Density Based Traffic Signal System using PIC Microcontroller

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Abstract— *The aim of our project is to develop a Density Based Traffic Signal System using PIC microcontroller. Nowadays, controlling the traffic becomes more difficult because of rapid increase in the number of automobiles and due to large time delays between traffic signals. In order to reduce this problem, we can choose density based traffic signal system. In this system, we will use IR sensors to measure the traffic density. We have to mount three IR sensors for each road; the distance between these sensors will depend on nature of traffic on a particular junction. These sensors will sense the traffic on that particular road. All these sensors are interfaced to the PIC microcontroller. Based on these sensors, controller detects the traffic and dynamically set up the time delay of signals.*

Keywords - *Traffic signal system, traffic density PIC microcontroller, IR sensor.*

I. INTRODUCTION

The traffic signal was first discovered in 1912 by a Detroit policeman named Lester Wire like two-colour, red-and-green light with a buzzer to warn pedestrians ahead of the impending transition. After that, in 1920, this basic design was updated by William Potts to include the tri-coloured red, yellow, and green lights widely used today. This simple, three-color icon has allowed for nearly a century with little change, using modern technologies such as automatic timers, diode lights and motion sensors.

Traffic signals are mainly developed to ensure the correct flow of traffic, provide an opportunity for pedestrians or vehicles to cross a junction and help to reduce the number of collisions between vehicles entering intersections from opposite directions. Traffic signals should be considered when they will alleviate more problems than they create. A warranted signal properly operated may provide for more orderly movement of traffic, and reduce the occurrence of certain types of collisions. Unwarranted signals can result in increased crashes, delays and congestion.

The traffic congestion problems are increasing day by day because of the increasing number of vehicles with limited infrastructure. Under this situation, the existing traffic light systems which are timer based are not able to control traffic. To solve this problem, a real time traffic control system is needed which will control the traffic signal according to traffic density. For effective traffic management and signal control, it's important to know road traffic density. Based on this density value time delay of signals can be set up dynamically.

The existing traffic signal system is implemented with delays where the signal transition time slots are fixed and do not depend on current traffic flow. The existing traffic system needs to be upgraded to solve the severe traffic congestion problems. So here we propose a simple, low-cost, and real time traffic signal system that aims to overcome many problems and improves the traffic system. The system is based on PIC microcontroller that evaluates the traffic density using IR sensors mounted on either sides of each road and dynamic timing slots with different levels. Our system will be very useful for solving most of the traffic congestion problems occurs today.

II. LITERATURE REVIEW

In recent years, surveillance systems and video monitoring [1] have been widely used for traffic control. Historically, there exist several vehicle detectors such as radar, ultrasonic, and microwave detector. But these sensors are expensive, with less capacity and difficult to maintain, difficult for installation and implementation and extra maintenance charges be there. Radar sensors are affected by metal barriers near road [2, 3].

In mathematical modeling [1, 4] parameters of a vehicle are designed mathematically using the geometric positions of camera, sunlight and vehicle and compared with values obtained using video. The manual dependencies between intersections lead to a complicated derivations with fault parameters. These parameters are hazardous and most of the problem is because of the variance of these parameters with time.

Several techniques are designed for traffic congestion detection that is based on sensing [6]. Another approach is that measure the traffic density based on the number of occupied fraction of road based on RF signals which was placed on road side. This method was inefficient because significant manual work was required at different roads [5].

A lot of innovations have been made for predicting the density of the traffic based on image processing [7, 8]. But these techniques require the good images whose quality is weather dependent, especially with the rain and the fog. Algorithms to model the various states of the traffic such as fuzzy logic were used.

Traffic signals operating on fixed signal timing delays cannot be used properly to control the traffic congestions. When the traffic density increases more than a limit on a particular road, it needs larger green light duration to reduce the traffic flow. The major problem of the existing traffic light system is that the transition timing slots are fixed in software and unnecessary waiting time when no vehicles are present on opposite route. Since the vehicle to stand in a proper line due to which many of the traffic occurs.

Our system uses PIC microcontroller that is interfaced with IR sensors [9]. Three IR transmitters and the IR receiver are placed on each road. When an automobile passes between the IR sensors, the photodiode is activated and the object is detected counter is incremented. The collected information about the traffic density of each roads of a '+' junction is analyzed in order to change dynamically the delays of green light. Traffic density is measured as "low, medium and high". Based on this density varies the traffic signal duration for a particular way. LCD display is used to display the waiting time. The entire procedure will repeated in a cyclic manner for every road.

III. PROPOSED SYSTEM DESIGN AND METHODOLOGY

The traffic light issue is a critical problem in day to day life of that peoples and governments. The proposed system consists of a traffic light controller that manages the traffic lights of a "+" junction of bidirectional roads. The system consists of a PIC microcontroller which does all the function according to code. Power supply is given to the microcontroller and the IR sensor on both the side of the road sense the density of traffic and gives the information to PIC microcontroller. The controller provides output signal to traffic light.Display the waiting time using LCD Display.

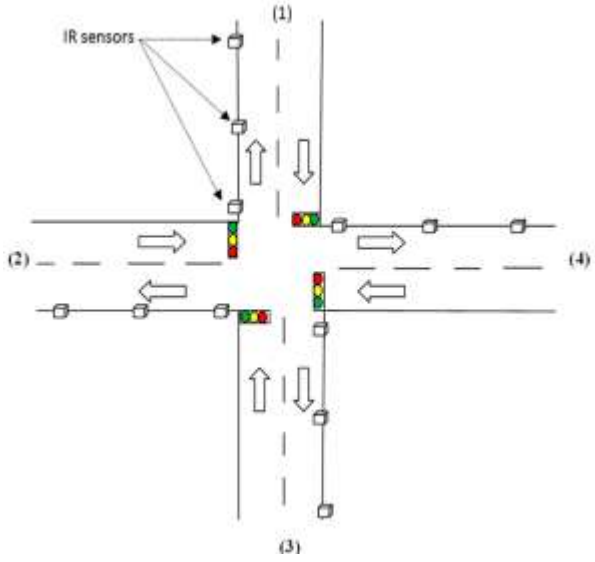

Fig. 1. Intersection of 4 bidirectional roads.

Fig. 1 shows the intersection of four bidirectional roads ("+" junction). There are three IR sensors are mounted on either sides of each road. The distance between each IR sensors depend on the nature of the traffic density. These IR transceivers are used to detect the vehicles passed through it. The IR transmitter generates a 38 kHz square wave signal while the IR receiver connected to the traffic master controller receives the signal. When a vehicle passes the road between the IR transceivers, the IR radiation spreads and the object is detected. And vehicle counter is incremented. Then it will input to the microcontroller, it can change the time delay of signals corresponds to the density value.

The IR transmitter looks like an LED. The white LED indicates IR transmitter and black indicates receiver. This IR transmitter emits IR rays from it. The operating voltage of this IR transmitter is 2 to 3v. These IR (infra red) rays are invisible to the human eye. But we can view these IR rays through camera.IR receiver receives IR rays that are transmitted by IR transmitter. When it is receiving IR rays the resistance is very low. The operating voltage of IR receiver also 2 to 3V. We have to place these IR pair on either sides of each road. IR receiver should be able to receive the IR rays. When we give the power, the transmitted IR rays hit the object and reflect back to the IR receiver. Instead of traffic lights, we can use LEDs (RED, GREEN, YELLOW). In normal traffic system, we have to glow the LEDs on time basis. If the traffic density is high on any particular path, then glows green LED of that particular path and glows the red LEDs for remaining paths.

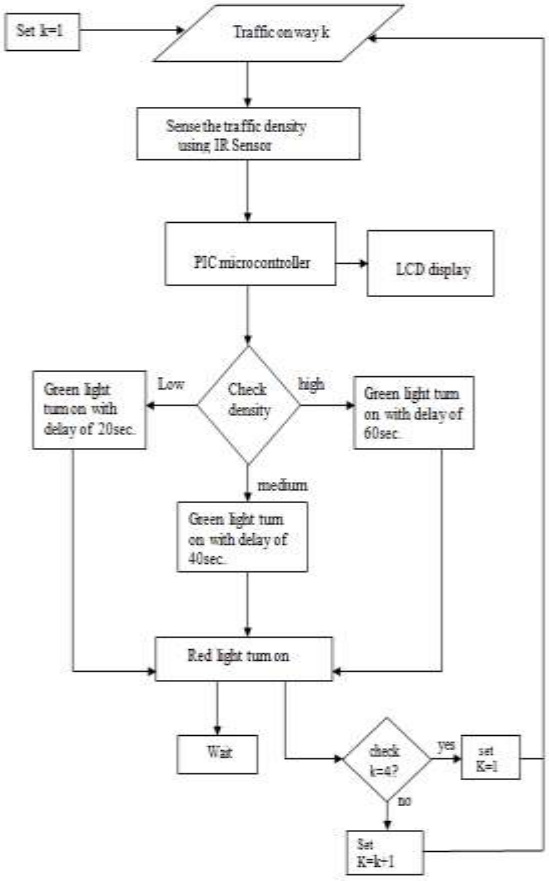

Fig. 2. Working of Proposed System.

Actually, three modes of lighting transition slots are there: the normal mode, the traffic jam mode, and the soft traffic mode. The three timing slots associated to the normal, jam, and soft modes of traffic are respectively 40, 60, and 20 s. The shifting between these three modes is done dynamically using software. The timing slots of the different modes are depicted in Table 1.

Table I. Timing slots for three modes of Traffic.

Traffic Modes	Timing slots
Normal Mode	40
Jam Mode	60
Soft Mode	20

The system architecture was shown in Fig 3. The system is composed of using PIC microcontroller, IR sensors, LEDs and LCD display. In normal conditions, i.e. when there is no vehicle on the road, the IR transmitter or the IR LED transmits IR light which is received by the photodiode, which starts conducting. As the photodiode conducts, the corresponding transistor also conducts giving an output of low logic signal (0V) to the microcontroller. The same principle works for all other IR sensor- transistor arrangement. The microcontroller makes each LED glow for a fixed amount of time. Now if there is presence of vehicles, the communication between the IR transmitter and the receiver is interrupted, i.e. the photodiode receives less or no amount of light from the IR diode and accordingly the base current to the transistor reduces, eventually making the conductor go to off condition. This causes an output of high logic signal from the transistor, to the PIC microcontroller. The microcontroller accordingly changes the glow time of the green LED of the corresponding junction to a higher value. Thus as number of vehicles increases, the green light glows for more time, allowing a quick flow of traffic from the junction side.

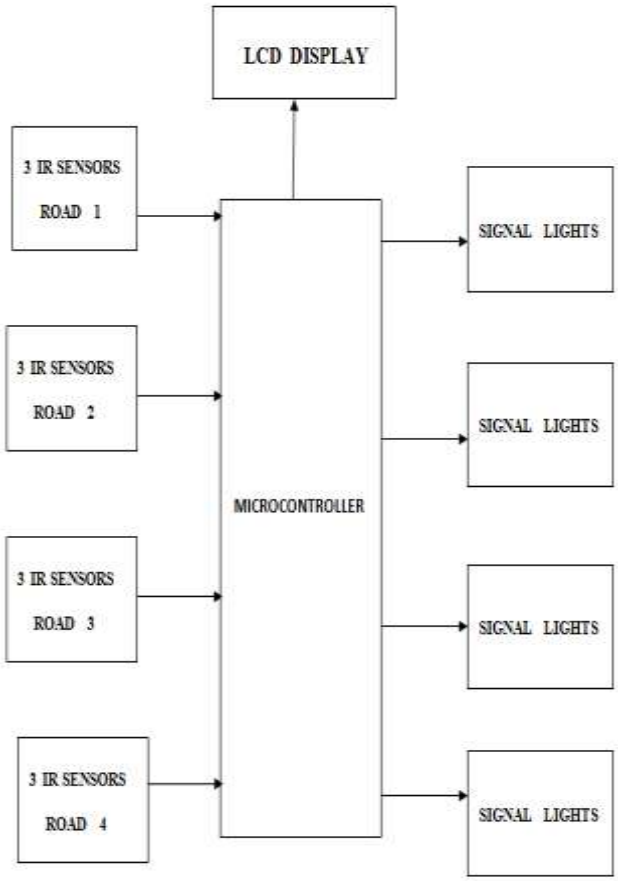

Fig. 3. Architecture of the proposed system.

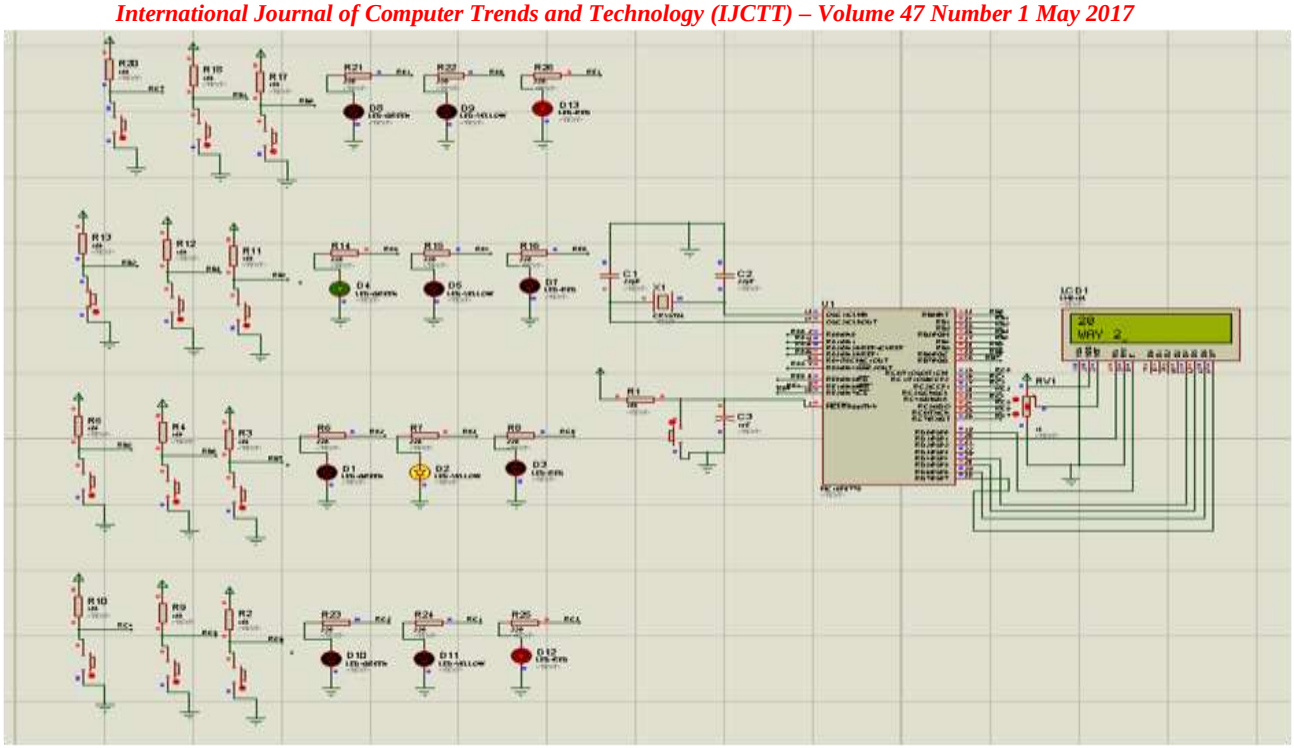

Fig. 4. Circuit Diagram of the proposed system

The code will be compiled by using the HI-TECH C compiler. The working principle of IR sensors is similar to switches [10], also it is impossible to interface sensor in a simulation circuit. LED lights have been interfaced across each road to represent the signal system. LCD display is used to display the waiting time for each road. The Switch is closed to represent the density of the traffic system. When the switch is closed it indicates that the traffic is detected and gives preference to that particular path. Likewise all the other side's functions based on the position of switch. We can dynamically set up the waiting time based on the traffic density (soft mode, normal mode, jam mode). After the waiting time has expired, the preference will shift to the next path. The entire procedure will be repeated in a cyclic manner for every road.

Fig. 4 shows the hardware implemented circuit of the proposed system using the Proteus software. Here we can see that, 12 switches and LEDs are equipped with a microcontroller and a LCD display also. In figure, the first switch of way 2 is closed and the remaining switches are open; then glows green LED of that way 2 and glows the red LEDs for remaining paths with a delay of 20 s. Here the yellow light on way 3 indicates that next the system will prefer to it. The system is implemented based on various electronic components that include: the Programmable Intelligent Controller or Peripheral Interface Controller (PIC) 16F877A microcontroller, an LCD display device, IR sensors, and many of the colored LEDs that represent the three lights (red, green, and yellow) of the traffic lights.

A. Microcontroller PIC 16F877A

The PIC 16F877A, is an integrated circuit (IC).It consumes less power and it contains less number of pins and more performance. It consisting of a CPU, RAM, ROM, and EEPROM memories. It contains also clock, timers, A/D converters, and five I/O ports named as A,B,C,D, and E. It has 35 instructions make it easy and simple to program. Moreover, its power consumption is low and it has a wide operating voltage range (2 V to 5.5 V) while its input clock operates at up to 20 MHz.

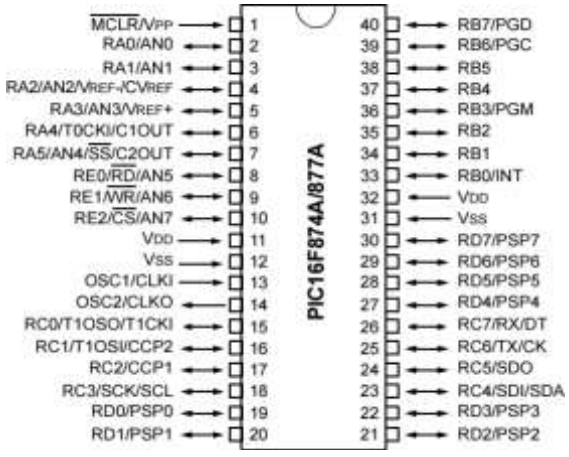

Fig. 5. Pin configuration of PIC 16F877A

B. LCD display

Liquid Crystal Display (LCD):16x2 LCD used in the implemented to display data over 2 lines, each of 16 characters. Actually, two types of registers are used to configure the LCD; the command registers and control registers. Other aspects are LCD initialization, clearing the screen, setting the cursor position, and controlling display. While the data register holds the ASCII code of the characters that are appeared on the display.

C. IR SENSOR AND LEDS

An infrared sensor is an electronic device used to detect the objects. It is used to measure an object heat or its motion. The IR sensor emits or receives the infrared radiations that are invisible for the human eye. The working is simple: when IR radiation of the LED reaches the photodiode, the output voltages change according to the magnitude of the IR light(5v or 0v).

It is universal that the black colour absorbs the entire radiation incident on it and white colour reflects the entire radiation incident on it. It consists of an IR LED, a photodiode, a potentiometer, an IC Op-Amp and an LED. IR LED emits infrared light.

The 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 short stop, and the red signal prohibits any traffic from proceeding.

IV. CONCLUSION

Nowadays, traffic congestion is a main problem in major cities since the traffic signal lights are programmed for particular time intervals. However, sometimes the demand for longer green light comes in at the one side of the junction due to huge traffic density. Thus, the traffic signal lights system is enhanced to generate traffic-light signals based on the traffic on roads at that particular instant. The advanced technologies and sensors have given the capability to build smart and intelligent embedded systems to solve human problems and facilitate the life style.

Our system is capable of estimating traffic density using IR sensors placed on either side of the roads. Based on it, the time delay for the green light can be increased and we can reduce unnecessary waiting time. The whole system is controlled by PIC microcontroller. The designed system is implemented, tested to ensure its performance and other design factors.

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