International Journal of Research and Review
Vol. 10; Issue: 9; September 2023
Website: www.ijrrjournal.com
Research Paper *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Development of Adaptive Realtime Mobile Based Traffic Management System for Congested Urban Cities

Engr. Fidelis. U. Didigwu[1], Prof. G.N Ezeh[2], Engr. Dr. N. Chukwuchekwa[3], Engr. Dr. O.C Nosiri[4]

[1]Department of Electrical/Electronic Engineering, University of Port Harcourt
[2]Department of Electrical/Electronic Engineering, Federal University of Technology, Owerri
[3]Department of Electrical/Electronic Engineering, Federal University of Technology, Owerri
[4]Department of Electrical/Electronic Engineering, Federal University of Technology, Owerri

Corresponding Author: Engr. Fidelis. U. Didigwu

DOI: https://doi.org/10.52403/ijrr.20230912

ABSTRACT

This study evaluates urban traffic congestion in Nigeria, focusing on Port Harcourt. The study analyzed four main routes: Location, Rumuokoro, Rumuokwuta, and GRA Junction. Field surveys collected traffic volume and video recordings of cars traveling the indicated routes between 7 am and 7 pm. The Rivers State Command of the Federal Road Safety Corps provided further data. A mobile-based Traffic Management System was designed and simulated using Proteus. The technology transmits real-time traffic data from congested areas to a local server. This data is easily accessible on mobile devices. Python software was used to classify traffic congestion as heavy (0-14km/hr), medium (15-28km/hr), and free (29km/hr and above). Background subtraction was used for vehicle image analysis. The system can detect road traffic, correctly determine car speeds, count the number of vehicles, and send this traffic information to consumers via mobile devices via online communications. After simulating 1200 traffic data instances, 36 had mistaken, while 1164 were classified. This represents good accuracy, with 97% accuracy and 3% inaccuracy. The traffic data will be maintained in a database to help researchers identify places with recurring traffic congestion. These findings suggest that authorities should build alternative routes. It can also help build traffic-congestion-reducing policy review, organization, and enforcement initiatives.

Keywords: Background Subtraction Technique, Mobile devices, Proteus, Traffic Congestion, Python

1. INTRODUCTION

Urban regions in emerging countries have witnessed a notable growth in industrial activities, resulting in increased pressure on urban spaces and transportation systems. The escalating population expansion and heightened traffic congestion in African urban areas represent a multitude of challenges. Urban areas in Nigeria are experiencing comparable levels of traffic congestion due to the rapid development of city dwellers and the inadequacy of urban infrastructure to accommodate the ongoing trend of migration from rural to urban areas.

Port Harcourt, a prominent hub for industrial activities and crude oil research in Nigeria, is constantly plagued by issues of traffic congestion. Port Harcourt, a city characterized by a significant presence of the petroleum industry, has experienced remarkable expansion in both its physical and demographic dimensions. Various administrations have undertaken the construction of novel highways and the expansion of preexisting ones as a means of addressing the surge in commercial enterprises and population. However, the problem of congested roads in the region has not experienced much amelioration. The metropolitan area of Port Harcourt encounters considerable congestion due to traffic on its primary road networks, leading to adverse outcomes for the local populace [1]. This study investigates the impact of traffic congestion on various key intersections, specifically GRA Junction, Location Junction, Rumuokoro Junction, and Rumuokwuta Junction. Congested roadways in the region have numerous consequences. These include the hindrance of movement, the reduction of labor productivity due to longer travel times and decreased revenue, concerns related to social well-being, psychological impacts, and health issues. Additionally, traffic congestion contributes to the worsening of noise and air quality issues, as well as an increase in criminal activities. The incidence of criminal behavior is more prevalent in densely populated places. According to [2], there have been instances of theft involving high-value items such as bags, phones, jewelry, laptops, and other important possessions in Port Harcourt. These crimes were ascribed to individuals who deviate from social norms. [3] underscore the psychological ramifications of reckless driving on roadways, with a particular emphasis on the human factor. The projected population growth of Port Harcourt is anticipated to result in transportation congestion. The exacerbation of the situation is attributed to the region's lenient regulatory framework and inadequate land use planning.

The management of congestion in Port Harcourt has been facilitated with the implementation of traffic lights and the deployment of traffic wardens. The objective of these methods is to effectively govern the flow of vehicles on roads and mitigate the socio-economic consequences associated with it. The current traffic congestion has placed a significant strain on the road traffic control system.

Therefore, the implementation of a Realtime Mobile Based Traffic Management System was deemed necessary in Port Harcourt in order to effectively address the issue of traffic congestion. This technology enables road users to access precise traffic information from their residences or workplaces using their mobile devices. Prior to entering a road, users are provided with real-time traffic information. The Port Harcourt surveillance system, which has demonstrated an inability to efficiently control traffic congestion, is evidently ineffective in its current state. In recent times, there has been a notable emphasis in research on the use of versatile and adaptable platforms such as smartphones and other electronic devices for the goal of gathering comprehensive data and providing a holistic representation of the traffic situation on road networks [4]. In contemporary society, mobile devices have emerged as the predominant medium via which individuals interact with their immediate environment. These devices seamlessly establish internet connectivity over WiFi as well as many cellular networks, including 2G, 3G, 4G, and 5G. According to [5], smartphones have the capability to function as routers by utilizing Bluetooth and Portable WiFi, enabling them to share their cell signal with nearby devices. According to [6], energy consumption and data transfer vary across different communication standards. [7] assert that smartphones possess robust processing capacities and a diverse range of integrated sensors, hence propelling the progress of mobile sensing technologies. According to [8], crowd sensing has the capability to gather significant data. Crowd sensing leverages a variety of sensors, including the accelerometer, gyroscope, the compass, microphone, camera, GPS navigation, and wireless internet interfaces, to systematically watch and evaluate the surrounding environment. According to [9], a lane identification system utilizing smartphones has demonstrated a detection accuracy of over 90% in identifying lane-level markings. [10] and [11], have put forth various methodologies for monitoring road traffic. These devices facilitate the collection and analysis of GPS vehicle location data. The utilization of these techniques necessitates the presence of a mobile device within the automobile. This methodology is incapable of monitoring the entirety of motor vehicles. In their study, [12] examined the application of Internet of Things (IoT) in the field of Intelligent Traffic Management, with the aim of minimizing the need for manual intervention in the regulation of traffic congestion. The researcher utilized application-based Internet of Things (IoT) technology. The proposed system utilizes Raspberry Pi and Radio Frequency Identification (RFID) technology. The proposed solution involves the attachment of a vehicle-mounted RFID tag that is equipped with a singular unique identifier. The RFID reader retrieves information from the RFID tag and transmits it to the Raspberry Pi using a wireless network connection. The lane input is recorded, configured, and transmitted to the server. The traffic indicator is subsequently adjusted based on the determined density.

In their study, [13] developed a smart system for traffic control that utilizes the Internet of Things (IoT) to mitigate congestion and provide timely alerts. Within this particular model, the load cells are strategically situated beneath the roadways, enabling them to convert the force exerted on their components by passing automobiles into electrical impulses. The present model subsequently makes estimations regarding the quantity of cars present on the roadway and, utilizing the traffic volume as a basis, calculates the necessary duration for traffic clearance on both sides of the road. Subsequently, the traffic light will exhibit the duration of the waiting period. During the period while the signal was displaying the color red, the aforementioned process took place. When the color of the light changes to yellow, the cloud system adjusts the validity period to provide users with information regarding traffic density. A traffic control board displays a countdown of the remaining time when the traffic light is green. In a study conducted by [14], researchers introduced a novel method that employs handheld electronic devices and low-energy wirelessly beacons leveraging Bluetooth for the purpose of detecting road traffic. The vehicle detection component of this system utilizes mobile devices, such as smartphones, positioned on the side of the route to assess the strength of the Received Signal Strength Index (RSSI) signal when receiving radio frequency frames produced by Bluetooth beacons located on the opposite side. In order to identify and classify different types of mobile vehicles, such as cars or trucks, Bluetooth beacons are strategically placed at varying elevations along the designated path. Mobile devices collect and store the Received Signal Strength Indicator (RSSI) and corresponding location data for each route traversed. Data is transmitted via cellular or Wi-Fi connections. to servers. The present communication system is designed to observe and analyze the flow of vehicles and the level of congestion on roadways. In their study, [15] presented a novel intelligent system designed to regulate traffic lights in an adaptable manner. The present technology employs a Wireless Sensor Network (WSN) along roadways that converge at a junction. The magnetic sensors, referred to as nodes, are deliberately positioned within the ground's surface along the intersecting pathways. Every individual sensor inside this network configuration is capable of detecting motor vehicles. The closest head cluster facilitates the transmission of data from vehicle detection nodes to the base station. The utilization of a base station algorithm involves the utilization of data from a wireless sensor network (WSN). This methodology facilitates the dynamic regulation of signals at road crossings by effectively detecting and analyzing lane-specific traffic congestion. In their study, [16] employed Wireless Sensor Networks as a means of monitoring congestion at road intersections in order to effectively regulate traffic flow. The system consists of two components. The system employs two distinct modules. The initial module, known as the Traffic Density Monitoring Module (TDMM), employs an ultrasonic sensor for the purpose of quantifying vehicular congestion. The Traffic Management Module (TMM), which is installed on the computer, is the second module. The system utilizes information from many Traffic Data Monitoring and Management (TDMM) units located on highways to control and regulate traffic lights. Self-organization engenders a tree-based architecture among the nodes that is not autonomous. Every monitoring node establishes a direct connection with its closest neighbor, enabling data to be transmitted to the traffic management module via intermediary nodes until it reaches the sink node. [17] proposed a framework for an urban traffic control system that utilizes the Internet of Things (IoT) technology. This approach involves the integration of road infrastructure with the Internet through the utilization of sensor nodes for vehicle detection and subsequent transmission information to a cloud platform via a border router. The data is distributed by a network to traffic signal actuators, thereby facilitating the control of traffic at city junctions. In their study, [18] devised a wireless sensor network-based computerized traffic control system for urban road traffic surveillance. This system was designed to monitor various areas including roadways, traffic lights, as well as key locations such as hospitals and gas stations. The objective is to minimize both distance and duration of travel in order to mitigate traffic congestion. The technology employs intelligent roadside cameras to identify and document license plate numbers of vehicles. The data is transmitted to a centralized system for the purpose of monitoring municipal cars inside the city. Contemporary technological advancements facilitate the amalgamation of diverse urban functionalities, hence fostering the development of a smart city. In their study, [19] devised "Intelligent Vehicle Counting and Classification Sensor (IVCCS) for Real-Time Traffic Surveillance". The real-time recognition and counting of autos were achieved by the utilization of a solitary node within the Integrated Vehicle Control and Communication System (IVCCS). This unique approach effectively facilitated the aforementioned tasks. The algorithm employs a set of five-state machines. The magnetic field of the Earth flux (FM) can be determined by taking the square root of the sum of all of the squares of the three components of the geomagnetic field. The study conducted by [20] investigated the impact of traffic congestion on the quality of life inside communities. The available data indicates that the expansion of the population has exerted pressure on transportation infrastructure, resulting in a notable rise in truck traffic. The aforementioned factor contributes to the occurrence of traffic congestion in Seri Kembangan. This research investigates the impact of daily routines and lifestyle decisions on traffic congestion and community dynamics. Site surveys were employed. A statistical analysis was conducted on a total of 382 survey responses. The research indicates that traffic congestion has a detrimental impact on the quality of living circumstances. The study proposes the implementation of traffic planning and management strategies as a means to enhance the quality of community life. In their study, [21] employed image processing techniques to evaluate a substantial quantity of image frames within real-time traffic management platforms. The system provides data on vehicle detection, presence, occupancy, speed, categorizing, and count. The technique of Background Subtraction is employed to identify and isolate moving objects in images acquired during the capture process, as well as to perform necessary pre-processing tasks. In [22] developed a research paper titled "Adaptive Traffic Management System Utilizing Internet of Things (IoT) and Machine Learning." The objective of this project is to monitor the flow of traffic in individual lanes with the aim of minimizing the average waiting time experienced by vehicles. PCA, or principal component analysis, is a technique that effectively decreases the dimensions of an image, resulting in a reduction in its size and thereby saving storage space. The proposed system entails the utilization of software in a centralized manner to ascertain the activation and deactivation timing of traffic signals via internet-based transmission. The study conducted by [23] examined the issue of vehicular congested roads in the satellite cities of Abuja, Nigeria. The present study investigates the extent and underlying factors contributing to traffic congestion in the Federal Capital Territory (FCT) of Abuja, with a particular focus on its impact on commuters residing in satellite towns. In order to accomplish the objective, the study selected six extensively utilized roads that connect peripheral settlements to the Abuja Municipal Area Council (AMAC). The researchers disseminated a total of 655 questionnaires to individuals residing within the designated study area in order to gather primary data. The Federal Road Safety Corps (FRSC), Abuja Command, conducted a study over a period of seven days to gather data on vehicle traffic volumes. The study focused on six routes that connect satellite communities to the Abuja Municipal Area Council (AMAC). The present study investigated the extent, underlying factors, and interconnections of traffic congestion by the utilization of descriptive statistics and graphs theoretic indices. The results indicate that traffic congestion can be attributed to various factors, including limited road capacity, substandard road conditions, commercial activity along the roadside, inadequate connection within the road network, and the presence of roadside parking. The researcher posits that the utilization of this data has the potential to provide valuable insights for the development and implementation of strategic land use planning efforts. These proposed measures have the potential to enhance road connectivity and capacity, hence reducing traffic congestion in satellite towns. The project additionally aims to enhance traffic efficiency between the urban core and its densely populated peripheral areas. The research conducted [24] focused on the investigation of traffic congestion on Nigerian roads, specifically examining the case of Sango T Junction in Ibadan, Oyo State. The phenomenon of traffic congestion has witnessed a surge in recent years as a result of the migration of individuals from rural areas to urban centers and the concurrent development in population. The study employed many methodologies, including direct observation, a traffic queue time countdown, and analysis of traffic information. The study data was analyzed using mean plots, t-tests, and analysis of variances. The investigation indicates the presence of traffic congestion during the early morning hours. Nevertheless, it is common for drivers to wait throughout the night. The data additionally indicates that there is a resemblance between peak and non-peak traffic patterns.

Upon conducting multiple reviews, it was seen that the writers neglected to take into account the categorization of vehicle speed for the assessment of mobile device traffic congestion. The objective of this study is to develop a mobile-centric congestion management system that enables road users to obtain road traffic updates via their mobile devices. The system offers alternative routes in situations of heavy traffic congestion.

The user's text is already academic and does not require any rewriting. The user's text can be rewritten in an academic manner as follows: "The diagram provided illustrates the system block configuration."

The integration of multiple components is illustrated in Figure 1, which represents the system architecture in this study. The purpose of providing an explanation for each block is to clarify the operational mechanisms of the system.

2.1 The Input Unit

The input unit is responsible for receiving and processing data from external sources. It serves as the interface between the user and the computer system, allowing for the input of information into the

The research encompassed the acquisition of traffic video recordings, which were afterwards subjected to image analysis through the utilization of OpenCV. The objective of this investigation was to extract pertinent traffic data, including vehicle speed, amount of traffic, and vehicle count.

2.2 Processing Unit

It is a fundamental component of a computer system. The processing unit is mostly composed of background subtraction, OpenCV, and algorithm for clustering. This particular place functions as the designated area for the implementation of image processing procedures. The processing unit is responsible for modifying the format of the raw data stream from the camera to ensure interoperability with the visual-based part of the system. In the preliminary stage of processing an image, the edge-detection method is utilized to eliminate superfluous visual interferences, such as precipitation, that could have been detected by the camera. The individual pixels inside a given frame experience a smoothing procedure that is defined by the adjacent pixel values, leading to the overall blurring of the image.

2.3 Output Unit

The output unit, also known as the output device, is a component of a computer system that is responsible for presenting or displaying information to the

The findings of the vehicle image analysis are shown subsequent to the implementation of Background Subtraction. The presented display provides information pertaining to the density, velocity, and volume of vehicles. In current times, algorithms utilized for the classification of traffic congestion have incorporated the consideration of both vehicle speed and number. This integration enables the categorization of congestion levels into three distinct categories: heavy, medium, or free-flowing.

Hence, we are currently in the process of building a real-time traffic surveillance system that utilizes vehicle speed and volume to assess the level of traffic congestion on a given route. The algorithm will categorize vehicle speed as follows:

i. Speeds ranging from 0 to 14 km/hr will be classified as heavy traffic.

ii. A speed range of 15-28 km/hr is classified as medium traffic.

iii. Traffic moving at a speed of 29 km/hr and above is considered to be free-flowing.

When vehicles traveling at varying speeds converge at an intersection, the software undertakes an analysis of their velocities and subsequently categorizes them into several groups. This form of traffic data can be regarded as an additional means of discerning the presence of heavy traffic, moderate traffic, or uncongested traffic along a specific route.

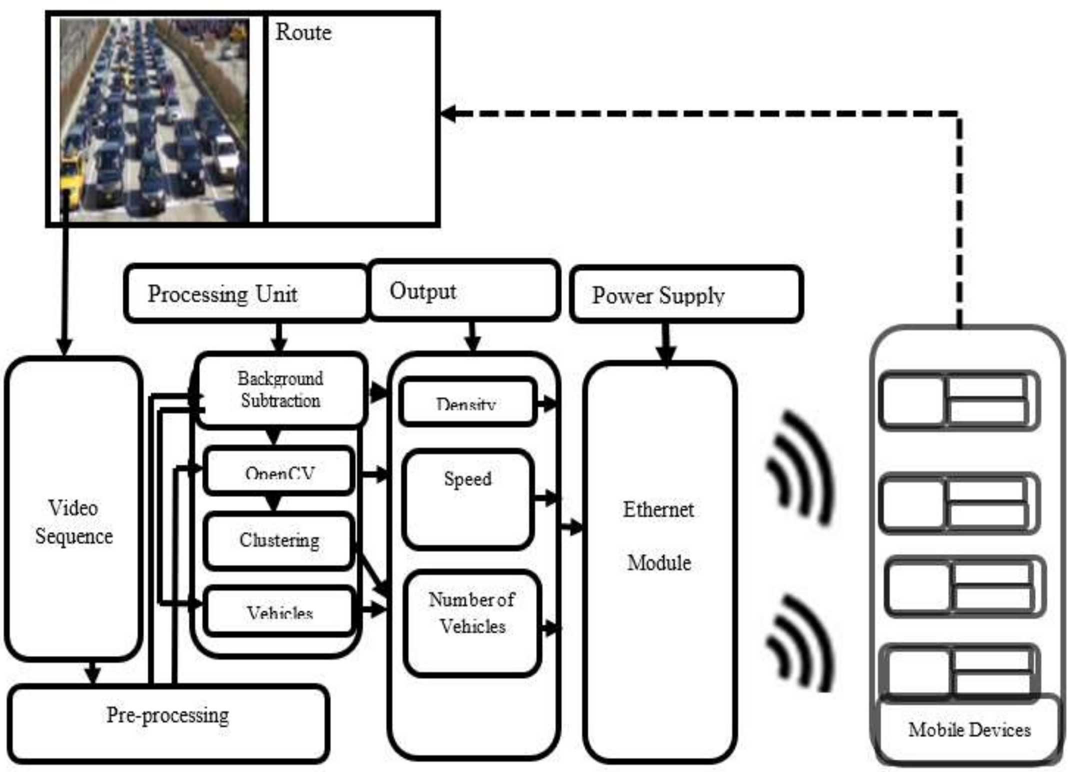

Fig.1 System block diagram

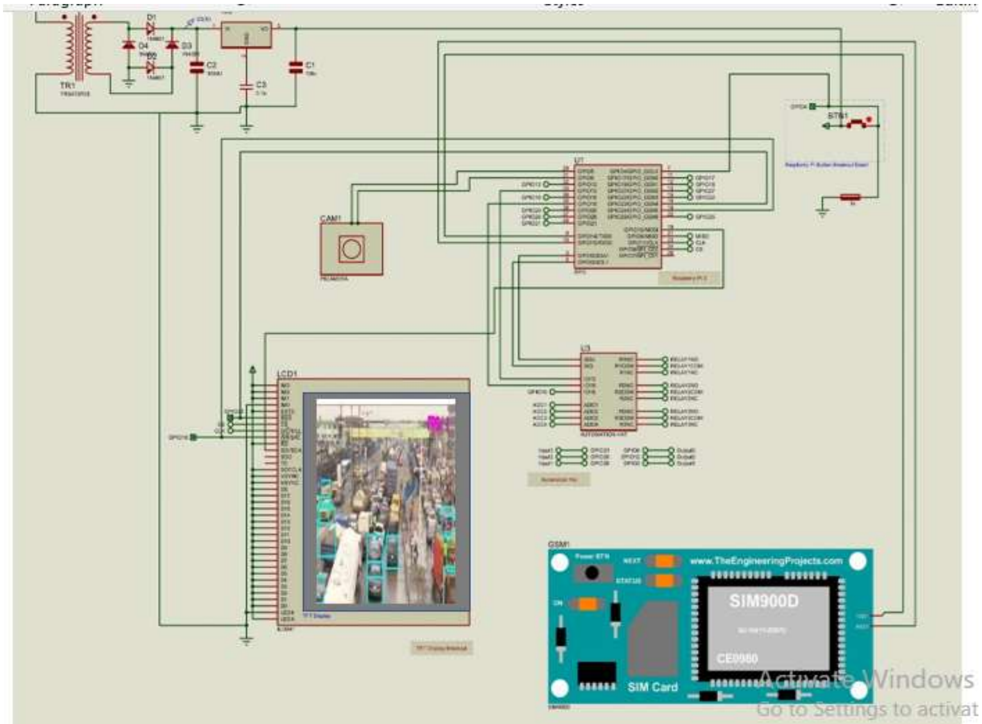

Fig. 2: Adaptive Realtime Mobile Based Traffic Management System

The highway traffic management system illustrated in Figure 2 use proteus simulation to efficiently observe and address instances of road congested traffic in real-time. The system consists of various components, specifically the power module, IP camera, Raspberry Pi, display unit, and ethernet module. The management of all elements is enabled through software drivers created using the Python programming language and the OpenCV package. The application of the Python programming language in combination with the Raspberry Pi enables the calculation of vehicle speed through the examination of IP camera footage. The variables being measured are the speed and quantity of vehicles. The aforementioned data is afterwards being transferred to a local server via the utilization of an ethernet module. Users will have the ability to access real-time road traffic information via mobile devices.

3. MATERIALS AND METHOD

3.1 Material

i. Laptop
iv. Ethernet
ii. Raspberry pi
v. Proteus
iii. Ip Camera
vi. Python

3.2 Method

3.2.1 The Technique of Background Subtraction

The process of background subtraction entails the detection and recognition of dynamic entities by comparing the present image with the reference background image. The modules address the processes of foreground identification and background modeling. The background image serves as the beginning frame that forms the visual composition. If the disparity between the present image and the background image that was previously recorded exceeds a predefined threshold, the pixel is categorized as either constituting the backdrop or as being associated with a mobile vehicle.

In this study, the process of object detection, specifically for vehicles, involves performing foreground-background subtraction on each Red, Green, Blue (RGB) color channel. Subsequently, the greatest absolute values of the resulting differences are computed and referred to as the color space value, Diffc. In this phase of the study, the researcher employed the Python programming language to execute frame differencing, a technique utilized to separate the background and foreground elements from the original video frame.

$$\mathbf{Diffc} = \mathbf{max}\left(|\mathbf{Rf} - \mathbf{Rb}|, |\mathbf{Gf} - \mathbf{Gb}|, |\mathbf{Bf} - \mathbf{Bb}| \right) \quad \mathbf{(1)}$$

The initial stage in the process of object tracking involves the task of distinguishing the objects of interest from the surrounding backdrop. Two frequently employed techniques in computer vision are frame differencing and background subtraction. Frame differencing involves calculating the discrepancy between the present image and a series of previous images, under the assumption that the backdrop remains constant throughout consecutive frames. This discrepancy is then compared against a predetermined threshold. The aforementioned method demonstrates simplicity and efficiency across numerous applications. However, challenges arise when attempting to monitor numerous objects or whenever an object comes to a halt, resulting in inaccurate detection of the moving entity. The implementation of background subtraction involves the utilization of the Red, Green, and Blue (RGB) paradigm.

Equation 1 demonstrates the procedure of foreground-to-background subtraction within the RGB color channel. It calculates the color difference (Diffc) in color space by determining the largest absolute values among the three differences. The variables Rf, Gf, and Bf represent the red, green, and blue values respectively, which correspond to the elements of the background frame. The acquisition of the underlying pixel is determined by specific parameters.

$$\boldsymbol{F(x,y)} = \begin{cases} \mathbf{1}, \ \mathbf{Diffc} > \boldsymbol{thrsh} \\ \mathbf{0}, \ \boldsymbol{otherwise} \end{cases} \quad \mathbf{(2)}$$

Equation 2 illustrates that when the absolute magnitude of the difference (Diffc) exceeds the specified threshold, the foreground is represented as 1 (white), and if the absolute degree of the difference is below the threshold, the foreground is represented as 0 (dark).

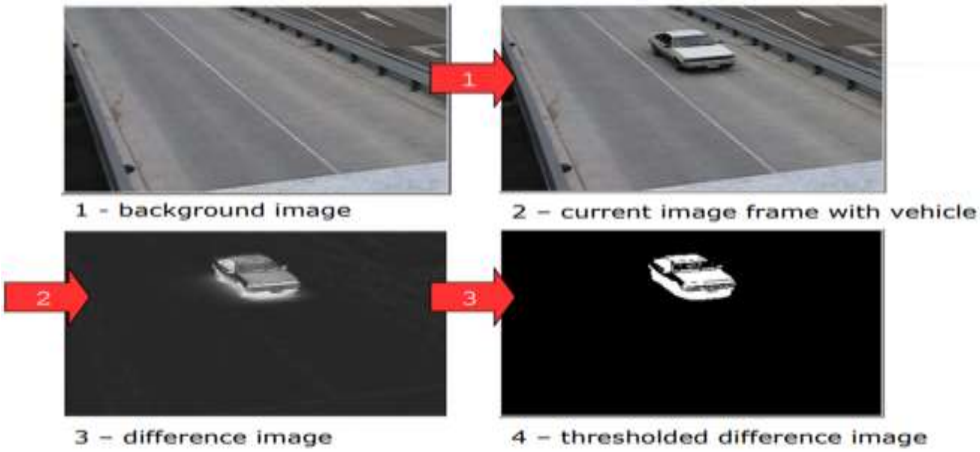

Fig.3: Background Subtraction technique

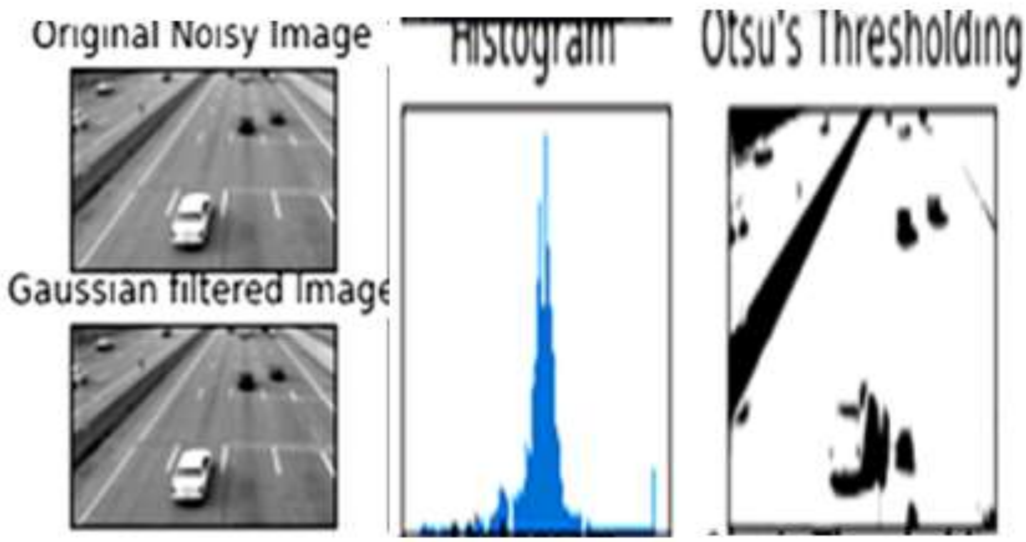

Fig.4: Filtered image with histogram equalization and thresholding (Threshold = 127)

Figure 4 depicts a standard Python execution of the denoising procedure, whereby the Gaussian filter is utilized to improve the quality of the vehicle image. The filtered image may be subsequently transmitted for the purpose of facilitating straightforward interpretation. The approach aims to identify an optimal threshold value (t) that reduces the weighted within-class variance, as expressed by the preceding equation.

$$\sigma_w^2(t) = q_1(t)\sigma_1^2(t)+q_2(t)\sigma_2^2(t)$$

where

$$q_1(t) = \sum_{i=1}^{t} P(i) \quad \& \quad q_1(t) = \sum_{i=t+1}^{I} P(i)$$

$$\mu_1(t) = \sum_{i=1}^{t} \frac{iP(i)}{q_1(t)} \quad \& \quad \mu_2(t) = \sum_{i=t+1}^{I} \frac{iP(i)}{q_2(t)}$$

$$\sigma_1^2(t) = \sum_{i=1}^{t} [i-\mu_1(t)]^2 \frac{P(i)}{q_1(t)} \quad \& \quad \sigma_2^2(t) = \sum_{i=t+1}^{I} [i-\mu_1(t)]^2 \frac{P(i)}{q_2(t)}$$

4. VEHICLE DETECTION AND COUNTING

A digital camera was deployed to gather traffic data in the bustling city of Port Harcourt and afterwards documented. A total of six distinct traffic recordings were captured during varying periods of time. The movie had a resolution of 1280 × 720 pixels, accompanied by a temporal resolution of 30 frames per second. A comprehensive analysis was performed on a variety of example videos. The applications were implemented using Python 2.7, with support from OpenCV, a software for image processing, along with its corresponding libraries. The visual representation is extracted from the video source and subsequently transformed into a grayscale format. The picture (vehicle) is obtained by subtracting the background. The image undergoes a conversion process to binary format, followed by the calculation of the vehicle's area. The algorithm establishes a region of interest (ROI). In this scenario, a virtual boundary is established, and upon the vehicle's entry, it is identified and subjected to image processing processes. The binary image that has been discovered is subjected to thresholding, hole filling, and filtering processes. The provided image is now utilized as an input for the counting mechanism. There are two variables employed in the process of vehicle counting: the counting variable, which keeps track of the total number of vehicles, and the register counter variable, which stores information pertaining to the registered vehicles. Bounding boxes, also known as frames, are utilized to establish a counting region that encompasses vehicles with equal areas. Once cars enter the designated boxes, they are tallied and the registration count is incremented. Furthermore, the counting area is deactivated until the vehicle exits the designated area. Subsequently, the count area is reactivated by the system, allowing the procedure to proceed uninterrupted. The process begins by converting the object, whether it is an image or video, into grayscale. Subsequently, background subtraction is performed on the item. Once a region of interest (ROI) is defined, each vehicle that enters this specific area is identified and subjected to thresholding, where it is converted to either black (0) or white (1). Currently, certain voids that have been generated are afterwards filled, followed by the application of image filtering techniques to eliminate noise. afterwards, the system proceeds to enumerate automobiles as they are discovered.

Figure 5 (a) depicts the unaltered image, whereas (b) represents an image that has undergone edge detection. The system is capable of detecting picture features, such as outlines, which facilitates the tasks of tracking and counting. The present study utilizes the canny edge detection algorithm for image processing of vehicles. The algorithm is built using Python 2.7. Subsequently, the RGB image of the car is transformed to grayscale.

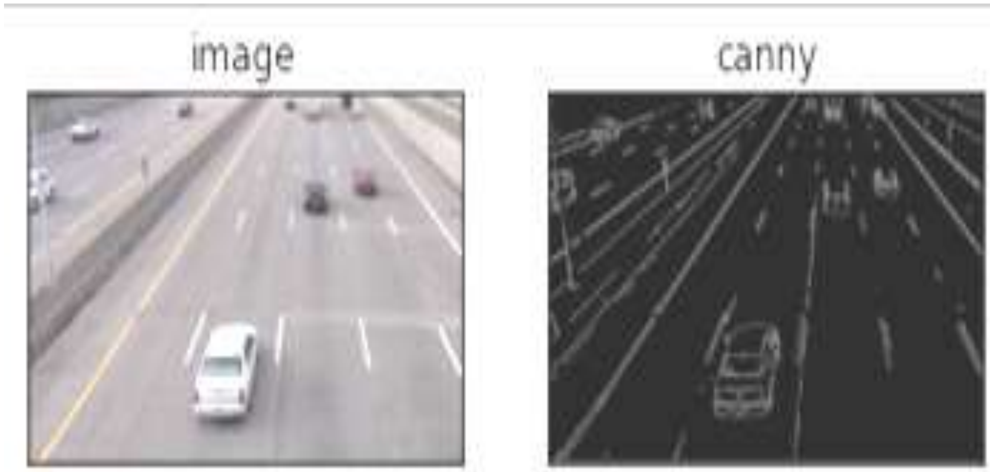

Fig.5: Canny edge detection

(a) Original image **(b) Canny edge detection**

5. MySQL/PHP Data Base Development

The creation of a relational database plays a crucial role in ensuring the efficient storage and retrieval of essential traffic data. Various tables have been developed for the purpose of monitoring and reporting traffic to road users. Several tables have been created, including tbl traffic_area, tbl_users, tbl_simulated_reading, and tbl_traffic_Report. The tables presented in this study consist of the primary database framework and its corresponding contents. The table Tbl_traffic_area is responsible for storing traffic data obtained from various intersections.

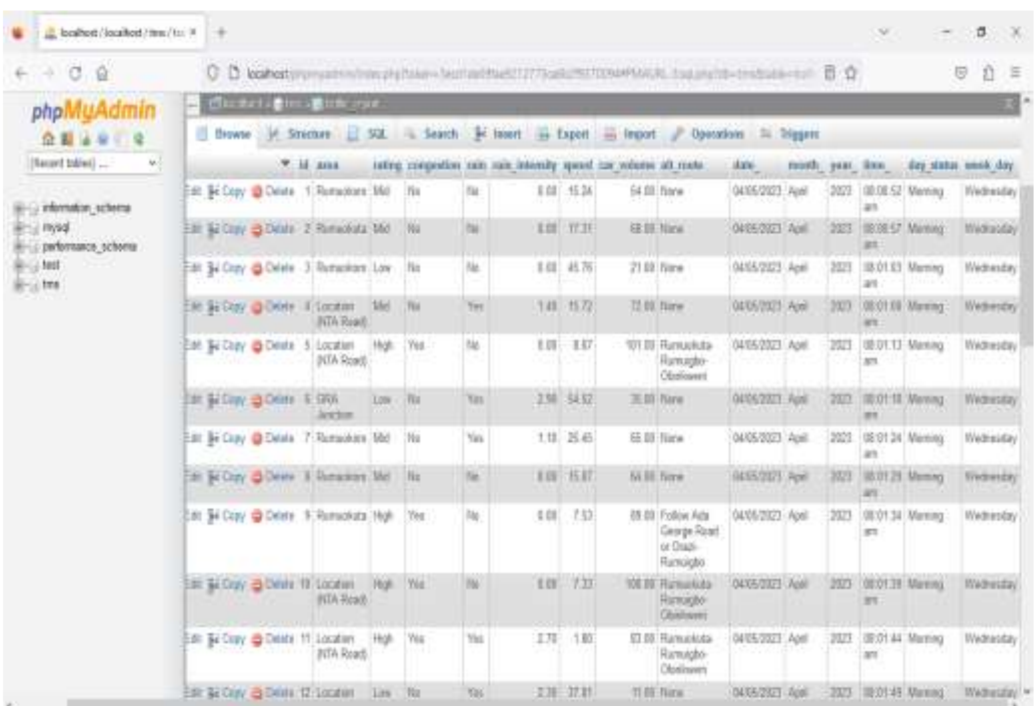

Fig.6: Database with simulated traffic report from intersections

6. DEVELOPMENT OF GRAPHICAL USER INTERFACE (GUI)

In the context of this research, a mobile internet-based application was built to facilitate road users' ability to make traffic requests along a specified route by providing them with login credentials. The user provides their username and password, and subsequently selects the login button in order to gain access to the checktraffic page. At this juncture, the user proceeds to choose the designation of the route or intersection for which they seek information regarding the prevailing traffic conditions.

The road's traffic conditions are indicated as heavy, medium, or free, with the number of automobiles present in no particular order. This provides road users with firsthand knowledge to make an informed decision on which direction to follow not to proceed with their journey.

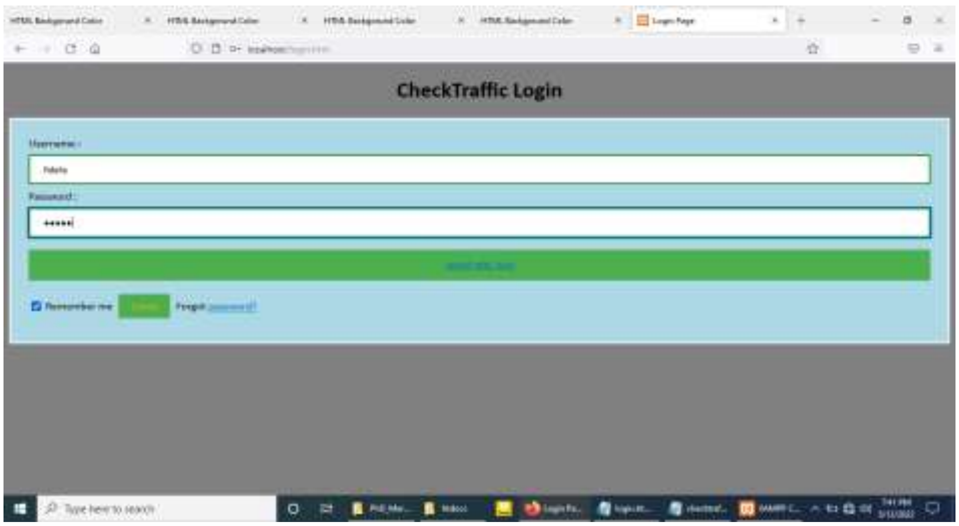

Fig.7: CheckTraffic login page URL: localhost/login.html

Figure 7 depicts the visual representation of a login screen presented to users, facilitating their access to the portal by the act of clicking the login button subsequent to supplying their login credentials.

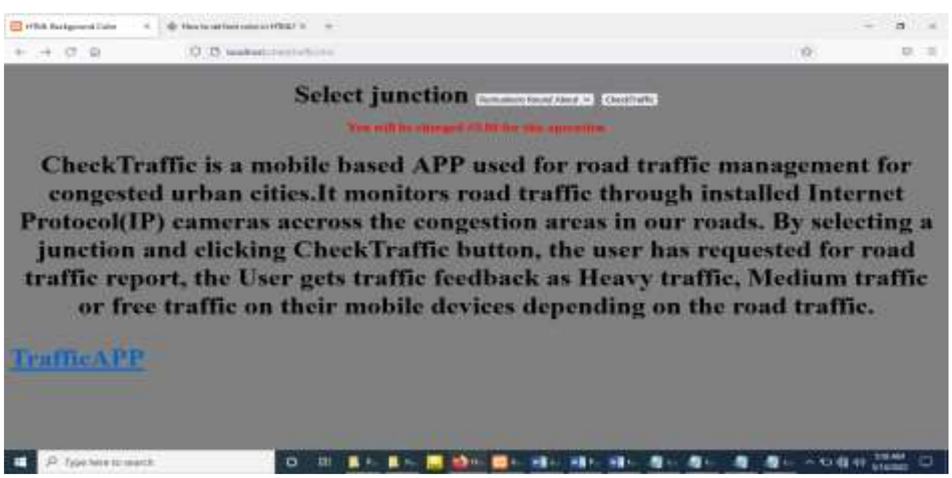

Fig.8: Check Traffic select junction page

Fig. 8 displays a selection of intersections in Port Harcourt. The inclusion of a drop-down arrow in the traffic report interface enhances user experience by providing the option for users to select their desired route or junction. This feature streamlines the interaction process, making it more user-friendly and efficient.

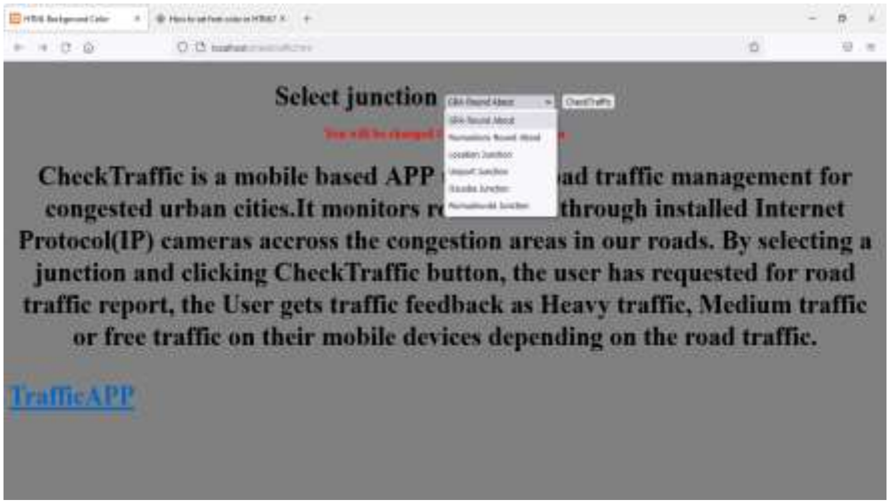

Fig.9: Check Traffic page showing list of junctions

In Figure 9, the user proceeds to make a selection from the listing of intersections that are provided, followed by clicking on the "checktraffic" button. Upon selecting the "check traffic" button, many traffic statistics will be presented.

7. RESULTS

The results presented provide evidence of the significance of the research.

i. The accuracy of vehicle counting
ii. Accuracy of Speed Measurement for Moving Objects
iii. Traffic reports.
iv. Error data
v. System performance

i. Accuracy in counting number of vehicles

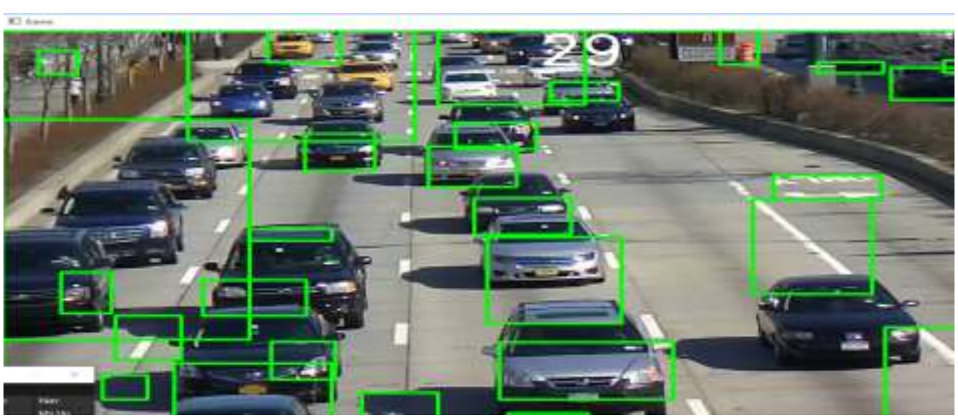

Fig.10: One of the videos being counted (output from Python 2.7) showing 29 vehicles

$$Accuracy = \frac{Count\ by\ system}{count\ by\ eye} x\ 100\% \qquad (3)$$

Table 2: System accuracy in counting vehicles

Sample Videos	Count by eye	Count by System	Deviation	Accuracy (%)
1	7	7	0	100
2	9	9	0	100
3	11	10	1	90.91
4	6	6	0	100
5	30	29	1	96.67
6	10	10	0	100
Total	73	71	2	97.26

ii. Speed determination accuracy result

Fig. 12: Speed estimation as Heavy traffic (0-14km/hr) (Output from Python Program)

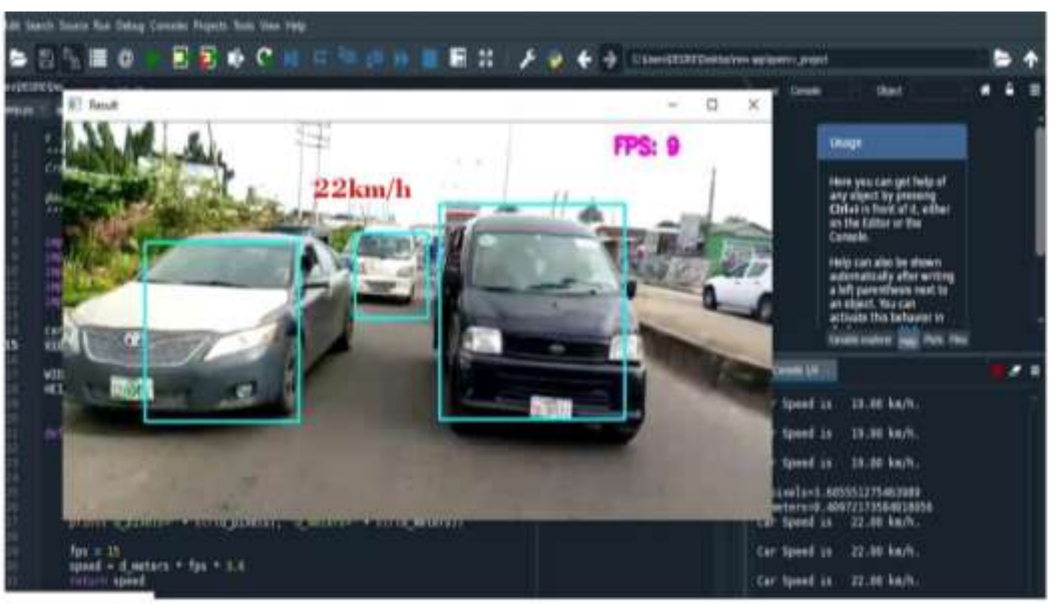

Fig.13: Speed estimation medium traffic (15-28km/hr) (Output from Python Program)

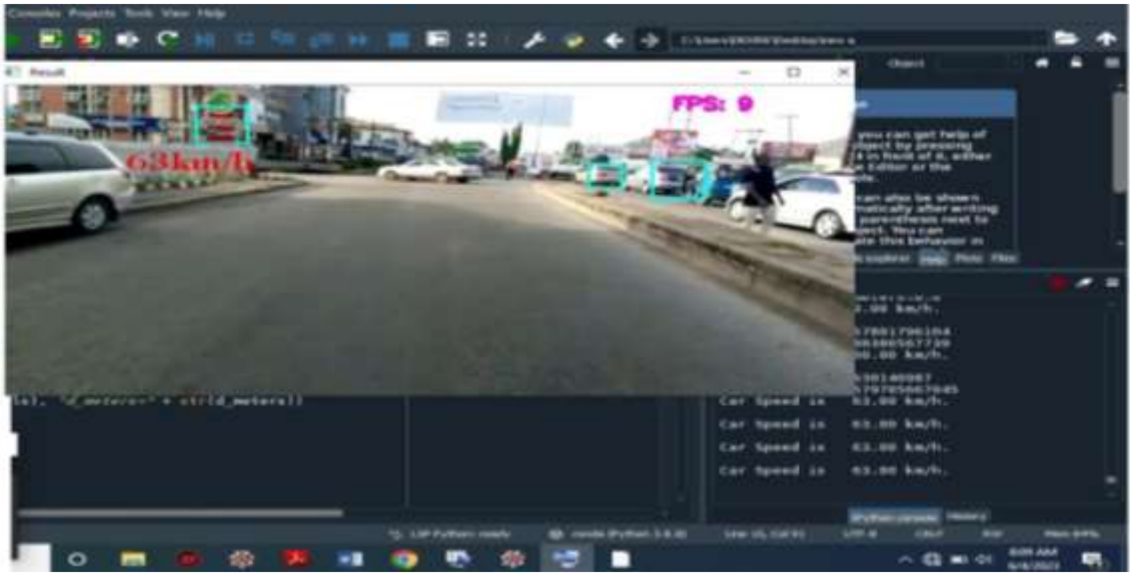

Fig. 14: Speed estimation Free traffic (29km/hr and above) (Output from Python Program)

Table 3: Vehicle speed comparison between actual and measured speed.

Distance	Execution Time (secs)	Actual speed (km/h)	Measured speed (km/h)	Accuracy (%)
3 meters	0.3	70	66	94.29
4 meters	0.4	40	40	100
5 meters	0.5	35	32	91.43
6 meters	o.6	45	43	95.56
7 meters	0.7	50	46	92
8 meters	0.8	51	50	98

$$Accuracy = \frac{measured\ speed}{Actual\ speed} x\ 100\% \qquad (4)$$

iii. Results of traffic report as displayed on mobile devices

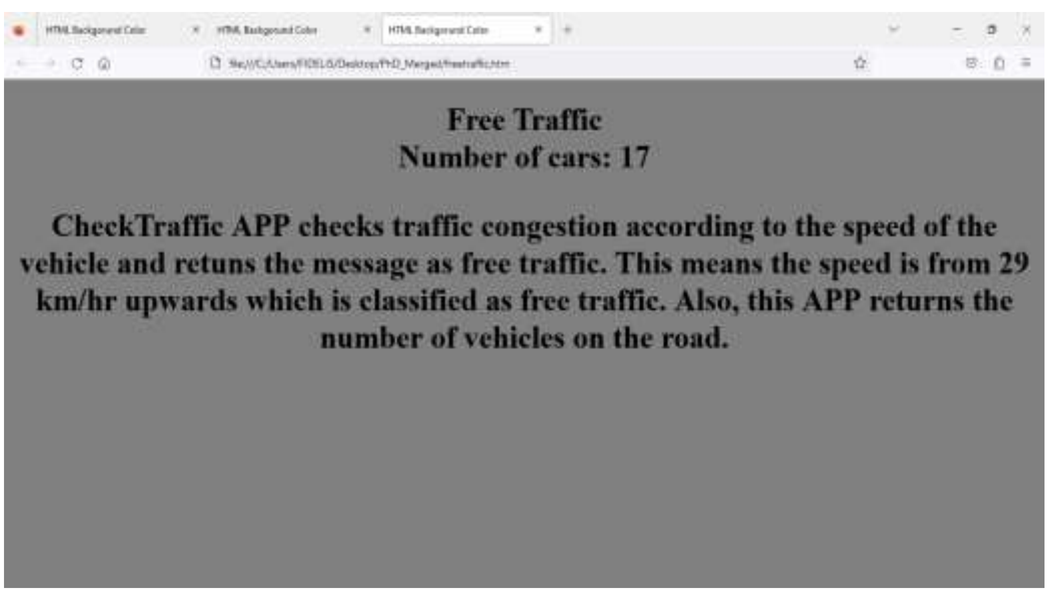

Fig.16: Traffic report as free traffic

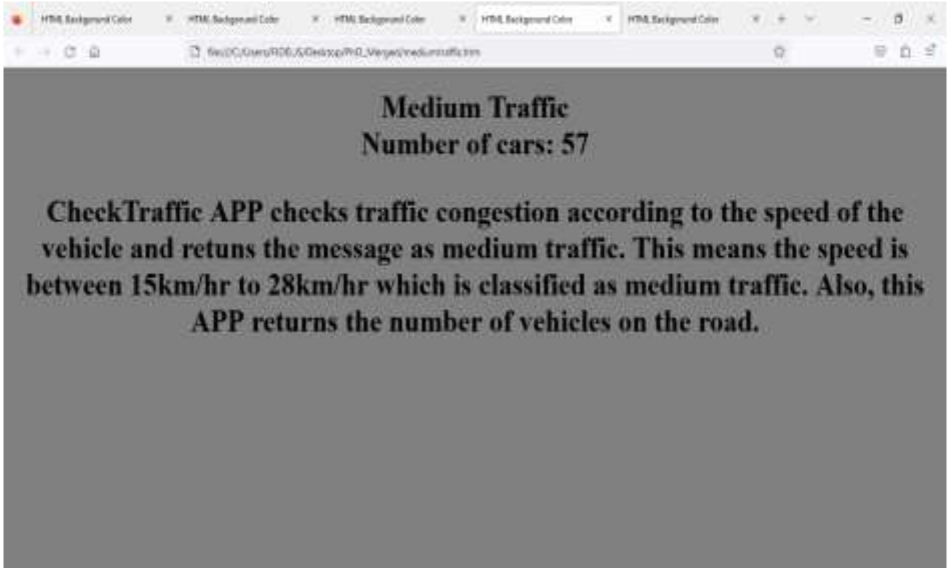

Fig.17: Mobile device webpage showing medium traffic with 57 vehicles

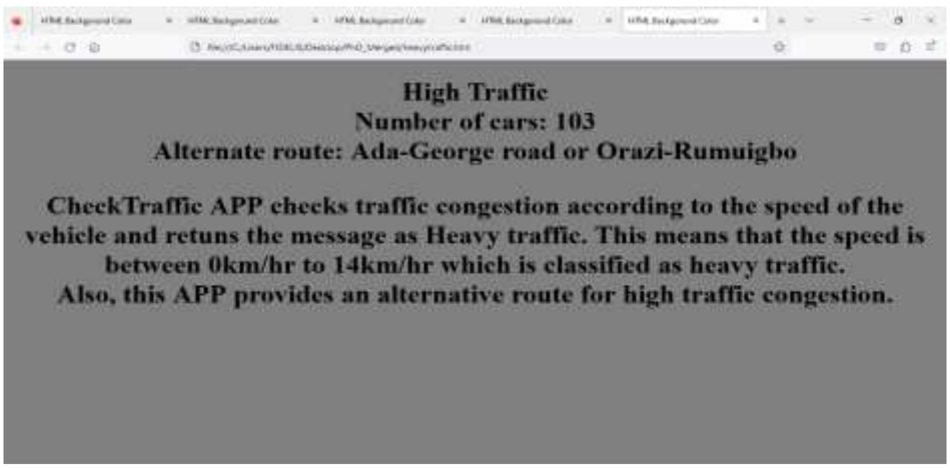

Fig.18: Mobile device showing heavy traffic with 103 cars

iv. Error data

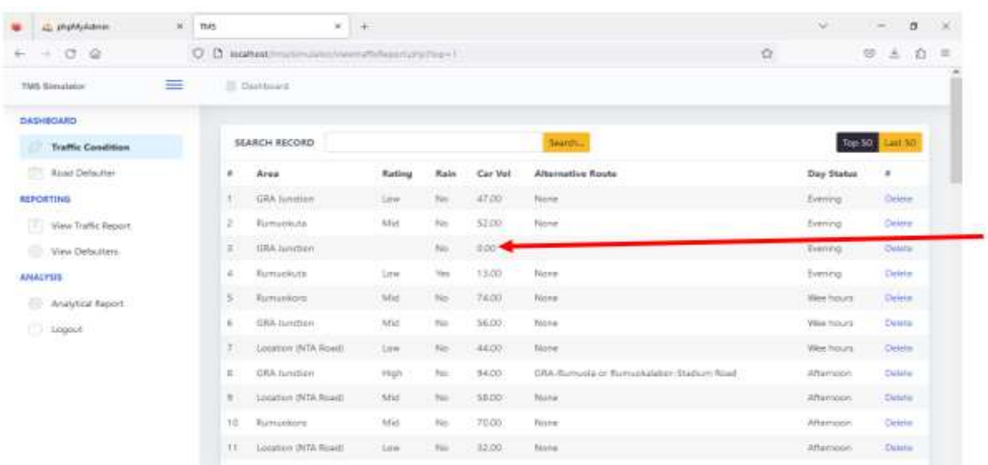

Fig. 19: System showing zero traffic data at GRA junction

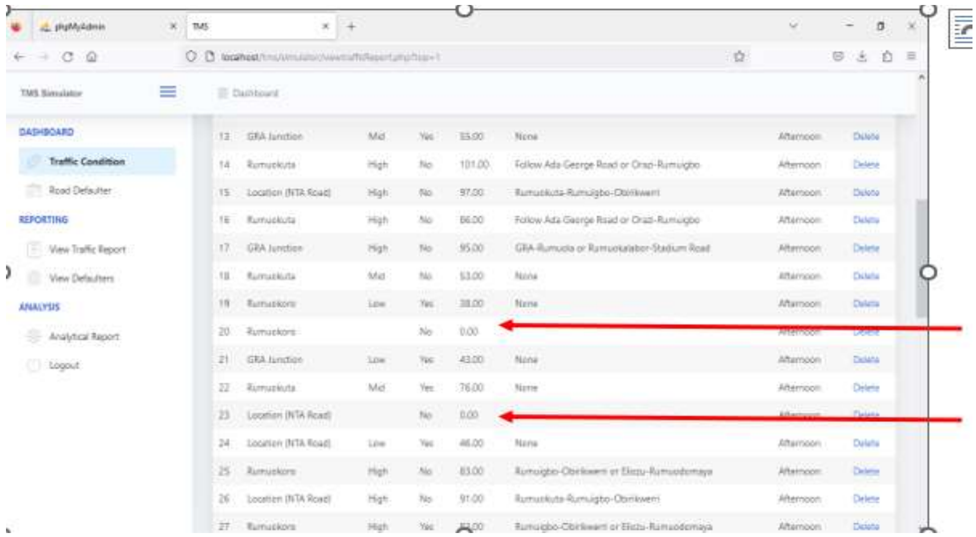

Fig. 20: System error showing zero traffic data at Rumuokoro and Location junction

v. System performance

Table 4: System Performance

System Performance	
Data Classified	1200
Correct Classification	1164
Incorrect Classification	36
Accuracy (%)	97
Percentage Error (%)	3

8. DISCUSSIONS

Table 2 presents a collection of six (6) distinct example movies that were obtained during the field study. The system successfully detected and quantified the number of vehicles, and this count was afterwards compared to the count obtained from visual observation. The system's accuracy is deemed high, as only two (2) out of the total 73 automobiles were excluded from the count. The algorithm successfully identified and quantified a total of 71 automobiles from a pool of 73 across six distinct input movies.

A comprehensive study of speed was conducted on six traffic videos utilizing Python, a programming language. The collected data revealed the existence of three distinct traffic conditions: heavy traffic, which was defined by speeds varying from 0 to 14 km/h; medium traffic, which encompassed speeds varying from 15 to 28 km/h; and free traffic, where speeds were seen to be 29 km/h and above. The research survey utilized a speed radar gun to assess velocity, with the measuring process being executed through the utilization of Python software.

Table 3 presents a comparison of the speed between the real speed of the vehicle and the measured speed obtained from the proposed method. The technology that was built was able to accurately measure the speed of cars, utilizing a radar speed gun to determine the actual speed of the vehicles. The system exhibited a notable degree of precision, as seen by the average accuracy rate of 95.21% achieved by the designed system.

The traffic outcomes are exhibited on portable devices subsequent to consumers' solicitation for a traffic report, which categorizes the traffic as either free-flowing, moderate, or heavy. Figures 16, 17, and 18 provide an elucidation of the traffic reports derived from simulations conducted using the Adaptive Realtime Mobile Based Traffic Management System. It is important to acknowledge that the system is designed to convey traffic information to mobile devices in a manner that facilitates easy interpretation. This transmission is based on speed classifications, specifically 0-14km/hr, 15-28km/hr, and 29km/hr and above, with corresponding labels of high traffic, medium traffic, or free traffic.

Figure 16 presents the output report that depicts the traffic conditions observed at the Location junction at the time of the request. Based on the data collected, it can be inferred that traffic circumstances were characterized by a lack of congestion, as evidenced by the presence of a mere 17 vehicles over the whole duration of the observation period.

Figure 17 illustrates a mobile device exhibiting a traffic report that indicates the existence of medium traffic, denoted by an observed number of 57 cars. The medium-speed traffic report is prepared by utilizing the program's stated range of vehicle speeds, which falls between 15km/hr and 28km/hr.

In Figure 18, the system additionally offered an alternative route in response to the presence of significant traffic congestion along the specified route. Consequently, individuals have the option to follow the recommended path in order to circumvent instances of traffic congestion.

Table 4 presents the performance evaluation of the Adaptive Realtime Mobile Based Traffic Management System. The algorithm accurately categorized 1,164 instances of traffic data, while 36 instances were misclassified. The presence of erroneous data is visually represented by a red arrow in Figure 19 and Figure 20. Hence, the system achieved a documented accuracy rate of 97%, accompanied by an error rate of 3%. Table 4 provides a comprehensive overview of the functioning of the system.

9. CONCLUSION

An Adaptive Realtime Mobile Based Traffic Management System has been created to analyze traffic congestion by considering factors such as traffic speed, vehicle density, and the number of vehicles on the road network. The system employs Internet Protocol (IP) cameras to record footage of traffic congestion at intersections, afterwards subjecting them to analysis through the utilization of the Python computer language. The system is capable of identifying road traffic patterns, making estimations of vehicle speed, tallying the quantity of vehicles present, and categorizing traffic congestion based on vehicle speed. This categorization includes heavy traffic (0-14km/hr), moderate traffic (15-28km/hr), and free traffic (29km/hr and above). The system then proceeds to transmit these reports to a local server. Users can subsequently access this information through their mobile devices in the form of web messages. The Mysql DataBase was designed with the purpose of storing traffic information obtained from road intersections. Additionally, a Graphical User Interface (GUI) was established to facilitate road users' access to the system, allowing them to log in and conveniently monitor the traffic conditions along their desired routes. During the simulation of traffic videos, the DataBase will undergo

updates to reflect pertinent traffic statistics such as vehicle speed, car count, geographical position, and traffic status indicating the presence or absence of congestion. The system demonstrated a notable level of precision in accurately determining vehicle counts and computing vehicle speeds, with small margin for error.
The system plays a crucial role in providing road users with real-time information regarding road traffic conditions, enabling them to make informed decisions before leaving their residences or workplaces. Additionally, it offers alternative routes as a contingency plan in the event of congested traffic conditions. The implementation of this solution has the potential to mitigate or eradicate traffic congestion, hence fostering enhanced work-life balance, increased human productivity, and positive economic growth at the national level.

Declaration by Authors

Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Fidelis. U. Didigwu, G.N Ezeh, Engr. N. Chukwuchekwa, O.C Nosiri. Development of adaptive realtime mobile based traffic management system for congested urban cities. *International Journal of Research and Review*. 2023; 10(9): 106-128. DOI: *https://doi.org/10.52403/ijrr.20230912*

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