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Smart traffic signal using parallel plate capacitor

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ABSTRACT

The most prevalent traffic signaling system in developing countries is the timer based system. This system involves a predefined time setting for each road at an intersection. While this might prove effective for light traffic, heavy traffic requires an adaptive system that will work based on the density of traffic on each road.In this paper, we propose an adaptive traffic intersection system where the traffic monitoring is done with the help of a parallel plate capacitor and traffic clearance at intersections will be carried out based on the density of traffic at that particular intersection. Also, traffic light at one intersection can communicate with the traffic light of the next neighboring intersections and traffic clearance will be done smoothly and adaptively without giving rise to any chaos.

KEYWORDS: Parallel plate capacitor, Adaptive system, Wireless sensor network, Traffic control.

I. INTRODUCTION

Nowadays traffic congestion in many cities around the world is severe. However, unlike a fluid, traffic flow is often affected by signals or other events at junctions that periodically affect the smooth flow of traffic. Several accident cases on traffic light have been reported in past due to poor control of traffic signal at cross roads [7]. In today's world speed is the ultimate word. Everyone is running a rat race and people definitely prefer to spend more time and utilize their energy in doing their respective professional and personal work rather than wasting both their valuable time and energy in commuting on road. This is the main reason behind accidents that people are in hurry and they do not want to waste their time waiting unnecessarily at traffic signals but instead reach their destinations and save time; and in the processthey often skip signals which result in fatal accidents especially at crossings where n intersections are meeting [1]. It is also seen that not all accidents are due to the fault of the driver of the vehicle making the accident, many a times it is due to the fault of other fellow people on the road. Suppose a vehicle has to travel a hundred miles to reach its destination via some city and on its way it has to pass through numerous intersections of city. If the traffic system at those intersections is controlled by preset timers then the vehicle will waste precious time at most intersections.Especially in case of long journey in order to save time there might arise a tendency in the driver to break the traffic intersection rule and drive even though the signal light is red [6]. This can result in accident or unnecessary chaos. Research has shown that local administrative authorities have done a study of traffic at local regional level to make smooth movement of traffic and accordingly these authorities have made traffic signals with static time limit to pass. More time is given for that intersection traffic where more traffic load is observed and this time increase or decrease in different time of day as per the traffic load to give more adaptive nature to intersections. But this work is not enough to handle traffic adaptively; hence work on reducing waiting time on traffic signal is done. A traffic intersection is shown in figure 1.

Figure 1: Intersection with heavy traffic

II.EXISTING APPROACHES

WSITMN: WSITMN is a traffic monitoring system that uses Radio Frequency Identification (RFID) tags and Wireless Sensor Network (WSN).[2] Here every vehicle is given a RFID tag and when a vehicle with a RFID tag enters the monitoring zone, the RFID reader reads the information on the RFID tag and gathers information about the traffic flow. All the data gathered are then processed and sent to the base station. The base station then compiles the data, and transmits it to the monitoring center, where all the data gathered are analyzed and a decision is taken. Here the drawback is that the main monitoring center is a centralized system and if it fails then the whole system becomes useless. This process is also a bit time taking and it is also not possible to set RFID tags on all the passing vehicles especially in developing countries like India.[3]

DIGITAL IMAGE PROCESSING: The first system proposed for adaptive signaling was based on digital image processing techniques. This system works based on the captured visual input from the roads and processing them to find which road has dense traffic. This system fails during environmental interaction like rain or fog. Also this system in testing does not prove efficient.

LASER SYSTEM: In this system the count of vehicles in each road is incremented whenever a laser which is transmitted and received at one end is blocked by a vehicle. But this method has been proven inaccurate as many vehicles would pass simultaneously which will not be detected at all.

Various sensors have been employed to estimate traffic parameters for updating traffic information. Magnetic loop detectors have been the most used technologies, but their installation and maintenance are inconvenient and might become incompatible with future intelligent Transportation systems (ITS) infrastructure. We can say that a sensor fitted in a vehicle can travel across more than one link which in turn can again be associated with more than one road. The result gathered can be accurate but having sensors in all the vehicles and also on all the roads is very costly especially when we are taking into consideration an economically developing country like India.[4][5]

III.SCOPE OF PROJECT

Every year the number of vehicles keeps increasing drastically. At this rate of growth the need of adaptive traffic system is necessary asset for a countries development. Increase in the number of vehicles tends to bring about a change in the transportation infrastructure too. This should be considered into effect while designing the system for the future. The method of counting can be done by measuring the value of change in capacitance and accordingly identifying the number of vehicles crossing above in order to improve the accuracy. Also this method can be fused with other existing methods too to account for its small inaccuracies.

By this method smooth traffic clearance is possible and involves practically no risk of failure of this system unlike WSITMN system. Thus this system prevents or at the least makes people to think twice about skipping the red light saving valuable lives and their productive time.Our precious time can be saved by this method and we can have a stress free ride. It will be a change that everyone around the world would welcome with a happy face.

IV.PROPOSED SYSTEM

In a country like India, where the economic condition is in development stage and the existing traffic signal infrastructure is non-automated and making the whole traffic signal system automated is not possible. So, the proposed idea takes this problem into account and with a partial change uses the existing infrastructure to fulfill the criteria.

The adaptive traffic signal system can do the following:

- Intelligent traffic signal system based on the volume of traffic on each side of the signal.
- Optimize the following:
- Minimize the average waiting time.
- Maximize the average number of vehicles passing through the intersection.
- Minimizing the number of accidents that occur due to red light violation.

A basic component of electrical circuits – a parallel plate capacitor which is placed under a speed breaker is used for traffic monitoring in this method. One of the basic parameters of electrical circuits is capacitance also called as condenser. This capacitance is a function of area between two plates, the separation between them and the dielectric medium in between them and the distance between the plates. In this method the distance between the plates is the variable parameter.

C for parallel plate capacitor is given by:

$$C = A(\varepsilon_o \varepsilon_r) / d \quad (1)$$

A= common area between plates
ε_0= permittivity of free space
ε_r= relative permittivity(dielectric constant of the medium)
d= distance between plates

So if one of the above three factors changes, the capacitance changes [12]. This change in capacitance can be suitably transduced into a voltage or a frequency signal.Here the plate under the speed breaker will act as the movable plate of the parallel plate capacitor and the plate attached to the ground will act as the fixed plate. The medium between the plates will be some compressible solid insulation such as nylon-66, buna etc. and it can be provided in order to increase the linearity of the transducer (capacitor). The position of the speed breaker would be around fifty meters from intersection or can be varied according to that particular area condition for best results. Whenever any vehicle moves over the speed breaker which is a movable plate of the parallel plate capacitor the weight of the vehicle will cause the movement of the movable plate.

Figure 2a: Types of speed breakers for this system

Figure 2b: Example to show the small bumped speed breakers

The above diagrams indicate the reason for choosing this type of speed breakers. The reason mainly being that the speed breaker itself shouldn't act as a hindrance for traffic. Hence low-height speed breakers are used for implementation of this project.

The movement of vehicle reduces the distance between the plates which causes a change in capacitance value. This change in capacitance can be transduced into a voltage pulse by using a suitable signal conditioning unit .This voltage signal (pulse) is then fed to the counter. The counter will count the number of pulses produced when each vehicle moves over the speed breaker from which the total number of vehicles can be determined by dividing the number of pulses by two since each vehicle produces two pulses (two tires).This counter output is given to the microcontroller which is programmed to control the traffic signal light's timings depending on the traffic density at the junctions and allows smooth clearance of traffic.

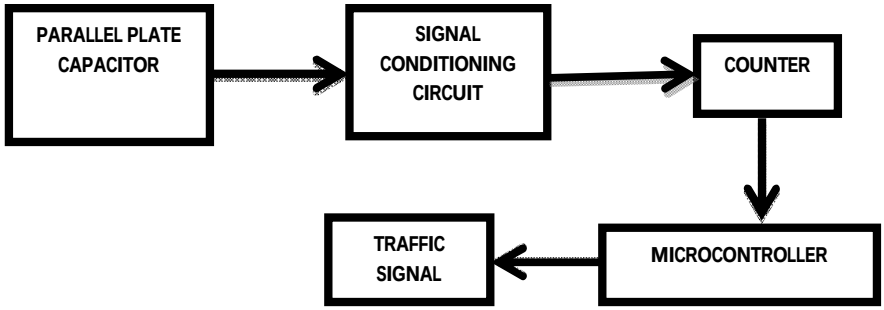


Figure 3: Block diagram of proposed system

The parallel plate capacitor acts as a sensor in this case. Its output is given to a signal conditioning unit namely a ballast circuit in this case to convert the displacement into a corresponding voltage pulse. This voltage pulse is given to a counter to visualize the number of vehicles numerically. This counter value is transmitted through a ZigBee module to the microcontroller controlling the traffic lights which modifies the signal timings depending on this count value.

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802.15.4 standard for personal area networks. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones [8] [9].

Hence this method uses already existing architecture and just needs a slight modification. It needs less maintenance and most importantly overcomes the drawbacks of the existing systems. It is not affected by any environmental conditions unlike image processing system. It is very accurate since the count is taken for each wheel rather than each vehicle and divided accordingly. Even when two vehicles pass simultaneously it is extremely rare that both the tires of those vehicles are going to be synchronous thereby assuring maximum accuracy. Many more advancements can be brought on in the future to ensure maximum accuracy.

V.EXPERIMENTAL RESULTS

The the counter part of this proposed system has been implemented successfully by us in small scale. The communicaion part of this entire scheme is going to be similar to the existing methods.The only exception is that the program will not be clearing traffic by comparing the densities in all lanes and giving priority to the lane with maximim densiy but it will be in a circular manner as present right now except that the timing for green light will change in accordance with the density at that particular lane.The complexity and efficiency of the circuits used can be improved when the project is implemented in large scale professionally.

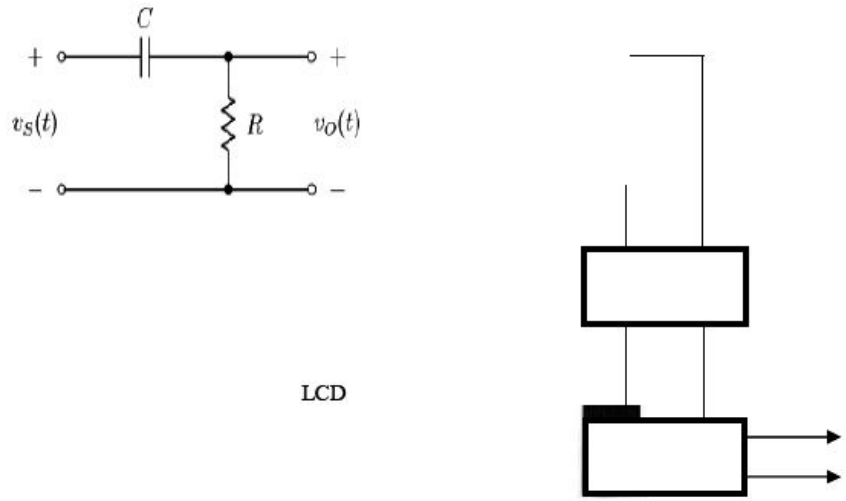


Figure 4: Counter model implementation diagram

In this implementation we used a ballast circuit (series combination of capacitior and resistor) for conversion of change in capacitance to voltage pulse. Everytime when there is a change in capacitance, a voltage pulse is produced across the resistor. This voltage pulse is given to a decade counter from which the output is displayed using a seven segment display by passing through a decoder. These values can be transmitted through zigbee module to the microcontroller controlling the traffic lights which will accommodate time for each signal depending upon this counter value.

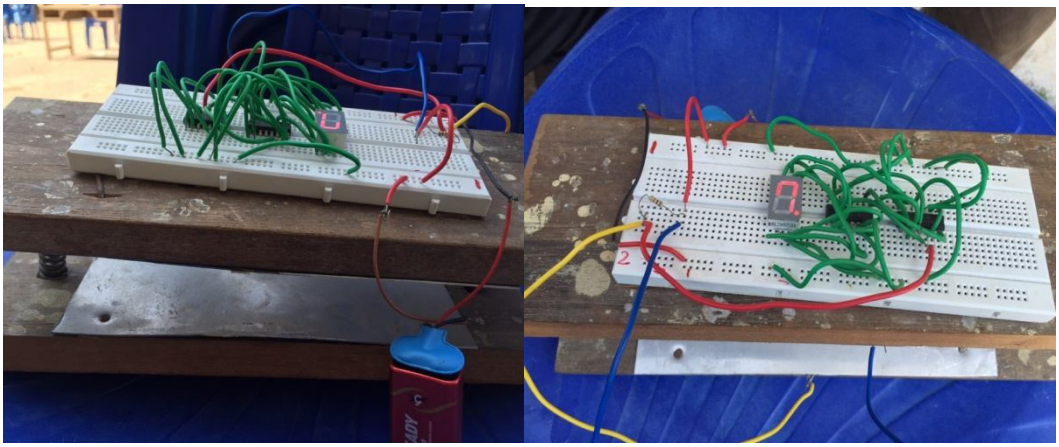
Based on the prototype that we construted the following output was obtained :-

Distance between the parallel plates at rest = 6 cm
Value of capacitance when the plates are at rest = 2.43 Pf

Table 1: Experimental results of the proposed system

S.No	Distance between the two parallel plates (cm)	Value of capacitance (pF)	Value on the LED display (count)
1	5.2	2.81	1
2	5.0	2.92	2
3	4.6	3.18	3
4	4.2	3.48	4
5	3.8	3.84	5

Note: These reading are not continuous measurements. Each reading is taken after the plates come back to their initial postion. The distance between the plates were manually adjusted (to imitate the movement of vehicles over it) to aquire readings for various cases. The dielectric medium is air and the voltage supplied is 9V.



5 (a) 5(b)

Figure 5(a), 5(b): Prototype of the counter part of proposed system

The above figure shows the practical implementation of the counter part of the proposed system. Two wires from each plate of the designed capacitor with the air as dielectric medium is given as part of a ballast circuit. The two wires across the resistors provide voltage pulses upon the displacement of the top plate. These two wires are given to the decade counter whose output is given to a decoder. Decoder provides a perceptible output via display through a LCD. The entire module is powered by a 9V battery.

VI.ADVANTAGES OF THIS METHOD:

Cost efficiency and maintenance:

- The reason why adaptive control technology is limited is due to high cost and maintenance.
- This is overcome by this method as it requires only low installation cost and very low maintenance.
- Moreover the fuel consumption is reduced too bringing about a drastic change in amount of fuel consumed adding to the cost efficiency.

The reason for using parallel plate capacitor (capacitive transducer):

- Very little displacements can also be detected. They are extremely sensitive and hence accurate. Not much affected by temperature and not affected by environmental conditions.[11]
- A resolution of 2.5 x 10^-3 mm may be obtained with this parallel plate capacitor.[10]

VII.CONCLUSION

This paper touched on key point to clear traffic smoothly based on adaptive technology depending on the density of traffic so that people can reach to their destination in least time by not stopping for long time at the traffic intersections unnecessarily by using a very cost efficient method. Traffic intersections will be smart enough to take care for flow of traffic if there is any emergency purpose vehicle need to pass on and in normal condition, traffic intersection will work normally as discussed in earlier paper. A practical implementation of this paper has been done to grass root level and optimization can be done accordingly in the future on further research.

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