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Implementation and Impact of ICT Technology on Vehicle Over-speed and Drinking Driving Monitoring in Tanzania: A Survey

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Abstract
Today's transportation status has rapidly grown due to the daily increase of population and use of road as main, easy and economical way of travelling as well as transportation of goods, Thus now a days due to the high quantity of vehicles several problems has arisen in road sector such as road damage, road accidents, congestion as road accidents has been a major problem in Tanzania which in many cases results from the Breach of Traffic rules. Many innocents Tanzanians are continuously losing their lives and some get permanent body disabilities and property destruction due to road accidents. From 2009 to 2010 there was an increment of 2,907 accidents which is equivalent to 13.2% and most of the causes were due to human factors which include over-speed, drinking and driving, reckless driving, overtaking and overloading. Some of the measures have been taken but still there are many challenges. Traffic Police have been using devices (speed radar and breathlayzer) but have shown some weakness on solving problems. Information and Communication Technology (ICT) Also contributed a lot to control the problem as introduced many ways of automatic control. Thus this paper will review the system used for prevention/avoidance of drinking & driving and over-speeding in Tanzania. It will also propose a system that will monitor and provide real time information of drivers drinking & driving status and over-speeding in different zones of different speed limits.
Keywords: Over-speed**;** Speed Radar Touch; Breathalyzer; Information Communication Technology (ICT)

1. Introduction

Many roads in Tanzania are networked in which there is trunked, regional, district, urban and feeder roads, all of these roads some are paved and unpaved, according to ministry of works there are national road network of about 33,891 km comprising 12,786 km of Trunk and 21,105 km of Regional roads[1]. Road transportation is one of the mostly used mean of transport used by many Tanzanians for their daily life activities; it has been easier way for travelling of goods and passengers thus many citizens prefer to use it frequently. Even if it has simplified the transportation system in Tanzania but it suffer many problems that results from road crashes. Road crashes are a serious societal and public health issue in Tanzania. The situation keeps on deteriorating; for instance during the period between 2000 and 2008, the total number of road crashes increased by 42 % (from approximately 14,500 to 20,600)[2]. The number of injuries went up 27% and the number of people killed increased by 67%. This is 30 to 40 times higher than in most Western European countries. Apart from the loss of many lives, the impact of the road crashes on the country's economy is enormous [2].

According to the World Health Organization (WHO), road crashes are the ninth factor worldwide for causing deaths [2-4]. If the situation is not reversed, road crashes will rise to the third place in causing deaths by the year 2020[3]. Road accident can be caused by many factors but mainly are due to Human, Road infrastructure(poor quality) and vehicles[2, 5]. According to the traffic police statistics, human factors caused 75% of the road crashes in 2008, while other factors such as Mechanical and Road Conditions contribute to the remaining 25 %[2, 6]. Human factors comprise all causes which are caused by human mistakes such as speeding, overtaking, drinking and driving, overloading or poorly loaded and careless driving[2]. Table 1 below shows the main causes of road crashes in Tanzania by 2000 up to 2005 and 2010.

General Over-speeding and drinking & driving are the most of the factors cause accidents and as a result many lives of Tanzanians have been lost in accidents. Driving while either on drugs or drunk is dangerous and drivers with high blood alcohol content or concentration (BAC) are at greatly increased risk of car accidents, highway injuries and vehicular death [7, 8].

The Road traffic act [9] states that it's prohibited to drive while under the influence of drink or drugs and reckless or dangerous driving to such an extent as to be incapable of having proper control of a motor vehicle on road or any public place shall be guilty of an offence and pressed charges. More efforts have been taken to discourage driving while drunk and vehicle over speeding, Information and Communication Technology (ICT) have also contributed many technologies so as to monitor speed and alcoholic status of the driver figure 1 below shows how Intelligent Transportation System can be used in road to monitor over all road transportation infrastructures. Tanzania National Roads Agency (TANROADS) under the Ministry of work have established many ways to reduce vehicle over speeding and Traffic Police also are using Breathalyzer for alcohol monitoring

while/during driving.

2. Related Works

ICT have risen and been used most in many sectors especially in this 21st century technology is changing and growing fast an making life easier and comfortable. ICT have also engaged in road sector, and one of the most profits of applying information and communication technologies (ICT) in the road zone is its likely to lessen public losses from vehicle accident .ICT proposes a wide collection of possible safety applications in road transportation. Such applications could provide collision avoidance warnings or involvements, for example, as well as warnings of driver drowsiness or lane departures [10].

Angela A. Runyoro, et al [11] proposed components for a framework, which will assist automation in road traffic management and hence enables the implementation of better traffic control networked systems in Tanzania, The framework identified the possibility on integrating the two existing ITS sub-system which is known as Advanced Traffic Management System (ATMS) and Advanced Travel Information System (ATIS) ,they used Forecasting of Traffic Objects (FOTO) model which identifies traffic phases and tracks synchronized flow, together with Automatische Staudynamik analyse: Automatic Tracking of Moving Jams (ASDA) model which applied to the automatic recognition and tracking of congested spatiotemporal traffic patterns on roads, on which they consider some component that will be added in order to integrate the ITS. These include demand side systems such as ATIS, supply side systems such as ATMS, control Centre and road users' information devices and media.

Automatic Vehicle over Speed Accident Alert and Locator System (AVOAALS) introduced in 2013, the system to detect vehicle over speed and provide location in the case of accident [12]. They uses GPS and GSM network, especially GPRS function of the GSM network. The system designed in such a way it monitors the speed and accident event of the bus. Once an event is detected, the system leads the current position of the bus using GPS. One of the shortcomings of the system is that it does not take into account the variation of speed limits (zones) along the road. In reality, roads have different speed limits throughout; therefore an adaptive speed monitoring is required in order to cope with the real world environment.

Smart On-board Public Information System designed by [13] using GPS & GSM Integration for Public Transport which used to trace a public transport using a GPS and let the desired organization where the bus is heading and where it's by use of GSM and the unit mounted on bus sends the data using GSM/GPRS module to central monitoring system & displays it on City Map.

In 2008, Peter Rieth et al, described how the ITS system used in road safety as explained how Telematics technology used into the vehicle to make a safety for a driver as well as surrounding while driving in which networking of active and passive safety (APIA) which is the fundamental basis for comprehensive vehicle and road safety[14].

3. Ways of Reducing Vehicle Over-Speeding and Alcoholic Drivers in order to prevent/avoid road accidents

In Tanzania there are many trunk roads and highways that buses, private cars and trucks always use them for easy transportation way, thus through these roads many accidents occurs and result in loss of Tanzanian life. Some of the measures that have been taken by the government upon reduction of roads accidents currently in Tanzania there are two systems used to manage speed limits and alcoholic drivers. The traditional way of speed and alcoholic management which includes Road signs and markings, Speed bumps, scheduling legislation and Physical traffic police. The modern system commonly employed is speed governors / speed delimiters, speed radar guns and alcohol testers (breathe analyzers)[2, 15].

3.1 Old Systems for Vehicle Over-Speed and Alcoholic Driver Management

It's somehow old model system but still is in use as it help in prevention of accidents, most ways used to prevent road accidents in Tanzania is by posting an advertisement and signs along the roads, another method in which government has taken an effort to construct speed humps and bumps in urban roads and highway roads and Physical Traffic police.

This system is used in nearly all roads but it failed to mitigate the problem. Moreover in some areas some of the posters and advertisement are damaged, stolen or sometimes weaken away because of sunlight, or drivers ignoring them, and those bumps and humps being distorted or not of standard, According to the Guardian newspaper of 24th Aug 2013 bumps are traffic calming structures, which aim at enforcing speed reduction. Most of the roads in the country have different humps and rumble stripes which in most cases have been causing accidents, so a standard would help reduce or eliminate such a problem, all highway road humps should not exceed 150mm in height while for those in towns the height would be at 100mm, and most current road humps did not meet the required standards[15]. Another mean of controlling the speed of upcountry-passenger buses is by issuing a Time table that will be used during the journey and will be shown at each of the check point by traffic polices and if driver travelled out of limit time he is penalized. The Surface and Marine transport Regulatory Authority

(SUMATRA) is responsible for setting bus time tables for buses going upcountry and towards Dar es Salaam[12].

3.2 Modern Systems for Vehicle Over-Speed and Alcoholic Driver Management

Now a days this system is used by Traffic police for monitoring a vehicle speed and drivers alcohol status at each check-up point as the vehicle approaches the check point the police holding the radar gun and find out the speed at that moment and if any offense is found, a fine is charged or taken to court . Devices like speed radar, alcoholic content analyzers and speed governors are used and ministry of Works under Integrated Road Project obtained and supplied these devices to the Traffic Police to improve traffic laws enforcement[16]. These devices are very helpful and somehow decreases the road crashes but sometimes they failed due to the circumstances that lead the driver to cheat the Traffic Police. Speed Governors were introduce in 1997 by Government of Tanzania for public service vehicles but they didn't last long because operators used to manipulate them easily and didn't have any automatic feedback or report sending feature to the enforcing authorities[12].

Radio Detection and Ranging System Touch (Radar Torch) shown on figure 2 below, is a handheld Touch like devices which uses the transmission of microwaves to detect the speed of the car, It measures the speed of the objects at which it is pointed by noticing a change in frequency of the reverted radar signal produced by the Doppler effect, whereby the frequency of the reverted signal is increased in proportion to the object's speed of approach if the object is approaching, and lowered if the object is fading, in means it uses a Doppler Effect to calculate the speed of vehicle approaching or going away equation (i) explain the Doppler Effect [17-19].Figure 2 below shows how radar gun works, it produces a microwave that will hit the aimed object and return back.

$$f_{D=} - \boldsymbol{v}\frac{f}{c}\cos\emptyset \qquad \text{(i)}$$

Where *fD* is the Doppler effect, *v* is the relative velocity between the transmitter and the receiver, *f* is the carrier frequency of the signal, *c* is the speed of light, and φ is the angle between the velocity of the relative motion and the direction of the transmission[19].

And speed of vehicle is calculated by following equation (ii)

$$\boldsymbol{v} = \frac{\Delta \boldsymbol{f}}{\boldsymbol{f}}\frac{\boldsymbol{c}}{\boldsymbol{2}} \qquad \text{(ii)}$$

Where *c* is the speed of light, *f* is the emitted frequency of the radio waves and Δ*f* is the difference in frequency between the radio waves that are emitted and those received back by the gun[17].

Since these devices are not automatic to the sense that they need to be hand held by the Traffic Police, they lack the continuous monitoring of speed and therefore their efficiency in speed detection is low as many drivers tends to reduce speeds when they approaches the Traffic Polices check points. Also according to the interview with senior assistant commissioner of police traffic division, stated that one of the challenges that speed radar is facing is that it don't have a camera thus it gives a driver capability to deny his/her over-speed offense. According to[20] police radar is overcoming several problems that results in incorrect reading, misidentification, etc. Some of the errors identified are as follows:

- Cosine Error
- Radio or Microwave Interference
- Multi-Path Beam Cancellation
- Scanning effect
- Multiple Bounce Errors

3.2.2 Cosine error

One source of error in the reading of the radar gun is called the cosine error. This is created when the transmitted microwaves strike the object at an angle to the travel path. The greater the angle between the wave path and the direction of travel of the object, the greater the error (resulting in a slower reading than the actual speed)[20].

3.2.1 Radio or Microwave Interface

Interference is produced by nearest devices working simultaneously in the same frequency band, disturbing each other by transmitting unwanted RF signals that can destruction the wanted ones[21, 22]. There is both natural and man-made interference's, but all have one common thing, that they create a false or incorrect reading on the radar unit's display. Common sources of electromagnetic interference include airport radar; microwave transmissions; VHF/UHF, and cellular two-way radio/ telephones, including police and business radios; faulty sparkplug wires; mercury vapour and neon lights; high-tension power lines; and high voltage power substations[20, 23, 24]. Thus the energy from these sources can confuse the delicate circuits in a radar gun and display the wrong speed measurement.

3.2.3 Multi-path beam cancellation

After hitting the target vehicle the radar beam which will return directly to the radar gun will be cancelled by secondary reflected signal. So this cancellation can occur while the target remains in plain sight of the operator.

Actually, multi-path beam cancellation occur when a 180-degree phase reverse take place between the direct path signal from the target vehicle and the signal from the reflected path. The signals, in effect, cancel each other out as far as the RADAR is concerned[20, 23, 24].

3.2.4 Scanning effect

This type of effect occurs when a rapid fluctuation of a hand held radar gun while operating or scanned past the side of a car, a brick wall, or some other stationary object is supposed to produce a speed measurement. The idea behind this charge is if the antenna moves, the RADAR will register the relative motion[20, 24].

3.2.5 Multiple bounce errors

This Error occurs when there are many moving targets in the main beam, which will cause several replicated signals of near-equal strengths but varying frequencies to arrive at the radar gun's antenna. Liable on the gun, the display may shift from one speed-reading to another, it may show a mixture of the reflections, or it may blank out[24].

Another Device that used by traffic police at the check-up points is alcoholic content analyzers (breath analyzer) figure 4, this helps to find out the blood alcohol content or concentration (BAC) of the driver by his/her breath this proves weather driver is drunk or not. Many of the road accidents are caused by reckless driving, excessive speed, overtaking errors, negligence of drivers and alcohol above blood level of 0.05g/100ml[25].Drivers and motorcyclists with any level of blood alcohol content (BAC) greater than zero are at higher risk of a crash than those whose BAC level is zero. For the general driving population, as the BAC level increases from zero the risk of being involved in a crash starts to rise significantly at a BAC level of 0.04 g/100 ml[26].

When the user breathes out into a breath analyzer, any ethanol present in their breath is oxidized to acetic acid, two free protons and two free electrons are released from the ethanol molecule, equation (iii) shows the reaction at anode side:

$$CH_3CH_2OH(g) + H_2O(l) \rightarrow CH_3CO_2H(l) + 4H^+(aq) + 4e^- \quad \text{(iii)}$$

And at the cathode side, atmospheric oxygen is reduced shown into the equation (iv) below:

$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l) \quad \text{(iv)}$$

The overall reaction as shown in equation (v) is the oxidation of ethanol to acetic acid and water.

$$CH_3CH_2OH(l) + O_2(g) \rightarrow CH_3COOH(l) + H_2O(l) \quad \text{(v)}$$

As illustrated in figure 5 below the two protons move through the lower portion of the fuel cell and combine with oxygen and the electrons on the other side to form water. The more alcohol from the breath sample that is oxidized, the greater is the number of free electrons that are produced resulting in the greater amount of the electrical current that is produced[27].

The electrical current produced by this reaction is measured by a microprocessor, and displayed as an approximation of overall blood alcohol content (BAC) by the Alco sensor[28].

4 Role of an ICT on Transportation Facilities

ICT can make main impact on several areas of human and economic growth, It has been very helpful due to the fact that can help reduce human activities by providing information or inverted in any device that can make work easier, as a technology rapidly broaden ICT is being playing a big role in many parts of technology issues, it can be adopted to increase road safety through addressing education, enforcement and vehicle engineering [5]. It can be applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport[29], Intelligent transportation systems (ITS) apply ICT to the real- time management of vehicles and transportation system as a whole involving the movement of people, goods and services [11]. Even when using it on roads it will be helpful to traffic police and emergency units in monitoring any offences or accident occurred as well as position of the event happened. ICT enables on building intelligent vehicles that provide intelligent solution which contribute to solving the key societal challenges and increasing road safety[30] and that intelligent functionality can assist driver in prevention or avoidance of accidents and providing real time information on road network condition. In Tanzania many efforts have been taken to make sure ICT is engaged in every sector, since the government of Tanzania constructed the national fiber optic cable network named as national ICT broadband backbone (NICTBB) with a view to attain its ICT vision [12].thus it is expected to improve usage of ICT applications for sustainable socio-economic growth. road traffic accident information system (RTAIS) and web based RTA database (RTAD) where developed and managed by Tanzania police force and traffic police department, thus it helped on recording accident information and analysis of accident data[5, 31].There is many private organisation in Tanzania that is using ICT in their services and products as for example fleet management, Vehicle and Cargo tracking system and fuel usage monitoring which all of them will provide a real time information with the help of ICT services and equipment's. The whole ICT infrastructure which can also be provided at the highways and main roads can offer a chance to came up with a low cost effective ITS application for vehicle over speed and driver alcoholic status monitoring in Tanzania.

5 Conclusion

With advances in technology more techniques have been proposed in order to prevent/avoid road accident, Also, ICT has been contributed somehow to some issues considering a road networking, transportation system and overall social-economy development. There are many causes of road accidents in which over speed and alcohol is the one of them. Traffic police department is doing enormous efforts on monitoring these events as they have been using manual or traditional ways for checking up but sometimes they failed due to the circumstances for instance when drivers try to cheat traffic polices with radar devices at the check points. Sometimes drivers can be alerting each other while travelling before they meet check point and hence they tend to reduce the speed only at that particular time. Another case is during the bad weather conditions which hinder a process of manual traffic police check-up. Due to numerous reasons mentioned earlier hence there is a need of intervening through an adaptive monitoring and control system which will monitor the speed of the vehicle throughout the journey. An integrated alcoholic and adaptive vehicle speed monitoring system can be of assistance contrary to the conventional way of traffic police manual monitoring. The system can also provide real time information of driver's behaviour on the road and store that information which will be helpful to find out repeated offence.

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Table 1: Causes of road crashes in Tanzania [2]

Causes of road accidents	**Contributory Percentage (%)**	
	2000-2005	**2010**
Human factors	77	74
Including, Careless driving	54	57
Over-speeding	8	9
Improper overtaking	7	8
Drink and Drive	3	0
Overloading	4	n.a
Mechanical factors	16	12
Road conditions	7	14
TOTAL	**100**	**100**

This table shows the causes of road accident in which three factors is mentioned as follows; human factor, mechanical factors and road condition in which Human factors with 77% in 2005 and 74% in 201 is leading in causing accidents.

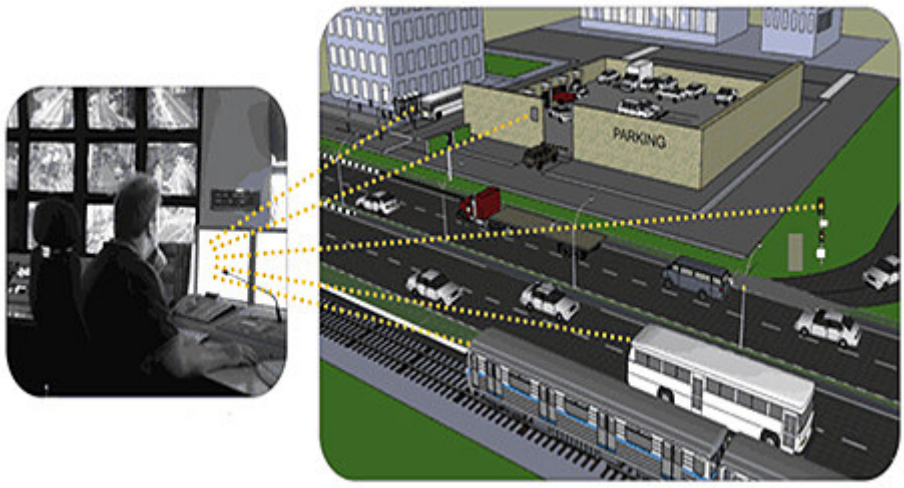

Figure 1: Intelligent Transportation System

Figure 2: Radar Gun

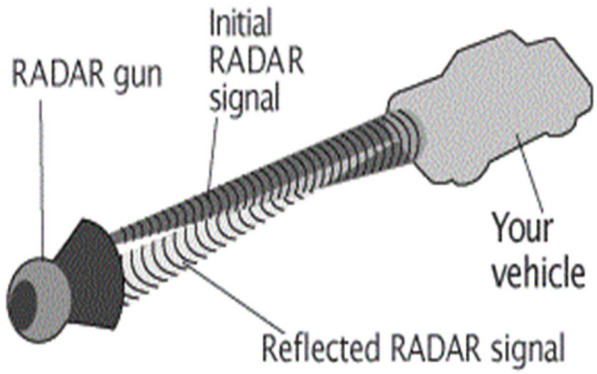

Figure 3: Radar Microwave Performance

Fig 4: Alcoholic Content Analyzers (Breath Analyzer)

Fig 5: How Breath Analyzer Works