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MODELING AND SUPERVISION OF SMART TRAFFIC LIGHT CONTROLLER USING AT89C51 MICROCONTROLLER

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Abstract

Traffic light control systems are widely used to monitor and control the flow of vehicles through the junction of many roads. They aim to realise smooth motion of cars in the transportation routes. However, the synchronisation of multiple traffic light systems at adjacent intersections is a complicated problem given the various parameters involved. Conventional systems do not handle variable flows approaching the junctions. In addition, the mutual interference between adjacent traffic light systems, the disparity of cars flow with time, the accidents, the passage of emergency vehicles, and the pedestrian crossing are not implemented in the existing traffic system. This leads to traffic jam and congestion. We propose a system based on AT89C51 microcontroller that evaluates the traffic density using IR sensors and accomplishes dynamic timing slots with different levels.

Index Terms: Traffic light system, microcontroller, IR sensor, traffic density

I. INTRODUCTION

Traffic lights, developed since 1912, are signalling devices that are conceived to control the traffic flows at road intersections, pedestrian crossings, rail trains, and other locations. Traffic lights consist of three universal-coloured lights: the green light allows traffic to proceed in the indicated direction, the yellow light warns vehicles to prepare for shortstop, and the red signal prohibits any traffic from proceeding.

Many countries suffer from the traffic congestion problems that affect the transportation system in cities and cause serious dilemmas. This is mainly due to the rapid increase of the number of automobiles and the constant rising number of road users. In spite of replacing traffic officers and flagmen by automatic traffic systems, the optimization of the heavy traffic jam is still a major issue to be faced, especially with multiple junction nodes. Partial solutions that are being offered are constructing new roads, implementing flyovers and bypass roads, creating rings, and performing roads rehabilitation.

However, there are a diverse number of parameters to be considered in the attempt to solve the current traffic problems. Firstly, the traffic flow depends on the time of the day where the traffic peak hours are generally in the morning and in the afternoon; on the days of the week where weekends reveal minimum load while Mondays and Fridays generally show dense traffic oriented from cities to their outskirts and in reverse direction respectively; and time of the year as holidays and summer. Secondly, the current traffic light system is implemented with hard coded delays where the lights' transition time slots are fixed regularly and do not depend on real time traffic flow. Also, the state of one light at an intersection influences the flow of traffic at adjacent intersections.

The conventional traffic system needs to be upgraded to solve the severe traffic congestion, alleviate transportation troubles, reduce traffic volume and waiting time, minimise overall travel time, optimise cars safety and efficiency, and expand the benefits in health, economic, and environmental sectors. This paper proposes a simple, low-cost, and real time smart traffic light control system that aims to improve traffic management. The system is based on an AT89C51 microcontroller that monitors the traffic volume and density flow via infrared sensors (IR) and changes the lighting transition slots accordingly.

II. LITERATURE REVIEW

There are many problems with congestion with traffic lights in many cities. This problem of congestion can be caused by long delays at traffic light's red light. When there is an emergency at traffic light intersections which are always busy with many vehicles, this problem can also be caused. A modern traffic light system implemented with microcontrollers could help develop traffic light flow and safety of the current transportation [1]. The system containing an IR transmitter and receiver which can be mounted on either side of roads is considered. The IR system gets activated whenever any vehicle passes on road between IR transmitter and IR receiver. Modern traffic systems implemented with microcontrollers could help develop traffic light flow and safety of the current transportation. Microcontroller controls the IR system and counts the number of vehicles passing on the road. Based on different vehicle counts, the microcontroller can make decisions and update the traffic light delays as a result.[2] An Intelligent Traffic Light Controller could be implemented to make the use of Sensor Networks along with Embedded Technology. The timings of red and green lights at each crossing of road will be intelligently decided based on the total traffic on all adjacent roads. Thus, optimization of traffic light switching increases road capacity and traffic flow, and can prevent traffic congestions. GSM cell phone interface is also provided for users who wish to obtain the latest position of traffic on congested roads in [3]. In [4], traffic is sensed using digital IR Sensors and IR Sensors detect vehicles further based on the signal reflected from them. Sensors placed adjacent to the road to control the traffic density by changing traffic signals appropriately. All IR Sensors are interfaced with Arduino Uno and it reads data from IR Sensors. Traffic Signals for the system are designed using LEDs and each signal consists of two LEDs for each lane. It will also provide a perfect opportunity to install monitoring equipment to collect much more detailed traffic and journey data than we have now. In order to address the problem of traffic congestion in

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cities, the paper [5] offers a framework for a dynamic and autonomous traffic signal control system. Using observed car arrival and departure times at crossings in areas, the authors created a simulation model. The model shows the possibility to alleviate traffic congestion in a big metropolis by adjusting light time and speed restriction. In order to measure traffic congestion on various roads at an intersection and cut wait times on key roads, the study [6] offers a foreground extraction model created in MATLAB. The system was tested in various weather and illumination scenarios for obtaining results. The paper [7] proposes the use of image processing techniques, specifically the Canny Edge Detection Technique, for smart traffic light control to improve pedestrian crossing experience and reduce waiting time at zebra crossings. This research [8] suggests a rule-based expert system called Traffic Lights Expert System (TLES) that manages traffic lights and keeps track of intersection congestion levels using dynamic cycle timings and hardware design using Arduino and Infrared Radiation (IR) sensors. This study describes an autonomous traffic signal system intended to improve urban regions' traffic flow efficiency. It addresses the development of a smart traffic light system and proposes the idea of adaptive traffic signal timing depending on current vehicle counts. The IoT-based system was first designed with a Raspberry Pi and PIR sensors [9]. In this paper [10], a traffic light controller electronic circuit with centralised control architecture and wireless network communication capabilities is studied and developed. Practical system control and monitoring tests were used to evaluate all of the designed circuit's properties. The electronic circuit ultimately showed promise for use in smart city applications. By analysing images captured by the long-range digital cameras that are based on fog computing and deployed at the intersection, the suggested adaptive system [11] assesses the level of traffic congestion and prioritises the flow of traffic accordingly. RFID and sensor networks can also be used to count the number of automobiles. In comparison to conventional approaches, analytical derivation and simulation show that STL offers an effective solution and improvement for managing traffic at intersections. This system uses radio frequency (RF) communication to respond to signals from emergency vehicles and uses an Arduino microcontroller to reset the traffic light sequence before the emergency mode is engaged. This invention [12] lessens collisions at crowded crossroads where drivers must make room for emergency vehicles. The research effectively illustrates the usage of 434 MHz RF transmission for emergency vehicle traffic signal control. In order to solve the problem of traffic congestion, [13] a smart traffic signal system based on fuzzy logic is presented in this work. The ATMega2560-based system uses light, infrared, and ultrasonic sensors to identify traffic congestion and improve traffic flow. A green signal is activated when a queue of cars approaches these sensors, easing traffic at intersections. [14] Increased data gathering and vehicle detection accuracy come from using many sensors per lane. For low-power, economical, and secure bi-directional communication within a 15-kilometre range, LoRaWAN technology is used. Tests validate the signal range. Grafana displays the level of congestion for each lane in order to calculate the algorithm. The focus is on congested metropolitan regions. The project [15] uses GSM and IR to regulate traffic signal operation, optimising lane scheduling to reduce congestion, with the goal of enhancing emergency response times. A four-lane traffic light

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junction with GSM (Global System for Mobile Communications) connectivity is part of the hardware, and an Arduino UNO controls it all. The second section is comparable but uses an IR (infrared remote) instead of GSM.

III. BACKGROUND

A. CIRCUIT COMPONENTS

1) AT8951 Microcontroller

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost-effective solution to many embedded control applications. It works with the popular 8051 microcontroller architecture. The 8051 series of microcontrollers are highly integrated single chip microcomputers with 8-bit CPU, memory, interrupt controller, timers, Serial I/O and digital I/O on a single piece of silicon. Its memory is organized in bytes and practically all its instructions deal with byte quantities. It uses an accumulator as the primary register for instruction results. Other operands can be accessed using one of the four different addressing modes available: register, implicit, direct, indirect or immediate. The five memory spaces of the 8051 are: Program memory, External data memory, Internal data memory, Special Function registers and Bit memory. The AT89C51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, a five-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

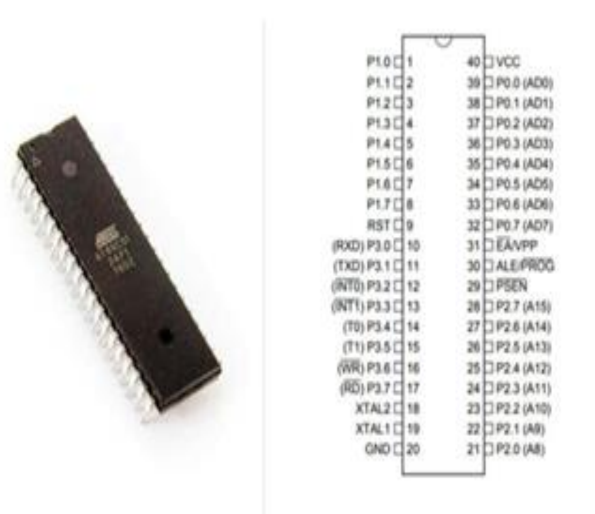

Fig 1: AT89C51 microcontroller and pin configuration

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2) IR Sensor

An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. The IR sensor emits or receives the infrared radiations (430 THz – 300 GHz) that are invisible for the human eye. The LED (Light Emitting Diode) may act as an IR emitter while the IR detector is a photodiode component which is sensitive to IR light having the same frequency as the emitted radiation. The concept of operation is simple: when IR radiation of the LED reaches the photodiode, the output voltages change according to the magnitude of the IR light.

Fig 2: IR Sensor

3) LED (Light Emitting Diode)

A Light-emitting diode (LED) is a semiconductor light source. The color of the light is determined by the energy gap of the semiconductor.

4) Connecting Wires

5) Breadboard

B. SOFTWARE USED

Proteus software was used for the circuit simulation.

C. BLOCK DIAGRAM

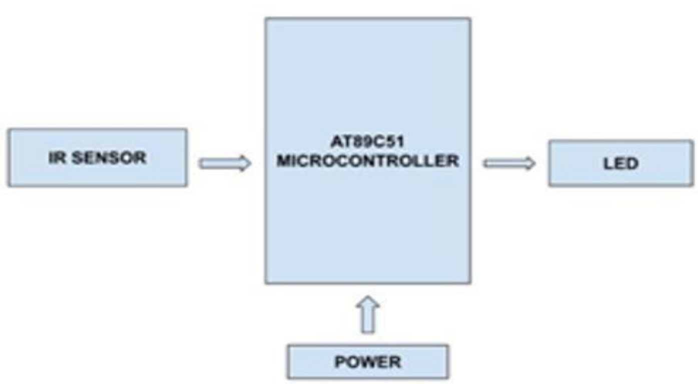

Fig 3: block diagram of the circuit

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IV. METHODOLOGY

Density based traffic controller system with pedestrian crossing:

IR sensors are used to detect traffic volume. Based on this information, the time dedicated for the green light will be extended to allow large flow of cars in case of traffic jams, or reduced to prevent unnecessary waiting time when no cars are present at the opposite route. In the simulation, switches are used instead of IR sensors. All the sensors are interfaced to the microcontroller. Based on the sensor output, the controller detects the traffic and the traffic system is automated. The Traffic lights are interfaced to the Port 0 and Port 1 of the microcontroller.

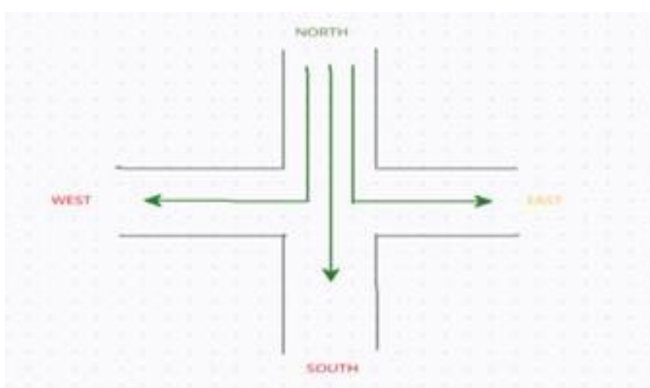
If the switches are closed, it is equivalent to the IR sensor being high and that particular side is having huge traffic which is to be cleared off first. When no switch is closed, it means traffic levels on all sides are normal and so, the count starts from 19. If any of the switches is closed, the green light on that side will be turned on first and for a longer time since congestion is observed. In this case the timer count starts from 29. Similarly, when there is flow of traffic from any lane, the red signal will be passed to stop the pedestrian crossing.

Since this is density based, if there is traffic congestion detected on any lane, the red light for the pedestrian crossing will be on until the traffic is cleared in that particular direction. When vehicle lanes are stopped by a red signal for Vehicle traffic, a green signal can be given to the lanes for pedestrian crossing.

Flow of traffic:

The traffic flow can be classified into four phases considering the direction 'North' as the starting point of this traffic flow.

Phase 1:



Initially, vehicles in the NORTH lane need to travel in the direction of other lanes. In the first Phase, green signal is given to NORTH lane and yellow signal is given to the WEST lane. EAST and SOUTH lanes are stopped by red signal. Further when pedestrian crossing is included, it is stopped by red signal on all lanes.

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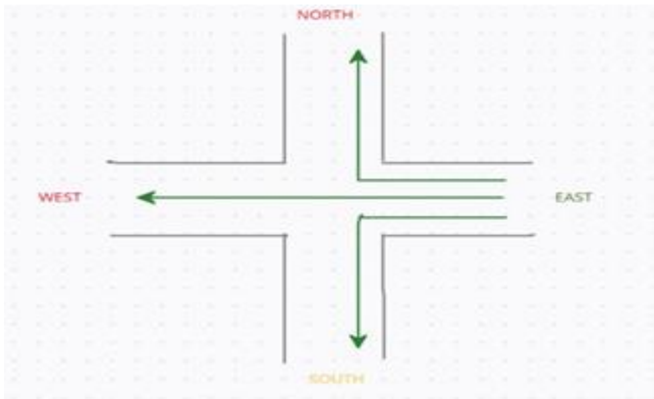
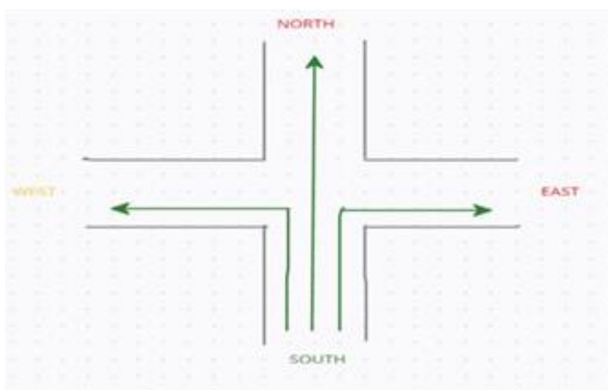
Phase 2:



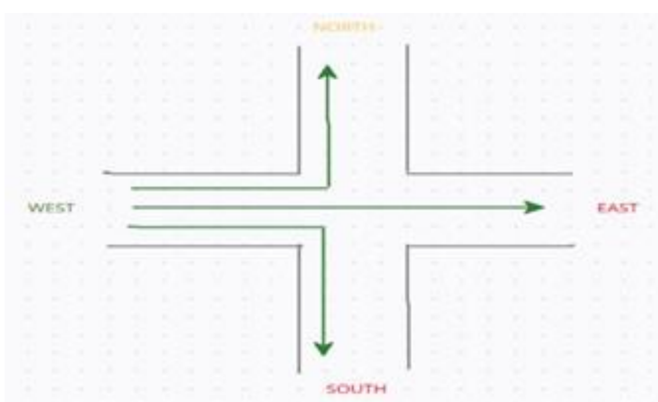
Phase 2 permits the vehicle to pass from the EAST lane. Traffic flow from the rest of the two lanes NORTH and WEST is stopped by means of red signal. Yellow signal is given to the SOUTH lane.

Phase 3:



Phase 3 permits traffic flows from SOUTH lane. Traffic flow in EAST and NORTH are stopped by means of red signal. WEST lane is given the yellow signal.

Phase 4:



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Phase 4 permits traffic flow from the WEST lane. Traffic flow in the EAST and SOUTH are stopped by means of red signal. Yellow signal is given to the North Lane.

V. CIRCUIT SIMULATION

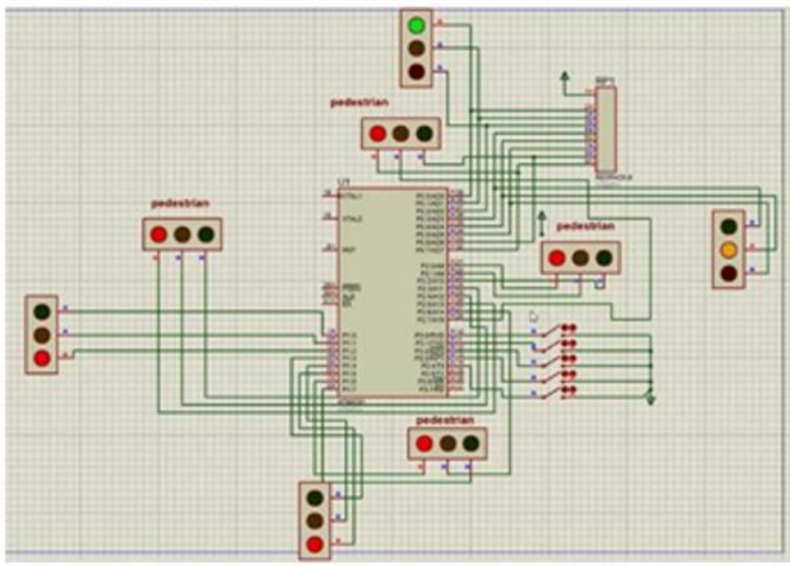

Fig 4: Circuit simulation on Proteus.

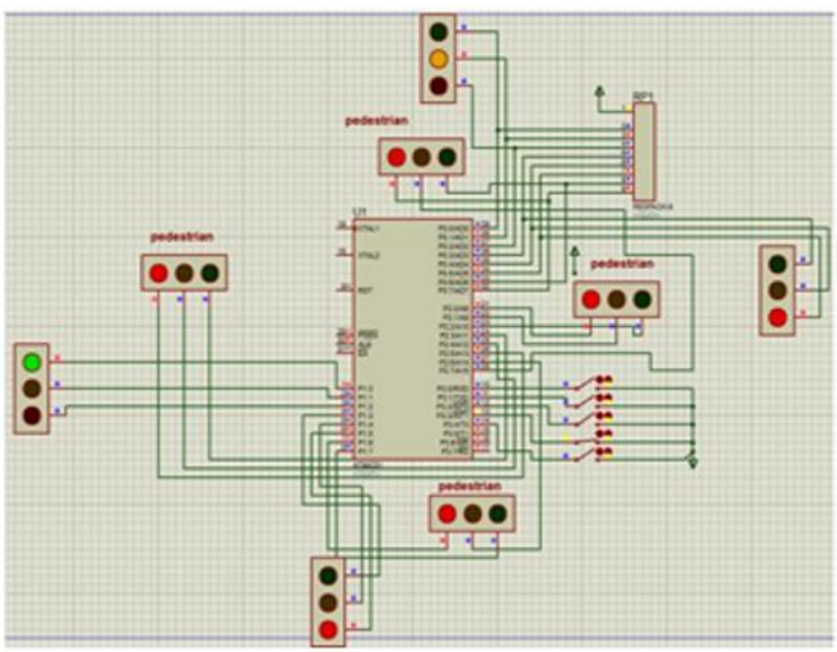

Fig 5: Circuit simulation on Proteus.

Switch 1- Traffic lights on the top (North)

Switch 2- Traffic lights on the right (East)

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Switch 3- Traffic lights in the bottom (South)

Switch 4- Traffic lights on the left (West)

Switch 5- Traffic lights for pedestrians

Here, the 4th switch is closed. So, green light on that side will turn on and that too for a longer time to clear the traffic in the particular area first.

VI. WORKING/IMPLEMENTATION OF HARDWARE

Using breadboard, connections are made as in the simulation for implementing the hardware. LEDs are used as traffic lights and IR sensors are used to sense the density. A 9V (approx.) is used as a power supply. Resistors are soldered between the pins and the LED's and proper ground connections are made. Once the code is dumped onto the board and the circuit turned on, depending upon the sensor outputs, the LED's start blinking in the traffic lights (for vehicles and pedestrian crossing) accordingly.

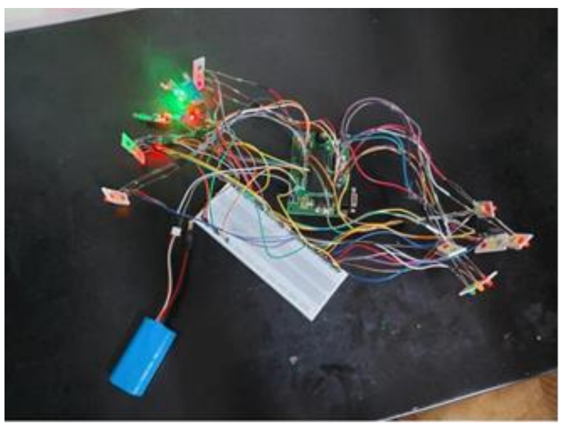

Fig 6: Circuit including connections to the IR sensors and power supply.

VII. CHALLENGES

As the number of intersections of the transportation routes increases, with the increase in the construction of new roads or by-passes, to develop an algorithm for the traffic lights to move the vehicles faster and more efficiently so as to decrease the traffic flow proves to be more and more difficult. Applying this system on a large scale, such as in a big smart city where the traffic light systems are connected (through the cloud) to each other requires more precise data management and analysis.

VIII. DESIGN CONSTRAINTS

For the proposed system, i.e., the prototype, finding the adequate power supply that could provide required voltage to all the IR sensors and traffic lights (LED's) proved to be quite a challenge. Smart Traffic management system (STMS) is a one of the important features for smart city. Methods of Internet of Things (IoT) are being used to acquire traffic data quickly and send it for processing. The Real time streaming data is sent for Big Data analytics.[7] There are several analytical scriptures to analyse the traffic density and provide solution through predictive analytics. In such cases, required power supply can be properly calculated while implementing STMS.

IX. RESULT AND FURTHER RESEARCH

The advancement of technologies and the miniature of control devices, appliances and sensors have given the capability to build sophisticated smart and intelligent embedded systems to solve human problems and facilitate the lifestyle. The proposed smart traffic light control system endeavours to contribute to the scientific society to ameliorate the existing traffic light systems and manage the flow of automobiles at the intersections by implementing innovated hardware and software design systems.

In this paper we have studied the optimization of traffic light controller in a city using IR sensors and microcontroller.

The current design can be promoted by monitoring and controlling an intersection with double roads. Future improvements can be added such as delay timing displays, as well as car accidents and failure modes. The integration of different traffic controllers at several junctions will be investigated in the future in order to accomplish a complete synchronization. The same system could be used to inform people about different places' traffic conditions. Data transfer between the microcontroller and computer can also be done through telephone network, data call activated SIM This technique allows the operator to gather the recorded data from a far end to his home computer without going there. Traffic lights can be increased to N number and traffic light control can be done for the whole city by sitting in a single place. To study the system performance, traffic data can be recorded and downloaded to a computer platform where statistical data analysis studies could be applied to better understand the traffic flows between the intersections. Finally, traffic light controllers could be powered by solar power panels to reduce grid electricity consumption and realize green energy operations.

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