Vision Robot Moving Control by Supervisory Fuzzy Neural Network

Yi-Jen Mon*  
Department of Computer Science and Information Engineering, Taoyuan Innovation Institute of Technology, Chung-Li, Taoyuan, Taiwan, R. O. C.  
*monbuy@tiit.edu.tw

Abstract  
Supervisory fuzzy neural network has been developed for the vision robot control. This fuzzy neural network (FNN) is constructed by method of adaptive learning algorithm. The FNN control is combined with supervisory controller (SC) to be a full controller called supervisory fuzzy neural network controller (SFNN). The SFNN is tuned by off-line method and designed by considering image processing such as to be nearly identical to the perfect controller. The error of system is come from captured image data, so the controlled results should be drive into a suitable switching plane such that the stability can be achieved. This SFNN can achieve good control performance of vision robot. Simulation results show the proposed method possesses satisfied performances for the vision robot.

Keywords  
Fuzzy Neural Network Control; Vision Robot

Introduction  
In many fuzzy neural network (FNN) has been used for more extensive and successful research. Have an efficient learning ability in FNN. Its related paper can be found in [1]. But by using the FNN controller alone will need a lot of human works such as the method of try-and-error to get satisfied performance. In this paper, a method called supervisory FNN (SFNN) developed vision robot control design. This SFNN controller includes a fuzzy neural network controller and management controller (SC) [2, 3]. The FNN controller is used to minimize a perfect controller, and the SC is designed to compensate the differences between FNN controller and the perfect controller. The FNN controller is a suitable mix offline learning process, as a basis for constructing a set of fuzzy IF-THEN rules, appropriate membership functions, fuzzy memory to produce the specified associated (FAM) input-output pairs and fuzzy rules. Matrix and then a fuzzy inference system (FIS) can be achieved. A SC is added to the uncertainty is bound to relax in SC requirements estimated mechanism is used to observe the uncertain constraints. Finally, the design and the proposed FNN SFNN between visual robot system compares to illustrate the effectiveness of the proposed design method. Visual robot control analog square path also verify the design method can achieve better control performance than individual FNN controller.

SFNN Controller Design  
The below system is considered:

\[ x(t) = A(x(t),t) + B(x(t),t)u(t) + d(t) \]  

where \( x(t) = [x_1(t), x_2(t), \ldots, x_n(t)]^T \in \mathbb{R}^n \) are the state vector, \( u(t) = [u_1(t), u_2(t), \ldots, u_n(t)]^T \in \mathbb{R}^n \) are the control input, \( d(t) = [d_1(t), d_2(t), \ldots, d_n(t)]^T \in \mathbb{R}^n \) are the unknown disturbance and \( A(x(t),t) \) and \( B(x(t),t) \) depend on \( x(t) \).

Because the parameters of system are not known so the perfect controller is difficult to be generated in advance. Regarding this point, an SFNN controller is designed to be nearly identical to perfect controller. Meanwhile, supervisory controller is used to do compensation works such as to minimize the difference between the SFNN controller and the perfect controller.
For past years, the adaptive-network-based fuzzy inference system (ANFIS) [1] is a good self learning FNN. It is recommended in this paper to serve the role of FNN.

The principle of ANFIS is to use the fuzzy sets as below and to tune all these parameters.

$R_i$: If $x_1$ is $A_{i1}$ ... and $x_n$ is $A_{in}$ then

$$u_i = p_{i1}x_1 + ... + p_{in}x_n + r_i$$

where $A_{ik}$ are the fuzzy sets of the antecedent parts and $p_{i1},...,p_{in}, r_i$ are the fuzzy sets of fuzzy output parts.

After all have been defined in the bound of estimation error, the supervisory controller will be designed by designing the sliding mode method [4] to compensate the error.

**Simulation Results**

Consider a vision robot walking on O-XY plane such as the state space dynamic model is [5]

$$\dot{x} = Ax + Bu$$

$$y = Cx$$

An SFNN is designed for the vision robot. The design purpose is to control a vision robot to move on a desired path. The SFNN input variables are the tracking sliding functions of robot velocity and angle and their derivative values. The outputs are $u_v$, $u_\phi$. Based on the SFNN design concept, both $u_v$ and $u_\phi$ include the FNN and SC inputs.

The design steps are to design the FNN controllers off-line firstly to tune the weights such as to get favorable performance, the following steps are to design the supervisory controllers such as to let the tracking errors converge to zero. Two FNNs controllers will be designed. One is velocity controller and the other is angle controller.

The simulations are manipulated with a square path and the sampling time of simulation is set as 0.01 sec. The square path of simulation results are shown as in Figure 1. It reveals that the performances are good.

![FIGURE 1. VISION ROBOT WALKING SQUARE PATH ON O-XY PLANE.](image-url)
Conclusion
This paper presents under the control of a square path of vision robot system which is developed by SFNN controller. It is composed of a fuzzy neural network (FNN) controller and a supervisory controller (SC). FNN controller is the target trajectory becomes zero for converging system, and a supervisory controller for a fast exchange of the drive rail to the surface and is continuously kept track on the surface, in order to ensure system stability. In the simulation, this is used to handle the controlling vision robot path. The simulation result shows the proposed method is effective and good.

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