

A Neuro-fuzzy Adaptive Inference System for Puma 400 Robot Manipulator Control

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Abstract: The learning process is highly dependent upon the characteristics of torque control of the robot manipulator based on dynamic model, and such calculated torque control is very sensitive to modelling error and external disturbances. Generally, obtaining a representation of the Coriolis torque, centrifugal force, and gravity vector is an uncommon problem. A very plausible control system for our candidate is Fuzzy Logic Controller because it is able to express the desired system behavior with relatively simple "if-then" relations that the designer can come up with through trial and error in a form of "if-then" rules. But neural networks may nevertheless be able to effectively overdetermine a system's function, but they are unable to check whether the result is correct or implausible. They work well together. When things are combined, we are able to learn from fuzzy logic and to represent knowledge with neural networks. Above, we demonstrate how calculated torque management of the Puma 600 robot arm using an adaptive neural fuzzy inference system was studied. As a dynamic model, the method is shown to be capable of improving the calculated torque method on a Puma 400 robot arm. The controller design is validated using a comparative analysis based on fuzzy computed torque control. The results show that the trajectory tracking precision and stability achieved by the ANFIS controller is close to that of the fuzzy controller.

Keywords: Adaptive neuro-fuzzy inference, Robot control, Fuzzy computed torque control and system

I. Introduction

Controlling robotic manipulator is one of the main areas of robotics study today. After all, what better, especially on minute time scales, for the robots to do than delicate, quick motions, and those cannot precisely be controlled. It takes advantage of a nonlinear decoupling for control in this direction. It is always called dynamic or calculated torque as it is based on a robot model. That controller shall be implemented correctly by using the optimal robot model. In this case, this control is the perfect thing. It is extremely difficult in practice to achieve this condition because of the external sources creating disturbances on the robot. This control method is remarkably ineffective in such circumstances [2]. The linearization control, however, have their limitations, and academics have begun designing head on novel iterations and approaches of smart and adaptable control that would mitigate their impact and render this technique more effective.

Fuzzy if-then rules and fuzzy reasoning-based idea are used to form the FIS form as a helpful computing paradigm. ANFIS is one of the utilized one FIS in an adaptive neural fuzzy network. Compared with the FIS, it combines the learning 'power' of ANNs with explicit knowledge representation. However, when human knowledge can be converted to a fuzzy system (rules, and fuzzy membership functions) the intended target response has not been precise. As a dynamic model of the Puma 400 robot arm, this work utilizes a Computed Torque controller constructed with an Adaptive Neuro Fuzzy Inference System which was implemented in an adaptive fuzzy neural network framework. Combining the power of learning by ANNs with the explicit knowledge representation capacity of a FIS. Human knowledge cannot be exactly transformed in to a fuzzy system (rules and membership functions). Based on that, the FIS parameters should be chosen as efficiently as possible. In this research, a Computed Torque controller with an Adaptive Neuro Fuzzy Inference System is applied to the dynamic model of a Puma 400 robot arm. The performance is verified by comparing with this fuzzy controller with the same tuning. Simulation results indicate that the neuro fuzzy approach produces good results and that the controller is reliable and effective.

II. Robots Manipulators Model Motion

A typical robot manipulator is a collection of rigid components connected by joints in series configuration, and has its body/effector in which the robot's end is attached, a base, and the ground on which the robot's end is grounded.

The closed loop system with asymptotic stability is obtained with the robot model known with precision through this controller. The limits of the computed torque control are shown in the case of some unmodeled dynamics or imprecise knowledge of robot characteristics. To offset for the undone zones of the system we propose an ANFIS controller, persistently acting to transform the controller parameters K_p and K_v . A block diagram for the system under control is presented in Figure 1.

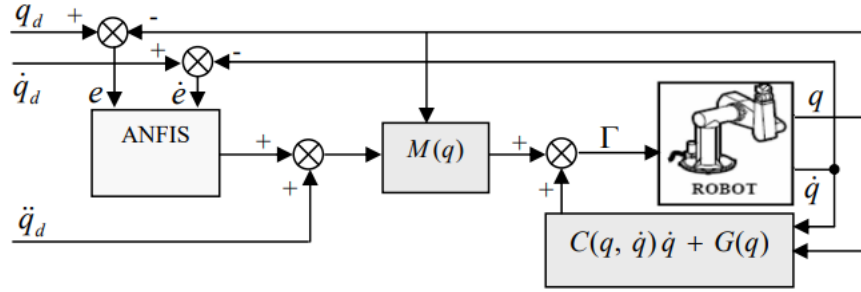


Fig 1: Block diagram of robot's manipulator system

III. Control of Adaptive Neuro Fuzzy Interference System

An ANFIS architecture shown in Figure 2 is represented by squares for an adaptable node and circles for a fixed node. Without loss of generality, we suppose that inference system m, n, z has two inputs and one output. Sugeno fuzzy model has been most popular among the several FIS models because of its high interpretability, efficient computation, inherent optimality as well as adaptability.

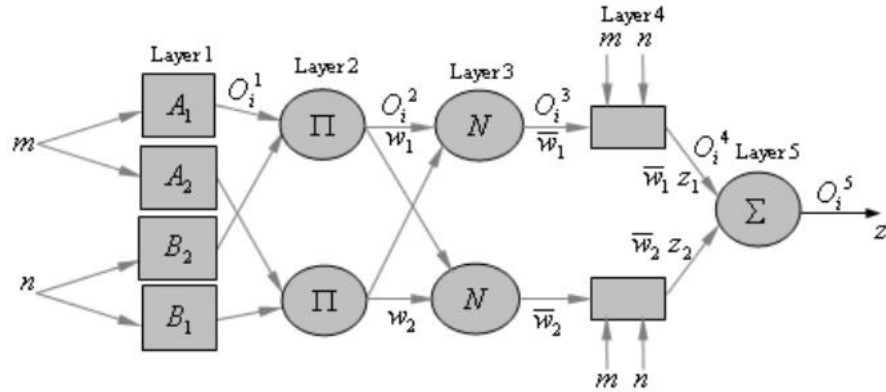


Fig 2: Architecture of ANFIS

Unlike standard fuzzy logic systems, the ANFIS contains adaptive parameters, that permit modification of parameters in the premise and consequent parts. The most unique feature of the ANFIS is the hybrid learning algorithm. The ANFIS parameter adaptation process has two processes. As the output of the ANFIS is linear combination of the consequent parameters, in the first step of training the consequent parameters we use Least Squares. At this point the premise parameters are set. Second, premise parameters are adjusted using back propagation of the approximation error to update premise parameters after back propagating the approximation error through each layer. This adaptive technique is a component of the adaptive process which is the same as the process of training the BP

neural by the gradient descent principle. The premise parameters were assumed fixed and the consequence parameters were determined by LS approach as the values which are least squares optimal.

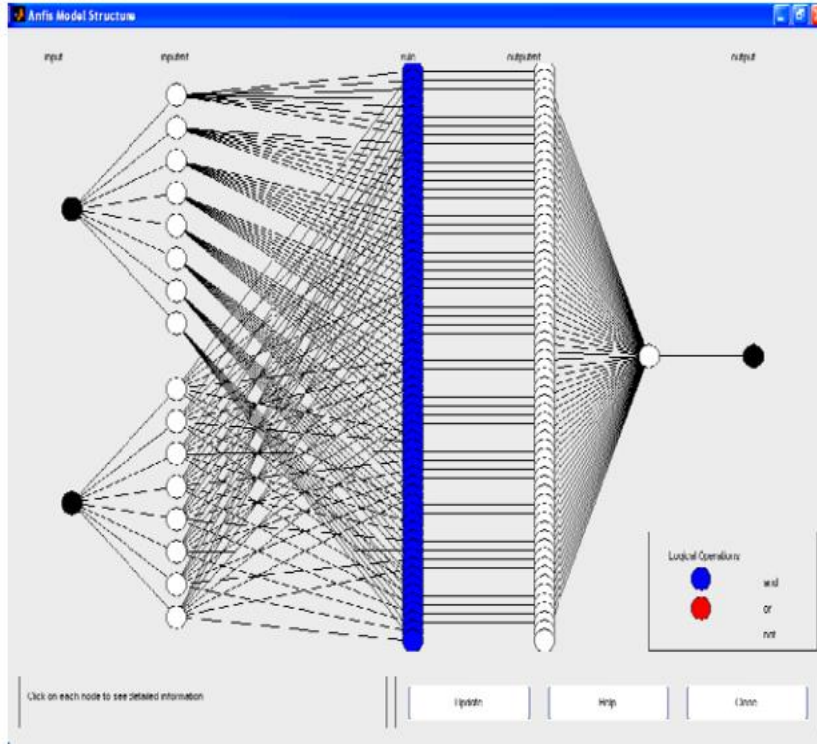


Fig 3: ANFIS Structure

III. Simulation Results

A simulation using the robot manipulator 400 puma was authorised in order to demonstrate the contribution of the ANFIS control and its superiority over the fuzzy logic approach.

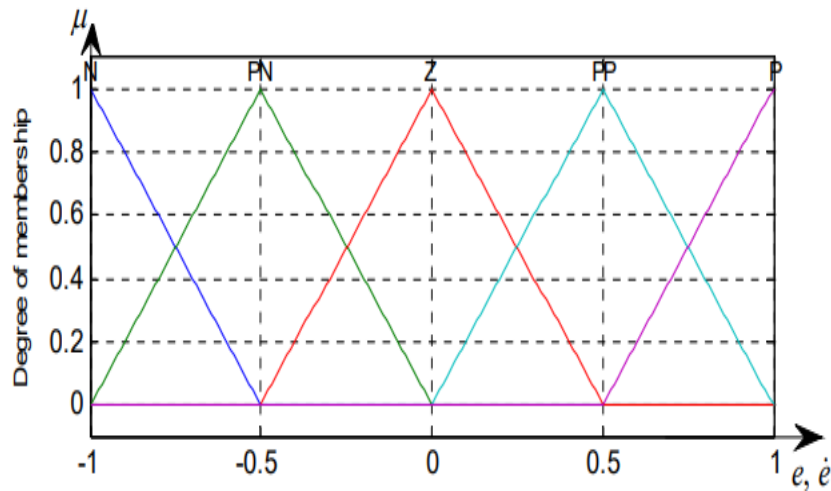


Fig 4: Fuzzy controller input-output function

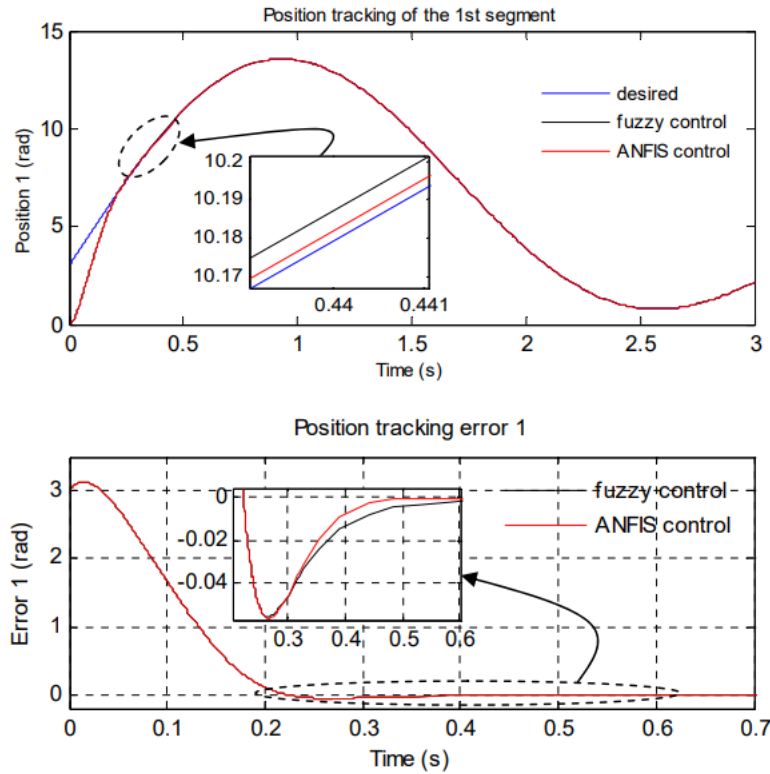


Fig 5: Behaviour of the robot as it pursues the intended path using fuzzy logic, calculated torque control, and ANFIS

IV. Conclusion

In robot manipulators a method of ANFIS control which improves upon the performance of linearizing control is outlined in this article. Simulation results also reveal that compared to the fuzzy controller, the ANFIS controller affords higher tracking precision as well as stability and better resilience (rate of correction of the PD gains fluctuations). Results from the simulation study confirm that, adaptive neuro-fuzzy control outperforms, since it is an adaptive controller by definition. It performs well also with unknown and uncertain plant parameters only when the reaction qualities meet. It is applied to control systems involving an unknown model.

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