

# A Double Parasols Neural Network and A Target Following Control For Nonlinear Discrete Time Systems

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*Abstract*- A new neural network, Double Parasols Neural Network, is proposed here which is similar to a multilayered neural network, but is derived from an interconnected neural network. EBP-EWLS Method can be used as a learning algorithm. The proposed network is considered as a generalization of a regressor model for linear systems to nonlinear systems. Using this network, identification and control are examined for nonlinear discrete time systems to present a validity of the proposed method. Control strategy used here is a Target Following Control (TFC) method which makes it possible for the system output to attain the desired output in one step.

*Index Terms*—Double parasols neural network, target following control, identification, nonlinear discrete time system

## 1. INTRODUCTION

Neural networks have been discussed in detail in many papers and books. Among them, a multilayered neural network with the back propagation algorithm is most well known [4]. For an interconnected neural network, Back Propagation Through Time [6] and Real Time Recurrent Learning Method [7] are well known with the extended algorithm of BP method. But, these have many drawbacks such as: 1) It is often slow to reach a satisfactory error level; 2) The training performance is sensitive to the choice of the learning rate and initial values of the weight parameters; 3) It is prone to getting trapped in local minima. To overcome these defects, there have been done many researches. Ma and Ji [3] developed a new algorithm for feedforward and recurrent networks based on the concept of moving targets and the expectation-maximization algorithm. Their algorithm was derived through a probabilistic framework. On the other hand, Yamamoto and Nikiforuk presented a new learning algorithm, EBP-EWLS Algorithm [8], which is composed of two steps; 1) Determination of fictitious target signals for the output of the hidden layers by the method of error back propagation (EBP); 2) Renewing each weight parameters by the exponentially weighted least squares method (EWLS). This is the fastest algorithm in the sense that the exclusive-or problem can be solved only four times iterations. The EBP-EWLS algorithm developed for a multilayered neural network can also be applied for an interconnected neural network with some modification in its structure. Using this algorithm, some trials have been

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done for control and adaptive control [9], [10].

The purpose of this paper is to present a new neural network called a Double Parasols Neural Network (DPNN) and apply it to the problems of identification and control for nonlinear discrete time systems. A fully connected neural network is first modified by shifting the time step of the equation of hidden units backward. Then, the resulted network is similar to a multilayer neural network and it becomes possible to apply the EBP-EWLS learning algorithm to this network. To cope with the application for nonlinear discrete time systems, the feedback term of the neural network output is replaced with the system output. But, the network includes only the current system input and output only. So, the network is finally extended to include all the available system input and output signals. This is the neural network proposed here, which is called a Double Parasols Neural Network (DPNN). It is possible to estimate the coefficients of the linear part of the discrete time systems separately with the other nonlinear term.

Effectiveness of the proposed network is examined by using it in the simulation study of identification and control problems for nonlinear discrete time systems. Control method used here is the target following control (TFC), which makes it possible for the system output to attain the desired output in one step. In this case, the estimate of the coefficient of current control input signal is most important and the identification result using the DPNN becomes available. Most of the literature related to a NN-based control are method using an inverse system or Lyapunov like method, and often require some special structure of the closed loop system [2], [12]. The method presented here is, conversely, considered as a natural extension of linear case since the linear and the nonlinear problems can be considered in the same framework using the proposed method.

Other topics of the identification can be seen in the reference [5] where there are many papers relating to nonlinear systems. But, this paper gives a distinctive approach of nonlinear systems for identification and control.

Among many control design methods, TFC proposed here is very simple and is applied for any nonlinear systems described by difference equations. The key problem of TFC is the stability of the controller, which will be discussed in another paper.

In section 2, the proposed network, DPNN, is explained. The target following control method (TFC) with some additional comments for compensation is presented in section 3. Effectiveness of the proposed method is











