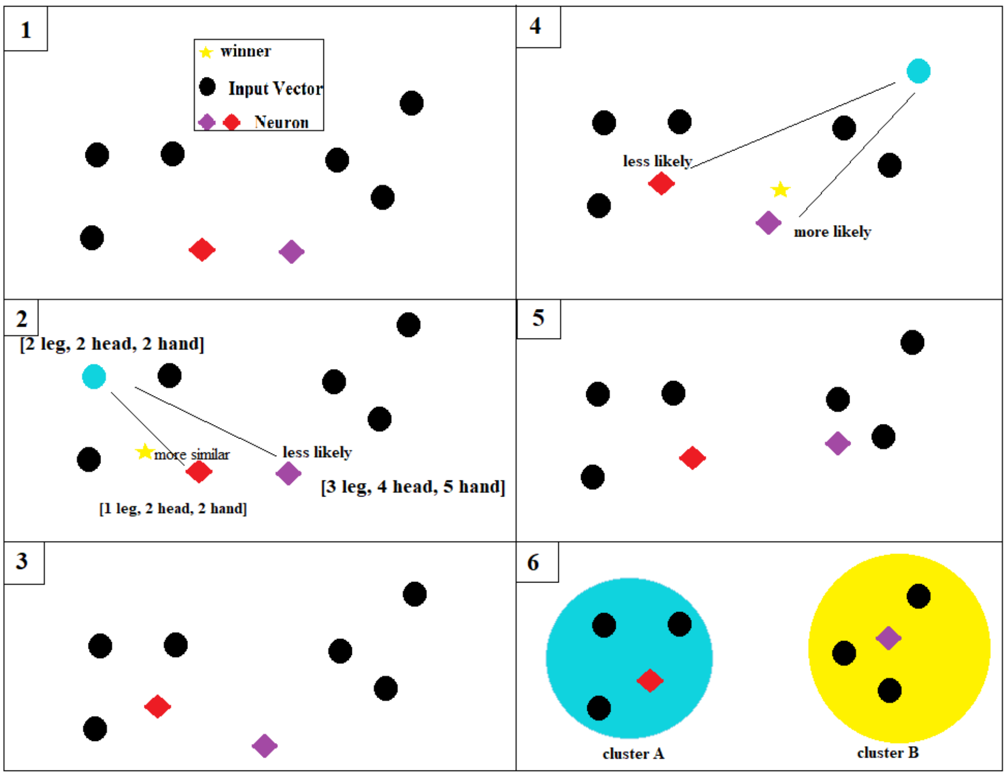

Figure 2.1Machanism of Self Organizing Map

1. Initiation state of the input vectors and neurons.
2. Blue colour input vector is selected and calculate the weight difference with other neurons. The red colour neuron is having the weight more likely with the input vector, red colour neuron is Best Matching Unit (BMU).
3. The BMU moves toward the input vector, and the neighbouring neurons do the same thing, but only very slightly.
4. Another input vector is selected and the purple neuron are more match and become the BMU.
5. The BMU (purple neuron) was move closest to the input vector, while the red neuron only moved slightly.
6. The number of iterations is continuing for other input vector. As time goes on, the number of neighbour neurons will gradually decrease and they will be further away from each other. Thus, form a topology that can be considered a cluster.

Method of Anomaly detection using SOM

Klement & Snášel (2010) introduced the unsupervised learning to discover anomaly of emergency call. The author used the historical incident data in the database for learning, to identify anomalies situation in a new monitoring incident. Self-Organizing Map (SOM) is used to perform clustering for database data. It will two situations for the clustering which is abnormal and normal cases. Each incident case will act as an input vector and will compute the shortest distance among the neuron available in the SOM topology. After that, will output all weight of neuron when all input vector is trained. In multiple clusters, two clusters with the shortest Euclidean distance will be merged together to formed a new one. It will repeat until reaching the specific cluster size. The normal data will create a non-anomalous cluster. Multiple emergency cases that exceed the threshold scale will be recognized as one case with partiality the same in the attribute. For the database data, it can explore the pattern in the emergency case. The anomaly record will be detected from the database when input into SOM, it will form an isolated cluster.

The author has to perform an encoding method to convert categorical data into a real number, at the same time preserved distribution characteristics of each original attribute. As no performing that process it will cause problem such as different category record is classified into the same node because categorical data are not suitable for SOM algorithm. In Figure 2.2 show that the frequency map before encoding and the Figure 2.3 is after encoding. The colour of each node is based on the average value of the record assigned to the particular node. The most record assigned is the darker node. The Figure 2.4 is the result of learning and clustering, the black colour line means one cluster. The anomaly data are formed the smallest cluster in red square.

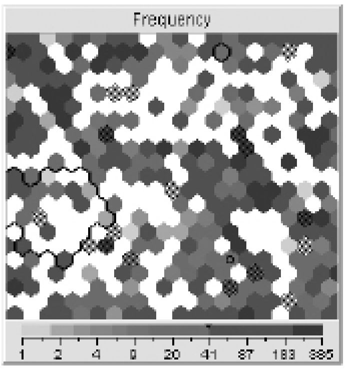

Figure 2.2 Frequency Map before encoding (Klement & Snášel, 2010)

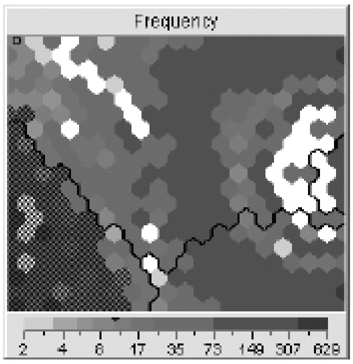

Figure 2.3 Frequency Map after encoding (Klement & Snášel, 2010)

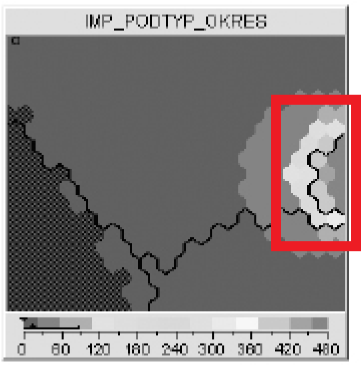

Figure 2.4 Output of Self-Organizing Map clustering (Klement & Snášel, 2010)

Driving Cycle Classification

The electric vehicle has developed in the current era, mostly it will face the problem of what is the best power mode and control strategy to get the have better efficiency. The concept of autonomous learning in the driving cycle developed (Hui, et al., 2008). During vehicle driving, real-time parameters such as speed, distance travel, acceleration time, travel time are collected by in-vehicle devices. This data is transmitted wirelessly to the data server using the GPRS network, and 28 different characteristic parameters (Table 2.1) were calculated. These parameters were used input vector to Self-Organizing Map (SOM) to classify which cluster of driving cycle belong to. There have 3 types of cluster which congested, freeway, and highway driving cycle. The advantage of this method is supervision is not required when using SOM, after SOM topology was trained with a training sample. With the input vector parameter, the SOM algorithm enables the performed automatic classification. After the closest current driving cycle is identified, the data server will send the optimal control parameter to update the ECU of the vehicle in real-time. Therefore, different driving control strategies will be adopted to have greater efficiency.

Table 2.1 Driving Cycle Characteristic Parameters (Hui, et al., 2008)

	Definition	Symbol	Unit
1	Travel Time	T	s
2	Acceleration time	Ta	s
3	Deceleration	Td	s
4	Uniform time	Tc	s
5	Idle time	Ti	s
6	Travel distance	S	Km
7	Max speed	Vmax	Km/h
8	Average speed	Vm	Km/h
9	Running speed (except idle speed)	Vmr	Km/h
10	Standard deviation of speed	Vsd	Km/h
11	Max acceleration	a max	m/s2
12	Max deceleration	a min	m/s2
13	Average acceleration	aa	m/s2
14	Average deceleration	ad	m/s2
15	Standard deviation of acceleration	asd	m/s2
16	Ratio of speed between 0 to 10 km/h	P0_10	%
17	Ratio of speed between 10 to 20 km/h	P10_20	%
18	Ratio of speed between 20 to 30 km/h	P20_30	%
19	Ratio of speed between 30 to 40 km/h	P30_40	%

20	Ratio of speed between 40 to 50 km/h	P40_50	%
21	Ratio of speed between 50 to 60 km/h	P50_60	%
22	Ratio of speed between 60 to 70 km/h	P60_70	%
23	Ratio of speed between 70 to 80 km/h	P70_80	%
24	Ratio of speed >80km/h	P80	%
25	Ratio of acceleration	Pa	%
26	Ratio of deceleration	Pd	%
27	Ratio of uniform	Pc	%
28	Ratio of idle	Pi	%

2.1.2 Growing Self- Organizing Map (GSOM)

Growing Self- Organizing Map (GSOM) is one type of the modified Self- Organizing Map (SOM). The modified map is formed to solve the limitation of overlapping clustering and clustering data distribution of the conventional Self- Organizing Map. Growing Self- Organizing Map (GSOM) has a dynamic structure, unlike the conventional Self- Organizing Map, which has only a fixed structure. GSOM first initializes 4 neurons and increases them as needed during the training phase. This allow GSOM to grow the map, provide better orientation for neurons, and easily find patterns in training data. The growth of the map will be controlled by a parameter called the spread factor. Spreading factor is lower, the smaller the map spread. The higher the spread factor, the wider the map spread and the more sub clusters formed. Firstly, the four neurons were initialized with random Numbers, and then the winning neurons were calculated according to the Euclidean distance, the same as the traditional method. The winning neuron and its neighbours will update their neuron weights according to the **Equation 2**. As the number of iterations increases, the learning rate decreases.

$$W_j(k+1) = \begin{cases} w_j(k), j \notin N_{k+1} \\ W_j(k) + LR(k) \times \left(x_k - w_j(k)\right) j \in N_{k+1} \end{cases} \quad (\mathbf{2})$$

Another parameter is the growth threshold, which is calculated based on the dimension of the training data and spread factor. The equation is expressed as **Equation 3**.

$$GT = -D \times ln(SF) \quad (\mathbf{3})$$

Whenever the winning neuron is calculated, the difference between the weight of the input vector and the weight of the winning neuron (error value) is accumulated. If the total error value exceeds the growth threshold, a new neuron will be added with the initialized weights that same as the neighbouring weights. The growth process will be repeated until the neuron growth is reduced to a minimum.

The final phase of GSOM is the smoothing stage. Each winning neuron and its neighbours will update their weights as before, but at a lower learning rate. This is to reduce quantization error (the distance between the winning neuron and the input vector).

GSOM performance on audio and visual data

(Fonseka, et al., 2011) use temporal data to test the performance of GSOM. The use of temporal data falls into two categories which is audio and visual data. The datasets are about different people saying one, two, three and four. In this experiment, the audio data has 12 features, namely, Mel-Frequency Cepstrum Coefficients (MFCC) and 6 features were extracted from visual data about measuring height and width of mount and lip. GSOM is used to train two different topology diagrams and test the performance algorithm with purity. Purity is the percentage of the total number of classes in the topology that have the same label. GSOM has a good effect on audio data processing, with an average purity percentage of more than 90% and spread factor of 0.01. Different spread factors were tested. When the diffusion factors were increased, more clusters were formed and the purity percentage was increased. However, visual data was not as good as audio data, achieving only 74% of the average purity.

2.1.3 ViSOM

ViSOM (Yin, 2002) is another type of modified Self-Organizing Map that provides a better visualization experience. Conventional Self-Organizing Map allows map high dimension data to 2-D map. During this process, SOM retains only the topological structure of the training data to the result mapping. The interneuron distance is not preserved. Interneuron distance is the distance between neighbouring neuron. Therefore, the visualization of map will be degraded. ViSOM regulates the distance between neurons so that the distance between input space neurons is similar to the distance between output space neurons after training. The initialization and competitive learning algorithm of ViSOM is the same as the conventional Self-Organizing Map algorithm. The only difference is the weight adaptation of the winning neuron's neighbours. When updating the weights of neighbouring neurons, the difference of weights and distances between neighbouring neurons and winning neurons in two-dimensional grid is calculated. The new equation is expressed as **Equation 4**.

$$w_k(t+1) = w_k(t) + \alpha(t)\eta(v,k,t) \cdot ([x(t) - w_v(t)] + [w_v(t) - w_k(t)]) \frac{(d_{vk} - \Delta_{vk}\lambda)}{\Delta_{vk}\lambda} \quad \textbf{(4)}$$

Lambda (λ) is a parameter based on the size of the map. The map size increases, the smaller the lambda (λ) will be used. ViSOM can maintain the distance between the neurons in the output map and topology structure. **Figure 2.5** show the visualization comparison between Convention Self-Organizing Map (left) and ViSOM (right). It is clear that although the neurons are of the same type, they are spaced apart. However, ViSOM has a better effect on the distance of neurons in the same cluster.

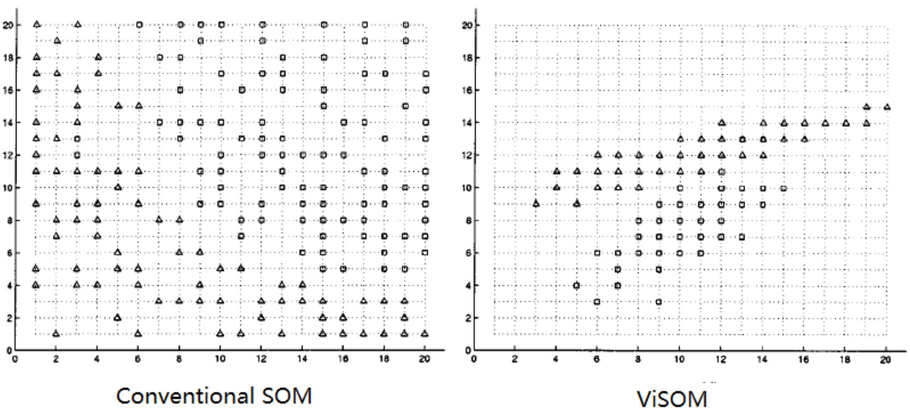

Figure 2.5 Comparison between SOM and ViSOM (Yin, 2002)

2.1.3 Others Modified SOM

Self-Organizing Map has the advantage of transforming high-dimensional data into low-dimensional space. However, Self-Organizing Map may not have sufficient support in some cases. Therefore, some researchers modified the traditional Self-Organizing Map in their own way to adapt to their own research problems.

Artificial Robot Navigation System

(Shabih, et al., 2012) proposed a semi-automatic navigation system for robots in different scenarios. Since the robot's navigation system has different angles in different situations, the robot needs to move in the right direction. Firstly, the authors calculated a set of modified weights from the trained Self-Organizing Map by calculating the weight difference between the input neuron and all the neurons. Next, two for loops are used, and the outer loop is used to loop the weight of each modified weight. The internal for loop is used to loop through the input vectors from the training data and calculate the different weights of all the input vectors and the modified weights in a particular iteration. Finally, the input vector that is least different from the modified weight is assigned to the neuron. Therefore, each neuron on the map represents a different situation and different turn angle. From the input vector, the Self-Organizing Map can calculate the correct neuron to help the robot get the right direction.

Modified SOM for Clustering Data

(Azlin & Rubiyah, 2016) introduced a modified version of Self-Organizing Map to provide better clustering and visualization of data. In traditional Self-Organizing Map, the performance of data clustering is acceptable. However, in a two-dimensional grid, although all the data belong to the same cluster, the problem of scatter data sometimes occurs. This leads to another problem, which is overlapping clusters, since scattered data points will exist in other clusters at the top, since there is no control over the dispersion of data. From the perspective of overlapping clusters, it is difficult for users to visualize and identify cluster boundaries. The method proposed by the authors is using Pheromone-Density Measure (PDM). PDM will be used to measure the average similarity of neurons to their neighbours and input vectors, not just the distance between neurons and input vectors. PDM is commonly used to aggregate different clusters and refine scattering class problems. The result of correcting SOM is shown in the **Figure 2.6**. By refining the three clusters, the clustering looks better.

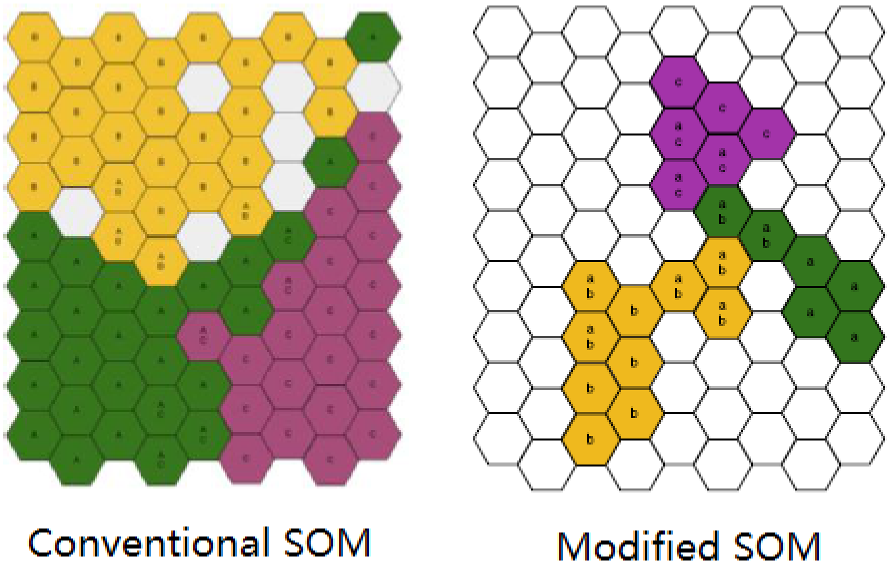

Figure 2.6 Difference between SOM and Modified SOM (Azlin & Rubiyah, 2016)

2.2 Siren Feature Extraction and sound localization through Self-Organizing Map

2.2.1 Binaural Model sound localization using Self Organizing Map

As for the part of my project, identify the source of the emergency siren is required to be analysis, and to inform the driver. Zhang, et al. (2008) developed a method to identify vertical angle the sound source from the origin and perform localization of sound. They use two microphones that are placed in a straight line the microphone head faces in the opposite direction to collect the sound signal for the left- and right-hand side. From the signal collect and go through some processing and estimate the direction of the sound. Firstly, is the feature collection for localization. There will 3 features will be collected, Interaural Time Difference (ITD) of sound, Ear Spectrum Ratio (ESR), and a derived characteristic vector from ITD and ESR.

In the Binaural model, there will have 2 important angles horizontal and vertical from the origin. ITD is the time difference the sound reaches the left and right ear, in this case, is sound reach the microphones. The Figure 2.7 shows that there was a directly proportional relationship between the horizontal angle and ITD. Thus, the time difference can be used to estimate the horizontal angle. ESR is the relationship between the horizontal angle and the vertical angle. ESR can estimate the vertical angle by using the horizontal angle obtained. ESR database is formed by collecting sound signal from a different point for either one side, as there will similar ration result for another side. The characteristic vector is derived by substrate ITD with the normalized value of ESR. As characteristic vector is the formation of ITD and ESR, it has a closer relationship with the vertical angle. After the computation of characteristic vector, it was fed into Self Organizing Map (SOM). When SOM complete it learning phase will output a map and with horizontal and vertical angles in different positions of the map as shown in Figure 2.8.

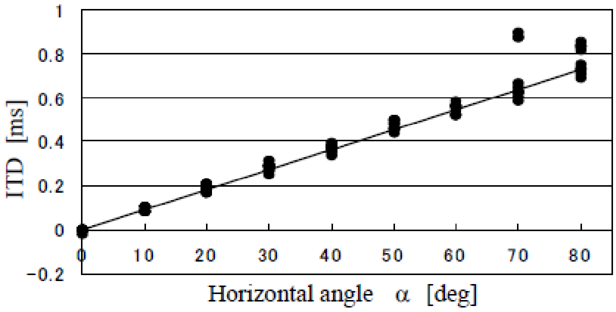

Figure 2.7 Relationship between horizontal angle and ITD (Zhang, et al., 2008)

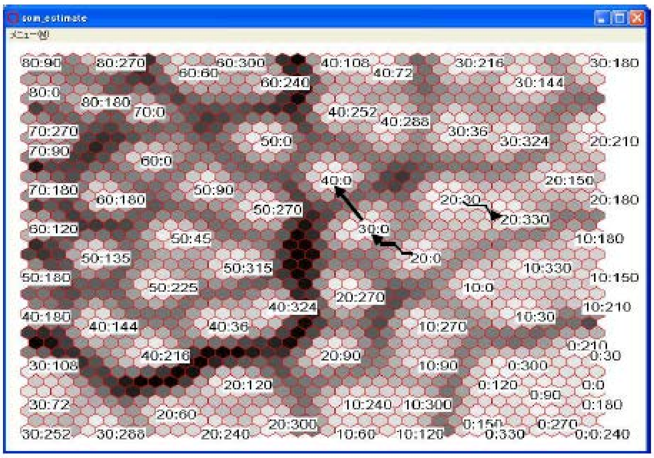

Figure 2.8 Sound direction of SOM map (Zhang, et al., 2008)

2.2.2 Features Extraction and Discrimination of Emergency Sirens

Otálora, et al. (2016) has proposed 4 methods for feature extraction of the emergency siren and recognize different types of emergency siren. Fourier Fast Transformation (FFT), Cepstrum, Mel Frequency Cepstral Coefficient (MFCC), and Spectrogram are those features that will extract from the signal. FFT is a “divide and conquers” technique to decompose a long sequence of values into different frequencies. MFCC is a type of feature extraction that extracts a set of coefficients which shows the overall shape of the spectral envelope. Spectrogram which visualizes the spectrum from sound event frequency, which using Fourier Fast transform to show the signal rate, window function and point overlap between the window. Cepstrum is used to calculate the logarithm about Inverse Fourier Fast transform of the spectrum, it can use to determine the tone of the signal.

FFT, Cepstrum, and Spectrogram feature are independently trained using Self- Organizing Map. While MFCC is working with cross-correlation. As previous obtain MFCC feature will be stored in the database and use it to calculate the correlation with a new unknown signal. From the testing, the result **Figure 2.9** shows that FFT is not optimal, as simple analysis on sound frequency is not enough capacity for good classification. The result for Cepstrum is moderate. Since MFCC has a more complex process, it obtained a very efficient result. Spectrogram has mostly the same efficiency with MFCC.

	FFT+ANN (%)				CEPSTRUM +ANN (%)				MFCC'S + CORRELACION CRUZADA (%)				ESPECTROGRAMA+ ANN (%)			
	E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4
1	42	45	42	40	59	57	60	62	78	77	77	80	71	73	76	75
2	39	46	40	41	58	62	60	63	78	83	82	80	76	75	77	75
3	40	45	43	41	61	60	57	55	80	80	82	85	75	75	76	76
4	47	43	41	41	61	56	58	63	82	82	76	78	77	76	75	74
5	42	37	32	40	60	61	61	58	80	80	78	76	76	71	77	73
M	42	43	40	41	60	59	59	60	79	80	79	80	75	74	76	75

Figure 2.9 Test result of different feature extraction method (Otálora, et al., 2016)

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2.3 Inter-Vehicle Communication

Durresi, et al. (2005) proposed a new scalable protocol, SICOMM protocol based on geographic routing, which is one type of Inter-Vehicle Communication (IVC) protocol. Each car is part of an ad-hoc wireless network that is more flexible because no permanent infrastructure is required. GPS location, speed, and direction of the car are transmitted to other vehicles using wireless networks such as IEEE802.11. This protocol can be used in any mobile Ad-hoc network. Each vehicle acts as a node and has own geographical position given by the Global Positioning System (GPS). The road is divided into the same optimal length of a virtual cell, each virtual cell will have a Cell Centre located approximately in the middle of a virtual cell. Cell Centre acts as a virtual base station.

The initialization of each cell is exchanging a “Hello” message with each node (vehicle). When a source node wants to send information to the destination node, it will first forward to Cell Centre. Cell Centre will check the routing table formed during the “Hello” message exchange process. If the destination node is in the cell, the information will direct forward to the destination node. On the other hand, the destination node is at another cell, Cell Centre will forward the information to the next Cell Centre in other cells which have the closest distance to the destination node, and the next Cell Centre will repeat the same process until the information is delivered. Most IVC protocol is using the flooding method which broadcast information to each node. When the number of nodes per cell increases, the performance degrades due to congestion, collision, and high bandwidth consumption of message. The proposed protocol has less overhead problem compare to flooding method, less delay during message transmission with the high number of nodes, it increases the possibility for real-time communication between the vehicle.

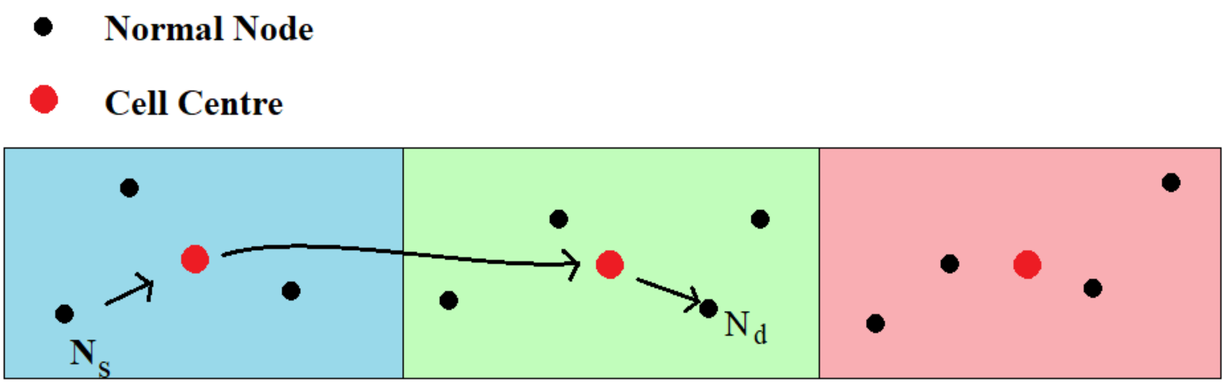


Figure 2.10 Illustration of communication process

Chapter 3 System Design

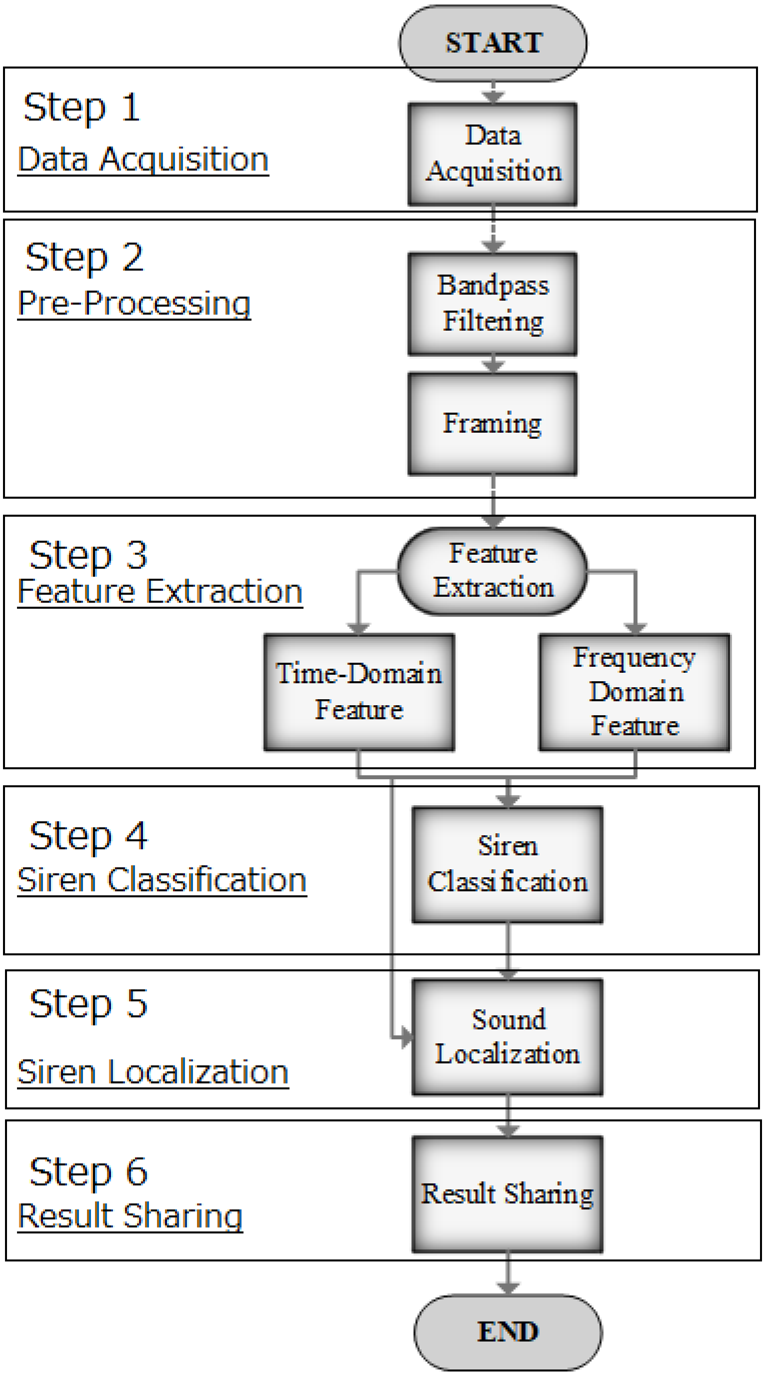


Figure 3.1 System Flow Diagram

Step 1: Data Acquisition

In the first step, the input data to be entered into the system is the ambulance siren that has been recorded and wants to determine the sound source distance. The properties of a sound file are (.wav) format. The recorded sound sampling rate is 44k Hz/s. The sound will be stored and used for further processing. In addition, the driver's GPS location was also collected.

Two data sets were collected in this project. One dataset was collected indoors and the other was collected outdoors. For the indoor dataset, a stereo speaker system is used to simulate the sound of the ambulance siren, and the speakers are placed in a fixed place with a constant volume throughout the process. The microphone is attached to a small box one meter high. By changing the position of the microphone, collect the ambulance alarm at 0-meter, 1-meter, 2-meters, 3-meters and 4-meters respectively.

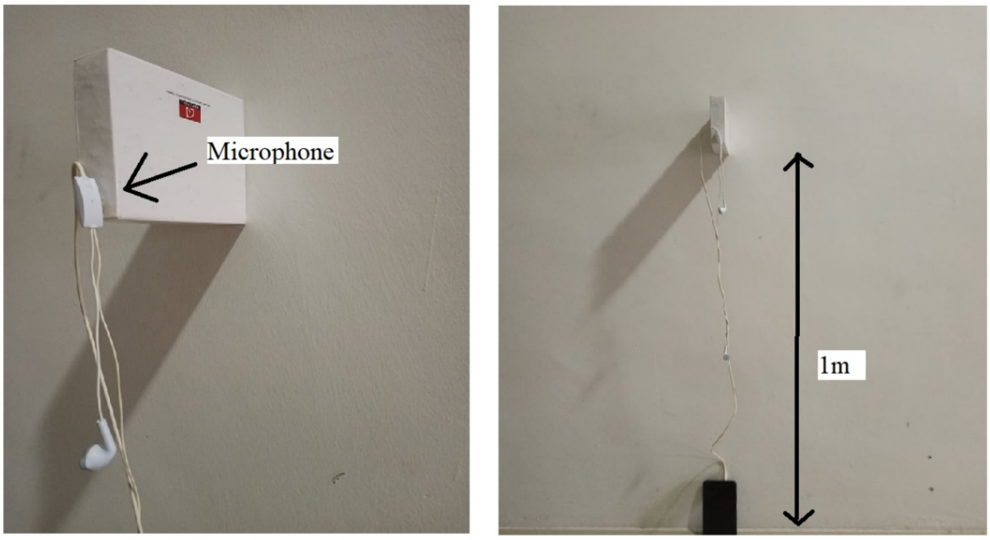


Figure 3.2 Indoor data collect (mounting of microphone)

Figure 3.3 Indoor data collect (mounting of Speaker)

After months of discussions and planning with St. John Ambulance (Ipoh division), the outdoor data set was collected in cooperation with the ambulance staff. An ambulance was provided by the St. John Ambulance as the source of ambulance siren. In Malaysia and most Asian countries, the driver sits on the right-hand side of the car. Traffic keeps to the left lane on a two-way road. The emergency lane used by emergency vehicles is located on the far-left side of the lane. Therefore, the microphone is mounted on the left rear side of the vehicle, which is the closest position of the vehicle to the inner part of the lane. When the ambulance arrives, the microphone can receive the ambulance siren within a short time. Firstly, the ambulance was in a fixed position. the microphones are mounted on the back of the vehicle, as shown in **Figure 3.4**. A total of 4 distances were collected, which were 0-meters, 25-meters, 50-meters and 75-meters respectively. During this process, vehicles are moved to different positions.

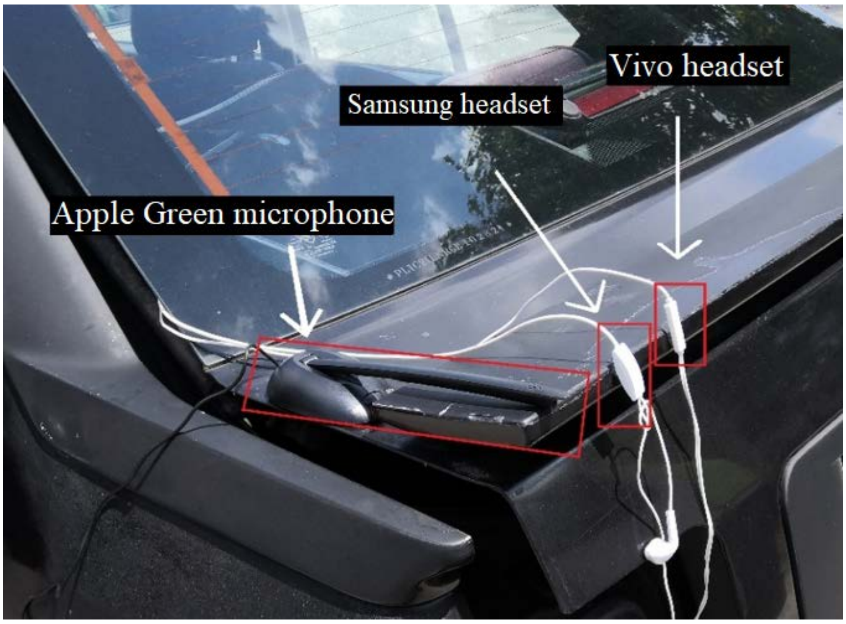


Figure 3.4 Outdoor data collect (mounting of microphone)

Figure 3.5 Outdoor data collect setup

Figure 3.6 Google map was used to measure the distance

Figure 3.7 Microphone installation process

Figure 3.8 St. John Ambulance Staff

Step 2: Pre-Processing

The input sound will undergo some pre-processing in order to get better accurate information extraction for the next step. The frequency of the siren is from the lowest to the highest and back to the lowest.

These two datasets are two different types of ambulance sirens. For the indoor dataset, the cycle time of ambulance alarm source is longer. In **Figure 3.9** The spectrogram showing the ambulance alarm requires 2.2s from low to high and 2.3s from high to low. The enlarged version shows that the operating frequency of the ambulance is 750-850 Hz at the low level and 1650-1750 Hz at the high level according to the spectrogram. To see the frequency clearly, the **Figure 3.10** shows the Fast Fourier Transform (FFT) of the signal, which extracts different frequencies from the signal and transforms the signal from time domain to frequency domain. The FFT of the signal is focused in the range of 750-850 Hz and 1650-1750 Hz.

For the outdoor dataset, which is the St. John Ambulance siren sound. St John's ambulance siren is a commonly used type of emergency traffic on the road, the sirens are faster and take less time to complete a cycle. In **Figure 3.11**, the spectrogram showing the ambulance alarm only take 0.125 second, to complete half of the cycle and 0.130 second complete for the rest part. It has more narrow operating frequency which between 650 -1550 Hz.

Bandpass filters are applied to input sound, this step will be allowing only frequencies in the 700-1800 Hz range to pass through. This filters out noise that is out of range. Next, frame block is performed the sound signal is divide into multiple small frame size of 0.025s. Small frames allow you to capture information in different time series. This is because if the frame is long, the signal changes too much throughout the frame. On this basis, the hamming window is applied to prevent spectrum leakage caused by finite length signal. **Figure 3.13** shows the comparison of band-pass filters to sound signals.

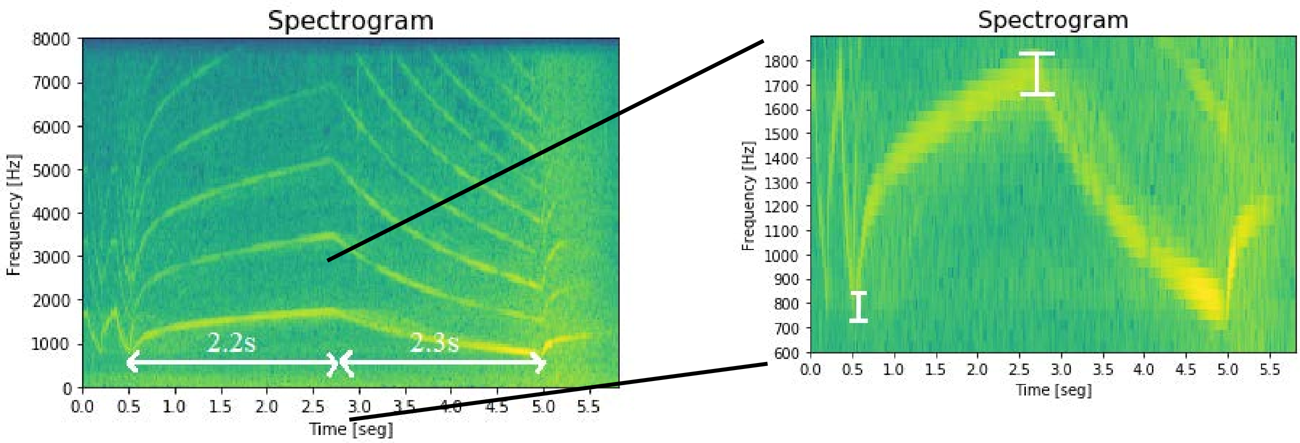


Figure 3.9 Spectrogram of ambulance siren

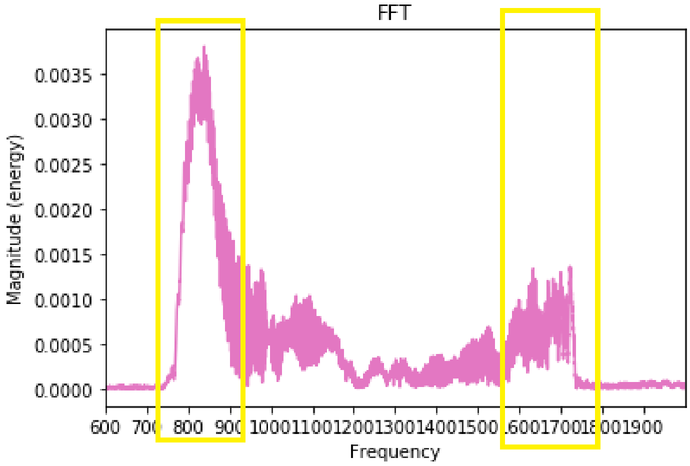


Figure 3.10 FFT of ambulance siren

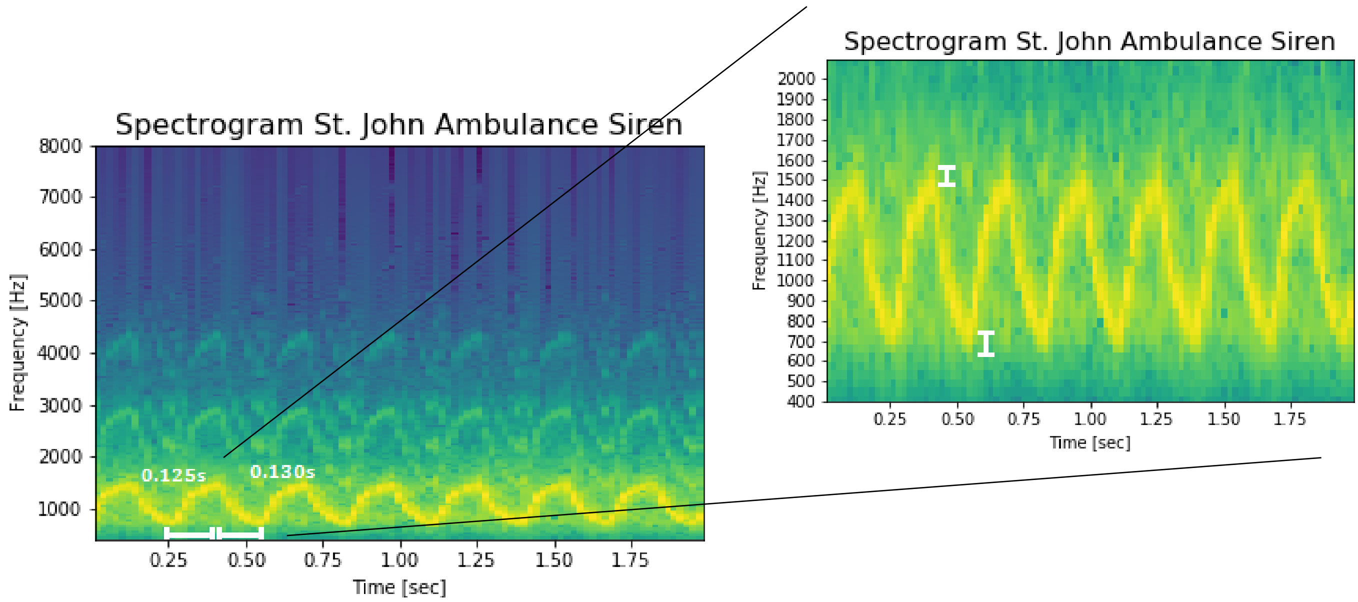


Figure 3.11 Spectrogram of St. John ambulance siren

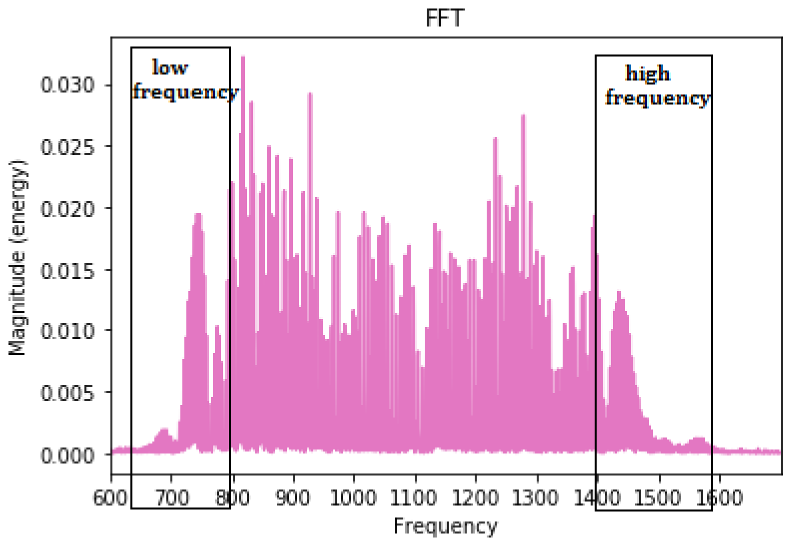


Figure 3.12 FFT of St. John ambulance siren

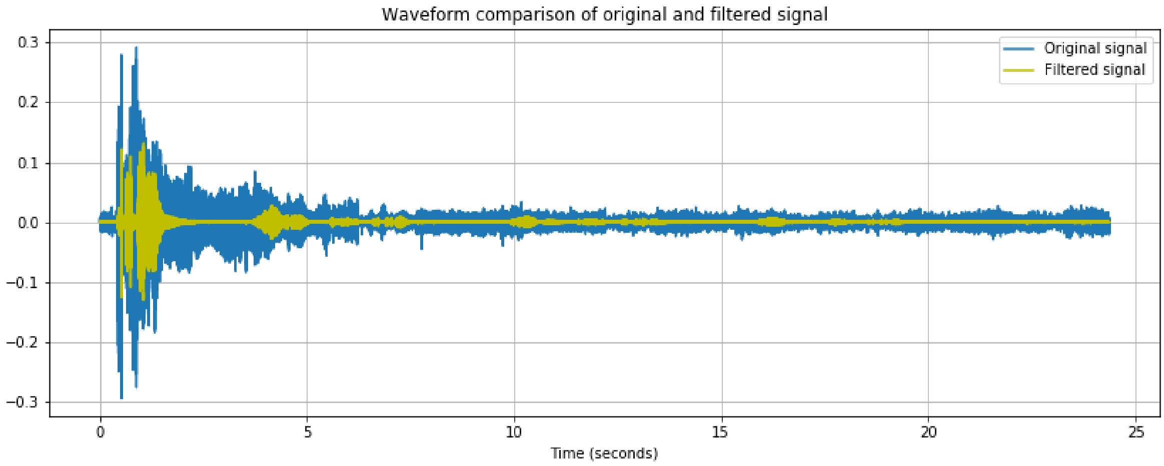


Figure 3.13 Comparison of bandpass filter

Step 3: Feature Extraction

Spectral features extracted from the sound signal include Mel-Frequency Cepstral Coefficients (MFCC), Linear Prediction Coefficient (LPC), spectral flatness, spectral flux, spectral centroid, spectral roll-off. First, the fast Fourier transform (FFT) is used to convert a time series signal into a frequency domain signal, the resulting product is called spectrum and the spectrum is used to calculate the feature. Spectral flatness is one type of feature used to measure the frequency variance of the signal spectrum. High spectral flatness means that the frequency band has the same energy. Low spectral flatness indicates that there is a small concentration of frequency bands, usually can identify as the siren. Spectral flux is used to measure the rate of change of sound, by computed the difference between the amplitude of frame. Spectral Centroid are used to measure the concentration of energy in the frequency range of a sound signal, which the mean value of the calculated spectral magnitude in the frequency bands. Spectral roll-off shows how much energy there is at low frequencies of overall spectral magnitude.

MFCC is the main feature of audio signal, because it represents the rate of change of different spectral bands, also known as cepstrum. The lower order coefficients contain most of the information about the overall spectral shape. In feature extraction, the first 12 coefficients of MFCC are selected. Firstly, pre-emphasis is to increase the energy of the high frequency and follow by Fast Fourier transform (FFT). FFT are process calculate the frequency spectrum from the audio signal and transforms the audio signal from time domain to frequency domain. The power spectrum is pass through the Mel filter bank to extract the frequency bands. Lastly, Discrete Cosine Transform (DCT) is used to extract the uncorrelated features of the filter bank output.

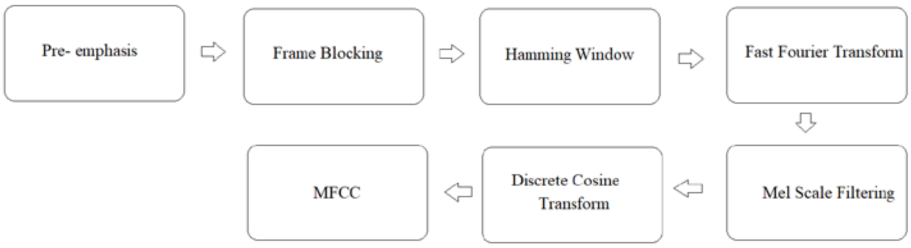


Figure 3.14 Block Diagram of MFCC

LPC also known as linear predictive analysis. These coefficients accurately reflect the instantaneous shape of the vocal tract and used to identify the type of sound being produced. The autocorrelation method is used, which able to estimate the characteristic of sound signal in small frame.

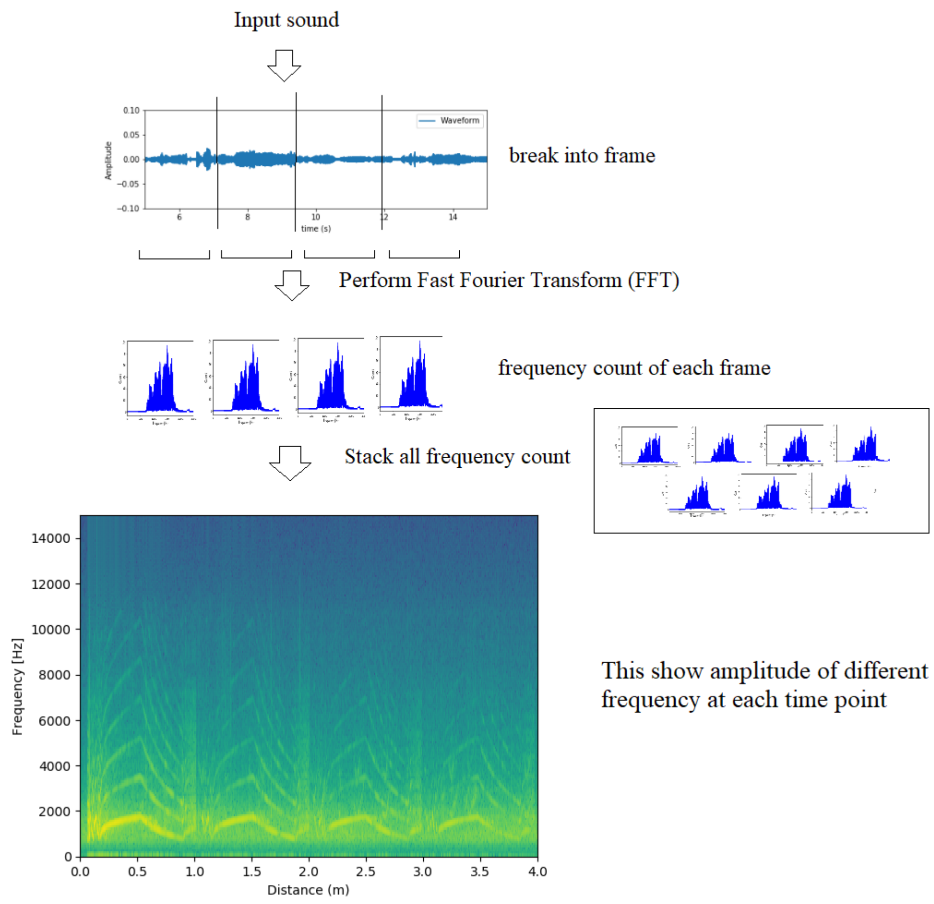


Figure 3.15 Process obtain spectrogram

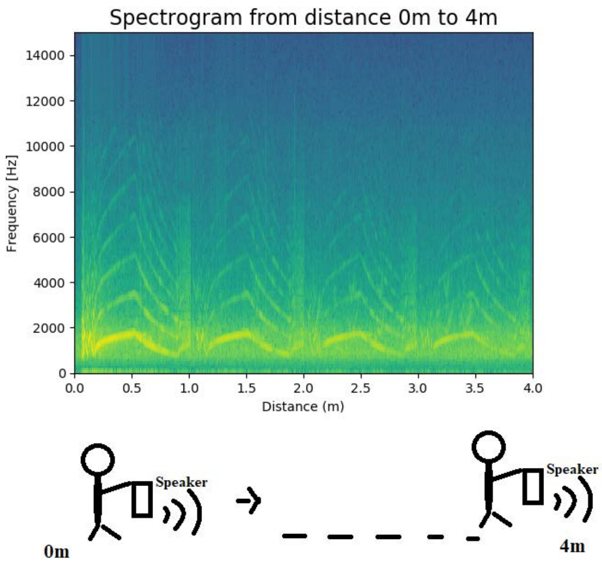


Figure 3.16 Spectral decay from 0m to 4m

Other than that, temporal feature of audio signal is calculated such as skewness, kurtosis, and root mean square. Spectral skewness describes the asymmetry degree of frequency distribution around the spectral centroid. A positive value indicates that more energy is concentrated below the centroid of the spectral, and a negative value indicates that more energy is concentrated above the centroid of the spectral. Spectral kurtosis used to measure the flatness and peakness of the spectrum near the spectral centroid, more peaky shape in the spectrum the greater the number of peaks, the greater the kurtosis. Root Mean Square (RMS) of the audio signal is also calculated, which describes the average power of the sound. Zero Crossing Rate (ZCR) is the rate of the sign changes from positive to negative and vice versa. The points were the sign changes is known as the zero-crossing point. The rapid zero crossing of the signal indicates more frequency information, otherwise it contains less frequency information.

Siren signal tend to contain high energy in certain frequency band, so the algorithm to deal with frequency shift will be beneficial (Schröder, et al., 2013). Short Time Energy (STE) is useful to measure interchangeable term like volume, energy, etc. It is helpful to detect siren sound, as siren have contained high energy value. Also, the short-time energy varies with the distance of sound.

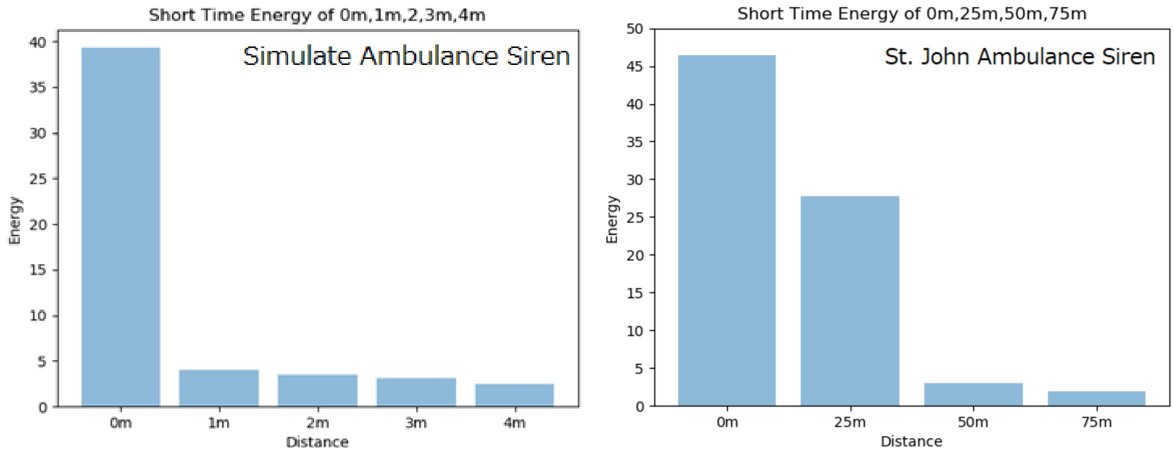


Figure 3.17 Comparison of simulate and real-word ambulance siren at different distance

Table 3.1 Comparison of simulate and real-word ambulance siren

Simulate Ambulance Siren	
Distance (m)	Average Short Time Energy (J)
0.0	39.33
1.0	4.09
2.0	3.48
3.0	3.16
4.0	2.47

St. John Ambulance Siren	
Distance(m)	Average Short Time Energy (J)
0.0	46.46
25.0	27.79
50.0	3.02
75.0	1.92

Figure 3.18 Zero Crossing Rate of filtered signal

Step 4: Siren Classification

In the training state, a total of 300 training samples were used. The dataset has a siren cycle of 4.62 seconds. The Mel-Frequency Cepstral Coefficients **(**MFCC) feature from the audio signal will fed into SVM classification algorithm. Those features are used to identify the type of sirens. SVM algorithm defines an optimal dividing hyperplane in a model to divide between classes effectively for classification problems. Maximizing the margin between classes through the dividing hyperplane is the aim of it. Hyperplane is a decision boundary that helps classify input vectors. The input vector falls on either side of the hyperplane, determining which class it belongs to. The SVM algorithm classifies the type of siren sound from the pre-train SVM model.

Step 5: Siren Localization

First and foremost, training data are used to train the Self- Organizing Map and the trained map will use to perform sound localization. At training stage, the features extracted from the training audio signal are normalized, which improved the computational performance of SOM algorithm. As Self- Organizing Map is unsupervised learning, therefore the label of training dataset is not included when fit into the algorithm. The size of topology map is 15x15, the learning rate and the neighbour function are set to 1. The neuron weight of SOM is initialized using the input dataset. The SOM algorithm will be sequentially picking the input vector from the training dataset, after that the Euclidean distance between the neuron and the input vector is used to calculated. The winning neuron is the neuron which have most likely weight. To achieve topological mapping, the neighbour of the winning neuron adjusts its neurons near to the input vector based on the sigma value, to prevent neurons other than the winning neuron from being left behind. (Laerhoven, 2001). **Figure 3.19** show the comparisons of SOM topology trained with simulated dataset (Left) and St. John Ambulance dataset (Right).

For testing phase, the feature extracted from a single testing audio signal are normalized. The testing vector will compute the weight different of weight with all winning neuron at training phase. The winning neuron with the most similar weight will be activated and get the label of it. The testing vector will know it belong to what sound source distance.

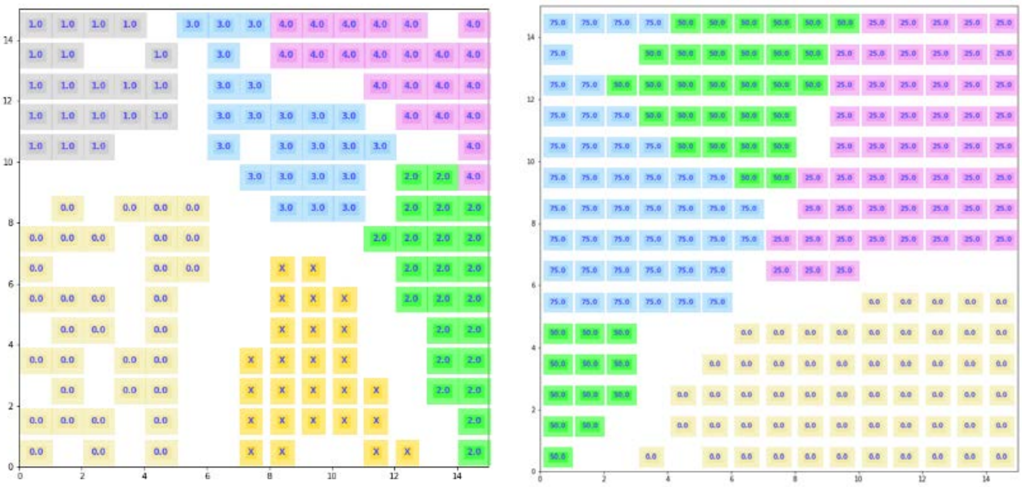


Figure 3.19 The comparison of different training dataset SOM topology

Step 6: Share Result

After the sound localization system outputted the results, the results are displayed graphically, as shown in **Figure 3.20**. These results and the current location of the vehicle will be uploaded to the real-time database. The real-time database use was provided by Google Firebase as shown in **Figure 3.21**. A mobile application is developed and installed on a smartphone by other users. The application will first retrieve the user's current location from time to time via GPS. The user can get the nearest ambulance notification based on the pre-set distance. The mobile application will calculate the distance from each hotspot notified to the smartphone user and show the user the nearest hotspot on the mobile application map. Based on the GPS location on the real-time database, the mobile application system will automatically search for location and street names based on the location. The time the hotspot exists is also generated by the system based on the timestamp.

When there is a new incoming notification, the mobile application first checks the user settings and then notifies the user to suit the user's needs. In addition, the user is allowed to change the current location to any other specific address or point on the map to allow the user to view notifications in that area.

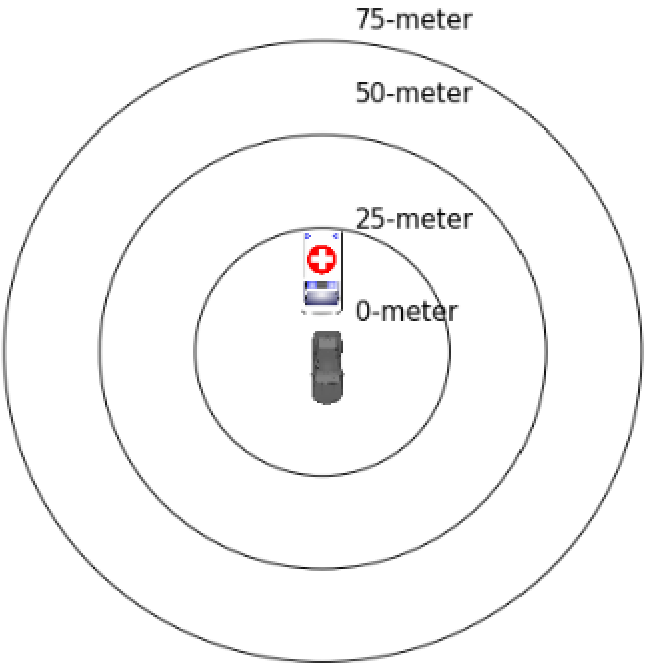


Figure 3.20 Siren localized result in graphical form

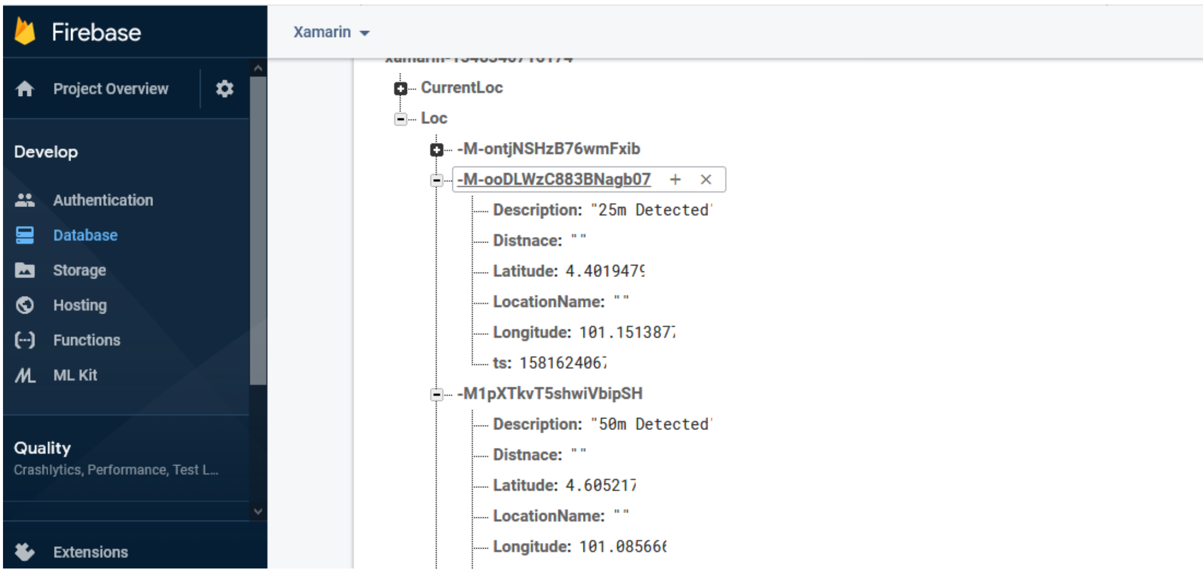


Figure 3.21 Firebase database console

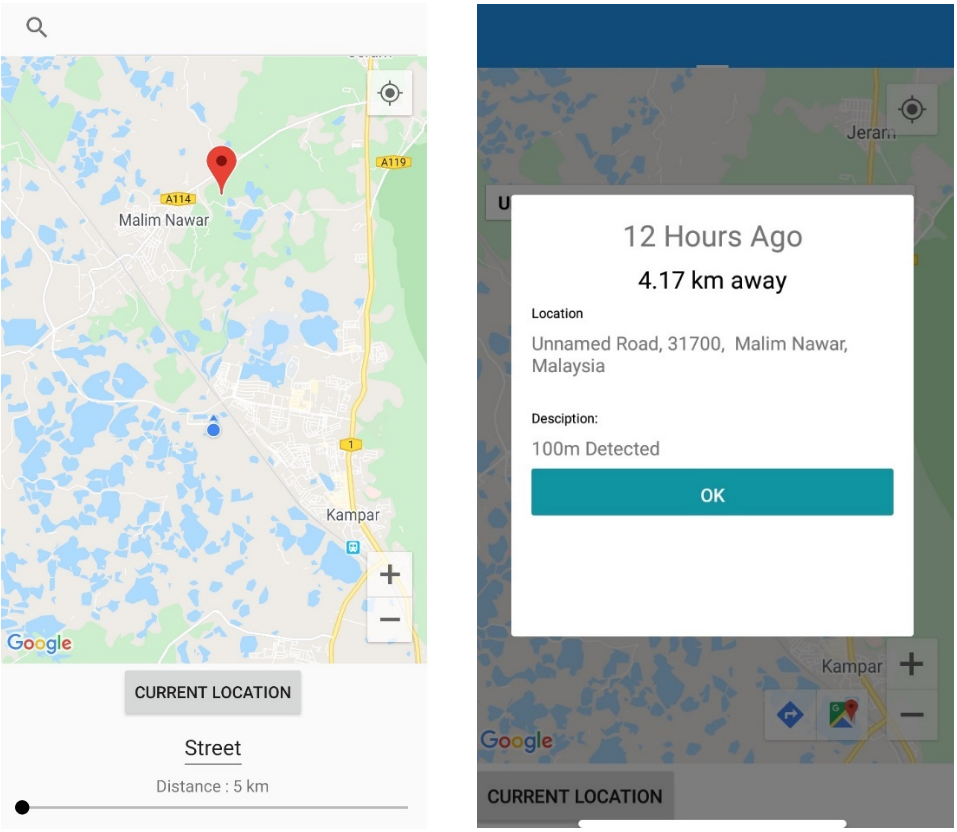
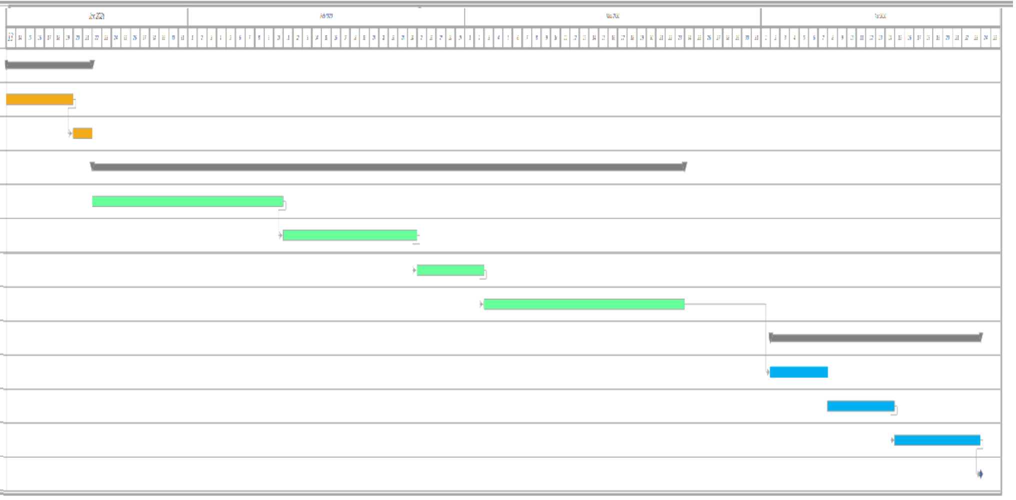


Figure 3.22 Mobile application interface

Timeline

ID	Task Name	Start	Finish	Duration
1	**Planning and Analysis**	**13/1/2020**	**21/1/2020**	**9d**
2	Review Final Year Project 1	13/1/2020	19/1/2020	7d
3	Develop Workplan	20/1/2020	21/1/2020	2d
4	**Improve Prototype**	**22/1/2020**	**23/3/2020**	**62d**
5	Data Acquisition	22/1/2020	10/2/2020	20d
6	Siren Classification	11/2/2020	24/2/2020	14d
7	Sound Localization	25/2/2020	2/3/2020	7d
8	Mobile Application Development	3/3/2020	23/3/2020	21d
9	**Implementation**	**2/4/2020**	**24/4/2020**	**22d**
10	Mobile Application Review	2/4/2020	7/4/2020	6d
11	System Testing and Analysis	8/4/2020	14/4/2020	7d
12	Prepare Final Year Report 2	15/4/2020	23/4/2020	9d
13	Submit Final Year Report 2	24/4/2020	24/4/2020	0d



Chapter 4 System Implementation

4.1 Tool Used

<u>Hardware</u>

- Computer
  Tools use tools to develop classification and sound localization systems and process recorded sounds. Also, the Xamarin platform is used to develop mobile applications on computers. At the same time, the computer acts as the platform on which the developed system runs. **Table 4.1** shows the specifications of the computers used.

Table 4.1 Laptop Specifications

Brand	ACER E15
Operating System	Windows 10 Home – 64-bit
Processor	Intel Core i7 4510U @ 2.0 GHz
RAM	8GB DDR3L
GPU	NVIDIA GeForce 920M
Hard Disk	1TB HDD 5400RPM

- Smartphone
  The smartphone acts as a notification system, allowing users to be notified when a new ambulance is detected, and to view details such as distance of ambulance detected and ambulance detection hotspots on the developed mobile application. The smartphone specifications used are shown in **Table 4.2**.

Table 4.2 Smartphone Specifications

Brand	Asus
Operating System	Android 7.0 (Nougat)
Processor	Cortex-A53 Quad-core 1.25 GHz
RAM	3GB
Positioning	A-GPS, GLONASS
Network	GSM/HSPA/LTE & WIFI 802.11 b/g/n

- Microphone
  Microphones are used to collect ambient sound, and the microphone is connected to a computer to run the recorded sound on the system. Microphones are also used to collect datasets for training and testing. **Table 4.3** shows the microphone specifications used in this project.

Table 4.3 Microphone Specifications

Model	Apple Green MP-1
Sensitivity	-60dB±2
Frequency Range	100-16000Hz
S/N Ratio	>60dB

Software

- Python 3.6
  - Open source Integrated Development Environment (IDE) used to developed the classification system. Python was chosen and used to develop the system because it compares to other languages, python is easier to learn such as R language and can quickly solve any problem faced with it, because python is used by the large community.

- Microsoft Visual Studio 2017
  - Integrated Development Environment (IDE) for mobile application development with association of Xamarin Platform. Microsoft Visual Studio 2017 was chosen as software for development because it can be used to develop Android applications by downloading development kits. In addition, it has better performance than other development software, and more familiar with this software because it was used to develop previous projects.

- Android Phone SDK
  - The Android SDK allows developers to develop without the need for additional phones because it supports a virtual android phone test environment. It is software development kit that simulates the android environment on computer. Also, it supports viewing the design interface during mobile application development.

- Xamarin App Development Kit
  - A mobile application development kit, which primarily with C# in Visual Studio. The Xamarin development kit was chosen because only a single language can support different platform Windows, Android and IOS. This allows for scaling from android to other platforms if needed. In addition, the development kit supports the reuse of parts of the code on another platform, and Xamarin is also open source, giving developers an option to gain insight into how the platform works.

- Firebase Mobile Platform
  - An online real-time database that stores the results of the classification system and allows mobile applications on smartphones to retrieve information. The firebase database was chosen because it is free to use and does not require a host server to support real-time databases. In addition, firebase is a "Non-SQL" database that supports faster processing.

Hardware Requirement

To run the system, mobile and laptop devices must meet several requirements.

- Laptops must allow the system to use microphones
- Smartphones must have a GPS receiver and be enabled
- Smartphone and laptop should have an Internet connection
- Smartphone android version 7.0 above
- Minimum laptop requirement
    - Intel Core i5 Processor
    - 8 GB RAM
    - 250GB Hard drive
    - Recommend: Dell Inspiron 3493 Laptop
- Minimum smartphone requirement
    - Qualcomm processor 1.25 GHz above
    - 3 GB RAM
    - Android 7 (Nougat)
    - Recommend: XiaoMi Note 8 Smartphone

4.2 Analysis

For this research project, analysing from different perspectives is an important process to explore the factors affecting the research system. Also, through the experiment to find the best settings and parameters, in order to improve the performance of the system. At the same time, to discover new insights, identify problems in system implementation, and find solutions. Therefore, the system can guarantee a better performance and less error. In this analysis step, different datasets were analysed, finding the new insights, and shows how the type of datasets affect the performance of the system. There are two types of data sets, one is a simulated ambulance siren and the other is a real ambulance siren. In both sets of datasets, different kinds of experiments were conducted.

<u>Simulated ambulance siren dataset</u>

1. Accuracy testing of ambulance sirens of various lengths

In this analysis case, the recorded ambulance sirens were trimmed with different lengths. The purpose of this experiment is to observe the effect of recorded sound length on the Self-Organizing Map trained using simulated ambulance datasets. As different lengths of ambulance siren of contain different numbers of features. This is to check what trim length of the ambulance siren will have the best performance on Self-Organizing Map. The data collection method is shown in **Figure 4.1**. The recorded ambulance alarms are trimmed into different lengths.

Figure 4.1 Setup for collecting test sample

Five sets of test cases were prepared at different distances of 0m, 1m, 2m, 3m and 4m. Each test case contains 20 samples. The length of each sample is 2 seconds. The samples were tested with trained Self-Organizing Map. The results are shown in **Table 4.4**. At a distance of 0 m and 1 m, the results of 2 second sampling showed positive results. This is because the weight of the neurons in this cluster is very different from other clusters, because they are closer to the sound source. However, the test results at 3m are poor, usually divided into 2m and 4m. This is because 3m is embedded between the two classes, and the power of the sound signal may not be as strong as the nearest distance. When a 2-second sample size is used, the sample collected may not be the primary power source. Since the original length of the sample signal is 4.62 seconds, it will be 2 seconds when collecting the first data, because the original alarm takes 2.2 seconds to reach the highest frequency, so the power will be greater in the next sample collected and so on. The length of the ambulance had been shortened. Features that can be used to prove true identity decrease. The segmented sound signal is shown in **Figure 4.2**

Table 4.4 Test results of model 2s ambulance siren

Distance	Test Data (2s)					Accuracy (%)
	0	1	2	3	4	
0	15	5	0	0	0	75
1	0	16	4	0	0	80
2	0	0	11	0	9	55
3	0	0	8	2	10	10
4	0	0	10	0	10	50
			Average accuracy			54

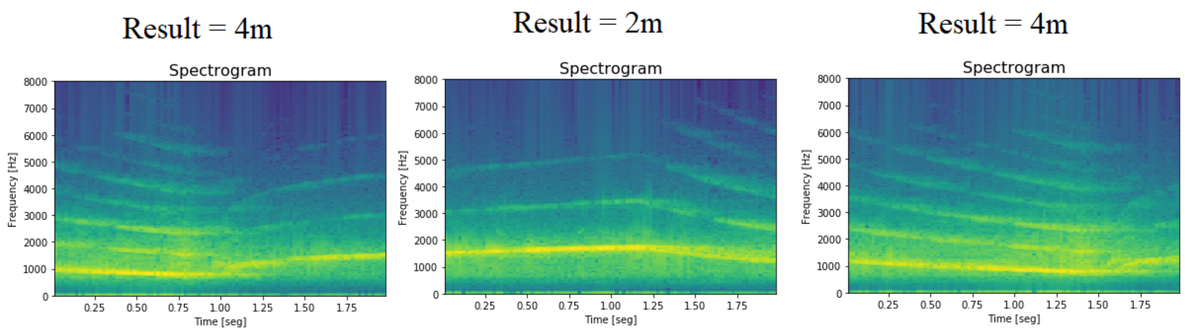


Figure 4.2 Spectrogram of each segmented sound signal

A total of 10 samples of 10 and 15 seconds were collected and tested with trained Self-Organizing Map. The results are shown in **Table 4.5** and **Table 4.6**. The overall accuracy is satisfactory, 78% and 82%, respectively. Only a little regret the accuracy of the 3m range hovers between 50% and 60%. Therefore, a longer sampling length is preferred over a shorter signal.

Table 4.5 Test results of model 10s ambulance siren

Distance	Test Data (10s)					Accuracy (%)
	0	1	2	3	4	
0	10	0	0	0	0	100
1	0	10	0	0	0	100
2	0	0	5	0	5	50
3	0	0	0	8	2	80
4	0	0	1	3	6	60
			Average accuracy			78

Table 4.6 Test results of model 15s ambulance siren

Distance	Test Data (15s)					Accuracy (%)
	0	1	2	3	4	
0	10	0	0	0	0	100
1	0	10	0	0	0	100
2	0	0	6	0	4	60
3	0	0	0	7	3	70
4	0	0	0	2	8	80
			Average accuracy			82

2. Police Siren testing on Simulated Ambulance Siren SOM

In this analysis case, police siren is used for testing. The aim of this experiment was to see how the police siren will perform on the Self-Organizing Map trained using simulated ambulance datasets. As police siren and ambulance siren have different characteristics. This is to analyse that whether the police siren will be acted like ambulance siren or will have different result. The data collection method of the police siren is the same as data collection of simulated ambulance siren, except that the ambulance siren is replaced by police siren.

In this experiment, the police sirens have been tested at 0, 1, 2, 3 and 4 meters. Twenty samples were collected at each discreate point and tested using a trained ambulance self-organizing map. The duration of each sample was 4.62 seconds. The results are shown in **Table 4.7**, all 4-meter police siren samples are correctly classified. At 1m distance, 80% of the samples were correctly classified and 6 samples were correctly identified at 2m distance. The analysis shows that the siren does not work well on the self-organizing map where the ambulance siren is trained. As can be seen from **Table 4.8,** the recall value of siren test data is not satisfied. In the **Table 4.9** show the comparison between average Short Time Energy (STE) of ambulance and police. Except the siren is smaller than the ambulance siren at 0m. An ambulance has almost half the energy value of a siren. As a result, sirens at 2m and 3m are often classified as 1m because they have a higher energy value than ambulance sirens. Next, police siren has a shorter cycle time than ambulances, so they can contain more frequency information. In **Figure 4.3** shows the frequency of different lengths of siren and ambulance siren cycles. In addition, police siren zero crossing faster than ambulances because the cycle is shorter. As shown in **Figure 4.4** It shows that the siren's zero crossing rate is several times that of the ambulance siren, so the more information there is, the greater the difference in its value.

Table 4.7 Test result of police siren

0m				1m				2m		
Cluster	Coordinate	Count		Cluster	Coordinate	Count		Cluster	Coordinate	Count
1.0m	(3,14)	18		1.0m	(3,14)	16		1.0m	(3,14)	5
2.0m	(14,0)	2		2.0m	(14,0)	4		2.0m	(14,0)	6
								4.0m	(8,13)	9

3m				4m		
Cluster	Coordinate	Count		Cluster	Coordinate	Count
2.0m	(14,0)	11		4.0m	(8,13)	12
4.0m	(8,13)	6		4.0m	(14,10)	6
4.0m	(14,10)	3		4.0m	(14,0)	2

Table 4.8 Confusion Matrix and Recall of Police Siren

		Predicted				
		0	1	2	3	4
Actual	0	0	18	2	0	0
	1	0	16	4	0	0
	2	0	5	6	0	9
	3	0	0	11	0	9
	4	0	0	0	0	20

Recall
0
0.75
0.3
0
1

Table 4.9 Comparison of energy value between police and ambulance siren.

Distance (m)	Average Short Time Energy (J)	
	ambulance	police
0	39.33	27.57
1	4.09	10.21
2	3.48	8.48
3	3.16	6.22
4	2.47	5.24

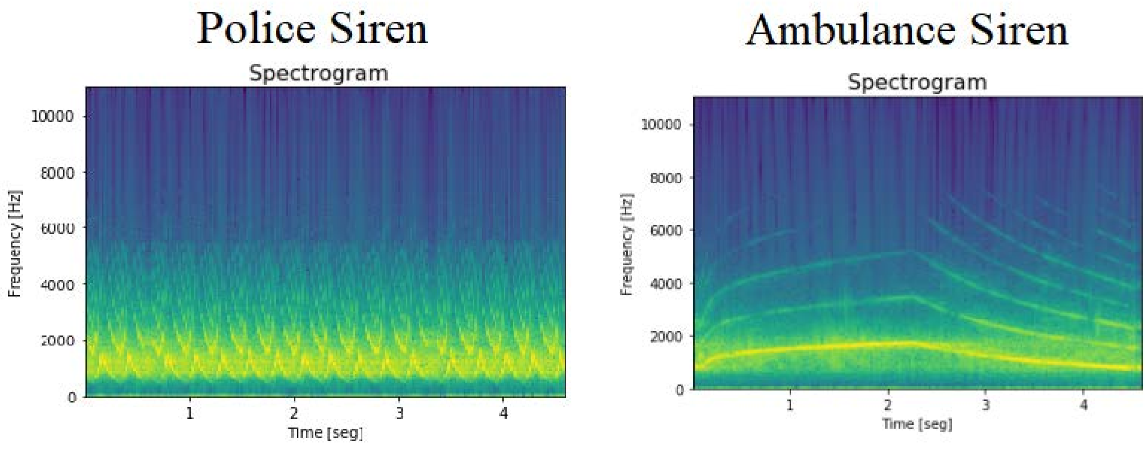


Figure 4.3 Spectrogram of ambulance and police siren

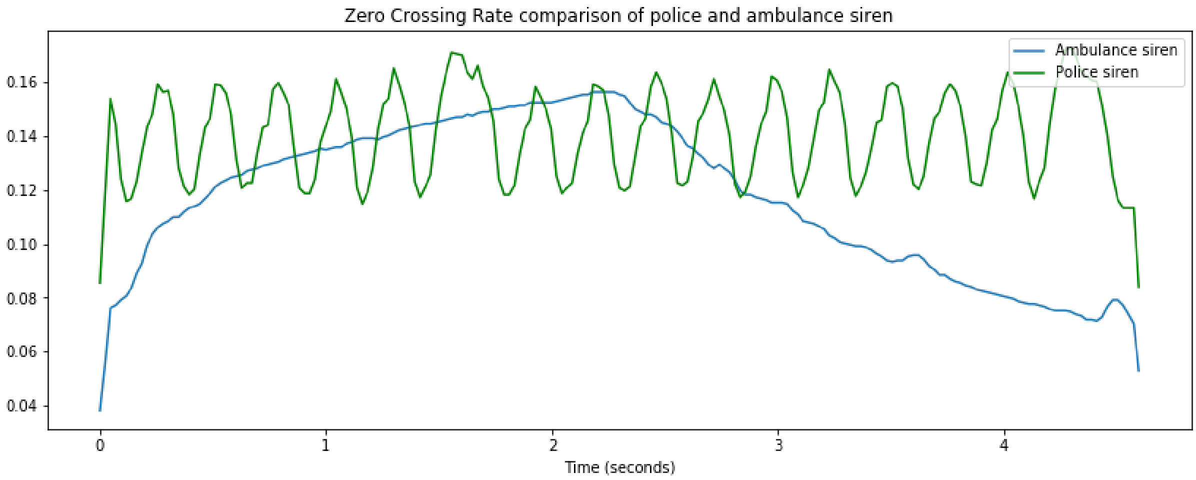


Figure 4.4 Zero Crossing Rate of ambulance and police siren

3. Test case for the closest distance to the sound signal

In this analysis case, the test samples used were simulated ambulance siren that collected at the intermediate distance. The intermediate distance of the simulated whistle is the siren sound collected between two discrete distances, such as two discrete distances of 1.0m and 2.0m, and the intermediate distance is 1.3m, 1.5m, etc. The purpose is to find out the effect of intermediate distance ambulance siren on the Self-Organizing Map trained using the discrete distance dataset. In order to check the ambulance's siren of intermediate distance will be classified to the nearest discrete distance or other longer distance. There is various intermediate distance was collected and the setup are shown in **Figure 4.1**. The illustration is shown in **Figure 4.5.**

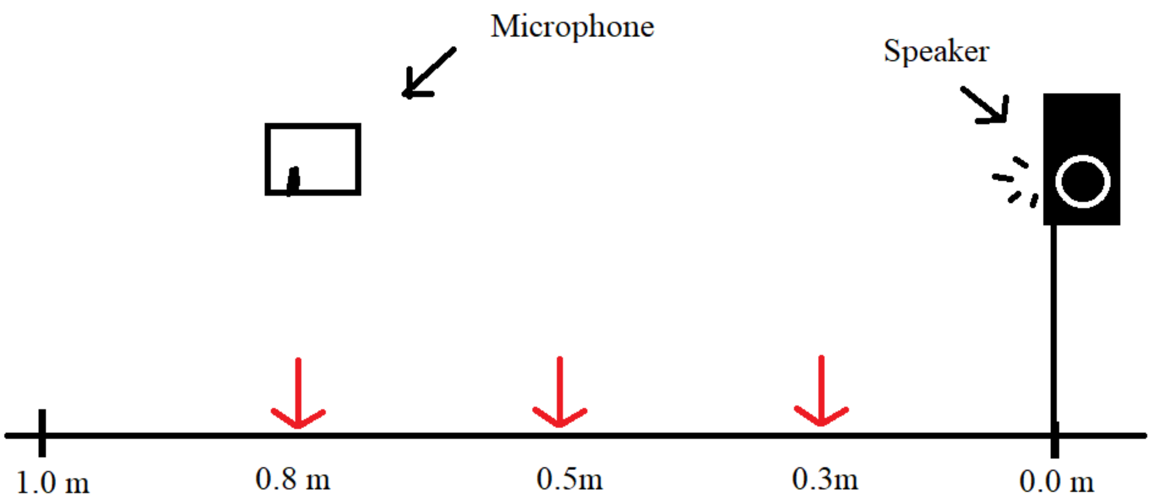


Figure 4.5 Illustration of sample collection process

30cm, 50cm, 80cm test case

A total of 3 sets of samples were prepared at different distances of 30cm,50cm and 80cm. A total of 20 samples were collected for each set. The length of the sound signal is 4.62 seconds. The results are shown in **Table 4.10**. All test data fell on the 1.0m cluster. This can be explained by the distance map of the self-organizing map in **Figure 4.6**, from which it can be seen that the boundary between 0m and other categories is very dark. The darker the colour, the further away the two clusters are. This is because neurons between 0m and 1m are far apart. The distance from 0m is only 30cm, but the difference in neuron weight is huge.

Table 4.10 Rate of activation neuron at 0.3, 0.5, 0.8m

0.3m				0.5m				0.8m		
Cluster	Coordinate	Count		Cluster	Coordinate	Count		Cluster	Coordinate	Count
1.0m	(0,14)	19		1.0m	(4,13)	15		1.0m	(4,11)	13
1.0m	(2,14)	1		1.0m	(3,14)	4		1.0m	(0,11)	4
				1.0m	(2,12)	1		1.0m	(2,14)	2
								1.0m	(2,10)	1

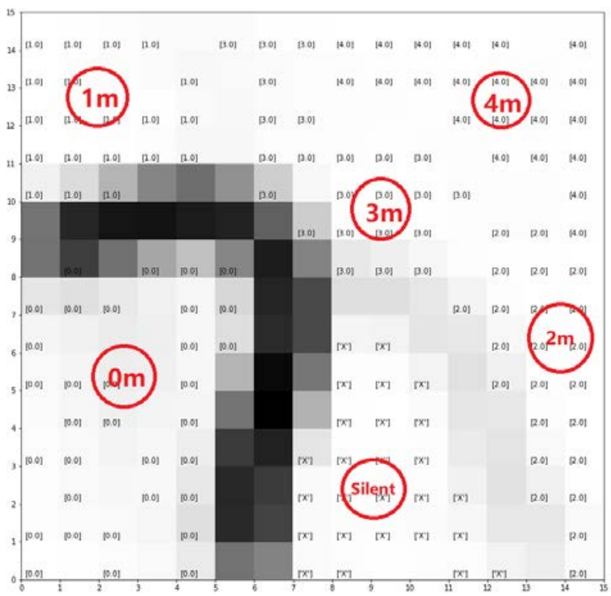


Figure 4.6 Distance map of self-organising map

1.3m, 1.5m, 1.8m test case

Next, A total of 3 sets of samples were prepared at different distances of 1.3m, 1.5m and 1.8m. A total of 20 samples were collected for each set. The length of the sound signal is 4.62 seconds. The results are shown in **Table 4.11.** All test samples were positive on 1m clusters at distances of 1.3m and 1.5m. For the test data at point at 1.8m, 14 samples were correctly identified as 2.0m, because 1.8m was close to 2m, and 2 samples were classified as 1.0m. Four test data were misclassified as 3.0m.

Table 4.11 Rate of activation neuron at 1.3, 1.5, 1.8m

1.3m				1.5m				1.8m		
Cluster	Coordinate	Count		Cluster	Coordinate	Count		Cluster	Coordinate	Count
1.0m	(0,14)	13		1.0m	(1,14)	12		1.0m	(2,14)	2
1.0m	(1,14)	6		1.0m	(4,13)	6		2.0m	(13,2)	14
1.0m	(4,13)	1		1.0m	(2,14)	1		3.0m	(8,8)	4
				1.0m	(0,14)	1				

2.3m, 2.5m, 2.8m test case

For the distance between 2m and 3m. A total of 3 sets of samples were prepared at different distances of 2.3m, 2.5m and 1.8m. A total of 20 samples were collected for each set. The length of the sound signal is 4.62 seconds. The results are shown in **Table 4.12**. More than half of collected samples at 2.3m point was identified as 3.0m, 25% as 2m, 4 samples are 4.0m, presumably misclassified. At 2.8 m, all test data is defined as 3.0m, which is theoretically correct. At 2.5m, half of them belong to 3.0m clusters and half of them were misclassified as 4.0m, which same as 4 samples in 2.3m. Most of the test data classified as 4m were caused by incorrect test data segment. The sample showed in **Figure 4.7** that incorrect data segment would lead to the loss of the main information contained in the sound, and the calculation value would be inaccurate due to the small value

Table 4.12 Testing result at 2.3m ,2.5m ,2.8m

2.3m				2.5m				2.8m		
Cluster	Coordinate	Count		Cluster	Coordinate	Count		Cluster	Coordinate	Count
2.0m	(11,7)	3		3.0m	(7,14)	7		3.0m	(6,13)	11
2.0m	(14,1)	2		3.0m	(11,10)	3		3.0m	(7,12)	7
3.0m	(11,10)	9		4.0m	(8,14)	1		3.0m	(11,10)	2
3.0m	(5,14)	2		4.0m	(11,14)	9				
4.0m	(14,9)	4								

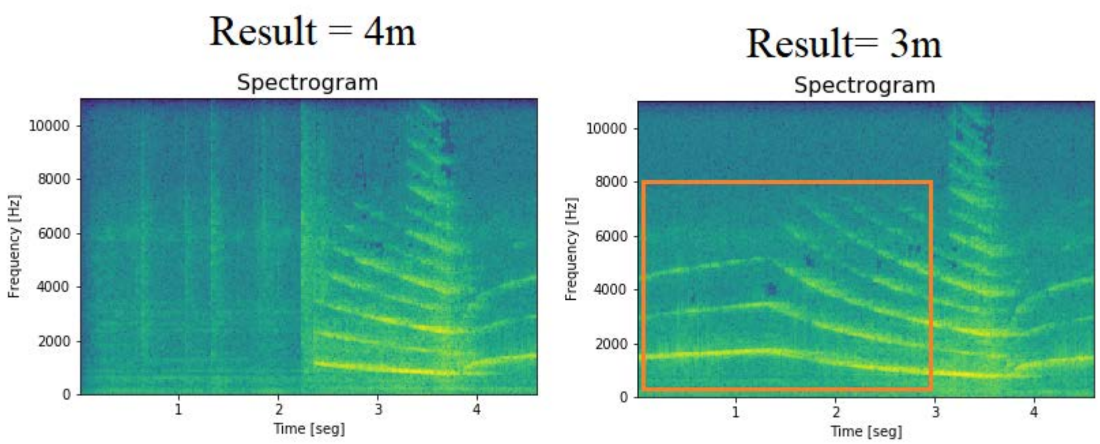


Figure 4.7 Comparison result spectrogram

3.3m, 3.5m, 3.8m test case

Next, the test results ranged from 3 to 4 meters. Three sets of samples were prepared at different distances of 3.3m, 3.5m and 3.8m respectively. A total of 20 samples were collected in each set, and the duration of the sound signal was 4.62 seconds. The results are shown in **Table 4.13** At 3.3m, 85% of the test samples were identified as 3.0m and 15% as 4.0m. At the point 3.5m, one sample seems to include some noise, and identified as 2.0m. From **Figure 4.8** show that the test sample was recorded at the wrong time, thus producing a noise in sound signal. The test data is near the end of recording, so the noise is caused by human factors such as the action to turn off the recorder and there will be some vibration. At the point 3.8m, 2 samples were identified as 4.0m, because the nearest neighbour was 4m and the rest were in the 3.0m cluster.

Table 4.13 Testing result at 3.3m ,3.5m ,3.8m

3.3m				3.5m				3.8m		
Cluster	Coordinate	Count		Cluster	Coordinate	Count		Cluster	Coordinate	Count
3.0m	(11,10)	14		2.0m	(12,5)	1		3.0m	(6,13)	15
3.0m	(6,13)	3		3.0m	(6,13)	10		3.0m	(5,14)	3
4.0m	(11,14)	2		3.0m	(5,14)	9		4.0m	(12,11)	2
4.0m	(7,14)	1								

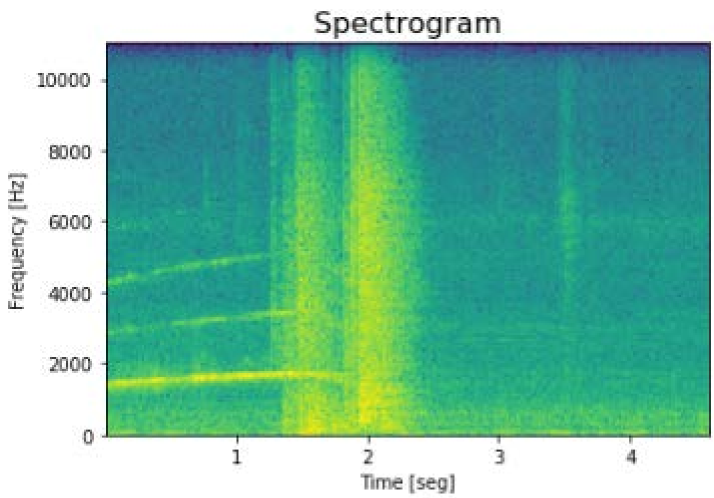


Figure 4.8 Spectrogram of test sample

Real-world ambulance siren (St. John Ambulance Siren)

1. Accuracy testing of ambulance sirens of various lengths

In this analysis case, the ambulance siren used is the St. John ambulance. The recorded ambulance sirens were trimmed with different lengths. The purpose of this experiment is to see the effect of recorded sound length on the Self-Organizing Map trained using St. John ambulance siren datasets. As different lengths of ambulance siren of contain different numbers of features. This is to check what trim length of the ambulance siren will have the best performance on Self-Organizing Map. Also, to check whether the St. John ambulance sirens have better performance than the simulated ambulance sirens. The data acquisition method is shown in **Figure 4.9**. The recorded ambulance alarms are trimmed to different lengths.

Figure 4.9 Different distance of siren sound setup

Four sets of test cases were prepared at different distances of 0m, 25m, 50m, 75m. Each test case contains 20 samples. There are three different lengths of samples (1 second, 10 seconds, 15 seconds). The samples were tested using a Self- Organizing Map, which was trained using 2 seconds St. John ambulance siren dataset. The results are shown in **Table 4.14, Table 4.15** and **Table 4.16**. The new trained Self-Organizing Map showed the positive result on various length of ambulance siren. According to the results, the new version of Self-Organizing Map is more flexible than previous versions Self-Organizing Map for different lengths of siren sound. Based on previous results, the average accuracy for lengths of 2 seconds, 10 seconds, and 15 seconds was 54%, 78%, and 82%, respectively. That is because the new version of Self-Organizing Map was trained using St. John Ambulance siren, which have rapid cycle time (0.255 second). Therefore, the chance of incorrect data segmentation will be reduced as it allows for multiple cycles of ambulance sirens in one sample. **Figure 4.10** show the comparison the number of cycles of the simulated ambulance siren and the St. John ambulance siren within 1 second.

Table 4.14 Test results of 1s St. John ambulance siren

Distance (m)		Test Data (1s)				Accuracy (%)
		0	25	50	75	
Actual	0	20	0	0	0	100
	25	0	20	0	0	100
	50	0	0	19	1	95
	75	0	0	2	18	90
				Average accuracy		96.25

Table 4.15 Test results of 10s St. John ambulance siren

Distance (m)		Test Data (10s)				Accuracy (%)
		0	25	50	75	
Actual	0	20	0	0	0	100
	25	0	20	0	0	100
	50	0	0	20	0	100
	75	0	0	2	18	90
				Average accuracy		97.50

Table 4.16 Test results of 15s St. John ambulance siren

Distance (m)		Test Data (15s)				Accuracy (%)
		0	25	50	75	
Actual	0	20	0	0	0	100
	25	0	20	0	0	100
	50	0	0	20	0	100
	75	0	0	1	19	95
				Average accuracy		98.75

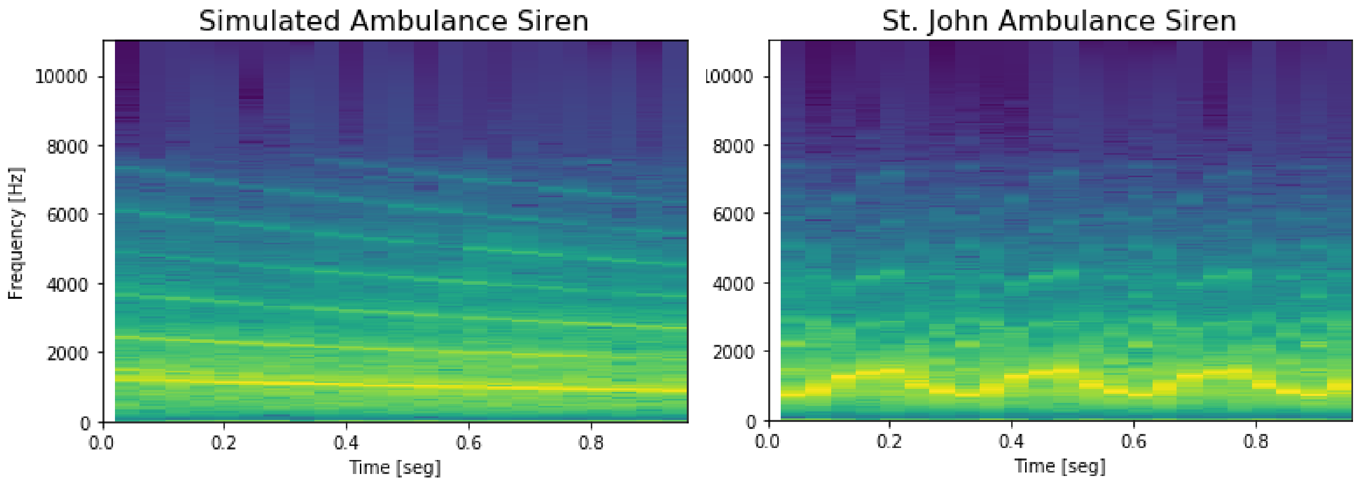


Figure 4.10 Comparison of two ambulance siren cycle time

2. Police Siren testing on St. John Ambulance Siren SOM

In this analysis case, police siren is used for testing. The aim of this experiment was to see how the police siren will perform on the Self-Organizing Map trained using St. John ambulance siren datasets. As police siren and ambulance siren have different characteristics. This was to analyse whether police sirens would react differently to powerful real-world ambulance siren. The police siren dataset used is the same as the police siren dataset in the analysis of simulated ambulance siren.

In this experiment, the police siren used to test at 0 meter. Twenty samples of police siren were collected and tested using St. John ambulance's self-organizing map. Speaker is used to simulate the police siren and microphone is used to record the siren sound. The police siren is sampled for 2 second each. The reason for the use of the 0-meter siren is that the range used by the St. John ambulance siren is 0.0, 25.0, 50.0 and 75.0 meters. Other than that, the speaker does not have enough power to simulate the police siren with 25.0, 50.0, 75.0 meters. The results are shown in the **Table 4.17**, and the results are better than the previous SOM that trained with simulate ambulance siren. If the previously trained SOM is used, none of the sirens are correct at 0-meter. This is because St. John ambulance siren is more similar to the police siren. Previous simulate ambulance siren used 4.62 seconds per cycle, while St. John ambulance used 0.255 second to complete one cycle. As can be seen from the **Figure 4.11**, the police siren completes a cycle in about 0.300 seconds, which is only 0.005 second different.

Table 4.17 Test result of police siren at 0m

Distance(m)	Predicted			
	0.0	25.0	50.0	75.0
0.0 (2 second trim)	20	0	0	0
0.0 (1 second trim)	18	2	0	0

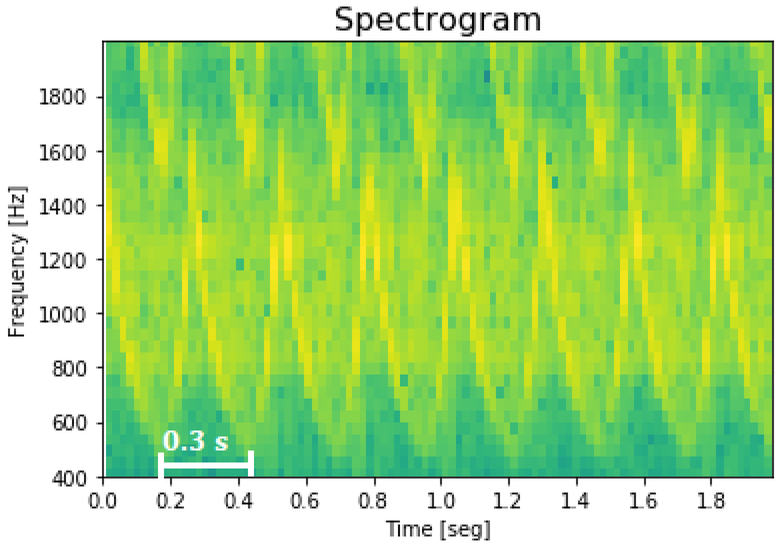


Figure 4.11 Spectrogram of police siren

3. Different microphone testing on ambulance siren

In this analysis case, the St. John ambulance siren was collected with type of microphone. The quality of the sound recorded is important for a classification system that deal with sound. As the only input is the recorded sound. The purpose is to see will different kind of microphone will affect the sound recorded that used for classification. As shown in **Figure 4.12**, three microphones are installed in the same position on the vehicle, and all face the same direction. The ambulance is stopped at on placed and the siren is on. The vehicle was stop at 0-meter, 25-meter, 50-meter, and 75-meter to collect the ambulance siren sound.

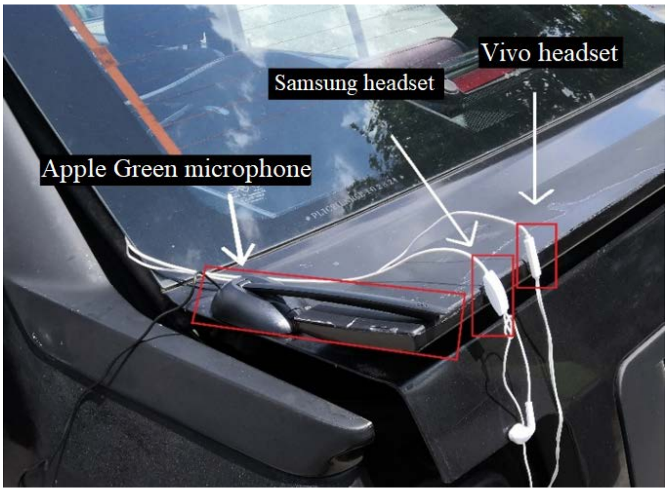


Figure 4.12 Microphone Setting on vehicle

In the process of data collection, a total of three microphones were used to collect the siren sound of the ambulance. The first microphone is Samsung headset microphone, the second microphone is Apple Green stand-alone microphone, and the third microphone is Vivo headset microphone. As can be seen from the **Table 4.18**, the average energy of sirens of the three types of microphones (25 meters, 50 meters and 75 meters) is almost in the same range. At 0m, the average energy of the two headset microphones is the closest, but the energy value of the stand-alone microphone is greater than that of the other two microphones. This is because the receiver boundary of a stand-alone microphone is broader than other microphones and can receive more information in a second, which means it can receive more energy and volume. As a stand-alone microphone, it can receive at least 148.72 J at a distance of 0 m, with the loudest and clearest siren. This means that the maximum power of the headset is only about 50J.

Table 4.18 Average Energy level of different microphone

Distance (m)	Average Short Time Energy (J)		
	Samsung Headset Microphone	Standalone Microphone	Vivo Headset Microphone
0.0	46.46	148.72	49.94
25.0	25.26	27.79	10.82
50.0	4.21	3.02	3.04
75.0	1.89	1.92	1.42

Chapter 5 System Testing

5.1 Verification plan

The emergency support system can identify the existence and distance of emergency vehicles with high reliability and accuracy. However, this may be affected by different circumstances, eventually led to the algorithm to false results. Therefore, some validation is required to ensure that the system works as expected, as shown below.

1. The system is tested as the ambulance moves towards the vehicle, the system function is tested, and the system can identify the distance of the ambulance.
2. The system is tested as the ambulance is moving away from the vehicle, and the system should be able to identify the distance of the ambulance.
3. The ambulance siren is detected, and the distance of the ambulance is identified, the system expected to update the results and share them with the user.
4. The result is shared with other users and the system is expected to have a quick received result, which will be in a few seconds.

5.2 Verification Test

<u>Test Case #1</u>

In this test case, the vehicle is at stationary condition and the ambulance is moves towards the vehicle from 75 meters. The ambulance siren is sampled every 2 seconds and fed into the system. The ambulance first did not switch on siren, which turned on and started moving. The process is show in **Figure 5.2**. The results are shown in the **Table 5.1**. According to the results shown, the first 6 second the system classifies the inputted sound as no ambulance siren. Six seconds later, the system is detected the ambulance siren, and the system carries on the siren localization, and outputs the localization result.

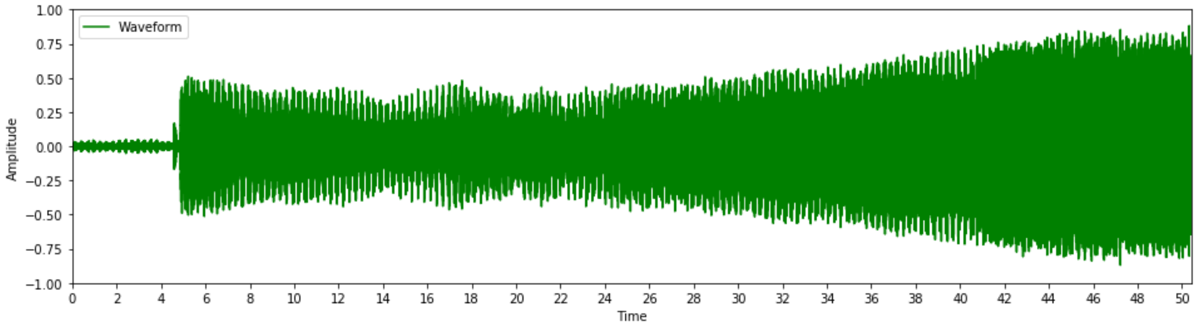


Figure 5.1 The sound waves of the input signal from 75m to 0m

Table 5.1 Result of 75m to 0m

Time sequence	Result	Time sequence	Result
0:00:00	No Siren Detected	0:00:26	50m
0:00:02	No Siren Detected	0:00:28	25m
0:00:04	No Siren Detected	0:00:30	50m
0:00:06	75m	0:00:32	25m
0:00:08	75m	0:00:34	25m
0:00:10	75m	0:00:36	25m
0:00:12	75m	0:00:38	25m
0:00:14	75m	0:00:40	25m
0:00:16	50m	0:00:42	0m
0:00:18	50m	0:00:44	0m
0:00:20	50m	0:00:46	0m
0:00:22	50m	0:00:48	0m
0:00:24	50m	0:00:50	0m

Figure 5.2 Process of ambulance moving toward

<u>Test Case #2</u>

The vehicle is at stationary condition and the ambulance is moves away from the vehicle. The ambulance siren is sampled every 2 seconds and fed into the system. The ambulance first did not switch on siren, which turned on and started moving. The process is show in **Figure 5.4**. The results are shown in the **Table 5.2**. According to the results shown, the first 2 second the system classifies the inputted sound as no ambulance siren. Afterward, the system was performed siren localization.

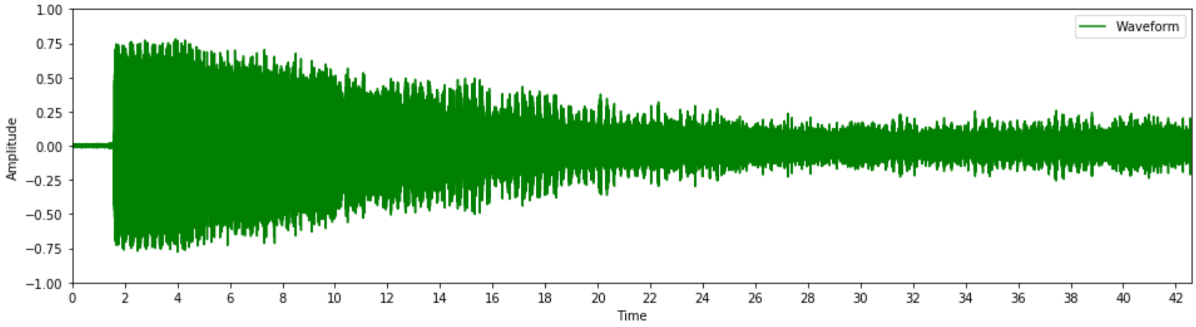


Figure 5.3 The sound waves of the input signal from 0m to 75m

Table 5.2 Result of 0m to 75m

Time sequence	Result	Time sequence	Result
0:00:00	No Siren Detected	0:00:22	75m
0:00:02	0m	0:00:24	75m
0:00:04	0m	0:00:26	75m
0:00:06	25m	0:00:28	75m
0:00:08	25m	0:00:30	75m
0:00:10	25m	0:00:32	75m
0:00:12	25m	0:00:34	75m
0:00:14	25m	0:00:36	75m
0:00:16	50m	0:00:38	75m
0:00:18	75m	0:00:40	75m
0:00:20	75m	0:00:42	75m

Figure 5.4 Process of ambulance moving away

Test Case #3

The purpose of this test case is to ensure that the user is allowed to receive important notifications when any ambulance siren is detected on the other side. Initially, the system was successful in classifying and locating the ambulance siren. Afterward, the system immediately uploads the results to an online real-time database. **Figure 5.5** shows the smartphone successfully receiving notifications from the system.

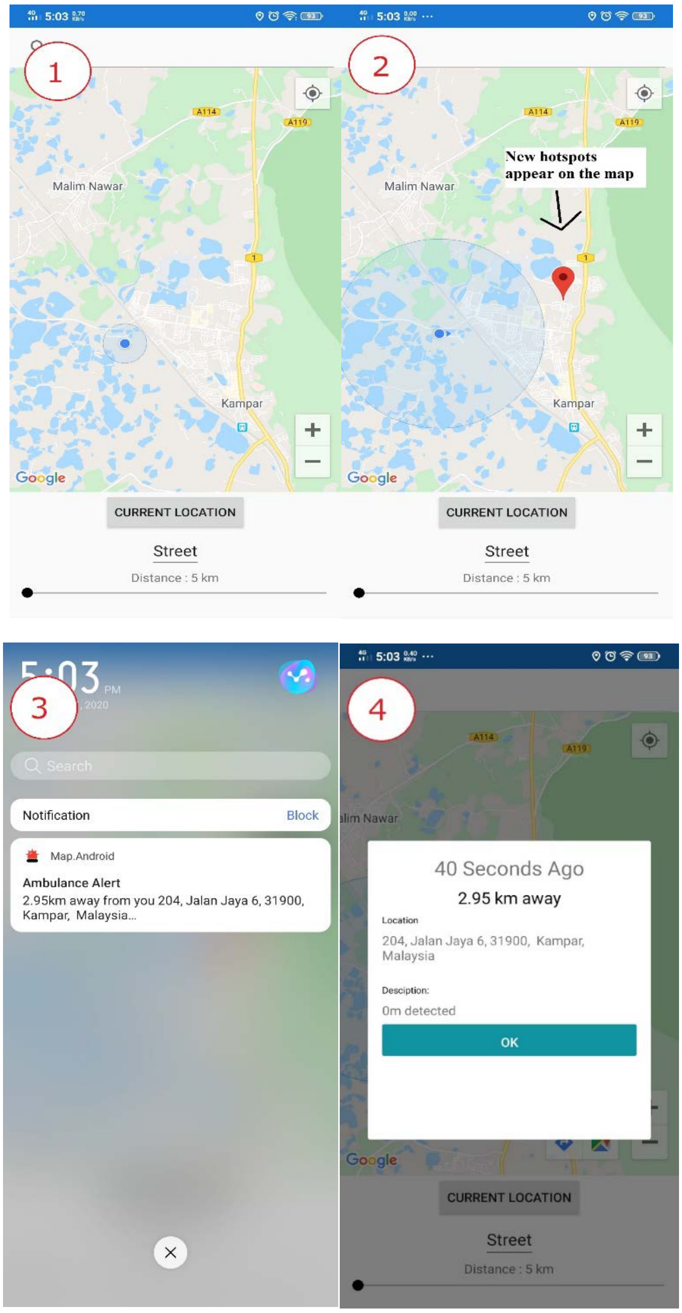


Figure 5.5 Smartphone received an alert message

Test Case #4

The purpose of this test case is to ensure that the user receives important notifications within a certain period of time. When details are uploaded to Firebase, the start timestamp is recorded and the end timestamp is recorded when a smartphone notification is received. The mobile application has modified the pop-up notification to display the timestamp. Both the system and the mobile application have been connected to the telco mobile hotspot. A total of 15 test samples were collected in this experiment. **Figure 5.6** shows the timestamp received on the smartphone. **Table 5.3** is the time interval derived from a timestamp.

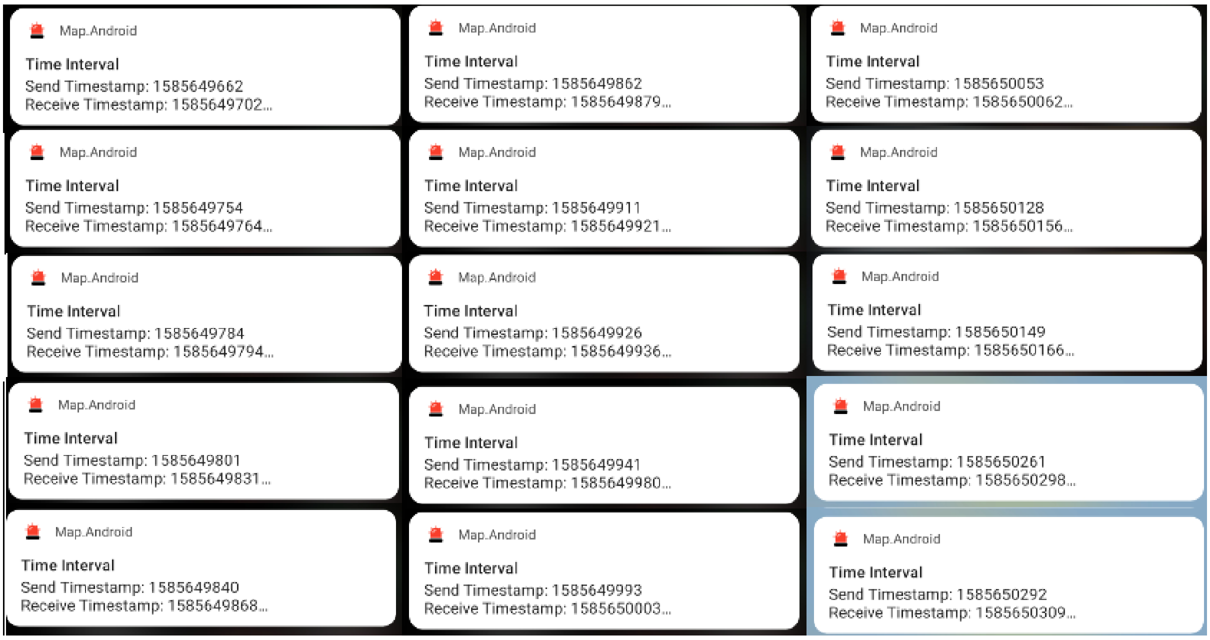


Figure 5.6 Timestamp received on smartphone

Table 5.3 Time interval for receiving notifications

Start timestamp	End timestamp	Time interval (s)
1585649662	1585649702	40.0
1585649754	1585649764	10.0
1585649784	1585649794	10.0
1585649801	1585649831	30.0
1585649840	1585649868	28.0
1585649862	1585649879	17.0
1585649911	1585649921	10.0
1585649926	1585649936	10.0
1585649941	1585649980	39.0
1585649993	1585650003	10.0
1585650053	1585650062	9.0
1585650128	1585650156	28.0
1585650149	1585650166	17.0
1585650261	1585650298	37.0
1585650292	1585650309	17.0
	Average	20.8

5.3 Accuracy Testing

1. Ambulance Siren Sound Localization

The ambulance siren sound localization is used to locates the position of ambulance based on the input sound. Two datasets were used to performed testing on the trained Self-Organizing Map model. The first dataset is the simulated ambulance siren dataset and the other is the St. John ambulance siren dataset. The test sample for first dataset used was 4.62 seconds long. A total of 5 sets of samples were collected, respectively 0.0m, 1.0m, 2.0m, 3.0m and 4.0m. Each sets of samples have 100 sound signals. **Figure 5.7** show that all test result of 100 testing data on the same map. The red circles represent the activated neurons and the predicted results of the system. Almost all of the samples were correct at 0.0m, 1.0m, 2.0m, and 3.0m distances, only one mismatched as 3.0m at 4.0m distances.

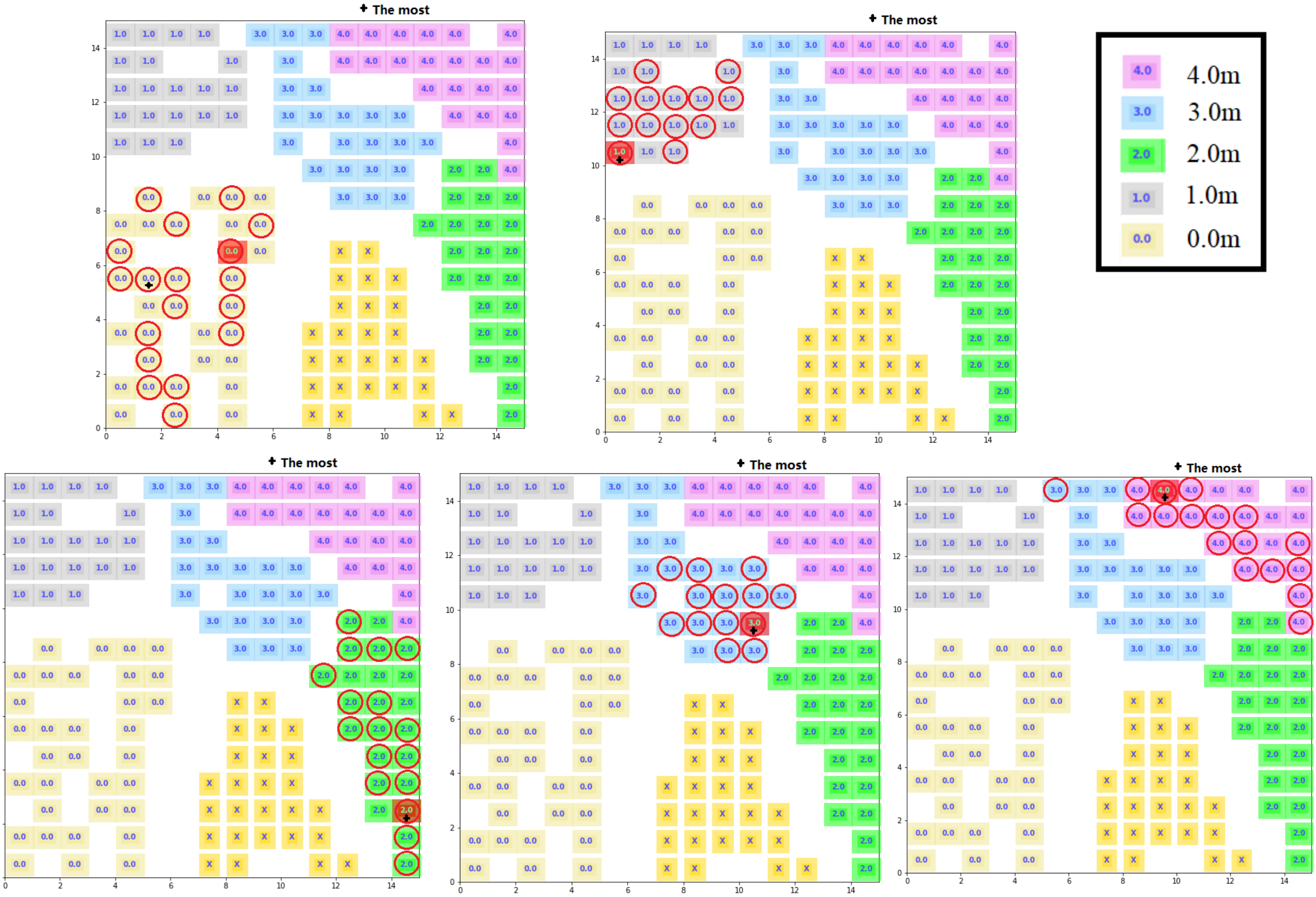


Figure 5.7 Test result of simulated ambulance siren samples

The second dataset is the St. John ambulance siren dataset, the dataset was collected at outdoors. The test sample for second dataset used was 2.00 seconds clip. Four groups of samples were collected, which were 0.0m, 25.0m, 50.0m and 75.0m respectively. Each group of samples has 50 sound signals. **Figure 5.8** show that all test result on the trained map. The red colour box represents the activated neurons and the predicted results of the system. For the test set of 50.0m, one test sample is determined to be 75.0m. For a test set of 75.0m, there are two sample mismatches of 50.0m. The misclassification is highlighted by black circles. This result shows a positive performance. Since the dataset is collected outdoors, it contains some traffic noise, and other external noise that affect the results.

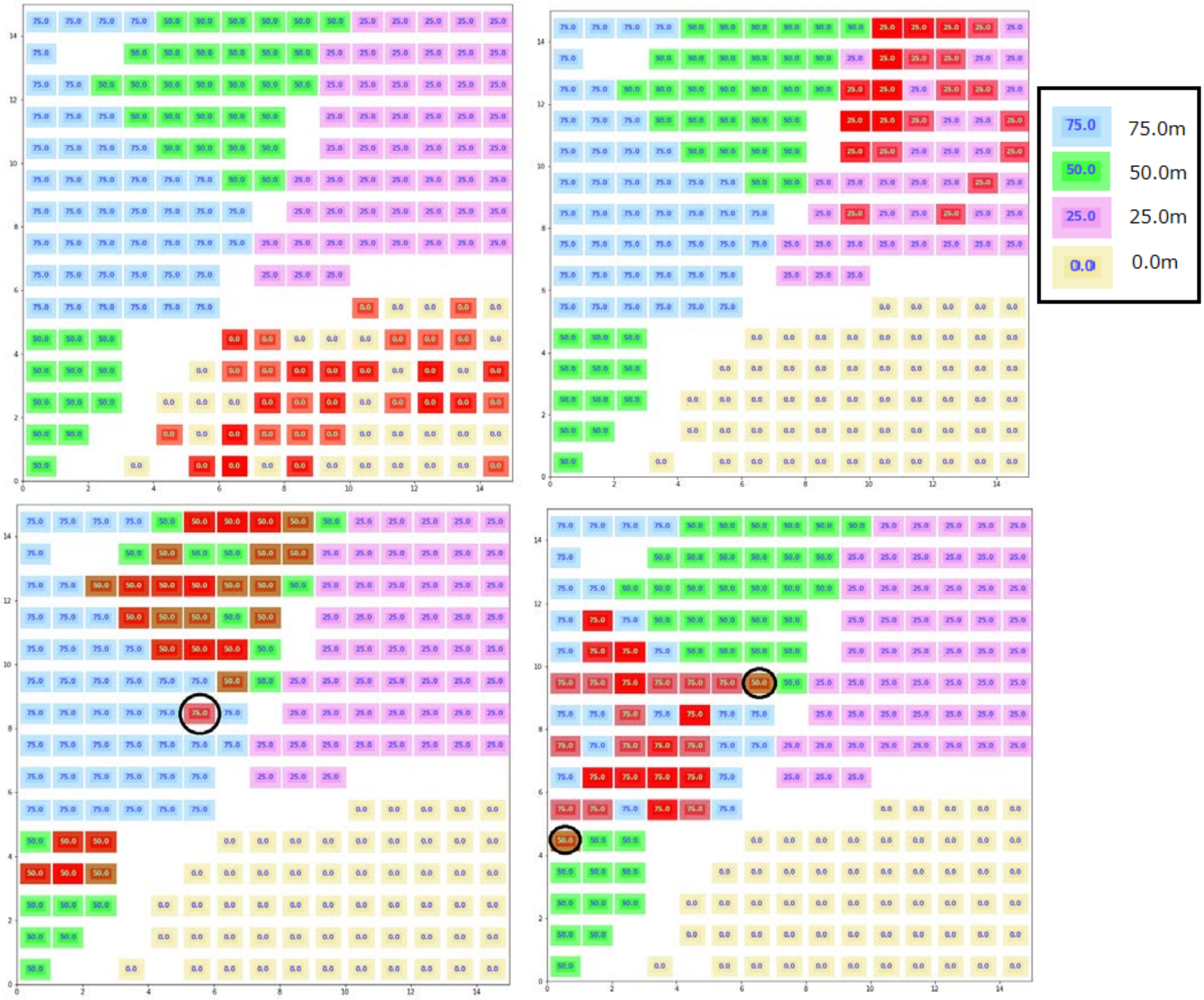


Figure 5.8 Test result of St. John ambulance siren samples

Table 5.4 Confusion Matrix, Recall, and Precision of the result

Distance (m)		Predicted			
		0.0	25.0	50.0	75.0
Actual	0.0	50	0	0	0
	25.0	0	50	0	0
	50.0	0	0	49	1
	75.0	0	0	2	48

Distance (m)	Precision	Recall
0.0	1.00	1.00
25.0	1.00	1.00
50.0	0.96	0.98
75.0	0.98	0.96

2. Ambulance Siren Classifier

The ambulance siren classifier is used to identify the presence of an ambulance siren. A total of three datasets were used to assess the performance of a trained ambulance siren classifier. The first dataset is the simulated ambulance siren. The second test dataset was from the St. John ambulance. To ensure that accuracy tests are more reliable, the third type of dataset was found on the Kaggle website to evaluate trained classifiers, which other researchers used to train and test their systems. The Kaggle dataset contains three categories: traffic, ambulance, and fire truck. Traffic is the normal recording of the street, and ambulances class and fire truck class are different types of emergency siren. Each dataset contains 20 test samples for each class. The results of three different data sets are shown in **Table 5.5**, **Table 5.6** and **Table 5.7**. The first two dataset show a positive result from the ambulance siren classifier. For the third dataset, five test samples in the fire engine category were classified as ambulance sirens. This is because the test samples contained several types of fire engine sirens, some of samples which were similar to the sound cycles of ambulance sirens used in training classifiers.

Table 5.5 Classification result of simulated ambulance siren

Simulated Ambulance Siren						
	Silent	0m	1m	2m	3m	4m
Ambulance siren exist	0	20	20	20	20	20
Ambulance siren not exist	20	0	0	0	0	0

Table 5.6 Classification result of St. John ambulance siren

St. John Ambulance Siren					
	Silent	0m	25m	50m	75m
Ambulance siren exist	0	20	20	20	20
Ambulance siren not exist	20	0	0	0	0

Table 5.7 Classification result of Kaggle Dataset

Kaggle Emergency Siren Dataset			
	Traffic	Ambulance	Fire truck
Ambulance siren exist	0	50	5
Ambulance siren not exist	50	0	45
Accuracy (%)	100	100	90
Average (%)	96.67		

5.4 Mobile Application Implementation

1. User Manual

a) Prerequisites for phone setup

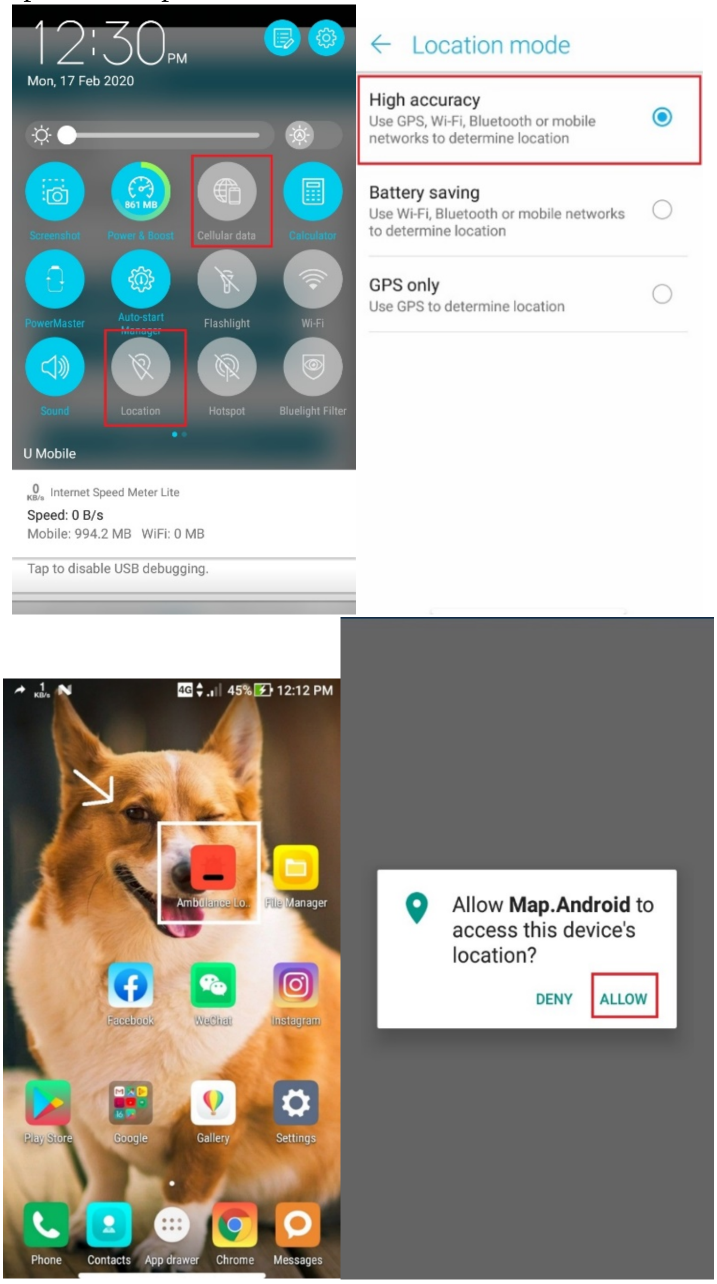


Figure 5.9 Screenshot of phone setting

Before the user can run the mobile application, there are several steps that need to be performed to make the mobile application work properly. Firstly, user required enable GPS location and mobile phone Internet connection. After that, user is need to enter the phone GPS setting and select **High accuracy** to improve GPS positioning accuracy Open the application. Lastly, open the mobile application and allow the permission to retrieve GPS location

b) Check nearby notifications

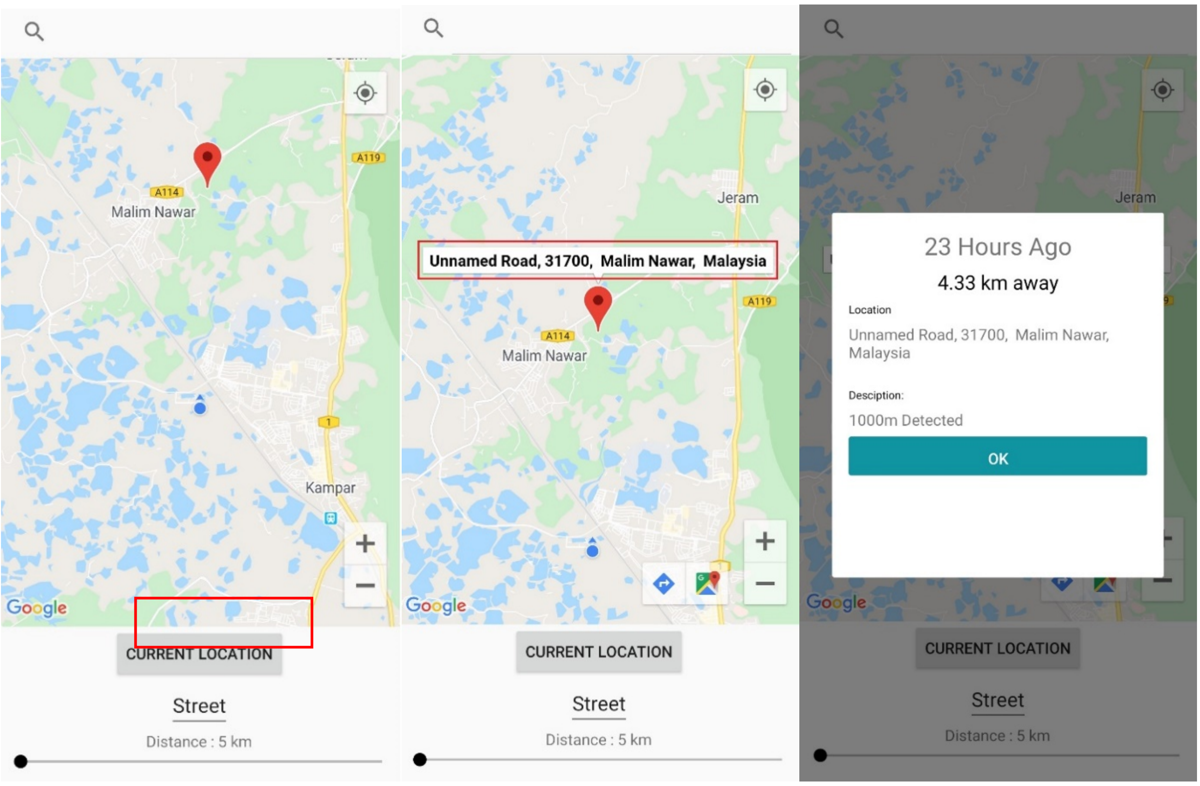


Figure 5.10 Nearby notification

There is a button on the home screen called current location. The current location button will retrieve the user's smartphone GPS location and locates the user's location on a map. After the map is moved to the user's current location, the red pin indicates the ambulance detected location and the blue dot is the current position. Click the red pin to display information about the alert, and then click OK to close the dialog.

c) Select the range of notification received

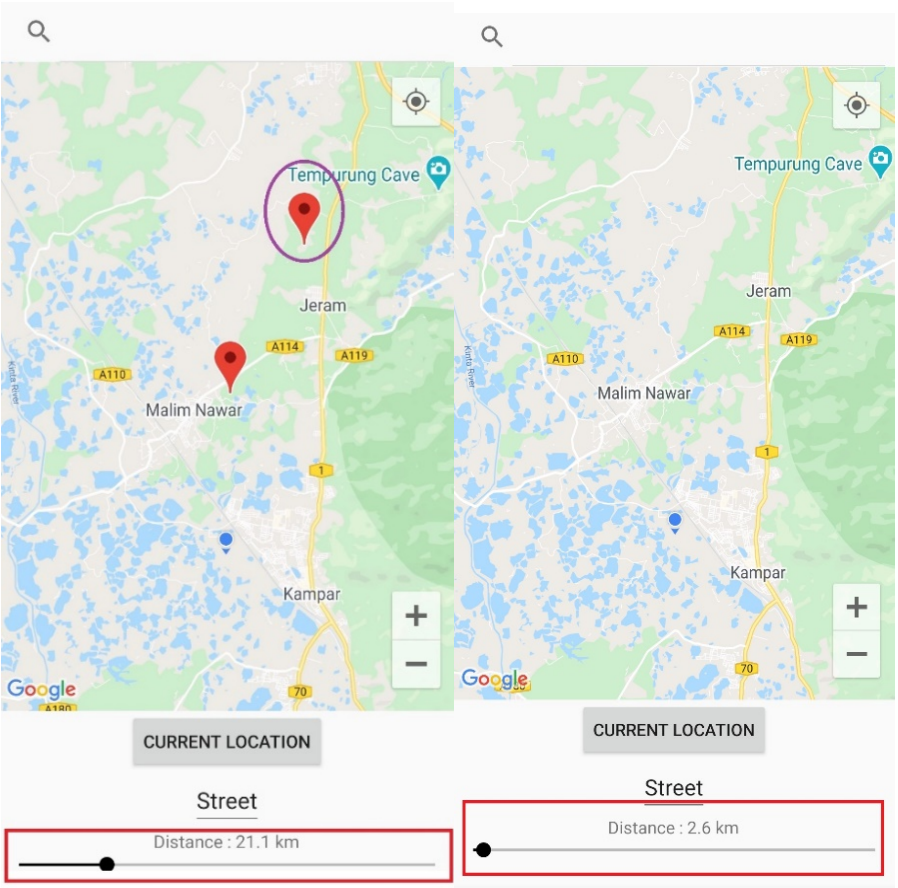


Figure 5.11 Slider on main screen

On the main screen, there is a slider to set the distances the user wants to receive notifications from. After changing the distance value, the detected ambulance hotspot will appear according to the distance value. In addition, the new incoming notifications also follow the distance range.

d) Receive new notification

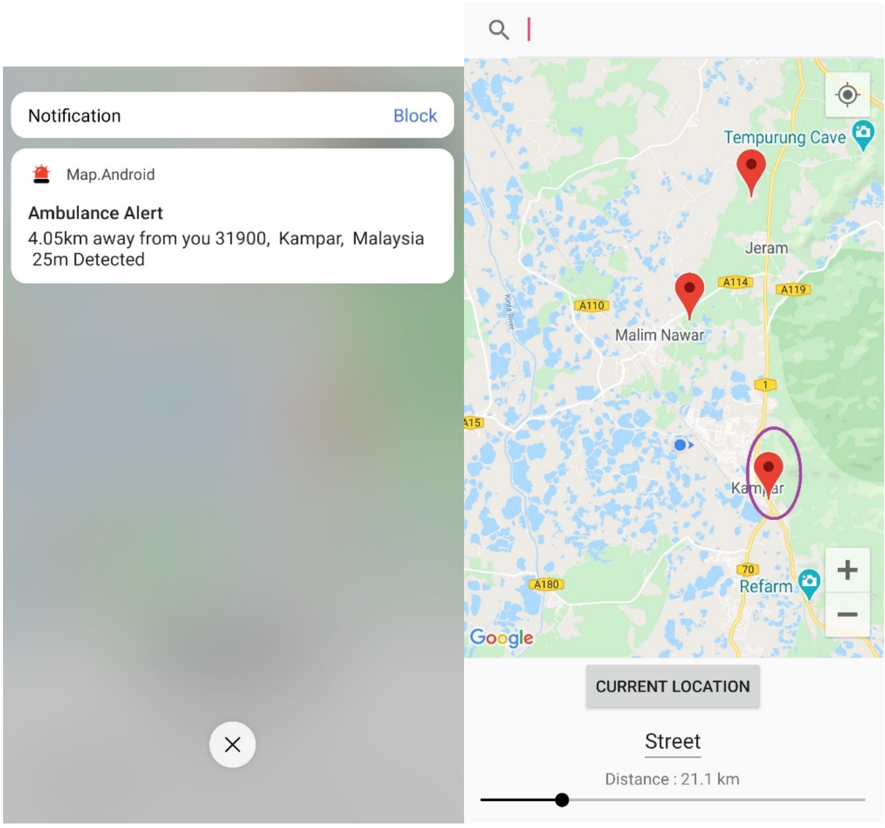


Figure 5.12 Incoming notification

The user will receive notification the new detected ambulance and receive the notification based on the distance selected by the user (in this case, 21.1km). New pins will appear at the same time (purple circles).

e) Search for the desired location

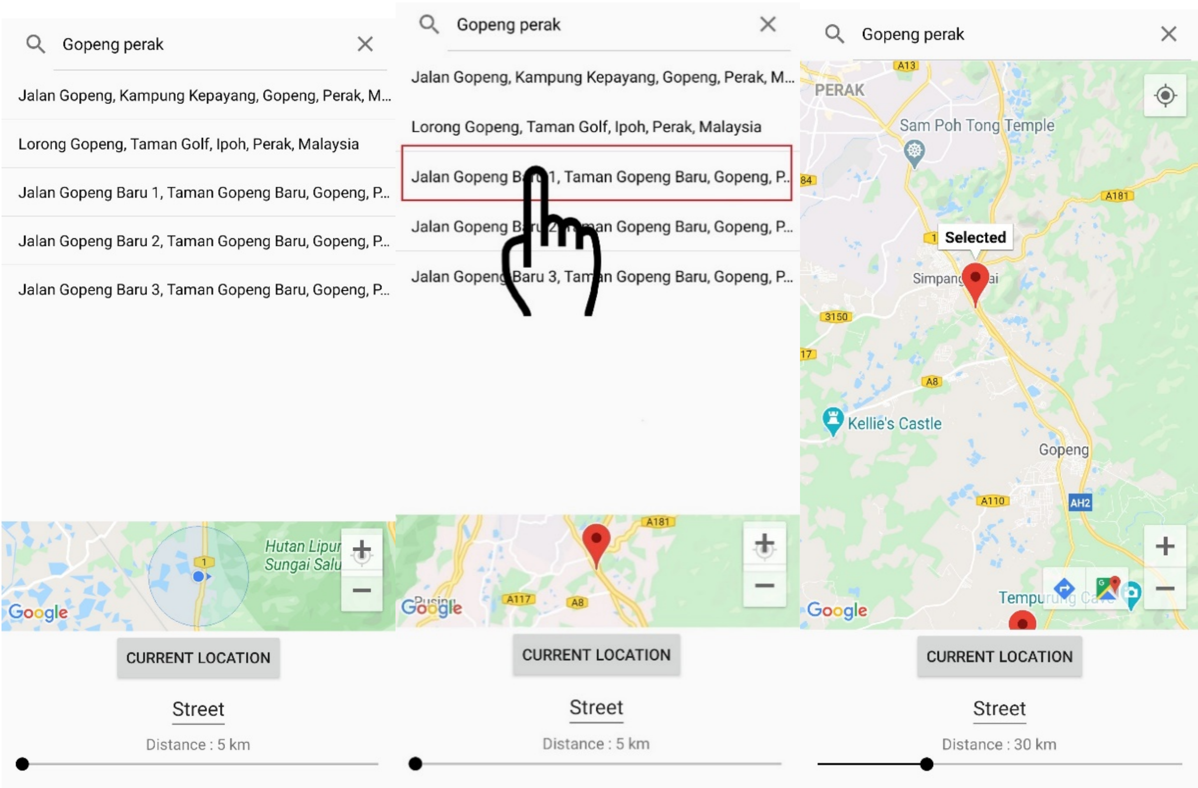


Figure 5.13 Search function

The search function is used by the user to search for the location where they want to receive notifications. Firstly, the user needs to enter the address. Next, select the address from the search results, and when the address is selected, the map will navigate to a specific location, and represent with red pin. The user can choose until the correct location.

f) Search with any location on map

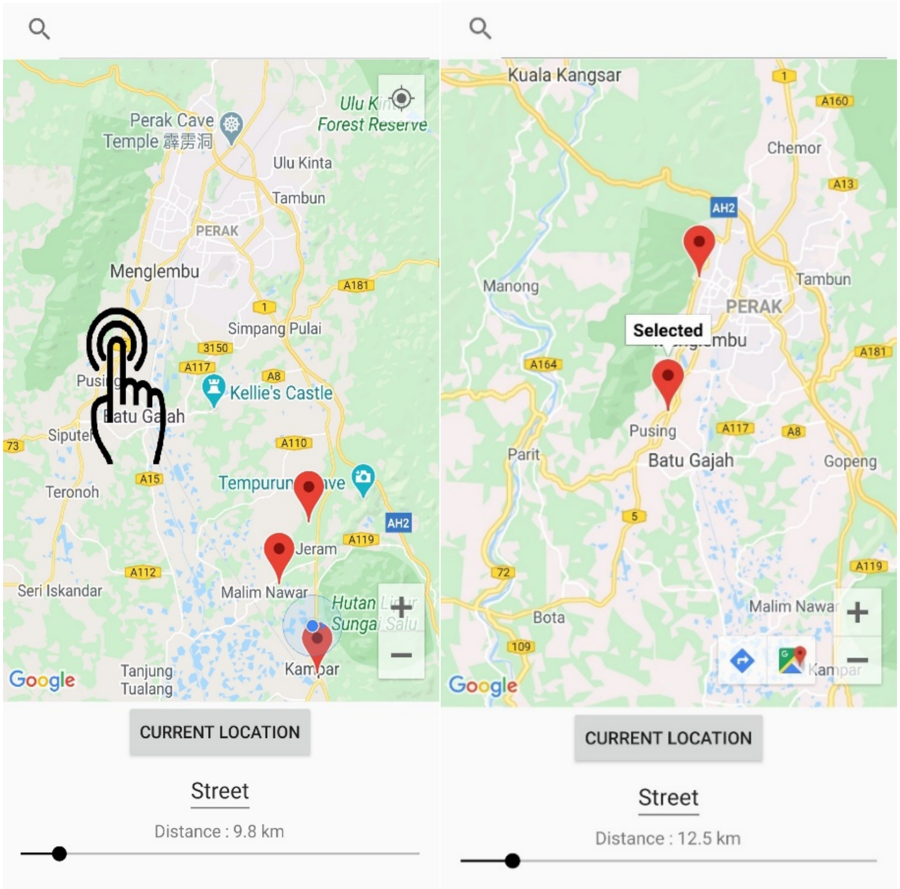


Figure 5.14 Screenshot of the map

Other than search function, the user can select any point on the map as the current location. The user only needs to find the desired location on the map and long press a specific point on the map. The red pin selected indicates the user's current location, and the user can view nearby notifications and view historical notifications (near Ipoh area).

g) Different view of map

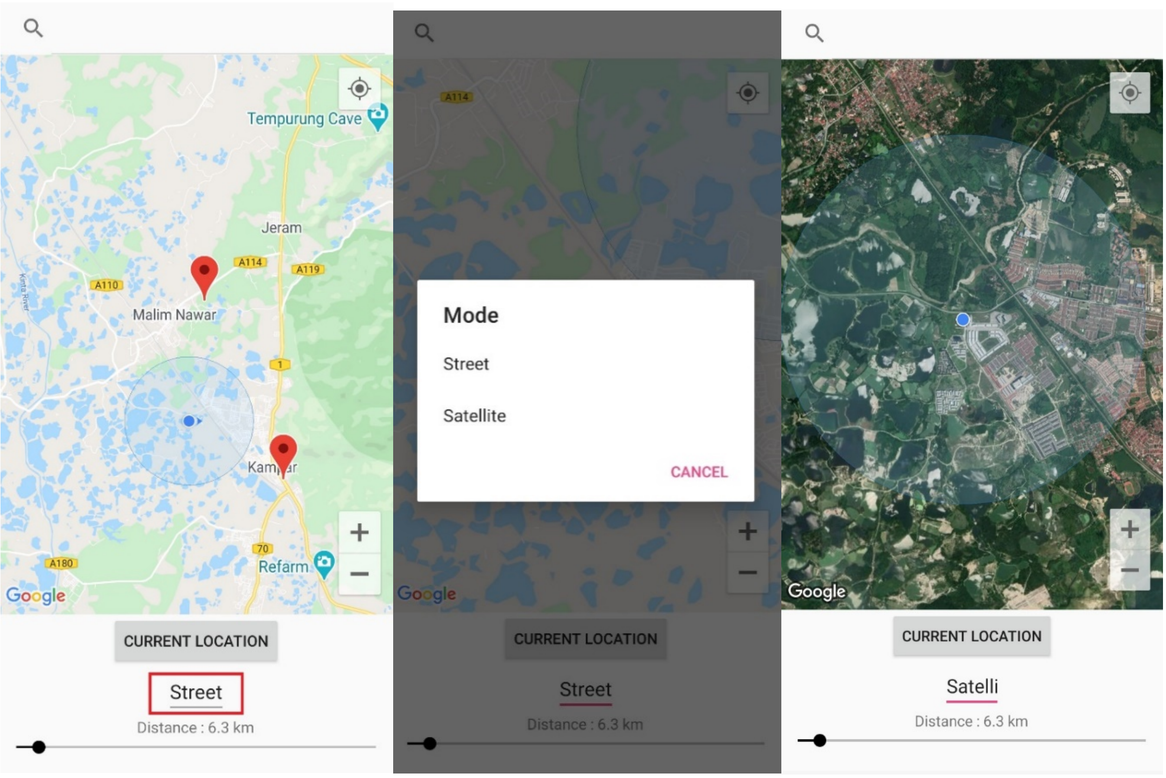


Figure 5.15 Different view of map

The mobile applications allow to view different types of maps and see different details on map. The user only requires click the view selection box and select the map view type. The map displays the user selected map view type.

2. Performance review on the mobile application

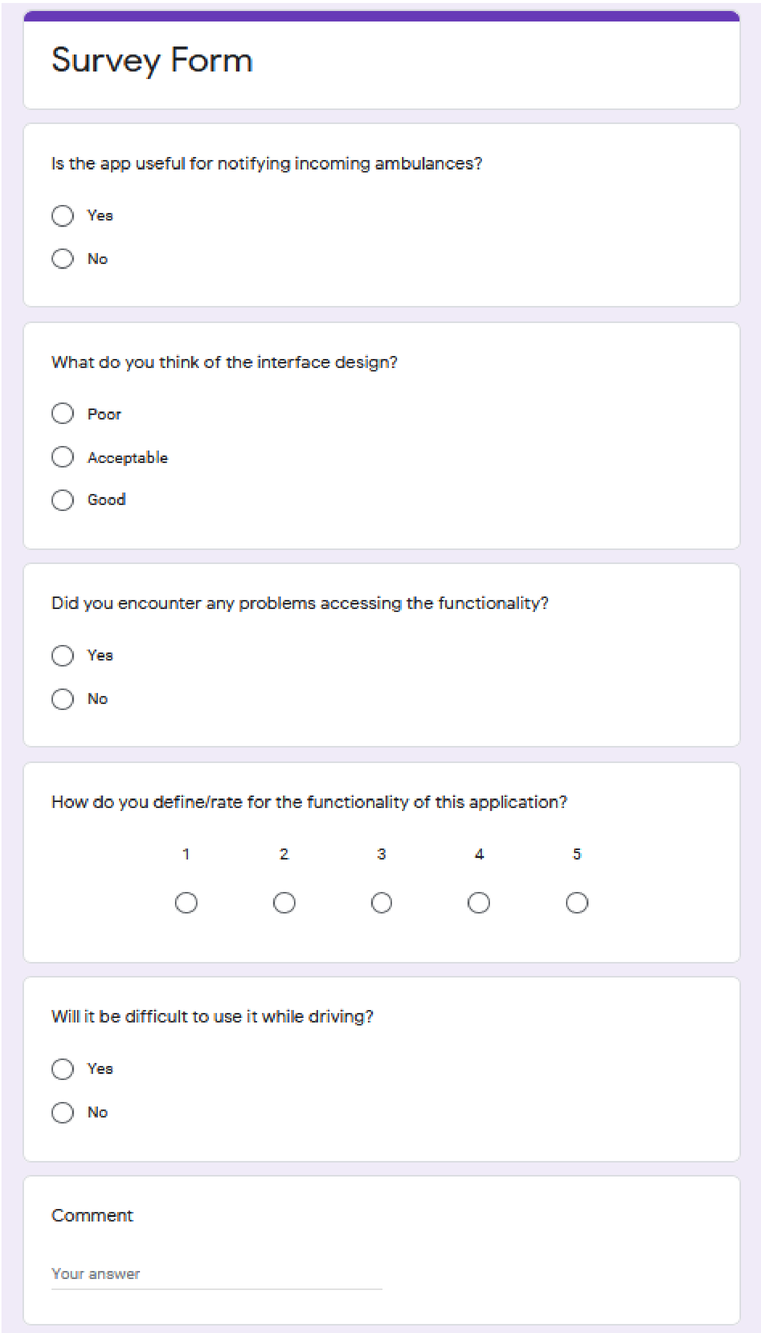
A survey was conducted to review on the sharing information mobile application. In this context, public community is the target of this survey process, which mainly involve student from different faculty, and also food vendor. The evaluation process was done according to their impression regarding to the functionality, and interactive design. Each user was using the same smartphone on testing the mobile application with internet connection. Before starting the testing process, the complete flow of the ambulance localization system and the role of the mobile system was explained and described to them.

According to their perspectives, each of them had provided their own comments and suggestion on the mobile application. For the interviewees, most of them claimed that this application was useful to notified the driver when driving, as it provides the description of the ambulance distance. From the survey, one student has instill that he won't be installing this mobile application because it is not beneficial to know that the ambulance is coming. Other than that, the function that allow user to change the location setting is good to have, which allow them to get notify of the location that they desired. As user have mentioned that the current location shown on the map was accurate.

However, the users have provided some feedback, while searching for the desired location by using the address on the search bar, after clicking on the back button of the navigation panel, the application closed itself which was not convenient to reopen the application again, which is an important thing to improve on. Also, during the testing process the internet connection is important in this application, for some interviewee had responded that it takes a certain time to wait for the result to be displayed in the search bar when they had typed in the address. Next, one of the interviewees claimed that, for the people who no familiar to their current location, the address is not useful at all for them as there do not know where is it. This required them to click into the application to see the exact location on the map, which may cause inconvenience for every driver when driving.

Apart from that, the food vendor interviewee will have difficulty to allow some permission and the phone setting, as they have less knowledge on using the smartphone. Some of the interviewees gave some suggestion on the application which involves cooperation with navigation map such as Google Map or Waze, to allow the user to navigate and get notification on the ambulance alert. Also, it is good to notify the user using sound, so that they do not need to check on the detail message on the application.

Based on the review done, the functionality on the mobile application is acceptable for users, as it provides what user need. They though application is useful to get notification for the ambulance alert, but there still some part on the application which no very user friendly. Some other feature such as change the type of map view, seem no attractive to user on this kind of application. Overall, users were satisfied with the mobile application, and user have provided some suggestion to allow the application to improve to have better user experience.



Survey Form

Is the app useful for notifying incoming ambulances?

- Yes
- No

What do you think of the interface design?

- Poor
- Acceptable
- Good

Did you encounter any problems accessing the functionality?

- Yes
- No

How do you define/rate for the functionality of this application?

1 2 3 4 5

Will it be difficult to use it while driving?

- Yes
- No

Comment

Your answer

Figure 5.16 Survey Question

Table 5.8 Survey Responses

Interviewee	Student 1	Student 2	Student 3	Food Vendor 1
Is the app useful for notifying incoming ambulances?	Yes	No	Yes	Yes
What do you think of the interface design?	Acceptable	Acceptable	Acceptable	Acceptable
Did you encounter any problems accessing the functionality?	No	Yes	Yes	No
How do you define/rate for the functionality of this application? (1- 5)	4	2	4	3
Will it be difficult to use it while driving?	No	No	Yes	Yes
Comment	-	Slow display search address results	Audio notification, work with Waze for easy access	Difficult to allow necessary phone setup

Chapter 6 Conclusion

6.1 Project Review, Discussions and Conclusions

The goal of the project is to help people become aware of the arrival of an ambulance. The motivation was to shorten the time it took the ambulance to get the patient to the hospital. The project involves designing solutions in computer and mobile application platforms to solve the problem of unaware incoming ambulance.

On the computer platform, a classification and sound localization system was developed to identify the presence of ambulance siren and localize the siren distance. The classification system can distinguish the presence of ambulance alarms at a specific time. The accuracy test is carried out and shows that the ambulance siren classification system is reliable. Next, the ambulance siren localization system was trained with Self-Organizing Map. The ambulance siren location system was allowed to identify the distance of ambulance based on the trained map, by find the Best Matching Unit (BMU) that have minimum weight with the ambulance siren. As classification and localization module work together to provide the driver emergency alert during driving. Through the output of the system, and the driver received the alert of the incoming ambulance. The system also uploads the results to the cloud and shares them with other vehicle drivers. The mobile app platform is developed for other road drivers, to receive alert message shared by other users. In addition, users can avoid hotspots being displayed on the application. As more ambulance hotspots are detected at the same location on the map, drivers will understand that something may have happened, such as an accident, and drivers can change other roads to avoid unnecessary traffic jams.

The purpose of mobile application development is to serve users. The user performs a brief review of the developed mobile application. Some changes were made based on user feedback, make the application more friendly and error-free.

I do hope this will really help people, especially hearing-impaired drivers, make ambulances easier. There are challenges and issue during the development process, such as the real-world ambulance siren was not available; The sirens are not allowed to be turned on when the ambulance is not in operation. Those challenges were successfully overcome and thanks to those who participated and helped solve the challenge. In a nutshell, the project is hoped to be delivered successfully and it could be useful and bring contribution to the society. In conclusion, the proposed system successfully classifies the incoming sound and locates the siren, the system also supports sharing results to raise drivers' awareness on the road.

6.2 Novelties and Contributions

This project aims to reduce the annual rate of death in Malaysia. Ministry of Road Transportation can make use of monitoring data to know where have an accident occur and heavy traffic congestion. After that, specific departments will help deal with these problems, just as the main cause of traffic congestion at a certain time in a particular area and may need to increase the width of the road to solve the problem. It also makes road users aware that their behaviour in giving way to ambulances has an important bearing on the lives of the patients on board. Other than that, the collected datasets will be uploaded online to make it available so that other studies can use these data sets. As previously, there are no online resources with different labels for the location of sirens at different distances. Therefore, this dataset will benefit other researchers who need this requirement.

6.3 Future Work

There still have a various types of emergency siren in different country that are not included in this system. Therefore, the Future datasets will be expanded based on the different types of emergency siren that exist in the world. With the extended dataset, the proposed system will be able to identify more types of emergency siren and perform sound localization. This could help more emergency vehicles overcome delays that cause drivers, due to unaware of incoming emergency vehicles.

Next, in order to improve the accuracy and performance of the system, a better sound signal pre-processing method will be explored in the future. If the system is equipped with better sound pre-processing steps, such as better noise reduction. This helps to extract the siren signal from the noise background and reduce the unnecessary noise. This will also improve the overall quality of the training and testing of sound signals, resulting in better siren classification system performance.

Lastly, the mobile application is expected to integrate with other navigation system applications, such as Waze, or Google Map. When the integration is successful, it makes it easier for users to use the notification function. This is because users do not need to install additional application, because most of the driver have navigation application installed on their smartphone. Integration with other navigation applications, this will allow additional functionality, such as providing alternative navigation for the drive, so that the user can avoid traffic that will cause emergency vehicle delays.

Bibliography

Azlin, A. & Rubiyah, Y., 2016. A modified kohonen self-organizing map (KSOM) clustering for four categorical data. *Jurnal Teknologi*, Volume 78, pp. 6-13.

Counts, R., 2016. *Autoblog.* [Online]
Available at: https://www.autoblog.com/2016/09/09/haas-alert-emergency-vehicles-smartphone-alerts/
[Accessed 1 August 2019].

Definitions, 2019. *What does traffic congestion mean?.* [Online]
Available at: https://www.definitions.net/definition/traffic+congestion
[Accessed 28 July 2019].

Dressler, F., Hartenstein, H., Altintas, O. & Tonguz, O. K., 2014. Inter-Vehicle Communication: Quo Vadis. *IEEE Communications Magazine*, 52(6), pp. 170-177.

Durresi, M., Durresi, A. & Barolli, L., 2005. Sensor Inter-vehicle Communication for Safer Highways. *Proceedings of International Conference on Advanced Information Networking and Applications,* Volume 2, pp. 599-604.

Ekwonwune, E. N., Ngozi, N. C. A. & Eberechi, O. O., 2018. ICT Devices: Vital Tools for Enhancing Road Traffic Monitoring. *Communications and Network,* Volume 10, pp. 43-50.

Fonseka, A., Alahakoon, D. & Bedingfield, S., 2011. GSOM sequence: An unsupervised dynamic approach for knowledge discovery in temporal data. *2011 IEEE Symposium on Computational Intelligence and Data Mining (CIDM),* pp. 232-238.

Goh, L., 2016. *Traffic jams are the main obstacle.* [Online]
Available at: https://www.thestar.com.my/news/nation/2016/06/11/traffic-jams-are-the-main-obstacle/
[Accessed 27 July 2019].

Hirschmann, R., 2019. *Number of road accidents in Malaysia from 2012 to 2017 (in 1,000).* [Online]
Available at: https://www.statista.com/statistics/794875/number-of-road-accidents-malaysia/
[Accessed 3 August 2019].

Hui, Z. J., Hui, X. & Ying, Y., 2008. Remote self-learning of driving cycle for electric vehicle demonstrating area. *08. IEEE Vehicle Power and Propulsion Conference 2008. VPPC,* pp. 1-5.

Jalanow, 2019. *Jalanow.com.* [Online]
Available at: Jalanow.com
[Accessed 1 August 2019].

Jantvik, T., 2009. Sensory Integration -Success & Failure. *Department of Computer Science and Electrical Engineering: Luleå University of Technology.*

Laerhoven, K. V., 2001. Combining the Self-Organizing Map and K-Means Clustering for On-Line Classification of Sensor Data. *Proc. International Conference on Artificial Neural Networks,* pp. 464-469.

Landoni, B., 2018. *FM RADIO-BASED EVENT WARNING AND EMERGENCY ALERT SYSTEM.* [Online]
Available at: https://www.open-electronics.org/fm-radio-based-event-warning-and-emergency-alert-system/
[Accessed 5 August 2019].

Liosa, J., 2019. *The real-time Traffic Flow Monitoring System.* [Online]
Available at: https://www.worldsensing.com/product/bitcarrier/
[Accessed 3 August 2019].

Liu, Y. R. & Guo, J., 2018. Design of Improved Vehicle Collision Waming System Based on V2V Communication. *2018 8th International Conference on Electronics Information and Emergency Communication (ICEIEC)*, pp. 95-98.

MEVAS, 2019. *MEVAS.* [Online]
Available at: http://www.mevas.us/product.html
[Accessed 28 July 2019].

Otálora, A. S., Osorio, D. E. C. & Moreno, N. C., 2006. Methods for extraction of features and discrimination of emergency sirens. *ARPN Journal of Engineering and Applied Sciences,* 12(5), pp. 1525-1532.

Panyaarvudh, J., 2017. *20 per cent of emergency patient deaths blamed on traffic jam delays.* [Online]
Available at: https://www.nationthailand.com/national/30304268?no_redirect=true
[Accessed 25 July 2019].

Ralhan, A., 2018. *Self Organizing Maps - Towards Data Science.* [Online]
Available at: https://towardsdatascience.com/self-organizing-maps-ff5853a118d4
[Accessed 28 July 2019].

Schröder, J., Goetze, S., Grützmacher, V. & Anemüller, J., 2013. Automatic acoustic siren detection in traffic noise by part-based models. *2013 IEEE International Conference on Acoustics, Speech and Signal Processing,* pp. 493-497.

Shabih, U. H. et al., 2012. Modified SOM based intelligent semi-autonomous navigation system. *11th Symposium on Neural Network Applications in Electrical Engineering,* pp. 25-29.

Stokoe, R., 2016. Putting people at the centre of tornado warnings:How perception analysiscancutfatalities. *International Journal of Disaster Risk Reduction* , Volume 17, p. 137–153.

TEE, K., 2019. *Police: Total road accidents up, but fatalities down 6.3pc in 2018.* [Online]
Available at: https://www.malaymail.com/news/malaysia/2019/01/30/police-total-road-accidents-up-but-fatalities-down-6.3pc-in-2018/1718052
[Accessed 1 August 2019].

Terry Caellp & David Porter, 1980. On Difficulties in Localizing Ambulance Sirens. *Human Factors: The Journal of the Human Factors and Ergonomics Society,* 22(5), pp. 719-724 .

Windle, D., 2002. *Emergency vehicle alert cuts car stereos.* [Online]
Available at: https://www.newscientist.com/article/dn2621-emergency-vehicle-alert-cuts-car-stereos/
[Accessed 27 July 2019].

Yin, H., 2002. ViSOM—A Novel Method for Multivariate Data Projection and Structure Visualization. *IEEE TRANSACTIONS ON NEURAL NETWORKS,* 13(1), pp. 237-243.

Zhang, Y. Q., Wu, C. X., Qiao, C. M. & Hou, Y. F., 2019. The effects of warning characteristics on driver behavior in connected. *Accident Analysis and Prevention,* p. 138–145.

Zhang, Z., Kazuaki, I., Miyake, T. & Imamura, T., 2008. 3-D Sound Source Detection by Binaural Model using Self Organizing Map. *International Conference on Innovative Computing Information and Control*, 6(1), pp. 66-66.

Poster

Traffic Monitoring System with Emergency Support using SOM

Supervisor : Dr. Lau Phooi Yee

Proposed by :Tan Hoai Thang

Abstract

With the advance of science and technology, more cars on the road, emergency vehicles such as ambulances are having a hard time bypassing busy lane. Therefore, with the help of the vehicle emergency alarm system, the driver can stay alert enabling the emergency vehicle to reach the destination as soon as possible. The system will provide emergency notification to alert the driver. By using Self-Organizing Map technique, the emergency siren can be localized and it will help to classify the presence of emergency vehicles. Next, the system will forward the information to the vehicle in front to notify other drivers

Problem Statement

- Vehicle driver unaware of the presence of emergency vehicles.
- Ambiguity on the actual location of ambulance

Project Scope

- Focus of this project is to study Self-Organizing Map (SOM) unsupervised learning on ambulance emergency siren localization.
- Involved identification of ambulance siren during good weather.
- The output will be shared with other vehicle drivers to inform them.

Objective

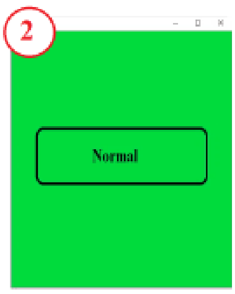
- To implement unsupervised learning Self-Organizing Map (SOM) to localized the ambulance siren and to infer the traffic condition.
- To identify the ambulances' emergency siren collected using microphone accurately and indicates the presence of nearby ambulances.
- To provide monitoring status for road users and trigger alerts whenever ambulances' siren was found.

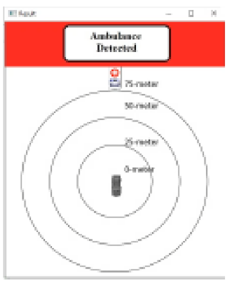
Self-Organizing Map of system

Methodology

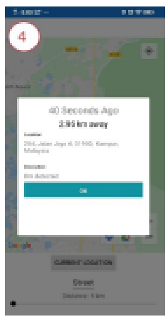
- Data Acquisition
- Pre-Processing
- Feature Extraction
- Classification
- Sound Localization
- Result
- Share with Other Vehicles

Result





Notification received by other user on smartphone



Reference

Ng, A., 2017. *Self-Organizing Maps Tutorial*. [Online] Available at: https://annalyzin.wordpress.com/2017/11/02/self-organizing-map/amp/ [Accessed 21 11 2019].

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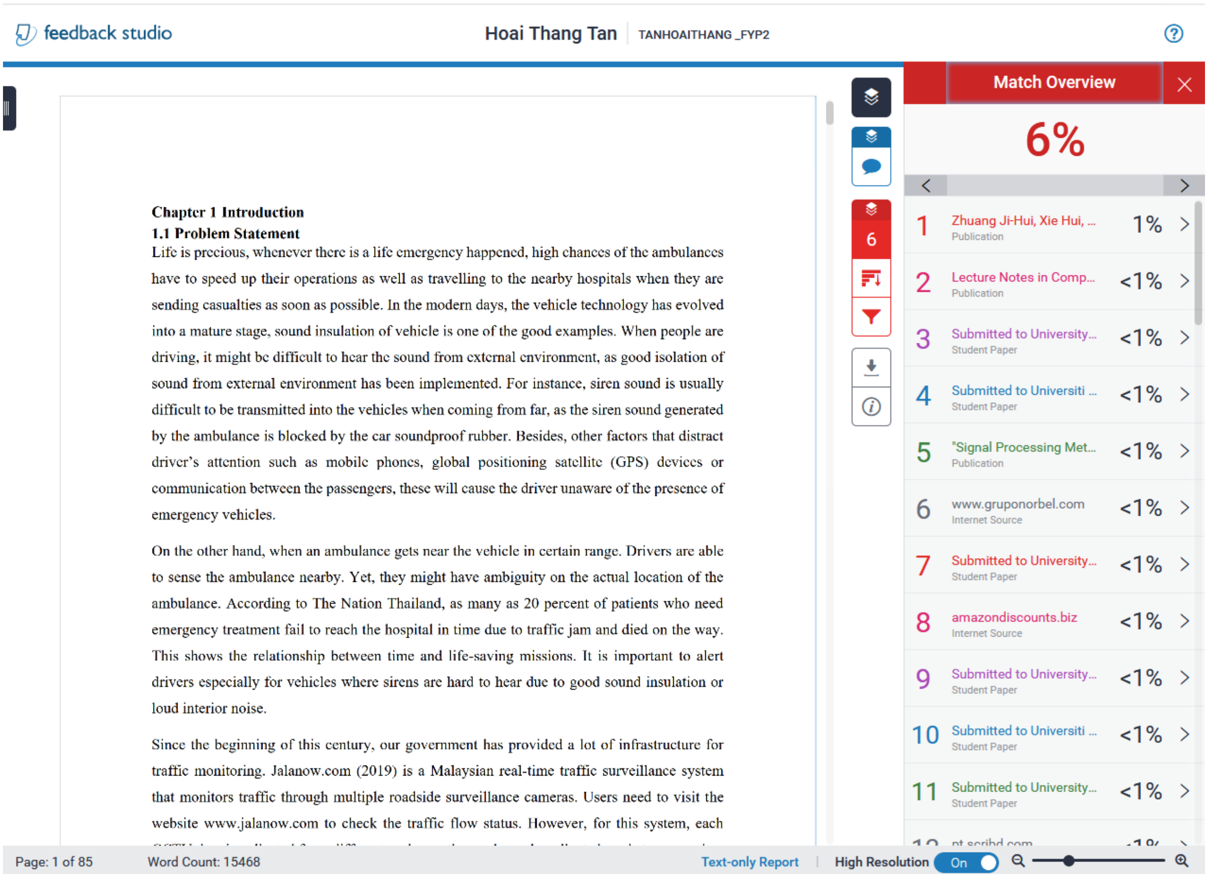
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Chapter 1 Introduction
1.1 Problem Statement
Life is precious, whenever there is a life emergency happened, high chances of the ambulances have to speed up their operations as well as travelling to the nearby hospitals when they are sending casualties as soon as possible. In the modern days, the vehicle technology has evolved into a mature stage, sound insulation of vehicle is one of the good examples. When people are driving, it might be difficult to hear the sound from external environment, as good isolation of sound from external environment has been implemented. For instance, siren sound is usually difficult to be transmitted into the vehicles when coming from far, as the siren sound generated by the ambulance is blocked by the car soundproof rubber. Besides, other factors that distract driver's attention such as mobile phones, global positioning satellite (GPS) devices or communication between the passengers, these will cause the driver unaware of the presence of emergency vehicles.
On the other hand, when an ambulance gets near the vehicle in certain range. Drivers are able to sense the ambulance nearby. Yet, they might have ambiguity on the actual location of the ambulance. According to The Nation Thailand, as many as 20 percent of patients who need emergency treatment fail to reach the hospital in time due to traffic jam and died on the way. This shows the relationship between time and life-saving missions. It is important to alert drivers especially for vehicles where sirens are hard to hear due to good sound insulation or loud interior noise.
Since the beginning of this century, our government has provided a lot of infrastructure for traffic monitoring. Jalanow.com (2019) is a Malaysian real-time traffic surveillance system that monitors traffic through multiple roadside surveillance cameras. Users need to visit the website www.jalanow.com to check the traffic flow status. However, for this system, each
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