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Brain signal based human emotion analysis by circular back propagation and Deep Kohonen Neural Networks☆

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ABSTRACT

Human emotion analysis is one of the challenging tasks in today's scenario. The success rate of human emotion recognition has high implication in practical applications such as Human Machine Interaction, anomaly detection, surveillance, etc. Artificial Neural Networks (ANN) is one of the highly favored computational intelligence techniques for human emotion recognition. However, the performance of traditional ANN is not satisfactory in case of applications such as human emotion analysis. This leads to the necessity of modified ANN with better performance than the conventional systems. In this paper, we propose Circular Back Propagation Neural Network (CBPN) and Deep Kohonen Neural Network (DKNN) to overcome drawbacks of the traditional neural networks regarding computational complexity and accuracy. Performance of the proposals is explored in classifying different emotions of humans using Electroencephalography (EEG) signals. It has been validated that the proposals have better performance than the related methods.

1. Introduction

Human emotion recognition is one of the significant areas in affective computing. The methodology of categorizing different types of human emotion is called as human emotion analysis [1]. Human emotions are extremely complex and vary from person to person. The complex nature of the human emotion makes recognition process highly challenging. However, human emotion recognition is extremely important in applications involving Human Machine Interaction (HMI). Several research works have been reported on human emotion recognition in the literature. Emotion recognition is mostly done in two ways: (a) facial expressions/speech signals and (b) through physiological signals. It is realized that most of those works are based on machine learning techniques.

Literature survey reveals the availability of face expressions/speech signals based human emotion recognition systems. The authors [1] used the hybrid Particle Swarm Optimization–Support Vector machine (PSO-SVM) technique for human emotion recognition. Speech signals from different databases were used in these experiments. However, the robustness of this approach was not validated. A similar work with speech signal database was reported in [2]. Seven human emotions were analyzed in this work [2]. The quantitative results were not sufficient to prove the efficiency of this approach. Extreme learning machines were used to recognize human emotions using speech signals [3]. Several benchmark signal datasets were used for experiments. Hierarchical classifiers-based emotion recognition system was developed in [4]. Several works analyzed the merits and demerits of various speech-

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based emotion recognition systems in [5–7].

Some other research works were dependent on facial expressions for human emotion recognition. Four basic human emotions were classified using face images in [8]. Machine learning techniques and different ethnic databases were utilized. Deep Convolutional Neural Network was used to recognize emotions in human beings [9]. However, there was scope for improvement regarding measures. Convolutional Neural Networks based facial emotion recognition system was developed in [10]. Face images with different orientations were used in experiments. Auto associative neural networks-based face emotion recognition was implemented in [11]. Few surveys were carried out specifically on face image based human emotion recognition techniques [12–14].

Physiological signals based human emotion recognition techniques were also available in the literature. The authors in [15] used the Multi-Layer Perceptron (MLP) neural classifier for emotion recognition. The EEG signals of audio music were used in the experiments. Deep learning classifiers were used for recognition of human emotions in [16]. Different physiological signals were used for emotion categorization with extensive feature set. Artificial Neural Networks based emotion recognition using multimodal signals was implemented in [17]. Evolutionary computation algorithms were also used for human-robot interaction applications. Support Vector Machines (SVM) based human emotion recognition system was developed in [18]. A feature selection methodology based on Late Positive Potential (LPP) was used. However, the accuracy rate in this work was relatively low. Physiological signals based human emotion analysis was also reported in [19–21].

Artificial neural networks-based emotion analysis was performed in [22]. The relation between the emotions and the physiological signals were studied. Echo state neural networks were used for human emotion recognition in [23]. EEG signals were used for the experiments. Images with positive and negative emotional content were used as stimulus for EEG signal generation. Probabilistic neural network-based emotion recognition system was developed in [24]. Brain EEG signals with different emotions were used. This method was validated on stroke patients. Deep neural classifiers were reported in [25]. This work was based on reservoir computing methods.

An observation of the literature works reveals the scope for improvement in the neural networks-based emotion recognition system. Another important area of concern is the lack of availability of many advantages in the same network. If it is accurate, then it is mostly computationally complex and vice-versa. In this work, a modified Back Propagation Neural Network (BPN) and a modified Kohonen Neural Network are proposed for human emotion recognition. The novelty lies in the different structural arrangement of BPN and Kohonen Neural Network. The training rules are also changed suitably to train these modified neural networks. EEG signals from DEAP dataset [7] is used in this work for identifying basic emotions of human beings. Experimental results show promising results for the proposed approaches. These are the significant contributions of this work

The rest of this paper is organized as follows: Section 2 deals with the background concepts of human emotions. Section 3 illustrates the proposed methodology. Section 4 covers the concepts of conventional neural networks. Section 5 describes the proposed approaches and Section 6 explains the experimental results and discussions.

2. Overview of human emotion

Human emotions can be defined as a conscious experience which is characterized by the activity of human brain [21]. Another significant part of emotion is cognition which is a major branch of artificial intelligence. Emotions are usually complex and very difficult to characterize. The number of emotions exhibit by human beings are enormous. For a large period of time, human emotions are not given much importance considering the fact that it is yet another natural behavior. However, the scenario completely changed with the introduction of Human Machine Interaction (HMI). The reason for the sudden attention is the requirement of the machines to behave like humans. In such a case, the machine must understand the various levels of emotions displayed by human beings [21]. Thus, the concept of emotion recognition has become increasingly important in the field of affective computing. The nature of the human emotions is mainly characterized by two aspects: (a) Valence and (b) Arousal [21]. Valence means positive or negative, and Arousal gives the information of silence level [21]. The major classification of the human emotions is performed using these two concepts. Fig. 1 shows the valence-arousal plane which segregates four different types of emotions.

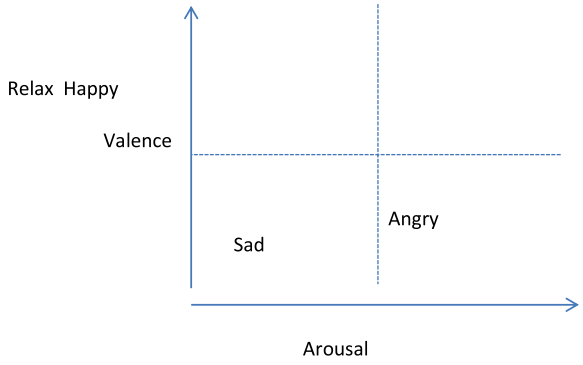

Fig. 1. Valence-arousal plane.