EFFECTIVE MANAGEMENT OF BUS TRANSPORTATION THROUGH DESIGN OF A FUZZY EXPERT SYSTEM

Abhinav S. V.[1] and Krishna Anand S.[2]
[1]B. Tech Computer Science and Engineering, SASTRA University, Thanjavur, Tamil Nadu, India
[2]SAP/CSE, SASTRA University, Thanjavur, Tamil Nadu, India
E-Mail: abhinavsv3@gmail.com

ABSTRACT

With rapid raise in population, vehicular traffic has increased in leaps and bounds. Road accidents have been on the rise every day. The system is more acute especially in metros and large towns. Besides, an exponential improvement in technology has lead to a fast moving world. The aim of organizations is to carry out work in a fast and efficient manner and at the same time cutting down the expenses incurred. With this perspective in mind, a fuzzy expert system has been designed for bus management system. This system considers a large set of input parameters and frames decisions. The chief focus of the system is to provide a threshold limit beyond which the number of accidents as well as the expenditure incurred can be cut down. The unique feature of the system is to simulate relationships between parameters which are difficult to compute mathematically. A specific instance of the relationship between speed of the vehicle and wear and tear has been clearly illustrated.

Keywords: fuzzy logic, fuzzy expert system, rule formulation, mamdani model, transportation system, membership functions.

1. INTRODUCTION

Human Population across parts of the world has exploded in leaps and bounds. The number of people moving from place to place has grown in great numbers. A wide variety of transport mechanisms are in use. Transportation through buses have been in place from time immemorial. The transport management system has managed to cater to the needs of the people with an eye on profit. These systems focuses on maximising the amount of profit earned by the company without compromising on the facilities provided to the customers and at the same time prevent loss of goodwill by taking customers to the destined place in a safe, fast and efficient manner.

This system gives enough emphasis on identifying the speed of the vehicle, road traffic, amount of hitting brakes based on the condition of the road, number of people in the bus during that instance and the age of the tyre. The chief aim of this system is to minimise the possibility of accidents and at the same time reduce wear and tear of tyres apart from minimising other incidental expenditures.

The system is expected to play a decisive role in minimising the overall expenditure and thereby increasing the level of profit.

2. IDENTIFICATION OF THE PARAMETERS

In order to design an efficient road transportation system, a larger number of parameters need to be taken into consideration. Safety is the primary feature that obviously gets the highest priority. With the provision of safety taken for granted, cost cutting measures seem to be the order of the day. A reduction in consumption of fuel goes a long way towards serving organizational needs. Apart from fuel consumption, other expenditures include maintenance of tyres. The tyres must be continuously monitored for wear and tear. The factors primarily responsible for each of these problems have been taken into consideration. These factors include speed, road condition, brake hitting force, traffic on the road, passenger load in the bus, thickness of tyre and distance travelled per litre of fuel.

In order to efficiently incorporate the various characteristics, a large amount of emphasis has been placed on design of the system in certain regions in Tamil Nadu, India. Even within the state, some areas are more traffic prone while others are relatively free of traffic. Instances have been considered in all kinds of categories including high traffic prone areas in central Chennai, regions where there is a medium level of density like Tirunelveli and less dense areas like Pudukottai. Apart from that, some of the roads will be national highways while others will include roads with potholes in between. The proposed system takes into consideration all these factors.

3. DESIGN OF FUZZY SYSTEM

3.1 Basic design

A fuzzy expert system has been designed for a bus transportation system. The primary purpose of the system is to enable an exponential reduction in the amount of accidents apart from easing the traffic and reducing expenditures incurred. A wide variety of inputs have been taken into consideration. The inputs include speed, road condition; break hitting, traffic, bus load, Age of tyre and kilometre per litre (KMPL). With the rising complexity of the system owing to a large number of factors, it has been decided to prune out certain factors. For instance, the aspect dealing with exact number of passengers getting in and leaving the bus at each stop has been left out from further analysis. Initial analysis showed that this factor plays a minimal role as far as the output parameters like occurrence of accidents are concerned. However, this parameter could be used for analysis of factors like congestion in the bus and determining number of bus stops which in turn is left for further research. Having determined the set of factors to be taken into consideration, a set of hundred and fourteen fuzzy rules have been framed. A sample rule is shown as follows:

if (speed is high) then Expenditure is high

In the specified rule, the antecedent deals with speed. When speed is high, a large amount of fuel is burnt. This in turn leads to added stress on the components of the vehicle thereby leading to wear and tear which in turn leads to a rise in expenditure.

For effective framing of rules, the minimal requirement is the construction of appropriate membership functions. The detailed discussion on choice of membership functions have been provided in Sec.4. The detailed structure of the designed system has been shown in Figure-4.

The system has been designed that performs continuous learning and takes decisions on cutting down of costs apart from mitigating possibilities of accidents.

3.2. Structure of fuzzy expert system

The structure of a fuzzy expert system has been shown in Figure-1.

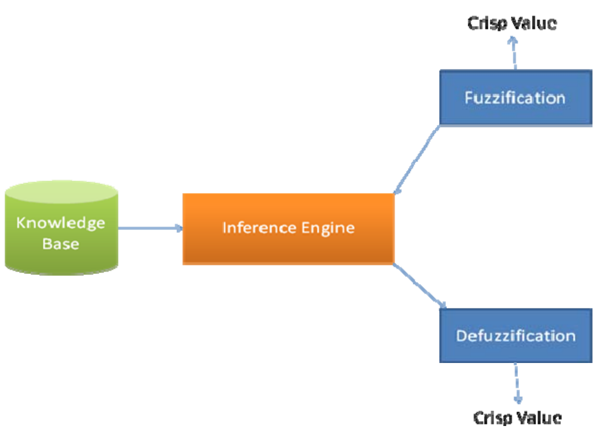

Figure-1. Components of a Fuzzy Expert System.

3.2.1. Fuzzifier

The membership functions defined on the input variables are applied to their actual values in order to determine the degree of truth for each premise in a rule. Fuzzy logic operators have been used to combine antecedents. Experiences in day to day world show that when the bus is driving at less than 23 kms / hr, the speed could be categorised as very low. For speeds approaching 23 kms / hr and beyond, speed could be categorised as very low to a certain extent and low to a certain extent. It has been observed.

For instance, for a speed of 23 kms / hr, the membership value has been found to be 0.7 as illustrated in Figure-2.

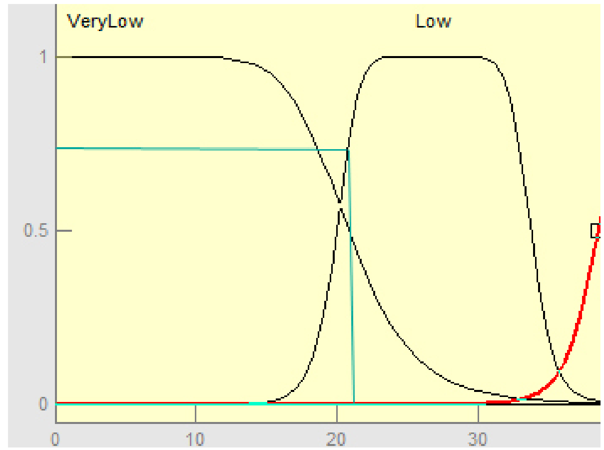

Figure-2. Fuzzification.

3.2.2. Defuzzifier

During defuzzification, the output set is converted into a crisp member. There are many techniques for defuzzification like centroid, maximum and other relevant methods.

In the designed system centroid method has been used as it can provide a reasonable estimate over a sample set.

The process of defuzzification for a sample rule has been illustrated in Figure-3.

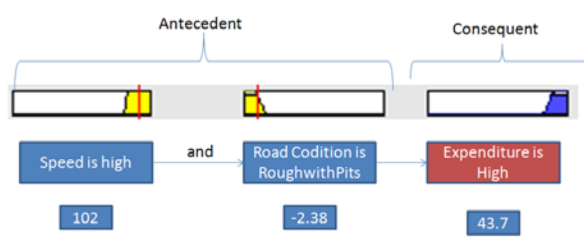

Figure-3. Computation of expenditure.

3.2.3. Rule base

As the parameters that have been considered do not have definite values, a fuzzy expert system has been developed. Figure-4 depicts the fuzzy system that has been developed.

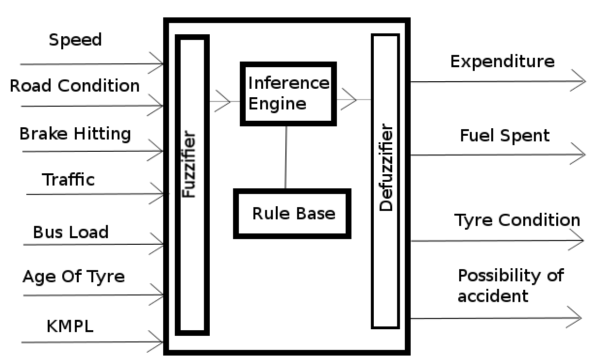

Figure-4. Designed fuzzy system.

VOL. 10, NO. 6, APRIL 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Real world scenario is engulfed with fuzziness. Thus an intelligent controller is built using fuzzy system. The controller takes the following parameters as input speed, condition of the road, number of times brake has been hit, road traffic, bus load or population in the bus, age of tyre and kilometers per litre of travel. The above parameters can be defuzzified to obtain the necessary outputs such as expenditure, fuel spent, tyre condition 0 and possibility of accident. The unique feature this system is its ability to accurately demonstrate the relationship between various parameters.

4. CHOICE OF MEMBERSHIP FUNCTIONS

The building blocks of a fuzzy set theory are its membership functions. It could be easily observed that the behaviour of various parameters differ based on the application in which they are used. Some of the parameters need to experience a dramatic change in behaviour with even minor variations in their values. It is hence needed to choose an appropriate membership function that would characterise the required behaviour. Membership functions determine the fuzziness in a fuzzy set. Accordingly, their shapes play a significant role in framing suitable inferences of the diagnostic fuzzy control system. Membership functions may take different shapes like Triangular, Trapezoidal, Gaussian, Bell and Sigmoidal. The only condition to be met by a membership function is that it should vary between 0 and 1. Thus, the basic problem with modelling a situation is to break the 0-1 modelling. This can be done by using triangular Membership function. However, if the situation is more complex and deep, we have a need to choose a special type of membership function. In order to make the best choice, experience about the given situation comes into play.

In this problem, the choice of the membership function has been made based on the demanding requirements of the situation. Seven input variables have been identified and implemented. Figure-5 gives a clear view of the various input and output parameters taken into consideration. A Mamdani model has been designed.

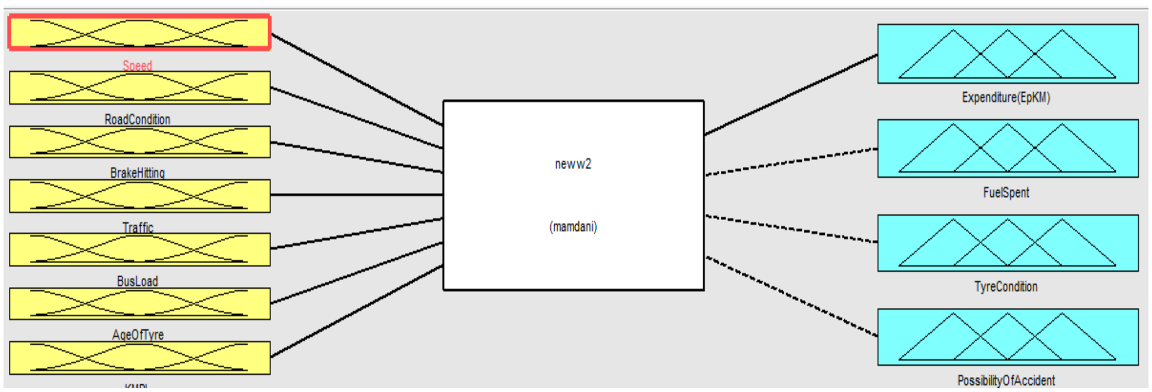

Figure-5. Inputs and outputs.

Speed

For the parameter speed, a generalized bell membership function (gbellmf) has been found to be more appropriate. The smoothness of the curve makes this function ideally suitable to describe the characteristic of variation in speed. Five different membership values have been described for this parameter varying from very low to very high. The membership function characteristic for speed has been plotted in Figure-6.

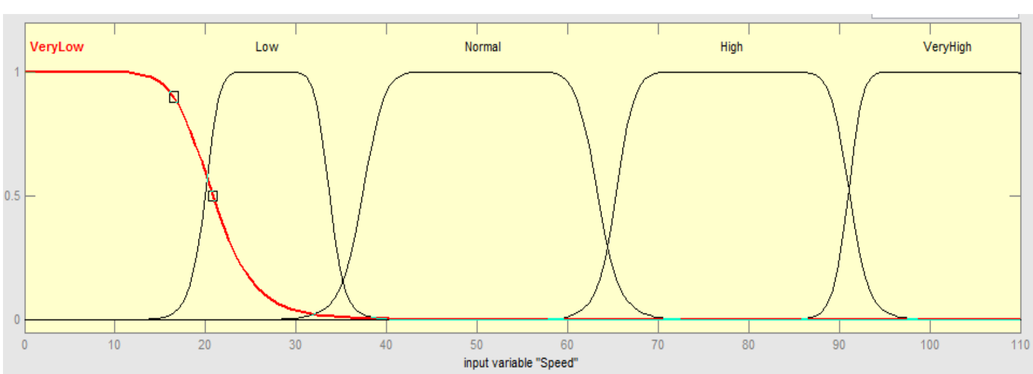

Figure-6. Membership function plots for speed.

ARPN Journal of Engineering and Applied Sciences

Expenditure:

Unlike speed, characteristics of the parameter 'Expenditure' are found to exhibit a wide range of behaviour. Hence, a single membership function may not be suitable to describe the characteristic. A combination of trapezoidal and generalized bell shaped membership functions have been used to describe the same. The plot for Expenditure has been shown in Figure-7.

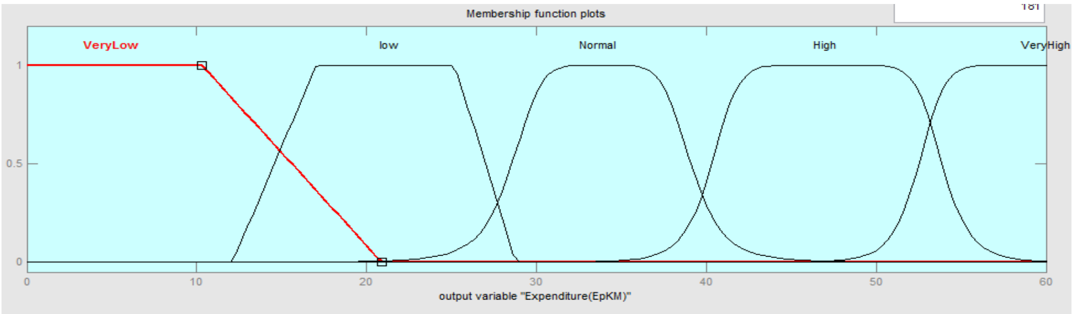

Figure-7. Membership function plots for expenditure.

5. DIAGNOSIS OF FUZZY MODEL

The process of obtaining a fast, safe and cost effective system appears highly impractical. The basic reasons owing to the same deal with the need for conflicting desirable characteristics. Hence, a balancing factor is needed during design of the system. The designed fuzzy expert system is able to handle the same.

This system is able to produce a variety of interesting results. The system is able to identify the point beyond which an increase in speed could lead to much higher fuel consumption. Besides, the effect of speed on wear and tear has also been clearly demonstrated.

5.1. Estimation of expenditure per kilometre incurred

With spiralling rates of fuel and other components, the market has become extremely competitive. The expenditures incurred appear to cross desirable limits. Measures must be taken to keep the expenditure within certain limits. In order to effectively carry out the same, it is first estimated based on the rules. These rules are in turn added to the rule base. This expenditure takes into account money spent for fuel; service and handling wear and tear of components. The relationship between expenditure and speed has been shown in Figure-8.

5.1.1. Expenditure vs speed

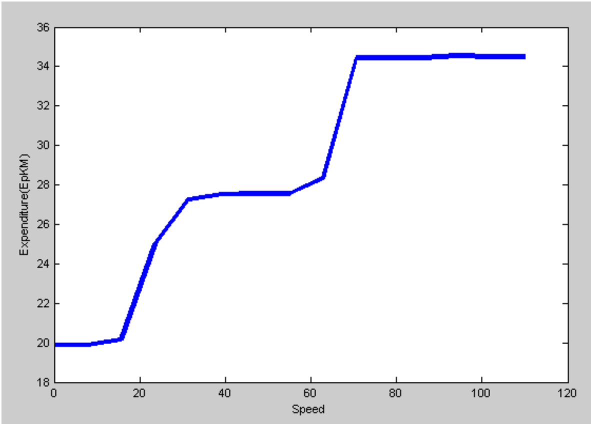

Figure-8. Expenditure vs speed graph.

The non-linear characteristics of the graph indicate that some other factors like wear and tear also influence the overall expense. For implementation purposes, distance in kilometres is considered as a standard for inferring the amount of expenditure.

It has been observed that there is an increase in expenditure with variation in speed. However, the variation does not exhibit linear characteristics. Results have shown that for variation in speeds between 30 and 60 kms per hour, the average expenses per kilometre of travel reduce. On crosschecking with transport department officials, there is a definite degree of concurrence with the actual values.

It has then been decided to estimate the average expenditure incurred during commonly occurred circumstances in the roads where vehicles are driven at the normal speed in which they are driven and the intensity of traffic is moderate. This has been depicted in Figure-9.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

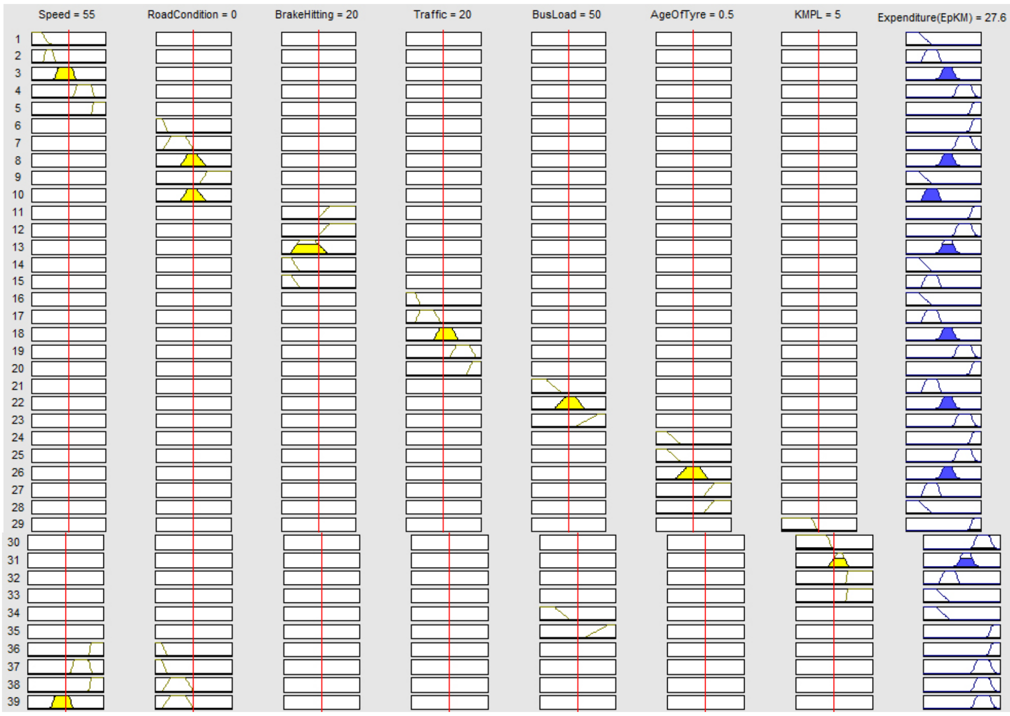

Figure-9. Estimation of expenditure.

5.2. Estimation of fuel spent

The choice of fuel plays a definite role in the amount of money spent. Some vehicles would be petrol operated or diesel operated. Apart from an increase in expenses, it can also lead to emission of green house gases. This is a very pressing problem. More than 90% of greenhouse gases come from fossil fuel. Amount of fuel consumed is another pressing issue with the depletion of fossil fuel. Since they produce significant amount of energy per unit due to higher energy density than gasoline, they are being used in most of the buses plying in Tamil Nadu.

A study on the amount of fuel consumed has been carried out in this work. Fuel spent is critically dependent on the speed, Road Condition, Bus Load, Traffic and KMPL.

5.2.1. Fuel spent vs speed:

Experiences have shown that the amount of fuel used depends upon the speed of the vehicle. However enough amount of research has not been carried out to find the exact relationship between them. Figure-10 shows depicts fuel spent vs speed graph.

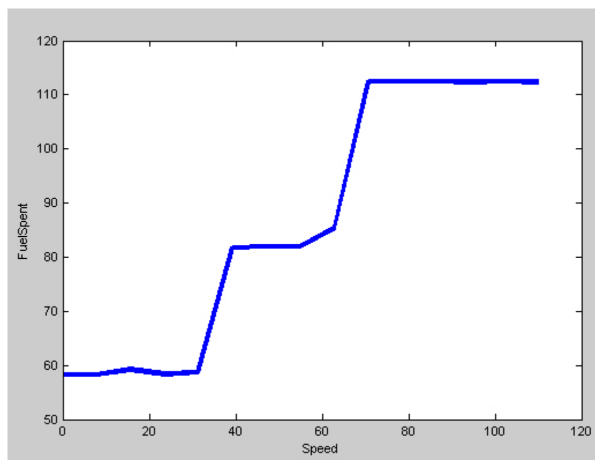

Figure-10. Fuel spent vs speed graph.

Special efforts have been put to identify the relationship. It has been found to produce amazing results. It has been observed that an increase in speed beyond 38 km/hr has lead to a drastic increase in fuel consumption. Similar cases are observed for an increase in speed beyond 65 Km/hr.

It has then been decided to estimate the average fuel spent during commonly occurred circumstances in the roads where vehicles are driven at the normal speed in which they are driven and the intensity of traffic is moderate. This has been depicted in Figure-11.

VOL. 10, NO. 6, APRIL 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

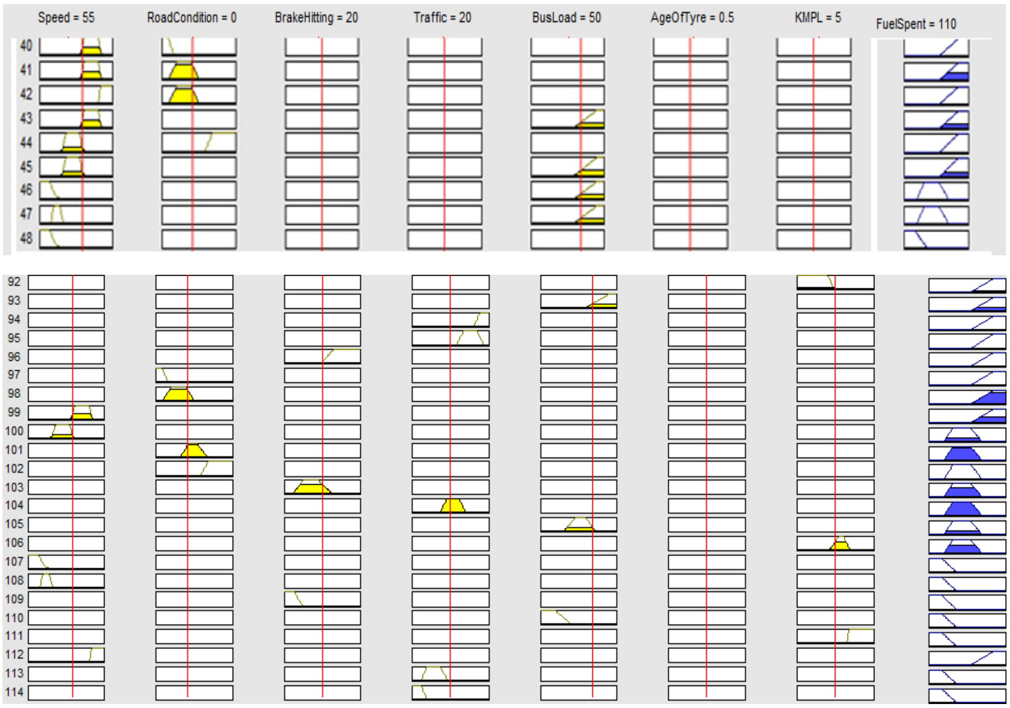

Figure-11. Rule graph for fuel spent.

5.3. Determination of the tyre condition

Tyre blowouts in heavy vehicles could lead to accidents. These accidents could be foreseen in advance by taking into consideration the condition of the tyre. There are usually six tyres in a bus. The blowout of a tyre pulls the vehicle onto one side. To avoid an untoward incident, an alert driver has to steer firmly in the opposite direction. The damage to the rear tyre may force the driver to hold the steering firmly and accelerate. To avoid such emergency conditions and sudden impulsive reaction from the concerned driver, it has to be ensured that probability of occurrence of tyre bursts must be reduced to near zero.

In this work, tyre pressure and physical appearance have been taken into consideration to determine the reliability of the tyre. Three fuzzy values namely High, Medium and Low have been ascertained for tyre reliability. The membership functions for the same have been shown in Figure-12. The state of the tyre is dependent on the Brake Hits, Road Condition, Speed of the bus and the bus Load. The rate of deterioration of the tyre is based on the combination of these parameters.

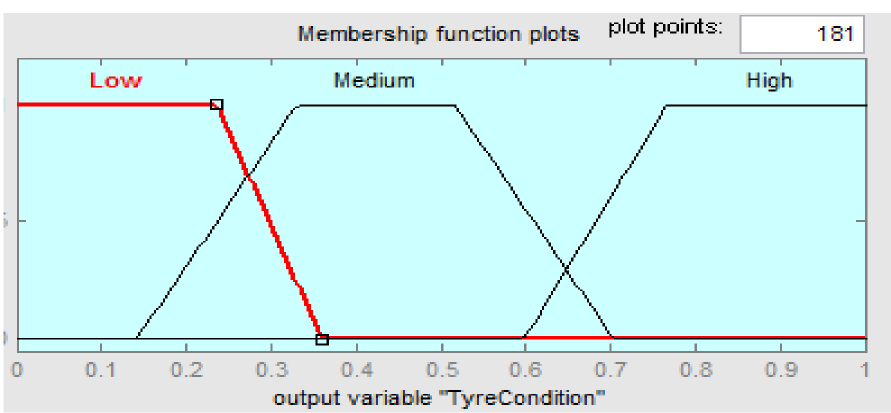

Figure-12. Tyre condition membership function.

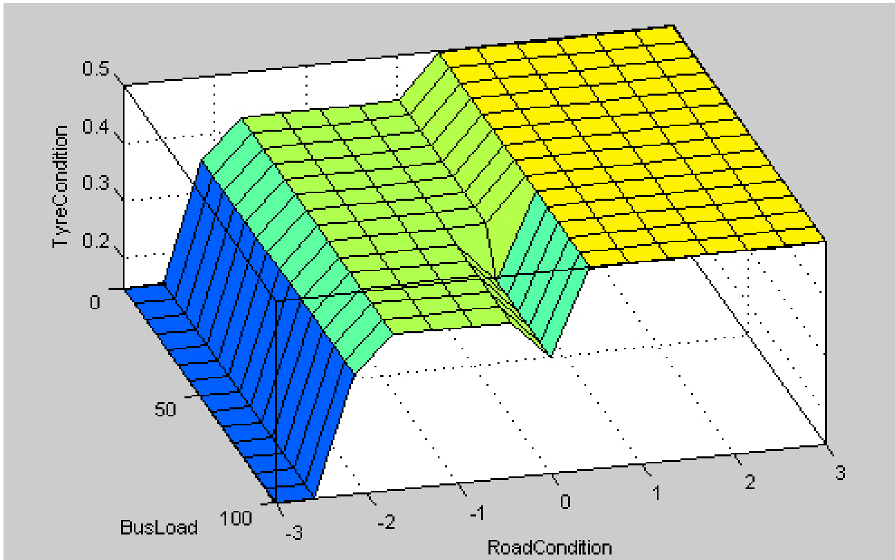

Figure-13. Tyre Condition vs road condition vs bus load.

Figure-13 depicts the level of damage of the tyre with respect to the load of the bus and the smoothness of the roads. It could be easily inferred that there is a significant amount of tyre damage when the roads are more rough (indicated by the negative values). Similarly, the amount of occupancy in the bus beyond which there is a sizable amount of tyre damage could also be observed in this Figure-13.

5.4 Determination of the possibilities of accident

To minimize the possibilities of road accidents taking place, a detailed analysis has been performed where factors like Bus Load, Age of the tyre, road condition and speed have been taken into consideration. Studies have shown that the reason for a sufficiently large number of accidents occur due to a combination of factors.

This work clearly demonstrates the threshold value beyond which there is an abrupt rise in chances of accidents. The threshold values have found to change depending on the combination of parameters.

Figure-14 clearly demarcates the region where there are significant possibilities of accidents. It could be observed that for speed ranges crossing 102 kms / hr, bus loads crossing a value of 85 and road conditions having an index value of less than -2, there is a sudden surge in the possibility of accidents as opposed to other circumstances.

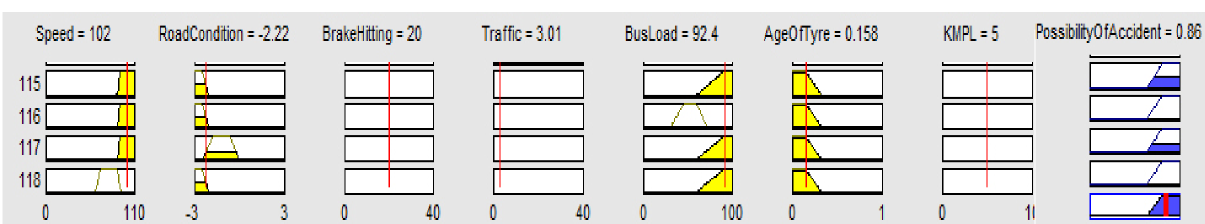

Figure-14. Rule graph for possibility of accident.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

An efficient fuzzy expert system has been designed for effective management of bus transportation. This system has been able to achieve a win-win scenario where both the authorities as well as customers derive a high degree of satisfaction. This system is able to analyse scenarios in which the overall expenses could be minimized. Indications of the approximate speed at which the vehicle should be driven based on the appropriate road conditions could be optimized. The added unique feature in this system is that enough emphasis has been given to reduce wear and tear of the tyres apart from minimizing fuel consumption. However, the major focus of this system lies in minimizing the number of accidents. Once put in a actual practice this system could provide an overall fillip to transportation system.

6.2 Recommendations

Although the designed system is found to be highly efficient, the system could be further improved in order to keep track of day to day developments. Apart from the parameters considered, some more factors could also be taken into consideration. These factors include frequency of the bus, stops involving a relatively high degree of passenger movements and availability of buses at the location. Besides, optimal usage of sensors at appropriate points could make the system more ontological. These devices would help in smart traffic control, parking, toll collection, logistics, fleet management and safety and road assistance.

With advancement in technology, Internet of things could be put into practice. Here, information could be transmitted between buses indicating the level of traffic on roads. This in turn could help the incoming bus to suitably modify parameters like speed and direction of travel. Information processing of transport systems like vehicle, infrastructure and aspects pertaining to driver operations could also be used to prevent accidents and traffic delays.

REFERENCES

Mukti Advani, Geetam Tiwari. 1998. Review of Capacity Improvement Strategies for Bus Transit Service. Indian Journal of Transport Management. pp. 363-391.

Chi-Feng Wu, Cheng-Jian Lin. 2012. Applying a Functional Neurofuzzy Network to Real-Time Lane Detection and Front-Vehicle Distance Measurement. IEEE Transactions on Systems, Man, and Cybernetics-Part C: -Applications and Reviews. 42(4): 577-589.

O. Pribyl. 2010. Fesole–Fuzzy Expert System for Determining the Optimal Level of Enforcement. IET Intelligent Transport Systems. 4(1): 76-81.

Chang-Shing Lee, Mei-Hui Wang. 2011. A Fuzzy Expert System for Diabetes Decision Support Application. IEEE Transactions on Systems, Man, and Cybernetics-Part B: Cybernetics. 41(1): 139-153.

Freddy Milla, Doris Sáez, Cristián E. Cortés, Aldo Cipriano. 2012. Bus-Stop Control Strategies based on Fuzzy Rules for the operation of a Public Transport System. IEEE Transactions on Intelligent Transportation Systems. 13(3): 1394-1403.

Takahiro Wada, Shun’ichi Doi, Naohiko Tsuru, Kazuyoshi Isaji, Hiroshi Kaneko. 2010. Characterization of Expert Drivers’ Last-Second Braking and its Application to a Collision Avoidance System. IEEE Transactions on Intelligent Transportation Systems. 11(2): 413-422.

S. Krishna Anand, R. Kalpana, S. Vijayalakshmi. 2013. Design and Implementation of a Fuzzy Expert System for Detecting and Estimating the Level of Asthma and Chronic Obstructive Pulmonary Disease. World Applied Sciences Journal. 23(2): 213-223.

Sanket Gupte, Mohamed Younis. 2012. Vehicular Networking for Intelligent and Autonomous Traffic Management. IEEE ICC 2012-Wireless Networks Symposium. pp. 5306-5310.

Krishna Anand S, Gayathri Narayanan, Gayathri Padmanabhan, Vishnuja Sivadas U. 2012. Design of Fuzzy Expert System for Vehicle Automation. International Journal of Engineering and Technology. 4(4): 238-245.

Yu Xian Xia, Yu Xue. 2010. Analysis of the Effect of Bay-Bus-Stop on Traffic Flow in One-Direction Two Road by the Continuum Model. International Conference on Artificial Intelligence and Computational Intelligence.