Realtime Adaptive Traffic System

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Abstract – Existing traffic control circuits deploy fixed time intervals between Red and Green signals. Such a disregard to traffic severity is often the root cause for slow moving traffic and prompts the need for manual labor. The vision of the project is to decongest a four-way junction road traffic in real-time. The number of vehicles on a lane is estimated by a Piezo-electric sensor which is self-powered. The data collected is in terms of potential difference developed by the sensor when a vehicle treads over it. This data is then referred to allot a signal time-frame dynamically by deploying a suitable algorithm. Another inclusive feature of this project is to the Emergency Vehicles using RFID technology to facilitate quicker decongestion of the lane with the emergency vehicle. To show a simulation of the proposed system, an Arduino board will be used to simulate data identical to the Piezo-electric sensor, and the traffic signal circuit which triggers signals dynamically is also built upon an Arduino board, the time frame for which is generated by using the decongestion algorithm.

Index Terms – Piezoelectric Sensor, RFID, Arduino, Decongestion Algorithm.

1. INTRODUCTION

The traditional road traffic circuit system does not give regards to the traffic intensity. Irrespective of whether there is less number of vehicles or severe congestion, the time-frame allotted for the Red and Green signals are same at a given junction. Such a traditional design leads to inefficiency in extreme traffic situations and mandates the presence of the traffic police. If there are very less vehicles on a lane, a green signal duration of, say 60 seconds, will be too much and on the other hand when a lane is severely congested, the same time-frame may be too little. It is also possible for a junction with more than two leading roads to have different traffic-severity levels in each of them. In such cases, the need for dynamic traffic signal time frame becomes more prominent as the road traffic is cleared by allotting exactly the required time duration based on severity on each lane.

Another feature that needs to be implemented in existing traffic system circuits is the need to detect emergency vehicles and enable them to reach their destinations faster. An emergency vehicle stuck in severe traffic is made to wait longer, as a result of which a life that can probably be saved, is lost. There is also the aspect of wastage of fuel and time. Heavy traffic congestion on roads increases pollution and heat.

As an effort to resolve such difficulties, a road traffic system that efficiently allocates signal time-frame based on traffic severity and gives priority to emergency vehicles is proposed. This system counts the number of vehicles in a lane using a Piezo-electric sensor (which is a self-powered sensor) which serves as an input. A Decongestion Algorithm uses this input to allot appropriate signal time-frame. The system takes in the input when a lane is allotted Red signal. After every Red and Green signal, an Yellow signal is issued for 5 seconds.

2. RELATED WORK

The recent increase in motorization is the main reason behind the frequent traffic congestion and improvement in the field of intelligent traffic systems. Even though many solutions had been put forth to resolve the issue, a lot of them used static time frames which cannot meet the demands of the dynamic traffic flow. The models for real time traffic management has increased in complexity through the years.

In [1] Tarik M. Hussain, Ahsen M. Baig, Tarek N. Saadawi and Samir A. Ahmed developed a system that uses infrared sensors to sense vehicles passing through its field of view, which in conjunction with computerized signal processing and correlation techniques was used to count the number of vehicles passing and compute their speed and length. Further field tests proved the system to be cost effective, weather resistant and have the potential for a variety of sophisticated traffic monitoring applications.

In [2] Rajeshwari Sundar, Santhoshs Hebbar and Varaprasad Golla proposed an intelligent traffic control system to pass emergency vehicles smoothly. In the proposed system,individual vehicle is equipped RFID tag which makes it impossible to remove or destroy. An RFID reader is used to count the number of vehicles that passes on a particular path during a specified duration. It also determines the network congestion, and hence the green light duration for that path. If the RFID-tag-read belongs to the stolen vehicle or Emergency vehicle, the corresponding information is sent to the control room and the time duration is changed as per.

In [3] Aman Dubey, Akshdeep and Sagar Rane introduced Beagle Bone Black/Rasp Pi to the traffic light system which provides numerous customizations to turn a traditional traffic light into a smart one. To control traffic at road intersections, system containing microcontroller is established on traffic light. Image processing algorithms, such as Haar Cascade and Background Subtraction are used to control timer. The real-time traffic image, traffic density and other statistics will be sent to server. The data can be broadcasted from server at any time on demand through digital solutions.

In [4] F.Andronicus, Maheswaran proposed a system that uses a CMOS image sensor to detect an Ambulance vehicle, the captured video is processed by Digital Image Processing using Matlab software based on a ripple algorithm. The ripple algorithm uses the templates of an ambulance from the number of frames abstracted from the input video. Then thresholding and Template matching is done and output is sent through UART to ARM processor where traffic lights can be controlled.

In [5] Leena Singh, Sudhanshu Tripathi, Himakshi Arora developed an "intelligent" system makes "real-time" decisions as to whether to extend green time for a set of signals. The model is developed using genetic algorithm implemented in MATLAB. A traffic emulator is developed in JAVA to represent dynamic traffic conditions. The emulator conducts surveillance after fixed interval of time and sends the data to genetic algorithm, which then provides optimum green time extensions and optimizes signal timings in real time.

3. SYSTEM DESIGN

The number of vehicles in each lane is estimated using a piezoelectric sensor which is self-powered. This data is processed to calculate time-frame for each lane, which is sent to the Relay Unit. If an emergency vehicle is present on any lane, the RFID sensor kept at a distance of 100M senses the RF waves sent by the emergency vehicles. An alert is issued to the control system and an over-ride function blocks the Severity-based Clearance Unit and transfers control to the Priority-based clearance unit. This unit controls the Relay till the emergency vehicle passes through the junction. When RF Waves are no longer sensed, the control unit transfers the control to the Severity-based Clearance Unit and appropriate time-frame is passed to the Relay, which sends countdown and power to the Output Unit. After each iteration, the relay sends a feedback to Raspberry Pi and the whole process repeats.

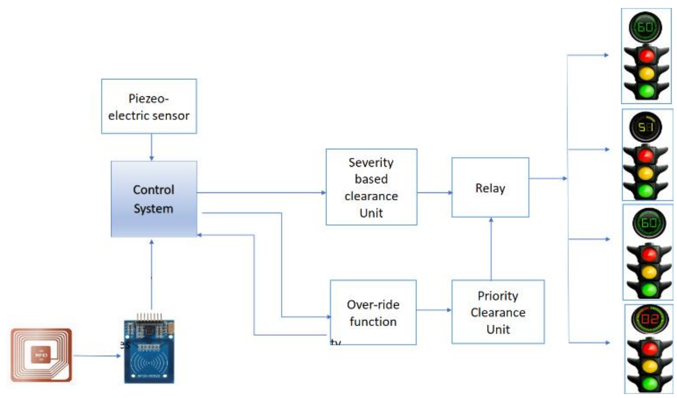

Fig 1: System Architecture

4. MODULES

A. INPUT CONTROLLER

The input module consists of a piezo-electric sensor which estimates the number of vehicles in each lane. This data is given to the control unit. The RFID sensor is placed for the purpose of detecting RFID tags which are present in emergency vehicles like ambulances and fire engines. When an emergency vehicle is present in the lane the RFID reader placed in the traffic signal reads the RFID tag of that emergency vehicle and sends it to the control system. The RFID tag is optimally placed at a range of 100m (threshold range) to enable its detection.

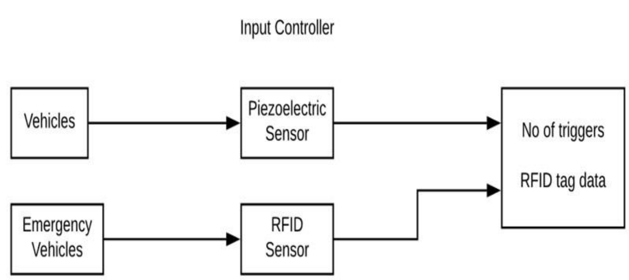

Fig 2: Input Controller

B. CONTROL UNIT

The control module consists of the control unit which further consists of the severity-based clearance unit, the override function and the priority-based clearance unit. The severity-based clearance unit handles the processing of the traffic signal duration based on the data derived from Google Maps. The input data from the Piezoelectric Sensor is used as a factor to determine the traffic intensity. The traversal time is prioritized from highest to lowest. For each of the lanes prioritized, a traffic signal duration is set.

The above durations set by the severity-based clearance unit is governed by a time quantum above which the duration cannot exceed. This forms the basis of the dynamic traffic system where the signal duration is fixed based upon the traffic intensity. The detection of an RFID tag implies an incoming emergency vehicle like an ambulance or fire engine. This detection shifts control from the severity-based clearance unit to the override function.

The primary responsibility of the override function is as follows. When the detection takes place, all the other lanes except the lane of the emergency vehicle is paused. The situation which is most likely to present itself during the detection is that there is going to be a substantial amount of vehicles which is still in transit at the junction. Also, the vehicles ahead of the emergency vehicle must be cleared in order to tidy up its pathway.

Therefore, a buffer time is set based on the number of vehicles to be cleared off at that instance which is also governed by a time quantum. This enables the pathway to be cleared for the emergency vehicle and thus enables it to pass through the junction without any hassle. The control then shifts to the priority-based clearance unit which governs the passage of the emergency vehicle. Once the emergency vehicle passes through the junction, the control shifts to the severity-based clearance unit which resumes normal operation.

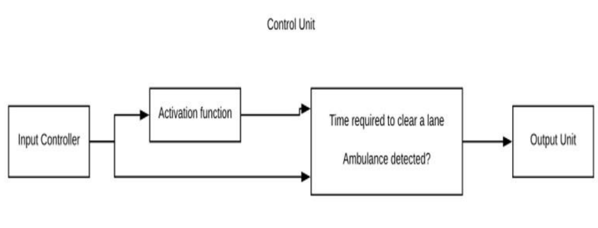

Fig 3: Control Unit

C. DECONGESTION ALGORITHM

The number of vehicles (n) is calculated from the input from piezoelectric sensor (x). With the assumption that no multi axle vehicle is permitted on the road.

$$n = \frac{x}{2}$$

Max wait time (mwt) and max no of vehicles (mnv) is set. The wait time for lane change (wlc) is calculated as

$$\text{wlc} = \frac{n * mwt}{\text{mnv}}$$

This wait time is calculated for each lane and prioritized by:

i. Lane with highest wlc is given highest priority.

ii. The above condition is overridden if a lane has not been opened for more than the acceptable wait time (awt) and it is prioritized first.

iii. Both the above condition is overridden if an emergency vehicle is detected in a lane, then that particular lane is opened and all other will be closed until the emergency vehicle passes through

D. OUTPUT UNIT

The output module consists of the relay circuit which reflects the processed data in the preceding modules onto the display unit. The display unit consists of the traffic lights and the countdown display. The traffic lights are controlled in parallel with the countdown display. When a particular lane is considered for traffic clearance, the relay unit toggles the green lights for that lane and subsequently toggles the red light for the other lanes.

Also, the time duration of traffic clearance is shown. When an emergency vehicle is detected, the override function enables the commencement of the buffer time which enables the ambulance to pass through. This buffer time is displayed on the countdown display which is toggled by the relay unit. Therefore, the output module is the acting interface which is visible to the outside environment. It reflects the processed data from the preceding units onto the signals and display in a robust and accurate mechanism.

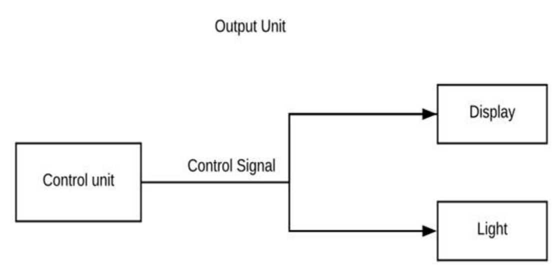

Fig 4: Output Unit

5. EXPERIMENTATION RESULTS

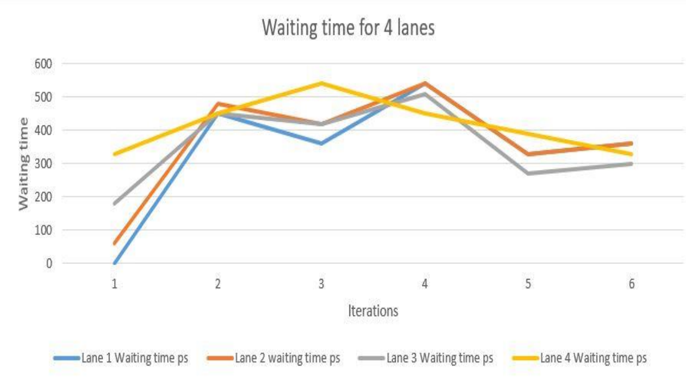

Fig 5: Waiting time with respect to the 4 lanes for 6 iterations

Fig 6: Comparison between existing and proposed system of waiting time for Lane 1

Fig 7: Comparison between existing and proposed system of waiting time for Lane 2

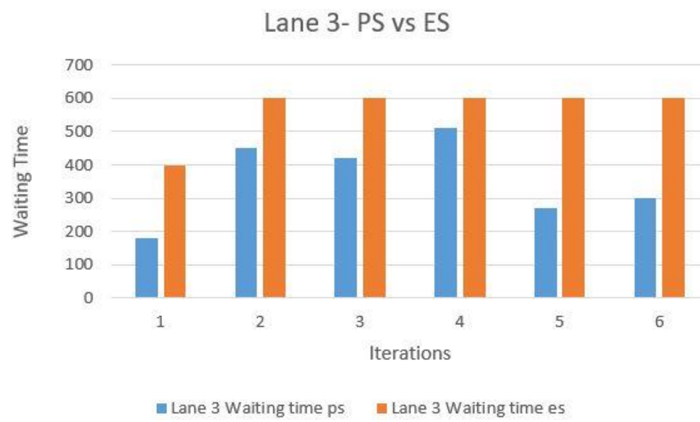

Fig 8: Comparison between existing and proposed system of waiting time for Lane 3

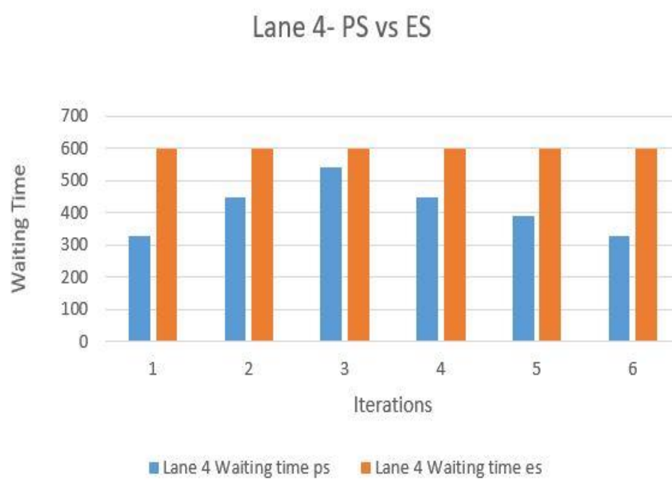

Fig 9: Comparison between existing and proposed system of waiting time for Lane 4

The above analysis is done on a sample scenario. A four way junction whose traffic is decongested using a traffic signal is considered. A comparison is drawn between the existing system and proposed system. The existing system involves the traffic signal duration to be fixed. A typical traffic signal takes about 200 seconds dedicated for each lane. On the other hand, the proposed system involves a dynamic signal duration setup based on the traffic intensity. The range of values of the signal duration ranges between 60 to 180 seconds from lowest to highest traffic intensity.

Fig 5 represents the variation of the waiting time for each iteration for all the four lanes. Fig 6, 7, 8 and 9 represents the comparison between the waiting time of lanes 1-4 in the proposed and existing system. The above results implies that the proposed system is more efficient in minimizing the waiting time in comparison to the existing system.

6. CONCLUSION

This system can further be enhanced by implementing machine learning which would reduce the commute time of the vehicles using the road containing the dynamic traffic system. Further, by taking into consideration the human intensity (pedestrians waiting to cross the road) the system would become more ideal for pedestrian's and commuter's travel.

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