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AN ALGORITHM OF SUPERVISED LEARNING FOR ELMAN NEURAL NETWORK

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Abstract. *Elman Neural Network (ENN) has found numerous applications in such as time series prediction, system identification and adaptive control since it has powerful dynamic memories. However, one of the problems often associated with this type of network is the local minima problem which usually occurs in the process of learning. To solve this problem and to speed up the process of the convergence, we propose an improved learning algorithm by adding a term in error function which relates to the neuron saturation of the hidden layer. The activation functions are adapted to prevent neurons in the hidden layer from getting stuck into deep saturation area. We apply the proposed algorithm into the Boolean Series Prediction Question (BSPQ) problem and Amplitude Detection (AD) problem to demonstrate its efficiency. The simulation results show that the proposed algorithm has superior executive efficiency and ability to achieve better generalization capacity than other algorithms by avoiding the local minima problem.*
Keywords: Elman neural network (ENN), Back propagation (BP), Back propagation through time (BPTT), Local minima problem, Gain parameter, Boolean series prediction questions (BSPQ), Amplitude detection (AD)

1. **Introduction.** The Elman Neural Network (ENN) is one type of the partial recurrent neural networks, which consists of a two-layer back propagation network with an additional feedback connection from the output of the hidden layer to its input [1]. The advantage of this feedback path is that it allows the ENN to recognize and generate temporal patterns and spatial patterns. This means that after training, interrelations between the current input and internal states are processed to produce the output and to represent the relevant past information in the internal states. As a result, the ENN has been widely used in various fields which includes classification, prediction and dynamic system identification, etc. [2,3].

However, since the ENN usually uses the Back-Propagation (BP) based algorithms to deal with the various signals, it has been proved that it frequently suffers from a sub-optimal solution problem [4-6]. At the same time, the efficiency of the ENN is limited to low order system due to the insufficient memory capacity when Back-Propagation algorithm is employed [1]. So, several approaches have been suggested in the literatures to enhance the performance of the BP-trained ENN with simple modifications of net structure [7-10], but not algorithms. These improved modifications attempt to add other feedback connections to the model that will increase the capacity of the memory in order to speed up the convergence and escape from the local minima. However, the ENN is difficult to overcome the weakness or inherent characteristics of the BP-based algorithms which suffers from slowness of convergence speed and easily gets stuck into the local