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Emotion Recognition from Physiological Signals : A Review

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***Abstract*—** Emotions play an important role in the psychology and physiology of the human. It originates from the day to day experiences, people they interact with and the environment they deal with. In the current day of technological development, emotion recognition has got great attention, since it can contribute to the Human-machine interaction and for complete automation. Several methods of emotion recognition has been carried out and they include facial recognition, speech processing, physiological detection and by body gesture processing. But physiological detection of emotion recognition has got added advantage over other methods since it is involuntarily controlled by the autonomous nervous system. A correct picture of underlying human emotion will be obtained by processing the physiological signals. Emotion recognition from physiological signals can help people with impairments in social interaction, communication and developmental disorders. This paper attempts to present a review of the emotion recognition of human using physiological signals mainly ECG. It also discusses about the different techniques of feature extraction and classification.

***Keywords*—ecg, autonomous nervous system**

I. INTRODUCTION

Emotion is the complex state of behaviour that influence thought and behaviour. Emotion consists of the subjective component which describes how we experience emotions, a physiological part that corresponds to how our body reacts to the emotions and an expressive component which reflects in the response of the human to each emotion. The term emotion refers to relations among external incentives, thoughts, and changes in internal feelings. Emotion recognition has evolved into a vast area of research in cognitive science engineering and psychology. In psychology, emotion recognition was used to understand the emotions of the people under counselling. In the medical field, emotion recognition is also used to assist paralyzed people and elderly people. In science and engineering, emotion recognition is used for human-machine interaction and for complete automation. Emotion can be represented in a two-dimensional scale with valence in the x-axis and arousal in the y-axis. Valence represents pleasantness or polarity of emotion stimuli whereas arousal represents the strength of emotion. Emotion recognition can be employed using various techniques. Facial expression and speech processing are the main early methods used but the main problem with these methods is that these can be disguised easily since a person can mimic himself and hide the real emotions. Analysing physiological signals and deriving emotional contents may improve the result of emotion recognition. Physiological signals like EEG, PPG, skin conductance and ECG can do the work. Since brain and emotions are not mapped to autistic children ECG signals are more preferred.

Autism spectrum disorder is characterized by impairments in social interaction, communication and other developmental disabilities. Emotional impairments are also part of this disorder [15]. In autistic people, the visual processing portion of the brain is more activated whereas for non-autistic people both verbal centres and visual information processing portions of the brain are activated in combined form so that a good picture of the context is obtained for these people. Autistic people are good at spotting a pattern in a distracting environment. They outperform normal people in auditory tests, detecting visual structures and mentally manipulating complex 3-dimensional shapes. Due to their disability in recognizing, expressing and regulating the emotions, an emotion recognition system can help them in a better manner. Many people had made research work in the field of emotion recognition from physiological signals.

This paper consists of 3 sections. Section II describes about the previous works done in the field. It gives a detailed review of works carried out in this field. Section III is the conclusion of the paper.

II. RELATED WORK

Ofer Golan et al. [8] had done experiments to study emotional features of children coming under Autism Spectrum Disorder. He studied emotion identification and regulation features by conducting experiments using 20 autistic children of the age from 4-7. He used 'The Transporter' an animation movie to induce emotions in them. He identified from his study that due to less attention of such children towards faces and eyes they have impairment in recognizing emotions and in face processing skills.

Many people took the idea of multimodality ie; using more than one physiological signal for analysis. Better result was obtained for such research works. The main steps in emotion recognition from physiological signal are pre-processing of the signal to remove noise, feature extraction, feature selection to eliminate those features which does not contribute much for emotional information and next comes classification. Several papers in this field make use of different methods in each of the steps. The work done by Sasikumar K et al. [10] was meant for identifying physiological signal variations between control group and autistic group. The experiment was conducted using 40 normal and 40 autistic children. They used clue cards containing alphabets, animals, colours and fruits to elicit emotions and acquired PPG and GSR signals from people under test. During the mental ability task it was seen that autistic children are not getting concentration level as that of control group. They become more stressed and have an increased ANS activity. As a result they showed an increased heart rate. The results of the paper shows that the PPG and GSR signal recorded are having high values for autistic children when compared to normal children.

A physiological reaction is a change in activity in the autonomic nervous system (ANS) that accompanies emotions. Murugappan et al. [2] tried to analyze and classify 5 different emotions happiness, disgust, fear, sadness and neutral from HRV signals derived from ECG. DWT is used to extract statistical features from HRV signal. It makes use of 4 types of wavelet functions daubchies6(db6), daubchies7(db7), Symmlet8 (sym8), and Coiflet5 (coif5). LDA and KNN are the classification technologies used. Fourteen level decomposition is done to obtain low-frequency(0.03-0.12HZ) and high-frequency(0.12-0.488 Hz) which contains emotional information. Of these KNN provided maximum classification accuracy compared to LDA.

Sneha Dinde et al.[3]described the two-dimensional emotional model with x-axis consisting of valence and y-axis with arousal. Figure.1 represents the two-dimensional emotion model. This is also called as valence arousal model.

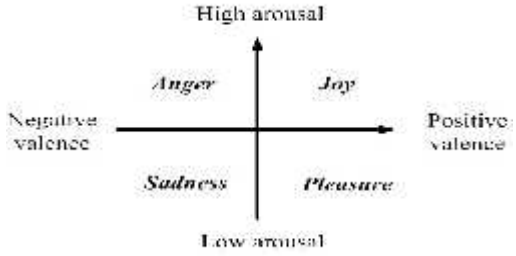

Figure 1 Two-Dimensional emotion model

Valence represents pleasantness or polarity of emotion stimuli whereas arousal denotes the strength of emotion. ECG signal is empirically decomposed by using Empirical Mode Decomposition (EMD) into finite set of small oscillatory activity called Intrinsic Mode Functions (IMF's). The information components of interest are then combined to create feature vector based on the combination methods for exploiting the fission-fusion processes provided by Hilbert-Huang transform. Multiclass support vector machine technique is used to classify emotions (joy, sadness, anger and pleasure).

Bio signals manifest directly underlying activity of the autonomous nervous system. The paper proposed by Jerritta et al. [4] use 6 emotional states happiness, sadness, fear, surprise, disgust and neutral for classification. Emotion is induced in the subjects using audio and visual clips. Hilbert Huang Transform (HHT) based analysis was done to obtain the emotional features in low and high-frequency ranges. Emotional data are more found in low-frequency intrinsic mode function than in other frequencies.

Krupa et al. [5] developed a wristband for acquiring physiological signals and the physiological reaction is found by variation in parameters like GSR and HRV. This paper focuses on the emotion recognition of autistic children so that it may help caretakers to provide them proper care during the early developmental stages.

Emotions surprise, boredom and pain are recognized and classified using DFA (the statistical method), and five machine learning algorithms LDA, CART, SOM, SVM and Naive Bayes by Eun-Hye Jang et al.[6] ECG, EDA, SKT and PPG are the physiological signals used for the analysis of these emotions.

The paper proposed by Jin Hun Sohn [1] is a comparative study of the efficiency of different classification methods. LDA, CART, SVM and SOM are the classification methods used. The efficiency of these classifications methods is found by classifying 3 different emotions boredom pain and surprise. It has considered four physiological signals EDA, ECG, PPG and SKT. Physiological signals are used for emotion recognition in individuals because acquiring these signals can be done non invasively using some sensors. Signals are acquired for time duration of 1-1.5 minutes

during emotional state. 23 features are extracted from all the physiological signals and are classified. Of that maximum accuracy is obtained for SVM classifier.

Hao Min [12] proposed a method of classifying two emotions joy and sadness from ECG signal. 391 subjects participated in the experiment. Emotion was stimulated using film clips. BIOPAC MP150 was used for acquisition of ECG signal. Emotion was detected and classified by extracting HRV parameters and several statistical features such as standard deviation of S wave amplitude, maximum of R wave amplitude, mean of S wave amplitude etc. Tabu search algorithm was used for feature selection to eliminate those features which are less relevant for emotion recognition from ECG signal.

Physiological responding of the human being as a result of his psychological reaction, human emotional states can be easily derived from his physiological signals. A study of physiological signal relation to emotion is done by [9] K Kiruba et al. They observed variation ECG signal, skin conductance, respiration rate and skin temperature with respect to emotional changes and changes in mental states. The study used AIEFS for feature selection and HEC for estimation evaluation. Support vector regression with genetic algorithm, multinomial naive Bayes, ensemble online sequential extreme learning machine are used in a combined form for classification to get increased performance.

The experiment conducted by Foteini agrafioti et al. [13] was at affect and cognition laboratory, of the University of Toronto. Two separate experiments were conducted with 44 and 43 volunteers. Experiment 1 used IAPS database for emotion elicitation. Detected and classified emotions as gore, fear, disgust, excitement erotica and neutral. The experiment was such that 5 images of same emotions are shown for a time duration of 8 seconds and the same is repeated for same emotion but now using another five images. A break is given between these two steps so that psychological activity of the person can be brought to a neutral value. Next experiment uses video game to induce stress. ECG, EMG, EEG, GSR, BVP, HR, HRV and respiration rate are acquired and LDA is the classifier used for classifying the emotions.

DECAF [14] is a database containing the physiological response to different emotions elicited in 30 subjects using 36 movie clips and 40 one minute music video segment. They had collected different signals such as MEG, horizontal electrooculogram hEOG, ECG, trapezium electromyogram (tEMG) and near-infrared facial videos which were recorded synchronously.

III. CONCLUSION and Future Scope

Several works are carried out in the field of emotion recognition. Of that physiological detection of emotion recognition will give the correct interpretation of one's emotions, since it originates from the activity of the autonomous nervous system. ECG, EMG, EEG are the physiological signal used for emotion recognition. Different time domain, frequency domain and time-frequency domain techniques of signal analysis and feature extraction are implemented in different papers to get better results. Emotion recognition from physiological signals can be implemented for people who have emotional and developmental impairments.

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