Smart Traffic light controller based on Microcontroller

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Abstract **–** The increase of population produces an increase of the number of automobiles on the road, which generates heavy traffic in the streets and that causes many problems for the Citizens and traffic policemen an additional two emergency cases therefore it's important with development technology of embedded systems to solve this problem. In this paper new traffic light controller was built to optimization using the Arduino UNO microcontroller board. The system tries to reduce traffic jams, caused by traffic lights, as possible. The system is based on microcontroller, which represent the brain of the system. The system contains ultrasonic sensors on the side of the roads. Also the system contains switches to control the traffic light manually. The ultrasonic sensor system gets activated when vehicles go along the road against it. Microcontroller controls the traffic light by driver circuit using the sensor network to determine the level of jam in the road. Different ranges of traffic light delay time intervals according to jam level are configured by microcontroller and updated regularly. In this paper the effects of temperature and humidity on the system were studied. The jam level displayer tool is another feature added to a system controlled by the microcontroller which is a traffic sign informs the drivers about the level of jam before reaching the road.

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Keywords: – Microcontroller, ultrasonic sensor, and driver circuit.

1. Introduction

The increase of jam produces many looses of countries resources because of the looseness of petrol, exhaustion of automobiles', and lateness of employers, in addition to fatigue for both the Citizens and traffic policemen. Many problems with the ordinary traffic light controller, heavy jam is the most important problem because of never configure the level of jam in each way and set the delay time. Another problem represents when there is no jam, but the waiting still continues. The solution for these problems is to determine the level of jam and set the delay time. In addition to delay time problems there is problem representing of emergency cars, like the ambulance, police, and fire brigade. This problem need of evaluation of the traffic policeman, then there is need for manual control of the traffic light. The traffic jam can reduce if the driver has the information about the level of the crowd in the road before reach it and takes another way. The aim of this work is to propose system provide solution for all above problems with minimum cost.

2. Related Work

A large number of approaches are presented to minimize the problems of the traffic light jams, bellow a literature survey for some solution in the last few years:

- Ganiyu R. A., 2014 [1] introduced a traffic light control system; the design consists of the microcontroller, and light emitting diode (LED). The sensing unit is designed utilizing a pressure switch which will sense the weight of any car that steps on it. When the pressure switch is pushed, a logic one is applied on the microcontroller to inform the control unit that there is car at that particular node. The system was designed to sample all the lanes in turn to detect whether there is an automobile on any lane and this action added a period of 15sec to the delay time by the microcontroller which is configuring the traffic light action.
- Sachin Jaiswal, 2013 [2] presented control system consist of microcontroller, IR sensors, in line of sight configuration across the loads to detect the density at the traffic signal, and for VIP automobile RF transmitters are installed on it while the receivers installed on traffic light control circuit to control the state of the traffic light. Three levels of jam and delays are defined high, medium, low density.
- Rashid Hussian, 2013 [3] presents system of Intelligent Traffic Routing using a Wireless Sensor Networks. The Wireless sensor network technology is used to sense presence of Traffic near any node and then able to route the Traffic based on density in the desired road. The system uses microcontroller with the Wireless sensor for Traffic management.
- A. Ms Promila Sinhmar, 2012 [4] propose multiple traffic light control and monitoring system. The system is based on microcontroller. The system contains IR sensors are mounted on the sides of roads respectively. The IR sensors network sense the vehicle passed through it. Microcontroller controls the IR system and counts the number of vehicles passing on the road. The vehicle count is stored in microcontroller memory. Based on a different vehicle count, the microcontroller takes decision and updates the traffic light delays as a result. Administrator sitting on the computer can command system

(microcontroller) to down-load recorded data, update light delays, erase memory, etc. Thus administrator of a central station computer can access traffic conditions on any approachable traffic lights and nearby roads to reduce traffic congestions to an extent.

- Shilpa S. Chavan, 2009 [5] introduced Intelligent Traffic Light Controller, which consist of infrared sensor mounted on the road to detect the vehicles, this acts as an input to the ITLC unit. This input signal indicates the length of vehicles on each road. The controller generates output signals for Red, Green and Orange Signal and monitors their timings, taking into consideration the length of vehicles on each road. The same information is transmitted to the mobile user which will request for congestion status. If a vehicle driver at junction sends SMS on GSM mobile phone to ITLC unit, the driver will get a message indicting congestion status of the road. The microcontroller that used is AT89c51.

3. Proposed System

The proposed scheme, as depicted in Figure (1), consists of processing unit presented by the microcontroller which control all the process in the system, ultrasonic sensors' that determine the level of jam in the road, switch to switch between the manual mode and auto mode, manual control switches to control the traffic light manually by Traffic policeman, the traffic light circuit, and the jams level displayer.

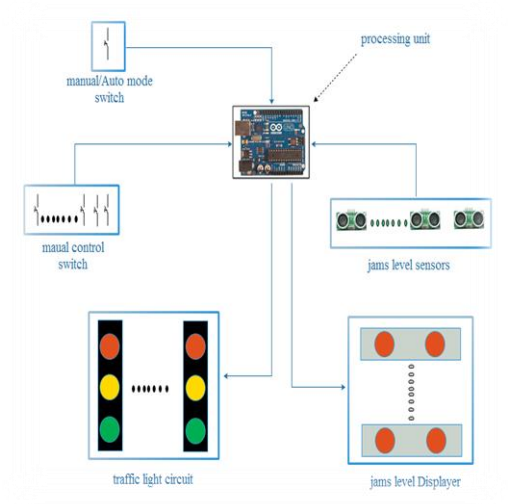

Figure 1 The proposed system organization

3.1. Driver Circuit

Driver circuit was constructed to link up the microcontroller board to drive high power consumption real traffic light and jam level Displayer circuit. The driver circuit as depicted in Figure (2) consists of (ULN2803) chip and relays to supply the force needed to get to the sign on.

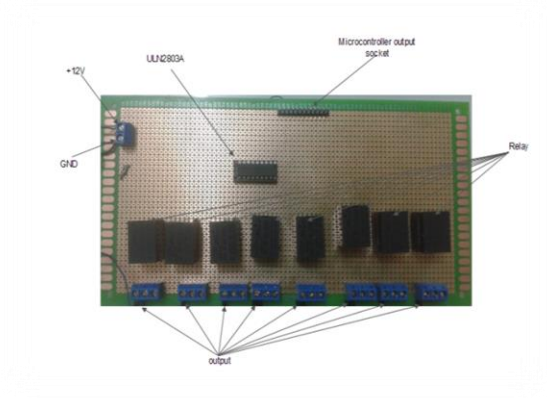

Figure 2 Driver circuit

The ULN2803A is a high-potential, high-current Darlington transistor array. The device consists of eight NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current valuation of each Darlington pair is 500mA as shown in Figure (3) [6].

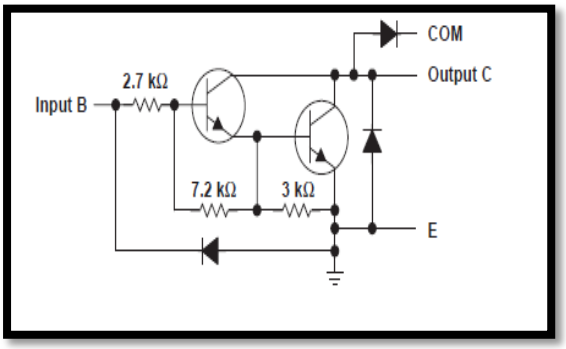

Figure 3 Each Darlington pair in ULN2803

The outputs of (ULN2803A) connected to relays which provide the power needed to drive traffic light and jam level Displayer circuit.

4. Ultrasonic sensor

The distance adjustment determined by ultrasonic sensor gets the trigger from the microcontroller and gets back the echo, and the distance measured by using the following equation[7]:

Distance = high level time * velocity of sound / 2 (1)

The ultrasonic sensor that used is module HC - SR04, which is provided (2cm - 400cm) non-contact measurement function, the ranging accuracy can reach to 3mm [7]. The effect of temperature on ultrasonic evaluated by the following equation:

$$c = \sqrt{\frac{1.4RT}{M}} \qquad (2)$$

Where R is the universal gas constant, T the absolute temperature, and M the mean molecular weight of the gas at sea level.

While the effect of humidity on speed of sound can be calculated as follows:

$$increase\ in\ velocity = 455.13\sqrt{\frac{\gamma_w}{M_w}} - 100 \qquad (3)$$

Where γ_w is the heat ratio of air with water and M_w is the molecular weight of air with water [8]. The effects of temperature and humidity shown in Figure (4) and Table (1). The change in speed of sound is inconsiderable proportional to the detection time of the system and does not affect it.

Table (1) Variation of speed of sound [9]

Temperature of air ϑ in °C	Speed of sound c in m/s	Time per 1 m Δ t in ms/m	Density of air ρ in kg/m3	Impedance of air Z0 in N·s/m3
+40	354.94	2.817	1.1272	400.0
+35	351.96	2.840	1.1455	403.2
+30	349.08	2.864	1.1644	406.5
+25	346.18	2.888	1.1839	409.4
+20	343.26	2.912	1.2041	413.3
+15	340.31	2.937	1.2250	416.9
+10	337.33	2.963	1.2466	420.5
+5	334.33	2.990	1.2690	424.3
0	331.30	3.017	1.2920	428.0
−5	328.24	3.044	1.3163	432.1
−10	325.16	3.073	1.3413	436.1
−15	322.04	3.103	1.3673	440.3
−20	318.89	3.134	1.3943	444.6
−25	315.72	3.165	1.4224	449.1

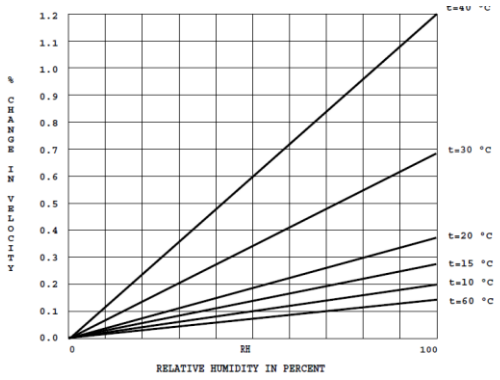

Figure 4 Relative humidity versus percentage change in speed of sound as a function of temperature.

The number of sensors depends on the length of the street and the increase of sensors increase the accuracy of the level of jam calculation but that increase the cost too, especially that consider each row of street so the distance between two sensors 7 meters because it's useless if its converge more less than [10]. To reduce the cost for the long distance in the main streets the sensors placed in convergent in the beginning of the main streets as the branch streets, then the sensors diverge as shown in Figure (5). The minimum number of sensors is four to estimate the level of jam.

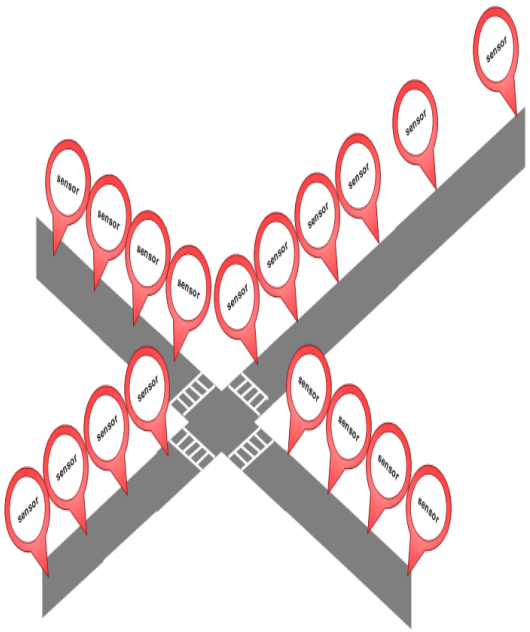

Figure 5 The distribution of the sensors on the streets

5. Procedure of the Proposed System

The proposed system consists of two modes the manual mode and the auto mode adjusted by a manual / auto switch. When the system work in the manual mode the traffic light work according to user (traffic policeman) choices using the manual control switches this mode is important, especially in the emergency that the user evaluate like a police car or ambulance, while the system be in the auto mode is determine the delay time of the traffic light according the sensors in the road by processing unit (microcontroller). The processing unit determines which road has more jam and gives it more delay time for green signal to reduce the crowd, but at the same time isn't determining the level of jam in the other road and give it the delay according to that level. Jams level displayer is a sign like a traffic light, but it's located before the road to inform the drivers the level of jam in the road so they decide to take this road or not this tool can reduce the jam too in a simple way. Jams level displayer can made like loading bar or like the street arrows that indicate to the locations its connected to processing unit that evaluate the level of jam in the roads, a flowchart of the proposed system is shown in the Figure (6).

6. Practice Model and Simulation Results

The proposed system was designed and simulated using Proteus program, as shown in Figure (7). And so the program loaded to microcontroller through the bootloader of Arduino microcontroller kit and finally the practical control system model was constructed, as shown in Figure (8). It is seen two roads with two ultrasound sensors and one traffic light for each road. Given a priority for road A, and assumed the maximum time for tracking is 5 min while the minimum time is 1 min. In probability of the jam in each road the traffic light take 5 min. The powered of the control unit is completely fed from producing power from solar cell

panel with assistance battery for dark environment. Also the solar cell is charging the battery in light environment. The experimental results obtained from a virtual two road construction as shown in Figure (9). Table (2) shows the results for all traffic cases in the two roads with the essay.

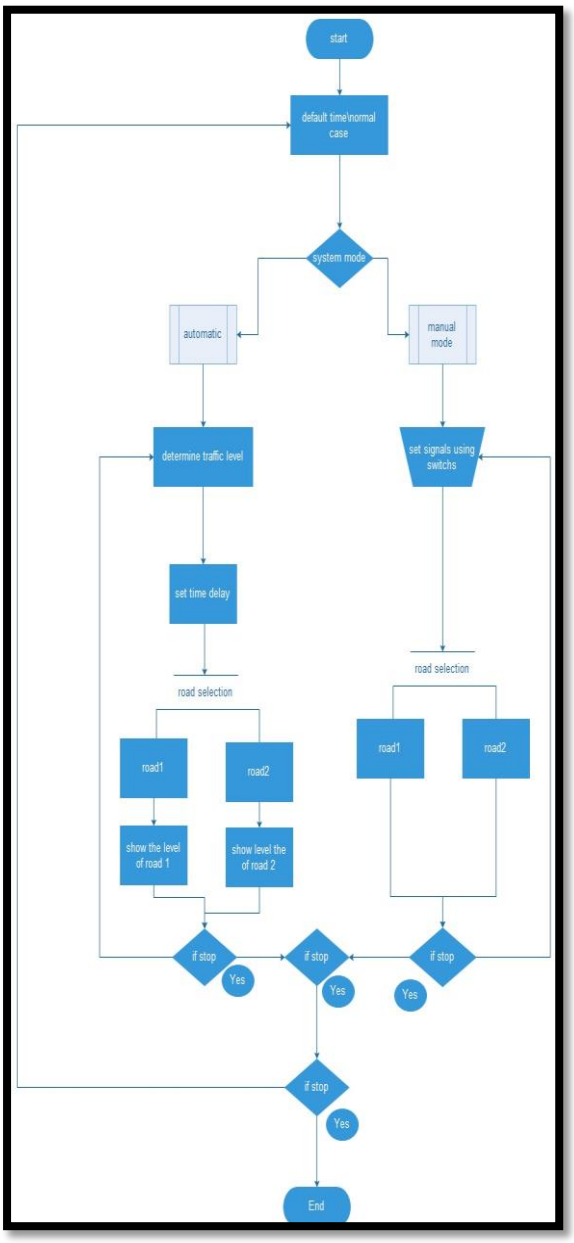

Figure 6 Flowchart of the proposed system

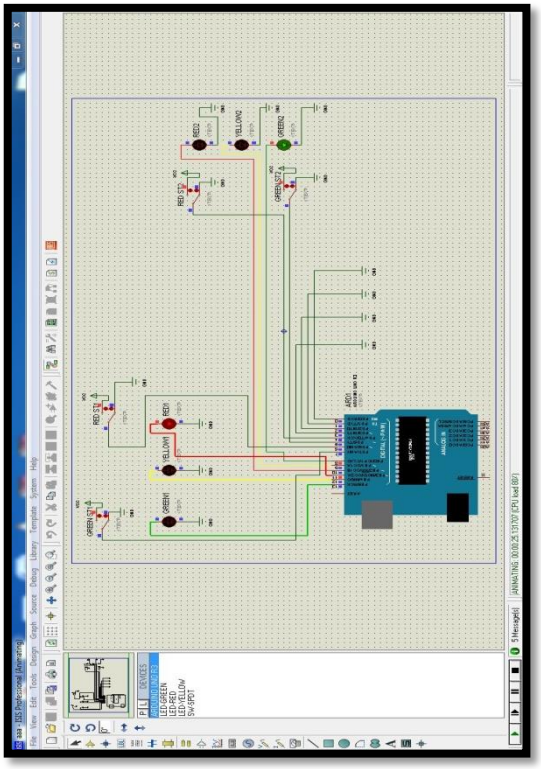

Figure 7 Simulation using Proteus program

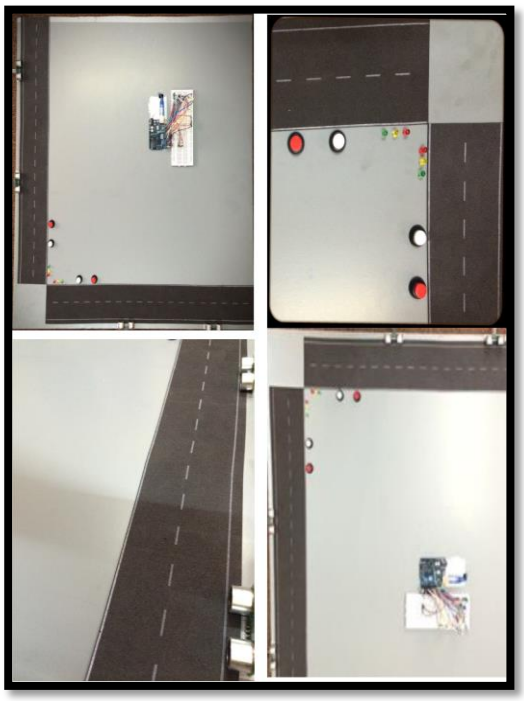

Figure 8 The practical control system model

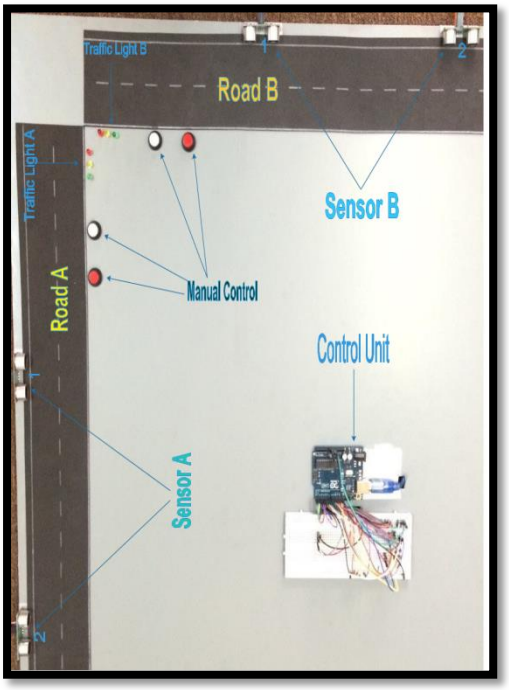

Figure 9 Virtual two road construction

7. Conclusion and Future work

This system solves the problems of crowds on the roads in the present and future because the increase of population and development generate heavy traffic in the streets. The system accuracy does not affect by humidity and temperature variation. The use of The Arduino microcontroller with ArduinoC, provide a suitable platform for implementing an embedded control system and it is possible to modify it to meet our future requirements easily and quickly. Several considerations may be achieved for future extension of this work like using GSM (Global System for Mobile Communications) to provide services to drivers, adding wireless to control the whole and send signal to jams level display, and feeding the system with solar cell to make the system independently.

Table (2) Practical Results for all Cases

Road A		**Road B**		**Traffic Lights**	
Sensor A1	**Sensor A2**	**Sensor B1**	**Sensor B2**	**Traffic (A)**	**Traffic (B)**
*	No	No	No	ON: open time	OFF
No	No	Yes	*	OFF:	ON: open time
Yes	Yes	Yes	Yes	ON: first 5 min, then Turn off for 5 min	ON: second 5 min, then turn off for 5 min
Yes	Yes	Yes	No	ON: first 5 min, then Turn off for 1 min	ON: second1 min, then Turn off for 5 min
Yes	No	Yes	Yes	ON: second1 min, then Turn off for 5 min	ON: first 5 min, then Turn off for 1 min
Yes	No	Yes	No	ON: first 1 min, then Turn off for 1 min	ON: second 1 min, then turn off for 1 min
Other Cases				Impossible	

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