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Intelligent Traffic Controller using Fuzzy Logic

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Abstract:
A metropolitan city cannot become smarter unless the traffic control problem is eradicated right through its core. This system is capable of providing important information regarding traffic density around various traffic junctions which would aid in reducing the travel time for the citizens as well as reducing the potential traffic jam problems. This paper proposes an intelligent traffic management system using WSP (Weight Spreadsheet Pad) technology, Fuzzy Logic Controller and PIC controller. Using WSP technology, this system collects necessary data regarding the traffic density at particular traffic nodes. The density is calculated by taking speed as well as the weight of the car into consideration, in order to find the number of cars at a particular junction. This data is then forwarded to FLC's (Fuzzy Logic Controller) where it manipulates data and carries out various algorithms based on the density data. After the necessary manipulation, the output received is then forwarded to PIC microcontroller which takes care about the timing of traffic signals. By placing WSP at every junction and monitoring the number of vehicles present at the junction, it is possible to make traffic very smooth. However, absolute advantage of such a system will only be felt if every junction in a city is controlled by this system.

Keywords: WSP (Weight Spreadsheet Pad), Fuzzy Logic Controller, PIC Microcontroller**.**

I. INTRODUCTION

India, a country with over 1.2 billion population has to deal with this problem. 40 percent of the India's population resides in urban area that means more than 440 million and it's a huge number. Even 4 of the top 12 densely populated cities in the world are in India. Car traffic is a serious issue. Traffic signals in India works on the specific allotted time which is constant throughout its period. Due to this, India faces a lot of traffic problem and the traffic signal has to be shut down. Traffic police have to do a lot of manual work in the polluted region making them unhealthy. In metropolitan cities of India, most of the working units come in their own car from other nearby cities. In morning the rush is for cars which are coming in city and in evening vice versa. In this technical paper, we provide you solution for this problem and help India to develop at a fast rate by making people reach their destination at correct time with no delay and make their all hard work a stone to pile up a development wall.

II. WEIGHT SPREADSHEET PAD(WSP)

WSP is a weight pad used to calculate the weight present on it. The main reason it offbeat others are its unique positional weight scaling system. WSP calculate weight at each point and this can be used for counting the number of cars present in the lane. For a car with 4 tires, the overall weight of the car is distributed across its all 4 tires and from this we can categorize it such as sedan, hatchback, etc. We can suppose the length of WPS be 500m. With the help of WSP, we can calculate the speed of car moving through it.

This can be done by calculating the distance of weight pressure point moving across the WPS. The distance travelled by a car in a unit time will be assigned by its speed by Controller. WSP makes us able to calculate the number of cars in the lane by counting the number of different weight points with different weight travelling in different speed as well as acceleration.

Number of cars on WSP is calculated by:
D=greater of (W or S)
Where,
W is the number of wheels with unique weight and
S is the number of wheels with unique speed.

III. FUZZY LOGIC CONTROLLER

The number of detected vehicles is sent to the controller which acts as the brain of the system. The capability of the system to cater inexact data and produce a unique output for each scenario forms the basis of operation. In order to maximize the depth of input acquisition, six fuzzy membership functions have been incorporated [1]. Their relationships have been defined in the form of 'if else' statements in the fuzzy inference system. A total number of 30 rules have been defined which include all possible scenarios for each traffic signal.

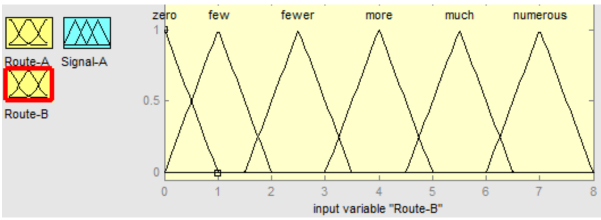

Figure.1. Input Fuzzy Membership Functions

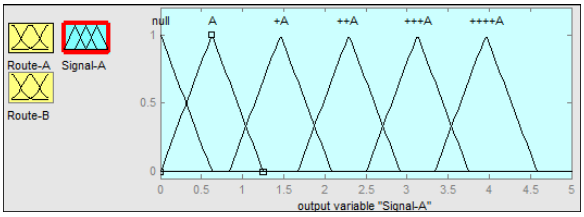

Figure.2. Output Fuzzy Membership Functions

1. If (Route-A is light) then (Signal-A is +A) (1)
2. If (Route-A is lighter) then (Signal-A is +A) (1)
3. If (Route-A is high) then (Signal-A is +++A) (1)
4. If (Route-A is medium) then (Signal-A is ++A) (1)
5. If (Route-A is higher) then (Signal-A is ++++A) (1)
6. If (Route-A is nothing) then (Signal-A is null) (1)
7. If (Route-A is light) and (Route-B is few) then (Signal-A is +A) (1)
8. If (Route-A is lighter) and (Route-B is fewer) then (Signal-A is +A) (1)
9. If (Route-A is high) and (Route-B is more) then (Signal-A is ++A) (1)
10. If (Route-A is medium) and (Route-B is much) then (Signal-A is +++A) (1)
11. If (Route-A is higher) and (Route-B is numerous) then (Signal-A is ++++A) (1)
12. If (Route-A is higher) and (Route-B is few) then (Signal-A is +A) (1)
13. If (Route-A is higher) and (Route-B is fewer) then (Signal-A is ++A) (1)
14. If (Route-A is higher) and (Route-B is more) then (Signal-A is +++A) (1)
15. If (Route-A is medium) and (Route-B is few) then (Signal-A is ++A) (1)

Figure.3. Fuzzy Inference System Rules

The concept of extension of signal operation time provides longer green light intervals for routes with a greater amount of traffic [2]. The testing and functioning of the system has been carried out on a scaled down version of the whole set up, therefore, overall number of the vehicles has been kept to minimum.

S/No.	Number of Vehicles	Output Time (s)
1	1-3	5
2	4-5	10
3	6	15
4	7	20

Figure.4. Projected Resultant Output Time according to Different Inputs

IV. MICRO-CONTROLLER

The fuzzy logic controller is then followed by the PIC 16F877A microcontroller which manages the traffic lights according to the data it receives from the controller. The main role of the microcontroller is to serially receive and manipulate the data from the controller and carry out particular actions [3]-[5]. For instance, when the input to the microcontroller denotes that there are six vehicles, the output from the microcontroller is 15 seconds. Moreover, the microcontroller also ensures that the green light of the traffic signals operates in alternate manner. Real-time functioning of the set up takes into account the traffic conditions only when the microcontroller is held at its default state which is during no operation of any signal [6]. The logic used in programming of microcontroller and the overall set up has been given in Figure 5. This figure shows the overall logic used for the whole system where two main stages of Simulink and microcontroller are involved.

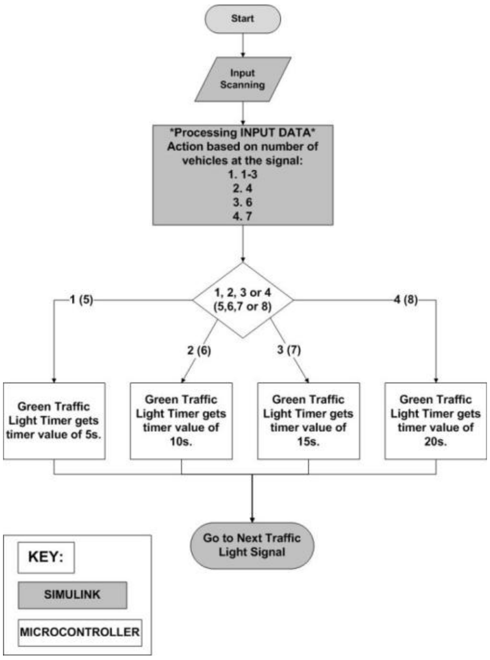

Figure. 5. Traffic Signal Operation

V. RESULTS AND DISCUSSIONS

The results are obtained from a specially made prototype shown in Figure 10. And they are compared to that of standard versions of traffic light operations. Such basic systems usually have pre-defined timing values [7]. Here the results show that there is an improvement of approximately 26% in overall performance as compared to the conventional traffic controller as shown in Table 1. This is based on a T-junction which includes only a single pair of traffic signals. The fuzzy inference system algorithm also offers the flexibility of prioritizing particular routes where the preference is given to the traffic on main route in relation to other participating routes [8].

Table.1. Results of Comparison between Conventional Traffic Controller and Intelligent Fuzzy Logic based Traffic Controller

Signal A No. of cars	Signal B No. of cars	Signal A Single operation time CTC (s)	Signal B Single operation time CTC (s)	Signal A Single operation time IFLTC (s)	Signal B Single operation time IFLTC (s)	Conventional Traffic Controller (CTC) (s)	Intelligent Fuzzy Logic based Traffic Controller (IFLTC) (s)
5	2	15	15	15	5	30	20
2	7	15	15	5	20	30	25
6	6	15	15	15	15	30	30
7	0	15	15	20	0	30	20
3	6	15	15	5	15	30	20
5	7	15	15	10	20	30	30
2	2	15	15	5	5	30	10
Total No. of cars	Total No. of cars	Total Time (s)	Total Time (s)	Total Time (s)	Total Time (s)	Total Time (s)	Total Time (s)
30	30	105	105	75	80	210	155

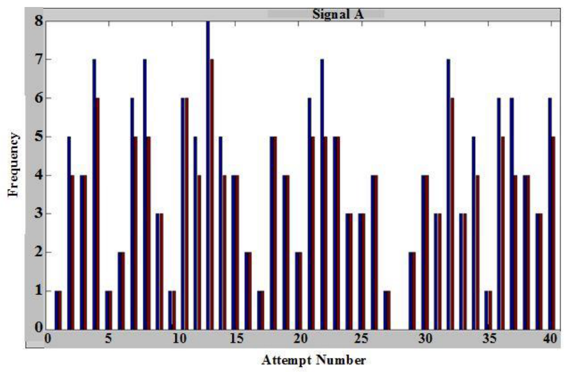

Figure.6. Output Trends between Practical and Expected Values for Signal A

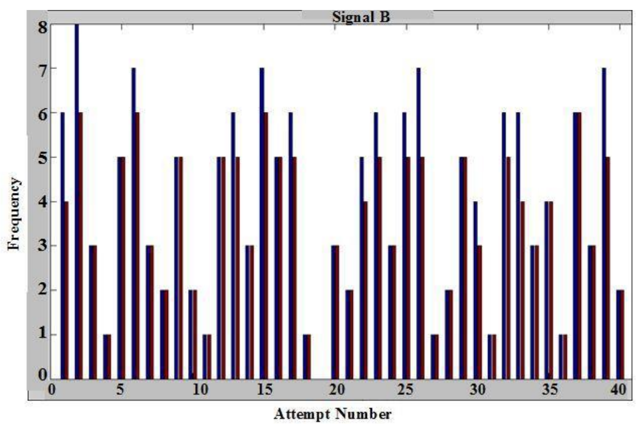

Figure.7. Output Trends between Practical and Expected Values for Signal B

The comparison of each route has also been tested separately and the time taken in each cycle to manage a given random number of vehicles by each traffic signal is represented in form of bar charts as shown in Figure 6 and Figure 7 [8].

VI. FIGURES AND TABLES

Variable	Expression	Equation
Vehicle Point	Presence or absence of vehicle on a roadway	N/A
Flow Rate	Number of vehicles passing through a certain point of a road	Q=N/T Where, Q = Vehicles/hour passing over detector N = Number of vehicles counted by detector during time period, T T = Specified time period, in hours
Occupancy	Time occupied by a point on a road by vehicle	$\theta = \frac{100}{TL}\sum_{i=1}^{N}(t_i - D)$
Speed	Distance traveled by a vehicle per unit time	
Density	Number of vehicles per lane mi (km)	$Q = K\overline{U}s$ Where: Q = Volume of traffic flow, in v/hr K = Density of traffic flow, in v/mi Üs= Space-mean speed, in mi/hr While density is an important quantity in Traffic flow theory, most traffic control systems do not use this parameter directly for implementing flow control. Density (K) may be directly computed from count and speed measurements by $K = \left(\frac{1}{T}\right)\sum_{i=1}^{N}\left(\frac{1}{V_i}\right)$ Where: N = The number of vehicles detected during time, T Vi = Speed of vehicle i crossing a detector in a lane K = Density of detected lane [6].
Headway	Time spacing between front of successive vehicles, usually in one lane of a roadway	Time difference between beginning of Successive vehicle detection [7].
Queue Length	Number of vehicles in lane	N/A

VII. CONCLUSION AND FUTURE WORK

An architecture for creating a smart traffic management system, effective management of vehicle transport is presented. An adaptive fuzzy traffic signal time manipulation algorithm based on a new traffic infrastructure using WSP and PIC microcontrollers is proposed. This system is believed to play a major role in removing the congestion problem and the major flaws in the traditional traffic control system. In future, the information gathered from the system can also be stored in database to keep us in track of the traffic information which is beneficial for security and pedestrian management.

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