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Review Article

Building Traffic Signal Control Systems using Arduino Nano

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Abstract

The batteries in this research power the entire system, and they may be charged if necessary. The system also has a switch that may be used to turn it on or off. The four traffic lanes in this study are designated as lanes A, B, C, and D. In the event that you choose not to utilize the system's control button, the four lanes are managed by a wireless system. A, B, C, and D are the labels on the buttons as well. The four research lanes are identified by the labels A, B, C, and D on the wireless system as well. You can utilize the system's control switch or the wireless control system to allow lane D to proceed in the event of an emergency when lane A is operating or providing permission to proceed. Once the vehicles in lane D have passed, they will immediately return to lane A, where they are now operating. Once every car has completed passing in lane A, they will proceed to lane B, lane C, and lane D before making their way back to lane A.

Keywords: Construction, LEDs, Simulation, Arduino, Radio Frequency Module (RF), Vehicles, Management. Traffic Lights.

I. INTRODUCTION

In order to manage conflicting traffic flows, traffic lights—also referred to as traffic lamps or traffic signals—are signaling devices placed at road intersections, pedestrian crossings, and other sites. Due to their inability to adjust to changing road conditions, traditional traffic signal systems, which operate on set cycles, can be a major cause of traffic congestion. Because they make it take longer for people to get where they're going, traffic bottlenecks are bad for both drivers and other road users. Ambulances and police cars are examples of emergency vehicles that could be seriously endangered by this delay. Using dynamic traffic lights—whose functioning changes depending on the traffic conditions at the intersection is one important way to alleviate traffic congestion at intersections. Since there aren't many scholars in the literature interested in finding solutions to emergency vehicle traffic jam problems, this paper's contribution is the introduction of a revolutionary traffic signal system operation strategy. Two algorithms make up the new strategy: a pure operation mode and a hybrid operation mode. The goal of these operation modes is to shorten the time emergency vehicles must wait at junctions. They make the assumption that an Internet of Things (IoT)-based smart infrastructure system exists that can recognize the arrival of emergency vehicles at a crossroads. The traffic signal operation is changed from fixed cycle mode to dynamic mode by the smart infrastructure system. In order to shorten the time that emergency vehicles must wait at junctions, the dynamic mode controls the traffic signals. The suggested algorithms are simulated in the study, which also emphasizes their benefits. We contrasted our method with the conventional traffic light system and the Wen algorithm found in the literature in order to assess the effectiveness of the new strategy. According to our evaluation study, the suggested algorithms performed better in various traffic circumstances than both the old system and the Wen approach [10]. The traffic light system is controlled by numerous studies. A portion of these techniques included hardware, such as logic circuits and controllers, and were static. These systems don't consider the flow of traffic when opening and closing the traffic light; instead, they rely mostly on a static, continuous time. To forecast the quantity of automobiles or the state of the traffic jam in each direction, several techniques were created [1]. An introduction to the use of fuzzy logic for traffic light control is provided by Study [2]. In this study, the number of automobiles, the length of the queue, and the width of the road are the criteria used by the researchers to manage the cars as a prioritized queue. The green lights that indicated an empty wait were eliminated during the construction of the fuzzy system. When compared to standard light control systems, the outcome was superior.

Researchers discuss the approaches utilized in traffic light system control in-depth in the study [3]. TST and TSC were the primary scopes of many of the searches. While some searches rely on a single parameter, others rely on a set of parameters. The traffic light condition, the length of each light, the required shade of green, the manner in which cars are waiting, the calibration between these cars, and several other significant characteristics are the primary parameters that these systems use. More than 77% of all queries, according to the search, involve the use of simulation tools. Green time, cycle length, phase sequence, change interval, and offset were the primary timing constants. An interview regarding the development of a smart traffic signal system by artificial intelligence is provided in Study [4]. Whether the car weighs more or less than eighty tons is a major factor in this system's operation. This study makes use of Google Earth traffic data; longer travel times are associated with higher traffic intensities. There was an emergency, and cameras were deployed. A software program for modeling logic simulation was used to assess the suggested system. This technology was able to raise the speed of cars to 55% and decrease the number of cars in a given amount of time to 55%. reducing by 29% the number of automobiles that need to wait and by 38% the amount of time that drivers must wait to cross junctions. Researchers attempt to address the issue of junctions passing on 4-way highways in the study [2]. This study considers vehicle and autonomous vehicle communication in addition to standard characteristics. Sensors, computation, and future car predictions were used to detect cars. According to research, establishing traffic as a network can help reduce traffic issues and provide effective control over traffic signals. Reinforcement training was employed by researchers to manage traffic signals in study [4]. Every study under this scope requires at least two intersections. Natural language processing is used in this study to provide the best answer. This investigation found that more than 160 articles used RL approaches to produce the greatest results. The traffic signal systems were controlled using a variety of techniques, including deep learning and machine learning. The primary benefit of the fuzzy logic approach is its speed in comparison to neural networks, which have a large processing overhead and might not operate instantly. Using historical data, neural networks attempt to forecast the number of automobiles. Although the image processing system can provide real-time data for fuzzy logic to process. The concept made it possible for the system to function in real time, displaying changes in the number of automobiles, the traffic light's response to each variation in the car's number, and the movement of the street directions. Similar to this, the image processing system adds value to the system, particularly in cities with heavy traffic, which can also reduce the likelihood of accidents and delays in time. This system can be designed to treat ambulances as a third fuzzy set, with the requirement that they open on the street instantly at the top priority, a medium priority with fire engines and police cars, and a lowest priority with other vehicles [5]. Traffic light control systems are used for particular lanes or crossings in metropolitan areas, while fixed cycle traffic lights are usually used to regulate traffic on the roads. Additionally, improper installation can lengthen the time it takes for traffic to clear junctions and result in excessively long wait times for crossing traffic, which can strand emergency vehicles at intersections. By lowering energy consumption and traffic delay, adaptive signal timing management is a technology that can enhance network-wide traffic operations and is more computationally feasible than existing fixed-cycle signal control systems. Despite the existence of specialized adaptive control systems, emergency vehicles cannot be contacted, which is a critical component of smart cities. This issue led to the creation of a unique framework called Emergency Vehicle Adaptive Traffic Lights (EVATL) for smart cities. EVATL combines emergency vehicle communication with an adaptive traffic light mode to improve traffic signal performance and decrease total traffic delay. EVATL uses GPS and the Internet of Things (IoT) to locate emergency vehicles. It interfaces with traffic lights and uses YOLOv8 to operate adaptively based on vehicle density at the traffic signal. Thus, the main objective of the suggested EVATL is to incorporate adaptive traffic signals for smart cities and prioritize an emergency vehicle at the same time. By building several scenarios for an adaptive traffic light and emergency vehicle communication, a graphical user interface (GUI) is created to assess the suggested model. When examining the simulation results of the suggested model EVATL, it is evident that the prompt identification of an emergency vehicle at a predetermined distance significantly reduces the wait time of cars at a traffic signal [6]. This work presents a smart traffic management system that makes use of the Internet of Things (IoT) [17, 22] to help authorities plan more effectively and handle a range of traffic management difficulties. An algorithm is used to efficiently handle various traffic circumstances, and a hybrid strategy—a blend of centralized and decentralized methods—is used to optimize road traffic flow. To do this, the system uses data on traffic density from cameras, sensors, and other devices to modify traffic signals. An alternative artificial intelligence-based technique is used to predict future traffic density in order to lessen traffic congestion. Furthermore, RFIDs [12, 13, 20] are used to prioritize emergency vehicles, such as ambulances and fire brigade vehicles, during a traffic gridlock. This system's component for detecting a fire on the road also includes smoke sensors [19, 21]. To demonstrate the value of the suggested traffic management system, a prototype is developed that not only facilitates better traffic flow but also establishes a connection between neighboring rescue departments via a centralized server. It also gathers useful information that is displayed graphically, which may benefit the government in the future when designing roads [7]. The population growth and rising car ownership in developing countries like India have led to an increase in traffic congestion and accidents [14, 15, 16, 18]. However, a smart traffic control system that uses RFID sensors can lessen these issues by recognizing congested areas and improving traffic flow. This method also enables emergency vehicles to get at their destination more swiftly by granting them priority. The real-time data provided by RFID sensors can also be advantageous to drivers as it can reduce idle time and save them money. Using this information, alternate routes can be suggested to drivers, allowing them to avoid congested areas and reduce the amount of time they spend trapped in traffic. This not only improves traffic flow but also helps reduce pollutants and fuel consumption, making the environment cleaner and greener. Emerging countries like India can employ a smart traffic control system with RFID sensors to regulate the increasing traffic flow and reduce traffic accidents. In rising nations like India, an RFID-based smart traffic control system has the potential to greatly enhance the welfare of road users, the economy, and the environment [8]. Using the minimal distance triggering mechanism, the dynamic navigation system and smart traffic light assess the movement of emergency vehicles. In the modern world, traffic congestion is a big problem that causes a lot of chaos and losses to both the economy and people's quality of life. The issues associated with traffic become much more significant when we consider emergency vehicles, including ambulances. In order to reduce travel time, ambulances nowadays frequently drive past intersections carelessly (for example, by speeding past a T junction without considering the risk factors), which raises the possibility that the ambulance will be involved in an accident. The traffic signals in the existing system follow a predefined sequence of green lights; that is, the lights don't turn green until the signal's predetermined timing limit is reached. This system's inability to account for emergency vehicles lowers the system's overall efficiency. Through our project, this static system is altered to become efficient and real-time (i.e., dynamic). First, Proteus DS is used to simulate the primary hardware, which will be a retrofit table system for the existing static time-based traffic system. Second, an Android Studios app is created to control the traffic signal. Thirdly, the desired cloud platform (AWS, Google Cloud, or Microsoft Azure) will be used to construct a web application. In [9], [11].

II. METHODS AND MATERIALS

2.1. The materials used in this research are shown in Table I below.

Table I: materials used in this research.

S/N	NAME OF COMPONENTS	AMOUNT USED
1	SWITCH	2
2	CAPACITORS	3
3	BATTERIES	3
4	LIGHT EMITTING DIODES	15
5	RADIO FREQUENCY (RF)	1
6	ARDUINO NANO	2

2.2. Method

Both components are based on Arduino microcontrollers, which are programmed using the Arduino IDE. The entire system is powered by three (3) batteries, which may also be charged with an adaptor charger in case they run out of power. There is also a switch on the system that is used to power it on or off. In this research, the four lanes of traffic are named lane A, lane B, lane C, and lane D. There is a wireless system that is used to control the four lanes in case you decide not to use the control button on the system. The buttons are also labeled A, B, C, and D. Also on the wireless system, it is labeled A, B, C, and D, indicating the four lanes of the research. If there is an emergency in lane D and lane A is the one that is working or giving permission to go, you can use either the control switch from the system or the wireless control system to give lane D permission to go. If the cars in the lane, which is D, have passed, then they will automatically go back to the lane in which they are operating, which is lane A. If all the cars have finished passing in lane A, they will then go to lane B, lane C, and lane D and return to lane A again.

III. System Design and Construction

The traffic light management system's development and execution are depicted in the figures below.

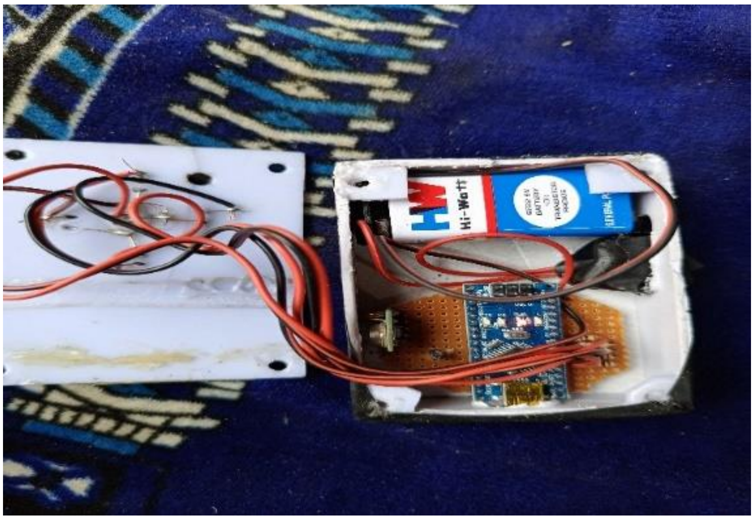

Fig. 1: The internal circuitry of the control switch.

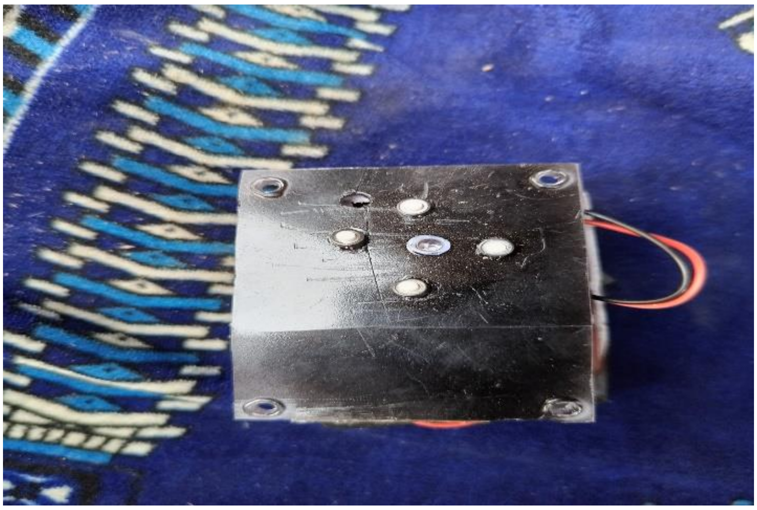

Fig. 2: The Control Switch

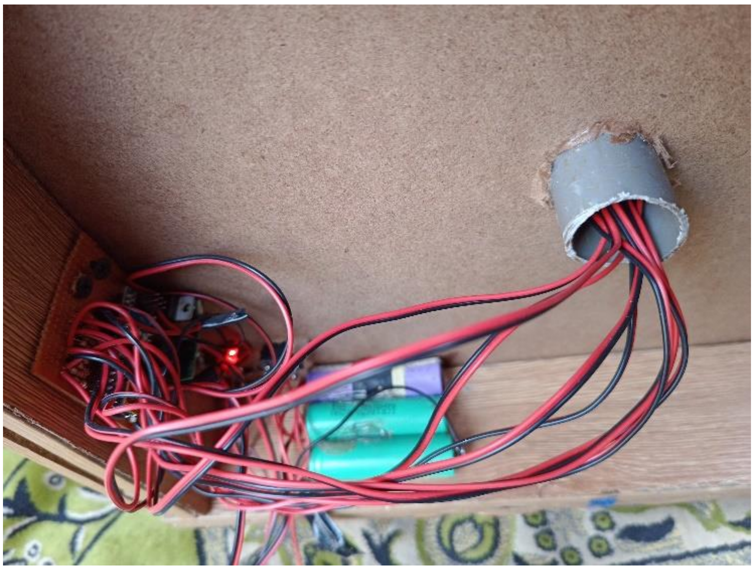

Fig. 3: Internal Circuitry of the Whole System

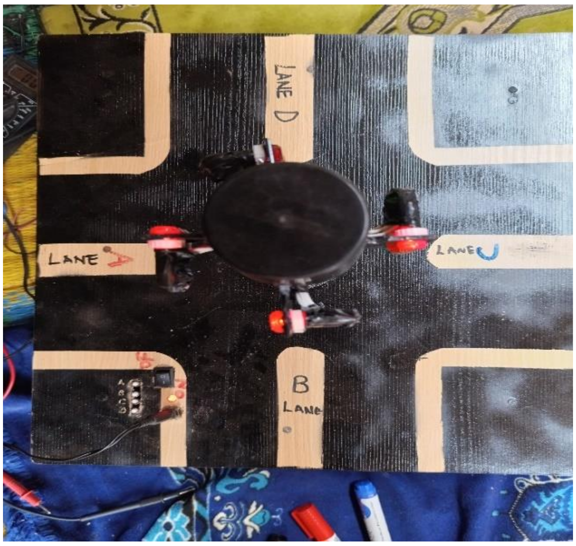

Fig. 4: Construction of the whole system

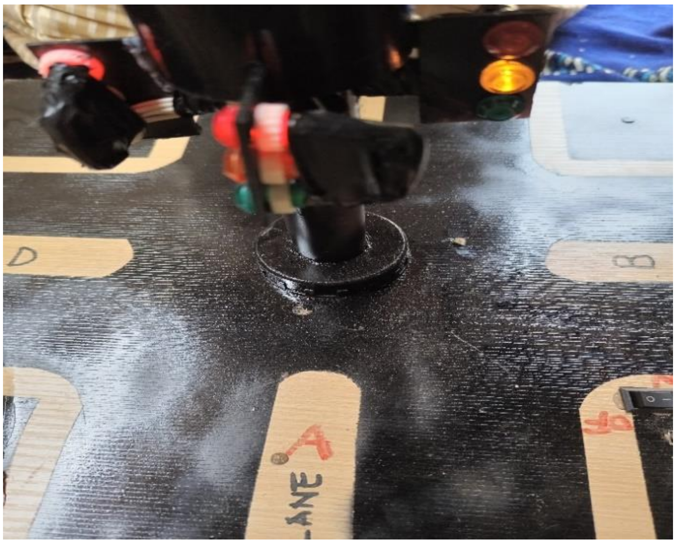

Fig.7: Lane A is showing ready to stop, which is yellow (L.E.D.)

Fig. 5: Charging point of the whole system

Fig. 8: Lane A is displaying red (L.E.D.), which is stop

Fig.6: Lane A is permitted to go, which is a green light

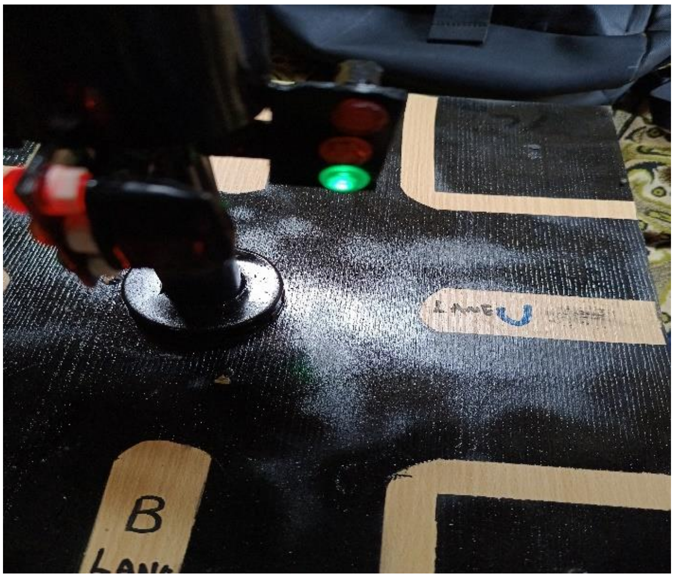

Fig.9: Lane B is displaying green, which means cars are passing

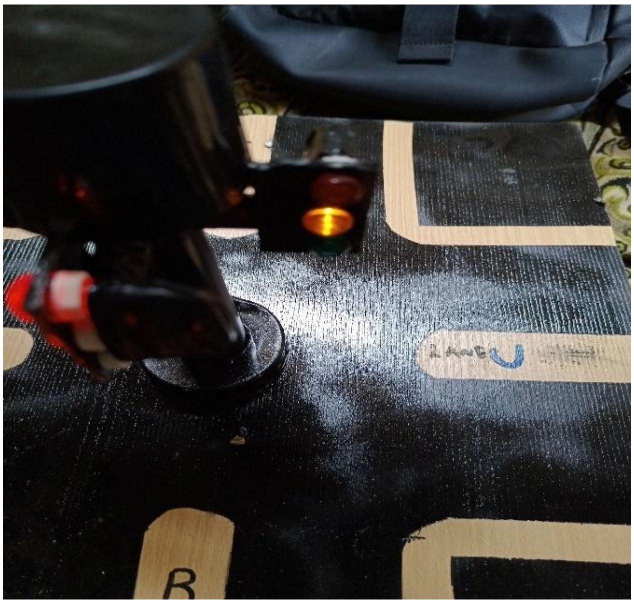

Fig. 10: Lane B is displaying yellow, which is ready to stop

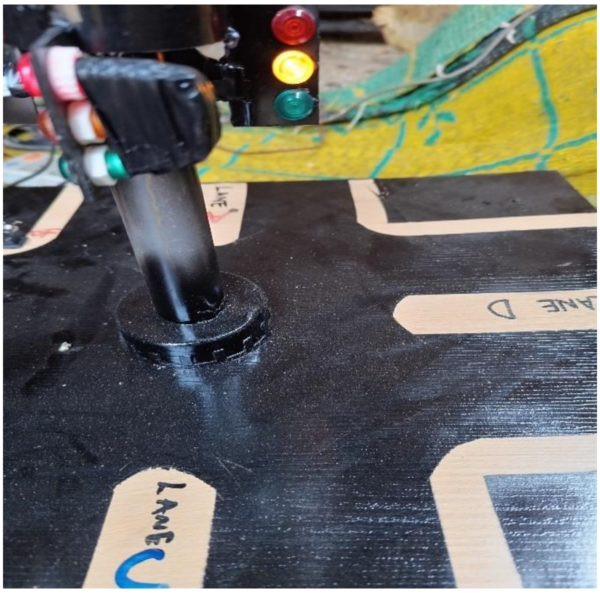

Fig. 13: Lane C is showing yellow

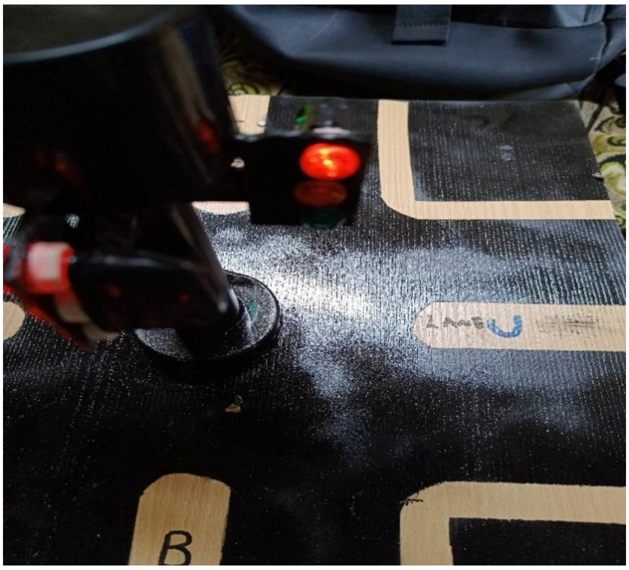

Fig. 11: Lane B is showing red (L.E.D.)

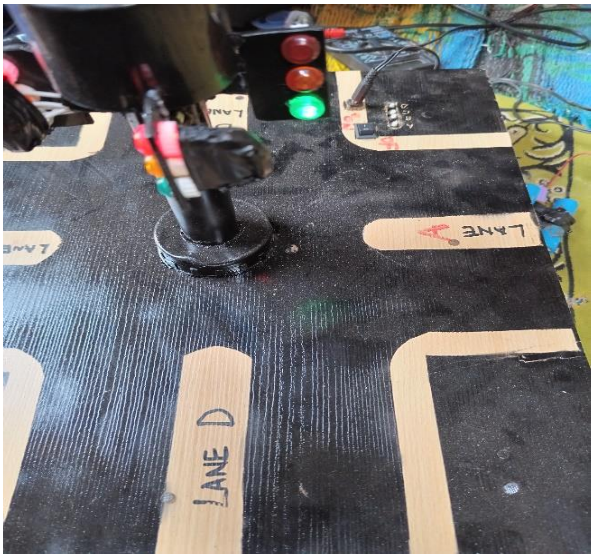

Fig. 14: Lane D is showing green (L.E.D.)

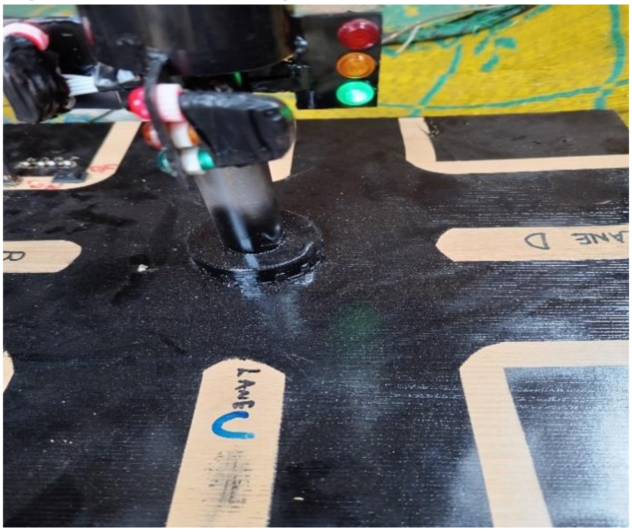

Fig. 12: Lane C is displaying green

Fig. 15: Lane D is displaying Ready to Stop, which is a yellow light-emitting diode

Fig. 16: Lane D is showing red (L.E.D.), which is stop vehicles

IV. CONCLUSION

For this research, a large number of articles were examined, and their technological innovations were noted. The simulation result for the system has been assessed and found to operate effectively; implementing the system will reduce traffic congestion and assist save lives [23]. The overall system's construction and the efficient operation of the four lanes have both been demonstrated in this study.

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