DESIGNING A FAULT DIAGNOSIS SYSTEM IN A PID PROCESS CONTROL SYSTEM USING FUZZY-NEURAL NETWORK

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Abstract- Detection and diagnosis of systems faults are very essential for protection of process control systems against failures and permanent damage. In recent years, monitoring and fault detection in control systems have moved from traditional methods to artificial intelligence techniques The objective of this paper is to design a Fault Diagnosis System (FDS) for a PID water control systems that will monitor the system during its normal working condition so as to detect the occurrences of failures, recognize the location, the time of such fault, defines the fault and hence suggests its possible rectification procedures. A PID Fuzzy Neural Network continuous water process control system that lets water be at a set level as water flows in and out of the tank was considered. In this paper, the FDS was designed using Fuzzy Logic technique. Using fuzzy Logic techniques to analyze this is well suited to low cost implementation based on cheap sensors, low resolution analog to digital converters, and 4-bit or 8-bit one chip microcontroller systems.. Moreover such systems can be easily upgraded by adding new rules to improve performance or add new features. Also machine operators will have an idea of the fault and the rectification procedure.

KEYWORDS: Diagnosis, Fault, rectification, detection, Fuzzy Logic, fuzzy rules, failures

(I) INTRODUCTION

Components, machines and processes fail in varying ways depending upon their constituent materials, operating conditions, etc. Failure modes are typically monitored by a sensor which is intended for failure analysis purpose, to capture those failure symptoms that are characteristics of a particular failure mode.

Pislaru, Trandabat and Olariu [1] in their work on Neurofuzzy system for industrial processes fault diagnosis featured a methodology to monitor and diagnose machine faults in complex industrial processes. They developed the diagnostic model capable of providing diagnosis for single and multiple faults based on noisy data. In their work, they only showed the faults incurred and ignored monitoring of the system while on operation, the type and time of fault occurrence and also the possible rectification techniques.

Wu, Karray and Song (2003) in Water Level Control by Fuzzy Logic and Neural Network designed an Intelligent controller for controlling water level system by building a prototype of water level control system first with Fuzzy Logic control and then with Neural Network. The performance of both were noted and compared and it was found that the neural network showed a better performance than that of fuzzy logic. Fuzzy Neural Networks implement the process of fuzzy reasoning through a Neural Network structure so that they behave as Fuzzy System with learning capabilities. In this paper, the design of the Fault Diagnosis System was discussed and then implemented in PID continuous process system for water level using Fuzzy Neural Network.

II) Design of the Fault Diagnosis System

The main aim of the Fault diagnosis system is the monitoring of the process control during its normal conditions so as to detect the occurrence of failures, recognize the location and time of occurrence [3]. Typical failure modes may include leaks, sensor failures, temperature, pressure, valve failure, etc which is the characteristics of a process failure. Also as a variety of vibration induced faults that are affecting mechanical and electro-mechanical process elements may occur. In this research fuzzy diagnostic system (FDS) was used. The FDS takes features of the process control as inputs and then outputs any indication that a failure mode has occurred. Fig 1.1 shows the FDS.

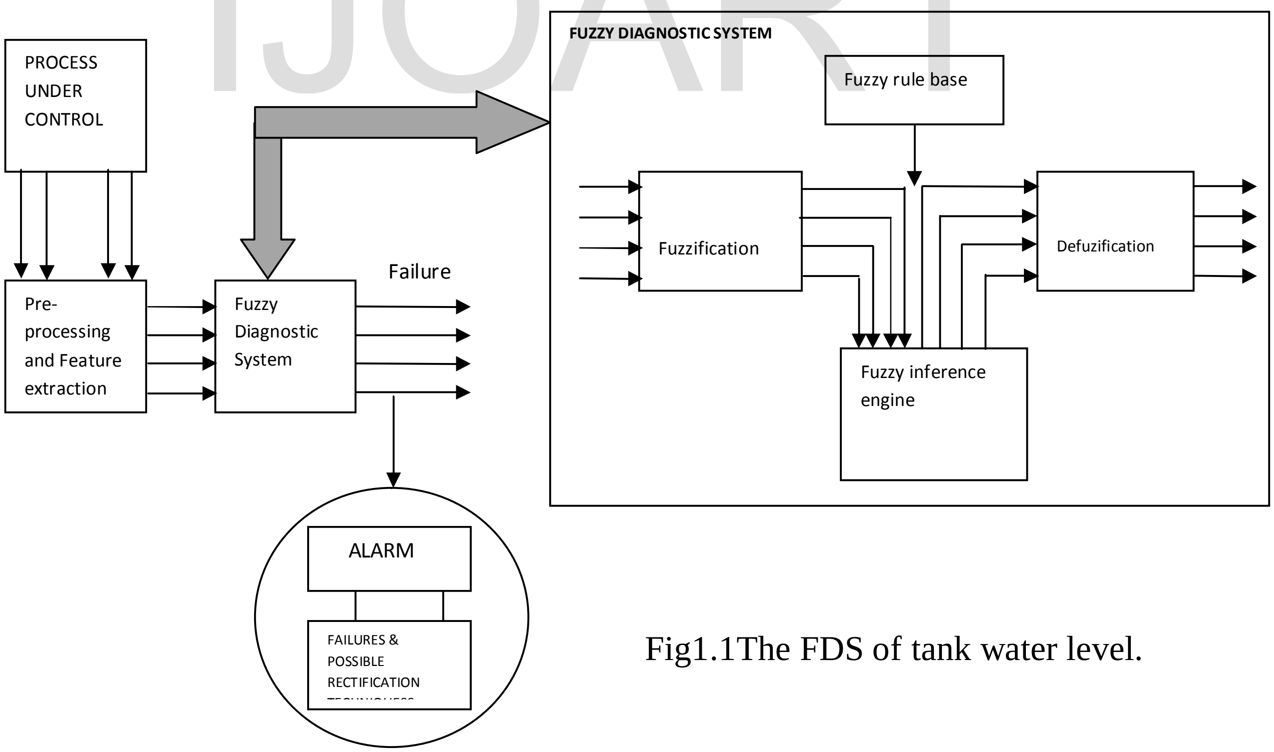

Fig1.1The FDS of tank water level.

The fuzzification block converts the feature extraction to degree and type of failure, the fuzzy rule base is constructed from symptoms that indicate a potential failure mode (This is developed directly from user experience, simulated models or experimental data).The inference engine determines the degree of fulfillment for each rule corresponding to each failure mode while the last stage defuzzifies the resulting output to indicate a failure and this triggers an alarm and at the same time suggests a solution to the fault. Table 1 shows the rule base for failure, the time of occurred fault and rectification techniques. This is easily produced by the inference engine.

Table 1 The rule base for failure, the time of fault and rectification techniques.

Time of Occurrence	**Observation (Rule Base)**	**Fault (Output)**	**Rectification Techniques**
12.00pm	If Water level is at constant position Then	Outflow valve /inflow valve is faulty	Verify which and change the valve
1.00am	If Outflow rate is below the lower threshold level then	The inflow valve is faulty	Change the inflow valve
....etc	... etc	... etc	... etc

Fig 1.2 shows the Fuzzy Neural control system running on PC interfaced to the process under control via an INTEL 8286 Bidirectional Buffer where the FDS was implemented. When the signal line B is active, the buffer sends information to the process under control via the output port latch. Similarly, when the signal line A is active, the feedback signals from the process are input via the input port latch to the bidirectional buffer and from thence to the PC. The process under Fuzzy-neural control has a valve that controls the inflow of the liquid into the tank and another one that controls the outflow from the tank. The heater increases the temperature of the liquid while the stirrer is used to ensure that the liquid is of uniform temperature. The control system tries to keep the liquid level in the tank constant within the set-point for level. This is achieved by fuzzy-neural control by adjusting the inflow rate and outflow rate dynamically as appropriate. Four sensors were also used: 1) to sense the liquid level in the tank and 2) to sense the outflow rate from the tank, 3) to sense the temperature and 4) to sense the pressure of the system. The four sensor outputs are selected one at a time via 4 X 1 analog multiplexer. The selected signal is first amplified and then converted to digital pattern via an analog to digital converter. The digitalized sensor output are latched by the input port latch and forwarded to the fuzzy-neural control system via the bidirectional buffer.

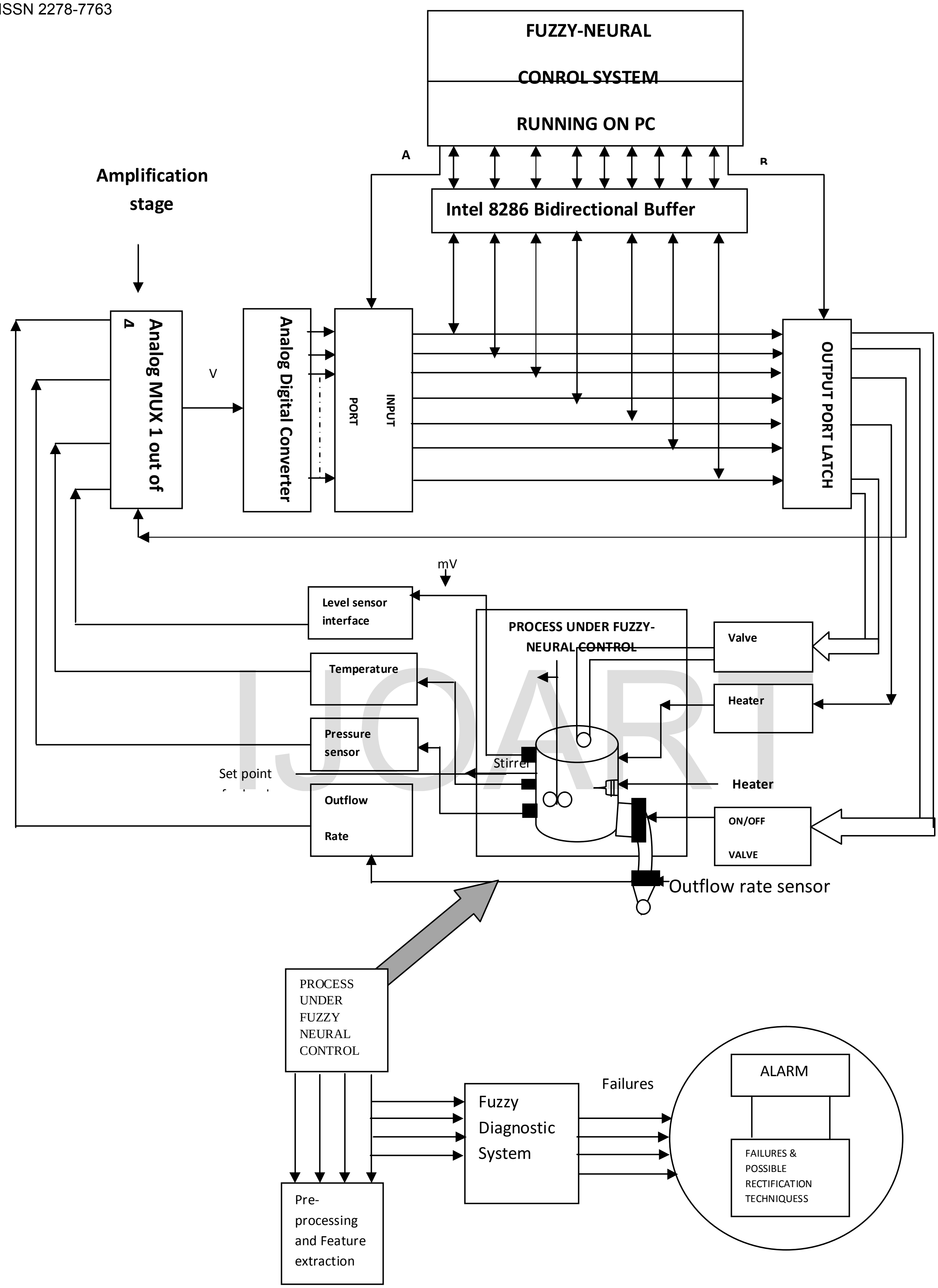

Fig 1.2 Block diagram of FDS being implemented in a PID Process Control System Using Fuzzy-Neural Network

III The Industrial Scenario

It is always necessary to perform a real-time simulation of any control system before the circuit is constructed, to ensure the workability of that system. In this work Proteus software package [4] was used for the simulation. The real time simulation of the control system used as a typical industrial scenario is activated by clicking the play button. When this is done the liquid from the upper tank flows to the lower tank. The valve at the water inlet of the upper tank is being controlled based on the rate of the outflow from the lower tank. This is done to make sure that the set-point of the process under control is maintained. The heater heats the liquid while the stirrer ensures that a uniform liquid temperature is maintained. Fig 1.3 shows the industrial scenario of the process control in Proteus environment. The first three computer system interfaces shown display the variables under control (liquid level/outflow rate, pressure and temperature) while the fourth one displays the fault diagnosis features (type of fault, time of occurrence and possible rectification methods).. It should be noted that when Proteus software is used to implement a real-time simulation, not all the system components are placed on the layout. Some are placed in the sub sheet for example the controller and some are not visible but are there by default e.g. reset circuit, bidirectional buffer, power, the interfaces, analog to digital converter, the multiplexer etc; while some are taken care of by the control program. In Proteus design, this is called ñreferencingò.

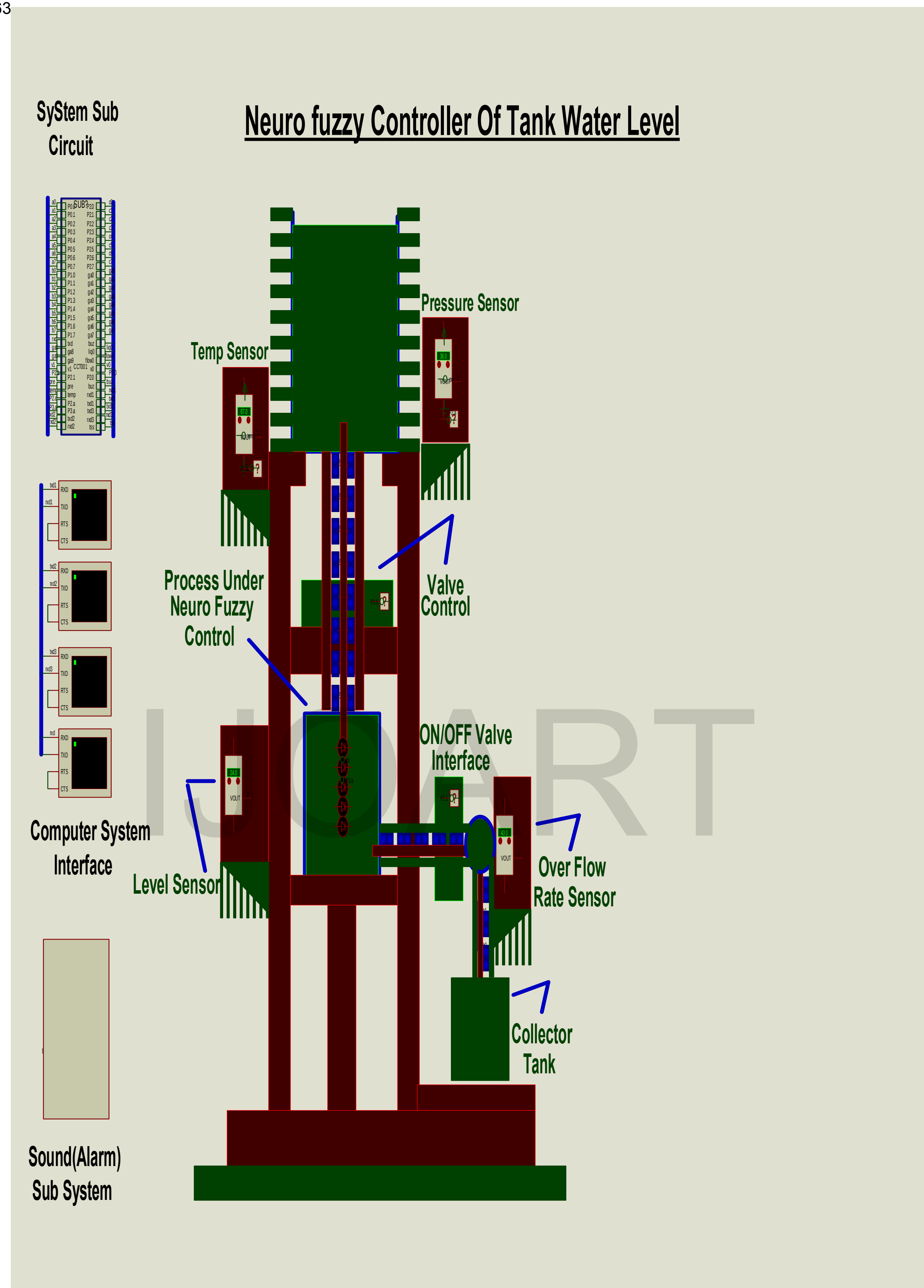

Figure 1.6 Real time simulation for a typical Fuzzy Neural controller of tank water level

IV CONCLUSION

Error detection and isolation system has been implemented in a Fuzzy Neural PID controller. The developed Fuzzy Neural Network features error detection and presents detailed rectification steps. This is much better than the trial and error method used in repair and maintenance of process control systems.

(V) References

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