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Fuzzy Modeling with Neural Network Compensation for Human-based Target Tracking System

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Abstract: This paper presents an intelligent modeling method using fuzzy logic controller and neural network compensation technique for human-based target tracking systems. It has been known that a human-based control system is difficult to be modeled because of time varying or nonlinear properties in human controller. We first developed a fuzzy human operator model of the manual controller which rely on the expert's experiences or trial-and-error. But the fuzzy inference controller may not be acceptable as a human model because of modeling errors due to individual characteristics and operational environments. In these situations, we adopt a neural network compensation technique to supplement fuzzy modeling errors. The neural network compensator based on feedback error learning scheme reduces the modeling errors by adding compensation signals at the control input level. The feasibility of the present fuzzy modeling scheme including neural network compensator has been investigated for the real human-based target tracking system.

Keywords: Fuzzy modeling, Neural network compensation, Target tracking system

I. INTRODUCTION

When we design a manual controller in human based target tracking systems, the human operator's dynamics must be concerned. It has been recognized that the human operator's characteristics changing with different operational environments give poor performances in a real plant. But a human operator in the loop is not easy to be modeled because of time varying or nonlinear properties [1,2]. For these reasons, several studies have been made on fuzzy inference for the human modeling. Most fuzzy logic controllers have been designed based on expert's knowledge or experience which is intuitive and heuristic nature of the human mind.

The goal of this study is to construct of the human operator model by a fuzzy model with neural network to compensate the modeling error using feedback error learning. To show efficiency and practice of the applied modeling method, we performed simulations with real experimental data of the combat vehicle as a typical example of the human-based target tracking system.

II. FUZZY MODELING WITH NEURAL NETWORK COMPENSATION

1. Human-based Target Tracking System

We consider the target tracking system as an example of the human-based control system. Human operator as a part of controller generates tracking command to reduce position errors between target and gun in the human-based target tracking system as seen in Fig. 1.

The input command shaping uses handle or joystick to generate control command and reduce the input noise using a low pass filter[3]. The gun/turret driving system aims the target while targets moving. The reference position of the target is given on the operator's display as real target position.

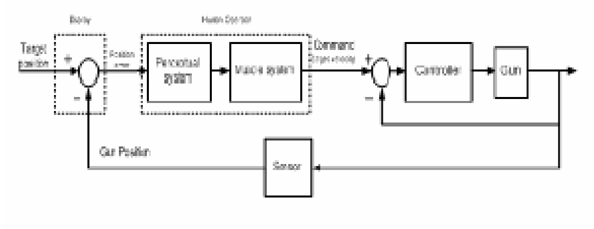

Fig.1. Human based target tracking system

2. Fuzzy Human Operator Model

Human operator as a manual controller can be constructed using fuzzy inference logic[4]. Fuzzy logic controller has two inputs of position errors and error variations from the monitor which display the reference input as target position and gun position simultaneously. We select triangle membership function in fuzzifier and defuzzifier, and design the fuzzy inference rules based on expert knowledge. Fig.2 shows the inference rules for the target tacking system.

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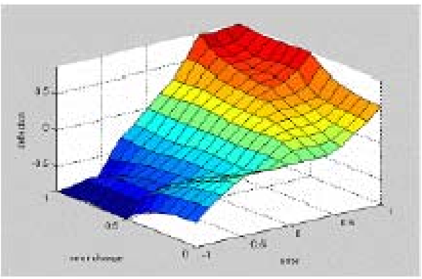

Fig.2. Fuzzy inference rule

3. Neural Network Compensation

Fig. 3 depicts the neural network as a compensator and the fuzzy human model designed for the target tracking system. The role of neural network is to compensate the input command of gun/turret driving system. The resulting neural compensator is then utilized as a feedforward controller to reduce modeling error caused by given fuzzy logic inference.

Now, the neural network compensator is designed so as to minimize the objective function

$$E = \frac{1}{2} u_l^2 \qquad (1)$$

where u_l is the output of the fuzzy logic. And by compensating u_l with the neural network output u_n, the input command u is finally composed as

$$u = u_l + u_n \qquad (2)$$

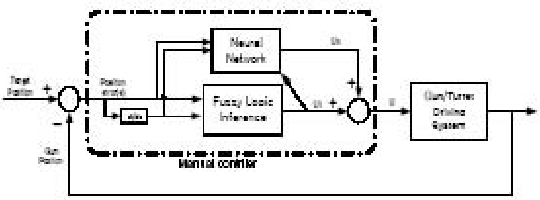

Fig.3. Neural network compensator

III. SIMULATION RESULTS

We developed a simulation model of the human-based target tracking system, and carried out extensive simulations. The data used in the model are based on some real plant with noise. The back-propagation algorithm is appied to learn and update the neural netwok. .

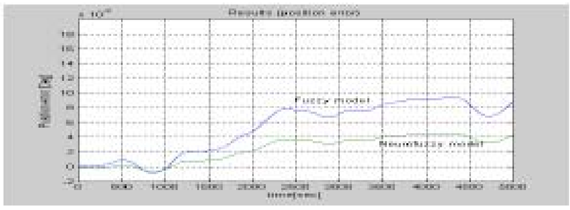

Fig.4. Position errors

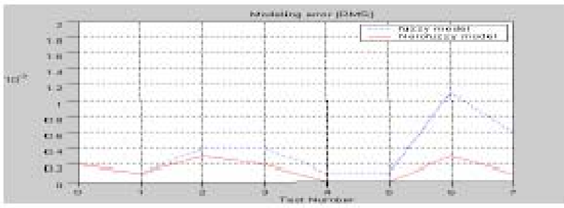

Fig.5. Modeling errors of the human operator

To demonstrate the effectiveness of the present intelligent modeling scheme, the fuzzy model with neural network compensation is compared with the case of fuzzy model only. Fig. 4 shows the position error profile between target and gun/turret positions, which indicates that the compensated fuzzy model is closer to real human model. Also, the modeling errors displayed in Fig. 5 show the similar tendancy.

IV. CONCLUSION

A fuzzy modeling method incorporating the neural network compensation has been developed for the target tracking system with human operator, and it's feasibility was tested using real data.The neuro-fuzzy scheme based on feedback error learning can reduce the human modeling errors by appending the compensation signal into the input command of the driving system

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