A Novel Approach to Road Traffic Monitoring and Control System

Franklin O. Okorodudu[1*], Philip O. Okorodudu[2] and Lawrence O. Atumah[3]

[1*]Department of Computer Science, Delta State Polytechnics, Otefe-Oghara, Nigeria
[2]Department of Electrical Engineering, University of Nigeria, Nsukka, Nigeria
[3]Department of Science Laboratory Technology, Delta State Polytechnics, Otefe-Oghara, Nigeria

Abstract– **Nowadays, increasing vehicular traffic volumes and dynamic traffic light management systems have become a huge challenge to road users and the society at large. These factors increase the stress level of commuters and drivers as they lead to time wastage and health related problems. This study developed a novel approach to road traffic monitoring and control system using a network of sensors and real-time image processing system to control traffic and reduce traffic gridlocks and environmental hazards resulting from smokes of car exhausts. The design consist of the power supply unit, the micro controller unit, the motion sensors, the timer, the digital calculator, the digital display and counter, the message processor and camera. The system takes into consideration the traffic jams and gives hints on how we can avoid the jammed traffic so we can be on time to our destination. Simulation of the various units was done individually using the procedural programming application Proteus 8. Most of the components used were according to design specifications from data book with alternatives used in cases where they are unavailable. The design was done in units and was tested individually and the whole system was tested collectively to perform the required task of giving a forecasted route to users. The designed model is capable of improving reliability, speed, operational safety and reducing pollution as well as road traffic jam.**

Keywords– **Digital Counter, Micro Controllers, Motion Sensors and Traffic Monitoring/Control**

I. INTRODUCTION

The road transportation system provides services to millions of passengers worldwide as it is one of the most widely used means of transportation. Within a given geographical location, road transportation is the most economical. The need to keep road journeys safe and reliable cannot be overemphasized. A number of recent road accidents have been attributed to poor road management systems which causes gridlocks on major highways [1]. The introduction of computerized road traffic and control system that has the ability to redirect drivers to routes with less traffic will improve the reliability, efficiency and safety of the road transport system as well as reduce the environmental hazards that are associated with gridlocks such as the smoke from the exhaust of vehicles especially diesel driven car engines.

With the number of registered vehicles increasing geometrically all over the world [2], there is the need to develop ways of appropriately addressing traffic situations. In Nigeria for instance, as of third quarter of 2017, according to the National Bureau of Statistics (NBS), the country had a total of 11,547,236 vehicles. At the end of the second quarter, the number of vehicles stood at 11,458,370. This implies that a total of 88,886 vehicles were bought between March 2017 and September 2017 [3]. Thus, with increase in traffic congestion globally and with detection and tracking of moving vehicles posing a huge challenge in the application of computer vision, researchers in the field of artificial intelligence have being seeking for ways to mitigate the effects of these congestions. [4] studied how artificial intelligence techniques can be applied to traffic data measurements. This was done using sensors with loop detectors that are limited in scope and can only solve a sub-set of road traffic problems. [5], [6]. Vision based cameras would have proved more useful as they are more sophisticated and easy to maintain than the pneumatic sensors. Studies carried out by [7] proposed the use of GPRS or radio for vehicular tracking and classification so as to convey information such as traffic situation, vehicle speed and distance between moving vehicles to drivers. The system proposed by [3] also included an incident detection system to be transmitted to drivers using the GPRS or radio. This method utilizes moving objects to extract images. However, this method generates large quantities of ghost which affects the clustering and tracking processes [8]–[10].

In this study, we designed a model that considered a multi-track road network. The direction of arrival of vehicles at different multi-track road was programmed into the memory of a microcontroller and this program handles all traffic related issues within the road network. The motion sensors were programmed to handle the issue of vehicle arrivals across the multi-track road. The microcontroller works in unison with the motion sensors and then feeds the timer which in turn feeds the digital calculator and tells the volume of traffic on the road for drivers to know the route which best suits them. The proposed system has the following advantages:

i). The model of a road traffic monitoring and control system will ease traffic on the road by informing drivers through the use of sensors installed in the vehicle of the traffic nature on a road.

ii). It will assist to reduce the likely effects of environmental hazards that could result from the release of carbon monoxide from the exhaust of moving vehicles.

iii). It will help to reduce the likely effect of head-on collision of vehicles that could result from vehicles coming from different directions or junctions

iv). The system will help with easy shutting down of roads that require maintenance without causing much damage to road users.

v). The system will reduce if not eliminate the task of road wardens at cross junctions to control motorist and pedestrians.

II. REVIEW OF LITERATURE RELATED TO ROAD TRAFFICMONITORING AND CONTROL

Traffic congestion is a burning issue in many cities due to the exponential growth of running vehicles [11]–[13]. Traffic congestion could be generally categorized as either recurring traffic congestion or non-recurring traffic congestion. While the recurring congestion occurs at the same place during the same time of the day, non-recurring congestion occurs randomly. Traffic congestion is occasioned by the inadequacy of the road capacity to effectively move the number of travelling vehicles on them. Studies have been carried out to address the challenges of road monitoring and control. In a study carried out by [14], an advanced traveler information system was developed. The study utilized a 16km long stretch road that includes heavy traffic roads. The study utilized over 100 GPS devices that were placed on city buses on the route and 32 video cameras mounted along the road to collect data. The information to travelers was provided through a variable message sign boards on the routes and on the website. One of the limitations of this system is the high cost that will be involved in the procurement of GPS devices and video cameras. There is also the issue of safety of these devices and willingness of drivers to ensure that the road is traffic free before plying them. This is especially so for developing countries like Nigeria where majority of the drivers lack basic education. [15] developed a high definition video surveillance and broadcasting system that will allow the analysis of video technology for traffic analysis and a deployable wireless image transport system. In a related study, [16] developed an agent based management techniques with reinforcement learning principle.

The study developed an adaptive operated traffic signal to cut down travel time, rate of fuel consumption and improve traffic flow rate. However, the literacy level of citizens in developing countries is a huge hindrance to the implementations of this advanced technology. The need for a road monitoring and control model that would be installed in vehicles without much ambiguity is would go a long way to address the traffic situation in developing countries.

III. COMPONENT DESIGN

The design and development of the system has both the hardware, software and user requirements. The hardware subsystems include the hardware units used to realize the visible test-bed for the model of the road traffic monitoring and control system. The software sub – systems include the software units used to realize the sensor that initialize the process, data transfers from the deployed visible test-bed to the vehicles in which the sensors have been installed and an online server and clients at the office of road monitoring agencies. The user requirements require that the users are able to read, write and interpret instructions properly.

The hardware sub system is categorized into the following major segments:

A) The Power Supply Unit

A centre-tapped transformer was used in the design of the power supply unity. The rectification process used was the bridge rectifier with four diodes connected to the secondary of the transformer as shown in Fig. 1 below.

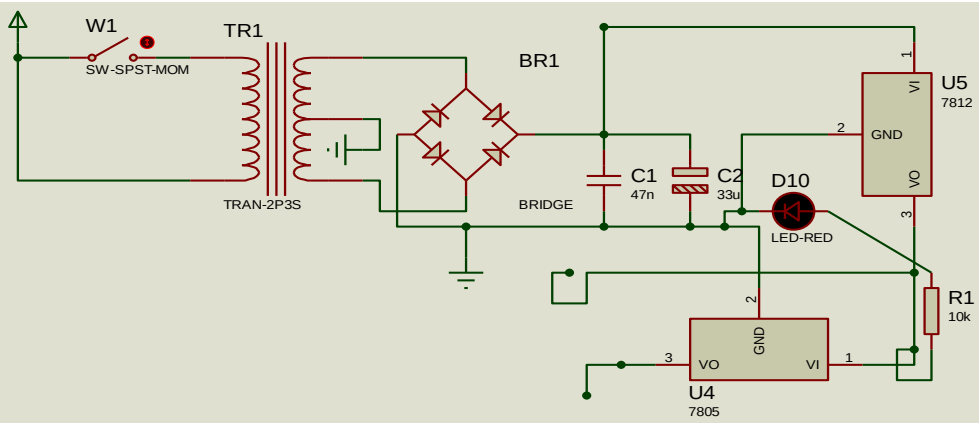

Fig. 1. Power supply unit

The major source of power for the designed circuit is from the generation and distribution companies. However, due to the unstable nature of electricity from the public power supply, provision was made for electricity using solar panels which are charged during periods of intensive sunlight and used when there is an outage of electricity from the public supply.

B) The Microcontroller Unit

This is the intelligent part of the system. The microcontroller is responsible for detecting and interpreting signals received from the motion sensors as shown in the block diagram of Fig. 2. The microcontroller is also responsible for information transmission between the designed system and the users of the information, in this case, drivers. The microcontroller in this system performs the same functions a processor does in a computer system; it governs its operations. The microcontroller chosen for this function in this design is the PIC16F 628A, a product of Microchips. The Functions of the microcontroller-16F628A include amongst others: to turn on the system automatically when power is connected, to interpret signals, to send and receive information from the motion sensors as well as communicate information to the timer and digital calculator etc.

C) The Motion Sensors

Motions sensors, conventionally, are used to detect physical motion on a device. Motion sensors have the ability to detect and capture physical and/or kinetic movements on a real time basis. The passive infrared sensor (PIR) was used in the design of this circuit. As observed from Fig. 2. It works in conjunction with the microcontroller to sense the number of vehicles on a particular road and sends the information to the timer and digital controller through the microcontroller while it in itself transmits such information to the message processor which then informs road users, in this case, car drivers on the status of each road.

D) The Timer and Digital Calculator

The timer is used for measuring time intervals that vehicles are held up on traffic while digital calculator computes the number of vehicles that are on the traffic at that point in time. The timer works in consonant with the digital calculator. The information obtained from the timer is relayed to the digital calculator and digital display counter. This way, road users can determine if they will be able to wait on the traffic considering the time and number of vehicles displayed on the digital counter or if an alternative route would be better off for them.

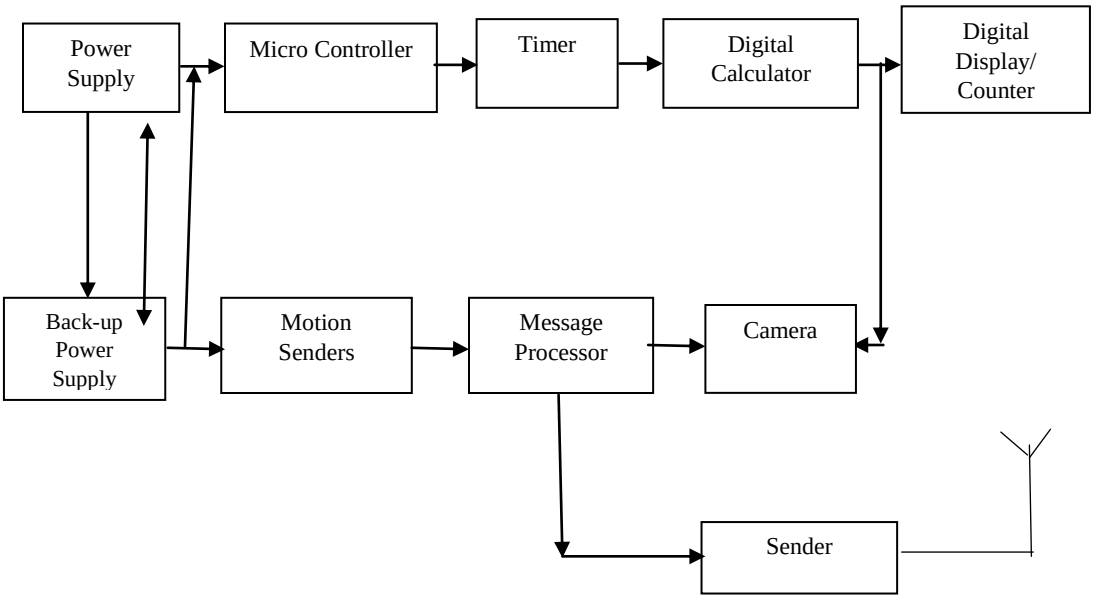

Fig. 2. Block diagram of the feedback traffic monitoring and control system

IV. USER REQIREMENT OF THE SYSTEM

The designed circuit is to be located within the premises of road traffic monitoring agencies like the Federal Road Safety Corps (FRSC) in Nigeria. The mode of operation of the designed circuit is wireless and will be using the power provided by the public power supply and in cases where there is an outage, electricity is obtained from the installed solar panel, and this is to ensure an all-round power supply.

V. RESULTS AND DISCUSSION

After the construction of the road traffic monitoring and control system, the complete unit was tested and implemented. The designed device was incorporated in vehicles. The device is coated with sensor wires. The system is set to read information from the data available at the office of the road monitoring agency and transmit same to the moving vehicles for guidance. The drivers of vehicles acts on

the information received and choose the route with less traffic or one which they believe has less traffic based on the traffic congestion information given by the digital calculator.

One major opportunity to regulate traffic in developing countries is for vehicles to be fitted with this device that would warn drivers of traffic situations in routes applicable to their destination. It is possible to equip vehicles with traffic information to prevent their being driven into areas where there is traffic congestion.

Drivers would choose roads to travel on based on the prevailing traffic condition. These choices are self-motivated according to the criteria which are person and situation dependent. One benefit from the use of currently available information technology would be the posting of traffic situation in an area.

Most roads in developing countries have been built to allow different types of road users going at widely ranging speeds in the same space and at the same time. Such all-purpose roads are liable to have a high traffic incident rate. Conscious road planning and design are key to better traffic management in developing countries.

VI. CONCLUSION

A novel approach to road traffic monitoring and control system capable of monitoring and controlling vehicular traffic was developed in this study. Motion sensors which provided a continuous electrical paths in conjunction with the microcontroller units, the timer, digital calculator and the digital display was used to indicate the volume of traffic as well as the probable time that the traffic will persist based on the scenario at a given lane or junction. The advantages of this system include easing of traffic on the road by informing drivers through the use of sensors of the traffic nature on a road, reducing environmental hazards that could result from the release of carbon monoxide from the exhaust of slowly moving or clustered vehicles, reducing the likely effects of head-on collision of vehicles that could result from vehicles coming from different directions or junctions, easing the ability to shut down a road or lane that require maintenance without causing much damage to road users. The designed system will also help to reduce to the barest minimum, the task of road wardens at cross junctions to control motorist and pedestrians.

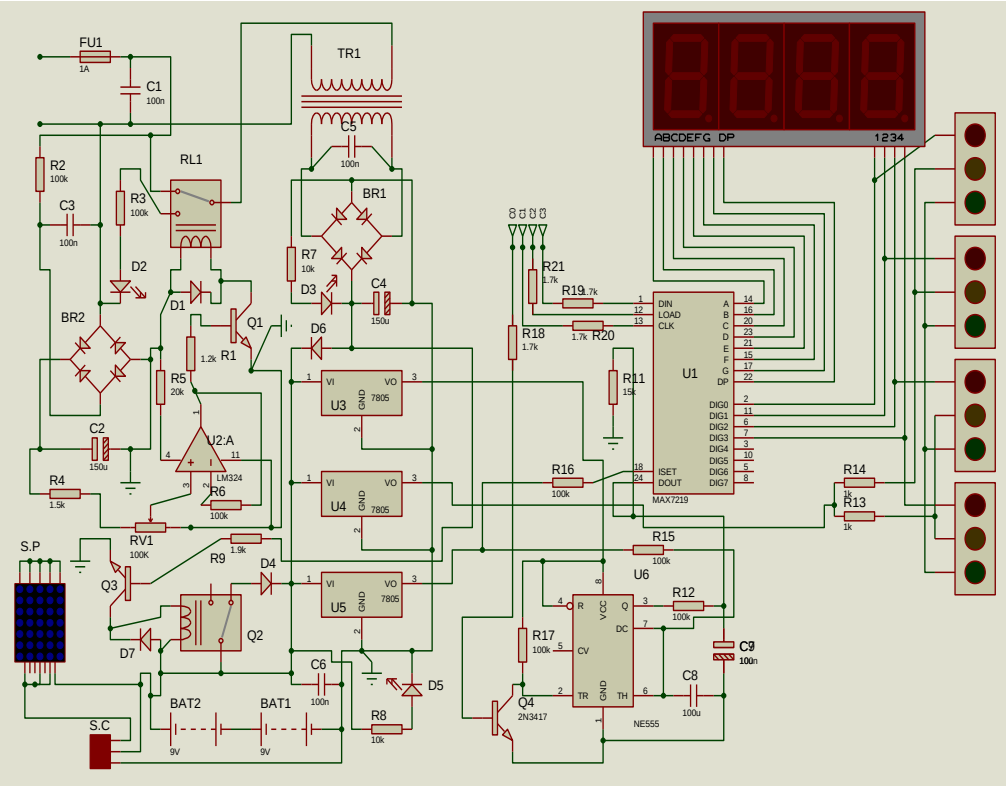

Fig. 3. Feedback traffic control circuit diagram

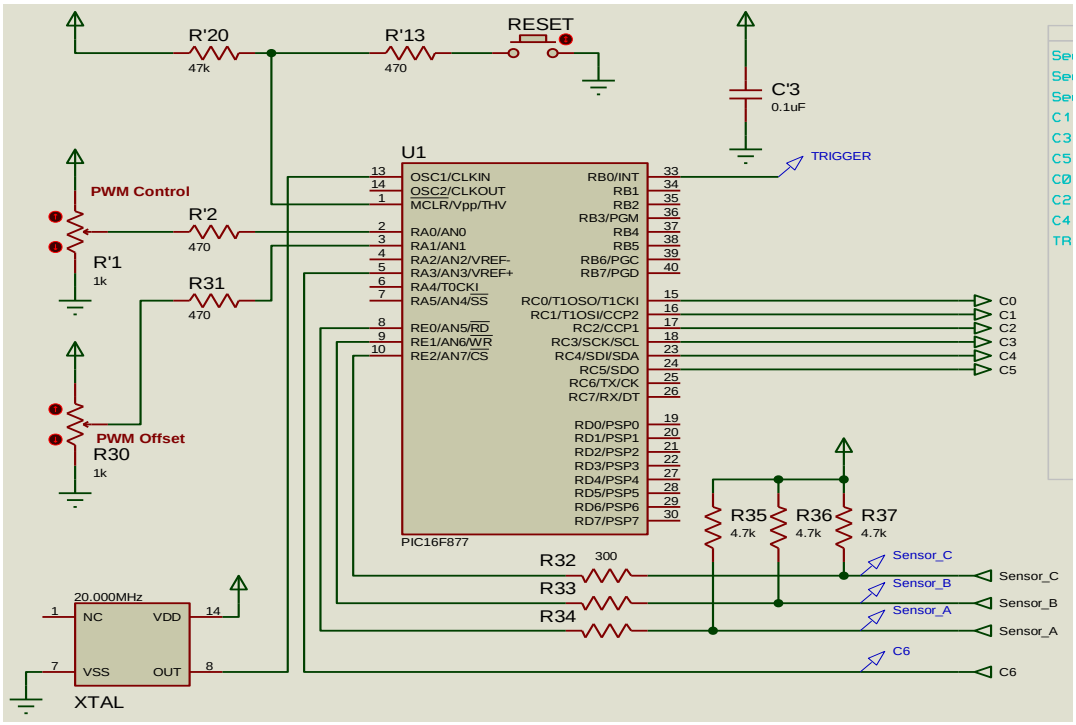

Fig. 4. Sensor input/ message processor circuit diagram

REFERENCES

[1] A. Adenuga. "Gridlock at Ikorodu road as container trailer falls". Connect Nigeria Publishers". Internet: http://www.connectnigeria.com/articles/2017/11/gridlock-ikorodu-road/ [Dec. 22, 2017].

[2] S. An., B. Lee., and D. Shin. "A survey of intelligent transportation systems". *In Proceedings of IEEE third international conference on Computational Intelligence, Communication Systems and Networks (CICSyN)*. 2011. pp. 332-337.

[3] Nairametrics. "Nigeria's vehicle population data reveals towering opportunities". Internet: https://nairametrics.com/vehicle-population-in-nigeria-is-11547236-nbs-data/. [Dec, 22, 2017].

[4] C. Remy., G. Tarak., and M.T Mohan. "Computer vision for multi-sensory structural health monitoring system," *In Proceedings of IEEE International Transportation Systems Conference (TSC)*, Oct. 2004.

[5] C. Rita., P, Massimo, and M. Paola. "Image analysis and rule-based reasoning for a traffic monitoring system," *IEEE Transactions on Intelligent Transportation Systems*, vol. 1, pp. 119-130, Jun. 2000.

[6] A. Kanungo., A. Sharma and C. Singla. "Smart Traffic Lights Switching and Traffic Density Calculation using Video Processing". *In Proceedings of IEEE Recent Advances in Engineering and Computational Sciences (RAECS) UIET*, 2014. pp. 1-6.

[7] B.A Erhan., T.F. Murat., and S. Sibel. "Automatic vehicle counting from video for traffic flow analysis," *In Proceedings of IEEE Intelligence Vehicle Symposium*, 2007. pp. 392-397.

[8] Y. Liu., and P, Payeur. "Vision-based detection of activity for traffic control," *In Proceedings of IEEE Canadian Conference on Electrical and Computer Engineering towards a Caring and Human Technology (Cat. No.03CH37436)*, 2003. pp. 1347-1350.

[9] C, C. C. Pang., W. W. L. Lam and N. H. C. Yung, "A method for vehicle count in the presence of multiple-vehicle occlusions in traffic images," *IEEE Transactions on Intelligent Transportation Systems*, vol 8, pp. 441-459. Sep. 2007.

[10] A Ramazani and H Vahdat-Nejad. "A New Context-Aware Approach to Traffic Congestion Estimation". *In Proceedings of IEEE International Conference and Computer and Knowledge Engineering*. 2014. pp. 504-508.

[11] N Kapileswar, and P. H Gerhard. "A Survey on Urban Traffic Management System Using Wireless Sensor Networks". *Sensors*. Vol. 16. pp. 21-25, 2016.

[12] B Yang and Y. Lei. "Vehicle Detection and Classification for Low-Speed Congested Traffic with Anisotropic Magneto resistive Sensor". *Sensors*, vol. 15, pp. 1132--1138. Feb. 2015

[13] H. Wang. "Wireless sensor networks for an extended city intelligent transportation system. *International Journal of Advancements in Computing Technology*, vol. 3. pp. 300--307. May, 2011.

[14] P. Kumar., V. Singh and D. Reddy. "Advanced Traveler Information System for Hyderabad City". *IEEE Transactions on Intelligent Transport Systems*, vol. 6, pp. 25-37. Jan. 2005.

[15] D. Christopher and M Stuat. "A proof-of-concept and demonstration of a high definition, digital video surveillance and wireless transmission system for traffic monitoring and analysis". Internet: http://www.citsm.umd.edu/documents/abstracts-finished/milner-abstract.php [Dec. 20, 2017].

[16] J.C Medina and R.F Benekohal. "Agent-Based Traffic Management and Reinforcement Learning in Congested Intersections". Ph.D. Thesis, University of Illinois, USA, 2012.