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Affective modelling of users in HCI using EEG

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Abstract

Emotions have potential to play a role in HCI which is primarily dominated by cognitive measures. Human physiological communication channels are dominated by emotions. Emotion affects several human activities like communication, learning, decision making, cognition, perception etc. Further, as emotions are difficult to interpret and hard to measure, technologists and designers have been struggling to incorporate them in design and technology. On the other hand, advancement of technology has both necessitated and enabled us to understand emotions and put them to use in contexts like human computer interaction. This study reports an attempt to model emotions by means of electroencephalography (EEG). Video stimuli of four representative basic emotions based on *Navarasa* theory of Ancient Indian treatise called Natya Shastra were shown to participants and EEG data was collected. Power spectrum analysis of EEG signals associated with emotions was done. Further, the EEG analysis findings were compared with the subject's self-reports about their emotional states during the experiment. EEG results have shown significantly consistent frequency patterns across the brain lobes for a given emotion. This study suggests that human emotions can be modeled for use in HCI either as an affect assessment tool or for affect based intelligent interactions.

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1. Introduction

Human body responds physiologically to physical and psychological stimuli and exhibits different physical changes. These changes comprise of facial expressions, skin conductance, heartbeat, brain signals, body temperature, pulse rate, etc. Advancement in biomedical technology has given us access to identify even smaller change in physiological parameters. For example fear release excessive amount of sweat compare to normal condition and happiness makes our body warm[1]. There are number of such physical changes reported in literature

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which bolster the era of Affective Computing. Since, last two decades human computer interaction has come over the surface of technology and captivated a wide attention of researchers towards the role of emotion in HCI[2, 3].

Since the birth of computer it has seen number of developments. It has come a long way from calculator to computer and finally took shape of smart computer. But still it lacks of emotional intelligence, response of person's anger, frustration, happiness etc. Affective computing is a forward step in the direction of filling this gap. Since last one decade, this title has grabbed a wide attention from all area of science and technology around the globe. Emotion assessment was successfully done in by different research community by means of different biomedical tools like, electroencephalography (EEG), electrocardiogram (ECG), galvanic skin response (GSR), heart rate variability (HRV) [4, 5, 6]. Various steps like data acquisition, preprocessing, feature extraction and classification have been followed in this process. The outcome of this area may benefit applications like Human Robot/Machine interaction, Interactive human computer interface, learning in autism, Affective computer etc.

1.1. EEG and Emotion:

EEG is a noninvasive measurement technique with temporal resolution in milliseconds. It shows the synchronized neuronal activity from a region of a brain, recorded by an electrode as an oscillating signal reflecting the electric potential from the group of neurons situated in close proximity to the electrode[7]. Ever since the invention of EEG, Constant attempts have been made to give meaning to the oscillating signal recorded from different parts of brain. This has resulted in the ability to detect a wide range of different psychological and physiological phenomenon. This recording was in the early days only suitable for detecting large differences in the pattern, such as epileptic seizures[8].

More precise recording equipment, empirical studies of EEG, and the availability of sufficient computational software tools, gives rise the possibility to detect even more subtle changes in the electric potential recorded. These subtle changes have been recognized to encode for cognitive and affective processes of brain such as attention, working memory, mental calculations, as well as different types of behavior [9, 10, 11]. These possibilities motivated to look forward for detecting emotion through EEG. Based on the brain functions EEG is categorized into five frequency bands, including delta (δ: 1–3 Hz), theta (θ: 4–7 Hz), alpha (α: 8–13 Hz), beta (β: 14–30 Hz), and gamma (γ: 31–50 Hz) [12]. Delta and theta bands are commonly found during sleep or clam state of brain. Alpha is evident mainly during the low mental activity whereas beta and gamma are produced when brain is involved in higher cognitive functions[13]. Alteration in these bands and their features are often assessed to examine the emotional states. YisiLui reports that arousal shows negative correlations in theta, beta, and gamma band. It means increase of arousal leads to a decrease of theta, beta, and gamma powers. It is found that beta band of electrodes FC2 has a negative correlation with arousal. For valence, we get a positive correlation in beta band and a negative correlation in gamma band. It means that an increase of valence leads to an increase of beta power and a decrease of gamma power[14]. Sander Koelstra states in DEAP database that central alpha power decreases with arousal. All frequency bands shows positive correlation with valance in occipital lobe but central beta power decreases with valance[15]. He further reports that valance shows negative correlation in right posterior alpha power whereas left central increases and right frontal decreases in beta power. Arousal shows robust decrease in right posterior in alpha power.

1.2 .Computational models of emotion

"The Emotions are all those feelings that so change men as to affect their judgments, and that are also attended by pain or pleasure. Such are anger, pity, fear and the like, with their opposites." (Aristotle, 1378b, English translation by W. Rhys Roberts) [15]

Since the term affective computing was coined by R. Piccard, It grabbed attention of many research community comprising Psychology, neuroscience, neuropsychology, physics, and engineering. To map emotions through physiological measures, it is very important to identify possible types of emotions. Two approaches can be found in literature to model emotions. One is mapping of individual emotions and another is representation of emotion on multidimensional space[16]. In first category, Plutchik proposed eight basic emotion states: anger, fear, sadness, disgust, surprise, anticipation, acceptance, and joy[17]. Ekman used model of six emotions while studying of relation associated with facial expressions: anger, disgust, fear, happiness, sadness and surprise. Later Ekman expanded the