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Neural Networks and Fuzzy Logic for Fault Diagnosis in Robotic Systems

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***Abstract*- Generally in Automation systems, error detection and comparison and fault diagnosis play a major role. Presence of an infinitesimal error leads to degradation in the performance of any system. There occurs necessity to implement a device to eradicate the errors if its presence leads to degradation in the system performance. Neural Networks and Fuzzy Logic Systems help in recognition and eradication of errors in Optimal Robot Control. The main goal of this paper is to investigate the problems in error diagnosis in robotic manipulators under computed torque control with the help Neural Networks and Fuzzy Logic Systems. Error approximation using neural networks provides a model on error characteristics. It can be used for the detection and elimination of errors in the functioning of a robot.**

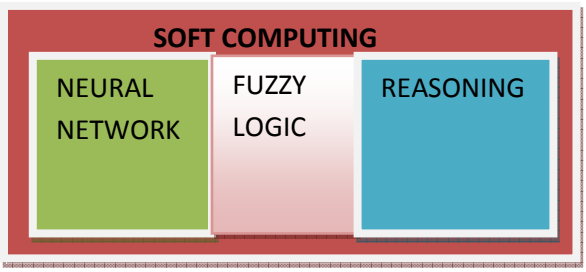
Keywords

Neural networks, Fuzzy logic element, Autonomous robotic systems, Error detection, Optimal Robot Control.

I. INTRODUCTION

Soft computing is a combination of neural networks, fuzzy logic and probabilistic reasoning. It includes neuro-fuzzy systems and techniques, probabilistic approaches to neural networks (especially classification networks) and fuzzy logic systems and Bayesian reasoning. Neural network and fuzzy logic system research is classified as follows:

1. Modeling various aspects of human brain
2. Modeling artificial system and related data



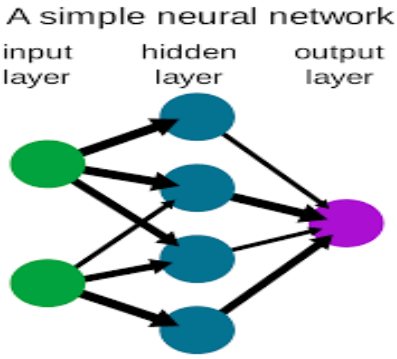
Neural network and fuzzy logic systems are parameterized computational non linear algorithms for numerical processing of data. The data can be signals, images and stimuli. The algorithm can be either implemented in a general purpose computer or build into a dedicated hardware. Learning process provides the network or system which acquires knowledge. The acquired knowledge is started in internal parameters which may be weights.

Areas contributing to Artificial Neural networks are as follows:

- Statistical Pattern Recognition
- Computational Learning Theory
- Computational Neuroscience
- Dynamical Systems Theory
- Non Linear optimization

II. NEURAL NETWORKS

In general, neural networks can do anything that a normal digital computer can do. They are especially useful in classification and function approximation/mapping problems which can tolerate some imprecision. Function approximation/mapping of problems has a lot of training data available but it is difficult to implement. Neural networks are difficult to apply successfully to problems that include symbols and memory manipulation. No methods are provided for the creation of information that is not updated in the training data for training neural networks. Neural networks involve active or decoding phase and learning or encoding phase.



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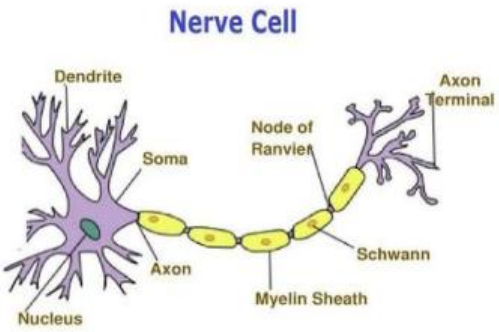
II.1 Biological Fundamentals of Neural Networks

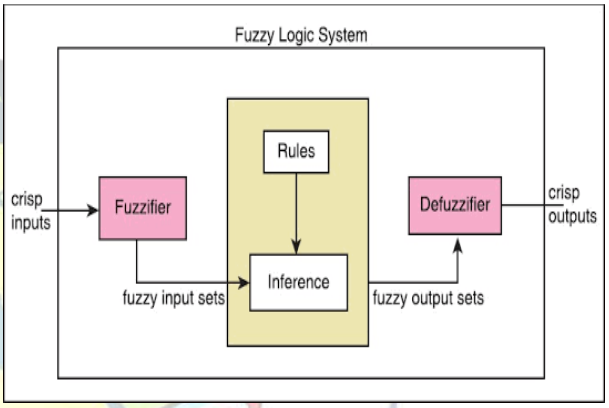
Most neurons in the vertebrate nervous system have several main features in common. Typical neuron or nerve cell has the structure given in the figure below.



The cell body contains the nucleus which is the store house of Genetic information. It gives rise to two types of cell processors namely ***axons*** and ***dendrites.*** Axons are the transmitting elements of neurons and dendrites are the receiving elements of the neurons. The action potential which is the cell conducting signal is initiated either at the initial segment of the axon, or in some cases slightly farther down the axon at the first node of Ranvier. Branches of axon of one neuron transmit signals to another neuron at a site called the synapse. The synapses are the elementary signal processing devices. It is a bio-chemical device which converts a pre-synaptic electrical signal into a chemical signal and then back into a post synaptic electrical signal. The input pulse train has its amplitude modifies by parameters stored in the synapse. The nature of this modification depends on the type of the synapse, which can be either inhibitory or excitatory. All the post synaptic signals together get transferred along the dendrites to the nerve cell body. The output neuronal signal, the activation potential is generated by the cell body which is transferred along axon to the synaptic terminals of the others neurons. The frequency of the signal transmission by a neuron (firing) is proportional to the total synaptic activities and is controlled by the synaptic parameters (weights).The pyramidal cell can receive 10^4 synaptic inputs and can direct the output signal to thousands of target cells. This connectivity is difficult to implement in artificial neural networks. Neuro-transmitters, the image carrying chemicals which are released pre-synaptically, float across the synaptic cleft and activate the receptors post-synaptically. The fundamental characteristics of a biological neuron are as follows:

1. The data is encoded in the form of instantaneous frequency of pulses.
2. Synapses are either inhibitory or excitatory.
3. Signals are summed as they travel along the dendritic trees.
4. The cell body generates the output pulse train of an average frequency which is proportional to the aggregated activation potential (post synaptic activity).

III. FUZZY LOGIC ELEMENTS:



The Fuzzy logic is based on the process of human perception and human cognition. It can deal with the information arising from computational perception and cognition i.e. uncertain, imprecise, vague, partially true, or without sharp boundaries. It provides an effective means for the conflict resolution of multiple criteria and better assessment of options. It can be used for the processes such as decision making, identification, pattern recognition, optimization, and controls which are the fundamental processes involved in the development of Artificial Intelligent systems. In robotics, control and sensing are vastly affected by the inaccuracy and errors. This may lead to the degradation in the performance of the system. Thus soft computing elements like neural network and fuzzy logics have been implemented in robotics to overcome such uncertainty and imprecision (may be sensed) that occur through readings (sensor's readings). But despite the shortcoming of findings, there are some basic practical concepts to be considered.

1. The system in use should be stable for many reasons since unstable control system may cause malfunctions, undesired output, and performance degradation.
2. The use of fuzzy logic may ensures no imprecision and uncertainty of the images (if sensed by image sensor). Since

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fuzzy logic uses approximation rather than the absolute analysis of classical logic, imprecision can actually be beneficiary in providing stability or in giving commands.

3. The cost reduction in sensors results in the reduction in the cost of the entire equipment.

IV. AUTONOMOUS ROBOTIC SYSTEM

Autonomous robots are classified into the following three types namely,

1. Programmable
2. Non programmable
3. Adaptive
4. Intelligent

Construction of a system conventionally involves direct human intervention in tools and equipment, careful preplanning, a slight or no true automation. Automation in this construction process has improved its speed and efficiency, as well as designing in the zones where human beings cannot intervene. Autonomous robotic systems build structures based on the user specifications. These specifications are made errorless with the help of neural networks and fuzzy logic elements.

V. ERROR DETECTION

The error detection process depends on the following assumptions:

1. Modeling uncertainties are not enlisted for robotic manipulators.
2. The robotic system remains bounded in presence of an error

But in practice the former assumption is not applicable since the presence of modeling errors always leads to discrepancy between the actual plant and the nominal model. This may lead to false warnings. Heuristic tools, threshold value, and eradicating the effects of faults and disturbances help to resolve this problem. In this, a small threshold value is assigned as the residual error to indicate the modeling uncertainties. If the residual error is greater than the threshold value, the system alarms that there is a fault. Different robotic simulation may require different threshold values. These values depend on the performance and functioning of a robotic system. The components of general fault diagnosis of a error detection robot is given in the figure 1;

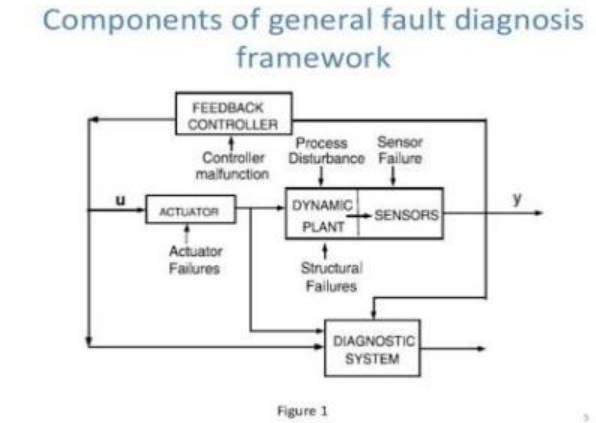

Figure 1

Neural network system is implemented as an error detector. Since it can do processes such as recognition of error patterns and error signals function approximation, system parameter estimation, etc. it normally stays as one of the main parts in a robotic system.

The general characteristic equation of a multilayered neural network can be given by

$$Y = E (i1, i2, i3, o)$$

Here, ***i1, i2,*** and ***i3*** are considered as input parameters whereas ***Y is*** considered as output parameter and ***o*** as the parameter to be altered (after residual error check). The function E (i1, i2, i3, o) may not only give the error detection result but also gives the approximation of faults occurring in a robotic system. An error in a system is detected by the basic process (comparison) of two values of which input value forms the first part and output value obtained first by the system. The deviation in the values is checked by the error detector loaded with the threshold value. The initial state of the system can be given as per the following characteristic equation:

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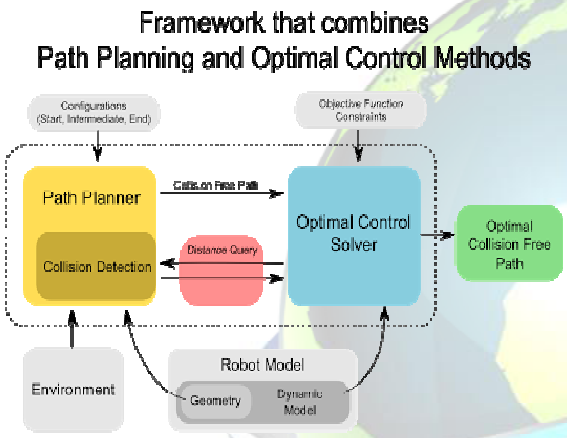
$$E' (i1, i2, i3, o) = 0$$

The deviation is determined from the two functions E (t) and E' (t).

VI. OPTIMAL ROBOT CONTROL

A Robotic system must include optimal control for its improved performance level. For the effective design of motion planning and control in obstructed environment, an effective algorithm or the knowledge on structures of the fastest paths is required. The self error detection fault diagnosis robot's framework is described through the below figure;



Fault recognition and diagnosis in robots can be literally termed as robot learning. It is the research field at the intersection of machine learning and robotics. Its studies techniques allowing a robot to acquire novel skills or adapt to its environment through learning algorithms. This involves collection of all types of problems that normally or occasionally occurs in a robotic system, collection of solutions given by the problem solvers, finding the solutions to the problems if there is none. With these data an algorithm is programmed and inserted in the robot. [3] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences.

Collection of errors or problems that normally or occasionally occur in robotics systems serves as the algorithm for the neural networks, and the solutions serve as the algorithm for fuzzy logic systems. The functioning of these two systems together improves the performance of a system. The time optimal trajectory for a robot is programmed for the planned motion of the robot. If any error occurs in its desired operation the neural networks and fuzzy logic systems enters to recognize and solve the problem. One less error in the system is the one high value assigned to the robot.

VII. CONCLUSION

The problems in error diagnosis in robotic manipulators under computed torque control with the help Neural Networks and Fuzzy Logic Systems is investigated. Error approximation using neural networks provides a model on error characteristics which used for the detection and elimination of errors in the functioning of a robot.

REFERENCES

[1] J.M. Zurada, Artificial Neural Systems, PWS Publishing Company, St.Paul, MN, 1995.

[2] E.H. Mamdani,"Application of Fuzzy Algorithms for Control of Simple Dynamic Plant", IEEE proceedings, Vol.121, No.12, pp. 1585-1588, 1974.

[3] Christo Ananth,"A NOVEL NN OUTPUT FEEDBACK CONTROL LAW FOR QUAD ROTOR UAV",International Journal of Advanced Research in Innovative Discoveries in Engineering and Applications[IJARIDEA],Volume 2,Issue 1,February 2017,pp:18-26.

[4] A.Barto, R.Sutton. and C.Anderson. "Neuron-like adaptive elements that can solve difficult learning control problems."IEEE Transactions on Systems, Man and Cybernetics, 13(5):834-846 September 1983.

[5] G.A.Carpenter and S.Grossberg.Art 3: "Hierarchical search using Chemical Transmitters in self-organizing pattern recognition architectures Neural Networks, 3(2):129-152, 1990.

[6] F.A. Lootsma. Fuzzy Logic for Planning and Decision Making.Boston, MA: Kluwer Academic Publishers (1977).

[7] M.J. Patyra and D.M.Mlynek (editors).Fuzzy Logic: Implementation and Application. New York, NY: Wiley (1996).

[8] I.S.Shaw. Fuzzy Control of Industrial Systems: Theory and Applications. Boston, MA: Kluwer Academic Publishers (1998).

[9] K.R.Ames."A Relational Approach to the Development of Expert Diagnostic Systems". Hampton, VA: NASA Langley Research Center (1984).

[10] N.Ayache (editor).Computer Vision, Virtual Reality and Robotics in Medicine.Berlin, Germany: Springer-Verlag (1995).

[11] K.SFu, R.CGonzalez, and C.S.G.Lee.Robotics: Control, Sensing, Vision and Intelligence. New York, NY: McGraw-Hill (1987).

[12] C.Torras (editor).Computer Vision: Theory and Industrial Applications. Berlin, Germany: Springer-Verlag (1992).