Vehicle Speed Tracking and Reporting System for Uganda

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Abstract
Uganda is one of the countries with the highest rate of roads accidents. The major cause is over speeding mainly by public transport vehicles. Attempts to curb this down include use of radar speed guns which are used by police traffic officers on roads to track over speeding vehicles. However, this is still a challenge because of the insufficient number of police officers and radar speed guns. Given the above challenges, the vehicle speed tracking system was developed to provide a cheaper and convenient alternative for tracking over speeding vehicles. The different system requirements were determined using questionnaires, interviews, prototyping. During system analysis and design, a context diagram and dataflow diagram were used to create an overview for the system. The system was developed using Java, My Structured Query Language (MySQL) and Hypertext Pre Processor (PHP) programming languages on different android platforms like android SDK and Eclipse. Extensible Mark-up Language (XML) was used to develop system layouts, permissions and to build the main manifest. The designed system was tested and validated and it performed as expected. The designed system is more effective and efficient in tracking and capturing information on over speeding vehicles and reporting to the traffic police automatically.

Keywords: GPS, speed tracking, road accidents, over speeding, reporting

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1.0 Introduction

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information, anywhere on or near the Earth with an unobstructed line of sight to four or more GPS satellites (Wikipedia, 2014). The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver. GPS has been used in a number of applications such as Google maps to track locations of places and buildings. Most mobile phones especially smart phones have GPS installed for many purposes like tracking the phone, determining locations, tracking motion speed and determining the size of an area. This research incorporated the technologies of GPS enabled phones to aid in the reduction of accidents by tracking over speeding vehicles.

1.1 Background to the Problem

Uganda has been ranked among the countries with the highest rate of road accidents (Daily Monitor, 2013). In Uganda, recent statistics indicate that road transport carries about 99% of passenger traffic, as the mode offers flexibility and ability to move between many different origins and destinations. In 2007, Uganda fatality death rate per 10,000 vehicles was 78, compared to Kenya with 37 and Tanzania 47 (Lukyamuzi, 2013). Although the fatality rate from accidents has since 2007 continued to decline, from 71% in 2007 to 46.5% in 2010, the number of accidents increased from 19867 accidents in 2007 to 22272 accidents in 2011 (Bagala, 2012). According to the daily monitor, a local Ugandan newspaper, the Global Status Report on Road Safety 2013, indicates that Uganda had 2,954 deaths in 2010 as a result of road accidents. This is unacceptably high and therefore one of the priorities of Ugandan traffic police is to bring this alarming figure down. In Uganda the process of tracking and monitoring the behavior of drivers has always been done by the traffic officers who often stand alongside roads and highways in specific areas using speed guns and radar antennas to catch over speeding vehicles. This was put in practice after sighting over speeding as one of the main causes of road accidents by the traffic police of Uganda (Mubaraka, 2013). However, these traffic officers cannot be assembled in all spots of the roads to control the traffic. This has left the lives of very many Ugandans using road transport especially public transport at the mercy of irresponsible drivers. The purpose of this research is to help improve the safety of passengers by designing a system that can be installed on GPS-enabled phones to capture information on over speeding vehicles and report to the traffic police automatically.

The main objective was to develop a vehicle speed tracking and reporting system that can be used by the passengers to track and report over speeding vehicles to the traffic police. The specific objectives were 1) To critically analyze the current traffic tracking process in order to identify requirements for the system and 2) To design, implement, test and validate the vehicle speed tracking and reporting system. The functions of this system are tracking speed of vehicles and generating reports for the traffic police. The study focused on public vehicles such as taxis, buses and special hire cars in which passengers can report over speeding vehicles. This system is not meant for other means of public transport such as air, railway or water transport. The geographical scope includes major highways such as Kampala- Mbarara, Kampala- Mbale and Kampala-Entebbe highways in Uganda.

This study is significant because it improves the safety of passengers travelling by public road transport means by ensuring that they are being driven at safe speeds. The study is an eye opener to researchers in the field of passenger safety and road transport which will lead to more solutions to other problems. The findings of similar research in South Australia led to use of speed cameras in urban areas, however these are not a viable and feasible solution to developing countries and cannot be implemented all over an entire country. Therefore

this research aimed at passenger involvement in their safety while travelling, making the possibilities of this study viable and applicable to the solving the problem at hand.

The use of this system will help the traffic police identify over speeding vehicles and in reduction of accidents by sensitizing, penalizing or punishing the drivers according to the severity of their crime. The project provides a way through which interested citizens can get involved in the process of reducing the rate of accidents through their co-operation with the traffic police. With the use of this application, passengers can take the initiative to report to police in case they sense danger; therefore their safety will no longer entirely depend on the mercy of the driver. The research will also provide a source of revenue to the government through the fines charged on over speeding drivers. The money collected from fines for over speeding will go to the Uganda Revenue Authority for other developmental projects by the government.

2.0 Literature Review

This section consists of a critical review of research work from journals, internet sources and other projects related to the subject area and an analysis of existing literature on the subject with the objective of revealing contributions, weaknesses and gaps in existing systems.

2.1 Global Positioning System (GPS) Technology

Like the Internet, GPS is an essential element of the global information infrastructure. The free, open, and dependable nature of GPS has led to the development of hundreds of applications affecting every aspect of modern life. GPS technology is now in everything from cell phones, cars, wristwatches, bulldozers, shipping containers, and Automated Teller Machines (ATMs) among others. GPS saves lives by preventing transportation accidents, aiding search and rescue efforts and speeding the delivery of emergency services and disaster relief. GPS is vital to the Next Generation Air Transportation System (NextGen) that will enhance flight safety while increasing airspace capacity. GPS also advances scientific aims such as weather forecasting, earthquake monitoring, and environmental protection. GPS remains critical to U.S. national security and its applications are integrated into virtually every facet of U.S military operations. Nearly all new military assets from vehicles to munitions come equipped with GPS. M*ost applications of GPS technology in surveying, mapping, and related disciplines have accuracy requirements that necessitate the use of a relative positioning technique. GPS works by simultaneously measuring the distance from the GPS receiver to several of the GPS satellites. GPS is the most accurate time transfer method available.* The accuracy of the newest GPS units can detect a point within 10 - 50 meters of a location and record data continuously per second for several hours (Wolf, 2006). The most advanced person-based GPS unit has up to 12 - 16 hours of battery life or 466,000 points of recording (NuStats, 2005). Loss of signal for GPS units could be caused by the urban canyon effect caused by high-rise buildings or being underground (Ohmori, 2003). In the past, areas covered by trees were also problematic, however; upgrades in GPS technologies have overcome this issue (Stopher, 2005). The optimal condition for the GPS unit to acquire signal when it is initially turned on is when the unit is motionless in an open space, otherwise it can be very difficult or even impossible for the GPS unit to obtain a stable signal (Stopher, 2002). Therefore with the benefits outlined the GPS technology is very vital for curbing accidents by tracking down over speeding motorists.

2.2 Mobile Based Applications

The mobile services and applications value chain has gone through many changes during the past few years (1990-2012) due to the evolution of mobile devices and their capabilities. According to Chohick (2011), a platform is "a product that can be extended by a user for the benefit of other users". The I phone or android

platform plays a fundamental role in the shift of developers attention to this new opportunity, consumer education and awareness of the benefits of applications to ensure a viable ecosystem as more and more community are transferred to mobile technologies. The number of people owning a Smartphone or a tablet has grown over the last few years and every economic aspect is faced with a new perspective in approaching customers. In the context of software progress, hundreds of millions of mobile owners and social media, insurance companies and their respective ecosystems cannot afford to be kept out of the digital loop with 3G and 4G being the latest platforms developed (Senn, 2009). Of the 59% of the population in Uganda who own mobile phones, 12% use internet occasionally and own smart phones (PewResearch global attitudes project, 2014). This implies that the new system can be used to track and report over speeding vehicles since more than half of the population own phones.

2.3 Study of Existing Speed Tracking Systems

A radar speed gun is a device used to measure the speed of moving objects. A radar speed gun is a Doppler radar unit that may be hand-held, vehicle-mounted or static. According to Marshall (2000), it is used in law-enforcement to measure the speed of moving vehicles and is often used in professional spectator sport, for speed measurement of pitched baseballs, runners and tennis serves. In the USA, the National Highway Traffic Safety Administration is well-established that speeding represents a risk to public safety. Excessive speed increases the likelihood of crashing and the risk of severe injury in a crash. In 2005, more than 13, 000 lives in USA were lost in speeding-related crashes, reducing speed is a high-priority objective and effective speed enforcement is an essential countermeasure to reduce speed and lower crash risk (Boos, 2009). Therefore the radar speed gun has been employed to curb the over speeding problem. In Uganda it is in use however it is not affordable and it is also expensive to deploy traffic officers on every road and later on avail each one with a speed gun.

According to Danny (2008), Automatic Vehicle Location (AVL) using GPS is a means for determining the geographic location of a vehicle and transmitting this information to a point where it can be stored and used with certain software and database applications. A common practice is to stand up a centrally located server that is connected to a network and the server acts as the gathering point where data is received and stored in a database. Most commonly, vehicle location is determined by using a GPS device, and the transmission mechanism of the data is a satellite, terrestrial radio or cellular connection from the vehicle to a receiving satellite, radio receiver, or nearby cell tower. Originally designed for fleet management, AVL systems have been in use for over 20 years to increase the accountability of field personnel and boost the efficiency of organizations dispatching procedures. The integration of AVL data into a Geospatial Information System (GIS) combines the concepts of dynamic geospatial location, intelligent geographic data and situational awareness. The added information of vehicle tracking information into an existing GIS provides a comprehensive approach for decision making and asset management. The aggregated information makes the system extremely useful since the data is updated on a minute by minute basis to provide real-time applications. AVL technology provides improved response time, resource management, schedule adherence and increased productivity on a day to day application. The use of this technology can support many activities such as fleet management, garbage truck tracking and mobile workforce management.

The challenge with the existing systems like the radar speed gun is that they work where traffic officers are and cannot operate without their existence. Based on the findings in the literature, it was necessary to develop the vehicle speed tracking system since it provides both functionalities of speed detection and GPS, to reduce road accidents that occur due to reckless over speeding along high ways in Uganda. Therefore the vehicle speed tracking and reporting system is more efficient because it can be used at every point by passengers to report over speeding using their GPS enabled phone with the application installed on their smart phones. The

vehicle speed tracking and reporting system tracks the rate of speed at which a vehicle is moving while the automated vehicle location system determines the geographic location of a vehicle using GPS.

2.4 Comparison of the System with Existing Systems

Features/ characteristics	Radar speed gun	Automated vehicle location	Vehicle speed tracking system (designed system)
Main objective	Measure speed	Determine geographical location	Track speed, report to police and shows location
Functionality	Complex	Complex	Simple
Affordability	Proprietary	Free	Free
Offline capability	None	Yes	Yes
Security	No	Yes	Yes
GPS enabled	No	Yes	Yes

Table 1: Comparison of the New System with Existing Systems

3.0 Methodology

The section below presents the activities that were carried out in the research process. The Software Development Life Cycle (SDLC) methodology was followed to achieve the objectives of the study. The study population majorly focused on public transport users and traffic officers in particular. A total of 20 public transport users and 3 traffic officers were purposively sampled to provide the relevant information to identify requirements. Data was collected through the use of questionnaires, interviews, literature review and observation. Questionnaires were distributed among 20 students to determine users' capability to use the system. Interviews were conducted with 3 traffic officers from the Uganda Central Police Station. Observation method helped make informed decisions, adjustments, and allowances based on what had been studied. The researchers saw how traffic officers track over speeding vehicles along high ways. Analysis of this collected data was done using Microsoft Excel because it features calculation, graphing tools, pivot tables among others.

System analysis determined the viability by performing a feasibility study that evaluated the technical, operational and economic feasibility of the system. A Data Flow Diagram (DFD) was used for system design. Implementation was done using android ADT and programming techniques including Structured Query Language (MySQL), Hypertext Pre Processor (PHP), JAVA, Hyper Text Mark-up Language (HTML) and Cascading Style Sheets (CSS). PHP is the server-side scripting language designed for web development but is also used as a general purpose programming language. PHP was used because it is open source, can easily be embedded into HTML, is platform independent, user friendly and enables fast implementation of complex solutions. MySQL was used as a database management system to store the content and data. JAVA is an object-oriented programming language developed by Sun Microsystems, designed to be small, simple, and portable across platforms and operating systems.

The Android SDK for Windows is an android development platform that contains all the necessary tools required for developing mobile applications on the android platform such as Application Programmer

Interface (API) modes, build tools and associated libraries. This platform was used because it is very popular for developing mobile applications by application developers. This Android platform was used in development of the main manifest which includes all java classes and functions used in the system. CSS is the technology used to provide the means to control and change the presentation of Extensible Hypertext Markup Language (XHTML) documents (Rao, 2004). CSS was chosen due to its unique ability to provide a means to control and change presentation of XHTML documents and as well impose a standard style on document(s). Testing was necessary to ensure that the system functions correctly and also verified that all system components work together as expected by confirming that the system can handle predicted data volumes in a timely and efficient manner. The system behavior was checked to identify errors through verification and the use of iterative prototyping. System validation involved users interacting with the system to check whether it meets their requirements. The system was documented to enable new users to learn how to use it.

4.0 System Study

Currently the Uganda traffic police use radar speed guns to detect over speeding vehicles. Traffic officers are deployed alongside roads, highways or streets to detect and stop over speeding vehicles. However, drivers exploit the loopholes within the current operational systems by reducing speed in areas where they suspect officers to be. This therefore does not reduce the over speeding and accident problems. The current traffic tracking system in Uganda has weaknesses which include the following;

i. There are limited numbers of traffic officers therefore not enough to deploy on all roads in the entire country.
ii. The cost of speed guns is high therefore this makes it hard to purchase them for every traffic officer. Consequently, just a few traffic officers possess speed guns.

4.1 Systems Analysis and Design

MS Excel was used to analyze data and results show 65% of the questionnaire respondents were willing to install this application on their mobile phones however 20% were reluctant and 15% needed more education about the system operations. 70% percent of respondents (passengers) rated the system excellent, 20 % rated it to be very excellent while 10% had no idea about the system.

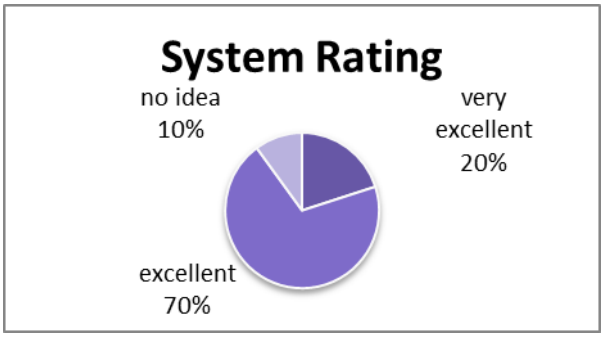

Figure 1: How the System was Rated

5% of every 10 respondents had smart phone with GPS embedded and 3% of those that had smart phones knew what GPS is and how to turn it on. According to interviewees, 50% of road accidents are due to over speeding of public vehicles on highways and other factors also contribute 50% of total accidents recorded per year.

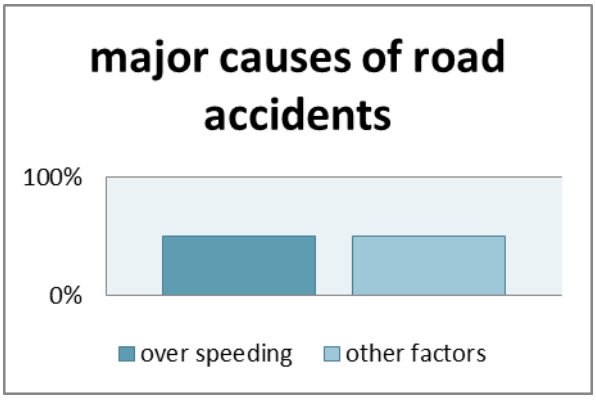

Figure 1: Major Causes of Road Accidents in Uganda

70% of every 20 people interviewed believe that this system alone can help to reduce road accidents and 30% believe other factors have to be considered first. The percentage that believe this system would do more than other factors say that public transport means transport more people and are more reckless therefore if 70% percent of peoples' lives are secure then the problem is half solved. Analysis was done to identify functional, nonfunctional and user requirements. The stakeholders of the system include the traffic police, the government, passengers and their requirements are sub grouped below:-

- The traffic police's desired system should be able to send notifications to the central hub of the traffic police in real time, to alert them in real time when speed limits are exceeded and have user friendly interfaces with the provision of easy to understand user guides.
- The Government's desired system should help to reduce on the costs incurred in purchasing radar speed guns and on the traffic officers' salaries that stand alongside roads countrywide.
- The passengers' desired system supports multiple users to use the system at the same time.

Therefore functional requirements identified include system accepting input from the user such as car registration number, tracking speed in real time and automatically sending a notification to the traffic police head office, identifying errors and notifying the user. The system generates an alert to the user incase the speed goes beyond the recommended speed limit set.

The non functional requirements include a system with quick response, easy to use by all especially passengers with limited computing skills; and the system should temporarily store the session and resume it without interference.

The hardware requirements include a GPS-enabled phone for the application to run efficiently and effectively, RAM of 200mbs internal for faster performance, memory of 250mbs, CPU 800MHZ processor speed. The Software requirements include android 2.0.1 Operating system for Compatibility.

4.2 System Architecture

This is the conceptual model that defines the structure, behaviour and more views of a system. This system is built for two users domains with the client-server architecture and administrators have access to the database hosted on the centralized server. The system is three-tier architecture with the presentation layer with a users interface to submit data into the database. The logic layer of system data passes as insertions from user interface and as user requests from the database and is referred to as output and data layers which make it. The

Data layer is where information records are stored in the database or any other storage file system and can be retrieved when needed.

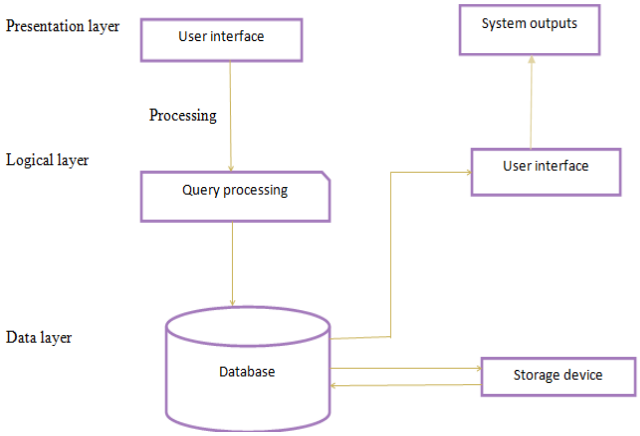

Figure 3: Illustration of the System Architecture

Process modeling is a formal way of presenting how the system operates. The Context diagram shows the system boundaries, external entities that interact with the system and major information flows between entities and the system. Context diagram evolves into the Data Flow Diagram (DFD) by breaking down the system into the major processes that occur within it.

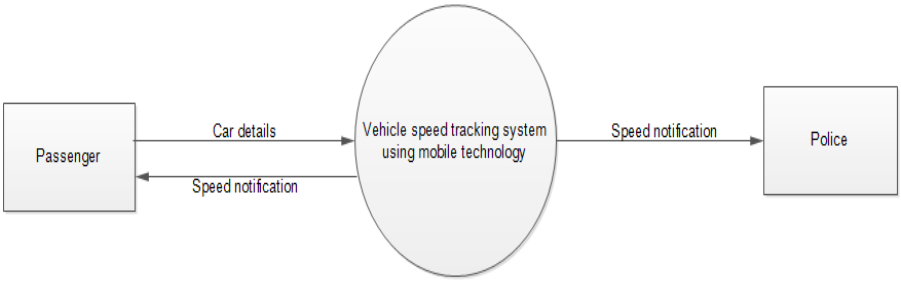

Figure 4: Context Diagram showing System Overview

The level 1 DFD shows the movement of data between external entities, the processes and data stores within a system. This DFD explains the information flow between processes in the system and results from context diagram broken down into major processes that take place within the system.

5.0 Results

This section discusses results and representations of system user interfaces that provide a view of how the user interacts with the system. The Mobile vehicle speed tracking system was developed with java and runs on different platforms such as android which includes android SDK and Eclipse. Extensible Mark-up Language (XML) was used for system permissions, settings and layouts. It was also used to build the main manifest that includes all classes and functions used in the application. Java helped in creation of location classes that pick out the current location of the device. Other java classes were written to calculate the speed or acceleration of the vehicle. PHP was used as a server side scripting language. The functionalities of the System include accepts input from the users, tracks speed in real time and automatically sends notifications, identifies errors, is easy to use, fast in speed and temporarily stores the session in case of disruption and resumes when the

problem is addressed. The application is installed on a mobile phone with GPS technology which enables collection of data about location, speed at which the vehicle is moving and this enables passengers to report over speeding cases using their mobile phones to the central police station.

I) How Passenger Captures the Number Plate

When a passenger is entering the vehicle they enter the number plate of the vehicle in the application by typing it or scanning it using a camera. The app uses character recognition and captures the number plate from the scan so the app does not store a picture, it reads the number plate.

II) How the Phone Captures the Speed of a Moving Vehicle

A device with a GPS receiver ranging from 2 to 4 channels receives signals from satellites enabling the phone to pick its global position using vector equations. However these equations are taken care of by android libraries which include location manager from which u can pick latitude and longitude of the receiving device in this case an android phone with a GPS receiver. As the passenger holding the phone keeps changing his geo location the GPS coordinates also keep changing causing displacement. Mathematically the rate of change of displacement is equal to velocity therefore velocity converted to scalar quantity speed is generated giving the tracking of a moving mobile phone of a passenger. However android has an inbuilt library that with a get_speed() method which takes care of all the math the application needs to track speed. So every 30 seconds speed is captured along the geo coordinates (latitude and longitude) the captured speed is compared to speed limits of that route as set by the ministry of transport. When the captured speed is above the set it displays a message on passenger screen and saves latitude and longitude of the place plus the speed with the number plate the user entered before and stored in a database where it can be retrieved by police.

a) Starting Interface

This interface displays when the system is powering. During testing, it took 7 seconds to fully load.

Figure 5: Interface Showing Starting Page

b) Entering the Vehicle Registration Number

This interface enables the user to fill in the registration number of the vehicle

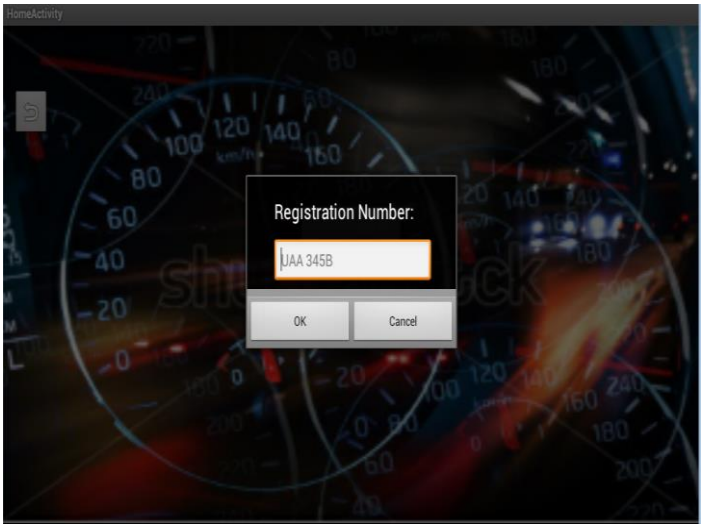

Figure 6: Interface for Entering Vehicle Number

c) Speed Detection

This interface shows the process of detecting speed when the passenger is in the moving vehicle.

Figure 7: Interface Showing Speed Detection

d) Speed Alert

The system was successfully tested and it displays a speed alert on the user's phone and sends notifications to the server whenever speed limit is exceeded. This interface shows an alert that is generated if the vehicles' speed goes beyond the limit. The user can therefore tell the speed at which the vehicle is moving.

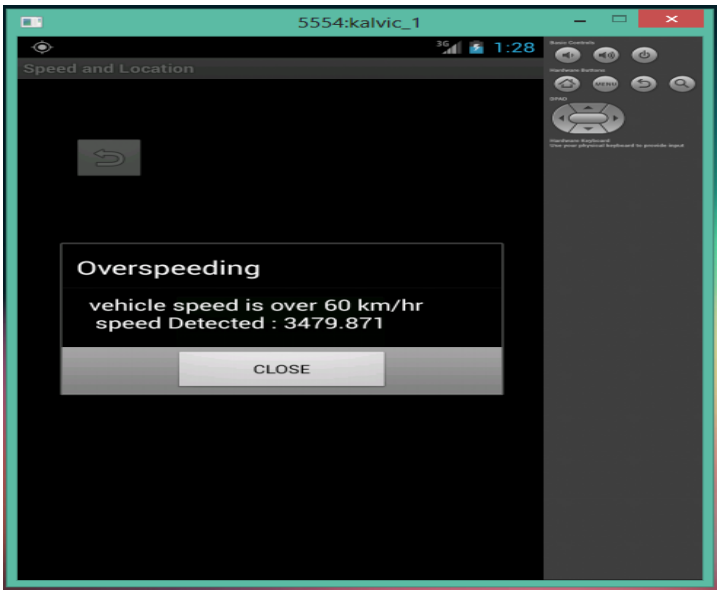

Figure 8: Interface for Speed Alert

During the validation process, the users interacted with the system to determine whether it fully met their requirements. Questionnaires were handed out to 20 system users and the results were analyzed using MS Excel. The responses from the system validation questionnaire are summarized below:

User Requirements of the System	Number of Users (Out of 20)		
	Fair	Good	Very Good
Track speed	3	10	7
Report to traffic police	5	10	5
Easy to Learn	5	10	5
Efficient (Data Entry, Processing and Retrieval)	4	5	11
Fast and Reliable	1	9	10
Easy to Navigate	5	7	8
Interaction	2	10	8

Table 2: Results from System Validation.

User Requirements of the System	Number of users (Out of 20)		
	Fair	Good	Very Good
Track speed	3		7
Report to traffic police	5		5
Easy to Learn	5		5
Efficient (Data Entry, Processing and Retrieval)	4		11
Fast and Reliable	1		16
Easy to Navigate	5		8
Interaction	1		18

6.0 Discussion, Recommendation and Conclusion

This section explains the achievements, conclusion, recommendations and the future areas of research aimed to achieve the major goals. The researchers' main challenge during development of the vehicle speed tracking and reporting system, was that some of the parties in the Uganda Police, especially the traffic police, were unwilling to share vital information.

The Limitations of the System include the following: -

i. The system is only used in public vehicles and does not include private cars yet they also cause accidents.
ii. Some passengers are not conversant with the system operation therefore are reluctant to use it.
iii. The system uses GPS signals which can be distorted by weather factors like heavy storms.

6.1 Recommendation

Sensitization on radios, televisions and social media should be done so that people who travel in public vehicles are aware that they can fight for their lives by using this system to report over speeding vehicles in real time so that appropriate action is taken using the traffic police coordination.

Training on the usage of the system should be done so that people can understand what the whole system can accomplish.

Over speeding is not the only cause of road accidents so the traffic police need to take measures on solving other factors that cause road accidents in Uganda. Further research should be carried out to find out the other causes of increased road accidents. New appropriate systems required for those specific problems should be developed to lower the percentage of road accidents in Uganda.

6.2 Conclusion

With the above recommendations considered and implementation of the system, the researchers believe that the problem of road accidents will reduce to some extent thereby saving a big percentage of lives lost every day in Uganda. This is true because of the following;

i. Most accidents in Uganda occur in public means and the designed system focuses on public vehicles.
ii. Most road accidents result from over speeding and the objective of the designed system is to track over speeding vehicles.

Therefore if the other causes of road accidents are eliminated or reduced and the designed system is used appropriately to reduce over speeding, the problem of road accidents will reduce to some extent.

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