SMARTCOP - AUTOMATED PLATFORM TO MITIGATE THE IMPACT OF ROAD ACCIDENTS

2020-052

Project Proposal Report

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DECLARATION

We declare that this is our own work and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of Supervisor Date

[Dr. Windhya Rankothge]

Abstract

Road accidents have become one of the major issues both locally and globally as they cause many deaths, injuries, fatalities and economic deprivations. Hence, the police administration finds it difficult to accurately predict road accidents and place police officers to the identified areas using their existing manual process. In addition, unawareness of the public is a prominent reason for increasing road accidents and consequences afterward. Therefore, the SmartCop research work has proposed to provide an automated platform to mitigate the impact of road accidents accurately than already provided conventional solutions. The proposed solution has four main areas such as a model for road accident prediction, scheduling and disseminating police officers according to the predictions of road accidents, a game-based learning approach to enhance road accident prevention awareness and also a game-based learning approach to improve road accident response awareness. Nevertheless, the prediction and scheduling processes are proposed to develop using supervised learning algorithms and the results will be displayed via a web-based application. In addition, the system can be accessed by the Department of Police. On the other hand, the game based approaches will be implemented using a reinforcement algorithm and launched as a mobile application in order to enhance the awareness of the public.

Keywords: road accident prediction, scheduling, game-based learning, supervised learning, reinforcement algorithm

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1. INTRODUCTION

In recent years, there's a significant tendency of increasing road accidents throughout the world especially in developing countries starting nearly 1.35 million deaths annually [1]. In addition, injuries and fatalities are also caused by road accidents. However, road accidents have a tremendous impact on society and the economy. As a developing country, Sri Lanka has also encountered a number of road accidents over the past few years reaching 3,554 of total deaths per year (2.80% as a percentage) [2]. Therefore, a solution to mitigate the impact of road accidents is a current requirement in Sri Lanka also.

However, the analysis of road accidents and its outcomes was taken into consideration by many types of research and authorities. But they couldn't achieve the maximum accuracy of their outcomes since many of them were analyzed according to some statistical records and simple surveys. In addition, some research was conducted in order to achieve some predictions and didn't consider providing a long term solution [3]. Therefore, the general goal of this research is to provide an automated platform called SmartCop to mitigate the impact of road accidents. In order to obtain better results, Machine Learning (ML) has been proposed to apply as it is one of the most efficient scientific areas of Artificial Intelligence (AI). This research focuses on both the public and the department of police in Sri Lanka. Since the public is the victim of these miserable road accidents, they are taken into the main consideration of this research work. In addition, the department of police also has a requirement to mitigate the impact of road accidents as the responsible party of the public. Therefore, the SmartCop has proposed four main research areas to facilitate both the department of police and public in Sri Lanka in order to reduce the number of road accidents and its outcomes afterword. The four main research areas are the development of a model for predicting road accidents, scheduling and disseminate police officers according to the predictions of road accidents, a game-based learning approach to enhance road accident prevention awareness and also a game-based learning approach to improve road accident response awareness.

Hence, the road accident prediction feature has proposed to predict the specific area, reason, severity, and frequency of road accidents. In order to obtain these results, seven main factors are taken into consideration. Such as identified areas of road accidents, time, reason, severity, weather condition, vehicle type, and driver's condition. The prediction will be conducted by implementing a supervised learning algorithm. In addition, scheduling and disseminating police officers is another main research area of the SmartCop which will be also implemented using a supervised learning algorithm. This platform will recommend the most qualified and available police officers to the relevant area and notifications will be sent for the appropriate officers. This scheduling process will be conducted by predicting the availability of police officers, analyzing their experience, analyzing their education with training and considering predicted road accident data. However, the above mentioned two research areas will be implemented on a web-based application and the outcomes can be observed by the department of police in Sri Lanka. In addition, the required dataset during the period from 2015 to 2019 will be gathered by the department of police in Colombo South in Sri Lanka. Therefore the results of the predictions and schedule will be implemented for the Colombo South Police region initially. On the other hand, public awareness has been taken into consideration in this research as prevention and response to road accidents. Hence, a game-based learning approach has been proposed to enhance road accident prevention awareness. In addition, the main expected outcomes are enhancing memorization skills of the public, tackling elapsed time, offering an overview explanation of traffic signs as feedback and analyzing the progress. In order to obtain results, a reinforcement algorithm will be used. The last main research area is also a game-based learning approach to improve road accident response awareness. Here, the best response speed of the public for a road accident will be improved. In addition, the awareness level will be measured. In order to obtain results, the reinforcement algorithm will be used. However, the data source for both public awareness approaches is real-time user data (score, elapsed time, playing style, etc.) obtained while users play the game application and the outcomes will be launched via android mobile applications.

According to the above mentioned facts, the SmartCop automated platform will be implemented.

1.1. Background & Literature survey

Road traffic accidents are a leading cause of fatalities and injuries worldwide. According to the World Health Organization (WHO), over 3700 people die caused by road accidents and tens of millions of people are getting injured or disabled every year globally [4]. People who face the inconvenience of road accidents are not only public road users such as drivers, pedestrians, cyclists but also the other responsible parties especially traffic police officers. Major reasons for the rapid increase in road accidents are not only the negligence of drivers and pedestrians but also the improper scheduling and enforcement of traffic police officers, public unawareness on both road accidents prevention and response, especially if they are inexperienced or unprepared for a sudden situation. Even though different governmental and non-governmental organizations around the world come up with different solutions to prevent or reduce the impact of road accidents still the issue is not resolved completely.

And effective and accurate road traffic management is a crucial requirement to reduce road traffic accidents. Several types of research have been conducted to address the issues related to road accidents from different aspects to come up with effective solutions. This review will critic researchers conducted under three major categories respectively,

1. Traffic accident prediction models to reduce the impact of road accidents.

2. Police officers scheduling for effective traffic management.
3. Improve public awareness of road accident prevention and response.

1.1.1. Traffic accident prediction models to reduce the impact of road accidents.

A study conducted by Rabia Emhamed et al has done an investigation on models formulated by various machine learning algorithms for classifying the severity of injuries caused due to road traffic accidents. Results show that the prediction of accidents through algorithms has 75.50% accuracy and predictive models can be used to identify key factors causing traffic crashes. Moreover, discovered that the Random Forest model is the best model to be applied to predict road crashes [5]. An innovative approach has been presented for traffic crash prediction which examines the interaction among roadways, traffic, environmental elements, and traffic crashes. The proposed model has been developed using both supervise and unsupervised learning algorithms. According to the findings current traffic, geometric, pavement and environmental features are the leading factors that directly affect the risk of crash occurrences and need to be improved to reduce the crash percentage[6]. The Neural network (NN) model was developed to predict intersection crashes in Macomb County of the State of Michigan. The prediction was conducted by grouping the crashes into these types respectively fatal, injury and property damage. A neural network has been trained to model a nonlinear relationship between crash types and crash properties such as time, weather, light and surface conditions, driver and vehicle characteristics. The study was able to provide a very accurate prediction(90.9%) of crash types by using 48 design parameters [7].

1.1.2. Police officers scheduling for effective traffic management.

A proper work schedule should consider not only police officers' satisfaction but also the need to meet management objectives. The study conducted by William W. Stenzel and R. Michael Buren examines the relationship between management objectives, field operations, and officers' individual goals to provide effective management of police officers’ work schedules [8]. Police officers excessively tired due to long and

inconsistent work hours, shift work and insufficient sleep. Police officers can perform a better job if the employee flexible approaches for staffing and work scheduling and can meet both demands for service and their families. The study found that sleep act as a mediating link between stress arising from traumatic, life-threatening experiences, and somatic symptoms. And also observed inter-individual variability in need for sleep, vulnerability to fatigue and sleep restriction [9]. Optimization-based decision support system for deploying patrol officers has been implemented by Taylor, P. E. and Huxley, S. J. The system forecasts hourly needs, schedules officers to maximize coverage and allow them to meet human needs. And also the system is capable of evaluating schedule changes and suggesting alternatives. Results show that the implementation of police patrol scheduling system improved productivity by $11 million per year. Response time has been decreased by approximately 20 percent and officer morale was positive [10].

1.1.3. Improve public awareness of road accident prevention and response.

A study has been done to explore the effect of a digital game designed to teach players about the road rules in Alberta, Canada. This study utilizes a game designed to teach safe driving knowledge and thus, to improve road safety. Results observed that playing an entertaining game which is designed to convey knowledge of road rules not only improves players' knowledge but also help them retain experiences gained from the game. Furthermore, different from traditional approaches this innovative study lets the player engages in active problem solving to acquire knowledge [11]. The majority of studies about pedestrian safety education have taken place in the classroom setting, to increase children's knowledge about traffic and their attitudes toward safety. However available research indicates classroom setting and group education are not the most successful methodologies for educating children. With the intention of teaching principles of pedestrian safety to elementary school children, a game-based educational tool has been developed. Third-grade children from different School Districts in Los Angeles were assigned to play a unique interactive video game about pedestrian safety or to a traditional instructive session about pedestrian safety. Observation of study participants revealed that the performance of students who played the educational video game and those who attended a more traditional and

labor-intensive didactic learning were similar [12]. An analysis of factors affecting road accidents by considering the severity of accidents and decision-making styles of drivers has been conducted by areaAli Azadeh et al. In this study major, decision-making styles of drivers were identified concerning the severity of injuries. Specific the dominant style of drivers, which has the most frequency at different levels of injuries in road accidents were identified and provided better training principles for drivers based on their styles. High speed, failing to wear a seat belt and violent driving are the most influential factors in all levels of injuries [13].

1.2. Research Gap

Although there are numerous studies conducted to mitigate the impact of road accidents, a review of the literature indicates that there are several research gaps as below.

Within the body of the literature surveyed when developing a model for predicting road accidents; most of the examined researches have done to obtain a report or analytics [14]. Also, several studies have done on road accident prediction concerning one prominent feature [15]. Additionally, several studies were only able to analyze the

number of road accidents and casualties without identifying the specific areas of road accidents [16]. Furthermore, some related work has evaluated their predictions only for the part of a pathway [17]. Besides, some studies have only defined the analysis of fatalities that occurred for pedestrians [18].

In addition to this, most of the studies conducted for scheduling traffic police officers for road accident prevention; have examined only the impact of shift work for better performance during the enforcement [21]. Moreover, in some studies, few predefined work scheduled patterns were identified for a specific period and assigned each police officer into identified schedules rather than considering the preferences of employees [20]. Furthermore, most of the scheduling approaches are limited for a period of one month with a few numbers of employees [23]. Apart from that, some studies explore the experience of traffic police officers by taking into consideration the protection of victims [22]. Nevertheless, instead of jointly considering the major factors which affect a well-planned scheduling system, several studies have only examined the impact of enforcement to decrease traffic accidents and fatalities [19].

On the other hand, among the game-based learning approaches that have been introduced for enhancing road accident prevention awareness; most of the studies have focused on children's education [24] or the respondents were limited to a specific age group [25]. Apart from that, several studies were conducted in just one city; therefore, the study results have yet to be generalized [26]. Moreover, instead of jointly considering all the main contributing factors, several studies have only examined the effect of a couple of chosen factors [27]. Additionally, for some participants, playing the game was a challenge because they had little previous exposure to video games and may have been concentrating on the gameplay rather than the lessons contained within [26]. Furthermore, in certain studies the game playing duration was short, and it is necessary to investigate more long-term exposure to learning through games for demonstrating an improvement in sensitivity [28]. As well as, some of the research has tested for any change in knowledge or improved behavior immediately after being exposed to the intervention and have not tested for knowledge retention [26]. Apart from that, most of the existing games [29] – [30] have not acknowledged dynamic difficulty adjustment in-game levels according to particular user's skill levels and also

those games were merely developed only to test user awareness and not used game results with traffic police for road accident prevention. Besides, compared to the point-and-shoot type of games, the need for the games which require more ‘thinking’ for the acquisition of situation awareness has often been pointed out [28].

Plus, within the game-based learning strategies that have been proposed for enhancing road accident response awareness; many of the researches focused on a specific age group [37]. Also, few studies that contained at least 3 hours of lesson time reported significant improvements in the knowledge and retention of information than ranging from 3 to 12 months of training. Therefore, shorter programs demonstrated significant changes in knowledge [38].

1.3. Research Problem

Nowadays, there is a considerable increase in the number of road accidents in Sri Lanka due to various reasons. As a result of these incidents, injuries and cause of deaths as well as damages for assets and public infrastructure are increasing. As a responsible government authority in protecting people and assets of civilians, the department of police in Sri Lanka has a major duty to eliminate road accidents into

acceptable levels. Even though there are several statistical analyses which are conducted manually by relevant police stations, still which has not been significantly contributed to decrease the trend of road accidents. In addition, police stations encounter various inconveniences in scheduling and disseminating police officers to control road accidents effectively and efficiently. Furthermore, the lack of awareness of the public regarding road accidents especially how to prevent road accidents and how to react and respond after road accidents is a major cause of increasing road accidents.

Additionally, Sri Lanka police is using accident reports to predict road accidents manually and when scheduling police officers, senior officers are not considering police officer's experience and qualification. On the other hand, the Sri Lanka police team and rescue team are conducting many awareness programs like seminars on "how to prevent road accidents?" and "how to react and respond after road accidents?" But they are a bit primitive to provide a better solution to increase the awareness level among people.

Moreover, most of the existing systems have been developed on road accident prediction, police officers scheduling, road accident prevention games and road accident response games are based only on few features. So developing a website and games that fulfill the requirements would be a key challenge that would be completed throughout this research. Model for predicting road accidents, schedule traffic police officers according to predicted road accident forecasts, game-based learning approach to enhance road accident prevention awareness among drivers and pedestrians and game-based learning application to improve the awareness on road accident response among people are covered as major research areas throughout this research work.

Research questions derived from the research problem

- ★ How road accident prediction exactly reduces the impact of road accidents?
- ★ How proper police officer scheduling systems reduce the impact of road accidents?

- ★ How critical thinking skills gained through game-based learning are more beneficial to learn road safety best practices?
- ★ How road accident response awareness will be improved through game-based learning?

2. OBJECTIVES

2.1. Main Objectives

To minimize the impact of road accidents using Machine Learning based prediction and Game-Based Learning.

2.2. Specific Objectives

- To develop a model for predicting road accidents
- To schedule traffic police officers according to predicted road accidents forecasts
- To introduce a game-based learning approach to enhance road accident prevention awareness among drivers and pedestrians
- To develop a game-based learning application to improve the awareness of road accident response among students and nonmedical professionals

3. METHODOLOGY

3.1. Introduction

This section explains how the SmartCop system (Automated platform to mitigate the impact of road accidents) will be designed and implemented. The process of each function will be described along with their flow in the system and technologies which will be used for the implementation.

3.2. System overview

The SmartCop system contains both website and game-based mobile applications. The website will be developed for both predicting road accidents and scheduling police officers. Road accident prediction will be done using the identified set of variables gathered from road accident historical data according to supervised learning algorithms. The output will be displayed accurately to the responsible parties of the police stations. The data and analytics will be categorized according to predefined measurements. Furthermore, several parameters will be used to analyze the performance and availability of each police officer in order to recommend the most suitable and available police officer for the duty.

The game-based mobile applications will be developed for both prevention and response to road accidents. The player's awareness level will be analyzed through real-time user data. Both games will educate and instruct the player on how to perform the game through a game guide so that users from any age range can be easily familiar with the game.

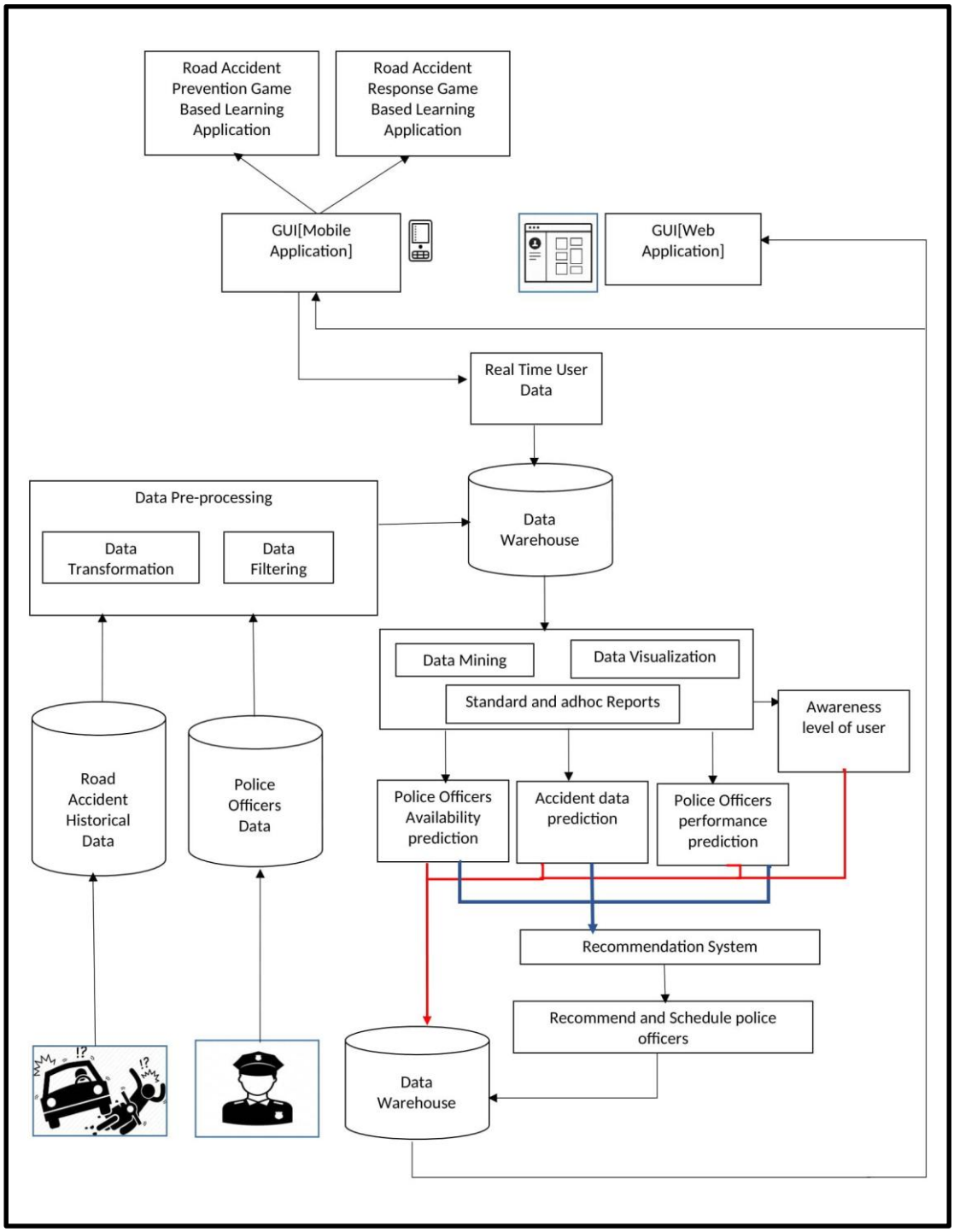


Figure 3.1: System overview diagram

3.3. Functionalities

3.3.1 Develop a model for predicting road accidents

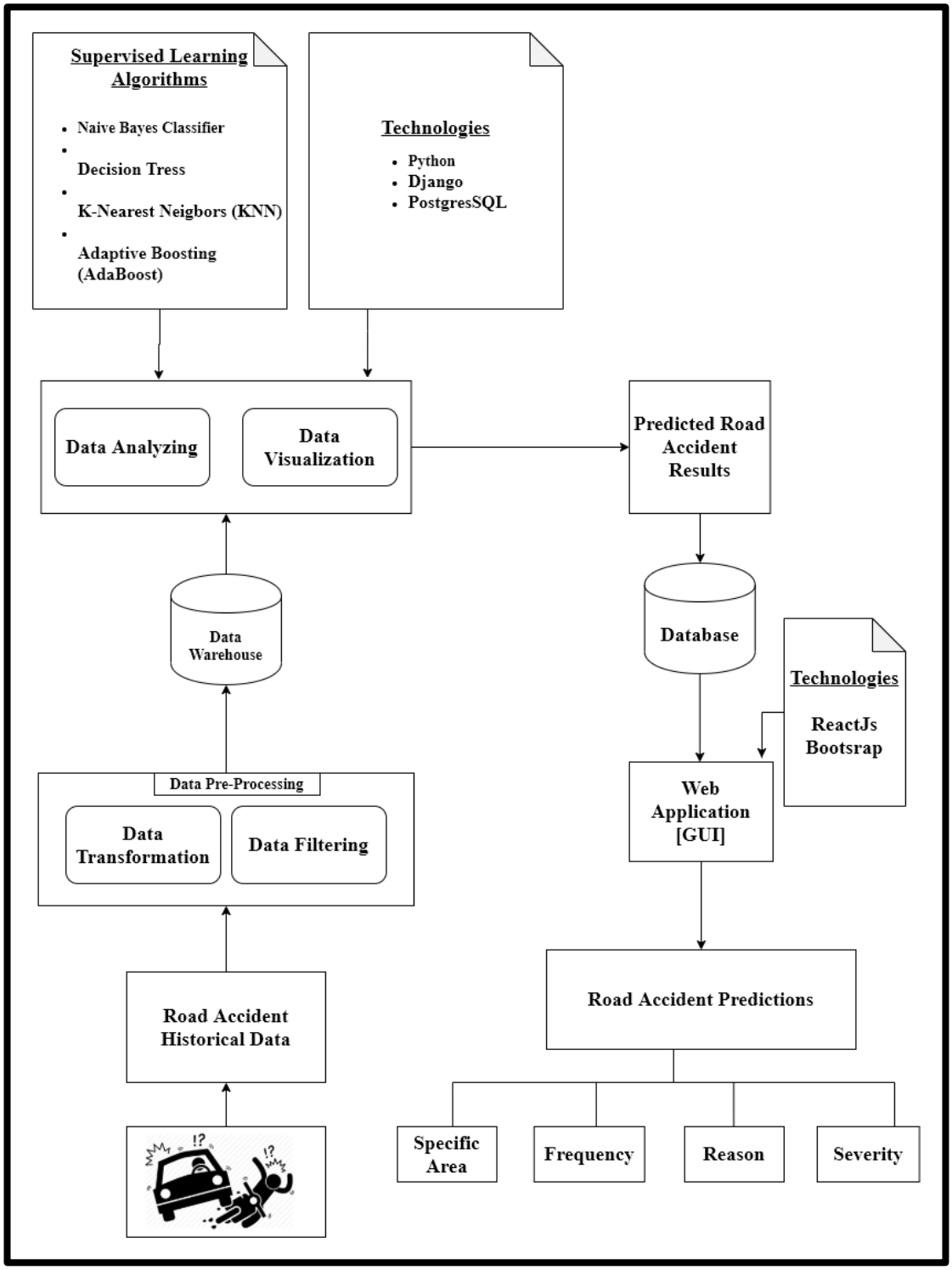


Figure 3.2: The methodology of road accident prediction

Road accident historical data is stored in the main police station of the particular police region. Therefore the required data for road accident prediction research will be collected from Mirihana Police Station (Colombo South) in Sri Lanka during the period from 2015 to 2019. Then the data pre-processing step will be performed.

Data Pre-processing

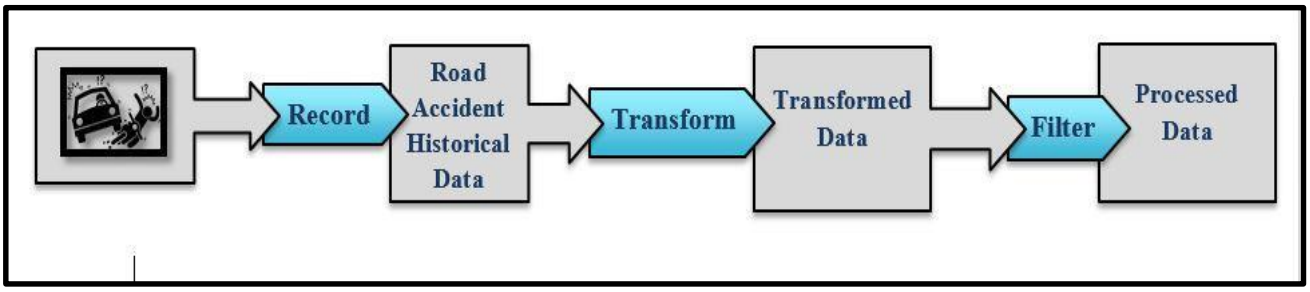


Figure 3.3: The initial phase of road accident prediction

Data Transformation

This is the first step in the data pre-processing step. Since road accident historical data is stored in hard copies at the police station, data should be transformed into a system accessible format.

Data Filtering

Then the transformed data will be filtered according to seven main factors. Such as identified areas of road accidents, time, reason, severity, weather condition, vehicle type, and driver's condition. In addition, unrelated data will be removed and only the required data will be summarized in this step. After that, the data will be stored in a data warehouse.

Data Analyzing

This is the main segment of the methodology. Machine Learning will be applied in order to predict road accidents. Under the data analysis, the supervised learning algorithm will be used to obtain predictions. Because supervise learning algorithms make predictions on a given set of samples. In addition, it explores patterns within the value labels assigned to data points. Since existing historical road accident data will be used, it's better to implement a supervised learning algorithm. There are four main supervised learning algorithms proposed to implement such as

- **Naive Bayes Classifier Algorithm**

- This is one of the most popular learning methods which are grouped by similarities and it works on the popular Bayes Theorem of Probability- to build machine learning models particularly for predictions and document classification [39]. When it comes to the classification, it's hard to classify a document, web page or any other lengthy document manually. Naive Bayes Classifier algorithm is more suitable for classifying such content more accurately. A classifier is a function that designates a population's element value from one of the available categories.

❖ **Decision Tree Algorithm**

- The decision tree can be represented graphically which is based on branching methodology to exemplify all possible outcomes of a decision, based on certain conditions [39]. Here, the internal node represents a test on the attribute, and each branch of the tree represents the outcome of the test. However, the leaf node represents a particular class label. The classification rules are represented through the path from the root to the leaf node.

❖ **K-Nearest Neighbors (KNN) Algorithm**

- This algorithm is non-parametric used to solve both classification and regression problems. This algorithm assumes that similar things exist in close proximity.

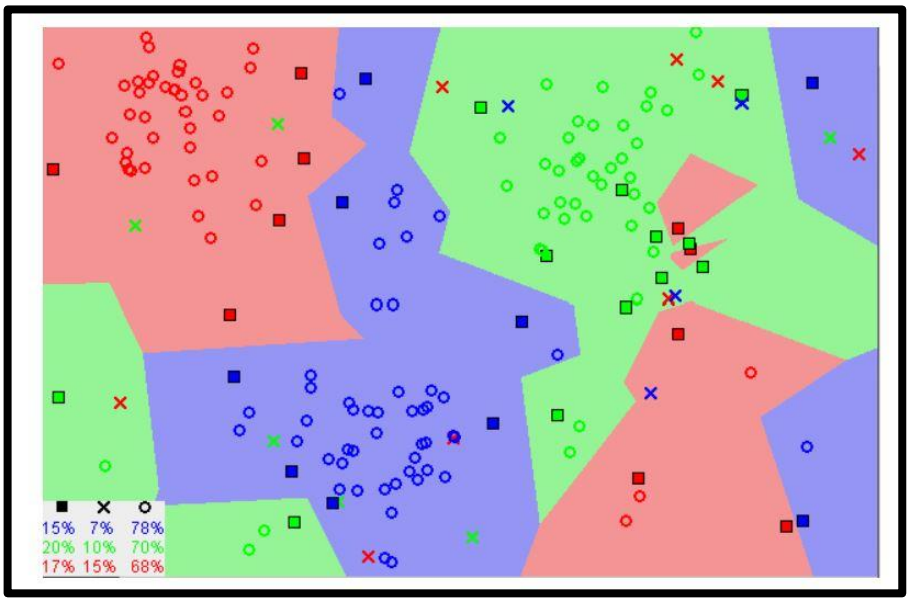


Figure 3.4: Image showing similar data points exist close to each other [40]

- **Adaptive Boosting (AdaBoost) Algorithm**
  - AdaBoost is one of the first boosting algorithms to be adapted in solving practices. It helps you combine multiple "weak classifiers" into a single "strong classifier" [41]. However, this can be used with many other types of learning algorithms to improve performance. AdaBoost is adaptive in the insight that consequent weak learners are tweaked in favor of those instances misclassified by previous classifiers.

Out of these, one or two more accurate algorithms will be implemented according to the context.

As a result of the above mentioned process, road accident prediction data will be generated and stored in a database.

Data Visualization

Meanwhile, the predicted information will be represented graphically. Here, several images will be used in order to highlight key factors that will be considered for predictions and to display the predicted key results. The relationships will be also pointed out as a result of this process. It's a systematic mapping process between graphic marks and data values.

Displaying Data – Web Application

As the final step of the road accident prediction process, the predicted data will be displayed through the SmartCop web-based application GUI. It will be implemented according to the best User Experience (UX). The predicted output has four main features.

- Specific areas of road accidents in a particular region
- Frequency of road accidents
- Severity of the accidents
- Reason for the accident

3.3.2 Develop a model for scheduling traffic police officers

Data Collection

Required data will be collected from Mirihana Police Station (Colombo South) in Sri Lanka during the period from 2015 to 2019. Officers' data including their personal information, experience gained, and training taken are stored in a hard copy database in the main police station of each police division.

Data preprocessing

Data preprocessing is the process that takes place before data analysis. Two main tasks will take place respectively data transformation and data filtering.

Data transformation

Details of all police officers are stored in hard copy data storage. Hence the data will be going through a data transformation process and concert to a format that features of data can be easily interpreted by algorithms.

Data Filtering

Transformed data of all officers will be filtered under a few categories such as police officers' experience, training taken, shift information and leave taken. Then the filtered data will be stored in a data warehouse.

Data analyzing

After the preprocessing data will be going through an analysis process in order to achieve expected objectives. Both supervised and unsupervised learning algorithms are going to be used for the analysis process. Among Supervised learning algorithms such as Naïve Based, K-Nearest Neighbors, Decision Tree, Random Forest a suitable algorithm will be selected to predict the availability through a shift based analysis. And

for the qualification analysis, a suitable unsupervised algorithm such as K-means will be used.

After the statistical analysis output data will be stored in a database that is only accessible for the limited number of authorized officers under two main categories respectively availability prediction data and Qualification data.

- **Random Forest Algorithm**
  - Random Forest algorithm is one of the most well-known algorithms among classification algorithms. The random forest comprises a number of decision trees and each decision tree created on data samples makes predictions. However, voting will be performed for every decision tree and tree with the most votes will become the best solution and that will be the final prediction result [42].

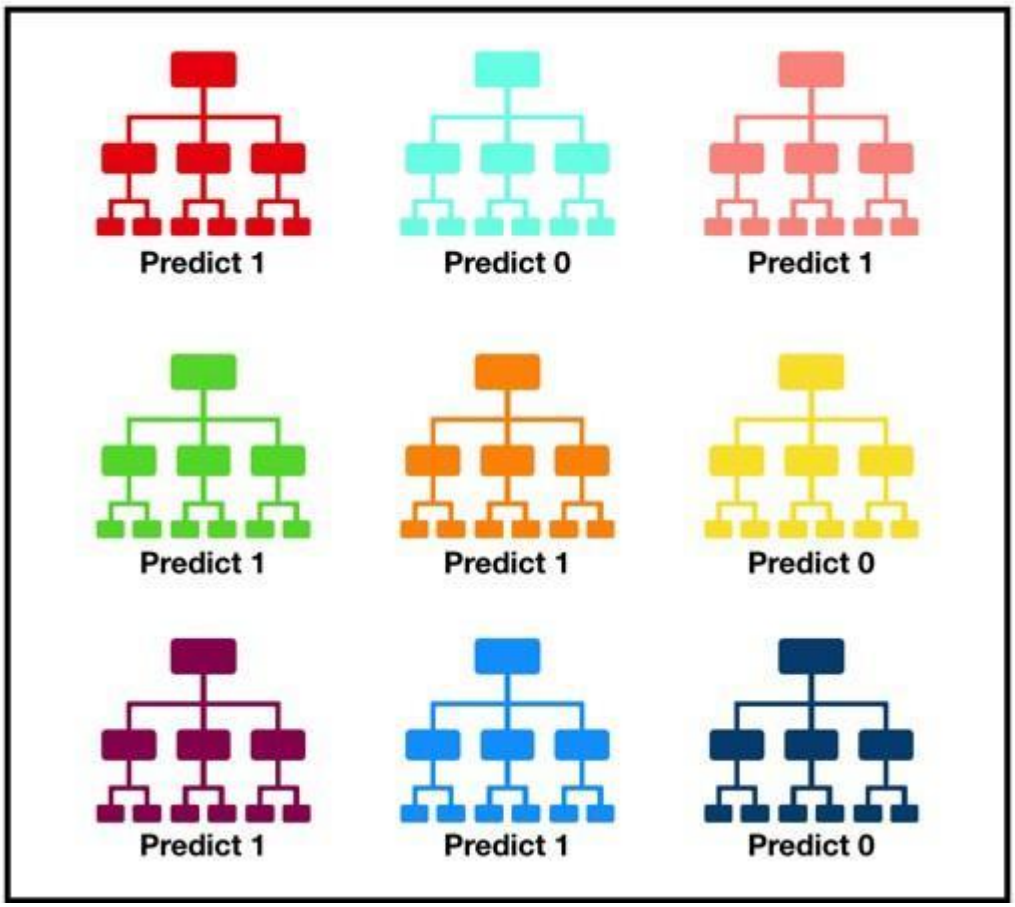


Figure 3.5: Demonstration of the random forest algorithm

- **K-Means Algorithm**
  - K-Means or Flat Clustering algorithm belongs to the category of unsupervised learning. K indicates the number of clusters that the data categorized into. Data points will be categorized where the sum of the squared distance between data points and centroid is minimum. The algorithm works iteratively on the data points and assigns data into categories based on the features. This algorithm is used to find the group of unlabeled data or to identify undiscovered groups of a data set [43].

Recommendation

Analyzed data will be going through a recommendation process in order to recommend the most available and appropriate officers. For this process, the predicted road accident data is also going to be used.

Displaying Data

Recommended police officers' information will be displayed in the SmartCop web-based application. This application is only accessible by the authorized police officers. The output will be displayed under four main categories.

- Officers details
- shift period
- Enforcement area
- Reason for the accident

Send Notifications

In order to inform allocated traffic police officers a notification through SMS will be sent to the relevant officers.

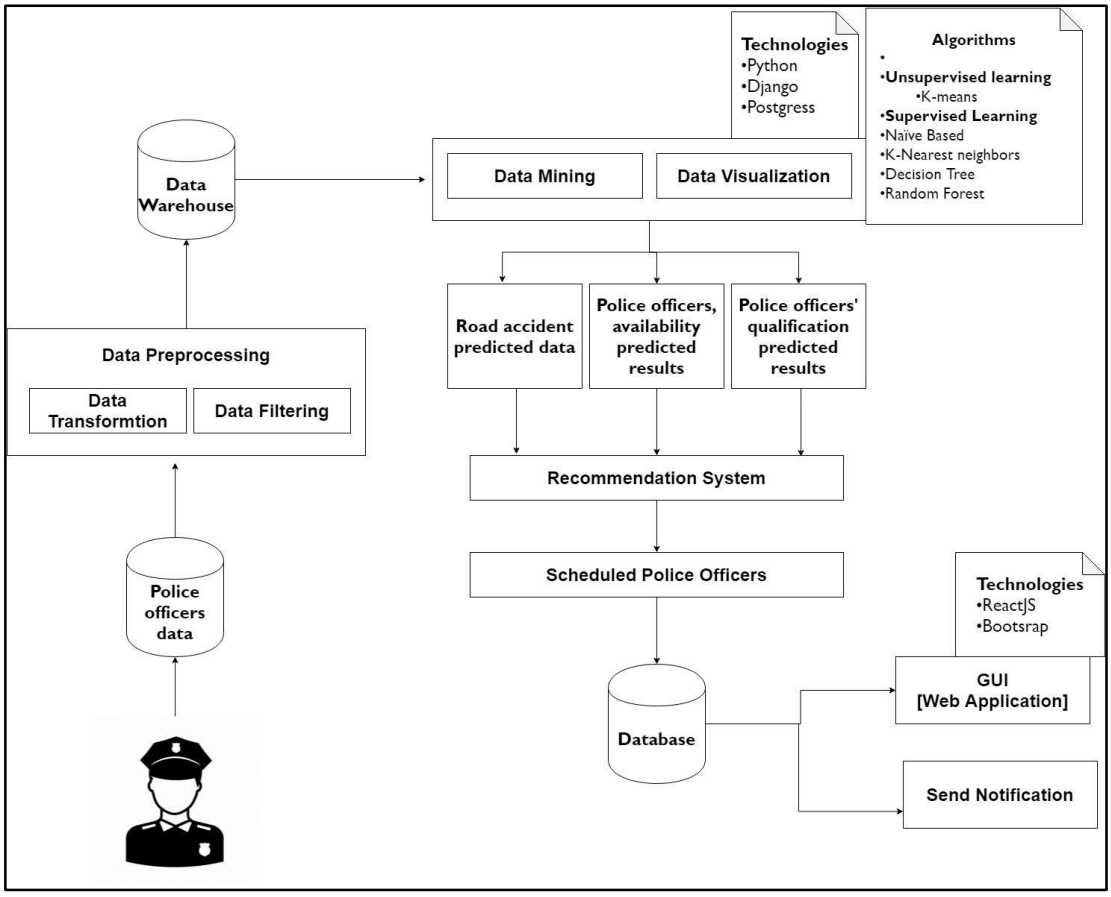

Technologies
•Python
•Django
•Postgress
Algorithms
•
•Unsupervised learning
•K-means
•Supervised Learning
•Naïve Based
•K-Nearest neighbors
•Decision Tree
•Random Forest
Data Warehouse
Data Mining
Data Visualization
Road accident predicted data
Police officers, availability predicted results
Police officers' qualification predicted results
Data Preprocessing
Data Transformtion
Data Filtering
Recommendation System
Scheduled Police Officers
Police officers data
Technologies
•ReactJS
•Bootsrap
GUI [Web Application]
Database
Send Notification

Figure 3.6: police officers scheduling methodology

3.3.3 Develop a game-based mobile application to enhance road accident prevention awareness among the public

Requirement Gathering and Analysis

A suitable game genre will be chosen after studying and reviewing existing systems, relevant research papers and a conducting survey (Appendix A).

Design and Implementation

According to the gathered information, an appropriate mobile game will be designed and developed using Android Studio. The proposed game will be used as a Game-Based Learning approach to enhance road accident prevention awareness among the community. The game will make it easier for instructing and retaining traffic rules and road safety ethics to people. Most of the road accidents causing factors will be addressed by the game. Therefore users can refresh and retain their existing knowledge. Moreover, since an overview explanation of the tested facts will be provided upon level completion, users may also be able to learn unknown factors. The game will measure a particular user's awareness level progress through the game

score, elapsed time in game levels and previous attempt details. These attempt details and awareness level progress reports will be accessible from individual user profiles.

Since the game playing styles and skills are different to each and every user, the predefined game levels may not be much engaging and effective when learning through games. Therefore, with the aid of Reinforcement Learning, the game playing styles and skills of each and every user will be tracked and the next level of the game will be dynamically designed for each user customized for their skill level. In addition, this system will permit police officers to review overall public awareness reports and help them in further required decision making.

Ultimately, the game will improve knowledge retention, decision making, and problem-solving skills of the users and that may enhance the road accident prevention awareness among the community.

Testing

Upon unit testing, integration testing, and system testing, the game will go through User Acceptance Testing (UAT). If the system will not be able to get UAT approved, it may have to redo the previous flow of events and continue to do modifications until the game gets UAT approved

Releasing and Distribution

Upon approval, the product will be released and will be available for the public freely accessible through the Google Play Store.

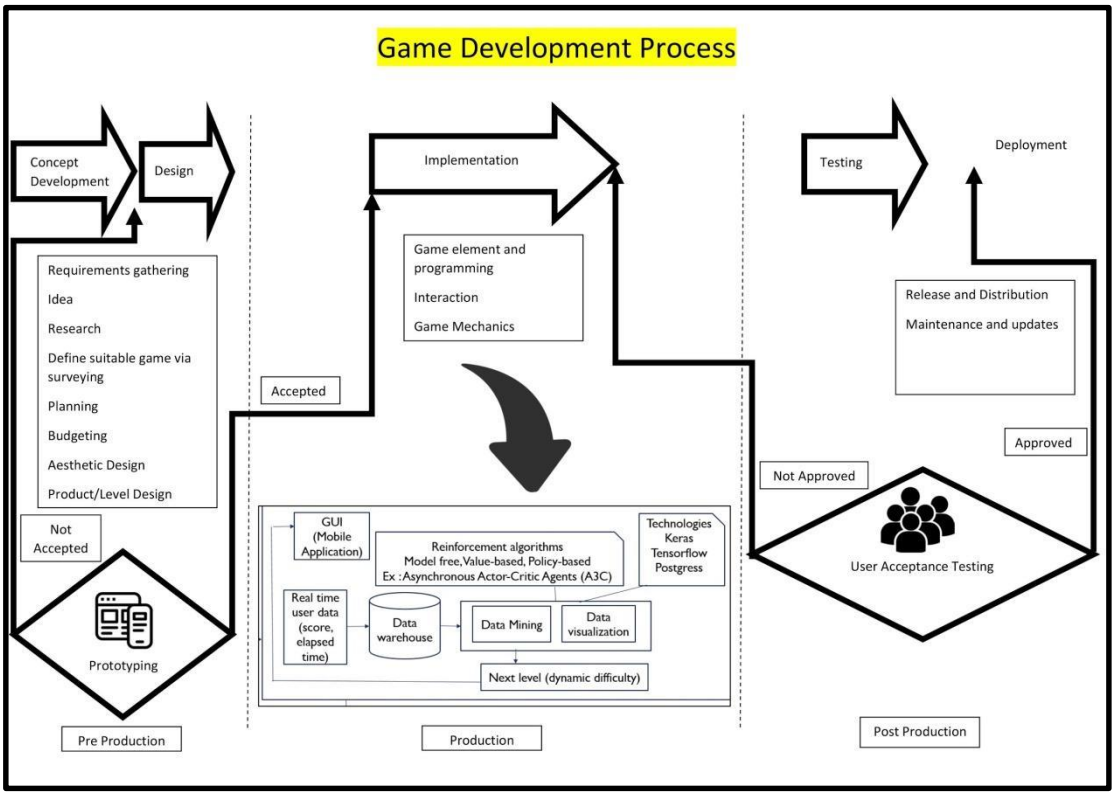


Figure 3.7: Game development process

3.3.4 Develop a game-based mobile application to improve the road accident response

According to the responses that were obtained through the survey (using Appendix B), 53.3% of responses suggested having a picture quiz game. So in order to design a picture quiz mobile application, the system will be going to use the android studio with java.

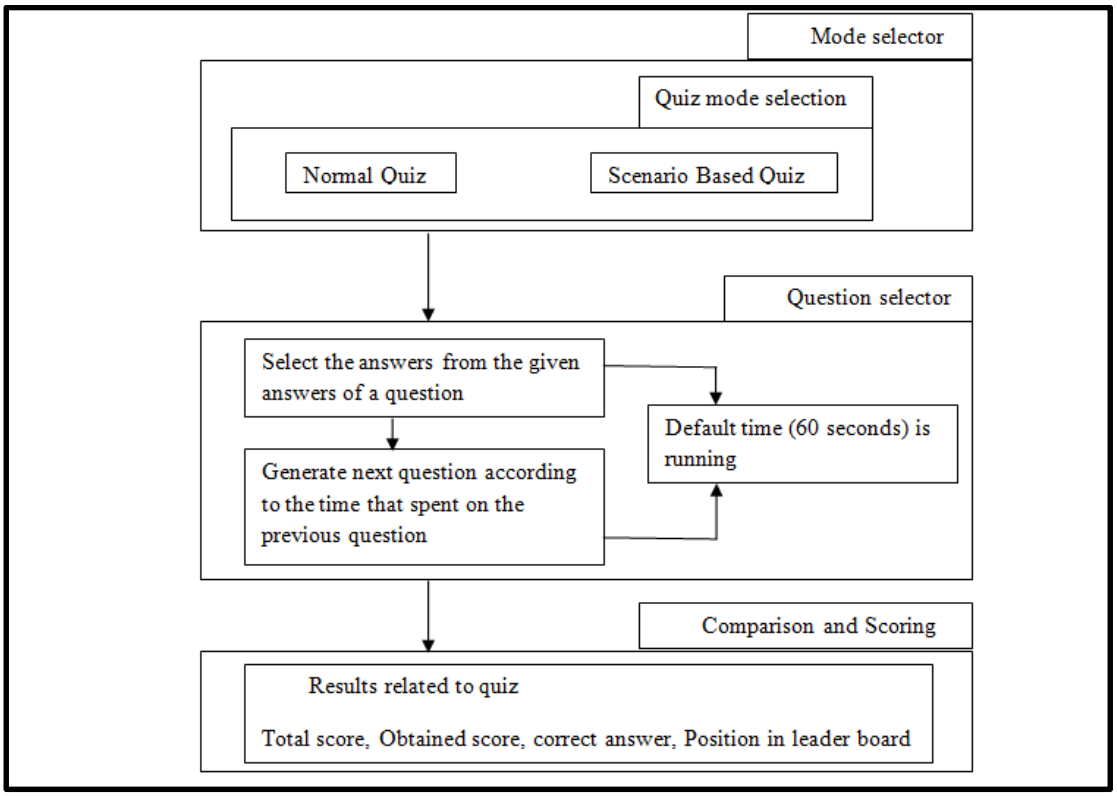


Figure 3.8: Proposed system overview diagram for road accident response awareness game

The proposed system Figure 3.3.4. a contains following 3 modules:

1. Mode selector
2. Question selector
3. Comparison and Scoring

3.3.4.1. Mode selector

The mode selector section allows the player to choose a mode out of given modes, that is, Normal Quiz mode and Scenario Based Quiz mode. If a player selects normal quiz mode then he/she plays with common questions. If a player selects a scenario-based quiz then he/she plays with specific scenario questions. For an example, if a player selects a Normal Quiz mode then a question will be displayed as below.

Figure 3.9: Picture of normal quiz mode

When caring for a victim with a bloody nose you would not ----------

1. Apply an ice pack to the bridge of the nose
2. Apply pressure to upper lip just beneath the nose
3. Have the victim sit with head tilted slightly backward while pinching the nostrils together
4. Have the victim sit with head tilted slightly forward while pinching the nostrils together

If a player selects a Scenario-Based Quiz mode then a question will be displayed as below.

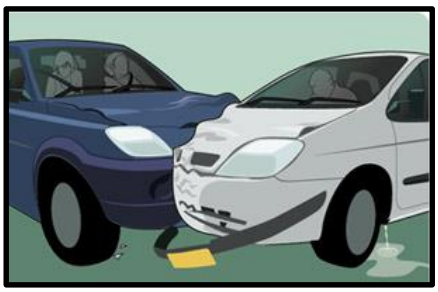


Figure 3.10: Picture of scenario-based quiz mode

Situation: Head-on collision of two cars. You first arrived at the scene of the accident.

Question 1. What should be your first action?

1. To turn on the emergency lights of your car to warn the other road users.

2. To stand in the middle of the roadway to warn the other road users.
3. To park your car, turn on the emergency lights of your car and call the "Ambulance".

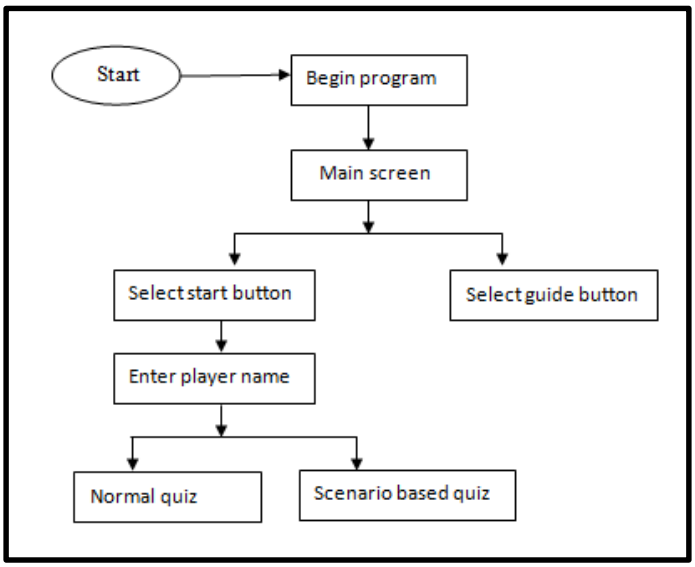


Figure 3.11: Flow chart of the mode selector

3.3.4.2. Question selector

In this section, the next question is generated randomly which means, if the player answered the question within the allocated time (60 seconds) then the system generates the next question with a little harder than the previous question if not generate the question with a little easier than the previous question. This step is done using reinforcement learning. One or more suitable algorithms can be chosen from value-based, policy-based and model-free. Questions are stored in a database.

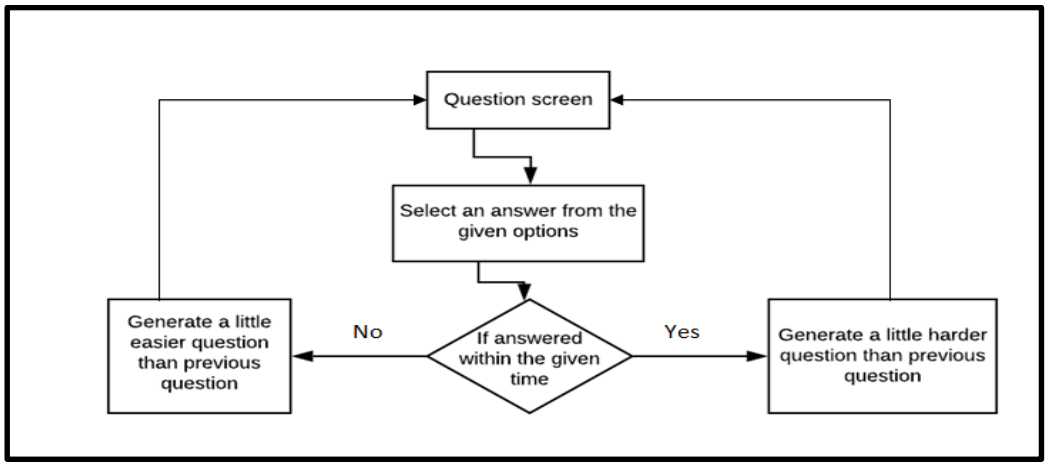


Figure 3.12: Flow chart of question selector

3.3.4.3. Comparison and scoring

In here outputs such as Total score, Obtained score, Position in the leaderboard and Correct answer are displayed based on the given inputs provided by the player. The outputs are stored in the database. Finally, select the home button to exit from the

game.

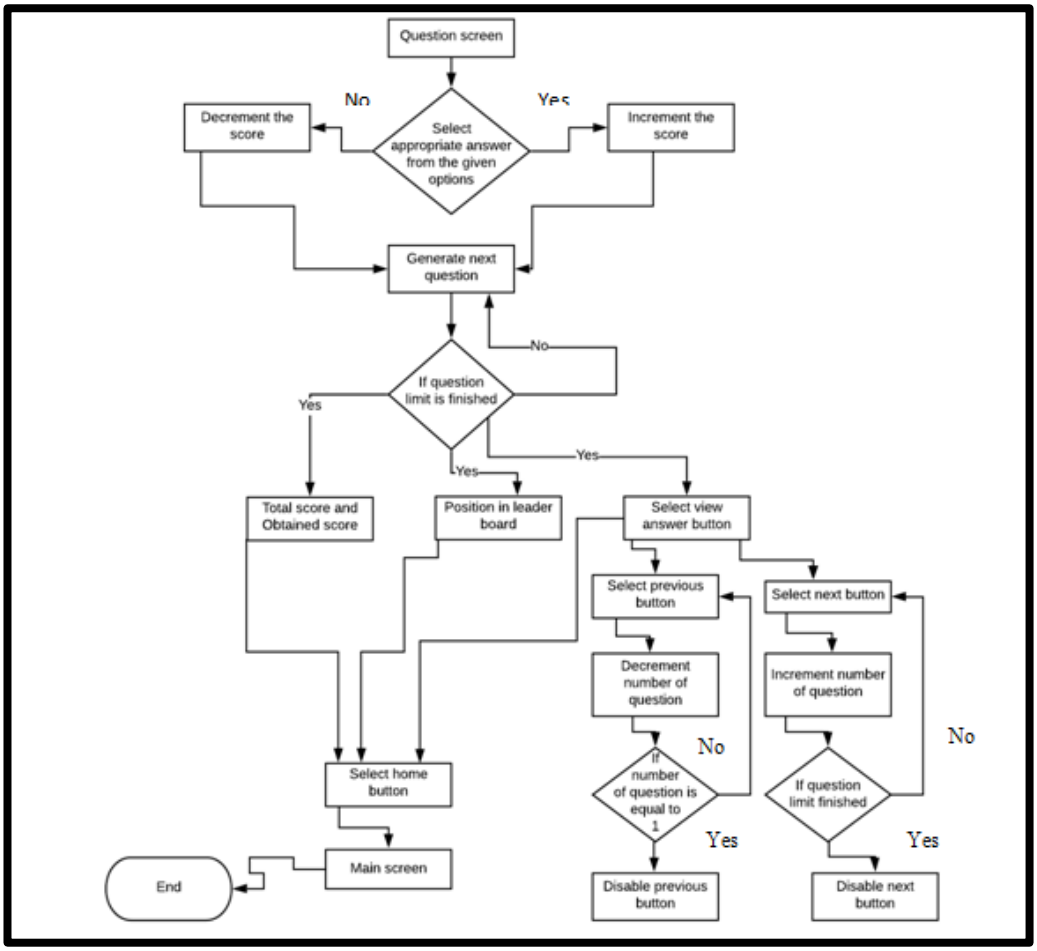


Figure 3.13: Flow chart of comparison and scoring

3.4. Tools and Technologies

3.4.1 Tools

SQLite will be used as the database for game-based mobile applications. SQLite is an open-source SQL database that stores data to a text file on a device [44]. SQLite

supports Integer, Text, Real data types. Android comes in with built-in SQLite database implementation. PostgreSQL will be used as the database for website development since it can hold both SQL and NoSQL data at the same time. In addition, it's a free and open-source relational database management system that is generated to handle a range of workloads from single machines to data warehouses or web services. Meanwhile, it provides the capacity to handle concurrent users.

Android studio will be used for mobile application development. It is easy to develop an innovative user interface and it has each and every tool that is required to implement android games.

Visual Studio Code or PyCharm will be used as the Integrated Development Environment (IDE) in order to implement the code. Visual Studio Code is developed by Microsoft for Windows, Linux, and macOS while PyCharm is an IDE used in computer programming, especially for the Python language.

3.4.2 Technologies

As the back-end technologies, Python and Django will be applied for the SmartCop web-based application. Python is an object-oriented, high-level and general-purpose programming language. This can be used for a wide variety of applications. It consolidates modules and packages, exceptions, dynamic data types, and classes. The Python interpreter and the substantial standard library are accessible in source or binary and freely distributed. In addition, Django is a high-level Python framework. As for front-end technologies, ReactJs, HTML5, CSS3, and Bootstrap4 will be applied.

Java will be used for SmartCop mobile applications. Java is a pure object-oriented language. Android applications can be developed using Java is easy. Java Platform Micro Edition (Java ME) is portable, secure, flexible and can take advantage of the native capabilities of the device [45]. Java ME addresses the constraints that are involved in building applications that are targeted at mobile devices.

4. DESCRIPTION OF PERSONAL AND FACILITIES

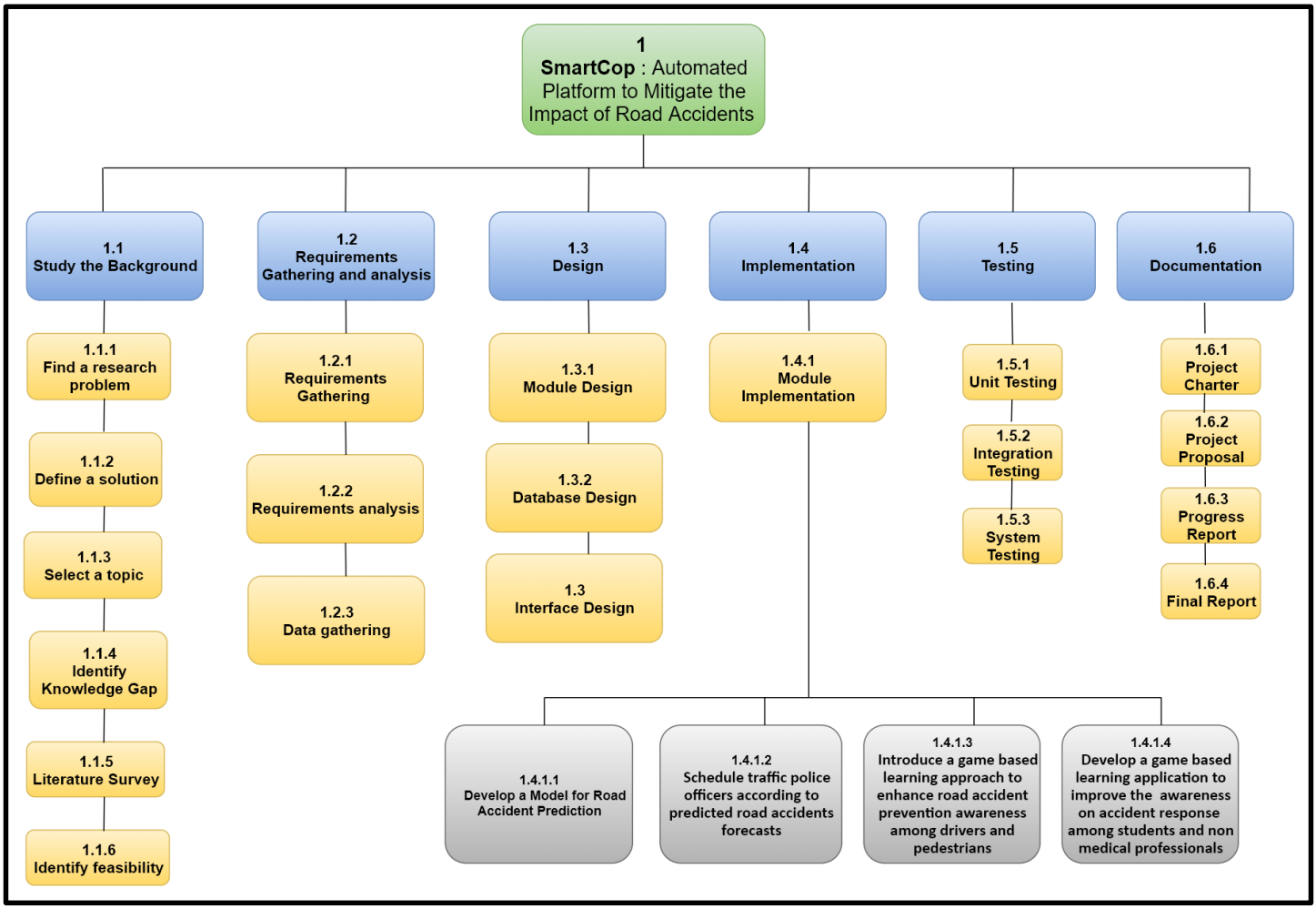


Figure 4.1: work breakdown structure

5. PROJECT REQUIREMENTS

5.1. Functional Requirements

SmartCop: Web-Based Application

- Observe road accident prediction information

Table 5.1: Functional requirement - view road accident prediction

Input	Process	Output
-	The relevant police officer clicks on the "Road Accident Prediction" button and predicted results will be loaded including the specific area, frequency, severity, and reason of road accidents.	Road accident prediction details

- View police officers scheduling and disseminating recommendations

Table 5.2: Functional requirement - view scheduling

Input	Process	Output
-	Police officer will direct to the Officers scheduling page and click on view schedule details.	Display Recommended officers. Display schedule details

SmartCop: Mobile Application

- View accident prevention game
- Observe the results of accident prevention game
- View road accident response picture quiz game
- Observe the results of the picture quiz
- Display feedback

Table 5.3: Functional requirements - Road accident awareness

	Input	Process	Output
Road Accident Prevention Game	The player answers questions.	Calculate the scores based on the answers Analyze player's playing skills, styles and dynamically generate the next level.	Display score, elapsed time, leaderboard position and next question.
Road Accident Response Game(Picture quiz)	Input answers for questions	Calculate the time spent on a previous question and generate the next question. Calculate the scores based on the answers provided by the player.	Display next question, score, and Position in the leaderboard

5.2. Non-Functional Requirements

- Performance: The system should recommend the most suitable, currently available policemen within 30 seconds for 95% of the time that it is requested.
- Availability: The system should be available 24*7.
- Usability: The games shall be self-explanatory so that it should be easy to use by both children and adult members of the public.
- Confidentiality: Only police officers with authorized logins may view accident prediction details and scheduling process.
- Portability: The web-based system should be compatible with new browser versions and different browser types.

5.3. Expected Test Cases

5.3.1. Functional testing test cases

1. To validate whether all the required mandatory fields are working as required.
2. To validate that the mandatory fields are displayed on the screen in a distinctive way than the non-mandatory fields.
3. To validate whether the application works as per as required whenever the application starts/stops.
4. To validate that the application allows necessary social network options such as sharing, posting, and navigation, etc.
5. To validate that the page scrolling scenarios are being enabled in the application as necessary.
6. To validate that the navigation between relevant modules in the application is as per the requirement.
7. To validate that the user receives an appropriate error message like “Network error. Please try after some time” whenever there is any network error.
8. To validate that the application resumes at the last operation in case of a hard reboot or system crash.
9. To validate whether the installation of the application can be done smoothly provided the user has the necessary resources and it does not lead to any significant errors.
10. To validate whether the application performs according to the requirement in all versions of Mobile that is 2g, 3g, and 4g.
11. To validate whether the application provides an available user guide for those who are not familiar to the app

5.3.2. Performance testing test cases

1. To determine whether the application performs as per the requirement under different load conditions.

2. To determine whether the current network coverage is able to support the application at peak, average and minimum user levels.
3. To validate whether the response time of the application is as per the requirements.
4. To evaluate the product and/or hardware to determine if it can handle projected load volumes.
5. To evaluate whether the battery life can support the application to perform under projected load volumes.
6. To validate application performance when the network is changed to WIFI from 2G/3G or vice versa.
7. To validate each of the required CPU cycles is optimization
8. To validate that the battery consumption, memory leaks, resources like GPS, Camera performance is well within required guidelines.
9. To validate the application longevity whenever the user load is rigorous.
10. To validate the network performance while moving around with the device.
11. To validate the application performance when only intermittent phases of connectivity are required.

5.3.3. Security testing test cases

1. To validate whether an application is not permitting an attacker to access sensitive content or functionality without proper authentication.
2. To validate that the application has a strong password protection system and it does not permit an attacker to obtain, change or recover another user's password.
3. To validate that the application does not suffer from insufficient session expiration.
4. To protect the application and the network from the denial of service attacks.
5. To analyze the data storage and data validation requirements.
6. To enable the session management for preventing unauthorized users from accessing unsolicited information.

7. To validate whether the business logic implementation is secured and not vulnerable to any attack from outside.

5.3.4. Usability testing test cases

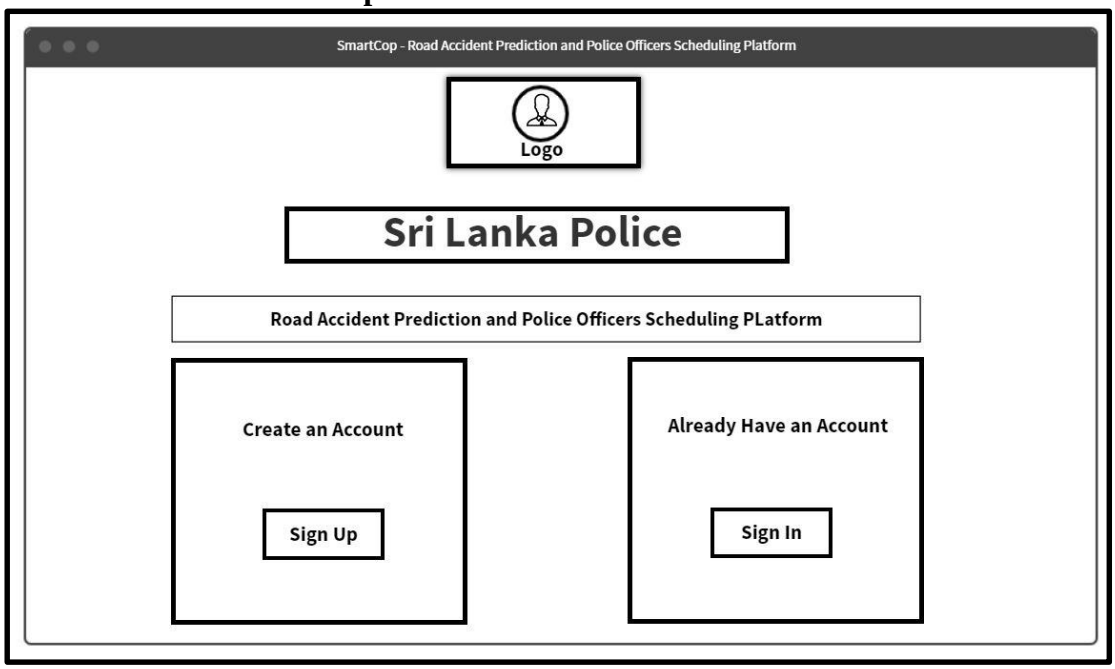
1. To ensure that the buttons should have the required size and be suitable for big fingers.
2. To ensure that the buttons are placed in the same section of the screen to avoid confusion to the end-users.
3. To ensure that the icons are natural and consistent with the application.
4. To ensure that the buttons, which have the same function should also have the same color.
5. To ensure that the validation for the tapping zoom-in and zoom-out facilities should be enabled.
6. To ensure that the keyboard input can be minimized in an appropriate manner.
7. To ensure that the application provides a method for going back or undoing an action, on touching the wrong item, within an acceptable duration.
8. To ensure that the contextual menus are not overloaded because it has to be used quickly.
9. To ensure that the text is kept simple and clear to be visible to the users.
10. To ensure that the short sentences and paragraphs are readable to the end-users.
11. To ensure that the font size is big enough to be readable and not too big or too small.
12. To ensure that the application items are always synchronized according to the user actions.
13. To ensure that the end-user is provided with a user manual which helps the end-user to understand and operate the application who may be not familiar with the application's proceedings

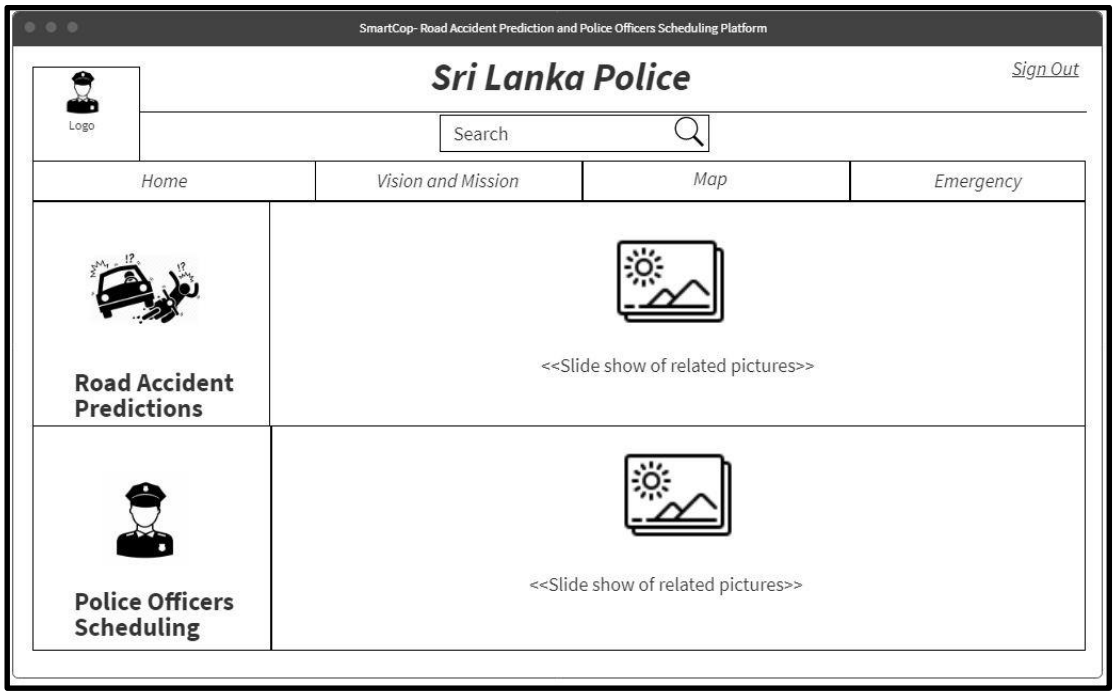
5.3.5. Compatibility testing test cases

1. To validate that the user interface of the application is as per the screen size of the device, no text/control is partially invisible or inaccessible.
2. To ensure that the text is readable for all users for the application.

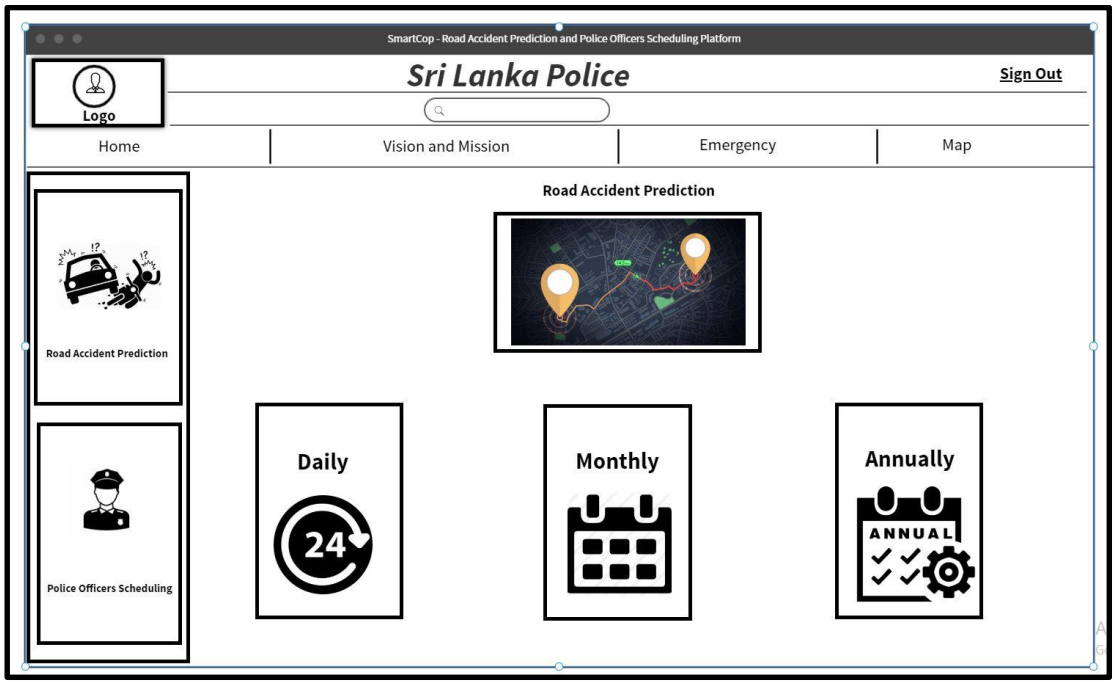
5.4. Wireframes

5.4.1. View road accident predictions




SmartCop- Road Accident Prediction and Police Officers Scheduling Platform
Logo
Sri Lanka Police
Sign Out
Search
Home
Vision and Mission
Map
Emergency
<<Slide show of related pictures>>
Road Accident Predictions
<<Slide show of related pictures>>
Police Officers Scheduling


SmartCop - Road Accident Prediction and Police Officers Scheduling Platform
Police Officers Login
USER ID
PASSWORD
CAptcHA
Enter the Characters
Login


SmartCop - Road Accident Prediction and Police Officers Scheduling Platform
Logo
Sri Lanka Police
Sign Out
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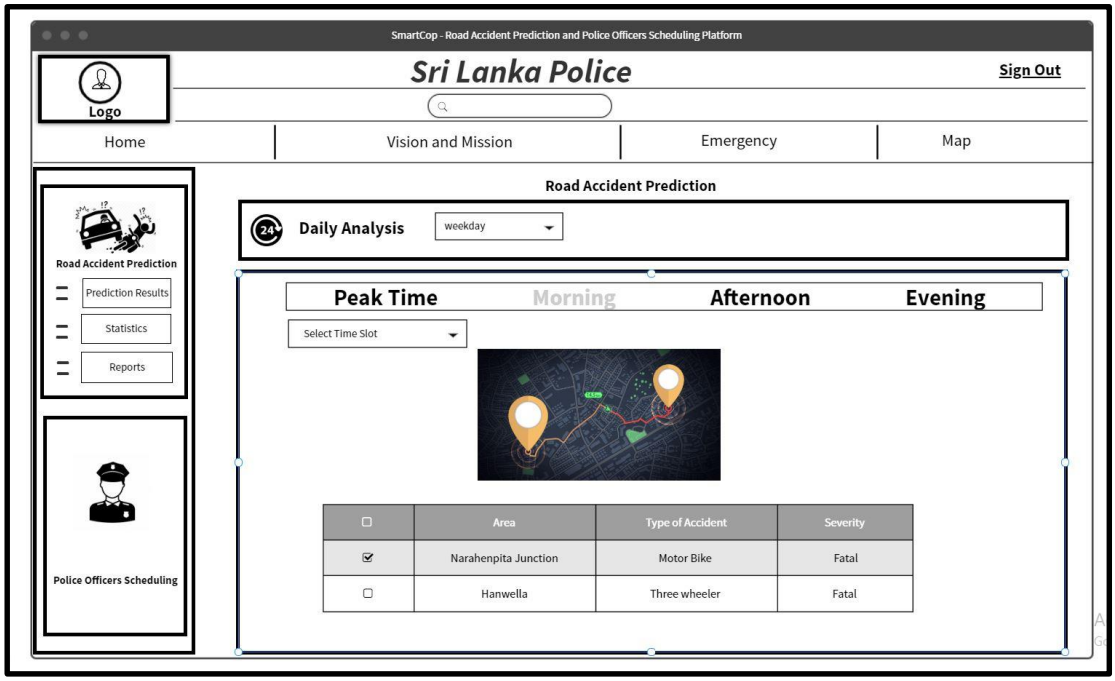
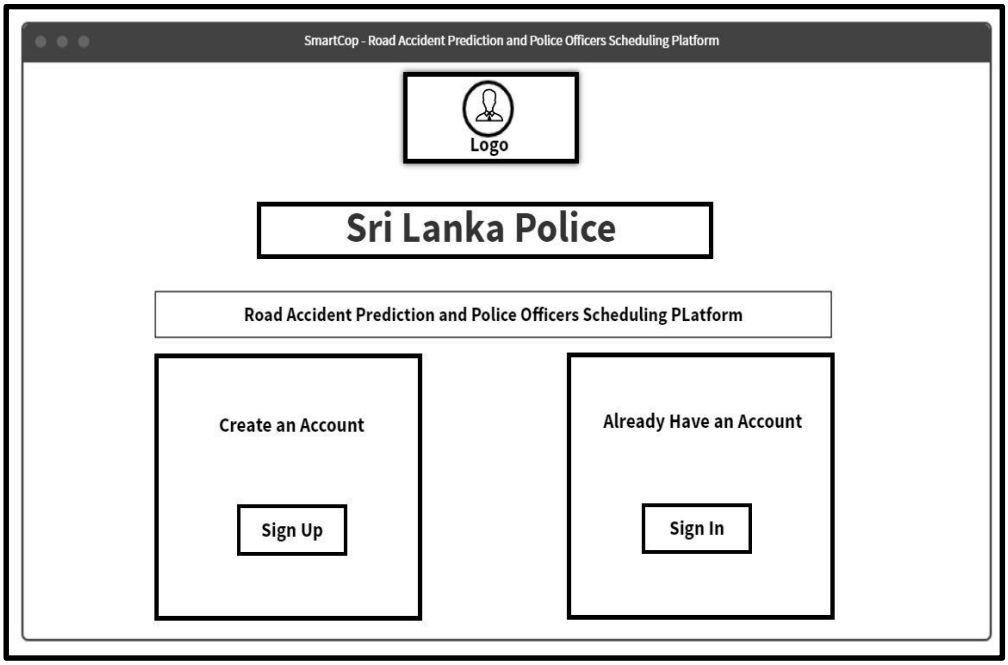
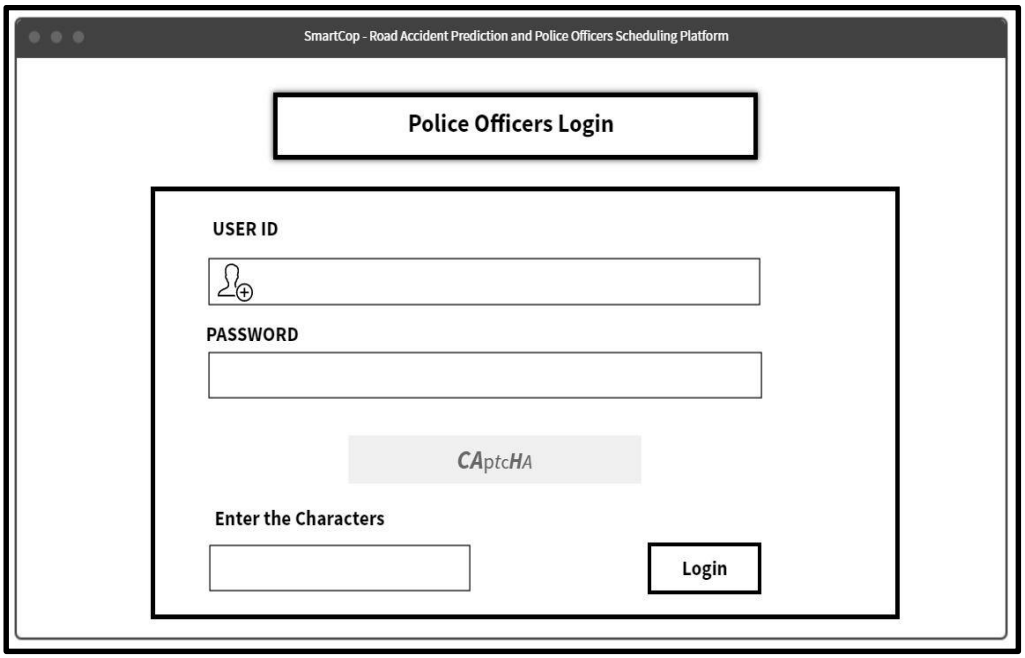
Vision and Mission
Emergency
Map
Road Accident Prediction
Road Accident Prediction
Police Officers Scheduling
Daily
Monthly
Annually
ANNUAL


SmartCop - Road Accident Prediction and Police Officers Scheduling Platform
Logo
Sri Lanka Police
Sign Out
Home
Vision and Mission
Emergency
Map
Road Accident Prediction
Road Accident Prediction
Prediction Results
Statistics
Reports
Police Officers Scheduling
Daily Analysis
weekday
Peak Time
Morning
Afternoon
Evening
Select Time Slot
Area
Type of Accident
Severity
Narahenpita Junction
Motor Bike
Fatal
Hanwella
Three wheeler
Fatal

5.4.2. Scheduling Traffic Police Officers




SmartCop - Road Accident Prediction and Police Officers Scheduling Platform
Police Officers Login
USER ID
PASSWORD
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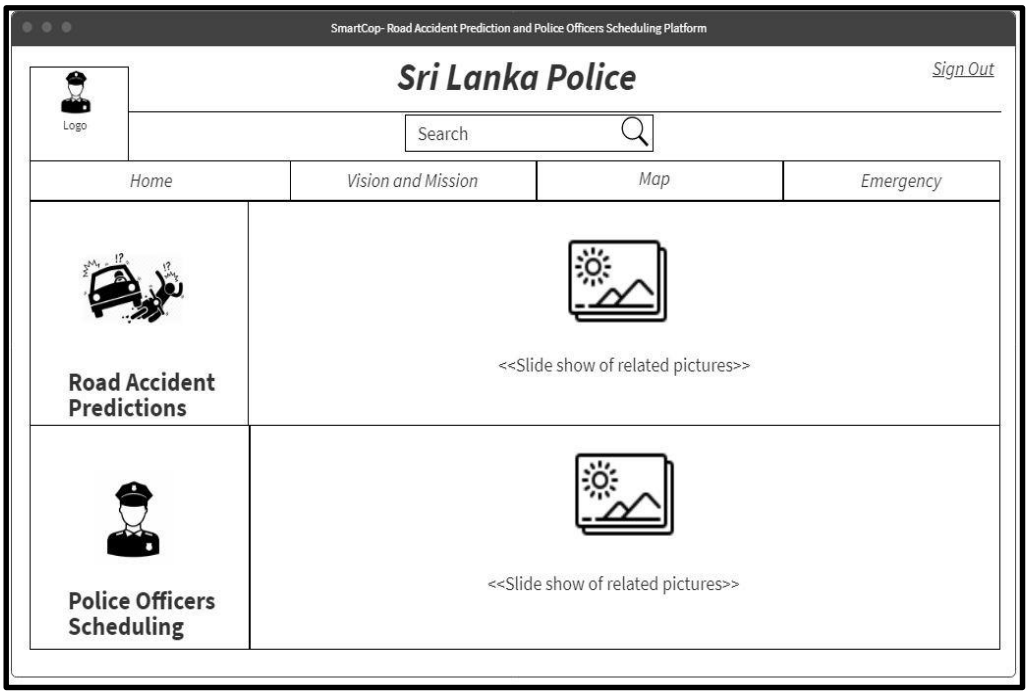
Enter the Characters
Login


SmartCop- Road Accident Prediction and Police Officers Scheduling Platform
Logo
Sri Lanka Police
Sign Out
Search
Home
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Emergency
Road Accident Predictions
<<Slide show of related pictures>>
Police Officers Scheduling
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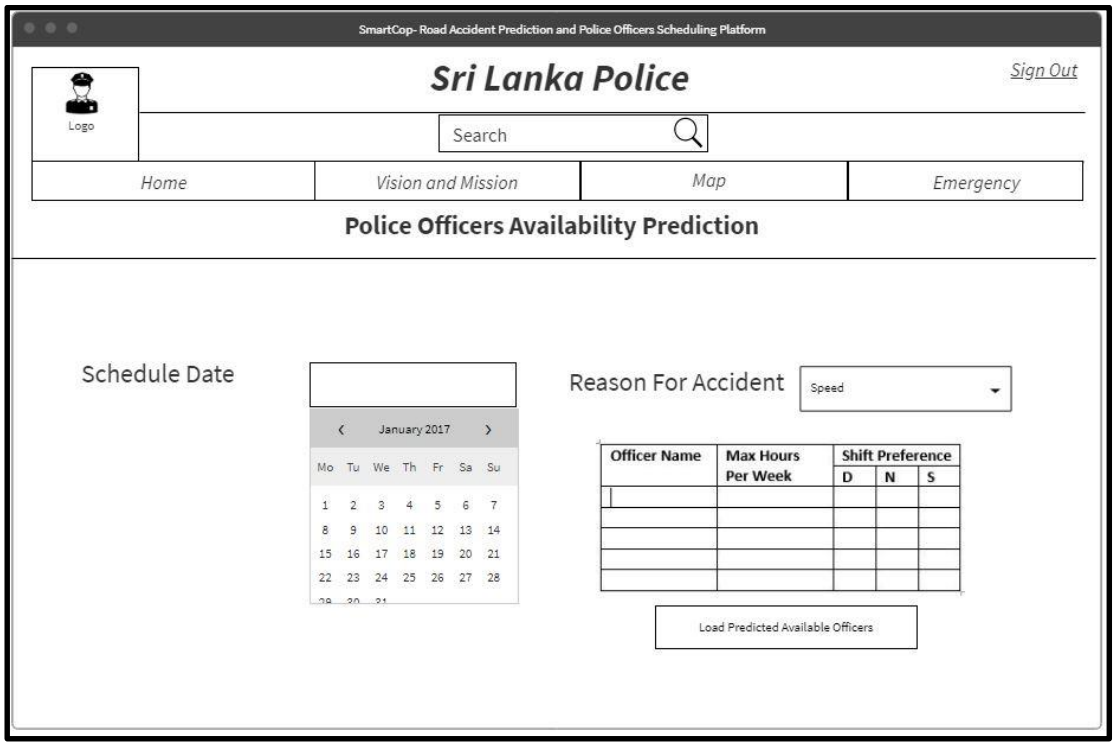
SmartCop- Road Accident Prediction and Police Officers Scheduling Platform
Sri Lanka Police
Sign Out
Logo
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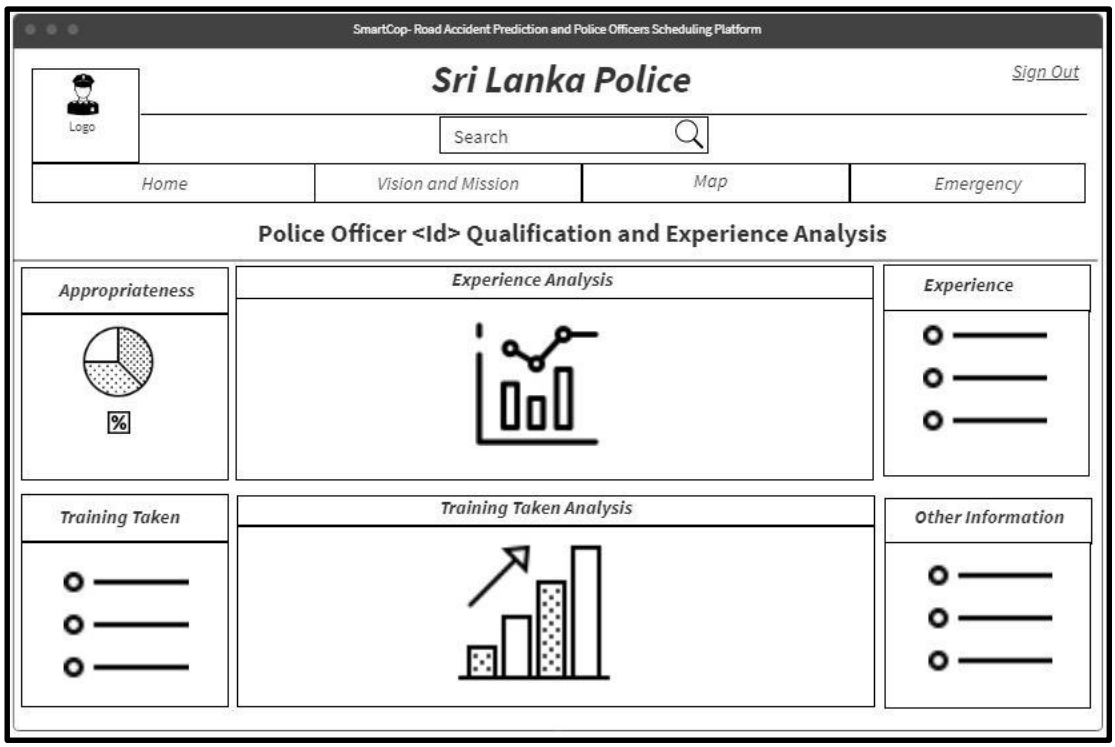
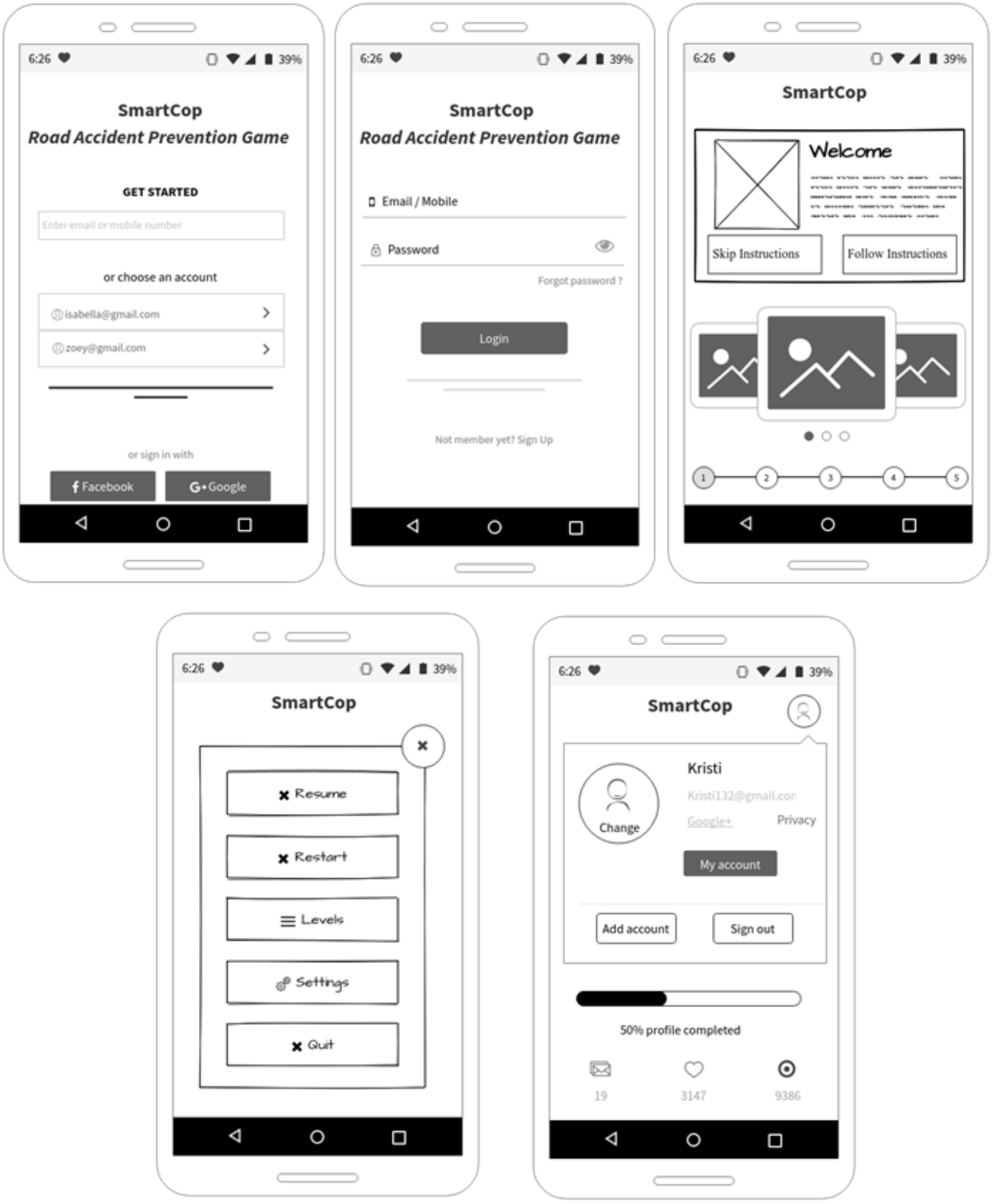
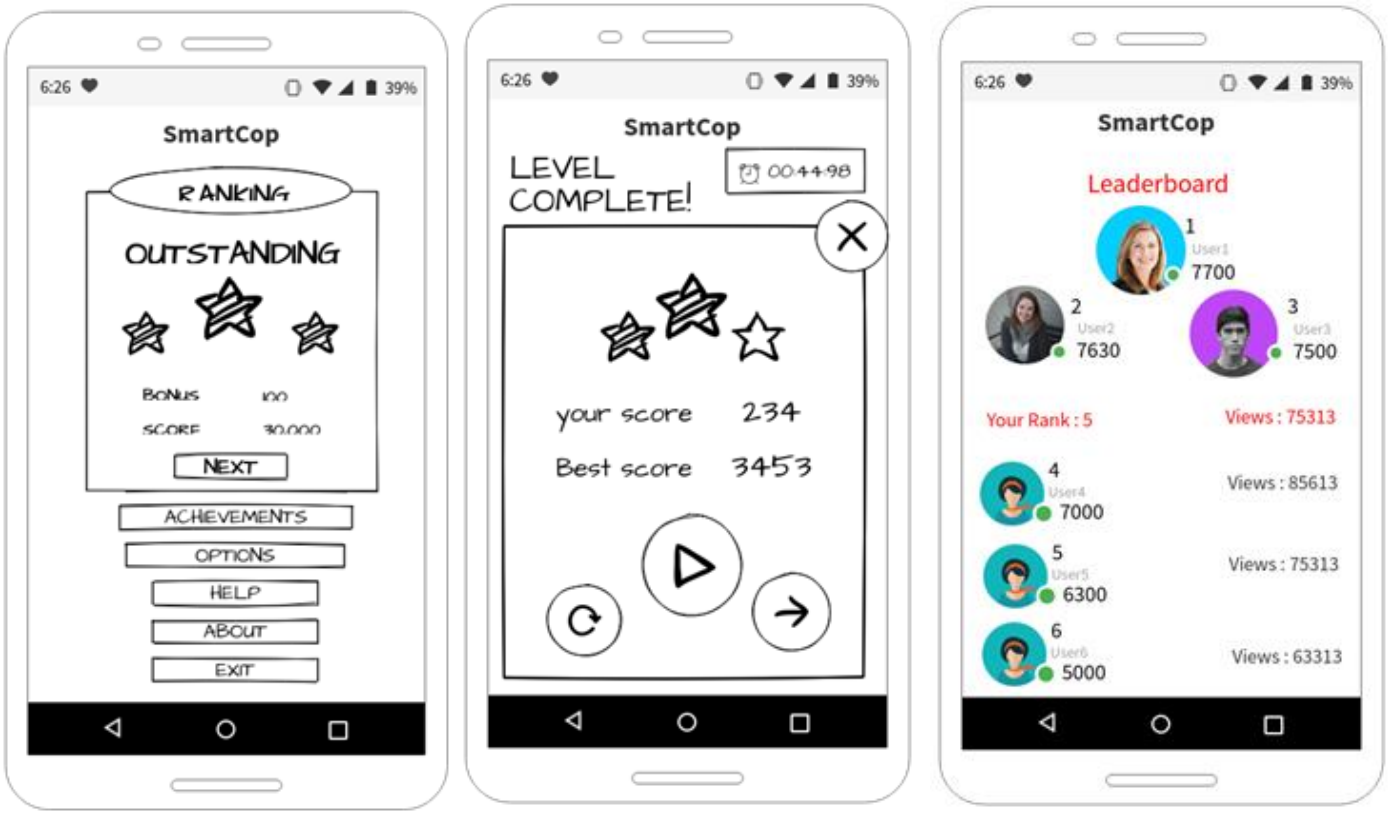
Home
Vision and Mission
Map
Emergency
Police Officers Availability Prediction
Schedule Date
January 2017
Mo Tu We Th Fr Sa Su
1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
Reason For Accident
Speed
Officer Name
Max Hours Per Week
Shift Preference
D
N
S
Load Predicted Available Officers


SmartCop- Road Accident Prediction and Police Officers Scheduling Platform
Sri Lanka Police
Sign Out
Logo
Search
Home
Vision and Mission
Map
Emergency
Police Officer <Id> Qualification and Experience Analysis
Appropriateness
%
Experience Analysis
Experience
Training Taken
Training Taken Analysis
Other Information

5.4.3. Road accident prevention awareness game




6:26
39%
SmartCop
RANKING
OUTSTANDING
BONUS
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NEXT
ACHIEVEMENTS
OPTIONS
HELP
ABOUT
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6:26
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SmartCop
LEVEL COMPLETE!
00:44:98
your score 234
Best score 3453
6:26
39%
SmartCop
Leaderboard
1
User1
7700
2
User2
7630
3
User3
7500
Your Rank : 5
Views : 75313
4
User4
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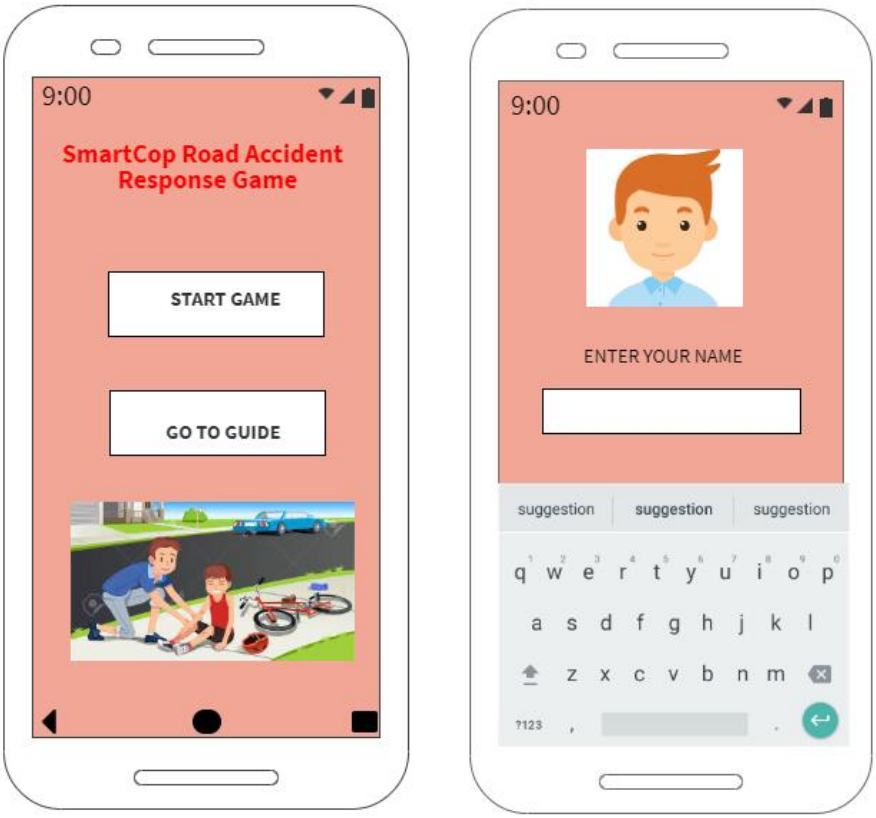
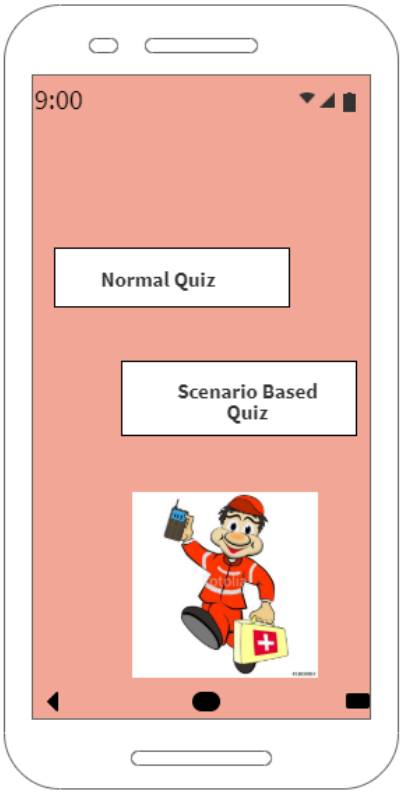
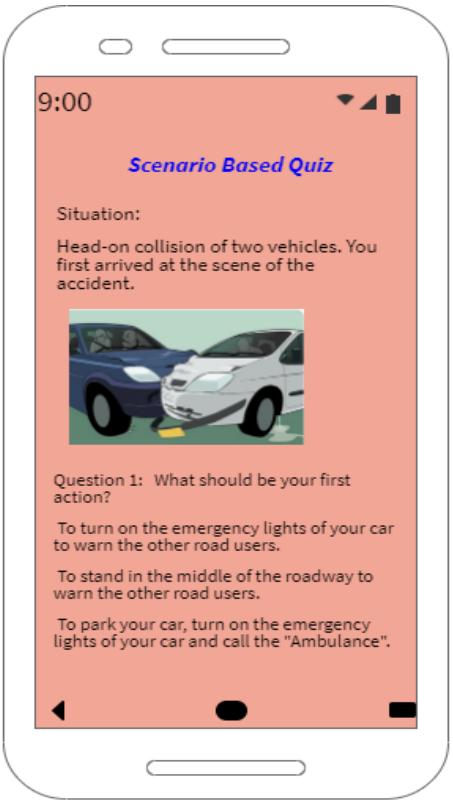
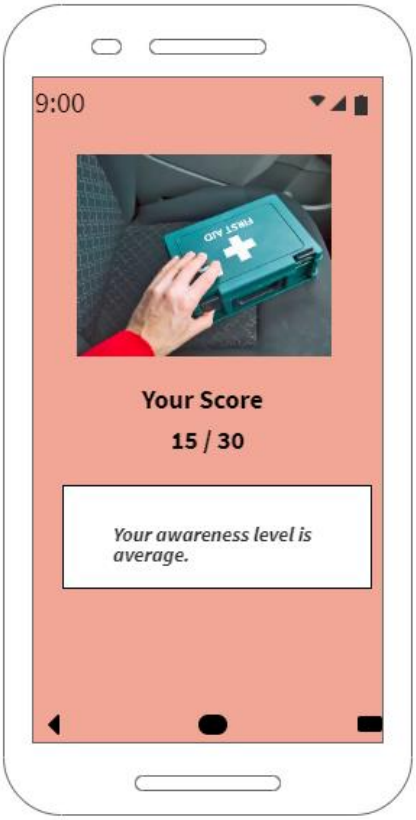
Views : 85613
5
User5
6300
Views : 75313
6
User6
5000
Views : 63313

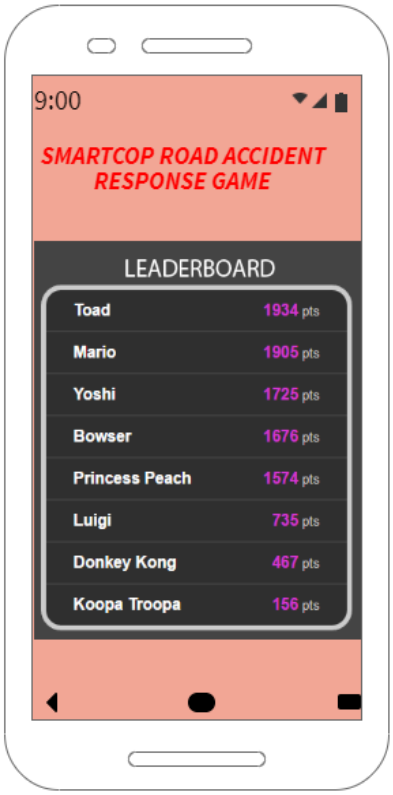
5.4.4. Road accident response awareness game




9:00
Normal Quiz
Scenario Based Quiz


9:00
Scenario Based Quiz
Situation:
Head-on collision of two vehicles. You first arrived at the scene of the accident.
Question 1: What should be your first action?
To turn on the emergency lights of your car to warn the other road users.
To stand in the middle of the roadway to warn the other road users.
To park your car, turn on the emergency lights of your car and call the "Ambulance".


9:00
Your Score
15 / 30
Your awareness level is average.


9:00
SMARTCOP ROAD ACCIDENT RESPONSE GAME
LEADERBOARD
Toad 1934 pts
Mario 1905 pts
Yoshi 1725 pts
Bowser 1676 pts
Princess Peach 1574 pts
Luigi 735 pts
Donkey Kong 467 pts
Koopa Troopa 156 pts

6. Budget and Budget Justification

Budget Items	Number of Items	Cost per Item(Rs)	Total Cash Cost(Rs)	Notes
Field visits	4	140	560	Public transport
Printing materials	8		5000	Topic registration form Project charter 4 individual proposal report 1 group proposal report Final report Product marketing materials(banners)
Access the database through cloud	1	6651	6651	Basic trial version
Hosting mobile apps on google play store	2	4500	9000	Host SmartCop first-aid game Host SmartCop accident prevention game
Hosting a website on google	1	8038	8038	Host SmartCop website
Twilio API	1	1000	1000	SmartCop has a communication system to inform traffic police officers about enforcement
Total budget			29929	

Table 6.1: Budget

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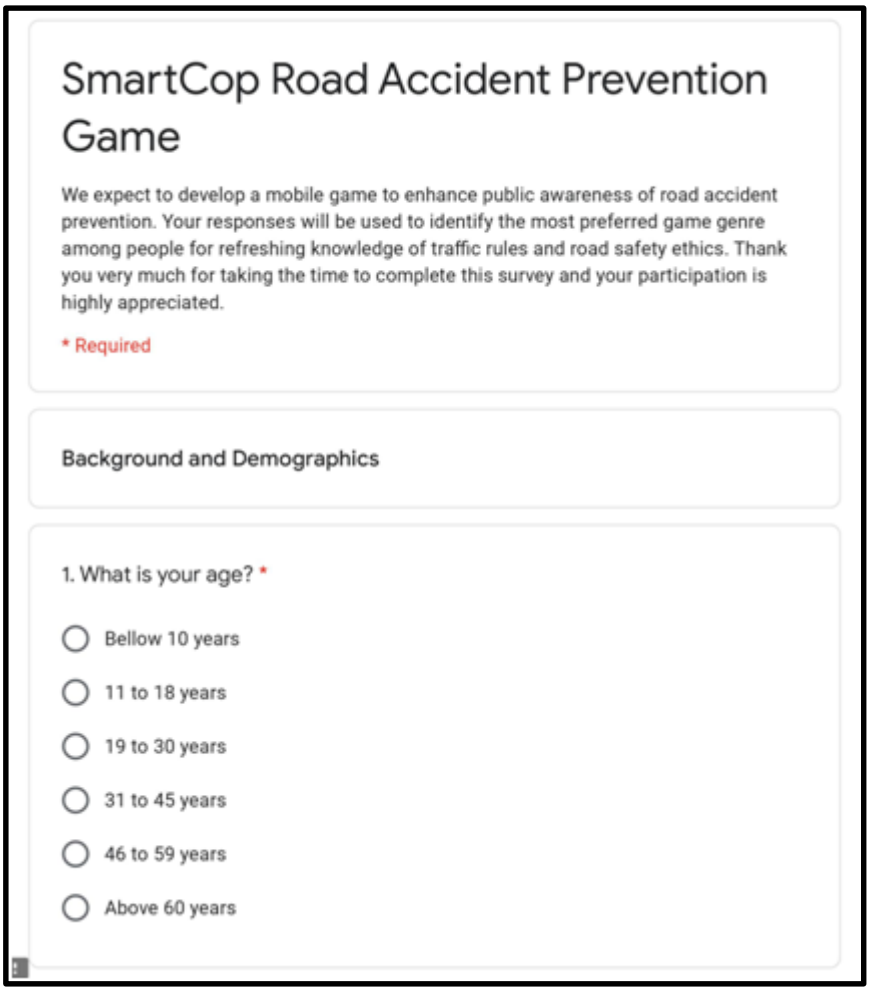
APPENDICES

Appendix A

The survey uses to identify the most preferable game genre among people for refreshing their knowledge of traffic rules and road safety ethics.



SmartCop Road Accident Prevention Game

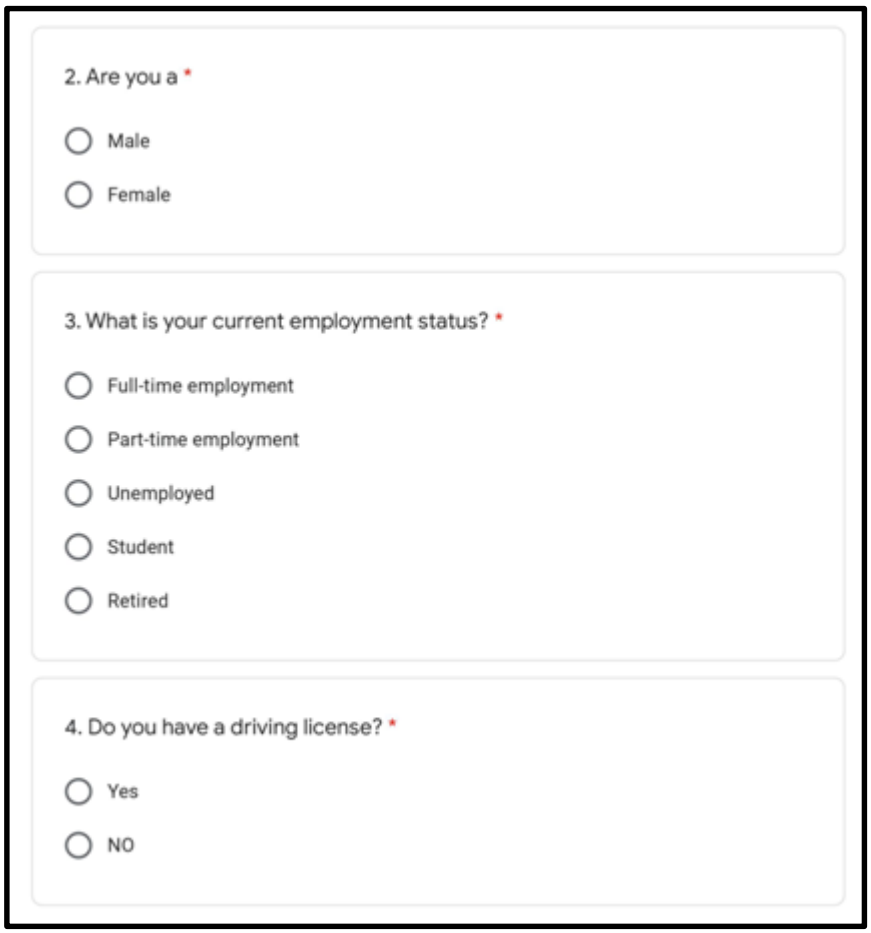
We expect to develop a mobile game to enhance public awareness of road accident prevention. Your responses will be used to identify the most preferred game genre among people for refreshing knowledge of traffic rules and road safety ethics. Thank you very much for taking the time to complete this survey and your participation is highly appreciated.

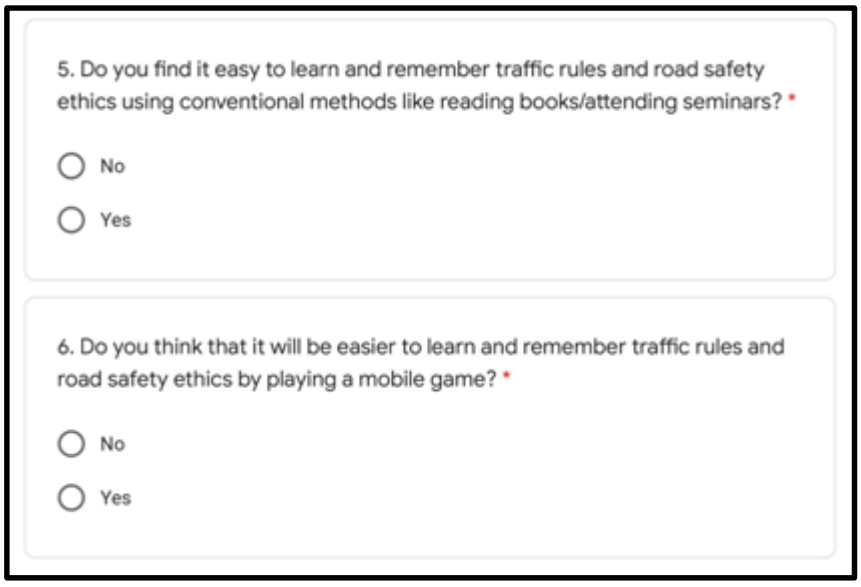
* Required

Background and Demographics

1. What is your age? *

- Bellow 10 years
- 11 to 18 years
- 19 to 30 years
- 31 to 45 years
- 46 to 59 years
- Above 60 years


2. Are you a *
Male
Female
3. What is your current employment status? *
Full-time employment
Part-time employment
Unemployed
Student
Retired
4. Do you have a driving license? *
Yes
NO


5. Do you find it easy to learn and remember traffic rules and road safety ethics using conventional methods like reading books/attending seminars? *
No
Yes
6. Do you think that it will be easier to learn and remember traffic rules and road safety ethics by playing a mobile game? *
No
Yes

7. If yes, which of the following game types that you think would be more effective to learn and remember traffic rules and road safety ethics? *

Crossword

Word Search

Word Sudoku

Hangman Game

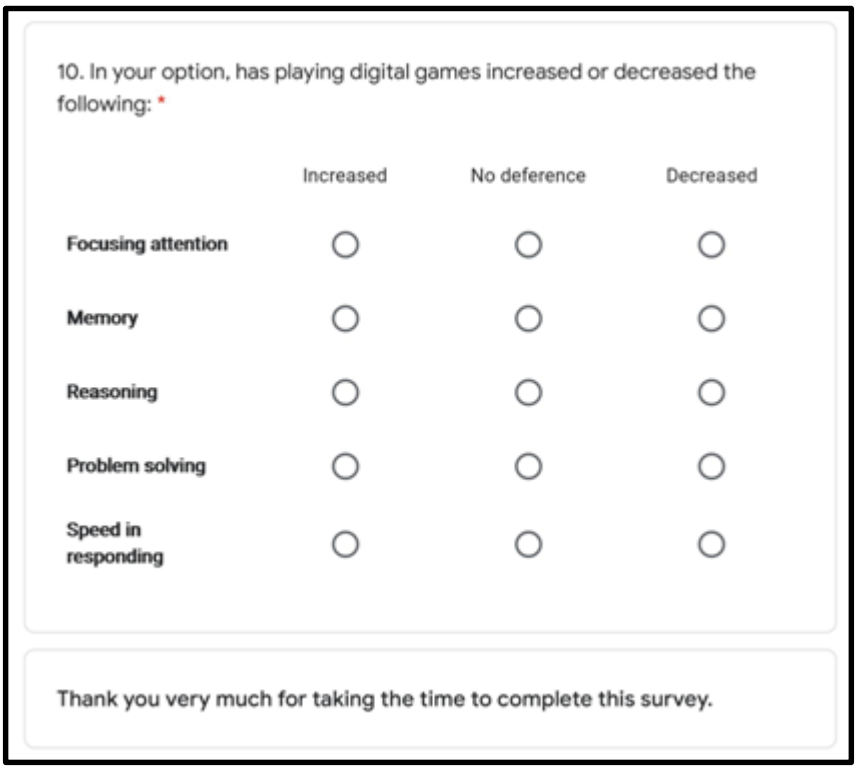
Trivia Quiz

8. What is the reason for your choice in 7th question? *

Your answer

9. What are your main difficulties when playing digital games? *

- [ ] Difficult to see or hear
- [ ] Too complicated
- [ ] Privacy concerns
- [ ] Difficult to use the controller
- [ ] Limited or no access to technology
- [ ] Other:



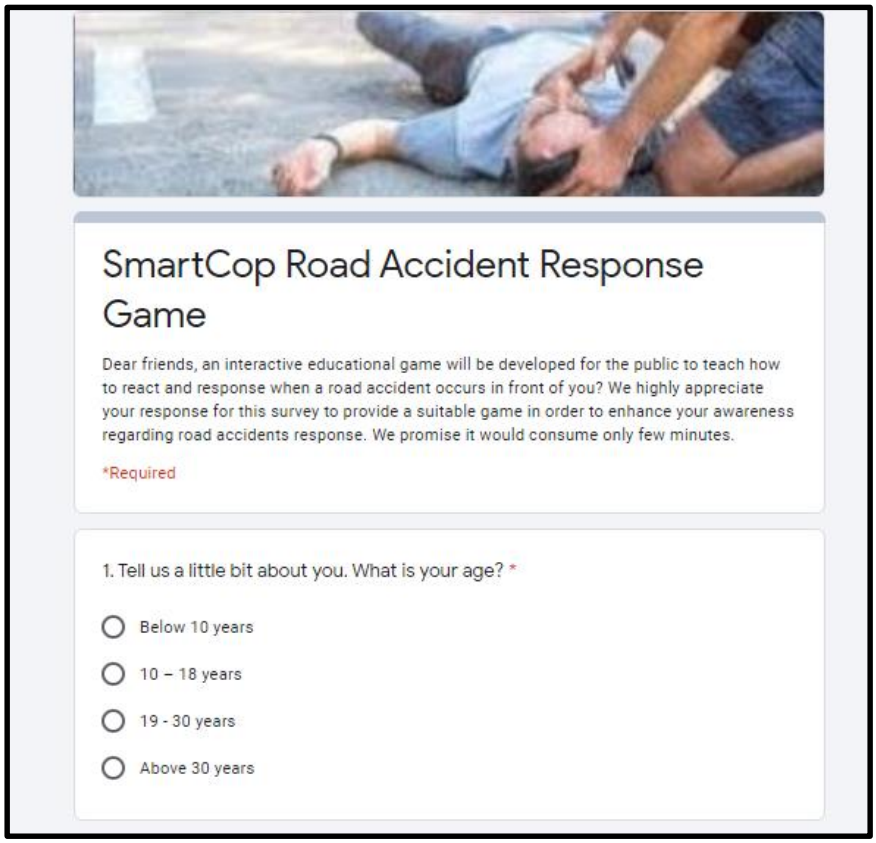
10. In your option, has playing digital games increased or decreased the following: *

	Increased	No deference	Decreased
Focusing attention	○	○	○
Memory	○	○	○
Reasoning	○	○	○
Problem solving	○	○	○
Speed in responding	○	○	○

Thank you very much for taking the time to complete this survey.

Appendix B

Select a suitable game to improve the public awareness on road accident response



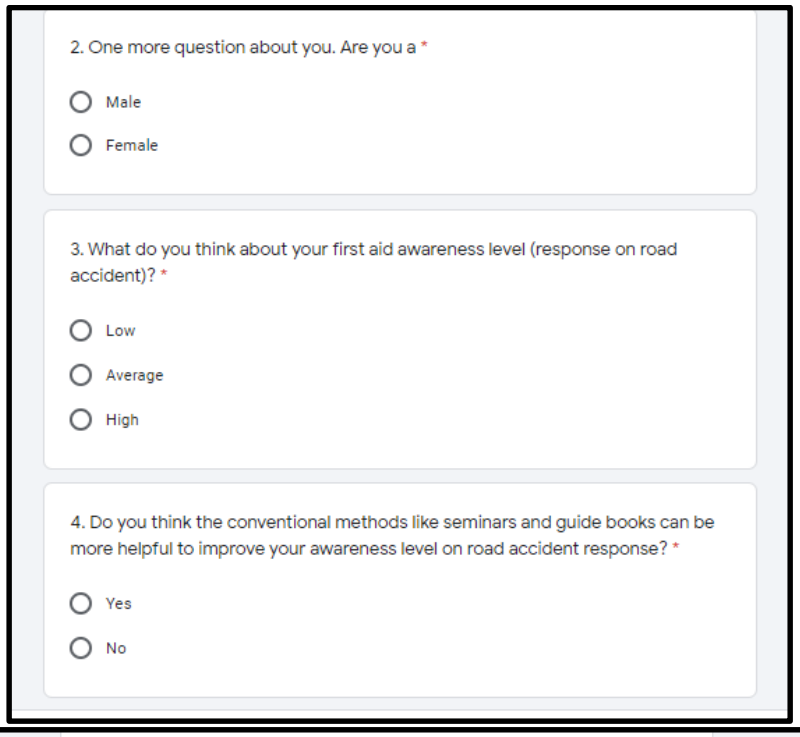
SmartCop Road Accident Response Game

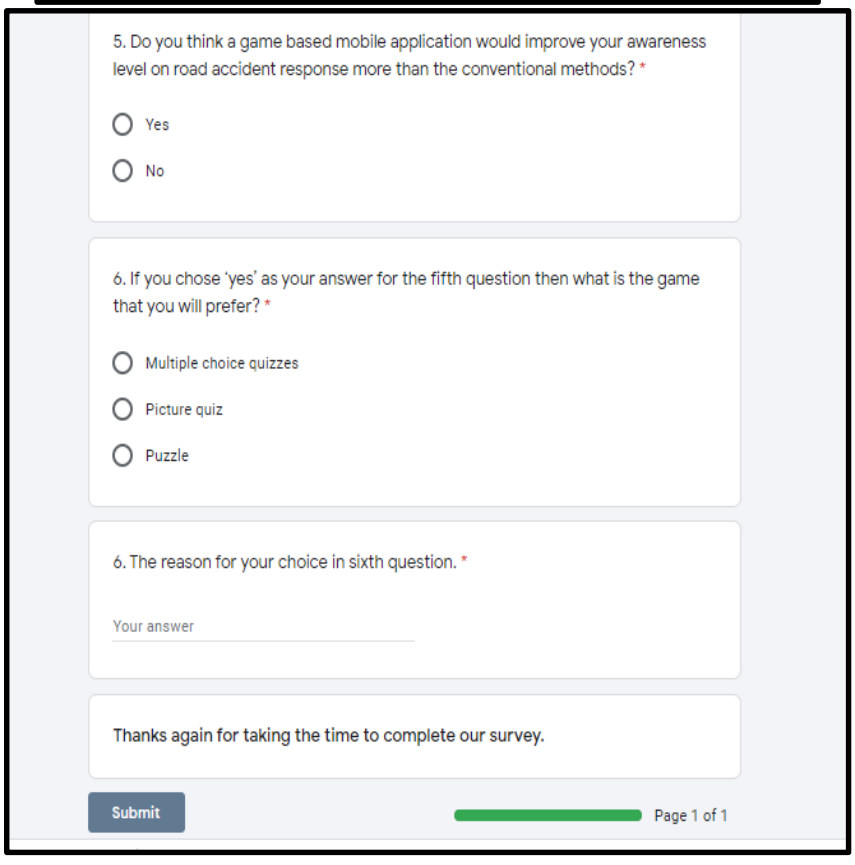
Dear friends, an interactive educational game will be developed for the public to teach how to react and response when a road accident occurs in front of you? We highly appreciate your response for this survey to provide a suitable game in order to enhance your awareness regarding road accidents response. We promise it would consume only few minutes.

*Required

1. Tell us a little bit about you. What is your age? *

- Below 10 years
- 10 – 18 years
- 19 - 30 years
- Above 30 years


2. One more question about you. Are you a *
Male
Female
3. What do you think about your first aid awareness level (response on road accident)? *
Low
Average
High
4. Do you think the conventional methods like seminars and guide books can be more helpful to improve your awareness level on road accident response? *
Yes
No

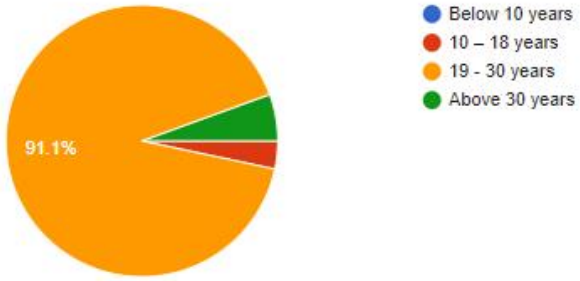

5. Do you think a game based mobile application would improve your awareness level on road accident response more than the conventional methods? *
Yes
No
6. If you chose 'yes' as your answer for the fifth question then what is the game that you will prefer? *
Multiple choice quizzes
Picture quiz
Puzzle
6. The reason for your choice in sixth question. *
Your answer
Thanks again for taking the time to complete our survey.
Submit
Page 1 of 1

SmartCop Road Accident Response Game

90 responses

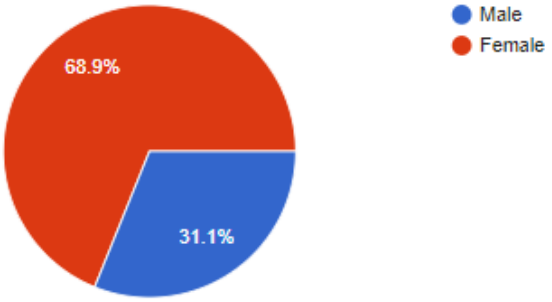
1. Tell us a little bit about you. What is your age?

90 responses



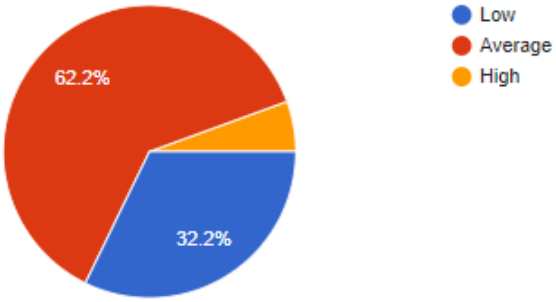
2. One more question about you. Are you a

90 responses



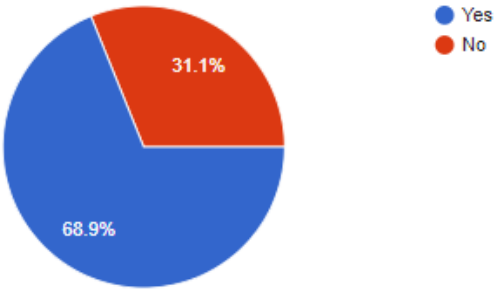
3. What do you think about your first aid awareness level (response on road accident)?

90 responses



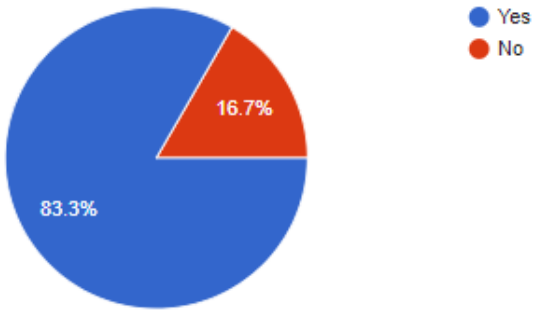
4. Do you think the conventional methods like seminars and guide books can be more helpful to improve your awareness level on road accident response?

90 responses



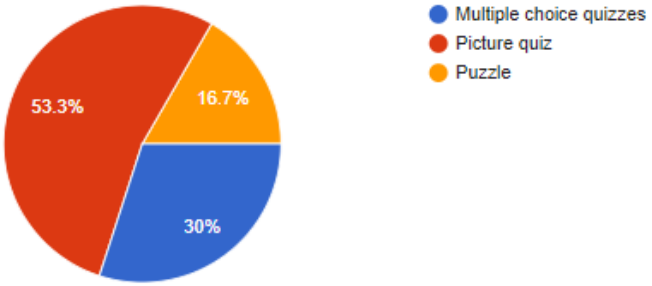
5. Do you think a game based mobile application would improve your awareness level on road accident response more than the conventional methods?

90 responses



6. If you chose 'yes' as your answer for the fifth question then what is the game that you will prefer?

90 responses



6. The reason for your choice in sixth question.

90 responses

Interesting

Easy to understand

I have no time

Because it is easy to get first aid idea

It's easy to understand the situation