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Development of Intelligent Traffic Control System by Implementing Fuzzy-logic Controller in Labview and Measuring Vehicle Density by Image Processing Tool in Labview

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Abstract

In this paper, we have described a whole new approach of rationalization of existing traffic control systems by means of Fuzzy logic based control system and Vision sensors based vehicle counting method. As Conventional traffic control systems are inefficient because they provide fixed time-delay though no vehicle is present in that lane. So it results in congestion of vehicles on the adjacent side. And it generates the Noise and Air pollution, which is undesirable and not favorable. In an Intelligent traffic control system (ITCS), vision sensors will measure the number of vehicles on arrival as well as on queue side, and fuzzy logic rule based system will provide the rational time-delay, which is dependent on vehicle density on both arrival and queue side. So it will give zero delays if no vehicle is present in that lane. So ITCS works with intelligence given by the Fuzzy logic system.

Keywords: Fuzzy Logic; Vision Sensor; Rationalized Delay; Adjacent; Rule.

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1. Introduction

Vehicle congestion at the cross junctions is a recurring problem around the world. And as a Developing Country, all major cities of India are facing this problem acutely.

This is because Infrastructural and technological development are slow compared to growth in a number of vehicles, due to space and cost constraints. Many of developed countries have adopted the technology of intelligent traffic control systems (ITCS) to overcome vehicle congestion problem. But for India, it is not easy to go with ITCS straight away. Because Indian traffic is non-lane based and chaotic in comparison with western traffic, so vehicle sensing method used must be able to count all present vehicles. For that purpose, I have used Cameras, which will give the continuous surveillance of crossroads. These signals from Cameras will go to LabVIEW software through USB interface. LabVIEW will process these Images based on Image processing tools. And it will give numbers of vehicles present on arrival and queue side.

So by utilizing image processing technique we can count the actual numbers of vehicles in all ambient conditions without any error. Once vision sensor gives the numbers of vehicles the Fuzzy control logic implemented in LabVIEW generates the rationalized time delay needed on that particular lane [3]. So time-delay will be varied based on a number of vehicles present on queue side as well as on arrival side. Unlike the conventional traffic control system which gives fixed amount of time-delay based on vehicles present on that lane only, so it results in vehicle congestion on the adjacent side.

This creates the Noise and Air Pollution, and fixed time-delay emission resulted from combustion of fuel pollutes the air and horns of vehicles generate the noise. In an Intelligent traffic control system (ITCS), we have varying time delay according to the density of vehicles at the cross road.

Hence the efficiency will increase. By this system, if fewer vehicles are present, then ITCS will give less delay. Thus, unnecessary time at the signal will be saved. Overall, It is time saving, noise reducing, pollution reducing and innovative technique.

2. Concept of Fuzzy Logic

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth -- truth values between "completely true" and "completely false" [2]. We can design the rules based on fuzzy Logic and the Fuzzy Logic will calculate the weight of the rules and accordingly it will generate the time delay [7].

Fuzzy Logic (FL) incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically [6]. The FL model is empirically-based, relying on an operator's experience rather than their technical background.

2.1. Architecture of Fuzzy logic Controller

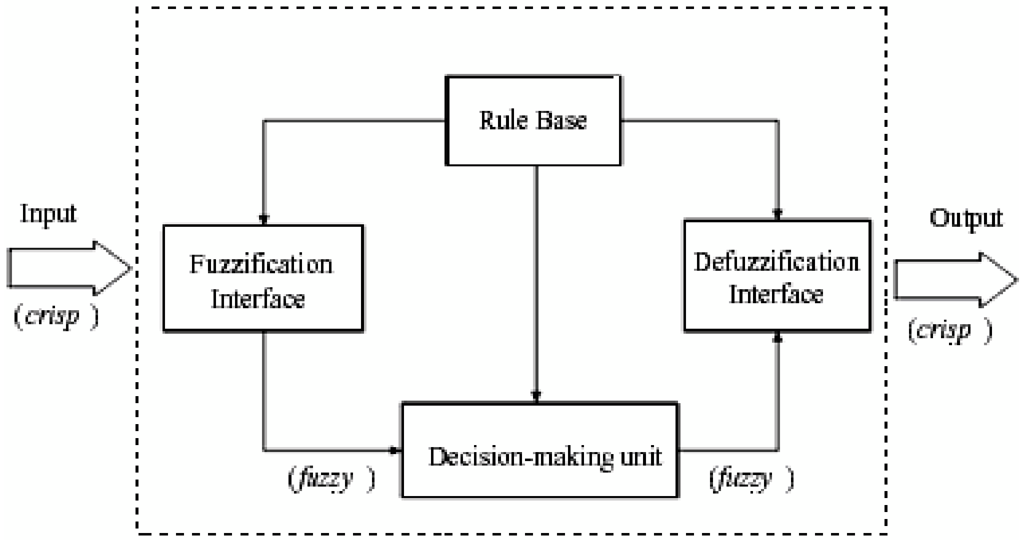

Figure 1: Fuzzy Logic Controller (FLC) Representation

As shown in fig. 1, the Fuzzy logic controller (FLC) converts the real-time inputs (Crisp values) into Linguistic variables based on particular membership functions. These variables are then given to Inference engine; this consists of a set of rules defined by the operator. Inference engine will execute these rules and decide the weight of each conclusion. Now these conclusions are converted to numeric values by defuzzification unit based on membership function defined for output variable [1-2].

So Fuzzy logic controller consists of mainly three parts:

1. Fuzzification

2. Inference Engine

3. Defuzzification

2.1.1 Fuzzification

Fuzzy logic uses linguistic variables instead of numerical variables. The process of converting a numerical variable (real number or crisp variables) into a linguistic variable (fuzzy number) is called fuzzification. This involves a domain transformation where crisp inputs are transformed into fuzzy inputs [7].

Crisp inputs are exact inputs measured by sensors and passed into the control system for processing, such as temperature, pressure, rpm's, etc.. Each crisp input that is to be processed by the Inference engine has its own group of membership functions or sets to which they are transformed.

This group of membership functions exists within a universe of discourse that holds all relevant values that the crisp input can possess. The following shows the structure of a Membership function.

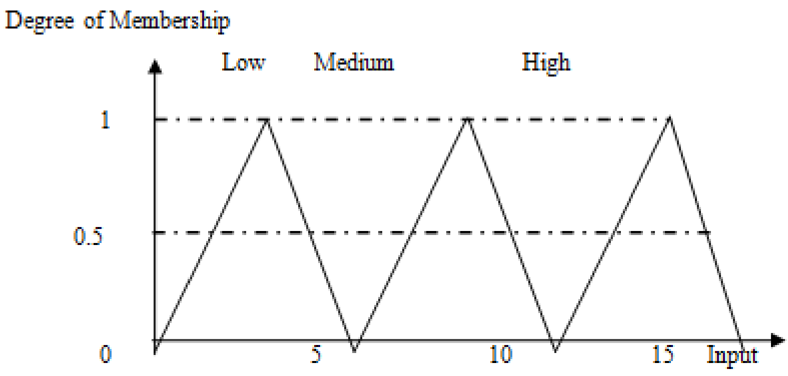

Figure 2: Structure of Membership functions

So here Triangle Membership function is structured with three ranges of low, medium, high. The membership function is a graphical representation of the magnitude of participation of each input. It associates a weighting with each of the inputs that are processed, defines the functional overlap between inputs. Triangular has mostly used the function, but bell, trapezoidal and, exponential are also used based on requirement.

2.1.2 Fuzzy Inference

Fuzzy logic operators can be used as the basis for inference systems. Such fuzzy inference methods have been extensively studied by the expert systems community. The knowledge that can only be formulated in a fuzzy, imprecise manner can be captured in rules that can be processed by a computer.

The advantage of formulating fuzzy inference rules is their low granularity. In many cases apparently, complex control problems can be modeled using just a few rules. If we tried to express all actions as consequences of exact numerical rules, we would have to write more of them or make each one much more complex.

2.1.3 Defuzzification

The reverse of fuzzification is called defuzzification. The Fuzzy logic controller (FLC) produces required output in a linguistic variable (fuzzy number). After the inference step, the overall result is a fuzzy value. This result should be de-fuzzified to obtain a final crisp output. This is the purpose of the de-fuzzifier component of an FLS. Defuzzification is performed according to the membership function of the output variable. According to real world requirements, the linguistic variables have to be transformed to crisp output. The weighted average method is the best well-known defuzzification method.

Basic Methods of Defuzzification:

1. AI (Adaptive Integration)
2. BADD (Basic Defuzzification Distributions)
3. COA (Centre of Area),
4. COG (Centre of Gravity),

5. WFM (Weighted Fuzzy Mean).

3. Designing of Fuzzy Logic in LabVIEW

We can create fuzzy rules in LabVIEW. This provides us the functionality to design fuzzy rules by creating .fs files. And by using these files as rule database for performing the execution.

Here 3 linguistic variables are used in ITCS.

1. Number of vehicles for arrival side
2. Number of vehicles for queue side
3. Time-Delay generated

Here as shown in Fig.3, two variables number of vehicles on arrival side and a number of vehicles on queue side are taken as input in fuzzy logic rule designing. After execution of these rules time, delay needed for that particular lane will be decided. And it will act as the output variable.

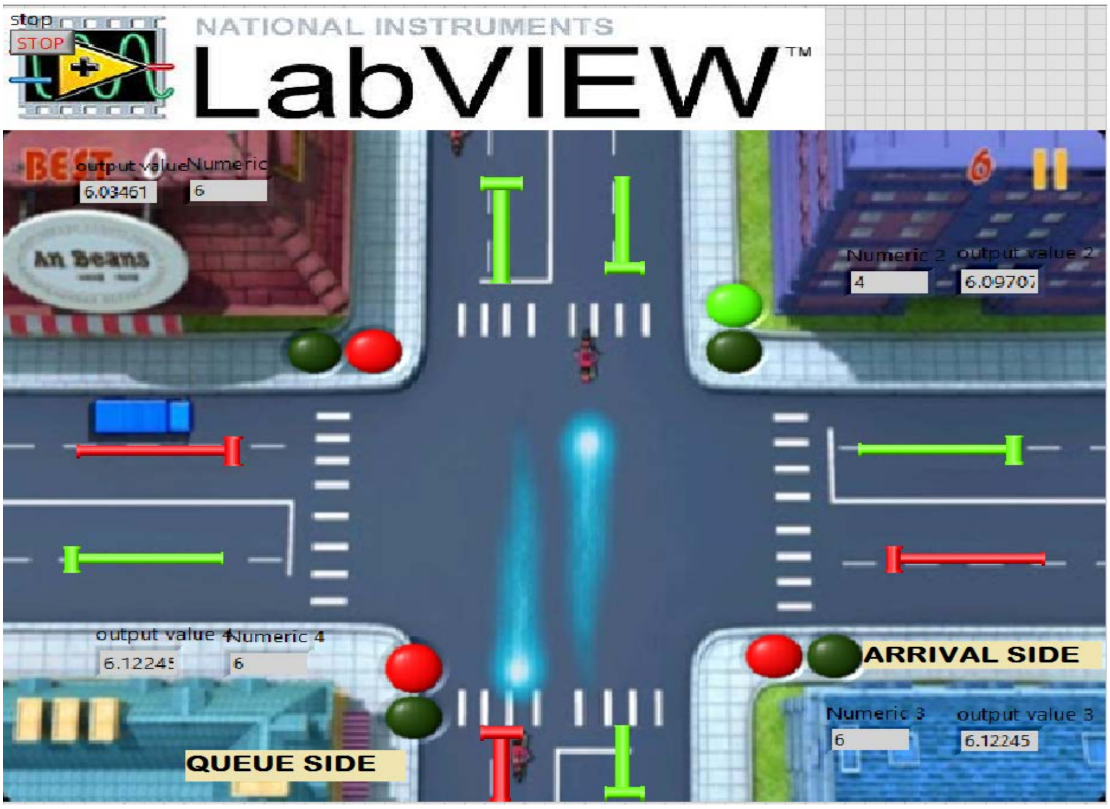

Figure 3: ITCS system

In LabVIEW software, PID and Fuzzy toolkit should be used and Fuzzy System Designer block is used for implementing FLC. Here we have 2 input variables and 1 output variables. Here i1 is a number of the vehicle at the arrival side, and i2 is a number of vehicles at queue side. Hence, Input variables and output variable and its membership functions are defined in Fig.4 as follow.

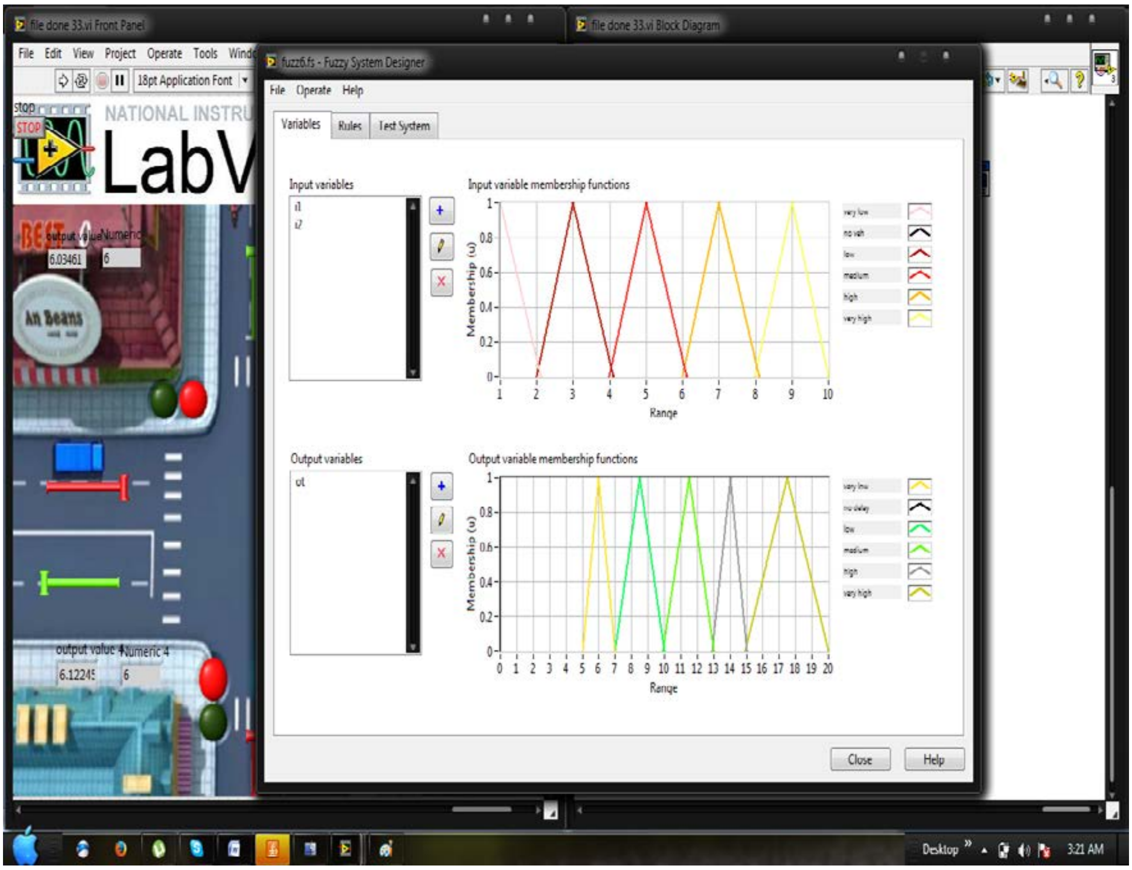

Figure 4: Variables Configuration

For Input variables, we have 5 conditions namely very low, low, medium, high, very high vehicles as shown in Fig. 5.

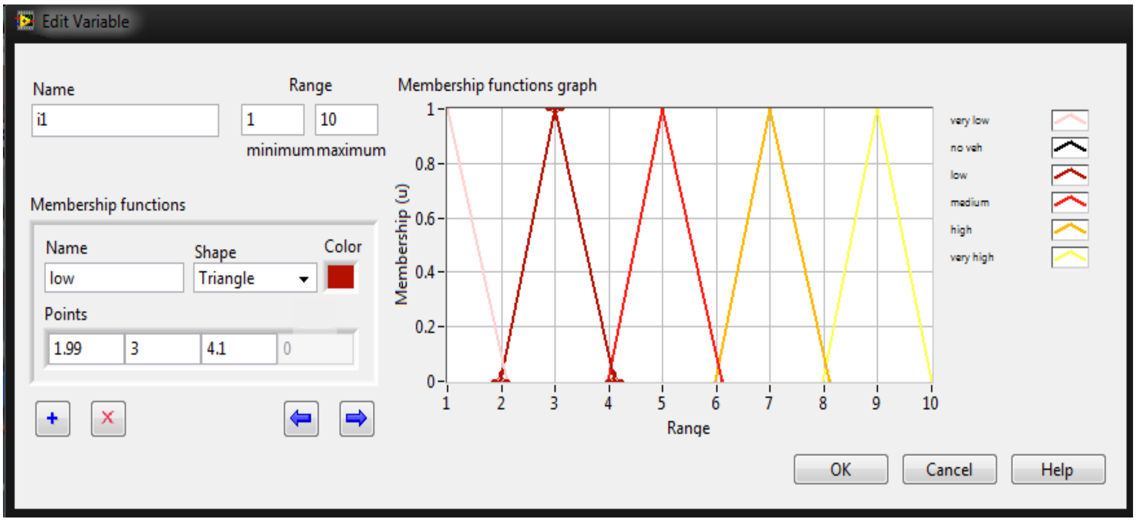

Figure 5: Input variables membership functions

For the output variable, we have 5 conditions namely very low, low, medium, high, very high Delay as shown in Fig.6.

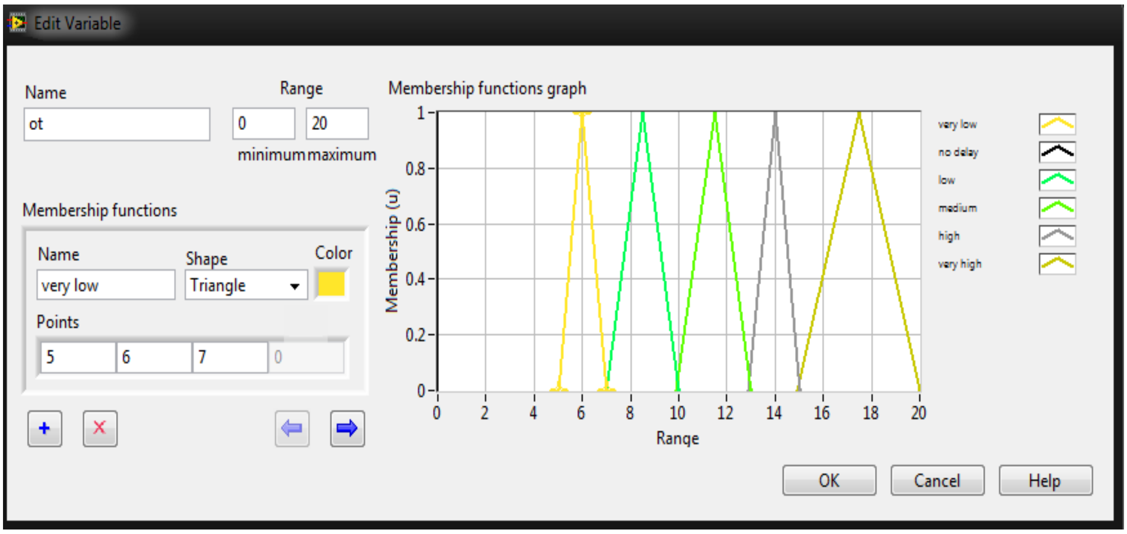

Figure 6: Output variable membership function

3.1. Rule Structure

Fuzzy rule designing is done in fuzzy system designer block. Here Rules are structured in two blocks as shown in Fig.7 & 8:

1. Antecedents block

In this block, we specify the portion of IF…….THEN structure. Here various logical operations like AND, OR are performed.

2. Consequent Block

In this block, we specify our desired output variable after IF…….THEN structure.

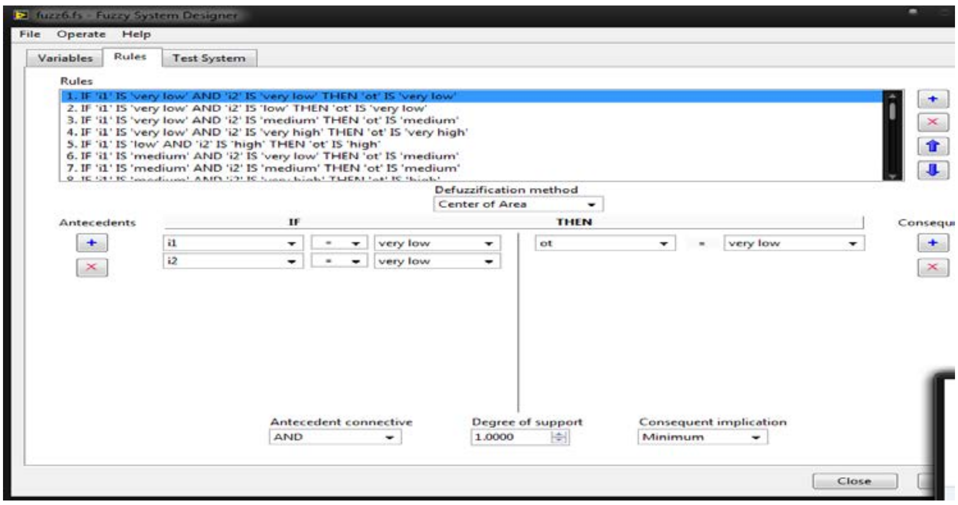

Figure 7: Fuzzy Rules

Rules

9. IF 'i1' IS 'high' AND 'i2' IS 'very low' THEN 'ot' IS 'low'
10. IF 'i1' IS 'high' AND 'i2' IS 'low' THEN 'ot' IS 'medium'
11. IF 'i1' IS 'high' AND 'i2' IS 'medium' THEN 'ot' IS 'medium'
12. IF 'i1' IS 'high' AND 'i2' IS 'high' THEN 'ot' IS 'high'
13. IF 'i1' IS 'high' AND 'i2' IS 'very high' THEN 'ot' IS 'very high'
14. IF 'i1' IS 'very high' AND 'i2' IS 'very low' THEN 'ot' IS 'low'
15. IF 'i1' IS 'very high' AND 'i2' IS 'low' THEN 'ot' IS 'medium'

Rules

16. IF 'i1' IS 'very high' AND 'i2' IS 'medium' THEN 'ot' IS 'medium'
17. IF 'i1' IS 'very high' AND 'i2' IS 'high' THEN 'ot' IS 'very high'
18. IF 'i1' IS 'low' AND 'i2' IS 'low' THEN 'ot' IS 'low'
19. IF 'i1' IS 'low' AND 'i2' IS 'low' THEN 'ot' IS 'low'
20. IF 'i1' IS 'low' AND 'i2' IS 'very low' THEN 'ot' IS 'low'
21. IF 'i1' IS 'low' AND 'i2' IS 'medium' THEN 'ot' IS 'low'
22. IF 'i1' IS 'low' AND 'i2' IS 'very high' THEN 'ot' IS 'high'
22. IF 'i1' IS 'low' AND 'i2' IS 'very high' THEN 'ot' IS 'high'
23. IF 'i1' IS 'very low' AND 'i2' IS 'high' THEN 'ot' IS 'high'
24. IF 'i1' IS 'medium' AND 'i2' IS 'low' THEN 'ot' IS 'medium'
25. IF 'i1' IS 'medium' AND 'i2' IS 'high' THEN 'ot' IS 'high'
26. IF 'i1' IS 'very high' AND 'i2' IS 'very high' THEN 'ot' IS 'very high'
27. IF 'i1' IS 'no veh' THEN 'ot' IS 'no delay'

Figure 8: Fuzzy Rules

3.2 Fuzzy System Designer

In a Fuzzy System Designer, We can vary Input variables and can see the delay which the Fuzzy System will provide. We can also see it in terms of Input and Output relationship. The execution of rules and its weight can also be seen in this tool box. It is one kind of simulator.

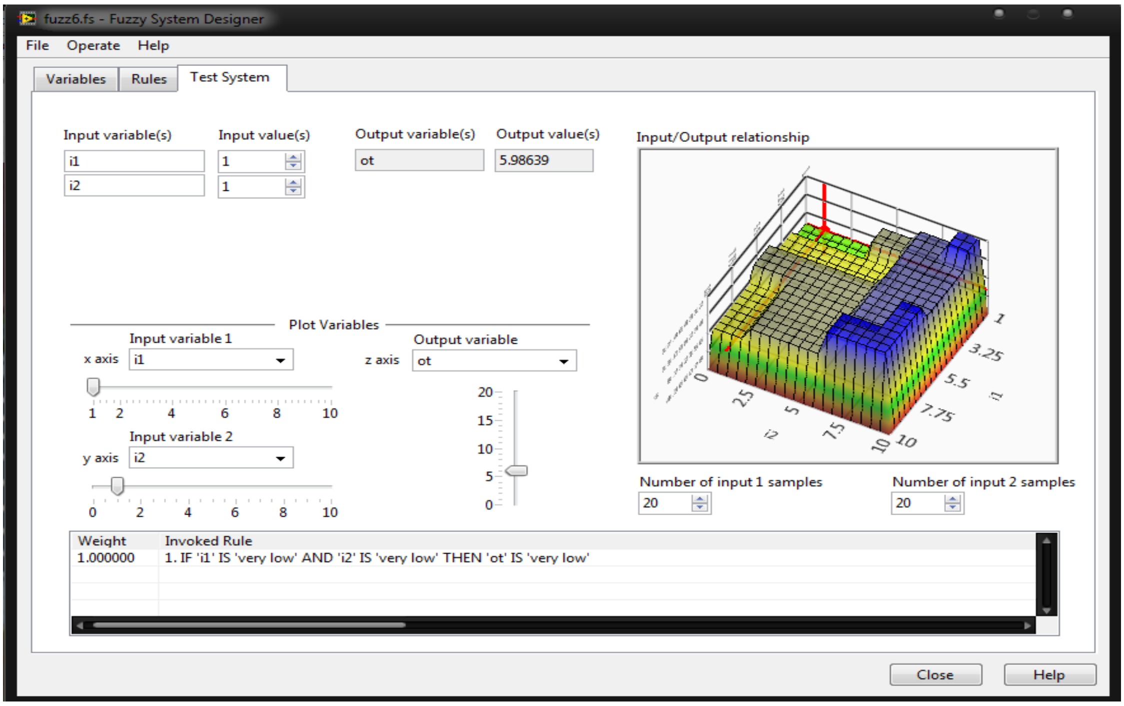

Figure 9: Fuzzy System Designer

3.3 Input-Output Relationship

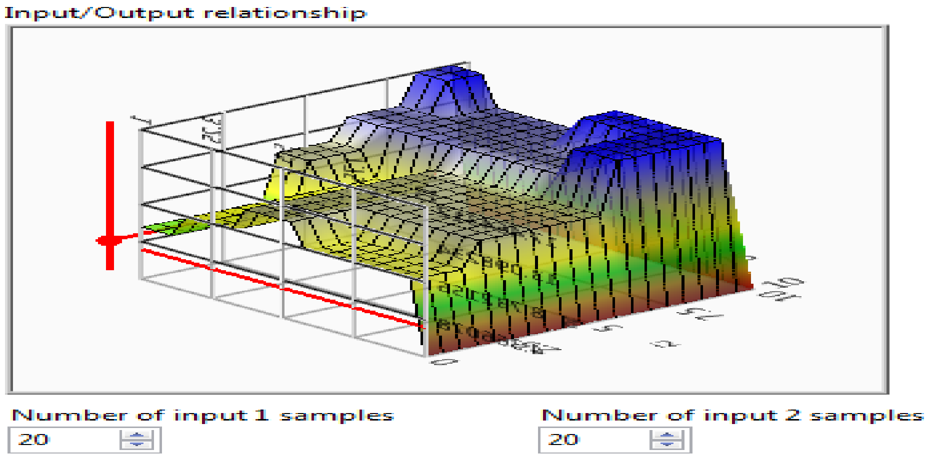

Figure 10: Fuzzy Input-Output Relationship

Here it is a graphical representation of Input/output relationship in 3 Dimension. Here, on X axis & Y axis represents the Input variables, which represents a number of vehicles. And Z axis represents Output variable, which is a time delay.

4. Image Processing in labview

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame, the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. In LabVIEW, we are using various tools for processing the acquired images by cameras. Then after we utilize various functions to improve the quality of Region of Interest(ROI).In LabVIEW Vision acquisition tool we will select USB camera as acquisition source as shown in Fig.11.

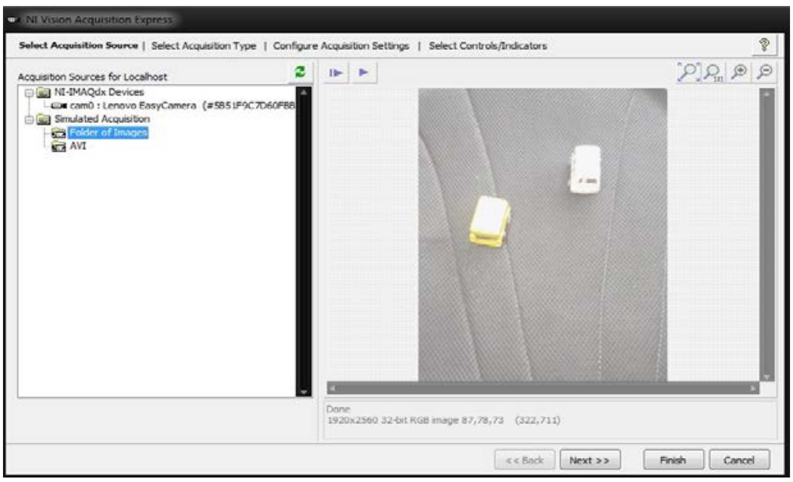

Figure 11: Vision Acquisition tool

We have used Edge detection technique for detecting a number of vehicles. And for that various LabVIEW functions are used as shown in Fig.12.Main Steps in Edge Detection are as follow:

1. Smoothing: suppress as much noise as possible, without destroying true edges.
2. Enhancement: apply differentiation to enhance the quality of edges (i.e., sharpening).
3. Thresholding: determine which edge pixels should be discarded as noise and which should be retained (i.e., threshold edge magnitude).
4. Localization: determine the exact edge location. The sub-pixel resolution might be required for some applications to estimate the location to better than the spacing between pixels.

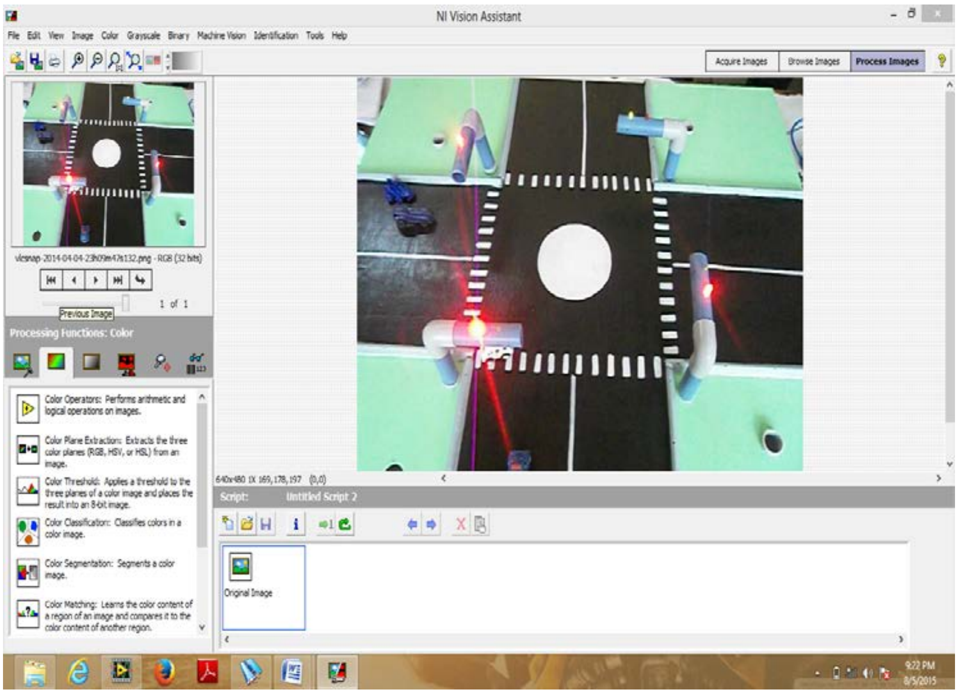

Figure 12: Image processing tool window

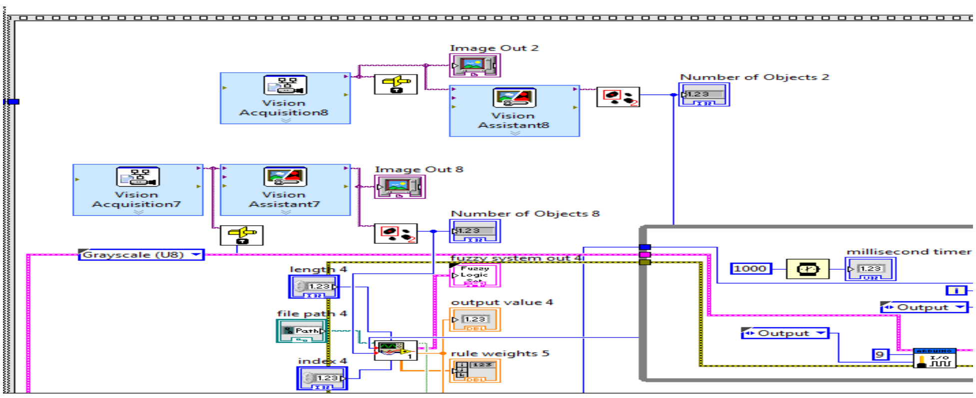

Figure 13: Image Processing Programming

As shown in Fig. 13 Programming for image processing is done in LabVIEW. Here Functional Block Diagram type programming method is used. After image processing, we will get Binary image which is then given as input to the IMAQ count Objects VI in LabVIEW. So this block gives a number of objects or number of vehicles present as shown in Fig.14.

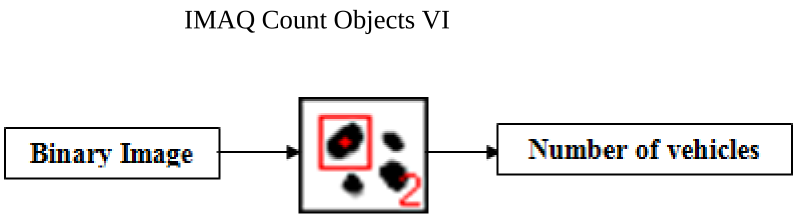

Figure 14: VI for Objects

5. Conclusion

By this kind of traffic control system, we can make sure that no one has to wait on traffic crossroad unnecessarily. So, time will be saved, noise & air pollution will be decreased. Hence, Traffic will be maintained efficiently. Here for counting of vehicles, Image Processing Technique is used which counts more accurately than any other technique. Image processing is unaffected by ambient conditions so it is robust technique for counting a number of vehicles. Hence, in our project, at the crossroad lights will be blinked according to the Fuzzy Logic rules.

6. Future expansion

We have implemented a project based on Fuzzy Logic based Control. On a later stage, ITCS can be complemented with an adaptive learning feature and with a set of fuzzy rules to incorporate heuristic knowledge of past experience, which gives artificial intelligence to ITCS. It means that Fuzzy logic rule will be integrated with past results and it will be taken into consideration for providing rational Time-Delay. We can also implement this project using GPS technique. In that, every vehicle will be GPS enabled, so GPS will track the location of those vehicles. Accordingly, it will give the density of vehicles available near the particular crossroad. Hence, these signals are given in central computer which will control the whole system according to the vehicles present at each crossroad.

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