International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 2 Ver. VI || February 2018 || PP. 42-45

I-TLS (Intelligent Traffic Light System) By Anatomizing Traffic Density

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ABSTRACT: *Traffic congestion is emerging as one of the most prominent problems globally, which leads to fuel waste, environmental pollution as well as long and unpredictable commute times. This paper recommends that the main reason for traffic congestion is the use of hard-coded traffic light system that generates fixed length signal timings and to enhance the working of traffic light system a model "I-TLS", having two modules is proposed hereby, which aims to optimize the green light signal timings thereby reducing the traffic congestion. Taking into account a four-lane intersection, as a part of first module an ultrasonic sensor hc-sr04 is placed on each of the lane and with the use of Arduino Uno the traffic density for that lane is identified. The second module is FIS where firstly, the classification of this traffic density into three categories: high, medium, low is performed. And then, a fuzzy algorithm is designed to elongate the green light timing for lane having a higher density, downscale it for the lane having a lower density whereas avoid its allocation to the empty lane and this is developed in SIMULINK environment of MATLAB .*

KEYWORDS-*Arduino Uno, fuzzy inference system, green light optimization, green light timings (GLT), I-TLS (Intelligent Traffic Light System), traffic density, ultrasonic sensor.*

Date of Submission: 14-02-2018 Date of acceptance: 03-03-2018

I. INTRODUCTION

Road transport is comparatively cheaper and much preferred mode of transportation in India and according to a data published by government by 31st March of 2015 the total road network in India estimated to be 5.4 million kilometers. Surprisingly, a research conducted by Calcutta University's Centre for Urban Economic (CUES) on only 10 roads of Kolkata, has found that commuters cumulatively lose over Rs. 74,000 in just 2 hours of traffic jams in the city, which sums up to a loss of Rs. 2.7 crore a year and on the other hand, a news published by Times Of India on 31st May of 2012, says that India loses Rs. 60,000 crores due to traffic congestion. While, the road transport plays a vital role in the economic development of the nation the traffic congestion proves to be a barrier.

Traffic signal can be considered as a key component for transportation network management and so to overcome the globally emerging problem of traffic congestion, improvisation of traffic signaling is must. Hereby, we propose "I-TLS", the model that makes use of the density on the road and instead of pre-set or hard-coded traffic signal timings, it allocates green light timings (GLT) based on the degree of density such that for the lane having higher density the green light stays longer than the one having lower.

The core of this system lies in the second module FIS i.e. the Fuzzy Inference System, wherein the data collected in the first module are used to generate the GLT. Fuzzy logic computes the output based on the "degrees of truthfulness" rather than simple true or false and so here it takes the density categorized as low, medium and high which is based on the defined ranges and accordingly GLT is allocated.

II. IDEOLOGY DEPICTION

2.1 Analysis of traffic density

The fig. 1 illustrates the overall working of the system. It can be seen that the total length of the road is divided into three parts, which acts as a range for distinguishing the density as low, medium or high. The density on each lane is sensed by using an ultrasonic sensor hc-sr04 placed at its end and is identified using Arduino Uno. Now the length identified as density is forwarded to the fuzzy logic controller, where the density's category (low-medium-high) is recognized based on the rules that contain the ranges as parameters. And with the use of membership functions appropriate green light timings are allocated rather than the predefined signal timings in the traditional traffic light system.

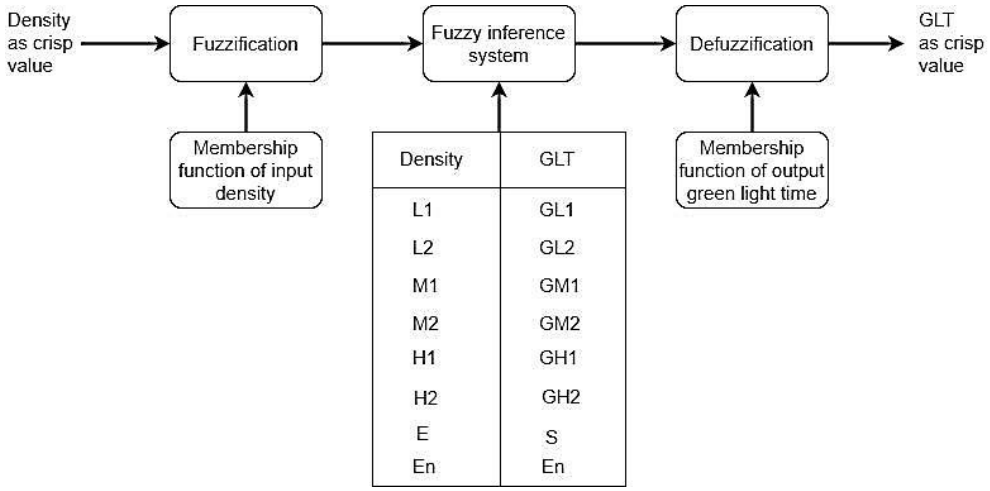

Figure 1. Fuzzy inference system

2.2 Fuzzy inference for traffic light controller

FIS is a three-step process. Providing appropriate output for the given input the steps are namely: "Fuzzification", "Rule Evaluation" and "Defuzzification". The fuzzy inference System for traffic light controller is illustrated in the fig 2.

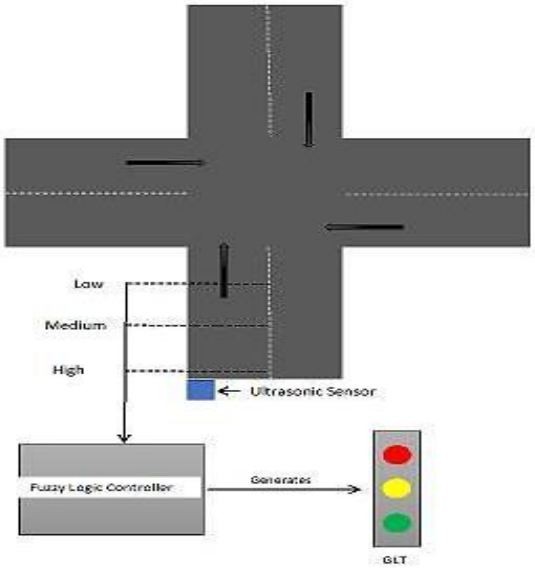

Figure 2. System architecture

2.2.1. Fuzzification

The first step in FIS is fuzzification, which involves transformation of crisp inputs into fuzzy inputs. Here, the crisp input is density, the exact input measured by sensor and passed into fuzzification system for processing. For the processing to be conducted by the FIS, density has its own group of membership functions. Membership functions of input density are designed between the range of 0-105, and are divided as: Empty (E), Low1 (L1), low2 (L2), medium1 (M1), medium2 (M2), high1 (H1), high2 (H2), and end (En).

2.2.2. Fuzzy rule evaluation

Fuzzy rule evaluation, the next step in the process that takes the density value from the previous step and performs decision making task with the use of fuzzy rules. It consists of a series of IF-THEN rules. The decision structure consists of rules that familiarize it with the system and its operations. Hereby, we define eight rules to meet the demands of an efficient Fuzzy Traffic Controller.

2.2.3. Defuzzification

Defuzzification involves transforming the fuzzy outputs to crisp outputs. Several methods are available for defuzzification like Centroid method, Centre of Sum method and Mean of Maxima method, herein the Centroid method is utilized. It converts the fuzzy output value (GLT variable) into a crisp value and here green single timing in seconds is obtained, which shows that fuzzy value is converted to numerical value.

III. SIMULATION RESULT AND DISCUSSION

For generating the simulated version of the traffic control system, MATLAB Update 2016a is used. The green light signal timings(in seconds) are obtained with the use of SIMULINK toolbox/environment of fuzzy traffic controller, which shows a linear increment in the green light time for increasing values of the traffic density. This result is based upon the feature that one of the features of Simulink that it can be used to explore the behavior of a wide range of real-world dynamic systems. When traffic density (0-105 unit) is varied within its full range, green light time also varies within its full scale (0-90 seconds). Thus, the simulation result shows linearity between inputs applied to the Fuzzy Inference System and output drawn from it; with this the optimization of green light timing is also achieved.

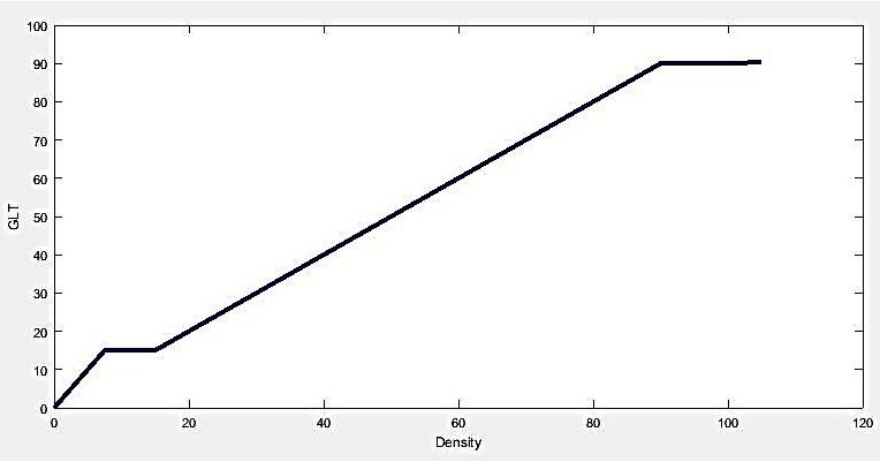

Figure 3. Result analysis

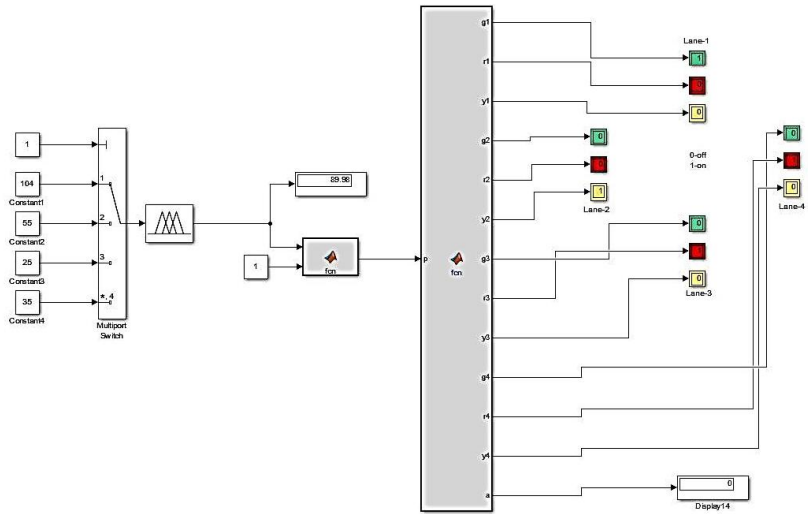

Figure 4. Simulated Fuzzy Traffic Signal Controller.

IV. CONCLUSION

To overcome the inefficiencies of conventional traffic light system that makes use of hard-coded signal timings, "I-TLS" developed in SIMULINK environment of MATLAB, uses the Fuzzy Inference System that allows the system to generate appropriate green light timings based on the input density and thereby results into green light optimization

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International Journal of Engineering Science Invention (IJESI) is UGC approved Journal with Sl. No. 3822, Journal no. 43302.

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