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Web-based Clinic Management System (CMS)

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Abstract: In healthcare services, patient medical records are becoming large in size and the complexity of exchanging patient records such as prescription detail, referral data, diagnosis status and appointment schedules between various clinic-units can be a problem without a fully integrated system. Moreover, access to patient records requires privacy. Quite a number of works have been conducted on healthcare services to address issues such as medical record inconsistency, lack of immediate record storage and retrieval and paper-based approach. Consequently, this work tries to automate and enhance the clinical services of Sule Lamido University Clinic by developing a web-based application. The application will allow both the clinicians and patients to have access to electronic records easily, which will, in turn, minimize the cost, difficulties, and ineffectiveness of working with patients' records manually and to enhance the benefits and profits in running the clinic services. It can be used in decision making as it provides complete, reliable, accessible and understandable information pointing to the clinic progress and shortcomings. Initially, the problems of the current system were identified, the requirements were however specified and analyzed. Model of the system was designed and implemented using SDLC and finally, the system was tested and validated. The results revealed that the system complies with the specified requirements. Hence, the objectives under which the system is defined were achieved.

Keywords: CMS, Clinic, healthcare, HMS, management, System, information system, SLU

1. INTRODUCTION

Over the years, a wide range of literature has revealed the roles being played by Information System (IS) in healthcare services. [3] defines information systems based on two terms; these are information and system. In the process of advancing the idea, information is an analyzed data, while System is a collection of a finite set of elements joined together to' achieve objectives. More often than not, information systems normally consist of smaller systems known as subsystems, which all function towards ensuring the efficacy of the large systems [7].

Significant improvement in clinical workflow, administration as well as revenue enhancement are some among the benefits that outweigh the challenges of Information System in healthcare industries. Furthermore, another key thing to remember is access to clinical information; electronic access to medical records helps clinicians to save time and an enormous amount of resources. Thus, IS provides a complete, reliable, accessible and understandable information in a timely manner as well as in the effective management of patient medical records [4].

Consequently, the need for effective IS in healthcare services is considered substantial since it depicts organizational performance which in turn helps in predicting the future of possible challenges and at the same time provides appropriate solutions that can be built with streamlined operations towards the enhancement of proper administration and control over the untimely threats.

The CMS is an integration of patient information systems that captures and stores demographic, financial, and medical information from ancillary services such as registration, billing, lab, radiology, pathology, pharmacy, and transcription. The CMS also includes the network that links these systems, databases, interfaces, physician' order entry, electronic communication systems, and the clinical workstations [2].

Patient medical records accumulate during the clinical operations, information such as records of patients, treatment records, inventory stocks and data of other sources. As the complexity in healthcare services increases, healthcare practitioners find it difficult to manually exchange patient information from one file to another and from one healthcare practitioner to another. Hence, some among the major problems include; lack of immediate information storage and retrieval, poor preparation of accurate and prompt reports, lack of prompt updates, Error prone manual calculation.

In this paper, a web-based application for managing the services of Sule Lamido University Clinic is developed to deal with the above-mentioned problems. The rest of this paper is organized as follows; the related works are discussed in section 2. The proposed clinic management system is discussed in section 3. The conclusion and future work are discussed in section 4.

2. RELATED WORK

Tremendous efforts have been made to address problems in healthcare industries, and various researches have been embarked to provide solutions to the existing problems. They employed different approaches and tools for requirement analysis, project design and implementation as steps towards enhancing the effective processes needed for a modern healthcare system. As raised by [2], healthcare information systems are developed to meet the following goals: improve quality of care, reduce organizational expense, and produce' a data stream for electronic billing. The CMS meets these goals through workflow automation, connectivity, and consistent data sharing.

In research projects conducted by [8] and [9], there were no functionalities such as online consultation and report generation. However, the systems (mentioned above) need to be adjusted to comply with current requirements needed in modern healthcare services. In view of this, functionalities such as online consultation, appointment scheduling, diagnosis manager, report generator are added to the new system.

Hospitals and clinics can be regarded as organizations based on high technology and information' intensive processes.

Such organizations are not hierarchically structured bureaucracies but are often based on democratic control mechanisms with institutionalized stakeholder influence in decision processes. It is also expected' that health care budgets and funding will depend significantly on the sophisticated patient and diagnosis classifications. The use of IT in diagnostic and treatment' processes will add to the development of networks of clinical, hospital and healthcare processes.

A considerable amount of literature has indicated that; healthcare management is a growing profession with increasing opportunities in both direct and non-direct care settings. [9] similarly opined that direct-care settings are those organizations that provide care directly to' a patient, resident or client who seeks' services from the organization. Non-direct care settings are not directly involved in providing' care to persons needing health services, but rather support the care of individuals through products and services made available to direct care settings.

Sule Lamido University clinic is currently operating manually. Its various services include; patient consultation, resuscitation and admission for observation during working hours, follow-up for hypertensive patients, treatment of minor trauma and counseling with medical issues, patient treatment services such as wound dressing and bandaging. The Clinic has full stocked pharmacy for provision of drugs and is being overseen by Pharmacist. The administrative section handles data processing services. Such services are being managed by assistant data processing officer and clerical officer using file processing approach. Therefore, with the ill-equipped Information System, the stock cannot be managed properly. Most of these problems can only be addressed if a proper Information System is developed.

3. THE WEB-BASED CLINIC MANAGEMENT SYSTEM

CMS is designed for both patients and practitioners. It will allow patients to create an appointment, print appointment card, generate medical reports, search for health tips, view doctor's profile, send emergency reports and chat with doctors online. The system will, however, allow practitioners to confirm, edit or cancel patient appointment request, diagnose patients, prescribe medicines to the patient, manage inventory, manage both patient and clinic staff records. As a step toward integrating the clinic operations, the proposed system composes of various modules, which are dependent on one another. The data flow between subsystems is illustrated in Figure 1. The sequence diagram of CMS appointment module is shown in Figure 2 and Use case diagram of CMS is shown in Figure 3.

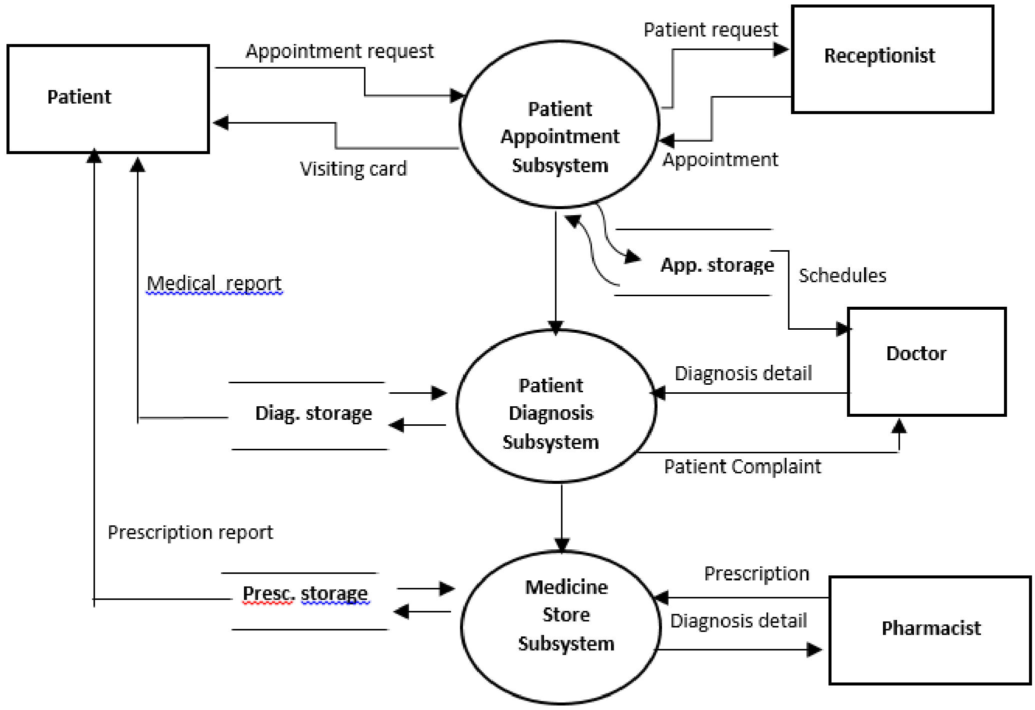

Figure 1: Level one DFD of CMS

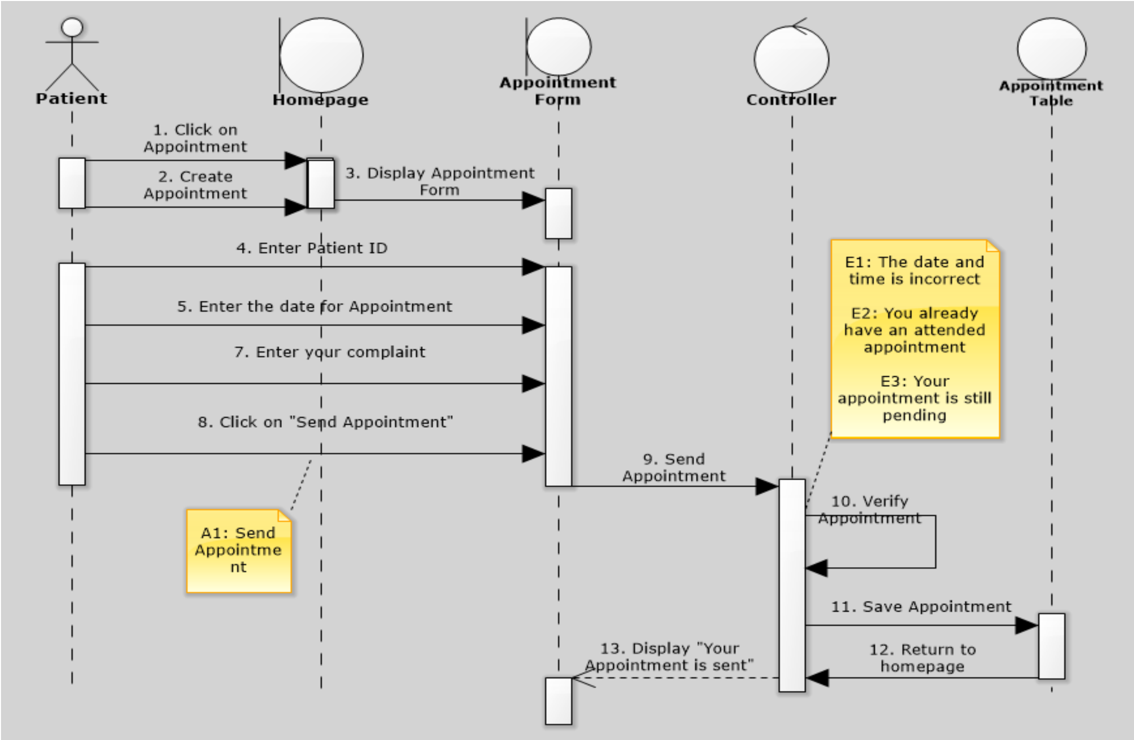

Figure 2: Sequence diagram of CMS Appointment Module

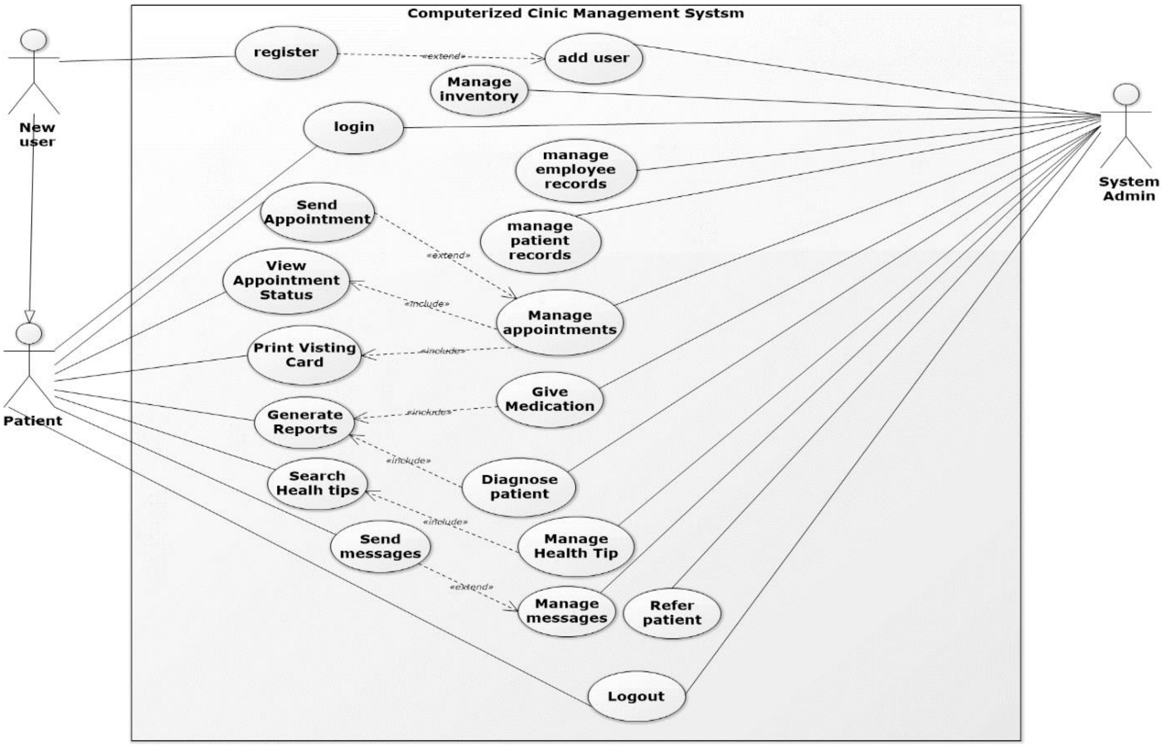

Figure 3: Use case diagram of CMS

Table 1. The programming languages used in the system implementation

Programming Language	Purpose	Environment for testing
Hypertext Pre-Processor (PHP)	Servers-side scripting	Web browser and XAMPP server
JavaScript	GUI behaviors and alerts	Web browser
AJAX	HTTP requests	Web browser and XAMPP server
Hypertext Markup Language (HTML)	Page structure	Web browser
Cascading Style Sheet (CSC)	Presentation and styling	Web browser
Structured Query Language (SQL)	Database queries	Web browser and MySQL DBMS

The database of this application is implemented using MySQL. It is an incredibly popular and powerful Relational Database Management System (RDBMS) that allows the creation of. MySQL is an open' source relational database management system (RDBMS) that uses Structured Query Language (SQL), the most popular language for adding, accessing, and processing' data in a database. MySQL is a true multi-user, multi-threaded SQL database server [12].

PHP is one of the programming language used in designing the program. Hypertext Pre-Processor (PHP) is a server-side scripting language, usually used to create web applications in combination' with a web server, such as Apache. PHP can also be used to' create command-line scripts akin to Perl or shell scripts, but such use is much less common than PHP's use as a web language [12]. The reason why PHP is used, because PHP is free, as there is' no 'cost to develop in and run programs made with PHP. PHP is compatible with the leading web servers: Apache HTTP Server for Linux/Unix and Windows' and Microsoft Internet Information Server. It also works with several' lesser-known servers. Specific web server compatibility with MySQL is not required since PHP will handle all the dirty work. There are other programming languages used such as JavaScript, SQL, HTML. The remaining details can be seen in Table 1. The modules that make up the system are discussed in the subsections below.

3.1 Appointment Scheduling Module

This module is designed to have two sections (patient section and staff section), each of these sections is only accessible to the authorized user; patient accesses patient section and staff accesses staff section. The patient section allows the patient to send an appointment request, while the other section of the staff provides the detail of each patient request, the functionalities of confirming, editing and deleting the patient appointment request. If a patient appointment is confirmed, then he can print his visiting card instantly.

3.2 Observation and Diagnosis Module

After the appointment is confirmed, then the patient record goes to the observation module where he will be diagnosed by a doctor. However, this module saves the diagnosis record. After the diagnosis, the patient record may be sent to either admission module for the patient's admission, pharmacy module for medication or referral module if the patient is to be referred to a different hospital. Observation module is only accessible by staff.

3.3 Patient Referral Module

This module deals with the information sent from the observation module for patient referral. It is designed purposefully if the patient is needed to be referred to another clinic or hospital. Here in this module, other information like hospital facility to be referred and the result of the diagnosis is provided.

3.4 Pharmacy and Inventory Module

This acts as a medicine store, where medicines are kept. Patient from observation units is sent to the pharmacy for collecting medicines. There is a waiting panel for patients to wait while another patient is being attended. The module keeps track of the pharmacist who offers the medicine, the patient who collects the medicine, date and time for the medication. The module also includes a sub-module for prescribing patient during medication. It has a panel for adding and updating medicines if in case there is a need for any of such operations.

3.5 Online Consultation Module

This module acts as a messaging system where both patient and doctor discuss health-related issues in real time. It, however, provides a panel which shows active users online to indicate whether the user is available or not.

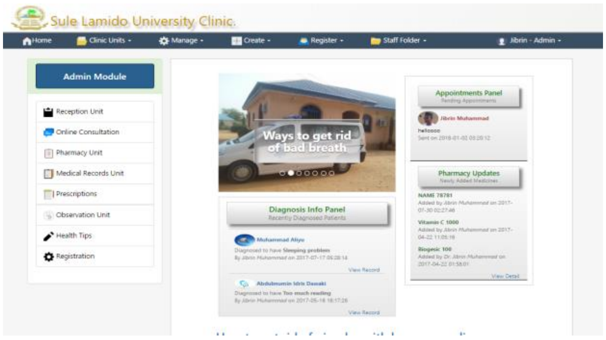

Figure 4: System Interface

4. ACKNOWLEDGMENTS

CMS is designed and developed to automate the manual system of Sule Lamido University Clinic and oust the manual method of record/file keeping. Both the practitioners and patients will find this system useful, to aid in their computerization. Thus, the system will promote effective, efficient and quality services. Clinic Management System (CMS) currently focuses only on the relationships between patients, receptionist, physicians, and pharmacists. It is part of the future plan for this project to incorporate other healthcare facilities and professionals, such as laboratory technicians who perform, report tests and analysis requested by physicians. However, another plan is to enhance the system to investigate whether our Clinic and Pharmacy modules can be interfaced to applications supplied by pharmaceutical companies that provide information on medications and dosages. In addition to that, the future plan extends to develop a mobile phone application that will work with the system over the internet network.

5. ACKNOWLEDGMENTS

Our thanks to the Sule Lamido University Clinic for and other staffs of the university who have contributed towards the development of this system.

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Real-Time Video Display System in Articulated Vehicle for Road Safety Enhancement

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Abstract- *Nowadays, auto crashes are being recognised as a major public health problem; with higher fatalities in third world countries. Wrongful overtaking has been one of the major causes of road traffic accidents (RTAs) especially that involving large sized vehicles (LSVs) or articulated vehicles. Driving behind such a vehicle has being a nightmare to most drivers especially on a single – lane highway. Even though the movement of LSV is relatively slow, overtaking it is a problem because of its size and the inability of the driver to see ahead of it. However, Real-Time Video Display System (RTVDS) in articulated vehicle for road safety enhancement provides a solution to such problems; by providing overtaking drivers with visual information on the state of the road ahead of the articulated vehicle so as to assist the driver in deciding on whether to overtake or not. Such information may also reduce the risk of accidents caused by sudden braking or animals crossing the road. The system basically consists of a digital camera mounted in front of the truck, a control unit (raspberry pi - RPi) and an exterior display unit located behind the truck. Shaky images captured by the camera were stabilized using Optical Flow algorithm of video stabilization before being displayed. The design was implemented using Python as the programming language. Results obtained from the design show that the system is capable of producing stable video images required for decision making before overtaking. Hence, reducing the rate of RTAs associated with LSVs if fully developed.*

Keywords: Auto Crashes, Articulated Vehicle, Road Safety, Raspberry Pi, Video Stabilization, Python

1.0 INTRODUCTION

The total number of serious auto crashes has been on the increase regardless of improvements in modern vehicular designs and road network for driver safety. Record from World Health Organisation (WHO) shows that about 1.24 million people lose their lives in Road Traffic Accidents (RTAs) annually and another 20 – 50 million are injured (WHO, 2015); with higher fatalities in developing countries. Record also revealed that without check, about 1.9 million lives could be lost by the year 2020. These high numbers of human deaths and injuries as well as losses in country's economy show how vital it is to deal with this menace.

Report by Mutya and Rudra (2015) indicated that 60% of deaths in RTAs were associated with Large Sized Vehicles (LSVs) such as buses, trucks and mini buses. Driving behind such a vehicle has being a nightmare to most drivers especially on a single – lane highway. Even though the movement of LSV is relatively slow, overtaking it is a problem because of its size and the inability of the driver to see ahead of it. Moreover, Bhumkar *et al*. (2012) showed that wrong overtaking is the second highest leading cause of road accidents. As at the year 2013, in Nigeria, 6,450 people lost their lives in road accidents (Adedokun, 2015) and 183, 531 people were injured as a result of RTAs between 2009 – 2013, (Agbokhese *et al*.2013).

According to Federal Road Safety Commission, FRSC (2015), there were a total of 21,199 road accidents in 2013 out of which 1,495 involved articulated vehicles such as tankers, trailers or buses which represent 7.05 % of the accidents. In 2014, a total of 16,779 vehicles were involved in crashes, out of which 998 were tankers or trailer-related, representing 5.94 % of the total crashes that year. As at first quarter of 2015, a total of 1,193 vehicles caused Road Traffic Crashes (RTCs) out of which 49 were articulated vehicles, representing 4.11 %, (FRSC, 2015). Researchers and vehicle manufacturers have come up with different strategies in an effort to curtail RTAs and to ensure safety on the road. Some safety mechanisms currently used in vehicles include (Kannan *et al*., 2010):

i. Adaptive Cruise Control

ii. Collision Avoidance System

iii. Lane Departure Warning System

iv. Driver Drowsiness Detection System

v. Night Vision Assistance Systems

vi. Visual packing and reversing aid

The idea behind this study is to reduce cases of accidents caused by poor decision before and during overtaking of articulated vehicles by providing a system for monitoring activities on the road ahead of such vehicles. This is to be achieved by capturing and displaying (in real-time) the image of the road ahead of the articulated vehicle on a display unit mounted behind the truck. This visual information can be utilised by the overtaking driver as a guide for decision making before overtaking. Figure 1 shows the conceptual diagram of RTVDS.

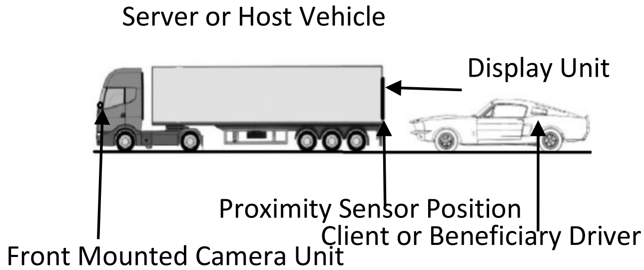

Figure 1 Conceptual Diagram of Real-Time Video Display System

2.0 RELATED WORK ON ROAD TRAFFIC SAFETY

Telematic technology, which is the art of processing and transmitting computer data over long distance, was introduced as vehicular digital video recorder system, for the recording of driver's behaviour during journey (Lin and Wang, 2010; RoSPA, 2013). An embedded microcontroller was employed as the hardware system. It operated online and in real-time, it also supports an offline video data viewer. The video data recorder was waterproofed to prevent it from being tempered with. Results from the application of this system indicated that rate of accident was reduced by 20 % and rate of specific unsafe driving behaviours were reduced up to 82 % (RoSPA, 2013). Information from the offline video viewer can be used to reveal facts on the status of the vehicle when accident occurred much like those of air craft flight data recorder. Other than safety, the device also increased savings in maintenance cost. The major obstacles to the system were its installation and maintenance costs and lack of acceptance by drivers; other challenges were handling and analyzing the data and ensuring that the technology was not used for negative assessments and punitive actions.

Similarly, on driver assisted systems, Kannan *et al*. (2010) proposed an "Intelligent Driver Assistance System" (I-DAS) for alerting driver during critical situations, using an ontology modelling method (a method of modelling which interprets information in an intelligent and decisive manner). The design was aimed at developing a system which focused on generating alert messages based on context aware parameters such as driving situations, dynamics of the vehicle, driver activity as well as environment. The parameter representations, consisting of date/maintenance of the system were managed in extensible mark up language, XML format while ontology modelling was applied for the interpretation of critical condition. Simulation of the system also incorporated other related safety technologies such as Collision Avoidance System, Adaptive Cruise Control, Drowsiness Detection System, and Parking Assistance System, which generated warning and alert to driver continuously. Java framework was used for the simulation test bed to generate safety alerts in various driving conditions. Best, average and worst cases of the simulation were studied to determine the effective performance of the driving scenarios in different modes like day and night for single, 2-way and 4-way road scenario; the approach showed that the simulation can be implemented on all vehicles in real-time scenario. However, this system lacks knowledge base on overtaking situation.

Mounica *et al.* (2014) came up with "The Intelligent Overtaking Model for Reducing Road Accidents Based on Animal Group Behaviour" by mapping the behaviour of Zoo Planktons to that of traffic on the road; in which safe distances were given high priority. Two novel algorithms were developed: the overtaking possibility check (OPC) algorithm (operating on the front vehicle) and the overtaking (OT) algorithm (operating on the rear vehicle). These algorithms provided a new mechanism for avoiding accidents due to overtaking by mutual communication between them. The safe range space around the vehicle was considered to be an ellipse shaped boundary. The algorithm refrained to allow overtaking if there was a significant amount of overlap between the ellipse regions of the vehicle. With the simulation result, it was shown that algorithms dynamic implementation in real-time scenario would potentially reduce the number of accidents occurring due to overtaking. However, this model is still in the development stage and requires more work before it can be implemented on real roads.

In an effort to warn or alert other drivers that a collision may take place, Mutya and Rudra, (2015) came up with a safety mechanism for accident prevention during overtaking. The system consists of proximity sensors, a camera, microcontroller and a display unit for sensing, capturing, image processing and displaying of the processed images respectively. This system also employed mechanical switches and indicators as human controlled sub-system. The design was cheap and gave the required result on road safety. However, the manual operation of the switches is a distraction which a driver may forget to switch ON or give a wrong command which may lead to a serious problem. Thus, this work unveiled a cheap and automated model that will guide drivers in their decision making during overtaking of LSVs using Raspberry pi platform.

2.1 Related Work on Image Stabilization

Video images captured from moving vehicle consist of unwanted translations due to vibration from the vehicle engine and uneven nature of the road. Thus, image stabilization is required to compensate the frames and to avoid losing of any useful information during image capturing. Various approaches have been used for the stabilization of captured images. These can be broadly classified as (Rawat and Singhai, 2013):

i. Mechanical stabilization
ii. Optical stabilization
iii. Digital image stabilization

Both the mechanical and the optical methods were considered as hardware techniques (Reddy *et al.*, 2015). Mechanical stabilizer adopted gyroscopic sensor to stabilize the entire camera while Optical stabilization approach activated an optical system to adjust camera motion sensor. On the other hand, the mechanical methods are not suitable for small camera modules due to their bulk nature and cost associated with it. Thus, image processing approach tries to smooth and compensate the undesired motions through digital video processes.

Digital image stabilization (DIS) techniques, as opposed to mechanical or optical devices, are most preferable due to their compact nature, fast response and lower cost (Naidu *et al*., 2016). This technique uses feature tracking method to obtain camera motion path using suitable motion model and motion compensation to stabilize the video. Generally, all digital video stabilization algorithm consist of three stages *(Lim et al*., 2017):

i. Motion estimation (ME)
ii. Motion smoother (MS)
iii. Motion compensation (MC)

The flow of the process is shown in Figure 2.

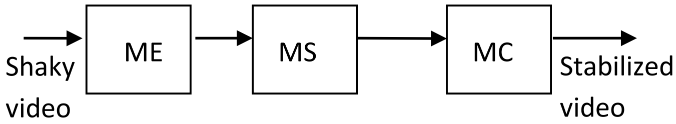

Figure 2 Video Stabilization Process Flow

To achieve real-time video stabilization in Unmanned Aerial Vehicles (UAVs), Lim *et al.* (2017), proposed "Real-Time Optical Flow – based Video Stabilization for Unmanned Aerial Vehicles" for fast video stabilization. The algorithm used optical flow corner tracker detection for the key points matching, hybrid mechanism for motion estimation and average window smoothing for motion compensation and image composition. The algorithm is capable of processing up to 100 frames per second for all the 3 stages of the algorithm; making it suitable for real-time video stabilization processes.

Optical flow is the pattern of apparent motion of image objects between two consecutive frames caused by the movement of camera or object. It is a 2D vector field in which each vector is a displacement vector, indicating the motion of points from first to second frames (Fleet and Weiss, 2005).

3.0 MATERIALS AND METHODS

The implemented system consists of three basic stages which were powered by the battery of the host vehicle; using a 12V – 5V buck converter as the regulator. These stages are: Input, Processing and Output stages as shown in Figure 3.

Figure 3 Block Diagram of the Basic Stages

3.1 Input Stage

The input stage serves as the eye of the system. It consists of a digital camera, which captures events on the road ahead of the articulated vehicle and feed the processing unit with real-time images of the events. It also incorporated three (3) proximity sensors which detect(s) vehicle behind the server vehicle.

3.2 Processing Stage

The shaky and blurred images captured by the camera are being stabilized and processed in this stage, the processing stage consist of a microcontroller (raspberry pi - RPi) which executes this function using its embedded codes and libraries. Its output signal serves as input to the output stage.

3.3 Output Stage

This stage consists of a Thin Film Transistor (TFT) liquid crystal display (LCD) unit and a Buzzer system; through which the stabilized and processed images are being displayed and for alerting of the host vehicle driver respectively.

3.4 Materials

Table 1 shows the list of materials used for the implementation of the RTVDS system.

Table 1 List of Materials

A	**Major Hardware Materials**
i	Raspberry Pi 3 board
ii	Raspberry Pi camera module
iii	3.2" Thin film transistor(TFT) raspberry Pi Liquid crystal display(LCD) module
iv	Buzzer unit
v	HC-SR04 Ultrasonic Sensor
vi	Buck converter module
B	**Software Materials**
i	Python Version 2.7
ii	OpenCV

3.4.1 Implementation of Processing Stage

This is the backbone of the entire RTVDS system. A raspberry pi 3 model B was used for the implementation of this stage, the camera, LCD and other peripherals were connected and configured using the programming language, python. Plate 1 shows raspberry pi 3 model B mother board. It is basically a microcontroller with small field programmable gate array (FPGA) on the same chip. It is sometimes called programmable system on chip (PSOC) or a credit card size Linux computer used for simple programming (Deepa and Parkali, 2016). One of the main advantages of using RPi is that it makes design easy and compact. From Plate 1, the required connections to the RPi were:

i. Camera serial interface (CSI)
ii. General purpose input output headers (GPIO)
iii. Micro SD card slot
iv. 5V micro USB input power port

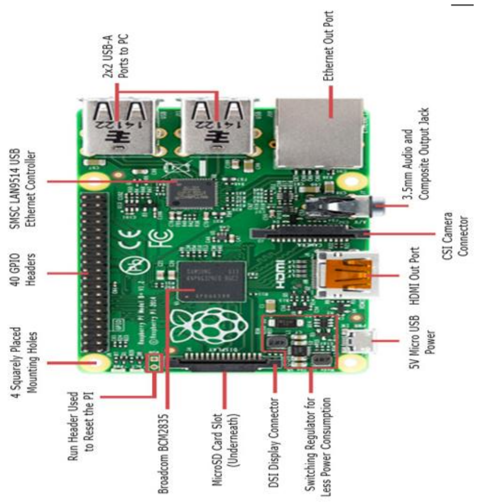

Plate 1 Raspberry Pi 3 Model B Mother Board

3.4.1.1 Configuration of the Raspberry Pi

Every Raspberry Pi requires an operating system (OS), which need to be installed, to enable it function as expected. This is because the RPi does not come with an OS. The traditional OS of the RPi is called raspbian operating system; it is contained in software called New out of box software (NOOBS). NOOBS is an operating system manager that makes it easy to download, install, and set up RPi.

3.4.1.1.1 Steps for the installation of NOOBS

Materials used for the installation were:

i. Keyboard
ii. 32GB micro SD card
iii. Laptop
iv. HDMI Cable
v. USB Cable
vi. 5V power supply

The above materials were set up as shown in Plate 2; all connected to the RPi.

Plate 2 Set up for the Installation of Raspbian OS

The following steps were taken for setting up of the RPi:

i. A 32GB SD card was inserted into a laptop via the SD card reader.

The SD card was then formatted using the platform-specific instructions listed below:

a. The SD Association's Formatting Tool was downloaded from

https://www.sdcard.org/downloads/formatter_4/eula_windows/

b. The Formatting Tool was Installed and run

c. "FORMAT SIZE ADJUSTMENT" option was set to "ON" in the "options" menu

d. The SD card inserted was then inspected to ensured it matches the one selected by the Tool

e. The "Format" button was then Clicked

ii. The files contained in NOOBS zip file were extracted and copied onto the formatted SD card
iii. Raspbian OS was then down loaded from the official website of RPi (https://downloads.raspberrypi.org/raspbian_latest) and installed onto the 32GB SD card
iv. The raspbian image was also written onto the 32GB SD card using Win32Disk imager
v. The SD Card was then inserted in the micro SD Card slot of the raspberry pi

vi. After plugging the peripherals (keyboard, mouse and HDMI Display) the system was powered using a 5V power supply unit

vii. The file system was expanded to the full length of the SD Card

viii. After the expansion was carried out, the system rebooted automatically and gave screen display as shown in Plate 3; this shows that the OS was ready successfully installed and that the RPi was ready for use with other peripherals required for the design.

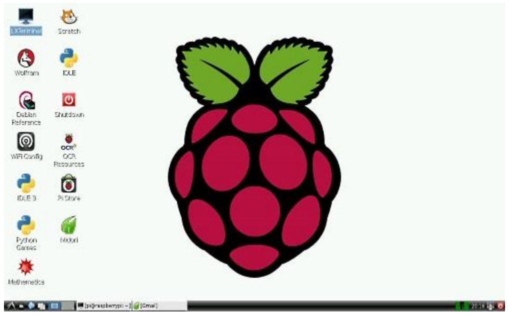

Plate 3 Screen Display for Successful Installation of Raspbian Operating System

3.4.1.2 General Purpose Input and Output (GPIO) header

Pin#	NAME			NAME	Pin#
01	3.3v DC Power			DC Power 5v	02
03	GPIO02 (SDA1 , I²C)			DC Power 5v	04
05	GPIO03 (SCL1 , I²C)			Ground	06
07	GPIO04 (GPIO_GCLK)			(TXD0) GPIO14	08
09	Ground			(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)			(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)			Ground	14
15	GPIO22 (GPIO_GEN3)			(GPIO_GEN4) GPIO23	16
17	3.3v DC Power			(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)			Ground	20
21	GPIO09 (SPI_MISO)			(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)			(SPI_CE0_N) GPIO08	24
25	Ground			(SPI_CE1_N) GPIO07	26
27	ID_SD (I²C ID EEPROM)			(I²C ID EEPROM) ID_SC	28
29	GPIO05			Ground	30
31	GPIO06			GPIO12	32
33	GPIO13			Ground	34
35	GPIO19			GPIO16	36
37	GPIO26			GPIO20	38
39	Ground			GPIO21	40

Figure 4 Raspberry Pi 3 GPIO Header

Figure 4 shows an alternative interfacing region on the RPi through which other electronic devices were interfaced with the raspberry pi. For this work, this section was used for the interfacing of the proximity sensors, the 3.2" TFT LCD display and the alarm module with the raspberry pi. A library called Python Library was then installed to enable the control of the GPIO pins (https://pypi.python.org/pypi/RPi.GPIO).

This gives a gate way for interfacing with other electronic devices by selecting the required GPIO pin(s) base on the function of the component(s) to be use.

3.4.2 Implementation of Input Stage

A camera Rpi NoIR Module was used for the implementation of this unit. It is a camera designed specifically for raspberry pi interface. It has a field of vision of about 56 degrees (Myklebust, 2015), a full high definition (HD) recording capability (Kaundaya *et al.*, 2017), a resolution of 8MP and video resolution of 1080p30, 720p60 and 640 x 480p30. The camera was plugged to its dedicated camera serial interface (CSI) port on the raspberry pi via its 15pin ribbon cable. Plate 4 shows the camera module.

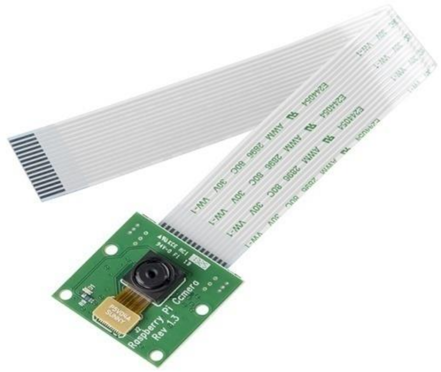

Plate 4 *Raspberry Pi Camera Module*

3.4.2.1 Camera Module Configuration

The camera was configured and enabled using the following Linux commands at the command line interface (CLI) of python (using the available network signal):

Sudo apt-get update

Sudo apt-get upgrate

Sudo raspi-config

In addition, three (3) HC-SR04 ultrasonic sensors were used as the proximity sensors, each with 120^0 angle of coverage. As shown in Plate 5, the HC-SR04 is an ultrasonic range finder with 4 terminals (Vcc, Trigger, Echo and ground). Commonly called a transducer or transceiver, it works on a principle similar to radar or sonar; which evaluates attribute of a target by interpreting the echo to determine distance to an object. It consists of a transmitter, a receiver and control unit.

Plate 5 HC-SR04 Ultrasonic Sensor Module

The main advantage of ultrasonic sensor is that it provides highest reliability in getting proximity and has lesser absorption than RF and IR frequencies (Vidhya *et al.*, 2016).

3.4.2.2 Implementation of the Sensor Unit

The three sensors were connected together with their respective pins to the general purpose input and output (GPIO) header as outlined below:

a. Vcc to 5V supply
b. Ground to Ground
c. Trigger terminals to GPIO 21
d. Echo pins to GPIO 20, GPIO 19 and GPIO 6

However, each of the Echo pins were connected to the GPIO header pins through 3.3V Zener diode, to protect the terminals from high 5V supply since the GPIO header are rated 3.3V. Final Implementation was carried out on a dedicated PCB before being connected to the RPi via a three input OR gate; which was executed in software form. See Plate 6.

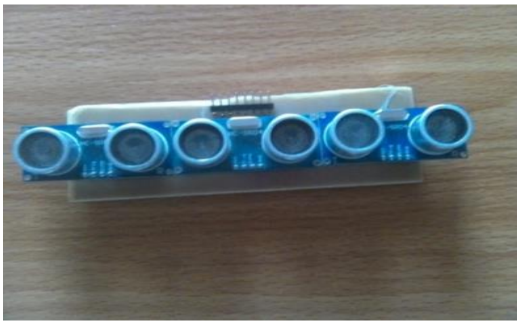

Plate 6 Implementation of Sensor Unit on Printed Circuit Board

The sensor unit was moulted at the back bomber of the host vehicle for the detection test at various distances to determine its performance.

3.4.3 Implementation of the Output Stage:

As shown in Plate 7, a thin film transistor (TFT) RPi LCD module was selected as the display unit for this work. Though any display system with HDMI input can be use for this purpose but this was used for the convenience of the prototype. It has a screen resolution of 320 x 240. Advantages derived from using the LCD include (Kumar and Reddy, 2016):

i. Lightweight with few thickness
ii. Less power consumption
iii. Does not generate heat
iv. It is less costing
v. Have long life and wide operating temperature range

Plate 7: 3.2" TFT Raspberry Pi LCD Display Module

3.4.3.1 Configuration of the 3.2" TFT Rpi LCD Module

This unit was configured by initial installation of the drivers of the 3.2" LCD board; since the RPi OS came with only the HDMI display pre-installed drivers. The LCD module was plugged directly on the GPIO header of the RPi through it 26 pin connectors; then, the following procedures were carried out for the installation of the drivers:

i. The drivers were downloaded from(http://www.waveshare.com/w/upload/4/4b/LCD-show-161112.tar.gz)

ii. The terminal was then lunched and the following commands were executed:

Extraction of the drivers

tar xvf LCD-show-.tar.gz*
cd LCD-show/

This toggles the mode from HDMI to LCD display:

chmod +x LCD32-show./LCD32-show

iii. The RPi LCD was ready for use, after system reboot.

3.4.3.2 Alarm System

For this work, a piezoelectric buzzer of single tone was used for the alarm system. See Plate 8. It alerts the driver of the articulated vehicle that a vehicle is behind and may overtake. It was installed inside the tractor cabinet of the articulated vehicle.

Plate 8 Buzzer Module

The entire system is expected to be powered using the truck battery via 5V buck converter with a USB cable. However, for the prototype, a power bank of 5V, 2.1A specification was used as the power supply unit.

Finally, the various units were cascaded to form a complete circuit of RTVDS system. See Figure 5.

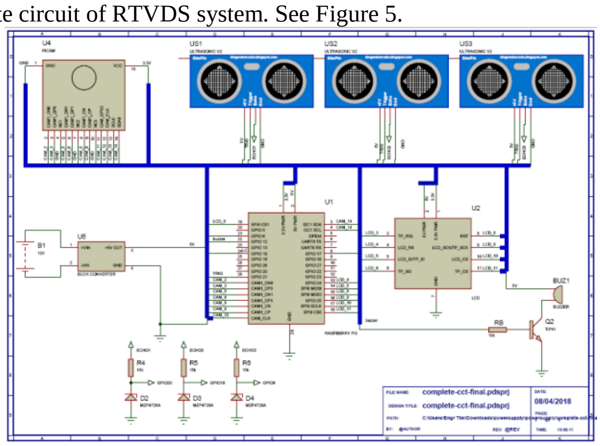

Figure 5 Complete Circuit Diagram of Real-Time Video Display System

3.5 Image Stabilization

To achieve the stabilization and processing functions, open source computer vision (OpenCV) library was installed. This library is highly efficient, and known to work well with real-time applications. Though written in C++, it has many language interfaces include Python. Optical flow algorithm of video stabilization was adopted for this work, using python interface of OpenCV library (http://www.docs.opencv.org/master/d7/d8b/tutorial_py_lucas_kanade.html). This method of image stabilization was selected for this work because it is simple and has high processing speed; making it suitable for real-time applications.

The procedure to carry out the stabilization function is described in the algorithm as shown in Figure 6.

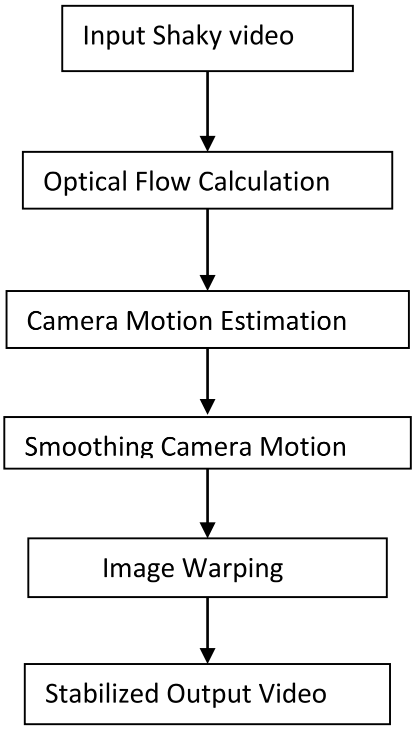

Figure 6 Flow Chart of Optical Flow Video Stabilization Algorithm

The following steps describe the components of the flow chart:

i. Transformation from previous to current frame using optical flow for all frames was determined. The transformation consists of only three parameters: dx, dy and da (angle). Basically, a rigid Euclidean transform, no scaling, no sharing. But for this work, da was neglected since angular changes were not observed.
ii. The transformations were accumulated to get the "trajectory" for x, y, at each frame.
iii. The trajectory was Smooth out using a sliding average window; with 25 frames as applied window radius.
iv. A new transformation was created such that new_ transformation = transformation + (smoothed trajectory – trajectory).
v. Finally, the new transformation was then applied to the video.

3.6 System Prototyping

Having completed the design of the various units of RTVDS, a prototype of the system was implemented on a toy truck as shown in Plate 9.

Plate 9 Prototype of the Implemented RTVDS

4.0 RESULTS

4.1 Proximity Sensor

Figure 7 shows the plots for the actual and desired distances against numbers of readings taking as obtained from the sensor unit

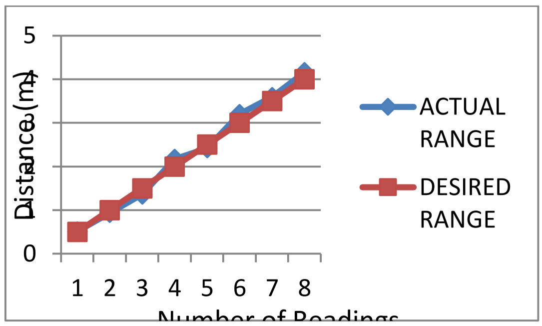

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Figure 7 Plots of Distances against Number of Readings

$$\text{Mean error (ME)} = \frac{\text{Sum error}}{\text{Total number reading}}$$

$$= \frac{0.35}{8} = 0.04375$$

Percentage error is 4.4%

This error may be as a result of the roughness of the surface where readings were taken or error due to parallax. However, this shows that the sensors are 95.6% effective; thus meet the design range specification.

4.2 Camera Output

Plate 10 shows the output image of the road on the LCD display as captured by the RPi camera; with resolution of 3.15MP, equivalent of 2048 x 1536 pixels. Applying the Official Highway Code (OHC) rules of overtaking, using rule 162 – 169 (www.highwaycodeuk.co.uk), the output is good enough to be used by any driver for judgement before overtaking.

Plate 10 LCD Output Display on Live scenario

4.3 Image Stability

System stability data were converted from text file to Excel before plotting; the Excel data were used for the determination of the system stability using MATLAB software for the plots. Figure 8 shows the plot of transformation from previous to current frames before stabilization. Figure 8 covers step (i) of the Optical Flow algorithm for all the frames by providing dx and dy parameters with da being neglected, since there was less change in rotational movement in this work. The clustered ripples of the plots correlate with the shaky images captured by the camera due to uneven surface of the road.

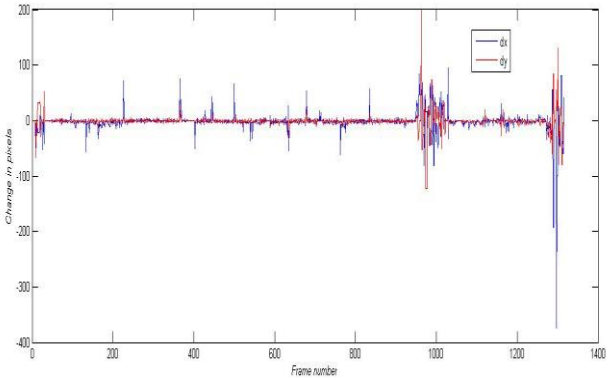
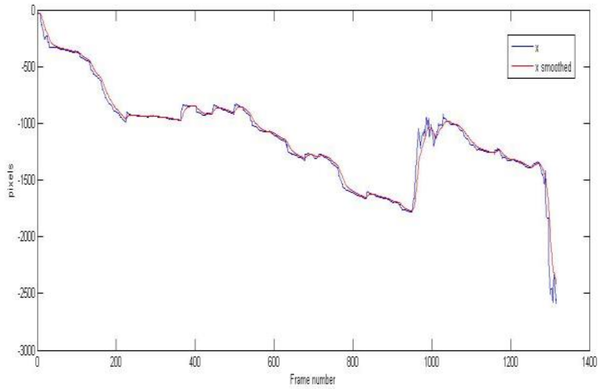


Figure 8 Plots of Transformation from Previous to Current Frames before Stability

Figure 9 and Figure 10 indicate the accumulated transformation which yield X and Y trajectories at each frame for both originals and smoothed versions of X and Y trajectories. For this work, + - 25 frames was used as the smoothing radius. The blue indicates the original trajectories while the red shows the smoothed trajectories for both X and Y trajectory plots. These defined steps (ii) and (iii) of the algorithm.

Figure 9 X Trajectory



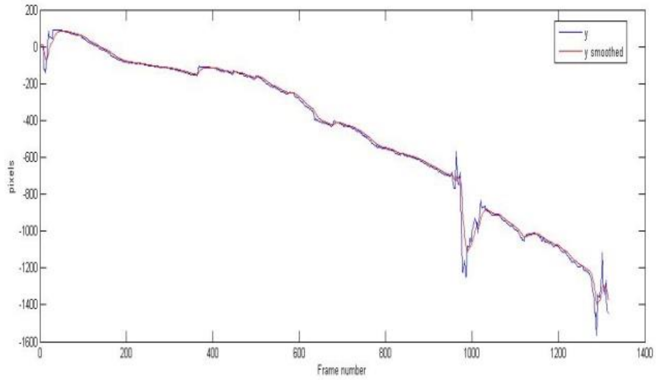


Figure 10Y Trajectory

The downward movement of the plots in Figure 9 and Figure 10 correlate with the forward movement of the camera, as the vehicle was moving against images being captured. Figure 11 reveals the final transformation applied to the video with both dx and dy being smoothed compared with the earlier plot of Figure 8.

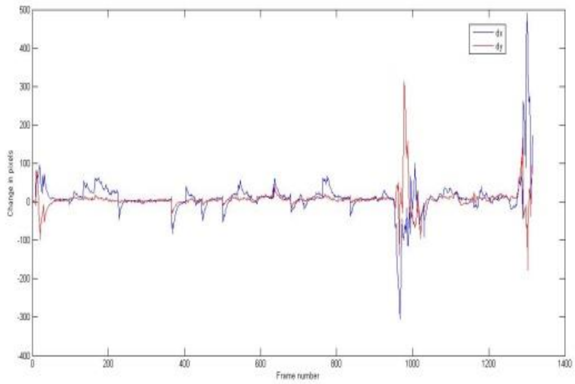


Figure 11 Smoothed Frame to Frame Transformation

The stability results indicated that the system is capable of providing proving images without distortions using the Optical Flow algorithm, when the host vehicle is in motion. With this, the beneficiary driver can get the right information that will assist him during overtaking scenario at real-time.

5.0 CONCLUSION AND RECOMMENDATIONS

From the results obtained, a novel road safety system for overtaking manoeuvre was implemented. This system is capable of providing an overtaking driver with detail information on the state of the road ahead of the articulated vehicle; for judgement on whether to overtake or not. If fully developed in real-live scenario, loss of lives and properties as a result of road traffic accidents especially those involving large sized vehicles will be greatly reduced; thus, contributing to improve safety on our roads as declared by WHO for decade of action on road safety.

Future work using wireless sensors and utilizing the WI-FI or Bluetooth facility of the RPi for remote accessing of the signal from the server vehicle in the client vehicles will make the system more compact with higher performance. In addition, pre-recorded video of advertisement can be incorporated in the system using sensor switch for playback, as advertising medium to other road users at halt state, during traffic waiting time.

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