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Comparative Study of Artificial Intelligence Algorithms for Autonomous Vehicle

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Abstract: ***Autonomous vehicle play a key role in transportation the main objective is the vehicle should adapt and deviate from the obstacles. In this paper different control systems are studied thereby implementing various computational tools like adaptive neuro fuzzy inference system (ANFIS), fuzzy logic control and neural network control using MATLAB. An Intelligence based control approach is presented so that the vehicles can be automated more effectively based on the control logic algorithms. It presents a novel based study of control algorithm by implementing the above MATLAB tools and their results of each control algorithm fuzzy logic, neural network and adaptive neuro-fuzzy inference system (ANFIS) were studied and compared to understand the best system.***

Keywords: Fuzzy logic, neural network, ANFIS, Automated vehicle, MATLAB, control system

1. Introduction

The objectives of the study is to introduce the new ideasin artificial intelligence algorithms this technique that offers an smooth transition and the motion in the systems, The study of the AI algorithm not only leads in the improvement of the machines but also for the betterment of the human activities. In order to solve the problems and reduce the errors, Mathematics which supports the modes that are very near to human logic but not the same. What differentiate the fuzzy logic system from the Boolean logic is their ability and the way they deal with the real world problems where there are only extreme responses, where the classical logic system proposes only true are false, where the fuzzy logic deals with matter of degree and making it possible the use of approximate and even with the interference of other particals is necessary.

In an autonomous vehicle the adaption to the environment is difficult and the vehicle may attain some errors, where the fuzzy's algorithms helps the vehicle to attain the maximum possibility to attain its function and gets adaptable to the environment easily and performs the complex operation and learns from the complex operation and get adaptable to that condition's.

2. MATLAB Control Logic Algorithm

a) Approach Using Fuzzy Logic

A fuzzy control algorithm is used to control the motor speed depending on the sensor reading which we attained from the three ultrasonic sensor (US1,US2,US3) which is placed in the front side of the vehicle . A fuzzy controller consists of three parts: Fuzzification, Fuzzy Logic Rule Base, and De-fuzzification(ThetKoKo, ZawMyoTun, & Tun, 2015).

- Fuzzification: It is the process of converting the crisp input value to a fuzzy value that is performed by the use of information in the knowledge base
- Rule-Base: They are used in the fuzzy logic system to infer a output based on an input variable. A group of rules using several variables to logically apply knowledge (HLL).
- De-fuzzification: Finally the rule base of the controller converts all the fuzzy terms to numerical values.

Fuzzy logic is a data driven computational model which emulates human inference and reasoning. When a transition occurs from one state to other a classical set doesn't provide clear decision either 0 or 1. Fuzzy set overcomes these drawbacks of a classical set 0 to 1. By using the fuzzy tool box (fuzzy) in MATLAB, the following input-output is being mapped for the Autonomous vehicle system and various results have been obtained.

Inputs

The inputs parameters for the Autonomous Vehicle system are as follows:

- Ultrasonic sensor 1 – US1very close, US1medium, US1veryfar.
- Ultrasonic sensor2 – US2very close, US2medium, US2veryfar.
- Ultrasonic sensor 3 – US3very close, US3medium, US3veryfar.

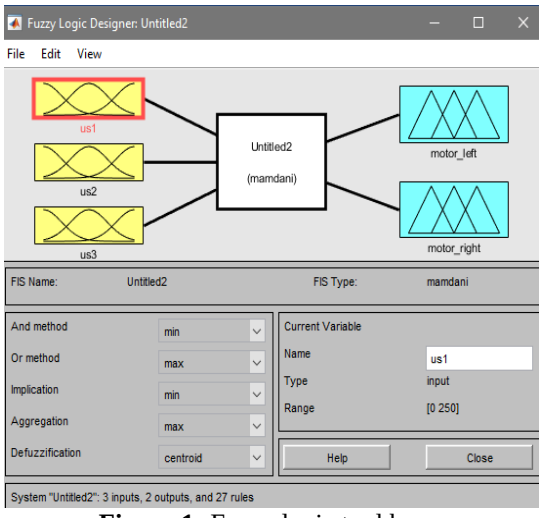

Figure 1: Fuzzy logic tool box

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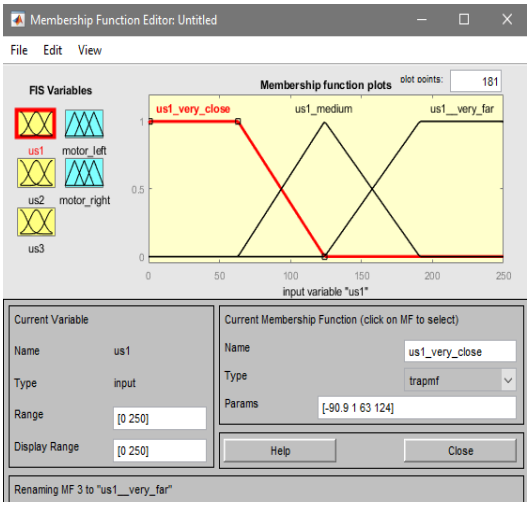

Figure 2: Membership function of Ultrasonic sensor 1

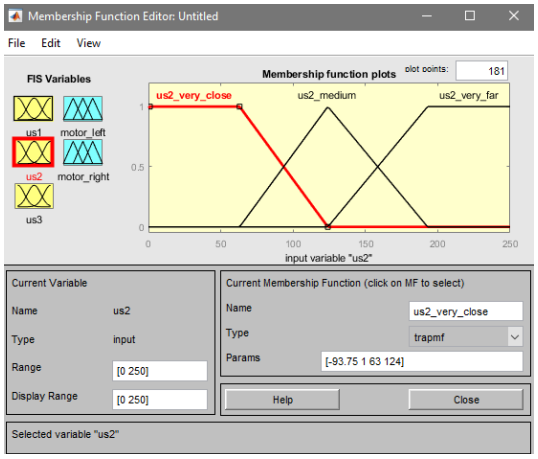

Figure 3: Membership function of Ultrasonic sensor 2

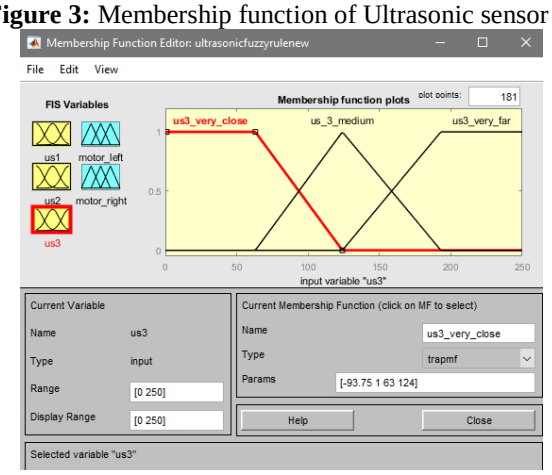

Figure 4: Membership function of Ultrasonic sensor 3

Outputs

The following are the output parameters of the Autonomous vehicle system.

- Motor Left speed
- Motor right speed

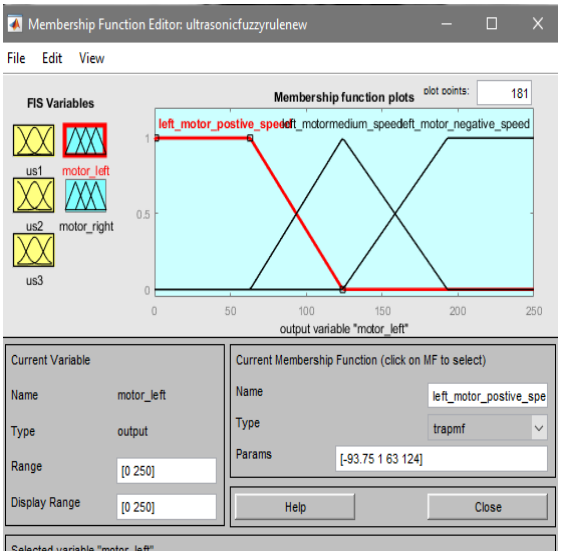

Figure 5: Membership function of motor left speed

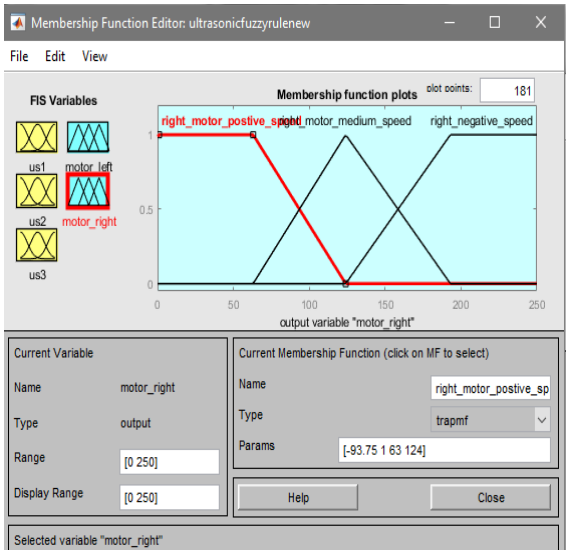

Figure 6: Membership function of Motor right speed

b) Approach Through Neural Network Logic

A Neural network provides automatic control of Autonomous vehicle. AnUltrasonic sensors generates a sensing signal indicating the range of the distance from the obstacle, and the neural network generates Motors velocity according to it the motors speed ischanged. A training unit uses manually generated ultrasonic sensor signals to create weight factors for the neural network. By using neural network tool box (nntool) in MATLAB the input and the target values are feed to the network, the network is trained by choosing certain algorithm and various plots are obtained(Beale, Hagan, & Demuth, 2010).

- Here Bayesian Regularization training algorithm is used since it can result in good generalization for difficult, small or noisy datasets. Training stops according to adaptive weight miniaturization (Regularization)
- There are three layers present in this network input layer, hidden layer, output layer.
- The input and the output layer consists of two neurons and the hidden layer and the hidden layer has 27 neurons.
- There are 27 data sets provided for each neuron in the input and the output layer

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- The system can be retrained by changing the number of hidden neurons if the network does not perform well after training

The data sets for input are taken from fuzzy logic data i.e. range values of Ultrasonic sensor 1 (0-250 range), Ultrasonic sensor 2 (0-250 range), Ultrasonic sensor 3 (0-250 range) and similarly for output motor left speed (0-100km/hr), motor right (0-100km/hr).

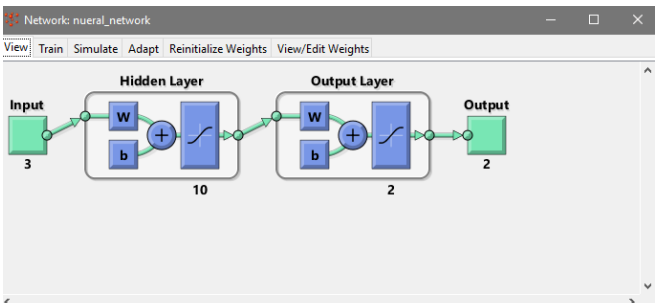

Figure 7: Neural network model developed for the MATLAB data

c) Approach Through Adaptive Neuro-Fuzzy Inference System

An adaptive neuro-fuzzy inference system or adaptive network-based fuzzy inference system (ANFIS) is a kind of artificial neural network that is based on Takagi–Sugeno fuzzy inference system. The technique was developed in the early 1990s. Since it integrates both neural networks and fuzzy logic principles, it has potential to capture the benefits of both in a single framework

A Neuro-Fuzzy system is a fuzzy system that uses all learning algorithms derived from or inspired by neural network theory to determine its parameters by processing data samples.The adaptive network based fuzzy inference system is the data driven procedure representing a neural network approach for the answer of functions approximate problems. By using ANFIS edit tool box in MATLAB, the Neuro-fuzzy window is opened and the data sets are load from the file or from the workspace.

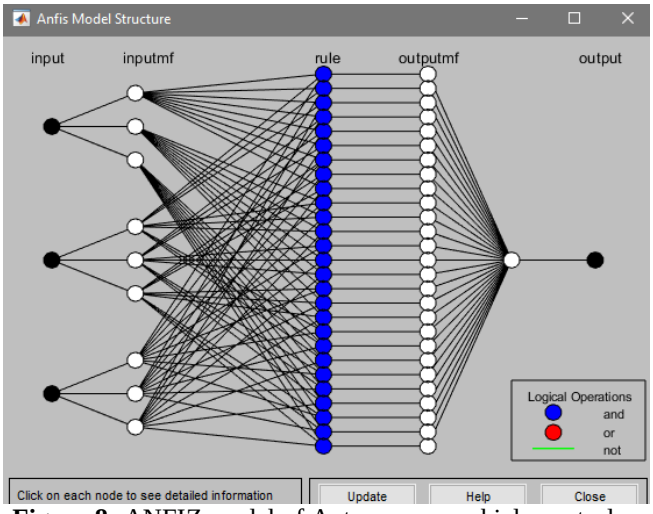

Figure 8: ANFIZ model of Autonomous vehicle control data in MATLAB

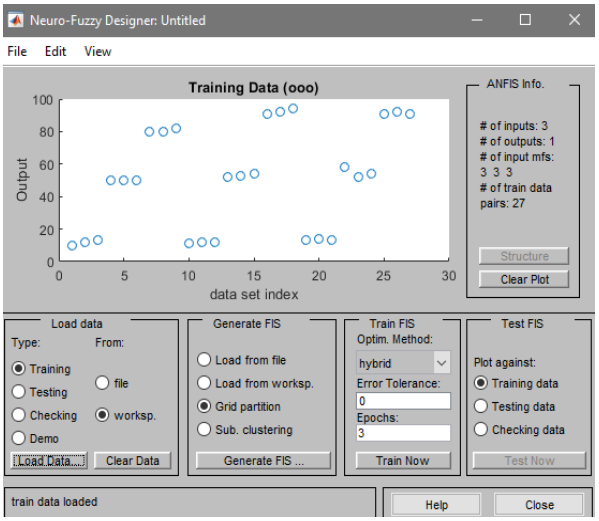

Figure 9: Training data-mapping of input & output

The limitation of this system is that only one output can be developed for the MATLAB data. The same data set used for neural network model was taken in order to find the best of three control logic system. In this approach the input and output data are mapped, artificial neurons assign weights initially by trial & error method and finally weights are modified according to the desired output data give by feed forward approach of back propagation. The mapping provides rule base in fuzzy logic system automatically since it is the combination of two control system fuzzy and neural network a hybrid. The plots of training, testing data and their results are discussed below.

3. Plots and Results of Control Approach

a) Fuzzy Logic Results

Fuzzy system develops a rule base with Boolean algebra, based on the interpolation of these data the system controls the output by modifying motor current which is proportional to speed and motor interval i.e. stoppage time of motor. Fuzzy clusteringafter taking the sensor output voltage readings at different Ultrasonic sensor position the range noted and used to analyse the system behaviour. FIS editor fromMatlab fuzzy logic controller is used to get the results in the rule and surface viewer(Bansode, Rajankar, & Ghatule, n.d.).

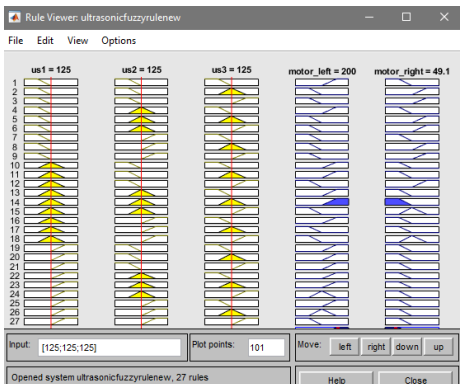

Figure 10: Rule base for fuzzy logic approach

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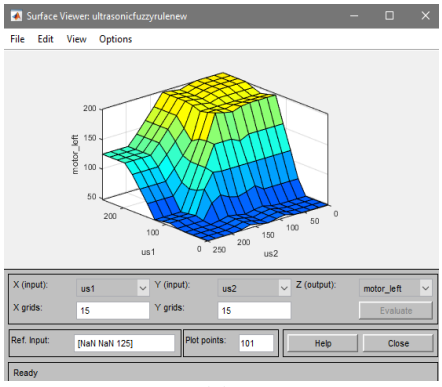
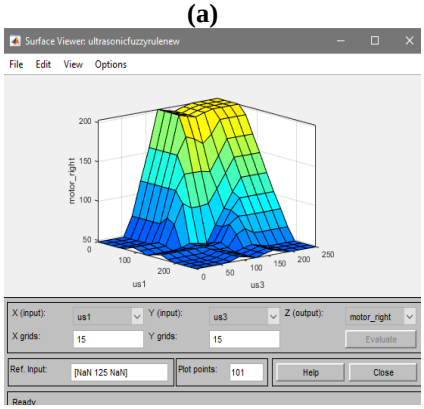


(a)



(b)

Figure 11: Solid surface generation for outputs (a. left motor speed, b. Right motor speed)

b) Neural Network Training Data & Results

Back propagation feed forward method is adopted to modify the weights of the neurons in order to acquire the desired left motor speed and right motor speed as output.

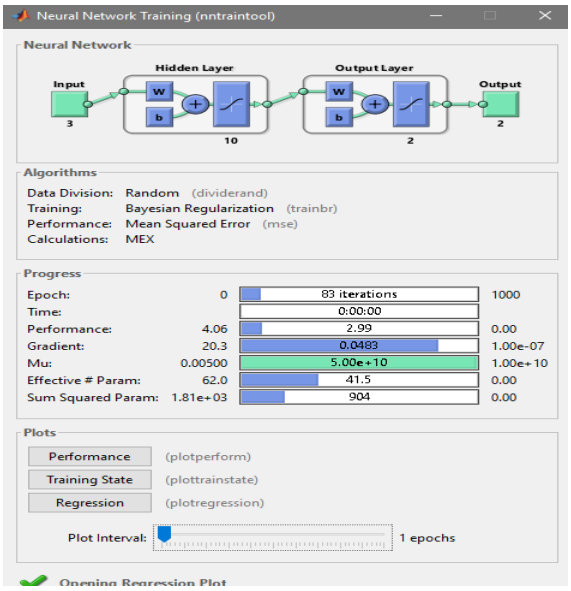


Figure 12: NN tool error and performance results

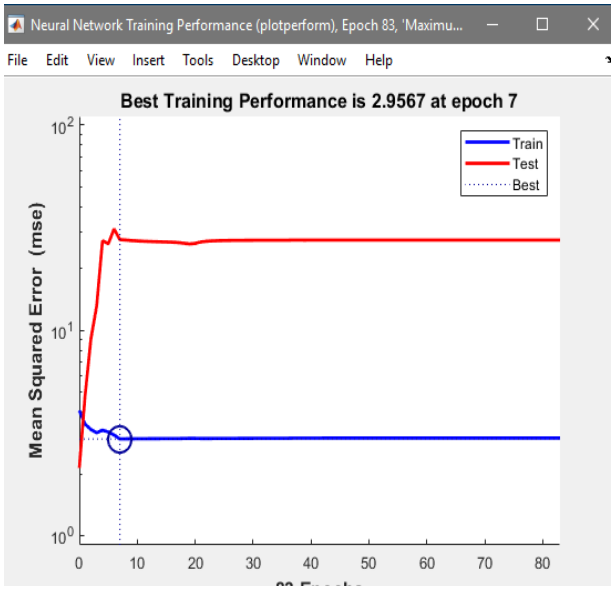


Figure 13: Best Training performance at 83 epochs

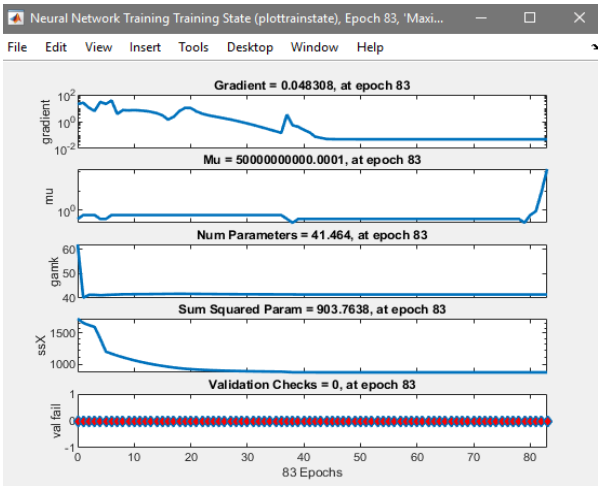


Figure 14: Training state of Autonomous vehicle

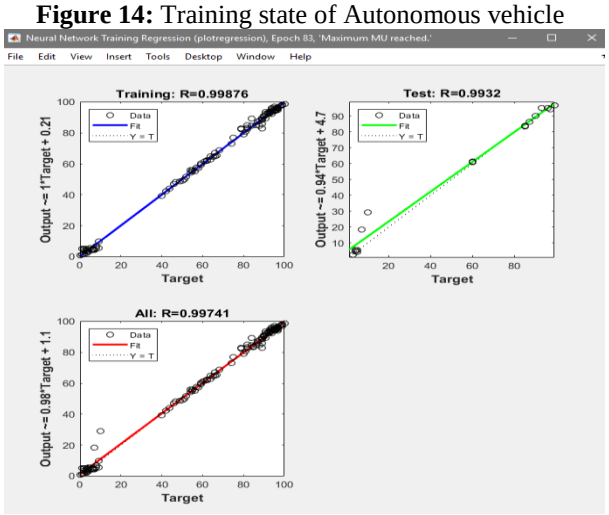


Figure 15: Training regression curves in nntool

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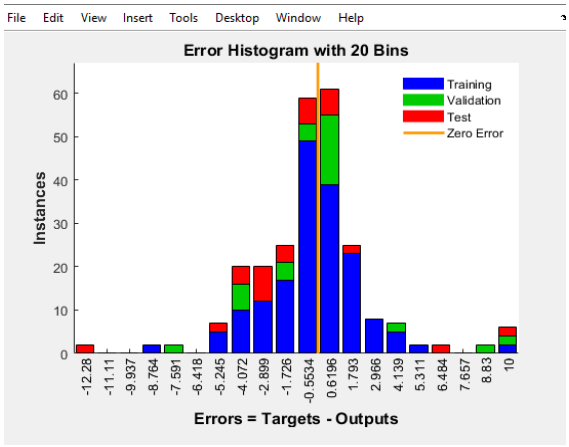

Figure 15: Error histogram-zero error at 0.2

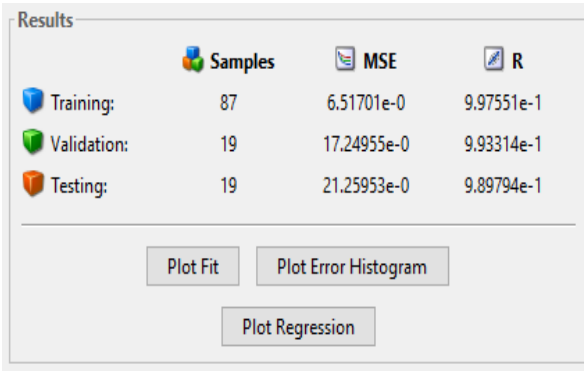

Figure 16: Results of sample trained and validated using nntool

c) Anfiz Approach Results

Based on the data, it creates a logic rule base in fuzzy inference system automatically. Training error - By choosing back propagation training method with error tolerance of 0.003 and 20 epochs the network is trained and the following plot is obtained.

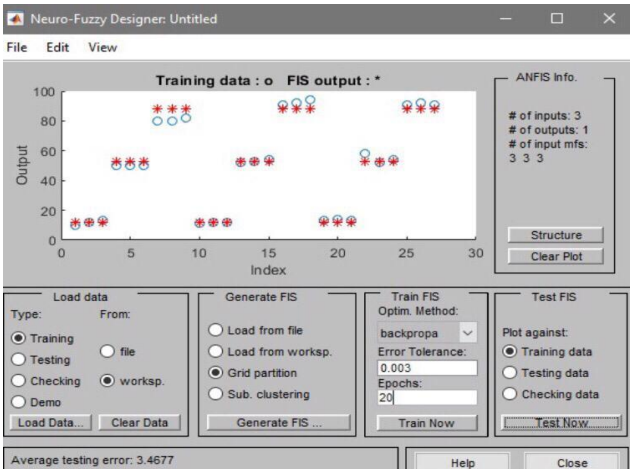

Figure 17: Training data with test points map

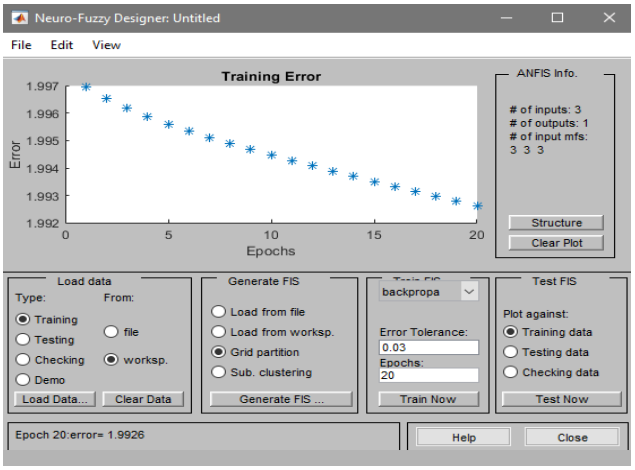

Figure 18: Error map for training the system in ANFIS

The generated ANFIS model can be converted to fuzzy model by editing the FIS properties.

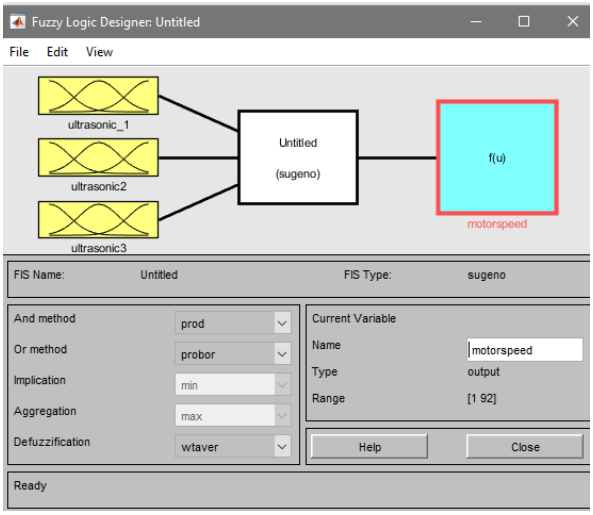

Figure 19: Generated fuzzy model

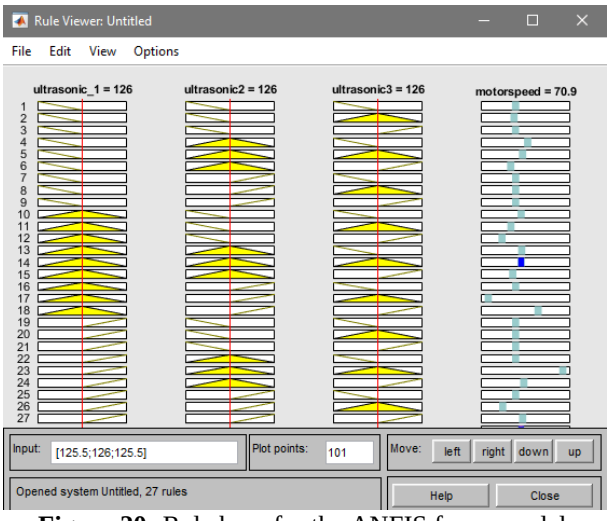

Figure 20: Rule base for the ANFIS fuzzy model

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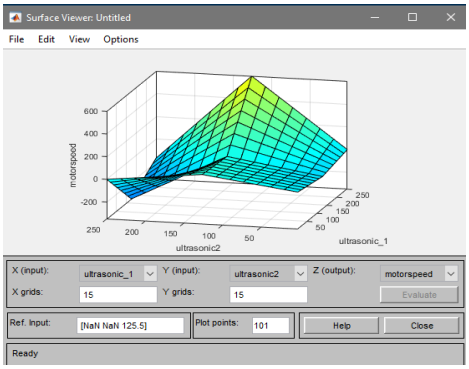

Figure 21: Generated Surface model

4. Conclusion & Future Works

An autonomous vehicle control system is virtually analysed in software environment to detect obstacle and disturbances in the environment using ultrasonic sensors and actuate the motors so that speed of the motors are controlled and adapted according to the environment. Three different control system approaches Fuzzy logic, Neural Network and Adaptive neuro-fuzzy inference system are studied and their results are evaluated. Fuzzy clusteringafter taking the sensor output from the three ultrasonic sensors and is used to analyse the system behaviour. FIS editor from the Matlab fuzzy logic controller is used to get the surface viewer and rule viewer. With the help of rule viewer user can predict and assume the obstacles distance by varying ultrasonic sensor range and motor output motor speed more accurately. Hence the focus in this project work was to do comparative analysis study onautonomous vehicle. From the results, it is inferred that ANFIS control system has an upper hand since it adopts fuzzy and neural network model both combined in it to overcome individual disadvantages as advantages of the system.

In future, the design and development of prototype process will be carried out as a task to test the control system in real time as Hardware in the Loop model. The performance of simulation results and HIL results will be compared to provide effective control system.

5. Acknowledgment

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Paradesipura, Indore-452003, India.

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