Smart Traffic Signal and Intelligent Street Light Management System based on the IoT

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***Abstract*— The use of vehicles has increased as the population has grown, and traffic control is one of the most difficult tasks. The frequent traffic congestion at important intersections needs the implementation of an effective traffic management system. These systems can eliminate the resulting waste of time and rise in pollution levels on a city-wide scale. We developed a real-time emergency vehicle detecting system in this study. If the RFID detects an emergency vehicle, that lane is given priority over all others. We're utilising an Arduino Uno, a weight sensor, an IR sensor, and an RFID chip, as well as Arduino Uno software. To discover a weight sensor or an IR sensor, image sequences are analysed using the threshold method. We're proposing a smart technology called the Smart Street Light System since India is one of the fastest-growing economies in the world. Even when there is electricity, the manual streetlight system shines brightest from twilight until dawn. To do this, the LDR sensor is employed. Depending on how strong the light is, we can switch a light on or off. Power for the system is changed by a relay after being supplied from the main supply. Every city requires an essential street lighting system. This is a smart control system that makes choices based on field data in real time.**

Keywords* — *Street Light; Arduino Uno; Sensors; RFID; LDR; Weight Sensor; IR.

I. INTRUDUCTION

A timer is used for each phase of a traffic signal in an obsolete automated traffic control system. Electronic sensors are another approach for recognizing cars and providing signals. However, under this system, a green light on an empty road wastes time. There was also traffic congestion while employing electrical sensors to manage traffic. The use of image processing is expected to eliminate all of these flaws. We propose a system that uses a weight sensor or an infrared sensor to control traffic lights. The technology detects automobiles by utilizing electrical sensors buried in the pavement. Along with the traffic light, a sensor will be installed. Image sequences will be captured. A weight sensor is a better way to regulate the traffic light's state change. It demonstrates how removing the time that would have been missed waiting for a green light on an empty route might reduce traffic and save time. It also calculates vehicle presence more precisely since it uses actual traffic photographs. It visualizes the practicality; thus, it performs far better than systems that rely on metal content detection in automobiles. For a number of reasons, image processing is a technique for refining raw photographs taken from cameras/sensors onboard space missions, aircraft, and satellites, as well as pictures captured in ordinary life. An image is a graphic object that is rectangular in shape. Image processing includes image representation, compression techniques, and a wide range of complex operations on image data. Sharpening, blurring, brightness, edge enhancement, and other image enhancement procedures fall under the category of image processing. Any sort of signal processing that takes an image as input, such as photos or video frames, and outputs an image or a set of image-related properties or parameters is known as image processing. The bulk of image processing algorithms treat the image as a two-dimensional signal that is processed using standard signal processing techniques. Although digital image processing is the most common, optical and analogue image processing is also feasible. The Internet of Things' potential has grown as a result of the integration of numerous advancements, real-time evaluation, AI, object sensors, and installed frameworks with systems. The Internet of Things is made up of new structures, remote sensor frameworks, control systems, automation, and other sectors. IoT uses a variety of progressions and displays to interact with devices depending on their needs.

II. LITERATURE REVIEW

A calculation was also made with the goal of allowing the most vehicles to pass in the shortest amount of time possible. High priority vehicles such as ambulances, fire engines, and VIPs are given more priority than regular traffic via IR sensors, which read each RFID tag that passes in front of them and classify them based on the priority system by which the cars are registered in the traffic database [1]. In a traffic jam, the IR sensors are crucial because they determine the traffic density between the first and last sensors and compare it to nearby streets. The green light turns on automatically if the traffic density in a roadway exceeds the previous level, giving the gridlock area priority [2]. The optimization approach is also used to provide precedence to the most congested direction in order to control traffic [4].

III. PROBLEM STATEMENT

It is vital to effectively control traffic flow by fully utilizing the road's existing capacity. Traffic congestion is causing a lot of problems in modern cities. The number of cars on the road increases in tandem with the population, causing traffic congestion. Congestion and traffic delays generate a number of issues, including wasted time and unnecessary fuel use.

Aside from that, it has a direct impact on everyday life and can even lead to death. For example, in an emergency, an ambulance transporting a critical patient may be unable to arrive at the destination hospital on time due to traffic congestion, where every second counts.

IV. OBJECTIVES OF THE PROJECT

By abandoning a road with a larger number of automobiles, the main goal is to decrease future traffic jams created by traffic signals to some extent. As a consequence, the number of cars in the waiting stage will be reduced, saving time. It will also aid in the clearance of the route for emergency vehicles (fire department, ambulance, VIP vehicles, etc.). The primary purpose of this paper is to illustrate how to design a basic traffic light controller.

V. SYSTEM DESCRIPTION

A. THE TRAFFIC LIGHT CONTROLLER'S LOGIC

In response to low and high sensor signals, the traffic light controller must turn lights on and off. Unless a driver is intending to turn left or straight ahead on the crossing street, the straight lights on the major highway are always green. The main street's straight lights will become yellow after 40 seconds, then red, and the straight lights at each intersection will change to green. All other lights will remain red. After forty seconds, the light on the main street will turn green, but the light on the fascinating street will go from green to yellow and then red. In other words, the reasoning is the same. Before translating this explanation into code, it was necessary and helpful to create a state diagram defining each situation for the traffic light controller. The general logic of the controller is shown in the state diagram below. Only the West Green Straight (WGST) and East Green Straight (EGST) are lit up green.

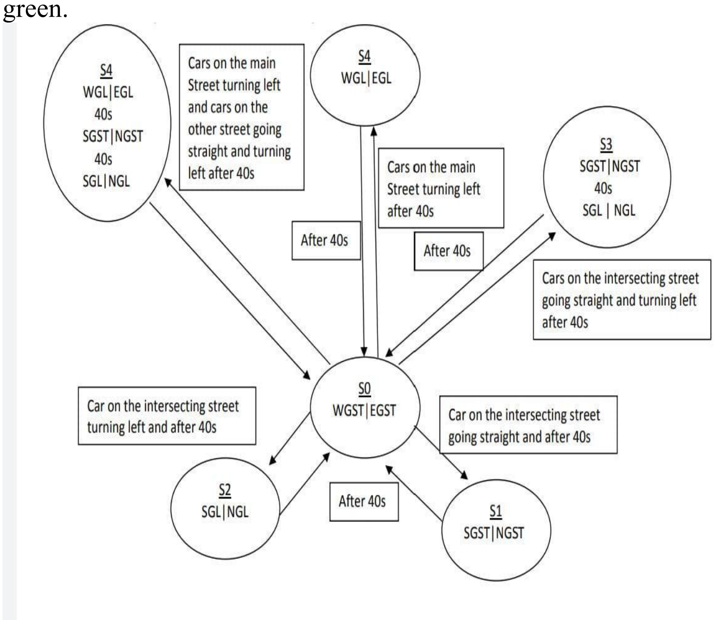

Fig 1: General logic controller state diagram

The only lights that are visible in this state diagram are the green ones; all other lights are red. Each state also contains substrates that control the duration of the transition. When a car stops in a straight lane on an intersecting road, the sensor turns on and the clock starts ticking. Once 40 has been reached, the status changes to S1, and the main street lights turn red while the crossing street lights turn green. South Green Straight (SGST) and North Green Straight (NGST) are the symbols for these on the state diagram. The only lights that are visible in this state diagram are the green ones; all other lights are red. Each state also contains substrates that control the duration of the transition. When a car stops in a straight lane on an intersecting road, the sensor turns on and the clock starts ticking. Once 40 has been reached, the status changes to S1, and the main street lights turn red while the crossing street lights turn green. South Green Straight (SGST) and North Green Straight (NGST) are the symbols for these on the state diagram.

B. DESIGN PROCEDURE

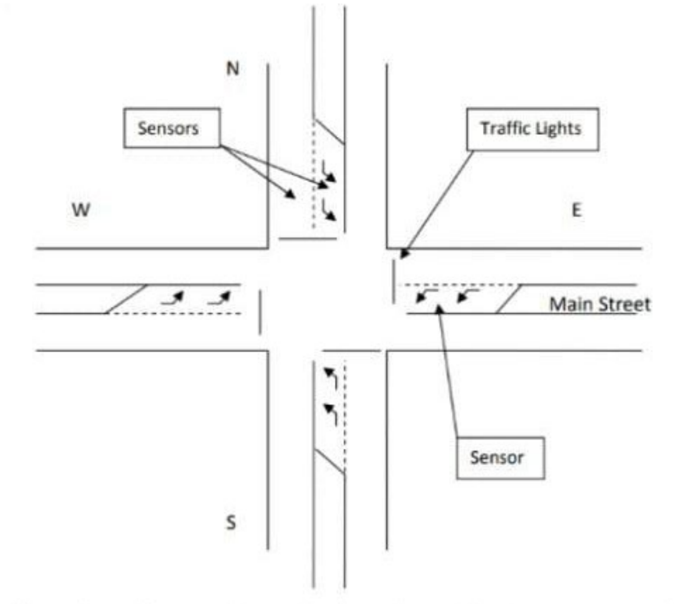

Fig 2: A traffic light controller's schematic diagram

The graphic above illustrates that, it was planned to construct an eight-light junction traffic light controller. At the crossroads, each street's single lane divides into two lanes: one for turning left and only one for going left, and the other for turning right or continuing straight. One of the streets is a main roadway, thus until a car travel along the main street or crosses over to the left-only lane, the lights to proceed straight are always green. A main street intersection has two sensors, one on each side. The lights are controlled by two sensors, one for a left turn and one for a right turn, in addition to a left turn sensor on the main street for each direction. Each street therefore has eight traffic lights, four of which are for left turns in both directions, and six sensors to control them.

VI. HARDWARE DESCRIPTION AND DESIGN

The client is at the board station, much like the Master Node, which serves as the governing mechanism for outlying gadget organizations, according to theoretical investigation. The customer should keep in mind a distant gadget arrangement-based application that is functional. The client must supply the proper system configuration parameters for an IOT-based application. The manual streetlight system glows fully from twilight to dawn even when power is present. The energy that is saved may be applied to a range of applications, including residential, commercial, and industrial ones. This is accomplished using the LDR sensor. Depending on the brightness of the light, we may turn a light on or off. The system's power source is the main supply, which is transformed via a relay. Every city needs a system of street lighting. Everything is becoming automated as the world drastically changes. This intelligent control system bases its judgements on accurate real-time field data.

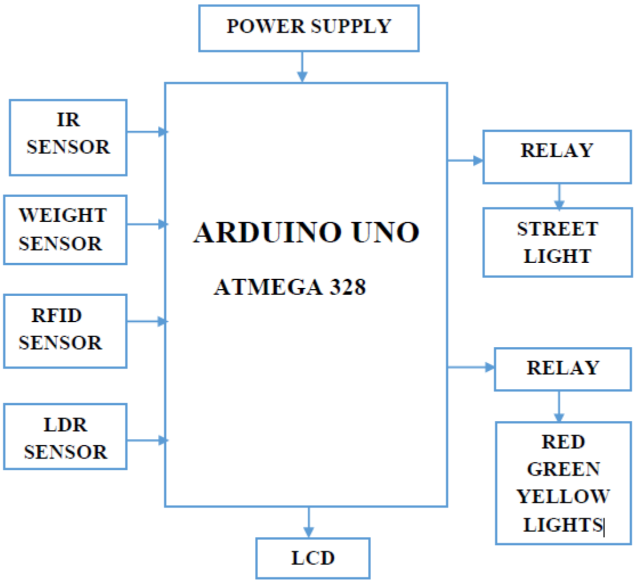

Fig 3: The suggested system's block diagram.

The intention was to build an eight-light junction traffic light controller. Each street has a single lane, which divides into two lanes at the intersection: one for turning left and only one for going left, and the other for straight-ahead driving or turning right. One of the streets is a main roadway, thus until a car travel on the main street or until cars on the intersecting street arrive on the left, the lights to proceed straight are always green. The reasoning behind the traffic signal controller is simple. Simply turning lights on and off in response to low and high sensor inputs will do. Unless a driver is intending to turn left or straight ahead on the crossing street, the straight lights on the major highway are always green. Straight lights on the main street turn yellow, then red after forty seconds, then the straight lights for each direction on the intersecting street change to green while all other lights remain red when a car goes straight across the crossing street. After 40 seconds have passed after the crossing street's straight light changed from green to yellow to red, the light on the main street will turn green. Or, to put it another way, the same premise holds true.

A. ARDUINO UNO

For students without any prior experience with electronics or programming, Arduino was created at the Ivrea Interaction Design Institute as a basic tool for fast prototyping. The Arduino board started to evolve to meet new demands and difficulties as soon as it attracted a larger audience, expanding its product range from straightforward 8-bit boards to IoT, wearable, 3D printing, and embedded contexts.

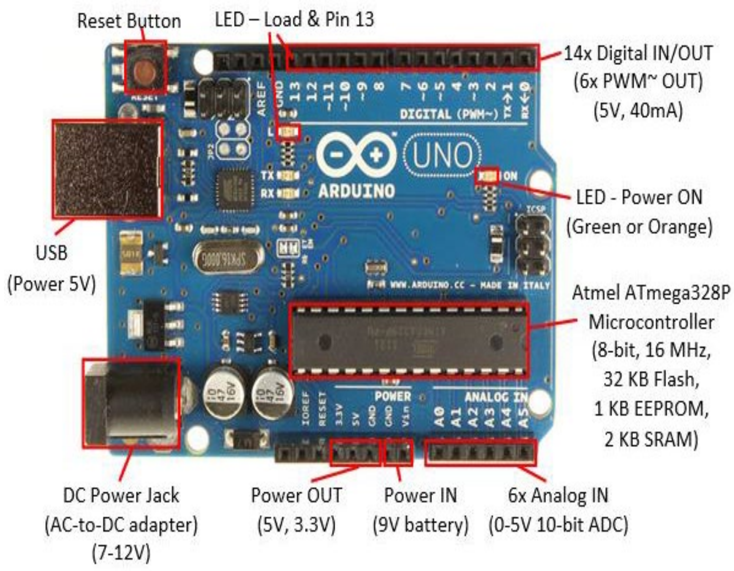

Fig 4: Arduino Uno board

Since every Arduino board is open-source, users may customize and construct them to their own requirements. The program is open-source as well, and as a consequence of contributions from all across the world, it is continually getting better.

B. CHANNEL RELAY

This board has two low-level 5V relay channels with a 15-20mA driver current for each channel. It can run a variety of high-current devices and equipment. There are other high-current relays with AC250V 10A or DC30V 10A. It has a common interface that a microcontroller may use to access it directly. For safety, when linked to a microcontroller, this module is optically segregated from the high voltage side and eliminates ground loop.

C. WEIGHT SENSOR

To read load cells for weight measurement, a straightforward breakout board known as the Load Cell Amplifier and ADC Module is used. When you attach the module to your microcontroller and perform some basic calibration, you can read fluctuations in the load cell's resistance and obtain quite accurate weight measurements.

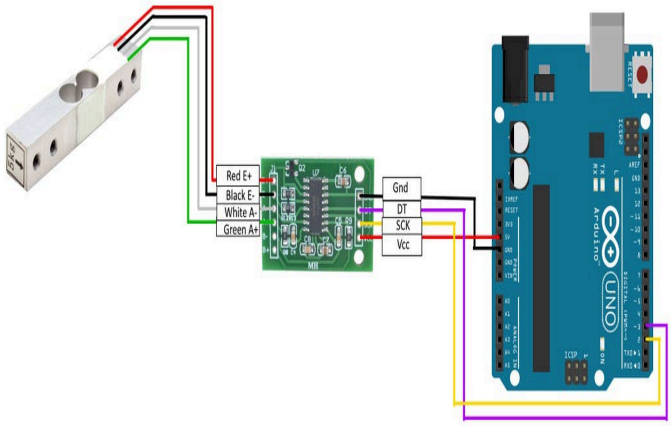

Fig 5: 24-bit ADC for load cell sensor

This is handy for constructing your own industrial scale, controlling processes, and detecting basic presence. The HX711 communicates through a two-wire interface (Clock and Data). Any microcontroller with GPIO ports should work, and there are various libraries available to make reading data from the HX711 simple. For further details, see the hook-up guide below. A four-wire Wheatstone bridge connects the HX711 to the load cells. The most common colors are RED, BLK, WHT, GRN, and YLW. Each color corresponds to the standard color labeling of the load cell.

- Red (VCC or Excitation+)
- Black (GND or Excitation-)
- White (Output+, Amplifier+ or Signal+)
- Green (O-, A- or S-)
- Yellow (Shield)

D. LDR SENSOR

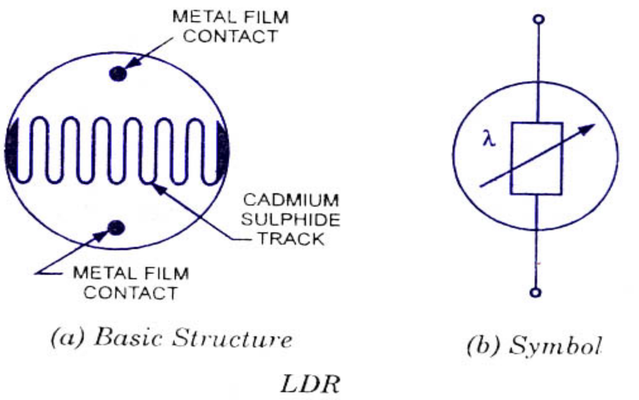

Fig 6: LDR Sensor Structure

A Light Dependent Resistor (LDR) is also known as a Photoresistor or a Cadmium Sulphide (CdS) cell. Another term for it is a photoconductor. It is only a photocell that operates according to the theory of photoconductivity. The passive element is simply a resistor with a resistance that decreases as the light intensity increases. This optoelectronic component is frequently used in switching circuits that are actuated by light and dark as well as sensor circuits that change sensitivity to light. Its applications include camera light meters, street lights, clock radios, light beam alarms, reflecting smoke alarms, and outdoor clocks. A CdS film that resembles a snake and goes through the sides is present below. Metal films are attached to terminal leads on the top and bottom. It is designed to make as much contact with the two metal films as is practical. The structure is covered in a transparent plastic or resin casing that allows unrestricted access to outside light. The most crucial element in the creation of LDR is CdS, a photoconductor that when unlit has no or few electrons. It is constructed with a high resistance in the mega-ohm range when there is no light. The conductivity of the material increases as light strikes the sensor, releasing electrons. Photons that are absorbed by the semiconductor when the light intensity exceeds a specific frequency are what provide band electrons the energy, they need to leap into the conduction band. As a result, the conductivity of the free electrons or holes lowers resistance (to 1 Kilo ohm) significantly.

E. RED GREEN YELLOW LED TRAFFIC SIGNAL MODULE

The new traffic signal lights use Light Emitting Diodes instead of incandescent halogen lamps (LED). Individual LEDs are little electrical lights that are created by putting electricity into a semiconductor chip and reflector within a small colored lens or outer shell. A colored filter, on the other hand, controls the color of an incandescent traffic light. While the filter is inexpensive to produce, it is a very inefficient way of traffic signal lighting. The red filter on a conventional incandescent signal bulb, for example, blocks 80% of the light and wastes energy. Conflicting traffic flows are controlled by signaling devices such stoplights, road traffic lamps, traffic signals, and stop-and-go lights at road crossings, common pedestrian crossings, and other locations. There are traffic lights in many cities all around the world.

F. RFID

RFID refers to a group of technologies that utilize radio waves to automatically identify persons or things at distances ranging from a few inches to hundreds of feet. This is an automated identification (Auto-ID) system that automatically recognizes any object. Barcodes, magnetic stripes, IC cards, optical character recognition (OCR), voice recognition, fingerprints, and optical strips are examples of identification technologies. RFID technology uses a self-contained data collection method that boosts system efficiency. For identification, a tag and reader combination are employed. An RFID tag is a code-encoded tag that is attached to a physical object. The object now has a unique personality. The code from the tag is then sent by the object. This provides information about the item to the reader. Although RFID is not a new technology, it is being applied in unique ways. RFID is a rapidly advancing technology. RFID has a number of advantages over traditional identifying methods such as barcodes. In order to read the label, the barcode scanner must be in direct line of sight. This implies that the items or scanner must be moved manually. RFID, on the other hand, does not require a direct line of sight to read data from a tag. Alignment is also unnecessary with RFID technology. A quick review of RFID technology is provided by Singh et al. RFID operates in the presence of a barrier and has a quick reading speed. This technology is more effective when a greater read range, rapid scanning, and flexible data carrying capabilities are required.

G. STREET LIGHT MODULE

The use of an LDR sensor as a switch in automatic street lighting is a simple but successful concept. With this method, we can fully remove manual labour. When the sun drops below the human eye's visible zone, the lights automatically switch on. A Light Dependent Resistor (LDR), a sensor that detects light in the same way as human eyes do, is used to do this. When the sensor senses sunlight, the lights are turned off immediately. This approach saves energy since manually controlled street lights are not turned off until the sun rises, and they are also switched on earlier before nightfall. This paper does not require manual operation, such as adjusting the ON and OFF times.

The functioning of a transistor in the saturation and cut-off regimes is demonstrated in this study. The relay's functionality is well-known. This initiative's implementation promotes digital work. To transform light energy into electrical energy, a light-dependent resistor, also known as a photoconductive device, was employed as the transducer. The essential principle behind the circuit is that when the voltage drop across the light dependent resistor varies due to lighting or darkness, the transistor is switched between the cut-off and saturation zones, and the LED is turned on or off.

VII. SOFTWARE REQUIRMENT

Arduino IDE has been installed on the PC. In addition to a few other functions, the IDE includes a compiler. The Arduino language seems similar to C++ on the surface. Through the use of the IDE, the program is written, constructed, and uploaded to the board. The language can be understood easily. The communication port that the Arduino board is attached to, along with a variety of Arduino boards with different controllers, are both selectable in the IDE. Real-time analytics, machine learning, pervasive computing, inexpensive sensors, and embedded systems have all helped the internet of things grow.

VIII. EXPERIMENTAL RESULTS

To ease excessive traffic and congestion on the road, we propose using a load cell-based traffic redirection system.

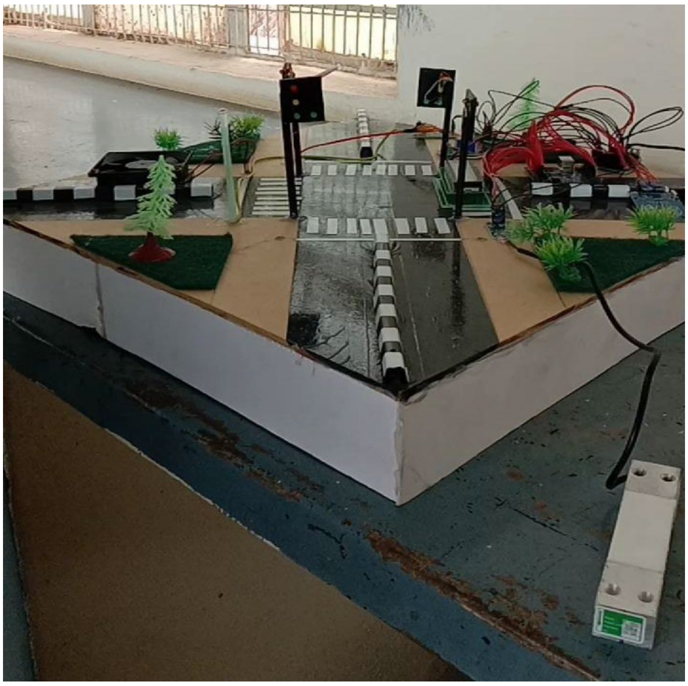

Fig 7: Load cell operation

Weight sensing would be used, with the output being transmitted to a load cell, which would control the traffic diversion. We will use the weight data on the road in this system to see which route has the most vehicles utilizing load cells, because the more vehicles on the road, the more congestion there will be. This weight information will be supplied to an Arduino board, which will compare it on each front and allow the route with the most vehicles to pass through. A weight sensor is installed beneath the traffic circle. It detects the weight and transmits a signal to the load cell. When data arrives at the Arduino Uno board, it compares the data on the basis of weight with all other data arriving from other outs. The path with the highest weight will be checked by the load cell. The load cell will now operate in accordance with this conclusion, stopping all routes save the one with the highest weighted data.

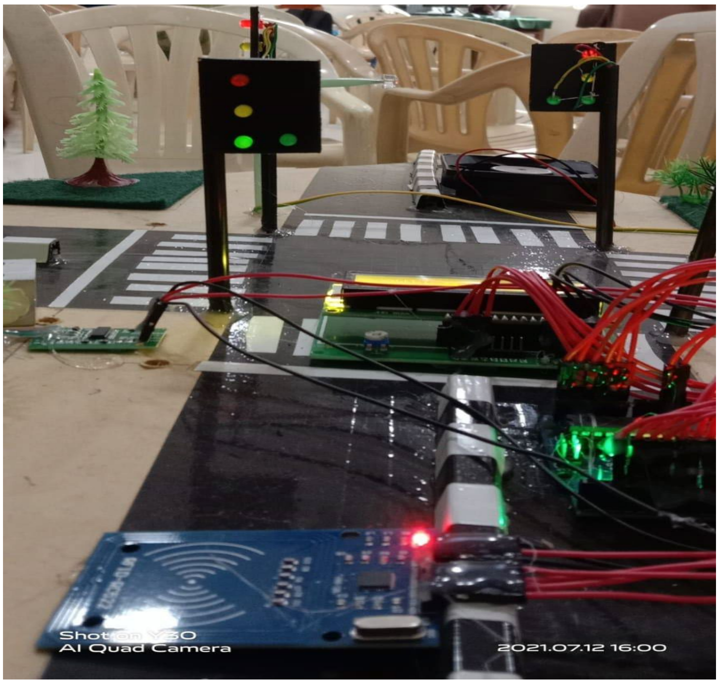

Fig 8: RFID's operation

The emergency vehicles are identified by the RF system, which transmits a message to the microcontroller. The microcontroller activates the green light for the emergency vehicle after receiving the message.

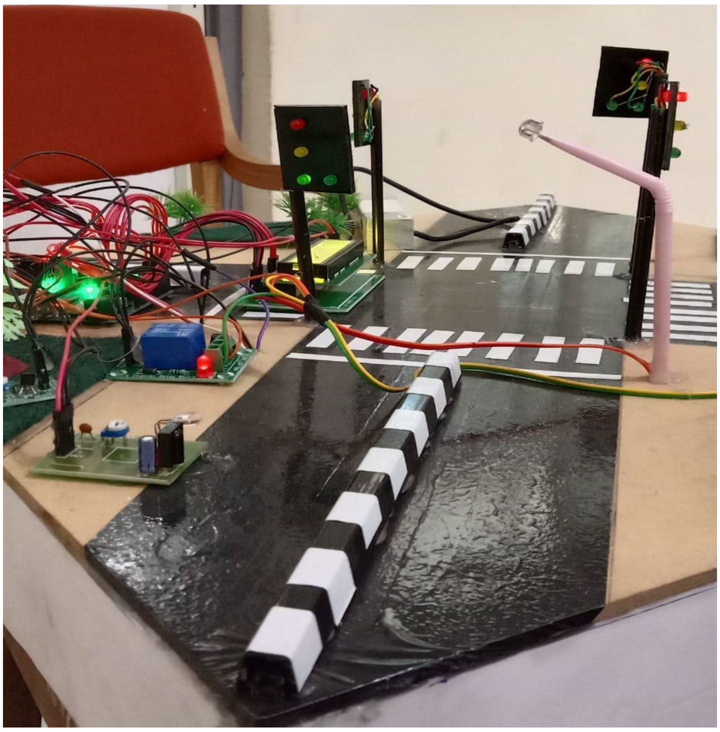

Fig 9: The IR Sensor in Action

To operate the traffic management system, an Arduino UNO microcontroller is employed. At each traffic signal along the crossing path, it is placed to maintain time. Traffic Light 1, Traffic Light 2, Traffic Light 3, and Traffic Light 4 each have three LED lights—green, yellow, and red—and IR sensors that are placed 100 meters apart. Based on the volume of traffic at each traffic signal, the Arduino UNO will produce a unique interval for the timing of the traffic lights. There is a three-second timer in each vehicle. On the basis of the number of cars passing through the intersection, expected delays are determined.

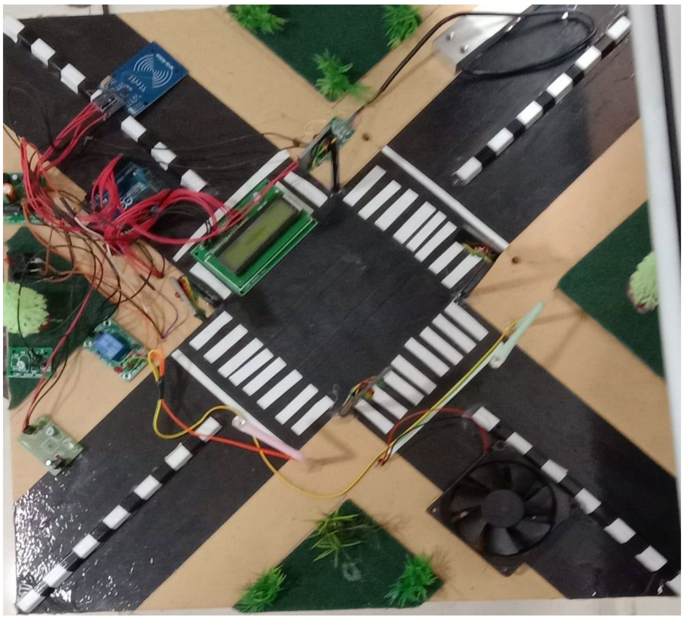

Fig 10: The Street Light Module in Action

This approach saves energy since manually controlled street lights are not turned off even when the sun comes out, and they are also switched on earlier before dark. This paper does not require manual operations such as ON/OFF time setting.

IX. CONCLUSION

Traffic congestion has come from the significant increase in the number of cars on the road. The method described above for detecting vehicle density and processing the time of a traffic light can be used to regulate traffic, avoid traffic congestion, and prevent accidents, among other things. This method might be used at each junction to help individuals continue their trip. The signals will also be monitored, and the traffic signal state will be updated on the server. This will come in handy in the future. We can now use this method to monitor the number plate (registration number) of the car to discover vehicles who contravene traffic laws because we are simply monitoring the number of vehicles present at the signal. We can also keep an eye on traffic at night because no patrol officers are needed and the vehicles can move freely.

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