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DESIGN OF INTELLIGENT TRAFFIC LIGHT CONTROL SYSTEM USING ARDUINO MEGA

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ABSTRACT

In large urban areas, traffic congestion is a major issue. The need for traffic management grows as more and more people demand pollution-free, hassle-free commutes and daily lives. The goal of the endeavor is to create a dynamic traffic light system that takes into account population density. Based on the detected traffic volume at the intersection, the signal time will adjust automatically. A camera is built into the framework of the traffic system. The number of vehicles in a given scene is determined by processing the camera's collected image. The camera can also tell when an emergency vehicle, like an ambulance or fire truck, is using its siren and gives them the go-ahead.

In this work, a masking method is utilized to analyse the image and determine the total number of cars on the road. With this algorithm, just the essential parts of the image are displayed, while the rest are hidden. The number of cars on the road is used as input into a visual simple programme that regulates the length of time the lights are on. In order to make the LED light up, a single board microcontroller called an Arduino is used as a controller. This method can be used to find road accidents and see if cars are not moving in a circle pattern. When the system is fully implemented on the road, it allows emergency vehicles to easily clear the traffic without the assistance of a sergeant.

Keywords: *Traffic signal system, Arduino mega, ultrasonic sensor, Bluetooth module, Traffic signal intelligent traffic management system*

1. INTRODUCTION

The most significant shortcoming of the standard automatic traffic light controller is that it sends green signals in many directions after a delay of varying amounts of time. If we take into consideration a junction, the traffic coming from each direction might not be the same, and the density of the traffic might shift with time. If the controller does not take into account the current level of traffic density, then what will happen is that traffic will continue to build up on one side and another side despite the fact that the controller is showing green lights to no vehicles. Because of our project, we won't have to worry about this issue [1].

The amount of traffic density will be assessed through the usage of infrared communication in this study. IR signals are sent to the microcontroller from the IR receiver, and the microcontroller, taking into account the traffic, produces the suitable result. In order to get superior results, we are planning to deploy a large number of infrared (IR) transmitters and receivers in all directions [2]. When there is more traffic on one side than on the other, a greater number of infrared receivers on that side will not get the signals. The microcontroller will then compare this result with the results from all other directions, and it will deliver green signals to the side with the greater number of infrared receivers [3]. Along with the traffic density, the person in charge of the ambulance must push the appropriate switches anytime it is close to but not quite at a traffic signal junction. These switches include emergency/normal priority and direction 1/2, and they provide information on the direction and priority of the ambulance as it approaches the signal junction. The second portion, which is located at the traffic signal, is the one that receives the information and determines the appropriate course of control action [4].

The control action takes the form of determining the time for the green lights. Whoever touched the button first will be given priority if both calls are considered to be of a high priority, such as an emergency. Zigbee technology is used in the process of communicating with one another between the portions. The central idea guides the design of each and every section. The following are several methods that can be used to govern the road's intermediate parts. The right-hand rule or, if there is more traffic, around about or the signal of a traffic

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warden can help direct traffic in the simplest of situations [5]. Nevertheless, particularly in large cities, in the more sophisticated circumstances when the roads in the inter sections contain Traffic Lights or Traffic Signals, which are signalling devices that are used to regulate the flow of traffic, Traffic Lights or Traffic Signals are signalling devices that are used to control the flow of traffic.

In most cases, they are placed at junctions, intersections, roads marked with a "X," pedestrian crossings, and other similar locations, and they rotate the priority of who must wait and who must proceed due to the presence of numerous lanes, the usage of traffic lights is unavoidable [6]. An additional problem develops in suburban traffic scenarios when, in addition to roads, there are also railway tracks present in the crossroads in question. This is a common occurrence. The typical cyclic lights control method is the one that is utilized the vast majority of the time when dealing with a junction of this kind [7].

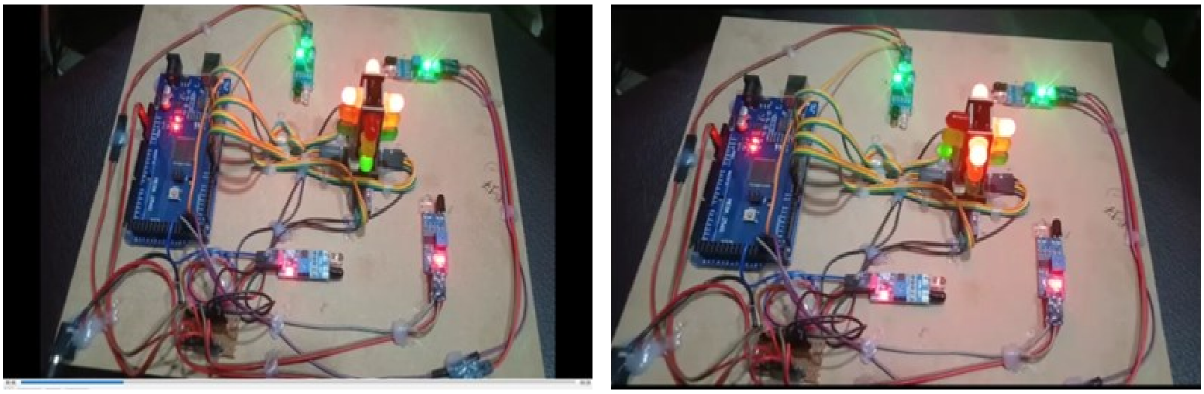


Fig. 1 General Prototype of 4-way road traffic system

In more advanced forms of control, the flow of traffic in a variety of directions is monitored by sensors, which allows for control of the signals to be attained. The overwhelming amount of variables and the requirement for extensive amounts of computational work are the primary causes of the issue [8]. The utilization of fuzzy approaches is one of the potential solutions that could help simplify his situation. In the most recent few years, a significant number of simulations have been carried out, in addition to the construction of realistic control systems that are based on straightforward fuzzy rules. However, in the most intricate circumstances, when the number of lanes is vast and maybe not just one but more than one road intersection and rail road are involved, it does make sense to utilize fuzzy methods containing hierarchy and apply interpolation in order to lessen the complexity. This is because these cases involve more than one road intersection and more than one rail road [9].

More sophisticated control involves sensors monitoring traffic in all directions and utilising the resulting control signals. The vast number of variables and the associated computational burden are a systemic issue. Fuzzy approaches could be used to help him simplify his situation. Simple fuzzy rules have been the basis for a lot of recent simulation work, and they have also been incorporated into real-world control systems [10]. However, it makes sense to employ fuzzy approaches comprising hierarchy and apply interpolation to reduce complexity in the most intricate scenarios, where the number of lanes is considerable and perhaps not only one but multiple road intersections and rail road are involved [11].

The traffic signals will display lights of a uniform colour to provide information to the users (drivers and pedestrians). Traffic lights have three different colours: red, yellow, and green. According to a recent survey, the number of automobiles sold around the world climbed from 52.57 million in 2012 to 75.24 million in 2016. In 2019, automakers broke a five-year sales record by moving over 17 million automobiles. In 2020, experts predict sales of between 16.7 and 17.1 million automobiles. Using this technique, the control modifies itself based on the volume of traffic. Unregulated roads increase the risk of congestion and collisions [12].

2. RELATED WORK

Many studies have been conducted to make traffic lights more adaptive and intelligent. These studies have one goal in mind, and that is to ease traffic congestion. Stress, wasted time, missed opportunities, accidents; extra fuel use, financial difficulties, and increased emissions of carbon monoxide (CO) are all results of traffic congestions brought on by poor vehicle management. Propositions made by researchers have relied heavily on research into advances in sensing, communication, and decision-making technologies [13].

In their research, S. Balasubramami and D. John Aravindhar [14] designed a VANET traffic signal system that takes into account the number of vehicles on the road. The traffic signal was dynamically adjusting the wait time based on a priority algorithm and the number of vehicles in the area. Reduced vehicle wait times at traffic signals were achieved by the use of VANET connectivity in the design of an adaptive traffic light.

To reduce drivers' idle time at intersections, Bashir and his team researched and created a smart traffic control system that dynamically allots green light time using vehicle-actuated signalling [15]. Time needed on each road was determined using traffic counts and then distributed accordingly. Nang Hom Kham et al. looked at alternate timings for the lights at the intersection. The first is the standard operating procedure, and the second is the emergency procedure. Using the C programming language and the PIC 16F877A microcontroller, they created a system that, once the emergency modes have been activated, may revert back to the normal sequence [16]. By subtracting the background image from the foreground and then using some morphological procedures, Kanungo et al. [17] employed a video processing technique to quantify the density of vehicles on each road.

Ruiqi et al. [18] use a support vector machine (SVM) for classification of the status of the road as congested or not congested. The parameters such as average traffic flow, decrement in traffic flow, and increment in traffic flow are used for the training of SVM. The approach not only detects the congestion but also reveals the status of traffic such as decreasing congestion or increasing congestion. Idé et al. [19] propose a lightweight intelligent traffic management system by using a low-quality camera with limited resources. This work uses the changes in frames of images to calculate the congestion on the route. With the help of the neural network, an unsupervised learning algorithm is used for estimating of congestion based on vehicle count.

Li et al. [20] estimate the road traffic congestion by processing the traffic video in time and spatial domain. The road occupation rate classifies the condition of the road as congested or not congested regions. Motion detection and segmentation use motion cues to distinguish moving vehicles from the stationary background. It can be classified into temporal frame differencing that depends on the last two or three consecutive frames, background subtraction which requires frame history to build a background model, and finally optical flow that is based on instantaneous pixel speed on the image surface.

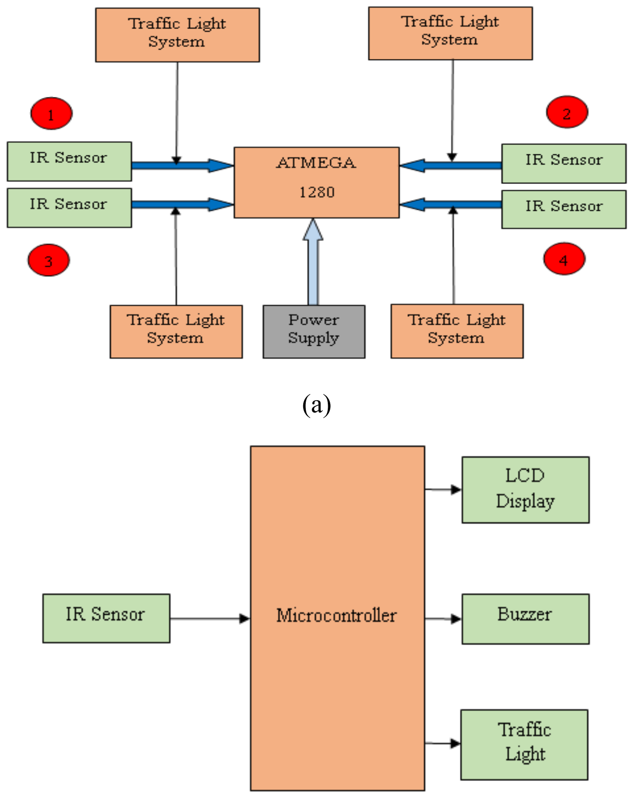
D`Andrea & Marcelloni [21] propose a GPS based congestion detection techniques. GPS enabled commuters" smart mobile phone is used to track the location of the vehicle, and vehicular congestion in a particular area and real-time traffic data is estimated. The GPS coordinate of the user"s mobile is used to detect the congestion on the road. A serious flaw of this approach is that it faces false congestion detection of the vehicle due to the count of GPS devices and considering each device as a vehicle.

Chattaraj et al. [22] propose an Intelligent Traffic Control System (ITCS) based on RFID. This technique utilizes a set of two RFID readers in each direction of traffic junction separated by some distance. The RFID enabled vehicles are detected at traffic junctions and the details are sent to the central server for making the traffic-related decision. Sharma et al. [23] propose an approach to prioritize the traffic light for emergency vehicles by using RFID. RFID is used for multilane, multivehicle, and multi road junction area. This approach requires the traffic police to emulate the signal in real- time. If the emergency vehicle is detected at any traffic signal, then the traffic controller abandons the round-robin schedule of the normal traffic light mechanism, and generates the green signal for the ambulance.

Wire- less Sensor Networks (WSNs) was proposed by Malik Tubaishat et al., [24] in their study on controlling traffic lights. Their concept provides a framework for a wireless sensor-based adaptive system with real-time intelligent control. The system's three layers are the wireless sensors that monitor traffic conditions (vehicle count, speed, etc.), the traffic model policy at the intersection level, and the higher level coordination of the traffic light agents. Stefan Lammer et al., [25] suggested an Optimization-based system for autonomously controlling traffic signals. Priority-based scheduling is used to monitor the length of the queue for vehicles and adjust the timing of the traffic lights accordingly [26]. If the queue length is unstable, the traffic model is adjusted, but if it remains stable, no adjustments are made.

3. PROPOSED SYSTEM

Finally, the projects stated goal of analyzing and implementing wireless communication via radio frequency (RF) transmission in the emergency vehicle traffic light control system has been realized. In comparison to the theoretically reserved range of around 3 kHz to 300 GHz of frequency, the prototype of this project is employing the frequency of 434 MHz. The project's functionality also demonstrated the achievement of the other goals, which included developing a mode of traffic lights that initiates an emergency sequence in response to emergency vehicles passing through an intersection and reverting to the normal sequence before the emergency mode was triggered. Microcontroller PIC 16F877A code was used to create the project's sequences. To make this traffic light system prototype better in the long run, it will be necessary to monitor and manage actual traffic conditions and conduct research on the system's operating range, reception quality, and gearbox problems.



(b)

Fig. 2 Overall block diagram of intelligent traffic light control system (a & b)

The overall system block diagram of a smart traffic control light system for a four-way traffic configuration can be seen in Figure 2, which represents the design of the system. In most cases, it is made up of the infrared (IR) sensors, the micro-controller, the power supply, and the traffic light system. The traditional traffic signal system that we are all familiar with does not take into account the volume of the flow of traffic because it gives the same amount of time delay to each lane regardless of the degree of traffic that is present in that lane. This is not a sensible move, and it also wastes a lot of time. This system, on the other hand, decides when to display the green, yellow, and red LED indications by taking into account the volume of traffic that is occurring at the moment. The infrared sensors detect the presence of vehicles on any of the lanes and communicate the information (the density that was estimated) to the microprocessor. The microcontroller then allots the appropriate amount of ON time to the green and red LEDs. Because of this, the timing of the traffic signals is determined by the number of vehicles present in any one of the four lanes.

3.1 Considering the components individually:

The IR sensors: The infrared sensors not only detect motion but also measure the amount of heat emitted by an object. Therefore, as the vehicle travels over these sensors, the sensors are able to easily count the number of vehicles and provide that information to the micro controller. Each one is made up of an infrared (IR) transmitter and an IR receiver, both of which are responsible for transmitting and receiving IR rays. There are other sensors that can determine whether or not vehicles are present on the roadway. They consist of, but are not limited to, things like video image processors, ultrasonic detectors, microwave wave radars, piezoelectric

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sensors, and so on. It is recommended to utilize an infrared sensor because it can function normally during the day as well as at night. They can also be mounted in both side and overhead configurations.

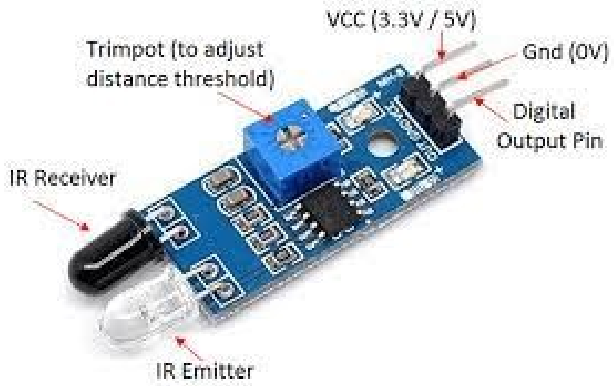

Fig.3 IR Sensor

Arduino Mega: The At mega 1280 was chosen as the microcontroller for this application. It takes in data from the sensor and adjusts the timing of the light to prioritise the flow of traffic at times of high density. The microcontroller then transmits a timing signal based on the volume of traffic on the surrounding road [9].The programmable nature of the microcontroller makes this possible. The numerous input/output pins on the Arduino mega are useful for connecting a wider variety of sensors and other devices.

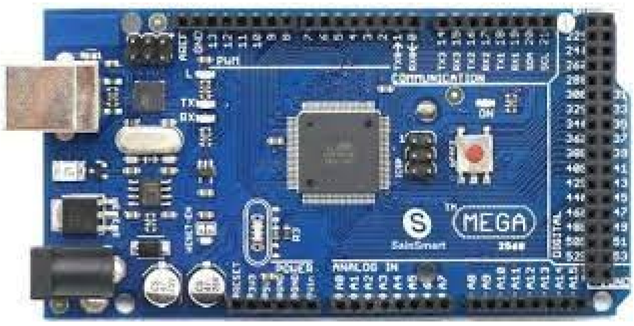

Fig. 4 Arduino Mega

Power supply: It merely maintains the microcontroller's state of operation by supplying power. Here, we get our juice from the sun and batteries as well as the regular electrical system. This is crucial in preventing any downtime throughout the system. Battery power can be used to run the system in the evenings, while regular electricity is used during the day.

Traffic light system: The seven segment display provides the drivers with a visible countdown, and the LED indicators red, yellow, and green are the system's other main components.

HARDWARE

For Traffic Signal Zone: Arduino, IR Sensors, Zigbee, LED’s, LCD Display

For Vehicle: Arduino, Zigbee, Buttons

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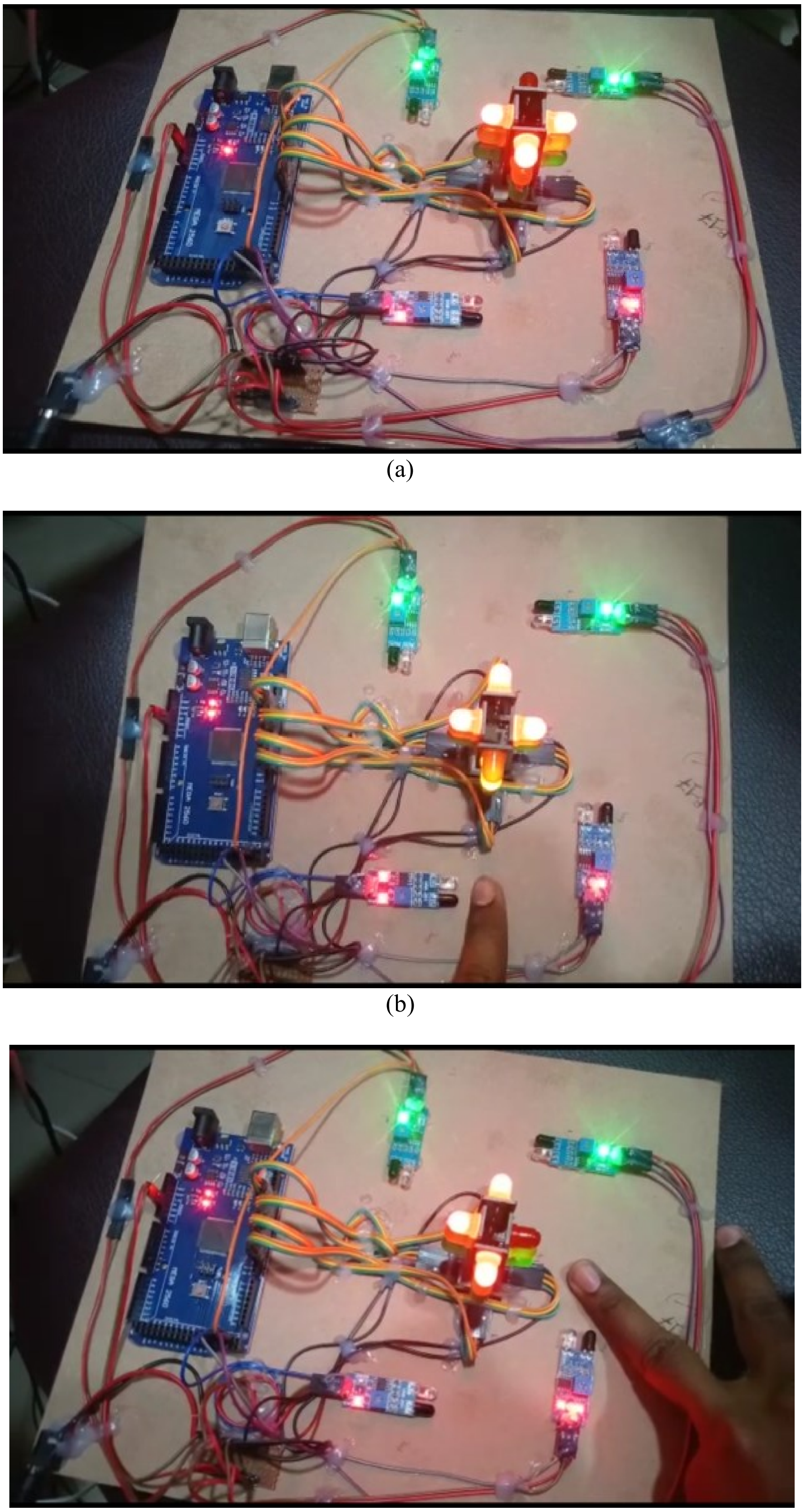

(a)

(b)

(c)

Fig. 3 Different categories of Traffic light system using Arduino Controller

4. ARDUINO PROGRAMMING STRUCTURE

In this paper, we will explore the structure of Arduino programmes and discover some of the newer terms used in the Arduino community. The code for Arduino is freely available. Both the Java runtime environment and the C/C++ microcontroller libraries have publicly available source code licences (GPL and LGPL, respectively).

Sketch: The word "sketch" refers to a piece of software used with an Arduino. Structure, Values (variables and constants), and Functions are the three primary components of an Arduino programme. This article will teach you all you need to know to build Arduino code that compiles and runs without any syntax errors.

i) Purpose: When a new sketch is created, it triggers the setup( ) method. Set the variables, activate the pin modes, load the libraries, etc. with it. After each power cycle or reset of the Arduino board, the setup function will execute exactly once.

INPUT OUTPUT RETURN

After you've created a setup() method to initialize and establish the initial values, the loop() function will do just what its name implies and loop successively, giving your programme room to adapt and answer. Put it to use taking command of an Arduino board.

INPUT OUTPUT RETURN

4.1 Steps to Upload the Program in Arduino Board

In this section, you will find detailed instructions on installing the Arduino IDE and preparing the board to receive the programme using a USB cable.

Step 1: First, you need an Arduino board and a USB cord. You can choose the board you want to use.

If you use Arduino UNO, Arduino Duemilanove, Nano, Arduino Mega2560, or Diecimila, you will need a standard USB cable (A plug to B plug), like the kind you would connect to a USB printer, as shown in the picture below.

Fig. 4 USB Cable

Step 2: Download Arduino IDE Software.

On the Arduino Official website, there is a page called "Download" where you can get different versions of Arduino IDE. You have to choose software that works with your working system, which could be Windows, IOS, or Linux. When you're done downloading the file, you'll need to unzip it.

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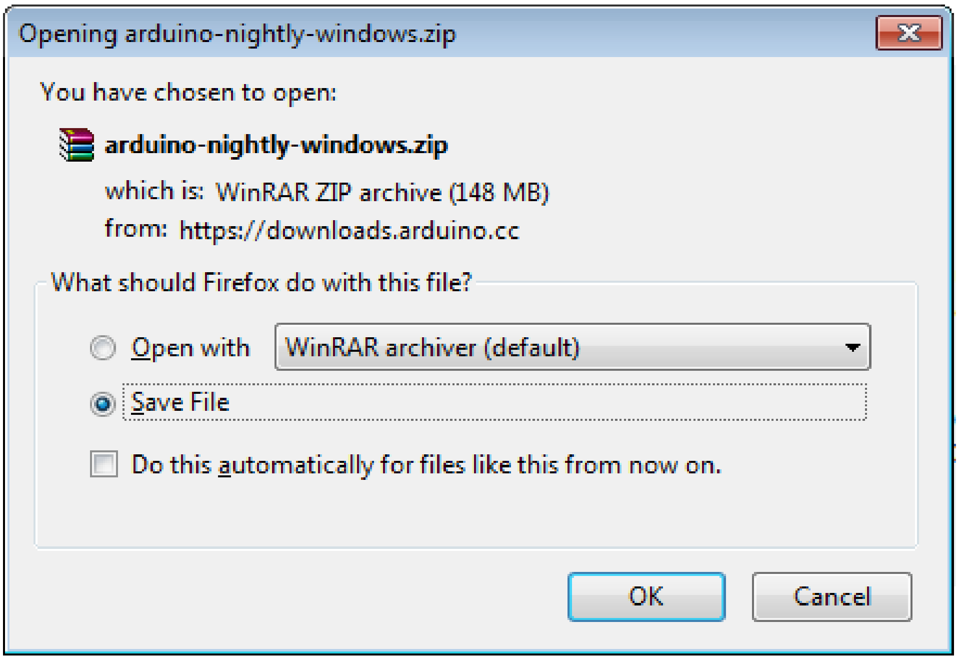

Fig. 5 Download Arduino IDE Software

Step 3: Power up your board.

All four sizes of Arduino boards, the Uno, Mega, Duemilanove, and Nano, can be powered directly from a computer's USB port or from an external supply. The Arduino Diecimila board must be set up such that it receives power from the USB connection.A jumper, a little piece of plastic that slides onto two of the three pins in the space between the USB and power jacks, is used to switch between the two power sources. Make sure it's on the two pins immediately adjacent to the USB connector. Use a USB cord to link your computer to the Arduino board. The PWR indicator light, which is green, must be on.

Step 4: Launch Arduino IDE.

When you've finished downloading the Arduino IDE, you'll need to extract the files. The infinitely labelled programme icon (application.exe) can be found inside the folder. To activate the IDE, simply double-click its icon.

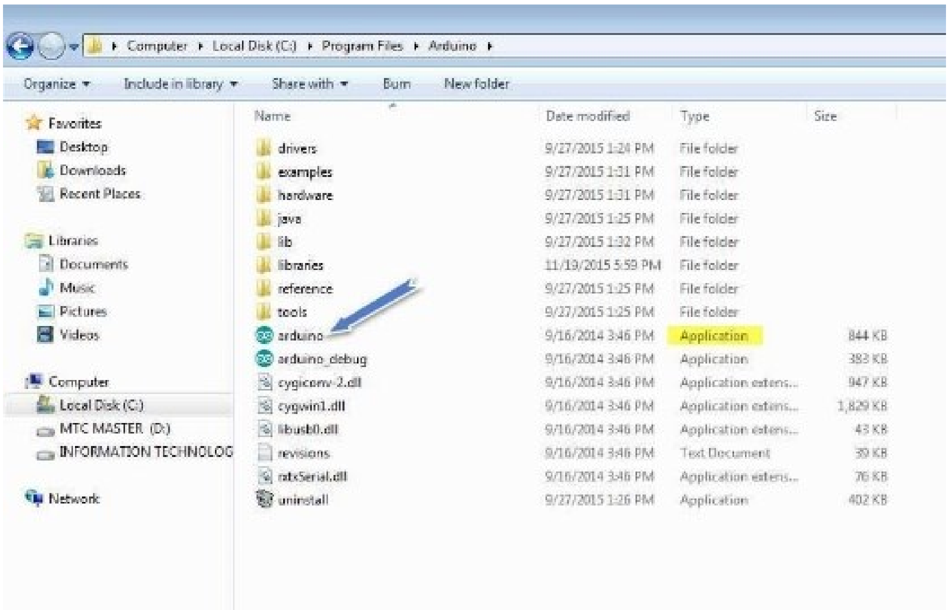

Fig. 6 Launch Arduino IDE

Step 5: Open your first project.

Once the software starts, you have two options: Create a new project. Open an existing project example. To create a new project, select File -->New to open

Here, we are selecting just one of the examples with the name Blink. It turns the LED on and off with some time delay. You can select any other example from the list.

Step 6: Select your Arduino board.

To avoid any error while uploading your program to the board, you must select the correct Arduino board name, which matches with the board connected to your computer.

Go to Tools -> Board and select your board

Here, we have selected Arduino Uno board according to our tutorial, but you must select the name matching the board that you are using

Step 7: Select your serial port.

C- Shortcut used to create a new sketch.

D- Used to directly open one of the example sketch. E- Used to save your sketch.

F- Serial monitor used to receive serial data from the board and send the serial data to the board.

Now, simply click the "Upload" button in the environment. Wait a few seconds; you will see the RX and TX LEDs on the board, flashing. If the upload is successful, the message "Done uploading" will appear in the status bar.

CONCLUSION

In conclusion, this project has been successful in accomplishing the primary purpose that was outlined earlier, which was to investigate and put into practise the wireless communication, specifically the radio frequency (RF), transmission in the traffic light control system for emergency vehicles. In comparison to the frequency range of around 3 kHz to 300 GHz, which has been theoretically reserved for the RF, the prototype for this project is using the frequency of 434 MHz. In addition, the functionality of this project demonstrated that the other goals have been successfully attained. These other goals included designing a mode of emergency sequence for traffic lights that activates when emergency vehicles pass by an intersection and changing the sequence back to the normal sequence before the emergency mode was activated. Both of these goals were successfully accomplished thanks to the functionality of this project. The programming in the microcontroller PIC 16F877A was utilized in order to construct the sequences for this project. In the future, this prototype system can be made better by controlling the actual traffic situation, and the study can be carried out by analyzing the length, reception, and gearbox issues associated with the system that is intended to be used in conjunction with the traffic signal system.

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