Embedded System for Vehicle Speed Monitoring

Murakaru Anne Wamuyu
Strathmore University
Faculty of Information Technology
Nairobi, Kenya
Anne.murakaru@gmail.com

Dr. Joseph Orero
Strathmore University
Faculty of Information Technology
Nairobi, Kenya
Jorero@strathmore.edu

Abstract

This paper investigated the impact of current approaches taken to curb speeding of public service vehicles in Kenya. A qualitative research pointed out that the existing systems are inefficient and ineffective in monitoring speeding and reporting speeding offenses to the relevant authorities. In addition, public service vehicle drivers are not aware of the current speed limit zones in various locations given that the National Transport Service Authority (NTSA) periodically changes speed limit regulations along particular roads. An embedded system for vehicle speed monitoring was proposed and tested. The objective was to design a real time microcontroller based system for mapping speed limit zones and reporting cases of speeding violations to the relevant authorities through an android mobile application. An LCD Screen was integrated to the microcontroller to provide a visual display of the vehicle location and speed limit within the location. In the event of speeding, an audio alert is triggered to notify the driver and an SMS is sent from the GSM module to a central server. Through this system, public service drivers are aware of the speed limit zones on various roads and are alerted once the speed limit is exceeded. The real time reporting system enables the transport agencies and other regulatory bodies to equally monitor speeding vehicles on the roads.

Keywords: Speed violations, Embedded system, Speeding, GSM module, GPS module, Microcontroller, speed limit, accidents, mapping, display unit

I. INTRODUCTION

According to World Health Organization, approximately 1.25 million people lose their lives as a result of road traffic crashes in the world annually [1]. Road crashes are currently the ninth major cause of death worldwide and are projected to rise by 65% by the year 2020, placing it third after major killers like malaria, Tuberculosis and HIV/Aids [2].In Kenya, about 3000 people are involved in road accidents every year. This relates to 68 deaths per 1000 registered vehicles [3]. 71% of road accidents are caused by speeding vehicles in Kenya. According to a research carried out by Margaret Ireri, many passengers report that the driver was at high speed and disobeyed traffic regulations [4]. Speeding on Kenyan roads has become a norm over the years, leading to accidents which contribute negatively to the economy of the country.

Speed is considered to be at the core of the road safety problem all over the world and greatly affects the risk of being involved in an accident. At a higher speed, it is more likely that a driver will lose control of the vehicle, fail to anticipate on coming hazards and equally misjudge speed of other vehicles. Additionally, speed affects the extent of injuries to the road users involved in an accident[5].

This paper presents a functional Embedded system for vehicle speed monitoring.The work presented includes the development a mobile application and web application for managing reports and escalations. The rest of the paper is structured as follows: Section II reviews the various technologies used to curb speeding; Section III presents the design and operation of the embedded system prototype. section IV presents the implementation architecture; section V presents testing and results of the prototype ; section VI concludes the paper.

II. SPEED DETECTION TECHNOLOGIES

There are a number of technologies and techniques developed in an attempt detect speed violations on roads. These technologies have been tested in various countries around the world including Kenya.

1) Radar Technology

The principle of radar technology is dependent on transmission of electromagnetic waves to a moving or stationary object. Reflection of the waves result in a change of frequency and is interpreted by radar device in a speed calculation [6].

2) Laser Light system

The Laser light system relies on the reflection time of light to determine the speed of objects in motion. Laser guns are used in this technology. These devices are mostly handheld and manually operated. When measuring speed, the delay period between the infrared pulses transmitted to the vehicle and back to the receiver makes it possible to calculate the distance between the two objects. Through this, speed can

be easily determined by dividing the distance captured with the time taken to transmit the infrared signal. Laser technique is mostly used within city limits or construction areas since the measurement distance is limited to 30 to 50 meters. Compared to the radar systems, laser light systems are more accurate and have less hardware installation requirements.

3) Vision Based System

This is one of the most intelligent and convenient methods in vehicle speed measurement. It uses two consecutive images captured form traffic camera system to determine the speed of an individual vehicle. The two images are transformed from image plane to 3D world coordinates. The difference of the two images is computed and mapped into one image. Finally, a block feature of vehicle closest to the ground is matched to estimate the distance and speed of vehicle.

III. EMBEDDED SYSTEM PROTOTYPE

This section presents the design and development of an embedded system for vehicle speed monitoring. System design involves modelling elements to help in visualization of the intended system. Unified Modelling Language (UML) diagrams such as use cases, data flow diagrams, flow charts among others, were used in various stages of the design process to visualize, specify, construct and document the system. Fig. 1 illustrates the layout of the embedded system

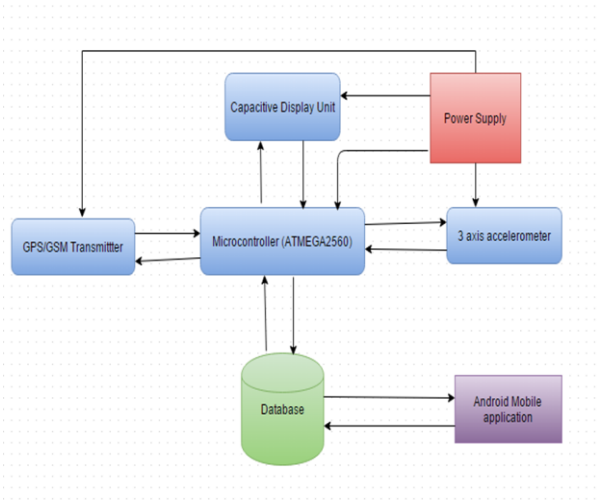

Figure 1: Embedded system design

The microcontroller provides supervisory control of the entire system. The display unit holds the map interface and shows the speed limit zones in various parts of the streets. The accelerometer will be used to detect speed in a particular direction and this will be used against the set speed limits in the area to gauge whether the driver is speeding or not. In case of speeding, an SMS with details of the exceeded speed, location and vehicle details is triggered from the GSM/GPS module to the central processing server. The motorists receive an audio alert from the device (buzzer on board). The GPS module is used to get the exact coordinate location of the motorist in relation with the specified speed zones. This data is correlated to database which can be queried by the traffic police trough an android mobile application.

The system is consisted of two main parts

- Client Side
- Server side

A. Client Side

This consists of the android mobile application and speed violation embedded system deployed in the vehicle. The mobile application is used as a tool to provide information about speed violations to the legal vehicle owners who have signed up their vehicles in the PSV agencies. The embedded system consists of a display unit to be used by the motorists to view various speed limit zones in relation to their coordinate locations in an effort to notify in the event of speeding.

1) Embedded System

Microcontroller: The Atmega 2560 microcontroller to use as the core processing unit. Atmega 2560 was selected due to its high performance and low power consumption characteristics.

Accelerometer: The researcher selected the ADXL345 3axis accelerometer to be embedded in the system. The function of the accelerometer is to measure acceleration of the vehicle in 3 dimensions; X, Y and Z. This sensor is very sensitive to changes in velocity and has the capability of sensing if the acceleration exceeds a particular user set level. This feature makes this sensor the most suitable to the system being developed. The figure below shows the accelerometer

Display Unit: The researcher selected a capacitive 7 inch display unit for map display. Capacitive touchscreens are very accurate and respond instantly when lightly touched by a human touch.

GSM and GPS module: The researcher selected SIM 808 which is a high performance integrated GSM andGPS module to be used in the embedded system. Its core functionalities are transmitting and receiving SMS notifications as well as locating position of the vehicle with respect to the specified speed zones. These features are in line with the requirements of the system proposed.

2) Mobile Application Implementation

The mobile application was built to run on the Android platform, this is based on the research done which showed that the target population uses Android phones. The application was built for the vehicle owners whose vehicles are registered in the Public Service Vehicle transport agencies. Below are screen shots of the application and their functionalities:

B. Server Side

This consists of the server where speed violation information is sent. The embedded system contains a GSM/GPS module responsible for sending an SMS notification with details about location of speed violation, vehicle registration number and the exceeded speed to a database which is queried by mobile application users and the supervisors. It is used to receive, analyze and act on data as well as provide information to the Client side.

1) Web Application Implementation

The supervisor's main role is to manage users, manage speed zones, manage vehicles and generate reports. To perform these functions, they access the system through the web application where they are required to provide authentication data i.e. used ID and password. The Figures below shows a screenshots of the main functions performed by the supervisor in the system.

IV. IMPLEMENTATION AND TESTING

A. Embedded System Implementation

The hardware system is comprised of the following components; Microcontroller, GSM/GPS module, accelerometer, display unit and Alarm buzzer. The main function of the embedded system is to collect data about the speed and location of the vehicle in relation to the speed zone and transmit this to the server for processing. The display unit provide the Graphical User Interface (GUI) through which the motorist/driver can view the various speed limits configured. Figure 2 below shows the setup of the embedded system.

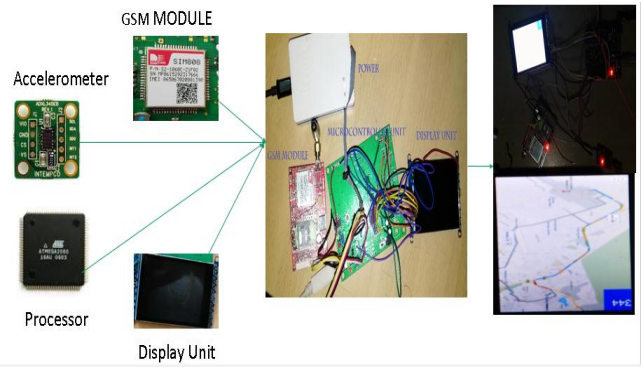

Figure 2: Embedded system implementation

1) Updating speed Zone data

This process enabled the updating of speed limit zones. Speed limit data which consists of GPS location coordinates and location name identifiers is stored in the server and upon updating, sent via SMS to the embedded system. This information is then relayed to the motorist display unit. Figure 3 below shows the high level data flow diagram showing the movement of data in the system. It shows the entire system as a single entity interacting with external entities and the processes that take place between the system components

2) Violation detection and reporting

The accelerometer sensor capture the current speed of the vehicle while the GPS sensor pin points the current location coordinate data. The microcontroller compares the captured data to the stored speed limit information. In the event that the speed recorded exceeds the speed limit, an audio alert buzzer is activated to notify driver about the speed. This data is herein sent to the server and can be accessed by supervisor or the vehicle owners. The reports generated contain details of the speed violations of a particular vehicle.

B. Mobile and Web Application Implementation

1) User Management

The vehicle owners, who are the primary users for the mobile application, are allocated user accounts for their profiles. These accounts are created in the web application by specifying the User ID and password. Vehicle owners are prompted to change password on first logon to be able to view speed violations of their vehicles on the roads. The supervisor can also suspend the user accounts in the event that user withdraws contract with the PSV agency.

2) Report Generation

The reports generated contain details of the speed violations of a particular vehicle. Figure 4 below displays the sequential flow of information within the system.

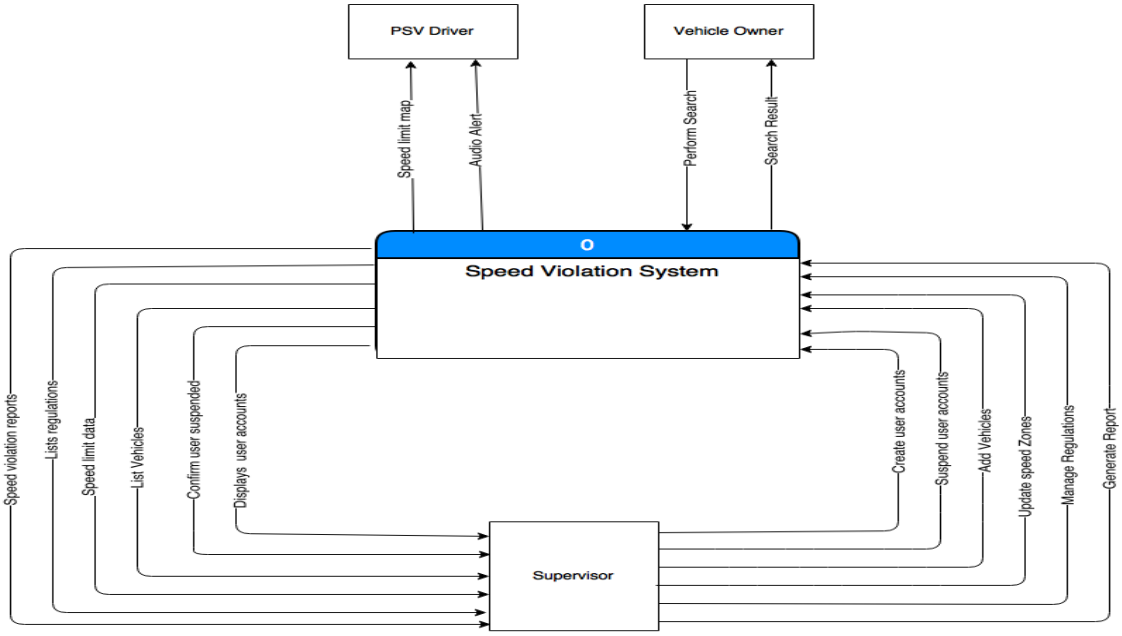

Figure 3: System Context Diagram

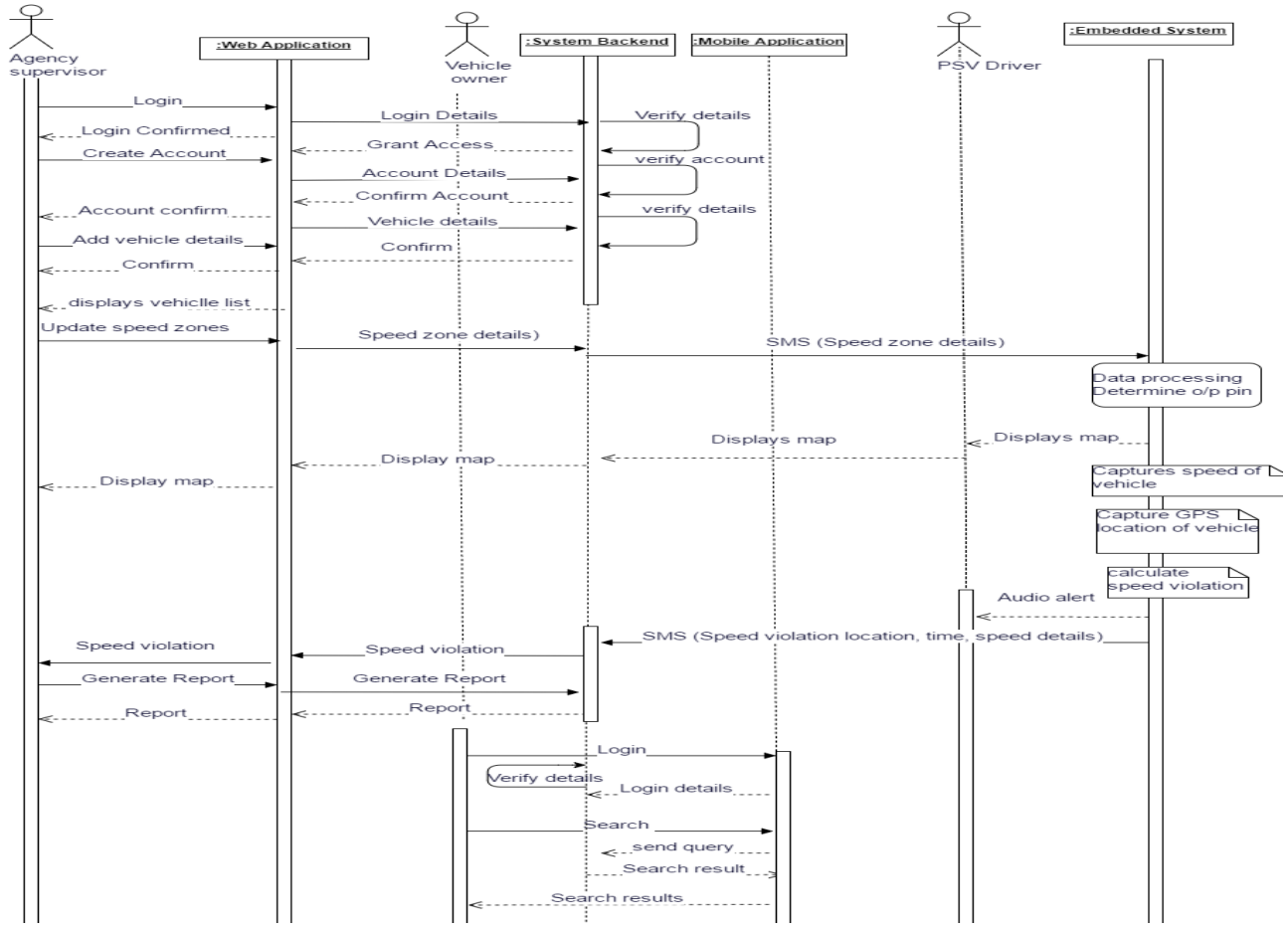

Figure 4: Sequence flow diagram

V. TESTS AND RESULTS

This Section presents proof of concept tests conducted on the system to ensure that it works well. The testing was divided into two sections, developer testing and user Assessment testing.

Developer Testing: These tests were conducted to ensure that the various functionalities were working well, the tests included: unit testing, integration testing, compatibility testing, functionality testing and user testing. In unit testing, the individual units were scrutinized to test for operation. The isolated hardware components were separately to ensure that each component performs required function. The input/output ports for the units were tested using hardware testing IDE. It was also performed to test the source code before deployment to the processor unit. Integration testing was performed after system integration where two or more of the components were integrated and tested for functionality. Compatibility test was done to ensure that the mobile and web applications are compatible with the available platforms. The mobile application was tested against the available Android versions while the web application was tested against the available web browsers that are commonly used.

User assessment testing: User assessment tests were carried out to test the features of the system implemented. This section tested both the hardware and software to determine whether all functionalities were achieved. For each use case testing measures were set with results being considered successful or unsuccessful.

VI. CONCLUSION

This research was carried out to improve the transport industry, where vehicles are registered under a particular agency, by designing and developing a system to help curb speeding. Prior to design and development, a comprehensive study was carried out to determine the existence of the problem and viability of the research. The data collected from sample population was analysed and helped in designing a relevant system to curb the challenge. This system not only reports speed violation, but maps speed limit zones on a specific route. This provides speed limit information to the drivers and speed violation data to supervisors/administrators in the transport agency. Additionally, drivers are alerted once they exceed a specific speed.

An android mobile application was developed to provide a platform through which speed violations can be monitored by the owners of the vehicles. A web application was designed and developed to enable supervisors to manage users, manage speed zones, manage regulations and generate reports. An embedded system was also designed and integrated to collect data about location and speed of the vehicle and transmit to the server through an SMS gateway

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