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Emotions Recognition and Signal Classification:
A State-of-the-Art

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ABSTRACT

Affective computing aims to create smart systems able to interact emotionally with users. For effective affective computing experiences, emotions should be detected accurately. The emotion influences appear in all the modalities of humans, such as the facial expression, voice, and body language, as well as in the different bio-parameters of the agents, such as the electro-dermal activity (EDA), the respiration patterns, the skin conductance, and the temperature as well as the brainwaves, which is called electroencephalography (EEG). This review provides an overview of the emotion recognition process, its methodology, and methods. It also explains the EEG-based emotion recognition as an example of emotion recognition methods demonstrating the required steps starting from capturing the EEG signals during the emotion elicitation process, then feature extraction using different techniques, such as empirical mode decomposition technique (EMD) and variational mode decomposition technique (VMD). Finally, emotion classification using different classifiers including the support vector machine (SVM) and deep neural network (DNN) is also highlighted.

KEYWORDS

Affective Computing, Deep Neural Network, Electroencephalography-Based Emotion Recognition, Emotion Recognition, Empirical Mode Decomposition Technique, Support Vector Machine

INTRODUCTION

Affective Computing (AC) is specializes in creating of and interacting with systems that are able to detect and respond to affective states (Picard, 2002). The AC field is based on the contributions of numerous domains, such as mathematics, engineering, education, computer science, sociology, physiology, and psychology. These several contributions reflect to which extent it is very complex to describe, understand and finally emulate the feeling experience. In fact, the term AC is quite new; it was first addressed in late the 1990s by Rosalind Picard (Picard, 1997). The main aim of AC is to establish more comfortable interaction between the human and computers (Hore, 2019); since the absence of emotions makes the humans feel uncomfortable and annoyed (Beale, 2008). Another opinion proposed by Clifford Nass, who revealed that humans deal with computers as they deal with each other (Nass, 1997). Hence, the emotionally respond of computers to the users is a

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must. AC show great benefits in different aspects such as in learning, the e-learning gains a severe attention and become favored by many students and enhancing the communication between students and computer improves the e-learning experience and the student mental state (Picard, 2001), and in social context (Breazeal, 2003).

The primary step to achieve an effective affective computing experience is detecting or recognizing emotions. Enabling a computer or any device to recognize emotions needs software and hardware requirements, examples of the hardware requirements are physiological sensors, video and depth sensors, and the standard input devices. The physiological sensors are used to measure the blood volume pulse, temperature, the skin conductance, and respiratory signal. Nevertheless, physiological sensors have a disadvantage that they are uncomfortable for users as well as these sensors are not practical and impossible to be used in the real life situations which require detecting emotions during daily working and learning processes, so they are usually used to verify the accuracy of a specific classifier. Video sensors like cameras grant information about the facial expression (Dey, 2019). The complexity of this method is due to the need of complex pattern recognition and image processing, whereas the depth sensors are often based on infrared light technology and used to detect human movements and gestures. The standard input devices such as the conventional mouse and keyboard represent an effective and unobtrusive method to collect the data from users; its effectiveness is for the no need of additional hardware to be added to the computer (Kołakowska, 2014). Computer or devices with such equipment result in affect-sensing systems, which are used in the field of affective computing to refer to systems that are able to detect emotions using information extracted from received patterns and signals (Daily, 2017).

The emotions influences appear in all the modalities of humans, such as facial expression, voice, and body language. Emotions also have further effects on the automatic nervous system (ANS) of the agent which in turn demonstrates the emotions influences on different bio-parameters of the agent, such as the electro-dermal activity (EDA), the heart rate variability (HRV), the respiration patterns, the skin conductance and the temperature as well as the EEG signals based on the theory that emotions arise in the brain (Zekri, 2018). Hence, all the mentioned parameters can be considered as methods may be used efficiently in emotion recognition. These methods differ in their accuracy and the types of detected emotions. In 1986, Arnold in his book "The nature of emotions" clarified that the term emotions has no single and general meaning. Therefore, researchers have the tendency to define technically architecture-based terms, which finally describe the types of states and process (Wright, 1996). Based on the former, emotions can be classified to basic and emotion schemes. In 1977, Izard classified emotions to be basic; if it's essential to adaptive behavior and human mentality (Izard, 1977). But later, many doubts were raised about this meaning and in 2007, Izard proposed a new definition defining the basic emotions "affective processes generated by evolutionarily old brain systems upon the sensing of an ecologically valid stimulus" (Izard, 2007). The literature on emotion science deals with the term of emotion schemes equally as the term emotion in general and defines it as the dynamic interaction between cognition processes and emotions which result in effects on the behavior and the brain, and these emotion schemes are being evoke by the appraisal processes as well as images, thoughts, memories, and the different non-cognitive processes including changes in hormones level and neurotransmitters (Izard, 1993). Emotion schemes are affected by the cultural and social contexts, individual differences, and learning.

For effective emotion recognition and for avoiding any mistakes during the emotion recognition process, emotion modeling becomes a must. Emotion models were classified to two basic categories are the categorical models and dimensional models. Categorical models take the view that the biological agent can only experience a limited set of emotions, called the basic emotions, these emotions are defined with the help of words or labels. Several approaches were proposed based on this theory, such as Frijda with six basic emotions are desire, happiness, wonder, sorrow, interest, and surprise (Frijda, 1986). Ekman also addressed six basic emotions, which are anger, surprise, joy, disgust, fear, and sadness (Ekman, 1992). Izard's approach proposed 10 basic emotions, which are