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Fuzzy Inference Rule based Neural Traffic Light Controller

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***Abstract* – The paper presents an idea of developing a simple neural network based traffic controller using fuzzy inference rules. The design of a neural traffic control system is proposed. The proposed system efficiently handles the traffic flow and congestion in the intersection. The goal is achieved by managing the duration of green light interval. The neural traffic controller is able to calculate the green light time duration of traffic signal. The time duration is calculated based on the information regarding the number of cars on the two lanes where the signal is green i.e. Arrivals and the number of cars that are waiting on all the remaining lanes which have red signal i.e. Queue. The system will use fuzzy inference rule based strategy to train the neural network from the input data of Arrival and Queue and output data of Time for green light of signal. MATLAB simulations are used to present the validation of the test data results.**

Index Terms* – *Fuzzy Inference Rules, Neural Traffic Controller, Training, minimum gradient, test data

I. INTRODUCTION

The problem of Traffic control is being faced by many big cities around the world. There are many effects of these traffic problems on the people's daily life. It also produces adverse effects on the economic condition, production, development and increase in cost of daily life products. There are many reasons of increase in traffic congestion in big cities. Increase in number of vehicles, insufficient roads and flyovers etc. are among few causes of traffic problem. The major factor of traffic problem and congestion is the use of traditional traffic light system [1]. Traffic light signal system is a very common feature for controlling flow of traffic in all the urban areas of the world. The purpose of traffic signals is to improve the traffic safety at the intersections keeping in view the minimum delays and maximum capacity at the intersection. The control of the traffic lights therefore plays a vital role in smooth flow of traffic by controlling the traffic with minimal delay.

II. TRAFFIC CONTROL PRINCIPLE

The traffic light signals at the intersection operate in cycle. The cycle comprises of the amber, red and green phases. These phases turn on for fixed time duration in sequential manner.

The cars that face a green signal turned on are allowed to pass the intersection. The movement can be straight, right turn or left turn. The cars that face an active red signal light are not allowed to cross the intersection and are restricted of any kind of movement in straight path. Only these cars have the right to make turns in right direction with active red signal as this movement does not hinder with the cars that are allowed to cross the intersection. The yellow light is active only in the transformation phase when green light changes to red. The yellow phase duration is fixed. The time durations of the red signal and green signals are managed and determined depending upon the condition of the traffic. Fig.1 shows traffic flow control at an intersection [2].

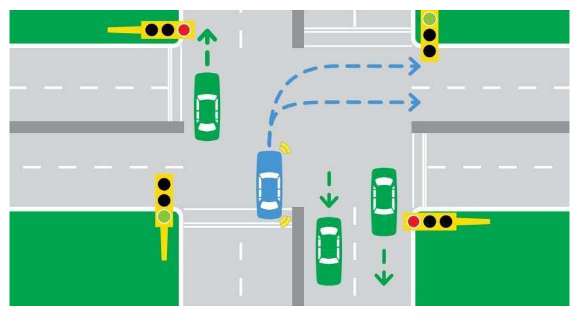

Fig.1 Traffic Flow Control at an intersection.

III. FUZZY TRAFFIC SIGNAL CONTROLLER

The main idea of fuzzy traffic light controller is to make of model from based on human expertize [3, 4]. A traditional traffic light controller work principle is based on fixed time intervals. The traffic lights changes states at a fixed and constant cycle time. This approach of fixed time cycle is definitely not the optimized solution. A more feasible design of a traffic control systems is the one that allows more cars to pass the intersection at the green phase if less cars are present in queue behind the red lights or vice versa [5,6]. Fuzzy Logic design overcomes the inefficiency of the traditional traffic controller by removing the feature of fixed time interval cycle of traffic signal lights.

In fuzzy logic design, fuzzy inference rules are developed based on the membership functions of the inputs and outputs. Based on these rules, output of the system is calculated.

By development of an intelligent traffic light control system, the traffic congestion problem can be solved in many cities. The aim is to implement fuzzy logic inference rules on a neural network to control a traffic system for an intersection. The proposed neural traffic light controller is capable of managing the congestion far better as compared to conventional traffic light control system. At red light, this traffic control system can efficiently reduce the vehicle waiting time.

IV. MEMBERSHIP FUNCTIONS OF THE PROPOSED SYSTEM

A fuzzy inference rule based is developed based on the membership functions of the inputs and outputs. For a traffic control problem, the inputs are the Arrival and Queue. Arrival refers to as the number of cars on the two lanes where the signal is green.

Queue refers to as the number of cars on all the remaining lanes which has red signal. Note that the Arrival and Queue keep on changing as traffic light condition changes.

Fig.2 show the membership function defined for the input Arrival and Fig.3 shows the membership function defined for the input Queue.

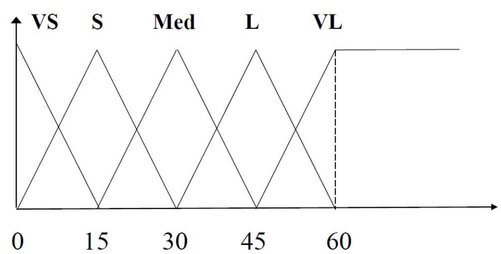

Fig.2 Membership Function of Input Arrival

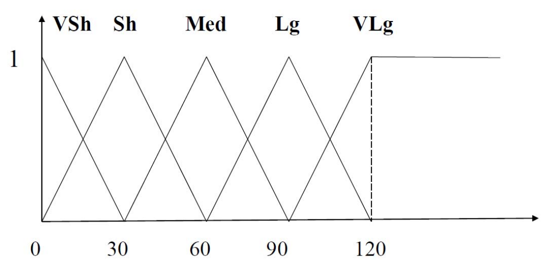

Fig.3 Membership Function of Input Queue

Fig.4 shows the membership function of the output,i.e. the time for green light.

Table I, Table II and Table III show the description of the three member functions defined for two inputs and one output

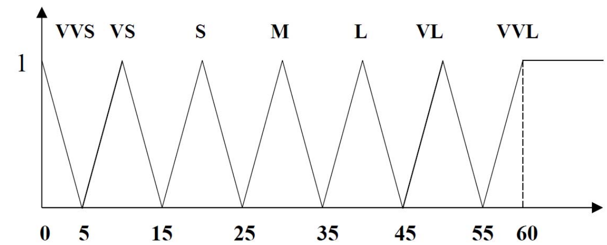

Fig.4 Membership Function of Output Time

TABLE I
DESCRIPTION OF MEMBERSHIP FUNCTION OF ARRIVAL

Arrival			
Index	Membership Function	Description	Range
1	VS	Very Small	0-15
2	S	Small	0-30
3	Med	Medium	15-30
4	L	Large	30-60
5	VL	Very Large	45 onwards

TABLE II
DESCRIPTION OF MEMBERSHIP FUNCTION OF QUEUE

Queue			
Index	Membership Function	Description	Range
1	VSh	Very Short	0-30
2	Sh	Short	0-60
3	Med	Medium	30-60
4	Lg	Large	60-120
5	VLg	Very Large	90 onwards

V. FUZZY INFERENCE RULES

Based on the membership function shown in Fig.2, Fig.3 and Fig.4, an inference rule base is developed. Fig.5 shows the fuzzy inference rules for the proposed system using membership functions.

TABLE III
DESCRIPTION OF MEMBERSHIP FUNCTION OF TIME

Time			
Index	Membership Function	Description	Range
1	VVS	Very very Small	0-5
2	VS	Very Small	5-15
3	S	Small	15-25
4	Med	Medium	25-35
5	L	Large	35-45
6	VL	Very Large	45-55
7	VVL	Very very Large	55 onwards

		ARRIVAL				
QUEUE		**VS**	**S**	**M**	**L**	**VL**
	VSh	S	M	L	VL	VVL
	Sh	S	M	M	L	VVL
	Med	VS	S	M	L	VVL
	Lg	VS	S	M	M	VL
	VLg	VVS	S	S	M	L

Fig.5 Fuzzy Inference Rules for the proposed system using membership functions

Using indexing from Tables for Arrival, Queue and Time, Data Set for the proposed neural network is constructed. Based on the inference rule based Data Set, a supervised learning algorithm is designed and trained using the Data Set. Table IV shows the Inference based Data Set using indexing of inputs and output. Screenshot of the Fuzzy Logic Design for Fuzzy inference rules is shown in Fig.6 for reference.

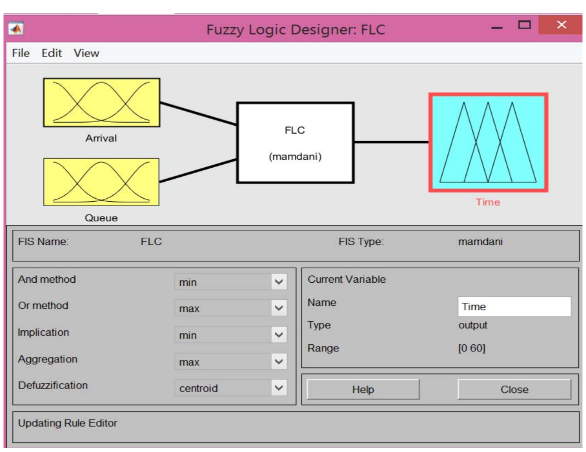

Fig.6 Fuzzy Logic Design for fuzzy interference rules

TABLE IV
FUZZY INFERENCE RULE BASED DATA SET

Arrival	Queue	Time
1	1	3
1	2	3
1	3	2
1	4	2
1	5	1
2	1	4
2	2	4
2	3	3
2	4	3
2	5	3
3	1	5
3	2	4
3	3	4
3	4	4
3	5	3
4	1	6
4	2	5
4	3	5
4	4	4
4	5	4
5	1	7
5	2	7
5	3	7
5	4	6
5	5	5

Fig.7 shows the screenshot of the firing of inference rules at Arrival 30 and Queue 60. The output time comes out to be 30 in this case.

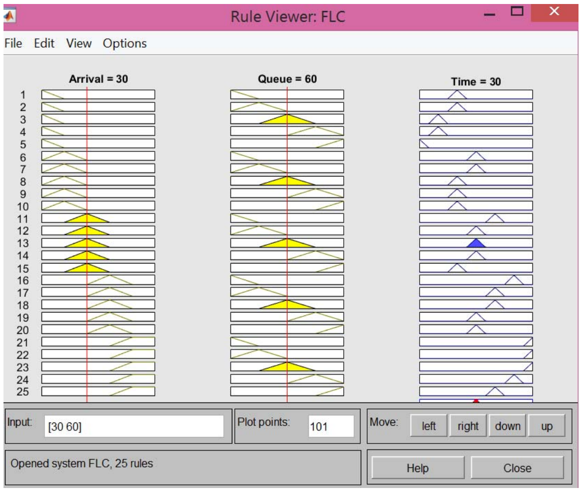

Fig.7 Firing of Inference Rules at [30 60] inputs

VI. Neural Traffic Controller

Based on the Data Set of the Table IV, 75 training examples were constructed. The neural network designed for implementation of fuzzy inference rules comprises of two inputs Arrival and Queue, and one output i.e. Time. Fig.8 shows the design of the neural network designed with one input layer one hidden layer with 10 neurons and an output layer.

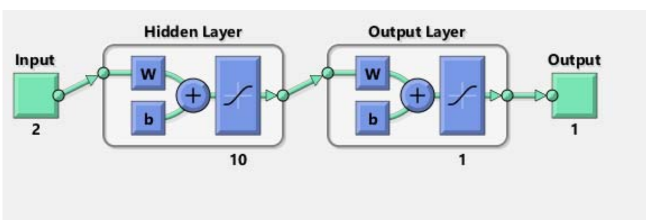

Fig.8 Design of Neural Traffic Controller

The designed neural network was trained using the training Data Set of 75 examples. The Neural Traffic controller achieved first minimum gradient at 693rd iteration. The controller is trained again and again using the training Data Set until it gets fully trained, indicated by achievement of minimum gradient in zero iteration.

A test Data Set with Arrival and Queue indices is then applied to the Trained Neural Traffic Controller. The Controller gave 100 percent accurate results for the output Time index based on the Fuzzy Inference Rule based Data Set. The results of both Fuzzy logic Traffic controller and Fuzzy inference rule based Neural Traffic Controller were compared and it was found that both the results match. This comparison proves that the idea of designing Neural Traffic Light Controller based on Fuzzy inference rules is practically possible. Fig.9 shows the regression plot of the Data, Validation, Test and overall results of the Neural Traffic Controller.

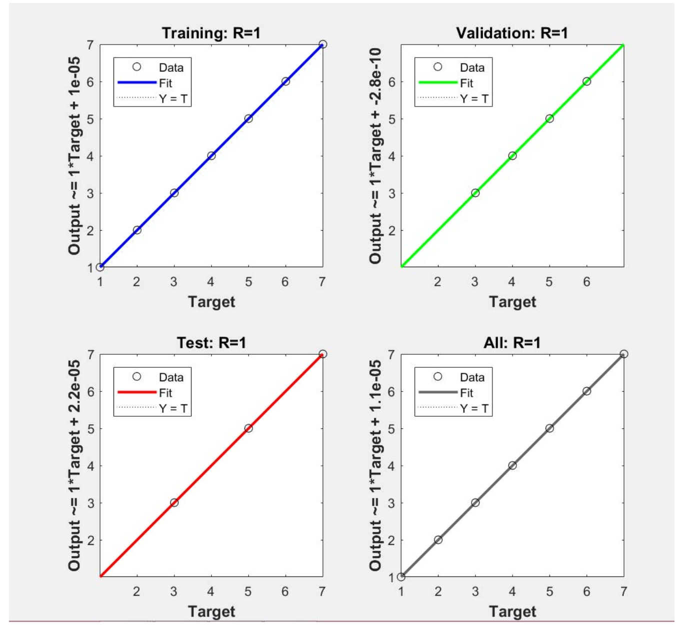

Fig.9 Regression Plot

VII. Conclusion

A Fuzzy Inference rules based Neural Traffic Light Controller is developed to control the problem of traffic congestion. The controller designed is first trained using the Data Set constructed based on the fuzzy inference rules. Each membership function is assigned an index and using the indices, Data Set for neural network is constructed. The results for the output variable Time is calculated using both Fuzzy Controller and Neural Controller. The results match with 100 percent accuracy indicating the possibility of designing the Neural Traffic Controller using fuzzy inference rules

Acknowledgment

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References

[1] G.H. Kulkarni, and P.G. Waingankar, "Fuzzy logic based traffic light controller", Second International Conference on Industrial and Information Systems, ICIIS 2007. 8 – 11 August, Sri Lanka,2007, pp107-110

[2] https://drivezonedrivingschool.com.au/category/blog/ Dated: 02-01-2018

[3] Jarkko Niittymäki, "Installation and experiences of field testing a fuzzy signal controller", European Journal of Operational Research 131 (2001), pp 273 - 281.

[4] M. B. Khalid, “Module 1: Basics of Fuzzy Sets and Fuzzy Relations”, Unpublished Course Notes, Universiti Teknologi Malaysia.

[5] Ambre, Mandar, "A Design Methodology for the Implementation of Fuzzy Logic Traffic Controller using Field Programmable Gate Arrays" Master of Science Thesis, Department of Electrical and Computer Engineering, FSU, 2004. Available online: http://etd.lib.fsu.edu/theses/available/etd-04122004-164143/

[6] Khalid, M. et al., "Control of a complex Traffic Junction using Fuzzy Inference" In proceedings of 5th Asian Control Conference, 2004. Available: http://ascc2004.ee.mu.oz.au/proceedings/papers/P227.pdf