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Comparative Study for Wiper Control Systems using MATLAB Tools

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Abstract: ***Windshield wipers play a key role during adverse weather conditions by wiping the rain continuously over the windshield area and provides a clear vision to the driver. The traditional system however requires driver's constant attention for controlling the wiping speed manually. In this paper different control systems are studied thereby implementing various computational tools like fuzzy logic control, neural network control and adaptive neuro fuzzy inference system (ANFIS) control using MATLAB. An Intelligence based control approach is presented so that the windshield wipers 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, windshield wiper, MATLAB, control system

1. Introduction

A windshield wiper is a very important part that permits a driver to collect the visual information at the time of precipitation of rain from the vehicle components aspect that influences the driver's safety and comfort. The traditional wiper system, requires driver's continuousattention in adjusting the wiper speed and thus implementing the appropriate wiper control system makes it easier to control the wiping action of the wiper motor automatically with the infusion of sensors or camera. Since the manual wiper adjustment distracts driver's attention, which could be a direct cause for traffic accidents, many companies have thus developed automatic wiper system using some of optical sensors with the various levels of success.

For solving these problems, a vision based intelligent wiping system is introduced which can sense automatically based on amount of precipitation of rainfall and it can not only measure the amount of rainfall but also the distribution of rain drops.Many attempts have been made at constructing an effective, reliable, and cheap rain detection and wiper control system for vehicles. Automatic rain-sensing wiper systems are relatively uncommon in modern vehicles for a number of reasons they are often too expensive, too unsightly, or too unreliable to be desired in new automobiles (Lubna Alazzawi & Avik Chakravarty, 2015)

2. MATLAB Control Logic Algorithm

a) Fuzzy Logic Based Approach

A fuzzy control algorithm is used to control the wiper speed depending on the rain intensity, rain distribution and vehicle speed. A fuzzy controller consists of three parts: Fuzzification, Fuzzy Logic Rule Base, and De-fuzzification(ThetKoKo, ZawMyoTun, & Tun, 2015).

- Fuzzification: Converting the physical values input data in the range of 0 to 1.
- Rule-Base: 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 i.e., either 0 or 1. Fuzzy set overcomes these drawbacks of a classical set i.e., 0 to 1. By using the fuzzy tool box (fuzzy) in MATLAB, the following input-output is being mapped for the windshield wiper system and various results have been obtained.

b) **INPUTS:** The input parameters for the windshield wiper system are as follows:

- Rain intensity – dry, drizzle and rain.
- Rain distribution – narrow, medium and wide.
- Vehicle speed – low, medium and high.

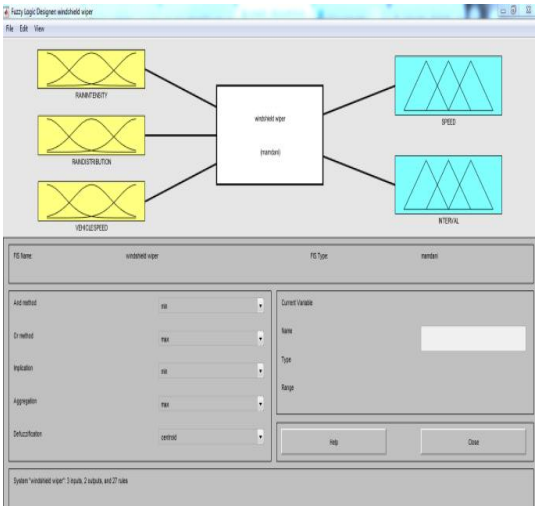

Figure 1: Fuzzy logic tool box

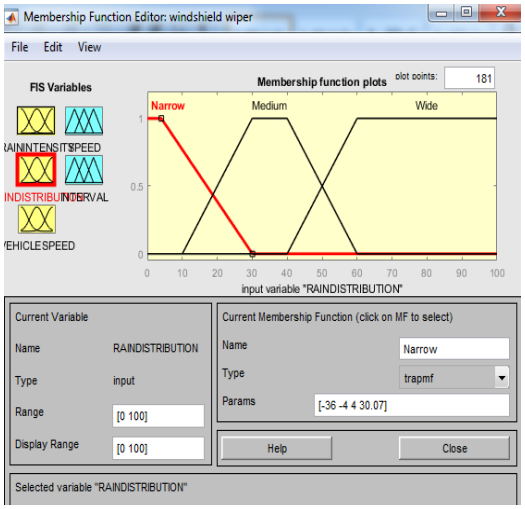

Figure 2: Membership function of rain distribution

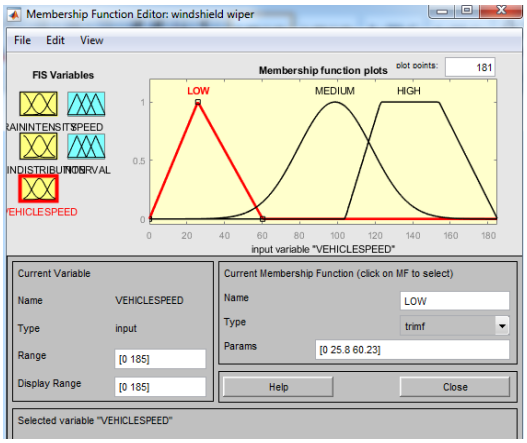

Figure 3: Membership function of vehicle speed

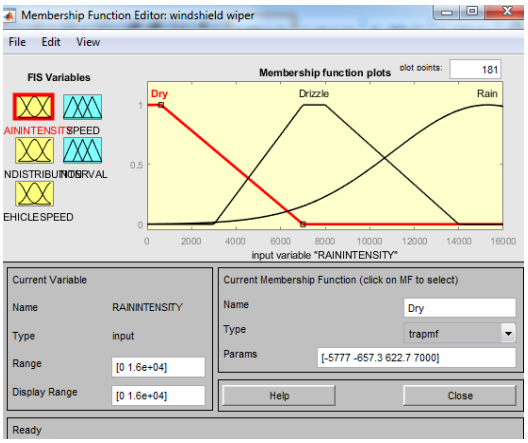

Figure 4: Membership function of rain intensity

c) **Outputs:** The following are the output parameters of the windshield wiper system.
- Wiper speed
- Interval

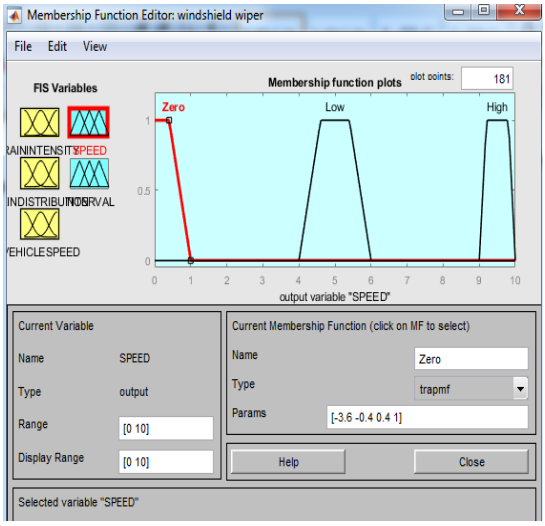

Figure 5: Membership function of motor speed

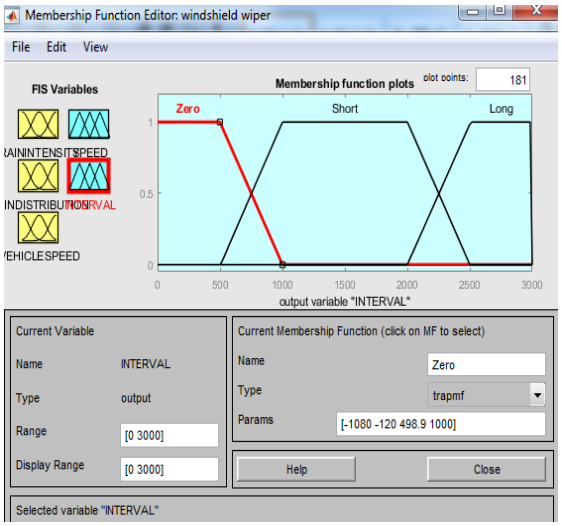

Figure 6: Membership function of speed interval

A. Neural Network Logic Approach

A Neural network provides automatic control of windshield wiper system. A rain sensor generates a sensing signal indicating a rain pattern, and the neural network generates wiping demand signals indicating a wiping action desired by the driver. A training unit uses manually generated wiping supervision 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 25 neurons.
- There are 25 data sets provided for each neuron in the input and the output layer
- 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 rain intensity (0-100 mm of rainfall),vehicle speed (0-180 km/hr) and similarly for output motor current (0-50A), time interval (1-10 second).

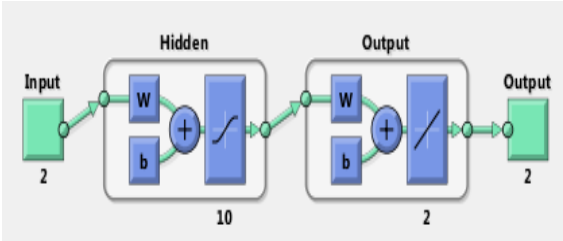

Figure 7: Neural network model from nntool in MATLAB

B. Adaptive Neuro-Fuzzy Inference System Approach

The adaptive neuro-fuzzy inference system (ANFIS), developed in the early 1990s by Jang, combines the concept of fuzzy logic and neural networks to form a hybrid intelligent system that enhances the ability to automatically learn and adapt hybrid systems have been used by researchers for modelling and predictions in various engineering systems(Omar, Haikal, & Areed, 2011).

A Neuro-Fuzzy system is a fuzzy system that uses learning algorithm derived from or inspired by neural network theory to determine its parameters by processing data samples. Since it integrates both neural networks, fuzzy logic principles, it has potential to capture the benefits of both in a single framework. 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.

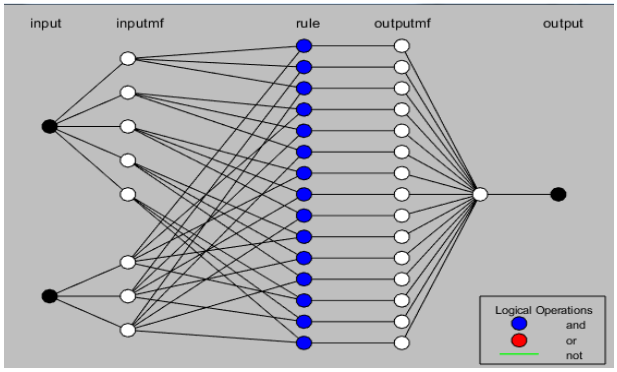

Figure 8: ANFIZ model of wiper control data in MATLAB

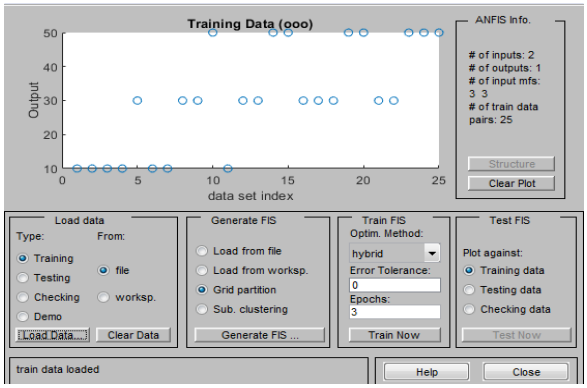

Figure 9: Training data-mapping of input & output

The limitation of this system is that only one output can be mapped for two input 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 giveby 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 rain intensity position is used to analyze the system behaviour. FIS editor of Matlab fuzzy logic controller is used to obtain the rule and surface viewer(Bansode, Rajankar, & Ghatule, n.d.).

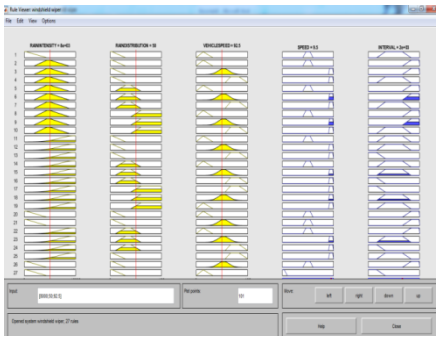

Figure 10: Rule base for fuzzy logic approach

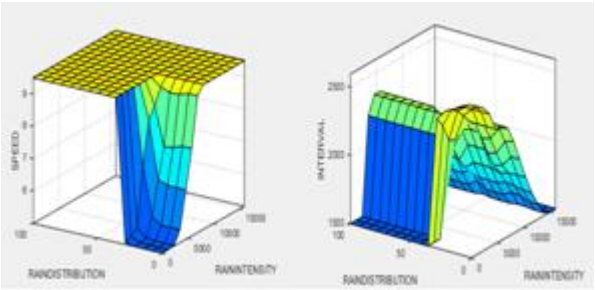

Figure 11: Solid surface generation for outputs (a. motor speed, b. time interval)

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 motor speed and time interval as output.

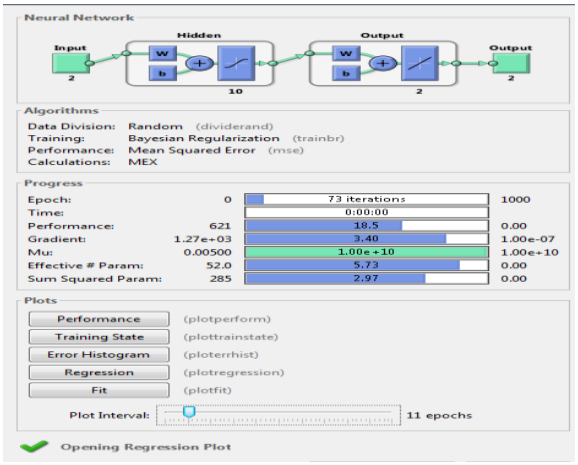

Figure 12: NNtool error and performance results

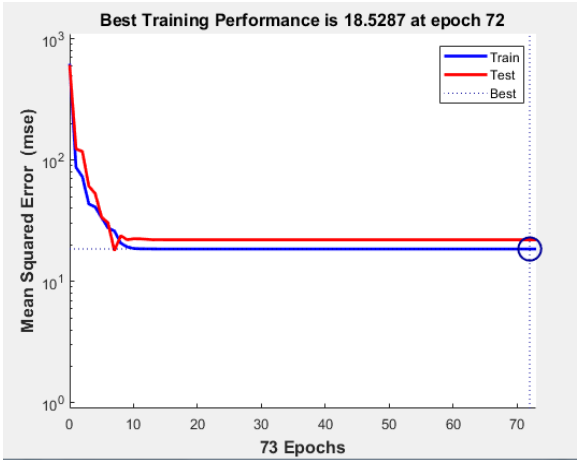

Figure 13: Best Training performance at 73 epochs

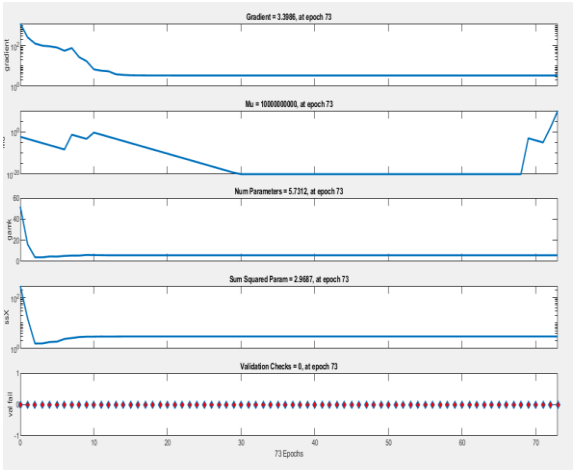

Figure 14: Training state of wiper system

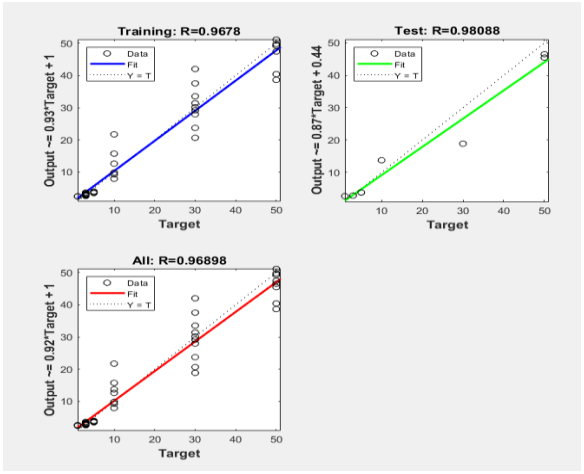

Figure 15: Training regression curves in nntool

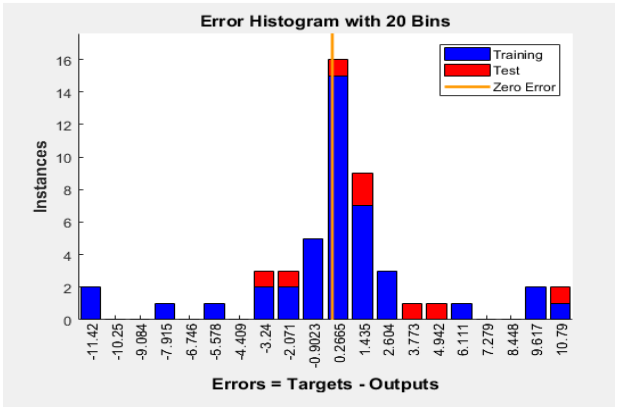

Figure 15: Error histogram-zero error at 0.2

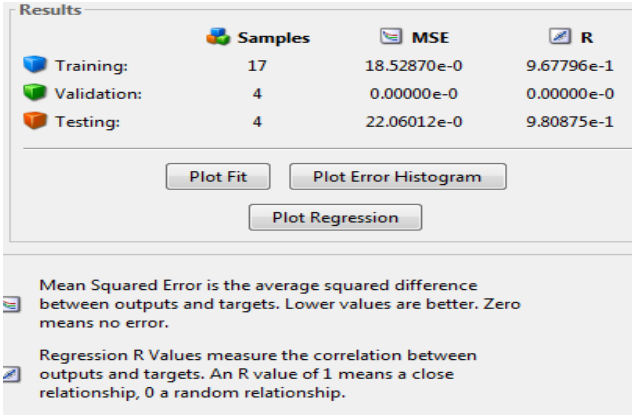

Figure 16: Results of sample trained and validated using nntool

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.

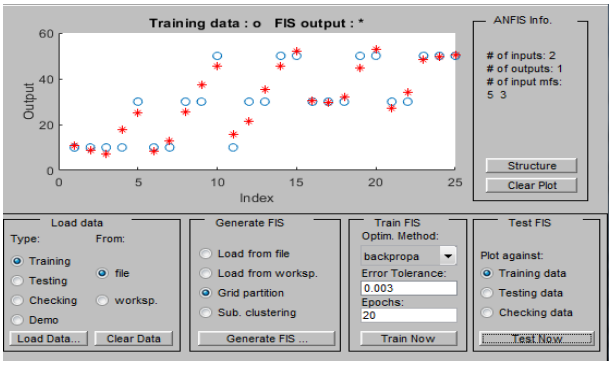

Figure 17: Training data with test points map

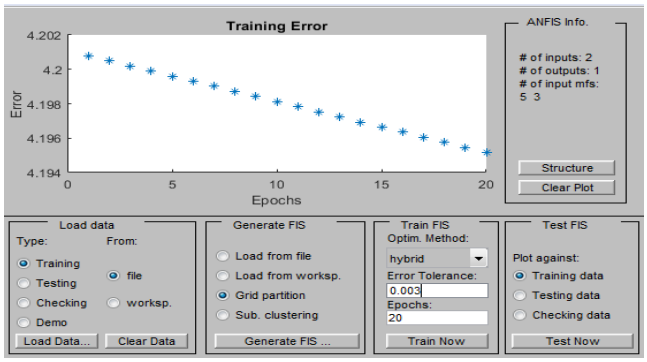

Figure 18: Error map for training the system in ANFIS

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

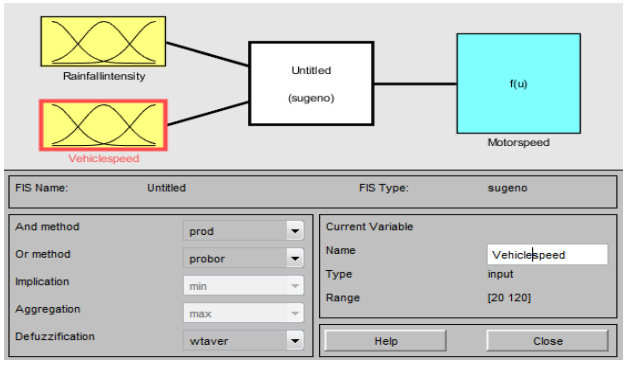

Figure 19: Generated fuzzy model

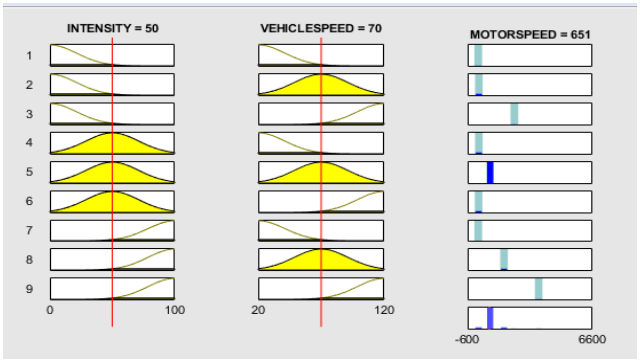

Figure 20: Rule base for the ANFIS fuzzy model

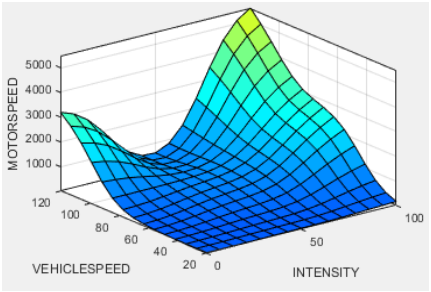

Figure 21: Generated Surface model

4. Conclusion & Future Works

An automated windshield wiper control system is virtually analysed in software environment to detect rain and actuate the windshield wiper based on the intensity of rain. 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 voltage readings at different rain intensity position is used to analyze the system behaviour. FIS editor of Matlab fuzzy logic controller is used to obtain the rule viewer and surface viewer. With the help of rule viewer user can predict the rain intensity by varying sensor output voltage more accurately.Hence the focus of this project work was to do comparative analysis study on automatic wiper control system. 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 a HIL (Hardware in the Loop) model. The performance of simulation results and HIL results will be compared to provide effective control system.

References

[1] Lubna Alazzawi, Avik Chakravarty "Design and Implementation of a Reconfigurable Automatic Rain Sensitive Windshield Wiper", IJAET, ISSN: 22311963, Vol. 8, Issue 2, pp. 73-82, 2015.
[2] ThetKoKo, ZawMyoTun, Hla Myo Tun "Implementation of Automatic Wiper Speed Control and Headlight Modes Control Systems Using Fuzzy Logic", IJSTR, ISSN: 2277-8616, Research Volume 4, Issue 07, 2015.
[3] Omar, B. A.A, Haikal A.Y.M, Areed, F.F.G "Design adaptive neuro-fuzzy speed controller for an electro-mechanical system", Ain Shams Engineering Journal, ISSN: 20904479, DOI: 10.1016/j.asej.2011.07.003, Vol. 2, Issue 2, pp. 99-107, 2011.
[4] Neural network toolbox in MATLAB https://www2.cs.siu.edu/~rahimi/cs437/slides/nnet.pdf
[5] Zhao Xiaoyu, Xing Yanfeng, Li Yengjie, 'Based On Matlab Electrically Operated Windshield Wiper Systems Design Method Research' Third International Conference on Measuring Technology and Mechatronics Automation IEEE, (2011), pp. 621- 624.

[6] Jian HU, Gangyan LI, Duanfeng CHU and Jun XU, 'Research on Passenger Car Windscreen Wiper Controller and Control Method Based on CAN'', Proceedings of the 2009, IEEE International Conference on Mechatronics and Automation Changchun, China, (2009), pp-4901-4906
[7] Brown .M, Mills D.J, Harris C.J., 'The representation of fuzzy algorithms used in adaptive modelling and control schemes', University of Southampton, Southampton, So 17 1BJ,UK,Fuzzy sets and systems 79,(1999), pp.69-91.
[8] Jang J.S.R. and N .Gully, 'Fuzzy logic Toolbox for use with Matlab Natic', MA.' The Math works Inc 1995.
[9] Shantanu Dharmadhikari, NaeemTamboli, NileshGawali, Prof. N. N. Lokhande, ―Automatic Wiper System‖, International Journal of Computer Technology and Electronics Engineering, vol.4, Issue 2, pp.15-18, April 2014.
[10] Ucar Mehmet, Ertunc Huseyin M., Turkoglu Onder, The design and implementation of rain sensitive triggering system for windshield wiper system' IEEE, (2001) , pp-329-336