AN INTELLIGENT TRAFFIC MANAGEMENT SYSTEM USING FUZZY LOGIC IN PORT HARCOURT CITY

Traffic problem is one of the major problems in Port Harcourt city. This traffic problem can affect the economy, slow down development, reduce production, increase cost of transportation, and hamper people's daily life. There are several causes of traffic problem in a big city. Among them are, increasing number of vehicles, shortage of sufficient roads and highways, and traditional traffic light system. All of these factors can create traffic congestion in the intersection but notably among them is the use of traditional traffic light system. This research is aimed at developing an intelligent traffic control system. Object-oriented methodology was used. The number of vehicles in a link was identified using camera sensor. Number of vehicles waiting at a red light was determined using fuzzy logic algorithm. Wireless Sensor Network (WSN) sends road density parameters collected by sensor camera to the fuzzy logic to decide the traffic lights phases. The essence of fuzzy logic was to make decisions regarding the traffic congestions using the well-defined rule base. System was implemented in Anylogic simulation tool. Result showed that 200 vehicles have mean time of 53seconds and 540 vehicles have mean time of 87seconds. Thus, the system minimized average time all vehicles spent in the module.

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INTRODUCTION

Intelligent System (IS) is defined as the system incorporating information into applications for machine handling [1]. Every system uses different technology types for intelligent systems, traffic congestion management features such as Infrared (IR) monitors, Radio Frequency Identification (RFID's), Zigbee, Traffic Warning Systems, Big Data, and Bluetooth. [2]established a navigational system for effective transport services, for urban bus drivers in Madrid City who assisted in micro-navigation, forecast crowd-conscious routes and provided detailed instructions to bus drivers.The system was based on Smartphone apps to connect with on-board sensors in order to detect the presence of passengers on board.

AIM AND OBJECTIVES

The aim of this research is to develop an intelligent traffic control system using fuzzy logic.

Objectives are as follows:

i. To identify number of cars in a link for automation using camera sensor
ii. To determine the number of vehicles waiting at a red light just before the green light using fuzzy logic algorithm.
iii. To develop traffic control system
iv. To test and evaluate the system

Traffic management system has a great impart in the economy:

i. It helps to create a continuous human movement and stimulates economic development.
ii. This reduces congestion, increases the efficiency of transport systems and reduces fuel consumption and environmental costs

Intelligent system has been used in other areas to overcome a variety of complex issues, and this research utilizes fuzzy logic to focus on the traffic control mechanism in Port Harcourt City As a consequence, all cars used in the network have significantly reduced the average time of the service.

2. RELATED WORKS

Traffic management system means traffic volume preparation and control [3]. Traffic congestion makes sure more people use a specific transport facility for a specific period than what is regarded to be acceptable levels of inconvenience or irritation. Delays at specific locations in the transport network certainly affect system users but this delay is part of a much broader picture of how the system is used. Congestion management is aimed at improving operational performance by improving alternative transport methods that modify traffic patterns, measures and improved traffic flow, like traffic management systems, improvements in signals for traffic and incident prevention [4]. The traffic lights in the traditional traffic light system are changing [5]. The reason is that the timing system is used by certain traffic light controllers, modified by various previous instances of traffic light and with time-based examples, in current practical practices. They concluded that it did not have an optimal effect on traffic volume fluctuations. They stressed then that drivers ' time to wait on each line was limited by the speed of the vehicle going through the intersection, dependent on phases of the traffic signal, order and alignment. The fuzzy optimization used in their research is therefore to determine the values of the input parameters of an advanced, high-performance virtual system. In order to evaluate congestions, to get warning details and to take appropriate actions, Fuzzy Logic controller is then used to implement fuzzy logic inference rules from the fuzzy rule base. At the end of each phase of the process, the number of vehicles on each lane is measured by sensors and used as inputs to the fuzzy controller. The Fuzzy monitor calculates the Green Light interval based on the traffic situation. The simulated results show a rise in traffic management overall, which reflects the enormous viability and practicality of the model. In various methods and traffic control scenarios,[6] implemented fuzzy logic agent-based technologies. [7]introduced a new approach in isolated intersection to the complex control of road illumination cycles and phases. The solution is a hybrid lighting control device that integrates a wireless sensor network with several fuzzy real-time monitoring logic controls and one for each operating in parallel process. Each fuzzy controller addresses vehicle movements and dynamically administers the phase and green light times.[8]have been working on the Fuzzy traffic controller design for over-saturated crossings.

3. RESEARCH METHODOLOGY

Research methodology is the study of how to carry out a specific research task using certain techniques. A constructive research technique is used to as the research methodology. The design methodology adopted for this research is the Object-Oriented Design Approach (OODA).

3.1 CONSTRUCTIVE RESEARCH

Constructive research is an experimental method for developing software. It provides basic reasoning by developing or using model diagram schedules, affiliations, etc. This research method is generally used in particular for science, examination exercises, number juggling, clinical drugs and operational research [10].The roots of a constructive approach to science lie in action research and pragmatism, the sources of which, in addition, lie in the American tradition. Its origins date back to the early 20thcentury [11]. The philosophy of pragmatism emphasizes action and its progress. Knowledge is based on experience and the reality of action.[12]was nicknamed after the Greek goddess of childbearing from constructive research, which, in conjunction with other electronic records of neonatal intensive caregivers, used high-speed physiological data at the Hospital for Sick Children in Toronto and Canada, to identify many premature and unfulfilled conditions earlier.

Constructive research is primarily based on the fact that technology is used narrowly in the light of current or existing knowledge and may involve a few missing connections.

3.1.1 ELEMENTS OF CONSTRUCTIVE RESEARCH

a. RELEVANCE PROBLEM

With Port Harcourt City's rapid population growth, cars are rising, and the crowded existence of roads has contributed to traffic congestion.

b. PRACTICAL RELEVANCE

The basic definition of the Traffic Control System (TCS) has already been established in order to fully understand the problem of the traffic control system through a conceptual understanding of traffic monitoring and traffic control system enquiries.

c. THEORETICAL RELEVANCE

The architecture is known to be articles by structuring the traffic control system This will encourage an object-oriented design (OOD) to construct a new device. MATLAB is going to upgrade the code. The new data framework will be based on a summary and a combined written survey. Planning for the new data framework.

d. THEORETICAL BODY OF KNOWLEDGE

The Traffic Control System will be tested using traffic information in Rumuokoro Junction, Port Harcourt City.

e. PROBLEM SOLUTION

The proposed traffic control system will use the Fuzzy Logic approach to delegate rules to incoming vehicles on the Rumuokoro axis East-West and North-South.

4. DESIGN METHODOLOGY

This reinforces the value of the Object-Oriented Design approach and the Top-Down Design approach. The system is divided into modules and the programming of known products is carried out. The program process in the element can be used for analysis, arrangement and execution. The Traffic Control System uses the Object-Oriented Development (OOD) and Top-Down layouts.

Object-oriented design (OOD): the design was designed to meet the requirements of an object-oriented system. Requirements planning; this process defines the inputs and outputs of the device. The Unified Modeling Language (UML) is used for structured object-oriented applications such as use-case, sequence and class diagrams.

5. SYSTEM ANALYSIS

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The analysis of the proposed system shall be carried out in order to identify the objectives of the system and to decide what the system is to do about its functionality or efficiency. The analysis of the proposed system is carried out in order to evaluate the system priorities and

specify what the system is to do. These requirements are based on the needs of system users and the expected results of the traffic control system.

5.1. SOURCE OF DATA

Primary data collection has been carried out. Interview and observation have been used. Interviews were conducted in Rumuokoro Junction, Port Harcourt, using verbal interviewing techniques for drivers and traffic controllers.

6. SYSTEM DESIGN

Architecture is a high level representation of the overall system. The system architecture for the proposed traffic control system gives the overall view of how the system should be structured as shown in figure 1.

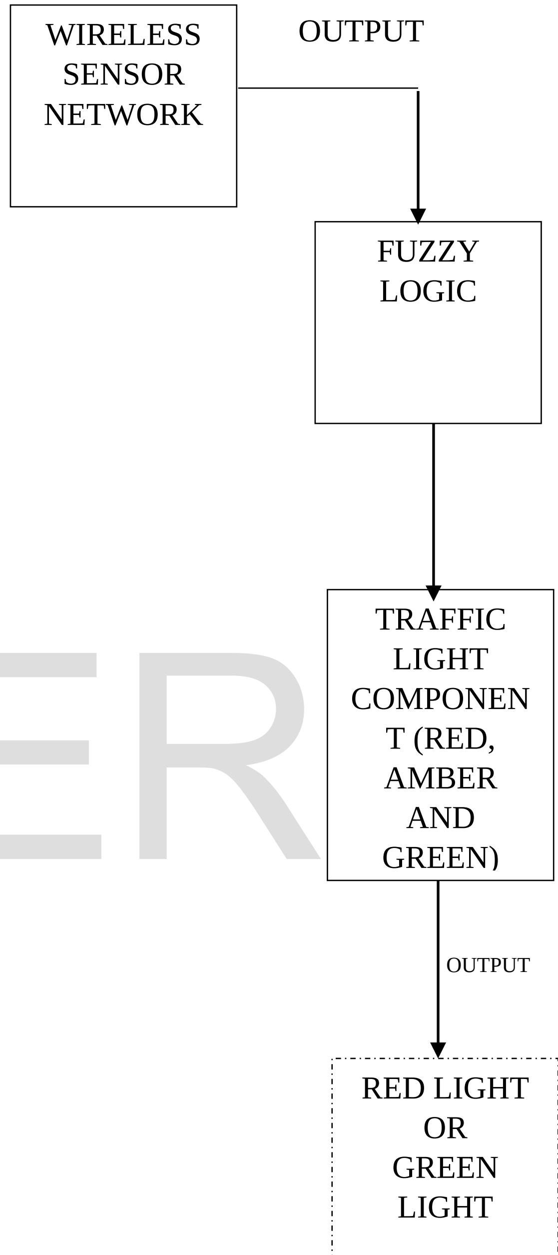

Fig 1:Architecture of the Proposed System

6.1. INPUT PARAMETERS

Traffic information from Rumuokoro Junction traffic region in Port Harcourt city. A four-way junction consisting of East (E), West (W), North (N) and South (S); the length of the vehicle queue and frequency of vehicles arriving at the junction are considered.

Assuming the number of vehicle occupancy of the road is 200 and it is scattered within the E, W, N and S traffic region of each road. The number of vehicles that can be moved during the signal changing time is equal to 120 and the number of waiting vehicle is equivalent to 80. The Waiting Vehicle (WH) within E, W, N and S can be obtained using the following:

$$WH = \frac{n}{80} * 100$$

Where,

n = number of vehicles arrived in to the traffic region at the current traffic cycle time.

Number of waiting vehicles is taken as RedQueue

The Moving Vehicle (MV) across the traffic region within E, W, N and S is obtained using the following:

$$MV = \frac{n}{120} * 100$$

Number of moving vehicles is taken as GreenQueue

The scope of the Green Moving Vehicles Queue is given as$0 \leq GreenQueue \leq 1$

6.2. WIRELESS SENSOR NETWORK

A Wireless Sensor Network can be defined as a network of devices which can sense their environment and communicate the information gathered through wireless links [9]. It can be used, together with other technologies, to control the environments in which they are placed. Figure2 shows Wireless Sensor Network in traffic environment.

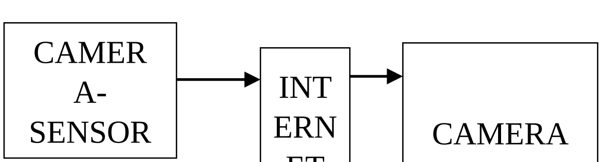

Fig2: Wireless Sensor Network

Camera sensor is placed round the junction to capture the number of vehicles using wireless sensor network. The road parameters captured are analyzed.

Frame detection is a function that groups pixels that are in motion. This would consequently group those pixels within the same area of the frame together if the pixels are white and surrounded by black pixels. The function then allows for the storage of each frame, identifying the size of each frame. The speeds at which individual vehicles are travelling is calculated using the parameters stored for each frame as well as the parameters of the camera analysis (number of vehicles). The average speed of the vehicle is calculated using the linear motion formula:

$$V = \frac{d}{t} (3.3)$$

Where,

v is the velocity of the vehicle.

d is the travelled distance.

t is the travelled time.

The time t in seconds during which the camera picks a vehicle is calculated using the frame at which the vehicle started being traced (frame created) and when the frame terminated (frame destroyed). Time is given as follows;

$$t = \frac{(framedestroyed - framecreated)}{framerate}$$

Where,

t represents time.

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Framecreated represents when the vehicle started being traced.

Framedestroyed represents when the frame terminated

The speed v at which vehicles are travelling in m/s is as follows

$$v = \frac{distance}{(framedestroyed - framecreated)} * framerate$$

Where,

V is the speed of vehicle.

Framecreated represent the time at which the vehicle is being captured.

Framedestroyed represent the time at which the frame is being destroyed.

The speed is converted to speed in km/h

$$averageSpeed(km/h) = 3.6 * averageSpeed(m/s)$$

6.3. TRAFFIC LIGHT COMPONENT

Traffic Light Component is mainly used to signify the actual tasks of the real world traffic light. The state chart of traffic light component is shown in

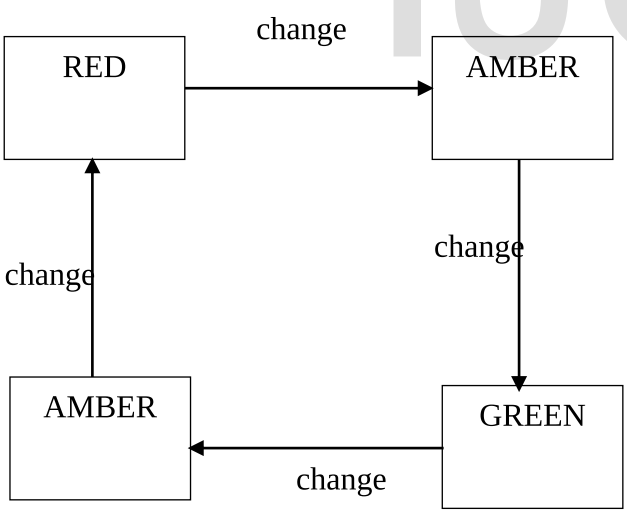

Fig 3: State Diagram for Traffic Light Component

Red is the starting point of start chart, Amber is the change time between Red and Green. If $time \geq stop\ time$, time changes to the next start. Three light emitting diodes, 'RED', 'AMBER' and 'GREEN', each having their meaning of 'STOP', 'READY' and 'GO'. The road layout for this design is the "+" road intersection represented in Figure 3.5. Rumuokoro Junction was chosen due to the constant traffic.

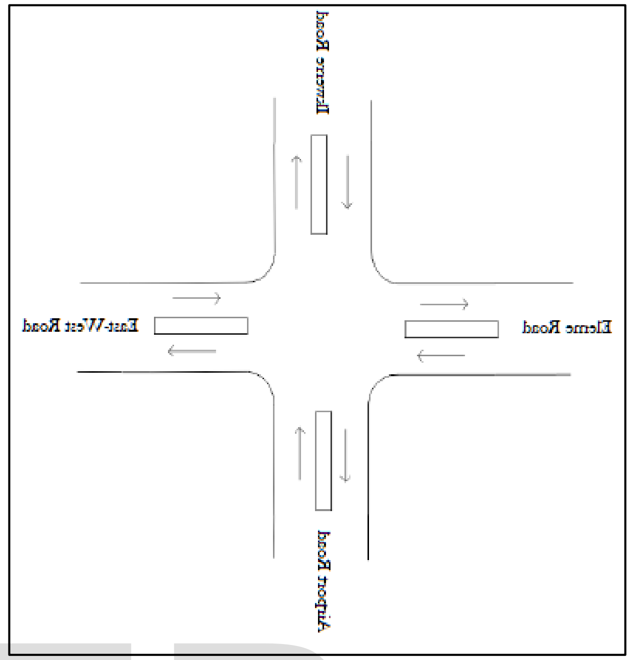

Fig 4:

Rumuokoro Road Layout in Port Harcourt

6.4. FUZZY LOGIC

The fuzzy logic allows quantity to be partially true than the usual true/false. The degree of truth to a set of criteria can be described numerically by membership function. The fuzzy will also be used to map a set of outputs to a set of inputs in a fuzzy inference method. The fuzzy logic model adopted in this work composed of two functional components as shown in Figure 3.6. One is the knowledge base, which contains a number of fuzzy if–then rules and a database to define the membership functions of the fuzzy sets used in the fuzzy rules. Based on this knowledge base, the second component is the fuzzy reasoning or decision-making unit to perform the inference operations on the rules. Using fuzzy sets to make the number of cars waiting in queue minimized by dynamically increase or decrease green phase duration of the four-way intersection where the fuzzy traffic has two crisp input values representing East-West and North-South.

The waiting and moving vehicles queue in EW and NS road are fuzzified, the Fuzzy Engine makes the intelligent decisions regarding the traffic congestions using the well-defined rule base. The changing of next cycle time (CHANGET) is defuzzified and produce an output of RedWVQueue/GreenMVQueue.RedWVGueue consists of four membership sets named as less, moderate, half and full. GreenMVQueue consists of three membership sets named as less, considerable and many. Membership functions of both RedWVGueue and GreenMVQueue are shown in Table 3.1.

7. EVALUATION

7.1. SYSTEM REQUIREMENTS

The system requirements include the working environments where the system is implemented, tested and evaluated. The system requirements may be broken down into hardware part which includes the personal computer system and the physical devices which are used in the software development effort and the software part which includes program tools and an Integrated Development Environment (IDE) for performing programming experiments or simulations.

7.2. \HARDWARE REQUIREMENT

The minimum hardware requirements necessary for the deployment of the system have the following configuration:

a) **Processor:** Pentium processor or higher with minimum of 1GHz speed

b) **Memory:** 1GB-RAM and 256MB virtual memory, 120GB HDD

c) **Monitor:** 32bit Screen Resolution and above

Apart from this minimum configuration, the operating system used may demand higher capabilities for the execution of applications.

7.3. SOFTWARE REQUIREMENT

The software requirements for the programming experiments include the following:

a) **Operating System:** Windows XP, Windows Vista and Windows 7, Linux, Solaris and Mac OS X are all compatible for the deployment of the IDE for coding experiments.

b) **Run Time Environment:** ANYLOGIC 8.5.0 is a minimum systems requirement though higher (more recent) versions can also be used.

8. RESULTS

The network of vehicles and traffic control logic are shown in Appendix B. The road module has a parameter start-time, with a default time function; which is the time a vehicle agent is being created, the time before the arrival time of each vehicle into the module. The initial population size of vehicle agent is 200, length is 5 meters, initial speed is 60 kilometers/hour, preferred speed is 60 kilometers/hour, maximum acceleration is 1.8 meters/second. maximum deceleration is 4.2 meters/second. Two simulations were executed; experiment before and after optimization. The mean duration time that vehicles spent in the module is 53 seconds. However, time spent is reduced during optimization.

The optimization result of fuzzy logic shows the reduction in the time all vehicles spent in the module as shown in Table 4.1.

RUNS	NUMBER OF VEHICLES	Fuzzy Output	MEAN TIME (SECONDS)
1	100	0.2	43
2	200	0.5	53
3	540	1.0	87

Table 1.: Fuzzy Logic Optimization

The average (mean) time is 53seconds for 200 vehicles. The statistic is shown in Figure 4.1.

9. CONCLUSION

In this research, we have developed intelligent traffic control system. In the Traffic Control System, Camera sensor was placed round the junction to capture the number of vehicles using wireless sensor network. The road parameters captured were analyzed, thus, the wireless sensor network sent road density parameters collected by sensor camera to the fuzzy logic to decide the traffic lights phases. The essence of fuzzy logic was to make decisions regarding the traffic congestions using the well-defined rule base, thus the fuzzy logic algorithm was used to change traffic light. However, the system modeled a traffic information from Rumuokoro Junction traffic region in Port Harcourt city. A four-way junction consisting of East-West (EW) and North-South (NS); the length of the vehicle queue and frequency of vehicles arriving at the junction were considered. The number of vehicle occupancy of the road was equivalent to 200 and it was scattered within the EW and NS traffic region of each road. Traffic Light Component demonstrated actual tasks of the real world traffic light, the Red Amber (Yellow color) and Green.

Object-oriented methodology was adopted, which used graphical notations to build models of software system. Class, sequence and use-case diagrams were used in the study.

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10. CONTRIBUTION TO KNOWLEDGE

Minimization of average time all vehicles spent in the module and immediate passing of emergence route.

11. RECOMMENDATION

This research can be extended to implement automated toll system.

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