A conceptual Model for Highway Speed Monitoring and Enforcement in Zimbabwe

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Abstract: Many African countries lack resources and sophisticated technology needed to monitor and enforce traffic speed regulations in highway. These countries rely on highway patrolling which is a manual technique used to oversee and enforce the traffic safety compliance on the roads. The technique seems to be woeful and inadequate, since police officers can be bribed and the equipment they use does not provide enough evidence to empower independent auditors to quiz why certain offenders were not ticketed. Because of the need to have an up-to-date technology to monitor and enforce highway speed regulation, the purpose of this study was to suggest for the adoption of a conceptual model for highway speed monitoring and enforcement that incorporates Automatic Number Plate Recognition (ANPR), GSM and back-end integration. Using various models in traffic monitoring and regulation, a conceptual model was designed in order to reduce corruption and speed related accidents in Zimbabwe. The proposed model is expected to improve highway speed monitoring and enforcement in Zimbabwe and other countries that are still lagging in this regard.

Key words: Conceptual model, enforcement, monitoring, speed enforcement, speed monitoring

1. Introduction

The mass increases in the ownership of vehicles in Africa have resulted in the increase of traffic in highway, which requires strict traffic control, especially speed limit regulations (Kirankumar, Samsuresh, & Balaji, 2012). Many African countries lack resources and sophisticated technology needed to monitor and enforce traffic speed regulations in highway. These countries rely on highway patrolling which is a manual technique used to oversee and enforce the traffic safety compliance on the roads. It can be argued that this manual patrolling method which is backward lack effective strategies to reduce road accidents, crime and corruption (Byrne & Marx, 2011). There is rapid need for police officers to respond to emergencies, safeguard citizens and perform investigations. Police activities require the handling and processing of large volumes of data hence there is need for high processing computers to match these requirements (Colton, 1972). Regrettably there are no integrations between ZRP systems with other government sectors whom are supposed to share critical information(Mahlangu, Mugoniwa, Chikonye, & Furusa, 2016). The purpose of this study is to
suggest a conceptual model for highway speed monitoring and enforcement that incorporates Automatic Number Plate Recognition (ANPR), GSM and back-end integration in order increase level of compliance within motorists, while at the same time reducing the levels of corruption in the ZRP Traffic Police.

2. CURRENT APPROACHES TO HIGHWAY SPEED MONITORING AND ENFORCEMENT

2.1 Manned Speed Traps

In order to curb the issues of over speeding, many traffic regulators use speed trap devices which act as manual patrolling methods (Willis, 2006). Speed trap systems have been utilised in many countries as a way to control speeding of cars. Zimbabwe is one of the countries that has utilised this technique to arrest unsuspecting drivers. A manned speed trap is any position where one or more police officers deliberately hide so as to catch speeding drivers. The officers may make use of parking areas which are next to a sharp turn, in a low ditch, behind billboards or any other place where a driver cannot see them. The objective is to make the driver recognise later the presence of the police officer. The traffic department uses mainly the Doppler/Radar gun for speed traps.

2.2 Doppler Gun

The gun measures the speed of moving vehicles by detecting the change of the reflected signal caused by Doppler Effect. The Doppler Effect is a shift in frequency and wavelength of wave caused by the motion of the source relative to its observer with respect to the medium. When the target is approaching, the reflected frequency is higher than the emitted frequency and when the target is receding, the reflected frequency is lower than the emitted frequency.

The Doppler radar suffers from real technicalities that can arrest innocent persons. The technicalities include the cosine error, calibration errors, ghosting errors and lack of target specificity (Goodson, 1985). The other limitation of the Doppler gun is that it only captures one vehicle at a time. Motorists tend to follow a speeding car in-front of them knowing that they will not be stopped and arrested. An arrested motorist may argue that the captured speed on the device is not his/her car’s as the device only captures the speed not the image or video of the vehicle. The same device cannot be used as evidence in court when the motorists may want the case to be tried in court. This is because when the officer arrests a motorist they have to reset the device so as to trap other motorists. During the argument other motorists are passing through where some are violating the rules. Consequently, there are well known zones where police officers operate and as such motorists will tend to warn each other before approaching the zones which in turn becomes an ineffective method to deter motorists from speeding. The speed trap devices only operate during the day for a specific interval time, which means at night motorists can travel without any regulating speed. Traffic officers have operating hours and motorists who frequent routes are aware of such operating times.

2.3 Automatic Number Plate Recognition

The system of ANPR is based on Charge-Coupled Device (CCD) infrared cameras, OCR software for number plate recognition, digital inputs and outputs, Databases and GUI meant to aid in interaction with the operators. The roads have lanes which are areas that accommodate vehicles and typically a single camera is utilised in a single lane. The license plates are captured within these lanes where the vehicle is. ANPR has the following steps:

2.4 Acquiring the image

This step involves capturing the image stream from the camera source and then sending it to the Personal Computer. Image acquisition is achieved using several tools such as digital or analogue cameras. The stage also involves extracting the number plate from the whole image body of the car by identifying the region that has the number plate either through aspect ratio or edge density. To facilitate this, there is an algorithm that determines what parts of the vehicle’s image is the plate (Nigrel, Ashokan, Barua, Patil, & Patil, 2015). The algorithm ascertains the exact area of the vehicle where the plate can be found. This means that the process must rule out vehicle components such as grills, mirrors, headlights, bumpers etc.
The algorithm also searches for geometric shapes which have a rectangular proportion. Though a vehicle can have plenty rectangular objects on it, there is a need for further algorithms to validate whether an identified object is a license plate by looking for characteristics that would indicate that it is indeed a plate. Furthermore, the algorithm should facilitate character isolation and identification for readability. To enhance visual and readability most countries are having plates that are retro-reflectors which will reflect the light back in the same direction of the source with limited scatter.

2.5 Image processing

Image processing is a form of signal processing where the input is an image that can be a photo or a video where the output can be an image or characteristics and dimensions related to the image (Nigrel et al., 2015). The input can be a picture or a movie scene and the output an image or a sequence of indicators and variables which are related to the image. The core operations in image processing involve restoration of images, removal of noise, image histogram, enhancement of the image resolution, edge detection, geometric transformations, colouring, compression of image and image difference.

3. Communication models for back-end operations

3.1 GSM based model

In this model, the first process has the speed trap camera capturing the image of the vehicle that will contravene the traffic law. The image is retrieved on a computer system that is connected to a GSM modem. The second process involves sending the image to the central database through the GSM network. The third process involves processing of the data from the GSM network and analysing it using image processing software before linking it to the database. The last stage encompasses tracing the owner using the central database. In a nutshell, making use of a high speed camera the photo of speeding vehicles are recorded and sent to a police department using Multimedia Messaging Service (Hafeez, Shammarani, & Shammary, 2015).

![Fig 1: Architecture for the Malaysian Traffic](Helmy, Wahab, Member, Gopalakrishna, & Johari, 2008)

3.2 RFID based model

The model has RFID readers, GSM/GPRS module with a SIM card inserted and a camera which will be interfaced to a microcontroller. Each vehicle has a RFID tag and as it passes through the first RFID reader its information will be extracted. There is a countdown timer within the microcontroller which will
be fixed to a specific time based on the distance between the two RFID readers. The speed limit violation is recognised in the event that the tag of the vehicle is read by the second RFID before the timer reaches zero. A signal is then sent by the microcontroller to the camera for it to take a picture of the car and to the GSM/GPRS modem for it to send an SMS to the number of the owner of the car who has the tag and to the Police to inform them about the speed violation for further action (Al-shabibi, 2014).

Fig 2: Model for speed violation and detection using RFID and GSM technologies

Source: (Al-shabibi, 2014)
4. PROPOSED MODEL

The proposed model integrates the Zimbabwe Republic Police (ZRP), Zimbabwe National Road Administration (ZINARA), Central Vehicle Registry (CVR) and Zimbabwe Revenue Authority (ZIMRA) and High Performance Computers Centre (HPCC).

ZIMRA is responsible for the issuing of registration plates and books for motor vehicles for both new vehicles and cars that are sold. They will forward the information to CVR who keep record of all the vehicles in Zimbabwe. In the proposed model, high speed cameras are placed on the highways and should a motorist violate the traffic rules, a combination of an image, speed and the location through GPS is captured and sent to a high speed supercomputer found within HPCC. Since it is a nationwide project, there is need to handle such volumes of data and process faster. The supercomputer will have image processing software to be able to convert the captured image into digital form so as to get the license registration of the vehicle.

After the process, the image and the computed registration is forwarded to the ZRP Headquarters where there is an automated system that will send requests to the Central Vehicle Registry to get the details of the vehicle owner. If there is a match, the system will generate an MMS which contains the image of the vehicle and the amount the offender is supposed to pay based on the speed recorded and will transmit using a GSM modem. The motorist can pay the fine at any ZRP office. In the event that the offender does not pay in the stipulated time, an alert is sent to ZINARA requesting the vehicle to be impounded until the fine is paid. ZINARA is responsible for licensing of vehicles and toll fees. The offender can be apprehended when passing through a toll gate or paying for a vehicle license.

5. DISCUSSION

Corruption in the ZRP is an issue of concern, especially in the traffic department. The police is employing manned speed traps as a measure to control speed on the highways. Although, the method is effective it has many limitations on the equipment they use, revenue collection and operations. The Doppler gun only captures one vehicle at a time and cannot be used in capturing many vehicles at a time. Motorists are aware of the spots where the Police hide and they tend to warn each other before approaching such zones. If offending motorists are caught, they can either bribe the police or ask for a picture or video evidence which the police cannot provide. As the police officer is arguing
other offending motorists will be passing, which will affect the revenue collection. The researchers propose the adoption of a conceptual model for highway speed monitoring and enforcement that incorporates Automatic Number Plate Recognition (ANPR), GSM and back-end integration between the four government departments ZRP, ZINARA, ZIMARA and CVR for the system to be fully effective. The model should consist of remote cameras placed in several locations country wide so as to reduce the corruption associated with highway speed monitoring and avoid speed related accidents.

6. CONCLUSION

A model that uses ANPR and GSM was proposed after identifying the weaknesses of the current highway speed monitoring system in Zimbabwe. However, for the model to be fully effective there is need to regulate the change of ownership of vehicles. At present, the legislature is silent on the time frame for changing vehicle ownership. This may affect the concept of operation of proposed model, for vehicle database details may be different with present ownership.

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References


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