Adaptive Driving Route of Busses along EDSA Using Fuzzy Logic

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Abstract: The study aims to reduce the number of busses travelling across the main road of EDSA, find the best station nodes at a given time frame to optimize the number of passenger in every travel. This paper focuses only in two nodes which consist of different alternate routes. These routes will cluster according to fuzzy sets and fuzzy rules in that way we can find the best route that the bus could pass through or not. In future research this paper will use wireless sensor network to get real time data parameters to be used by the fuzzy sets because of WSN the system will became self-adaptive. The fitness of those data will be evaluated using fuzzy logic and the route will be cluster as not passable, normally passable or highly passable then the resulting best route will be selected.

Keywords: Fuzzy Logic, Wireless Sensor Network (WSN), Rerouting, Epifanio de los Santos Avenue (EDSA)

1. INTRODUCTION

The use of Intelligent Transportation System (ITS) is growing not just among into the well developed countries but also into the developing countries as well like in Europe, America, Japan, Singapore etc. The integration of Information and Communication Technology in to the Transportation System will not just help the traveler to go from point A to point B but also getting there in safer, cleaner, greener and more convenient way. As we all know heavy traffic is one of the enormous problems facing of Filipinos every day in going to their respective destination such as in work, school, meeting, event etc. The government also loses millions of pesos potential income because of traffic. One of the challenges in implementing Intelligent Transport System (ITS) is the rerouting of vehicle in safer and more convenient way. This paper is focus in how to find a best route for Busses along Epifanio de los Santos Avenue (**EDSA**), Manila, Philippine with the use of Fuzzy Logic. As we observe one of the major causes of traffic in EDSA are the public busses. The main purpose of this paper is to develop a decision making system that will help the bus drivers in selecting their path way strategically. Fuzzy Logic is an algorithm widely use in developing or putting a computer intelligent which is need an decision making, selecting best actions and data clustering. The goal of this paper is to create a self-adaptive driving route with the use of wireless sensor networks which is the source of different data needed by the fuzzy logic.

2. RELATED LITERATURE

2.1 A Fuzzy Logic-Based Framework for Route Choice in Vehicle Navigation System [1]

Vehicle Navigation System s (VNS) is an important component of Intelligent Transportation Systems (ITS). This System s are designed to assist drivers in making pre-trip and enroute

travel choice decisions, and typically, they must provide route choice, route guidance and other related services. Although there have been a lo t of existed system s in the market, and most of them used lots of contemporary technologies, they are believed short of ″true intelligence″, because they paid little attention to the subjective issues in driver′s route choice behavior, such as travel objectives and personal p references, etc.

However, the VNS is designed for its users, and the successful implementation of VNS is largely dependent on the driver′s acceptance. If the driver feels that the VN S can′t give him (her) a satisfactory choice, he (she) will not use it, then, the marketing value of VNS will decline. And on the whole, the transport benefit that is mainly gained by the wide use of ITS will lost.

Supported by the research project of ″Beijing Intelligent Urban Transportation Systems″, this paper presents a conceptual model to deal with this problem. We first defined the driver′s objective as a linguistic statement that has a set of attributes. These attributes are then treated as the fuzzy sets on the universal of all the existed routes. By determining each attribute′s membership functions and assign driver dependent perception to these attributes, we can change the multi-criteria route choice problem into a fuzzy logic-based decision making problem. Then, to meet the demands of dynamic real-time route selection, we use limited routes set for choice and can swiftly get a satisfactory solution that we think is the driver′s actually needs.

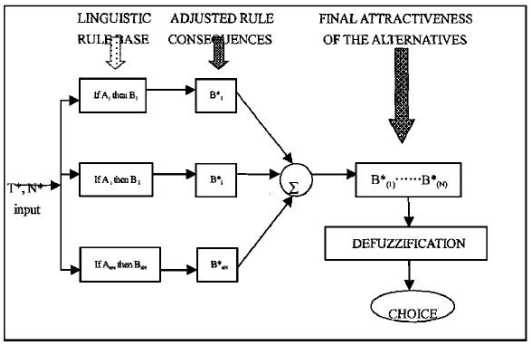

Figure 1: Shows the route decision process

2.2 Fuzzy Logic based navigation system [2]

Vehicular navigation is becoming increasingly difficult due to the high volume of traffic. Navigation systems are increasingly becoming common with the advent of digital maps. In this paper, we propose a navigation system from one place to another based on fuzzy logic considering real world parameters such as distance, traffic density, visual range and re-routing as inputs and based on these factors, a rating is designated for each path and the best path is chosen out of all possible paths. Simulation was done using MATLAB and the results were found to be satisfactory in accordance to the inputs provided.

2.3 Adaptive Route Selection for Dynamic Route Guidance System Based on Fuzzy-Neural Approaches [3]

One functionality of an in-vehicle navigation system is route planning. Given a set of origin–destination (O/D) pairs, there could be many possible routes for a driver. A useful routing system should have the capability to support the driver effectively in deciding on an optimum route to his preference. The objective of this work is to model the driver behavior in

the area of route selection. In particular, the research focuses on an optimum route search function in a typical in-car navigation system or dynamic route guidance (DRG) system. In this work, we want to emphasize the need to orientate the route selection method on the driver's preference. Each feasible route has a set of attributes. A fuzzy neural
(FN) approach is used to represent the correlation of the attributes with the driver's route selection. A recommendation or route ranking can be provided to the driver. Based on a training of the FN net on the driver's choice, the route selection function can be made adaptive to the decision making of the driver.

3. METHODOLOGY

This paper uses Bus Stops prescribe by MMDA and the data inputs is from wireless sensor networks that will provide time to time data and because of this the system will became self-adaptive. Just like what said in the earlier part of this paper the WSN design is not cover of this research. For experiment inputs the researchers use MatLab software and input the different data for Travel Distance (Td), Traffic Congestion (Tc) and Passenger Volume (Pv) manually. This paper use thirteen bus stop nodes from Magallanes to Araneta Cubao Northbound for the initial experiments aiming to find strategic route from point A (Magallanes) going to point B (Araneta Cubao).

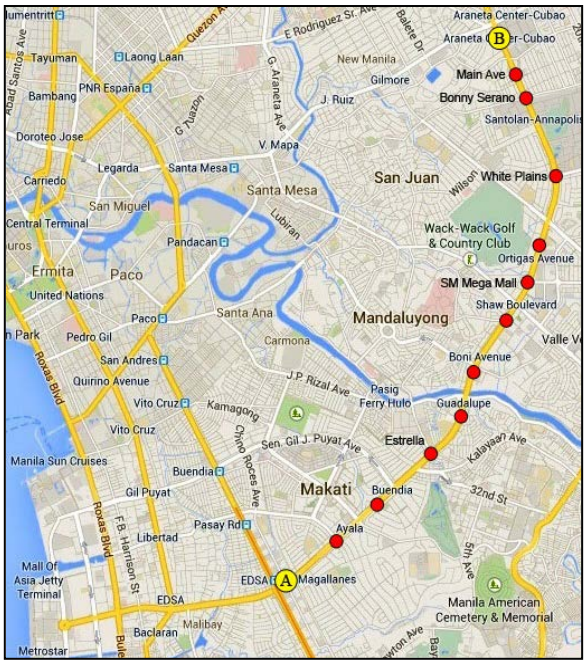

Figure 2: Thirteen Bus Stop Nodes for Initial Experiment these nodes are prescribe by MMDA

A Point A Magallanes

B Point B Araneta Cubao

Bus Stop Nodes

Table 1: Sample Survey Data Result
Route: Magallanes to Araneta Cubao Northbound
Date: 2/25/2014

Main Segment	Time	Embed	Dispatch
Magallanes	7:23 AM	1	11
Ayala	7:25 AM	9	22
Buendia Ave.	7:30 AM	0	0
Estrella	7:31 AM	10	12
Guadalupe	7:35 AM	12	0
Boni Ave.	7:37 AM	12	16
Shaw Blvd	7:41 AM	0	1
SM Megamall	7:41 AM	0	7
Ortigas Ave.	7:43 AM	30	24
White Plains	7:50 AM	8	2
Bonny Serrano	7:52 AM	0	0
Main Ave	7:54 AM	0	0
Araneta Cubao	7:55 AM	0	0

Table 1 is a sample data sets that will provide by the wireless sensor network each sensors are located in each bus stop along the entire road of EDSA measuring the passenger volume. But this paper does not cover the WSN design and this data sets are manually inputted in the system. In result the best bus stop node to hatchway by around 7:00 am are shown in Figure 3. This mean by around 7:00 am out of 13 bus stop nodes in Figure 2 there are only 6 highly demanded bus stop and that are show in Figure 3.

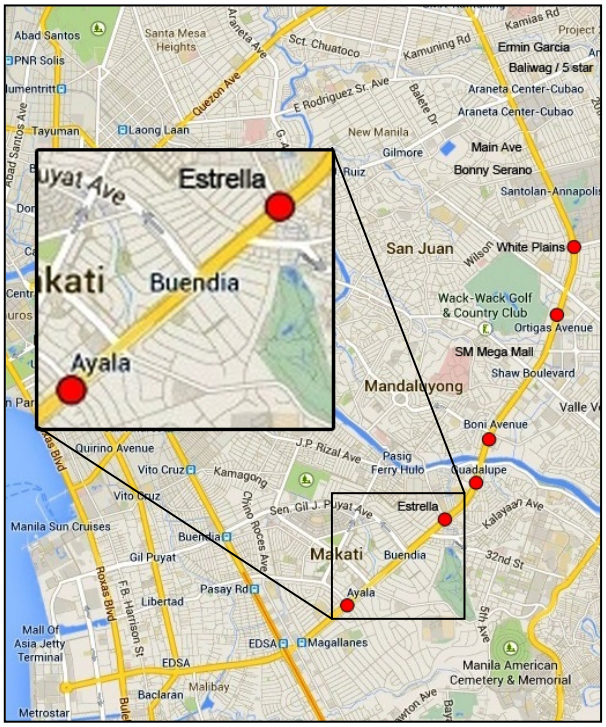

Figure 3: Resulting Nodes base fuzzy logic rules

Base on the Figure 3 if the bus stop node satisfy the enough number of passenger that node will be selected and use to undergo fuzzy rules. As we see in this case the different nodes that has

high passenger volume at around 7:00 am are Ayala, Estrella, Guadalupe, Boni, Ortigas and White Plains respectively. After the nodes with enough passengers is selected fuzzy logic focus into the first two nodes and uses the different alternate route of these first two nodes. After the bus stop node Ayala and Estrella are successfully rate by the fuzzy logic. The next nodes to be cluster are Estrella and Guadalupe until it's cover all 6 bus stops. This paper only show the rating result of fuzzy logic in Ayala to Estrella bus stop link and does not show all rating result of 6 bus stops. Supposedly we have 5 links to rate because we have 6 bus stops and those are Ayala-Estrella, Estrella-Guadalupe, Guadalupe-Boni, Boni-Ortigas and Ortigas-White Plain. Simulating all this 5 links will make this paper to long that's why this paper only show the simulation of Ayala-Estrella Link. In the case shown in Figure 3 the link from Ayala going to Estrella the researchers find 8 alternate routes. These routes are shown into the table below.

Table 2: Alternate Route for Ayala to Estrella

From	To	Route	Distance (km)
Ayala	Estrella	1	2.5
		2	2.4
		3	2.7
		4	2.9
		5	3
		6	2.6
		7	2.3
		8	2.2

The data in Table 2 are became the input of one membership function which is the distance. The distance of this 8 routes are obtained and determined by the google map. Speaking of membership function fuzzy logic in this paper uses three membership functions. Those are Travel Distance (Td), Traffic Congestion (Tc) and Passenger Volume (Pv) the 8 distance data in table 1 will be used by the Travel Distance (Td) membership function. The input data for Passenger Volume (Pv) is supposedly provided by WSN but in the case of this paper this is provided manually as show into the Table 1 and as the result the nodes are shown in Figure 3. The input for Tc is also manually inputted as Not congested, Normally congested and Highly congested and will be cluster using fuzzy logic.

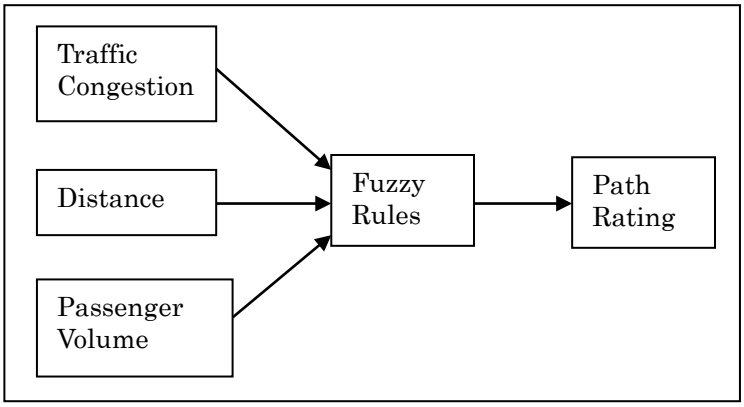

Figure 4: Shows the Fuzzy interface system consist of inputs going to fuzzy rules and Path rating as the result [2]

In this fuzzy system, we consider the following inputs: [2]

- Travel Distance (Td)
    - Near
    - Average
    - Far
- Traffic Congestion (Tc)
    - Not
    - Normally
    - Highly
- Passenger Volume (Pv)
    - Small
    - Medium
    - High

And also we consider the following outputs

- Path Rating
    - Not Passable
    - Normally Passable
    - Highly Passable

The Travel Distance parameter is scaled to a range between 0 km to 10 km. The Traffic congestion and Passenger volume parameter is scaled between 0 to 1. Also the output parameter is scaled form 0 to 1.

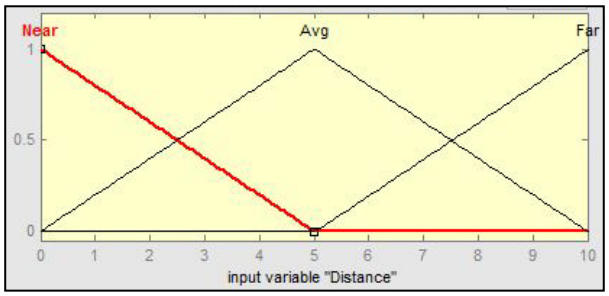

Figure 5: The input variable for Travel Distance Parameter

The Near criterion for distance is form 0 km which is the highest pick up to 5km which is the lowest pick. The Average distance start with 0 km the lowest pick up to 5km the highest pick and go back with the lowest pick which is the 10 km. Far distance starts with 5km up to 10 km is the highest pick of this parameter. As shown in the figure 5 the near and average variable has a crossover around 2.5 km and average and far variable have a cross over in 7.5 km.

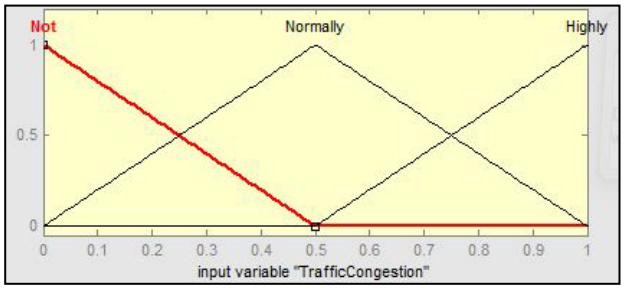

Figure 6: The input variable for Traffic Congestion Parameter

The not congested criterion is scaled from 0 is the highest pick 0.5 is the lowest pick. Normally congested is scaled form lowest pick which is 0 going to the highest pick which is 0.5 and back to lowest pick with the value of 1. The highly congested is characterized by the lowest pick of 0.5 and the highest pick of 1. Using this variable fuzzy logic will be able to cluster the traffic congestion using the centroid formula use by Mat Lab.

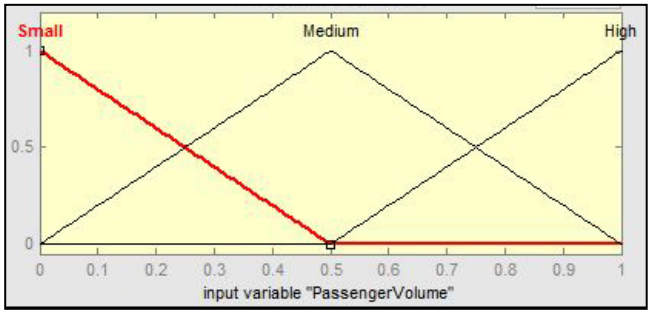

Figure 7: The input variable for Traffic Congestion Parameter

The traffic congestion consists of three variable small volume of passenger, medium volume and high volume of passenger respectively. Small volume scaled from 0 to 0.5, Medium volume scaled from 0 to 0.5 going back to lowest pick 1 and high volume scaled from 0.5 to 1. The scaled of 0 to 1 is can be associate with 0% up to 100%. The 0% means there is no passenger that the bus could get and 0.5 is 50% which means if the capacity of bus is 60 there a possibility to get 30 passenger along the way.

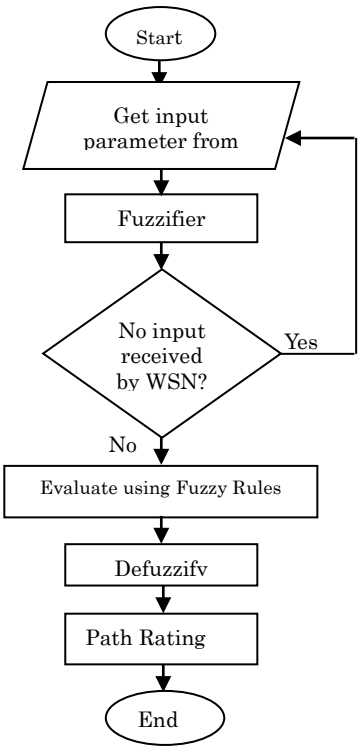

Figure 8: The flow chart that describes how Fuzzy Logic works to find the alternate route.

This show the process on how fuzzy logic able to find a right decision for selecting the path of bus. As seen in flow chart there's an infinite loop if the WSN does not sends data to the system. The fuzzifier wait until the WSD give the data and proceed to the evaluation phase. With the use fuzzy rules which will be show in the later part of this paper the fuzzy logic will be able to find the right decision for the bus path.

4. EXPERIMENTS AND RESULTS

Fuzzy logic uses 27 fuzzy rules to cluster and find the output. The output path rating is consisting of four variables not passable, shortly passable, normally passable and highly passable. This is illustrated below with the scale of 1 to 10. Not passable variable ranging from 0 to 2.5, shortly passable is ranging from 2.5 to 5, normally passable ranging from 5 up to 7.5 and lastly highly passable is ranging from 7.5 to 10.

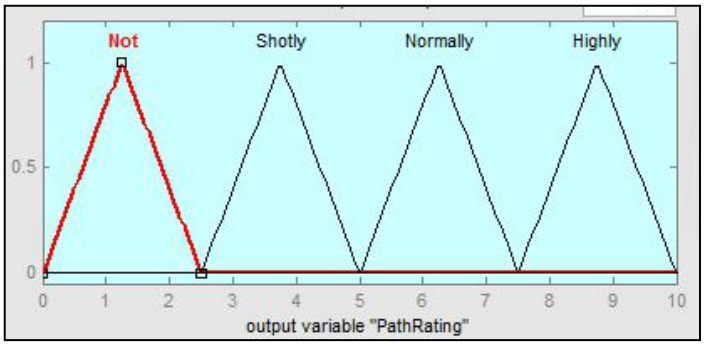

Figure 9: The out variable for Path Rating Parameter

Table 3: 27 Fuzzy Rules set by the Researcher for the fuzzy logic decision making

No.	Td	Tc	Pv	Path Rating
1	Near	Not	Small	Normal
2	Near	Not	Medium	High
3	Near	Not	High	High
4	Near	Normally	Small	Short
5	Near	Normally	Medium	High
6	Near	Normally	High	High
7	Near	Highly	Small	Not
8	Near	Highly	Medium	Short
9	Near	Highly	High	Normal
10	Avg	Not	Small	Normal
11	Avg	Not	Medium	High
12	Avg	Not	High	High
13	Avg	Normally	Small	Short
14	Avg	Normally	Medium	Normal
15	Avg	Normally	High	High
16	Avg	Highly	Small	Not
17	Avg	Highly	Medium	Not
18	Avg	Highly	High	Short
19	Far	Not	Small	Normal
20	Far	Not	Medium	High
21	Far	Not	High	High
22	Far	Normally	Small	Short
23	Far	Normally	Medium	Normal
24	Far	Normally	High	Normal
25	Far	Highly	Small	Not
26	Far	Highly	Medium	Not
27	Far	Highly	High	Short

This are the fuzzy rules followed by the fuzzy logic to determine what would be action need to reroute the bus. The researchers use all the possible combination that would get into three membership function. The overall combination is 27 that is because as we remember in multiplication rule in probability and statistics we have 3 membership with 3 possible variables. With this we can come up with 3 x 3 x 3 which is equal to 27 combinations. The output in this table is the same result that needs to see into the actual simulation of data in fuzzy logic using MatLab.

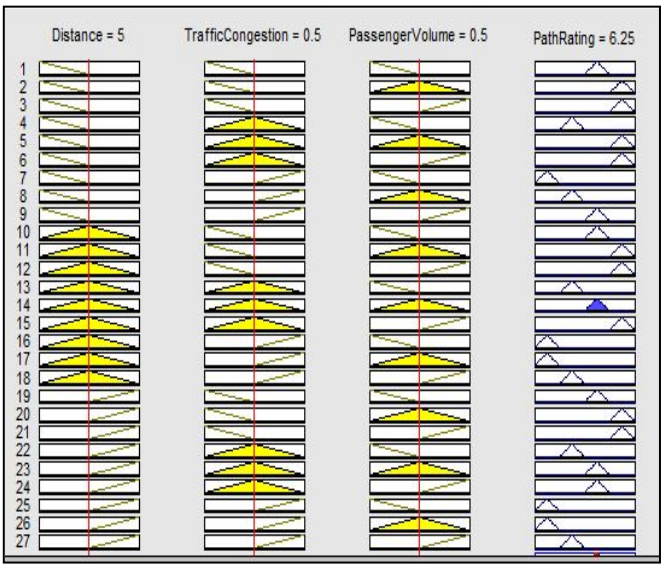

Figure 10: Experiment 1 Actual simulation of input data parameter this is uses Average distance, Normally congested and Medium volume of passenger.

The result of this experiment stated the path as Normally passable and if we check it into the fuzzy rule in table 3 the result is the same which is what we want to see.

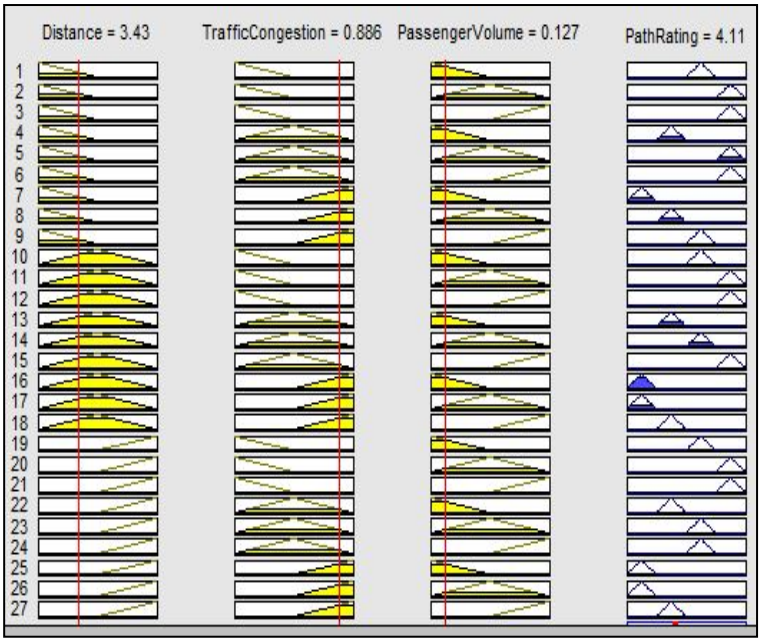

Figure 11: Experiment 2 Actual simulation of input parameter with Average distance, Highly congested and Small volume of passenger.

Fuzzy logic simulation again successfully finds the right output which is not passable. The result is the same with the fuzzy rules that the researcher set in table 3.

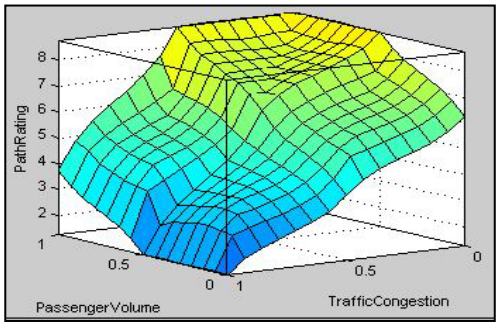

Figure 12: Passenger Volume and Traffic Congestion Vs Path Rating

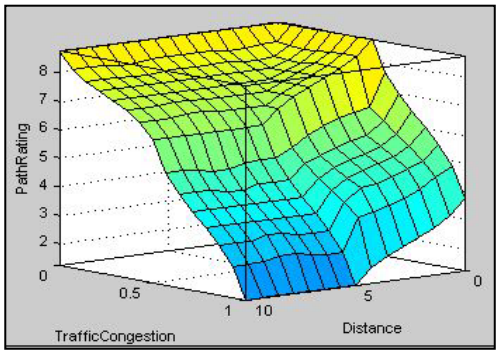

Figure 13: Traffic Congestion and Travel Distance Vs Path Rating

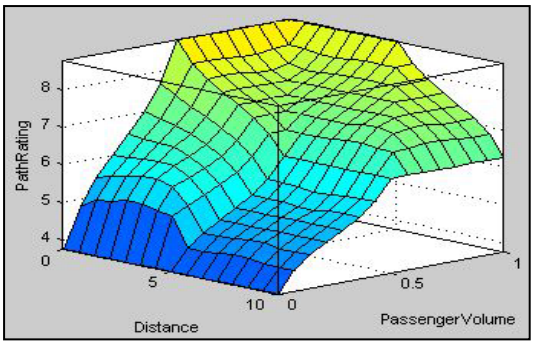

Figure 14: Travel Distance and Passenger Volume Vs Path Rating

This 3D graphs illustrate the overall result of the fuzzy logic and as observed it will come up with:

- Figure 12 the result is increases or more becoming highly passable as the passenger volume increases and the traffic congestion decreases.
- Figure 13 graph show that if the traffic congestion decreases and the distance became nearer the result of fuzzy logic is became better which means if will became more highly passable.
- Figure 14 if the volume of passenger increases and the distance decreases the higher the result fuzzy logic could get.

5. CONCLUSION

Fuzzy logic successfully makes the right decision set by the researcher and to guide the driver tin selecting their route. The result is also self-adaptive according to the data inputted by the user which is in actual system the data input will provided by the wireless sensor network. Fuzzy logic is a very good, reliable and powerful tool in creating a decision making system and that is been prove in this paper. The simulation result is successfully and exactly follow the fuzzy rules set by the researcher and as the result the system works accordingly to what the researcher want to achieve. In this results the bus drivers will be now guided in making decision which path is the best at this point in time. The result also helps the drivers to select to highly demanded bus stops that will help to increase their profit.

6. RECOMMENDATION

The wireless sensor networks are needed to design perfectly to give good and reliable data to fuzzy logic system. The researcher also needs to think more factors that will affect the driving route and add to the membership function. The researcher set only the main factor that has a highly impact or effect into the route and doesn't indicate membership function which is not really affecting the route. As observe increase in membership function your fuzzy rules will also increases and it will became more complicated.

7. ACKNOWLEDGEMENT

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