Supervised Brain Emotional Learning

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Abstract— In this paper we propose the supervised version of neuro-based computational model of brain emotional learning (BEL). In mammalian brain, the limbic system processes emotional stimulus and consists of following two main components: amygdala and orbitofrontal cortex (OFC). Recently several models of BEL based on monotonic reinforcement learning in amygdala are proposed by researchers. Here, we introduce supervised version of BEL which can be learned by pattern-target examples. According to the experimental studies, where various comparisons are made between the proposed method, multilayer perceptron (MLP) and adaptive neuro-fuzzy inference system (ANFIS), the main feature of the presented method is fast training in prediction problems.

Keywords- BELBIC; supervised learning; limbic; geomagnetic index

I. INTRODUCTION

Emotions are cognitive processes and multidisciplinary studies of emotion have a long history. From the psychological point of view, emotions can be derived by reward and punishment received from various real-life situations and studies of the neural basis of emotion are described using the limbic system (LS) [1-2]. The LS processes the emotional stimuli associated with reward or punishment [3-4] and is located in the cerebral cortex and consists of the following components [4]: amygdala, orbitofrontal cortex (OFC), thalamus, sensory cortex, hypothalamus and hippocampus (Fig. 1). Amygdala is located in sub-cortical area and its main cognitive functions are long term memory and responsibility for emotional stimuli [4-5]. Amygdala receives connections from the sensory cortical areas [4-5] and also interacts with the OFC. OFC tries to prevent inappropriate responses from the amygdala based on the context provided by the hippocampus [6].

Recently, researchers in artificial intelligence try to present computational models of LS. Morén and Balkenius [4-6] proposed a neuropsychological motivated computational model of the amygdala-orbitofrontal system. The main feature of the amygdala-orbitofrontal system is that the weights of amygdala cannot decrease (called monotonic learning). So once an emotional reaction is learned, it is permanent and cannot be unlearned. In this model, the reward signal is not clearly defined and this signal is vital for updating the learning weights of system. Lucas et al. [7] explicitly determined the reward as reinforcer signal and proposed the BEL base controller (BELBIC) which has been successfully utilized in various control applications [8-18]. BELBIC is an action generation mechanism based on sensory inputs and emotional cues. Also BEL based on reinforcement learning was proposed to predict the $K_p$ index of geomagnetic activity [19]. Babaei et al. [20] formulized the input reinforcer for multi agent optimization problems and presented a BEL based predictor to forecast $AE$ index in alarm systems for satellites. The $K_p$, $AE$ and $Dst$ indices characterize the solar winds and geomagnetic storms that is a complex system and can greatly disturb communication systems and damage satellites [20-21]. These indices have chaotic behaviour and can be considered as time series. And researchers use them as case study to evaluate their methods [20-21]. The high values of $K_p$ and $AE$ and the large variation at low values of $Dst$ often correspond to geomagnetic storms or sub storms [22-26].

All reviewed BEL models are based on monotonic reinforcement learning and need an input reward extracted from input data. Also all reviewed BEL based predictors show high accuracy in predicting peak points but not at the all points [20] particularly when signal level is low. They show low accuracy at low points. So they cannot predict some time series such as $Dst$ index where the low values are most important. Here, we proposed supervised version of BEL that can be learned by using pattern-target examples. The proposed method can be used to predict the $Dst$ index along with other indices such as $K_p$ and $AE$ as case study.

The organization of the paper is as follows: The proposed method is illustrated in Section 2. Section 3 presents the comparison between proposed method, multilayer perceptron (MLP) and adaptive neuro-fuzzy inference system (ANFIS) [27] which are popular predictors in geomagnetic phenomena forecasting.

II. PROPOSED SUPERVISED BEL

In contrast to previous methods, proposed method can be learned by pattern-target examples. Actually the supervised version of BEL is introduced here. The proposed method can be utilized in various prediction and fitting problems. Additionally, according to the previous section, the main