Sensor Fault Identification in Complex Systems

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Abstract

In the process control industries, one of the main works is to identify and channelize the fault sensor. The process of sensor troubleshooting is essential to increase the production flow without any interruption. In this project the level measurement in the conical tank is considered and the capacitive sensor is used to measure the level of the water inside the conical tank. First the standard sensor is placed inside and the level is measured and monitored and the history of data's are obtained. Using LABVIEW, programming is done for the standard sensor to measure the level. Now the measuring sensor is placed and the measurement of the level is done. Using any of the soft computing techniques, the fault can be identified and it is indicated in the display or alarm.
Keywords: ANFIS, Fault Identification, Neural Network, LabVIEW

I. INTRODUCTION

The Experimental evaluation of an automatic procedure for sensor fault detection and identification in a real process under closed-loop control is the objective of the present research. However the recent trend of generalized use of automatic supervision systems has introduced the need of improved algorithms for earlier detection and identification of the fault. This is much important in the Process Control system that a failure in one of the sensors used in the control loop can lead to erratic behaviour or even instability of the system. In parallel there are development of systematic algorithm for Fault identification and correction in the Process Control.

The fault identification can be done using Neural Network. In the paper [1] design of fuzzy interference controller and the modern predictive controller has been discussed. The fuzzy logic implementation technique for analog system is done by various methods. Fuzzy has many membership functions that will be suitable for the analog system. Fuzzy is a continuous time varying system so modeling can't be achieved [2]. The experiment results show that the designed pressure sensor prototype implements the self-validating function [3]. It can detect fault in real-time and identify sensor status with high accuracy.

This paper deals with the experimental implementation of such an automated scheme in the complex system, a conical tank. The setup is composed with two conical tanks, a storage tank and a process tank which is to be controlled. The tank consists of the capacitive sensor. Our main goal is to identify the data fault in the sensor. This is done using one of the soft computing techniques and represented in graphical format. The controller design and redundancy of the fault sensor can be implemented in future.

II. PROCESS DESCRIPTION

The level measurement in conical tank is the process in this project. The setup consist of conical tank (process tank), a rota meter, power supply, capacitive type level sensor, DRB (decade resistance box), multimeter. The length of the conical tank is 45cm (approximately). The input for the process is liquid (water) in LPH and the output is current (mA).

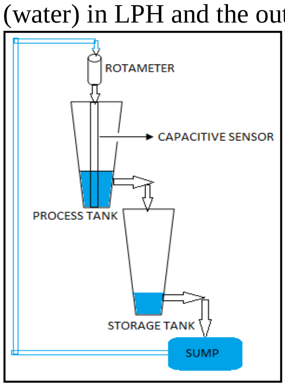

Fig. 1: Process Setup

A. Designing of Capacitive Sensor

The capacitive sensor is designed [10] with two copper electrodes acts as positive and negative plates which are supported by PVC pipe. The length of the capacitive sensor is 40cm (approx). The water acts as di-electric medium. Operating range is 0.02A to 1.5A. It's not suitable for the highly corrosive liquid. The designed sensor is fitted in the conical tank and the level measurement is taken. The rotameter is ON and the water is allowed to flow in the tank. There will be current output according to the level change. When the level changes, there will be corresponding change in the output current. This current value corresponding to the level is noted. This datas are taken for different values of resistance and the output values are stored.

B. Monitoring

The LABVIEW (Laboratory Virtual Engineering Workbench) is a system-design platform for visual programming language developed by National Instruments. This Project uses LABVIEW for monitoring of the level in the conical tank. The programming is done in such a manner that the levels are divided into three main divisions like lower, middle and higher using case structure and range function. The level will be indicated based on this program through an LED glow indicating the level.

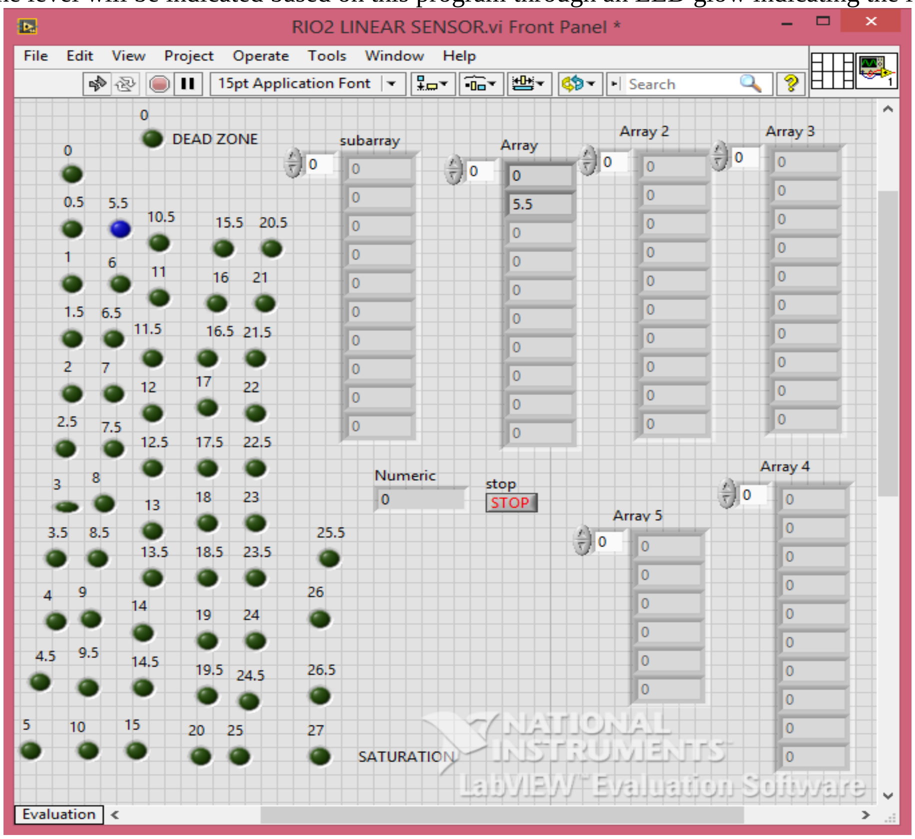

Fig. 2: Monitoring Level in LabVIEW

C. Methodology

ANFIS (Adaptive Neuro Fuzzy Inference System) is a type of artificial neural network. This integrates both neural network and Fuzzy so that it has a potential to produce the benefits of both in a single framework. In fuzzy systems, adjusting the parameters of membership function is difficult and need human experts with sufficient knowledge to design rules. Neural network training is a prolonged task and based on the quality and quantity the performance is depended [6]. To overcome the above disadvantages, ANFIS model is proposed for sensor fault diagnosis.

ANFIS model consists of single output and single input. The first step is to train the neural network with the datas obtained, then the model is created. The testing process is done with different data with the model created. If there occurs an error it will be indicated in the result graph. The general block diagram of ANFIS based fault identification is shown.

III. TRAINING

The datas obtained is trained in the ANFIS to create the model.

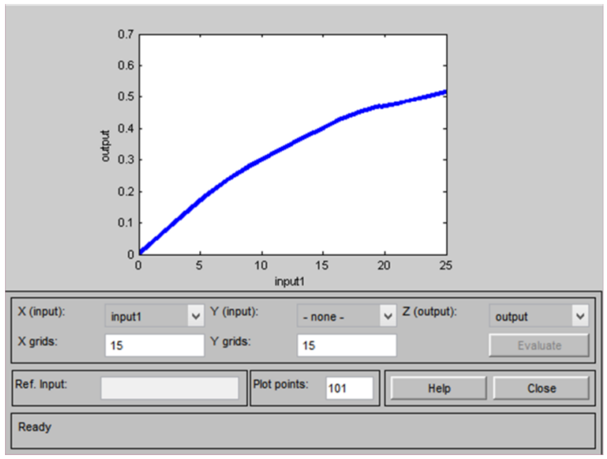

Fig. 3: Input Output Mapping

The obtained datas from the capacitive sensor are saved as .dat file in workspace of the MATLAB. The continuous mapping of input and output is shown in figure 1.

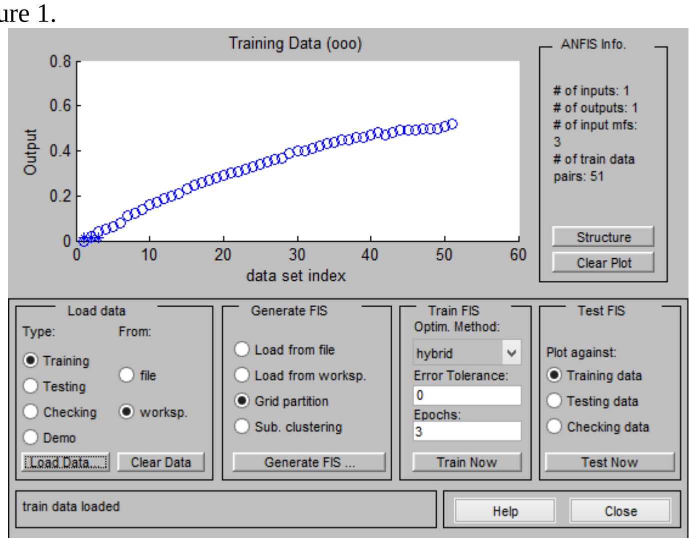

Fig. 4: Training Neural Network with Obtained Datas

For the initial training process, the datas are loaded from the workspace. The output of the training datas are shown in above figure

IV. GENERATION OF MODEL

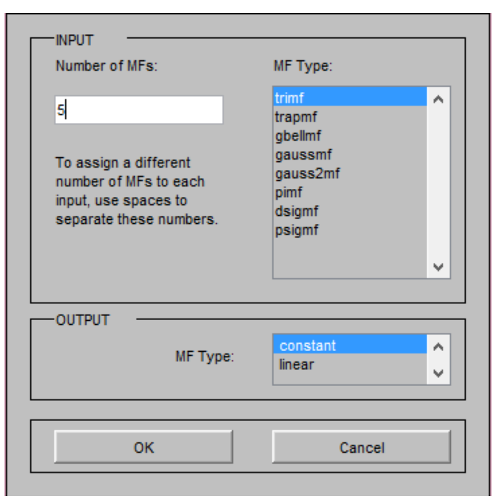

Fig. 5: Selection of Membership Function

Depending on the membership function the input output mapping is done. Normally GAUSS membership function is preferred with a constant membership type. The model will be created based on this selection. Then the error is reduced by increasing the epoch's value.

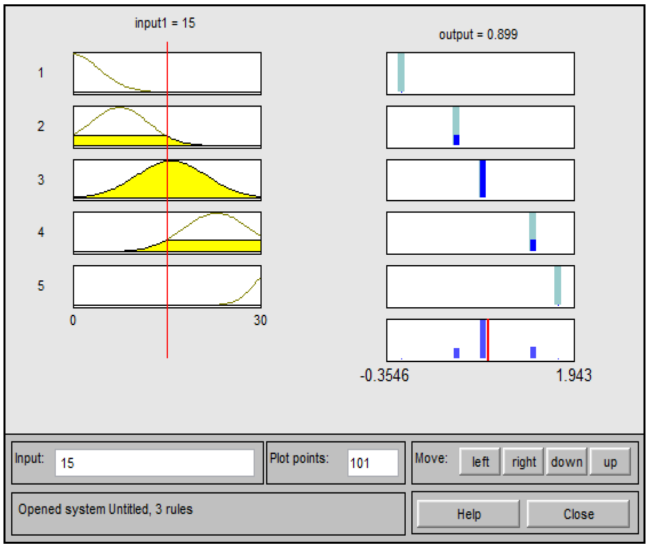

Fig. 6: Rules build based on Membership Function

Many types of membership functions are available. Here the number of input sets are denoted. The output varies from 0 to 1 (Fuzzy rules). By varying the input (central red line), the output can be varied.

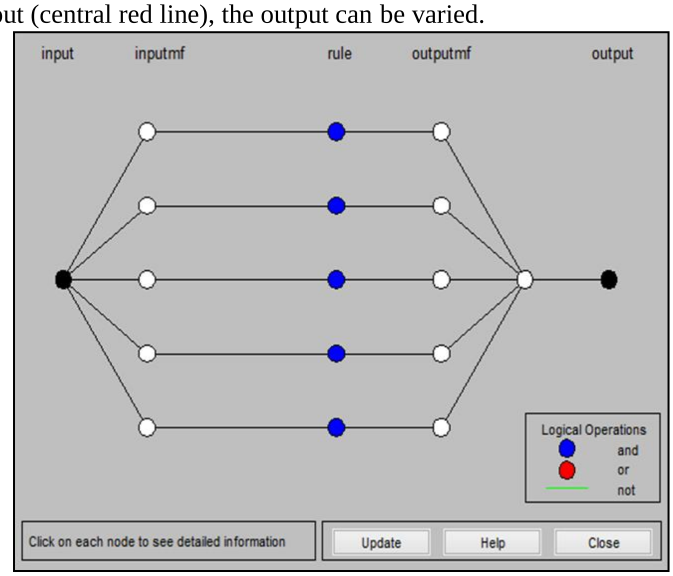

Fig. 7: Model Structure

The ANFIS has three layers.The input layer, fuzzification layer (input mf), hidden layer , defuzzification layer(output mf) and output layer. In input layer every node is an adaptive node with node function.In membership function layer every node is fixed whose output is the product of the input.In hiden layer rules are framed.In defuzzification layer normalization takes place. In the output layer with single node.

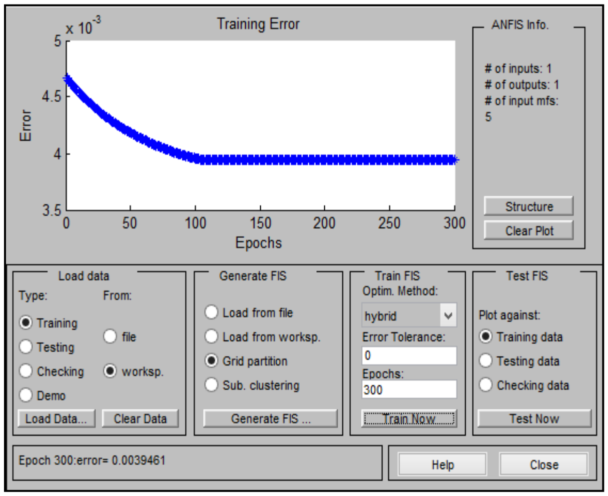

Fig. 8: Error Detection

For training the FIS model, the epochs value is selected to minimise the error as much as possible. As the epochs value increases the error value is reduced. When the created model is exactly matched with the output datas the error value is minimum. For Eg. Epochs is 100, the error value is 0.3. When the epochs is increased as 300, the error value is 0.0312.

V. OPTIMISATION

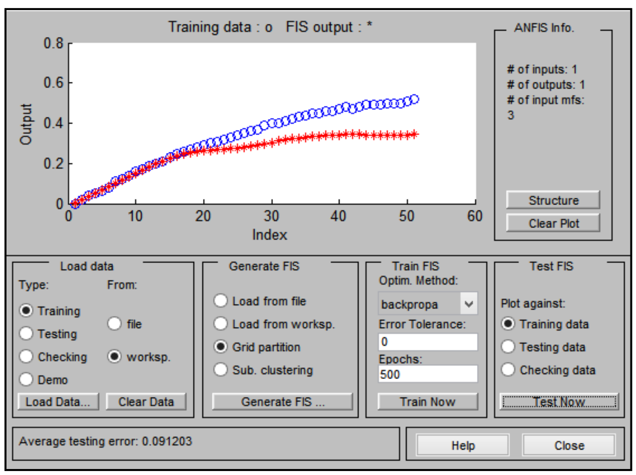

Fig. 9: Training using the Back Propagation Algorithm

Using the Back Propagation algorithm the generated model is trained and found that the error is high. Depending on the epochs value the error value changes. The above graph shows that the model and the datas donot exactly match. The error here is 0.091.

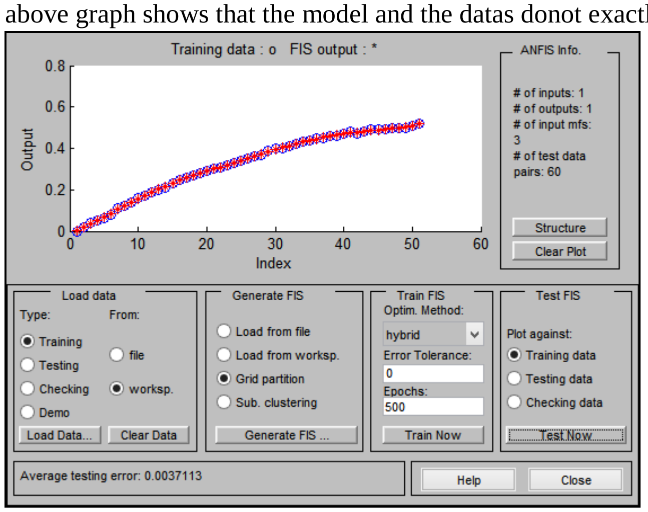

Fig. 10: Training using Hybrid Algorithm

Using the Hybrid algorithm the model generated is trained and found that the error value is less compared to the Back propagation algorithm. The error here is 0.003. It is found from the above graph that the datas are exactly matching with the model created.

VI. Results & Discussion

A. Testing

The trained model is tested with the real-time datas obtained and the error is identified. If there occurs an error then there will be a peak indicating the error in the graph. From this the error can be identified.

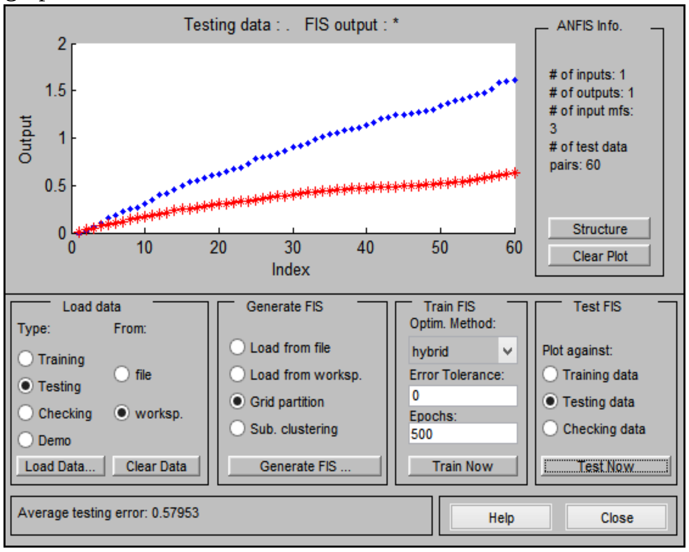

Fig. 11: Testing using Hybrid Algorithm

For testing the created model another set of sensor data (10ohm resistance) is loaded in the testing part. By applying the testing data in Test FIS icon, the datas are found to be deviated from model created with datas(5ohm resistance).

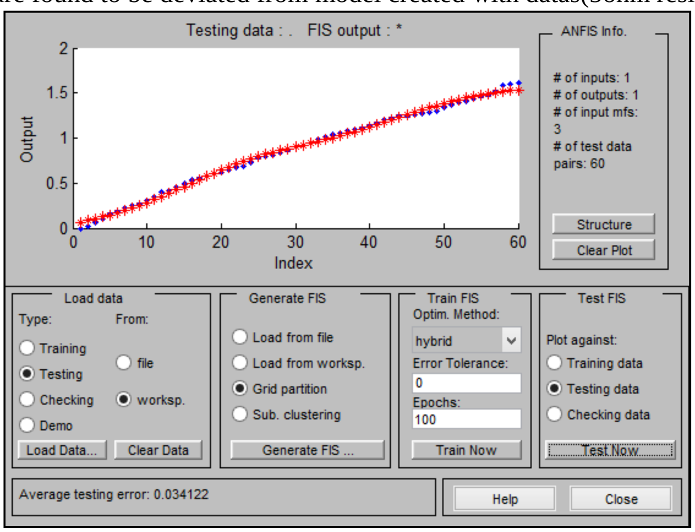

Fig. 12: Datas without Fault

When the training is done the data to be tested is loaded. It is found that the loaded data exactly matches with the model created with some tolerance (2%) and there is no major data fault in the sensor.

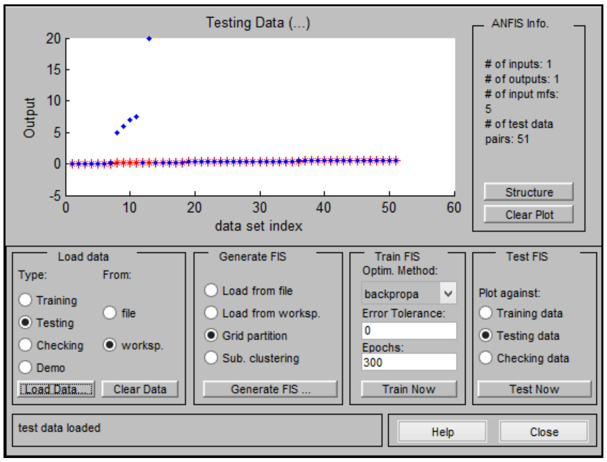

Fig. 13: Fault Identification

After the data to be tested is loaded, it is checked with the model created.

VII. CONCLUSION

Nowadays in the process control industries, the major problematic area is the sensor fault identification. If the sensor becomes fault then the whole automatic process will get collapsed. In order to overcome this issue the sensor data faults can be identified using the ANFIS model identification method and the fault can be identified. This method may reduce the complexity in finding the sensor fault in the automation field.

VIII. FUTURE WORK

After the fault identification process, faulty sensor is replaced or by-passed with redundant sensor there comes the redundancy. This channelization of the sensor is done by using the LABVIEW. Further this work is enhanced to store the dynamic data obtained by the level measurement in the cloud, which helps to perform the forecast proceedings. The work is projected to highlight the implementation of the data driven based fault diagnosis and troubleshooting practice of nonlinear system sensor.

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