



Review Paper

A review on: recognition of human emotions based on the analysis of EEG Physiological Signal

Manisha Chandani and Arum Kumar

Department of ETC, Bhilai Institute of Technology, Durg, CG, India
chandani.manisha09@gmail.com

Available online at: www.isca.in, www.isca.me

Received 8th April 2017, revised 10th July 2017, accepted 23rd July 2017

Abstract

Emotions are the state of mind and behavioural approach individuals use to influence their own emotional expertise. It is the inclusive term to individual, attentive practice that is described mainly by psycho physiological expression, mental states, biological reaction. Emotions are combining and express accordingly with mood, activity, temperature, nature and personality. In reasonable decision making and determined action emotions play the important role. Emotions give the ability to deal with unplanned occasion in our background which helps to increase our chance of survival. Physiological signal composes vital signals in the human body. In particular, to identify human emotions several physiologic signals have been used widely these signals are collected from Electroencephalogram, Electrocardiogram, Electromyogram, Respiratory system, Electrodermal activities, Muscular system and Brain activity. The purpose of this study is to recognize the mental emotional state of a human body by using EEG signal, which recognize the human emotions. This study would provide a deep view on current state of the research and require on emotion recognition based on the analysis of EEG physiological signals.

Keywords: Emotion recognition, Physiological signal, Electroencephalogram, Electromyogram, Empirical mode decomposition.

Introduction

Emotion is usually outlined as a fancy state of feeling that ends up in physical and psychological changes that influence thought and behavior. The primary aim of analysis of the physiological signal is to recognition of human emotions. Additionally physiological signals are continued movement towards a particular external or internal incident or the thing perceived, which results in the attitude and physical phase both. In particular, to identify the emotion of human several physiologic signals have been used widely^{1,2}. Generally, these signals are collected from Electroencephalogram (EEG), Electrocardiogram (ECG), Electromyogram (EMD), Respiratory rate (RR), Electrodermal activities, Muscular system and Brain activity, temperature, Galvanic skin temperature (GSR), blood volume pressure (BVP). The information components of interest combined to classify the data through signal processing.

One of the benefits of recognition of emotions by victimization physiological signals is that they're unintentional reactions of the body and in itself are terribly tough to mask. Among the earliest efforts for emotion differentiation victimization physiological signals is the work of Hasan et al³.

Emotions give the ability to deal with unplanned occasion in our background which helps to increase our chance of survival⁴. At last, several physiological signals attempts new facts for the emotio identification because emotional states are directly

interrelated to the physiological response. Many emotion research has studied that physiological signals are produced by the primary emotions and emotion detection of a human based on the analysis of physiological signals is performed by various algorithms (e.g. HHT, FFT, EMD etc.) and the emotion classification from the physiological response are also performed by various machine algorithms (e.g. SVM, DFA, LDA, CART, Arousal-Valence band, SOM, Naïve Bayes algorithm, etc.) The main objective of this study is to categorize varied emotion by EEG physiological signal and to observe the optimal algorithm for recognizing EEG physiological signals⁶⁻¹⁰.

The physiology of EEG

An electroencephalogram (EEG) check that detects electrical activity in your brain exploitation little, flat metal discs (electrodes) connected to scalp. Figure-1 shows electrode placement on scalp²⁶. Brain cells communicate via electrical impulses and area unit active all the time, even once you are asleep. This activity shows up as wavy lines on Associate in Nursing electroencephalogram recording. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time. An EEG is one of the main diagnostic tests for epilepsy. An electroencephalogram might also play a task in identification different brain disorders. All human display five different types of electrical pattern brain or brain waves across the cortex that is Gamma, Beta, Alpha, Theta, Delta. Figure-2 shows these five different brain waves¹¹.

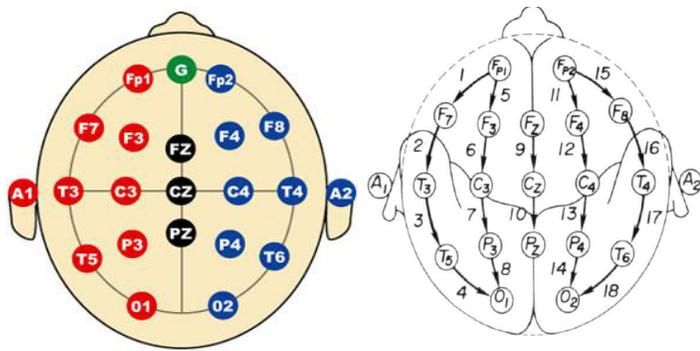


Figure-1: The pattern of surface electrodes placement following that of the universal system 20-10.

Gamma waves: Gamma waves are involved in processing any task as well as cognitive functioning. Gamma wave shown in Figure-2(a). The importance of these waves in learning, information processing and memory. The frequency range of Gamma waves in between 40 Hz – 90 Hz (highest). 40 Hz Gamma wave is essential for the binding of our senses to perception and involved in learning new things. Lower Gamma activity than average is the cause of learning disability and individual who are mentally challenged. Excess amount of Gamma waves leads to anxiety, stress, high arousal. Adequate production of Gamma waves helps in information processing, binding senses, learning, and cognition.

Beta Waves: Beta waves are involved sensible thoughts and logical thinking. Figure-2(b) shows the Beta Wave. These waves have low amplitude and high frequency brain waves that are observed while we are awake. The frequency range of Beta waves in between 12 Hz to 40 Hz (high). Abnormal Beta activity may experience poor cognition, depression,

daydreaming. Too much Beta waves leads to an inability to relax, Adrenaline, high arousal. Sufficient production of Beta waves conscious focus, memory, problem solving.

Alpha waves: Alpha wave is the frequency range between Beta wave and Theta wave. Figure-2(c) shows the Alpha wave. This Alpha frequency range bridges the gap between conscious thinking and the subconscious mind. It helps to calm down when necessary and raise feelings of deep relaxation. The frequency range of these waves is between 8 Hz to 12 Hz (moderate). Lower amount of Alpha waves creates anxiety, insomnia, high stress. An excess of these waves leads to daydreaming, too relaxed, inability to focus. Adequate production of Alpha waves helps to relaxation.

Theta Waves: Theta waves are involved in sleep, daydreaming and also involved in restorative sleep. Theta waves have its benefits of helping improving intuition, creativity. The frequency of Theta waves are 4 Hz to 8 Hz (slow) in Figure-2(d) Theta Wave is shown. Too little Theta waves are the cause of poor emotional awareness, stress. Sufficient production of Theta waves increases creativity, emotional connection, relaxation. Too much Theta waves create depression, hyperactivity, inattentiveness, impulsivity.

Delta waves: These waves are associated with the deepest level of relaxation and healing, restorative sleep. These are slow recorded waves in the brain. Most often these waves are found in newborn as well as young children. Figure-2(e) is showing delta wave. The frequency of these waves in between 0.5 Hz to 4Hz. Adequate production of Delta waves helps to feel completely rejuvenated after we wake up from a good night's sleep. Abnormal activity of Delta wave creates learning disability and have difficulties to maintain conscious awareness¹¹.

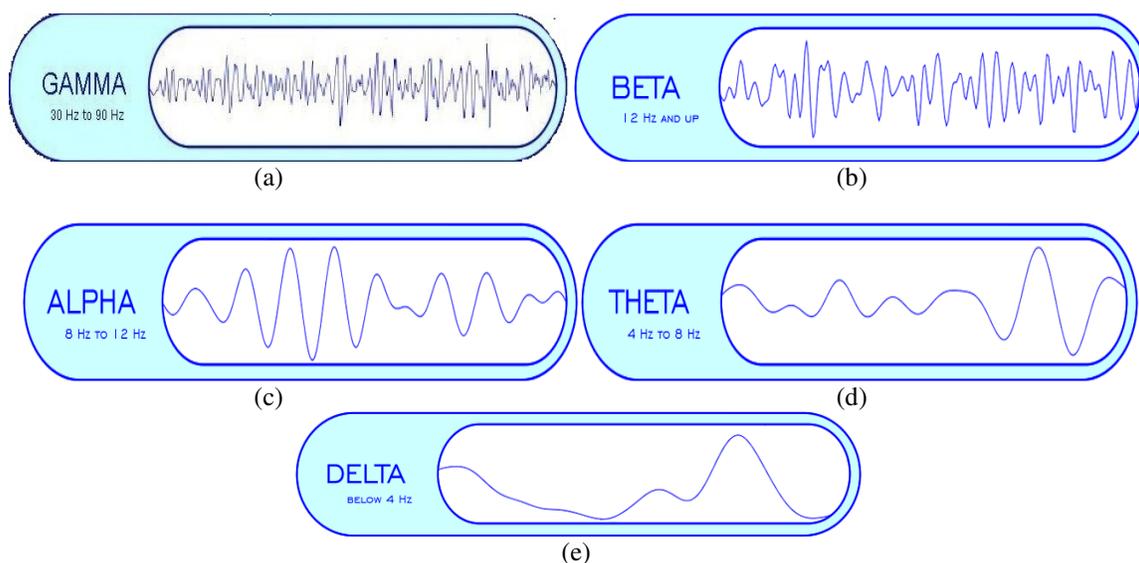


Figure-2: Brain Waves in the human brain.

EEG processing techniques

Several researches are done on emotion recognition by exploitation physiological signals with completely different process techniques. One in every of the encephalogram process technique is that the Empirical mode decomposition (EMD). EMD is that the process technique that breaking down a symbol while not going the time domain. The Empirical mode decomposition and Hilbert Huang rework (HHT) technique had been employed by Baby Shalini et al. EMD filters out functions that type an entire and nearly basis for the initial signal¹². The completeness of Empirical mode decomposition technique is predicated on the manner it is rotten implies completeness. From the information raw encephalogram signal has been collected. From the collected encephalogram signal noise is removed by exploitation Fourier rework to correct feeling detection. By exploitation the EMD technique any difficult information set may be rotten into a finite and infrequently tiny range of element that could be assortment of intrinsic mode function (IMF). This decomposition technique is operated within the time domain is adaptational and extremely economical. This technique of decomposing decomposition is predicated on the native characteristic continuance of the information; it may be applied to nonlinear and nonstationary processes.

IAPS and IADS are used with emotion-annotated pictures (IAPS) and sounds (IADS) offered for non-learning analysis, that area unit terribly helpful for emotion analysis. The International emotional image System (IAPS) and therefore the International emotional Digitized system (IADS) area unit developed and distributed by the NIMH enter for experimental investigations of emotion and a focus. The aim is to develop an oversized set of standardized, emotionally-affective, internationally - accessible and colour pictures that features contents across a large vary of linguistic classes. The International emotional Digitized system (IADS) provides a group of sounding emotional stimuli for experimental investigations of emotion and absorption. Primarily these two strategies area unit used for removing artefacts from signal this methodology is pioneered by M. M. Bradley¹³ and P. J. Lang^{13,14}.

Discrete Wavelet Transform (DWT) is a linear signal process that is applied to the actual knowledge. This knowledge has a similar length, and so these techniques area unit applied to the information reduction. Discrete Wavelet Transform (DWT) area unit orthogonal functions, this operate are often enforced through digital filtering techniques. Wavelets have energy concentrations in time and it's helpful for the analysis of transient signals. DWT is that the most optimistic mathematical transformation that provides each the time – frequency data of the signal and is computed by sequent low pass filtering and high pass filtering to style a multi resolution time-frequency level. The advantage of victimization DWT is it analyze the information in time and frequency each the domains. S.A.

Mallat et al projected the construct of mouldering the first signal employing a ripple and might be explained as a decomposition employing a set of freelance frequency channels having an abstraction orientation standardisation¹⁵.

Higher Order Crossing (HOC) is that the techniques shows that the finite zero means that series; level zero will categorical through the zero count. Therefore HOC is referred zero crossing count. HOC are often combined with spectral analysis and discriminate analysis to extract the actual feature. The feature uses signal segmentation and it extract the feature mistreatment HOC and from EEG mistreatment HOC methodology. This could be combined with spectral and discriminate analysis to extract the actual feature. The emotions are often known by mistreatment the signal segmentation and extract the feature mistreatment HOC and Cross correlation methodology. The options square measure extracted from the EEG mistreatment HOC methodology. The options square measure extracted from EEG mistreatment HOC. Muhammad Soleymani et al. HOC supports totally different feature extraction techniques and provides higher accuracy result. The most advantage of mistreatment HOC is it performance ought to be high and it provides optimum results¹⁶.

Short Time Fourier rework and Mutual data STFT is one amongst the ways used for feature extraction. It is used to extract from the every electrode sliding window of 512 samples and it overlapping between 2 consecutive windows. The mutual data relies on however every and each electrode pair's and the way those applied statistical dependencies the features are extracted and these extracted features are used for emotion analysis. During this approached showed the closed-form output from many varieties of the input series. Particularly, similar to the separate Fourier rework, the STFT's modulus statistic takes giant positive values once the input could be a periodic signal. One main purpose is that a racket statistic input leads to the STFT output being a complex-valued stationary statistic and it derives the time dependency structure like the cross-covariance functions. Okamura, Shuhei projected a technique projected the short time Fourier transform and local signal. During this approached showed the closed-form output from many varieties of the input series¹⁷. This approach centered on the detection of local periodic signals. The main advantage of using this technique has fixed slide window length.

Classification

After choosing the options that area unit relative to the emotional states, they have to be wont to train a classifier so it will classify the varied emotional states mistreatment the options desired. Numerous classification like Support vector machine (SVM) could be a non-linear model, that are used for the renowned emotion algorithms and support vector classifier distinct the emotional states with a outside boundary. The advantage of support vector classifier is that it may be extended

to non-linear boundaries by the kernel trick. Ability in choosing a closeness capability. In sufficiency of result once managing. SVM carries every regression and classification jobs and it handle multiple determined and categorical variables. Eun-Hye Jang, Byoung-Jun et al had been the SVM to point out the accuracy percent with order of elite physiological signal^{8,18}.

Linear Discriminant Analysis (LDA) is employed in several applications like face recognition, image recovery, and small array knowledge classification. LDA provides the extraordinarily quick analysis of unknown inputs, and it performed this input by distance calculations between a new sample and also the coaching knowledge sample in every category weighed by their variance matrices. LDA is incredibly straight forward however stylish approach to classify the various kinds of emotion. It doesn't need any external parameters for classifying the separate emotion. LDA conjointly referred to as Fisher's discriminate analysis. It's been employed in application of feeling recognition and face recognition. Eun-Hye Jang, Byoung-Jun Park et al. LDA works once the measurements created on freelance variables for every observation area unit continuous quantities. Once addressing categorical freelance variables, the equivalent technique is discriminate correspondence analysis⁸.

Discriminate function analysis (DFA) is that the applied mathematics analysis accustomed predict a class variable by one or a lot of continuous or binary freelance variables. Separate the group maximally DFA is used to decide the most closefisted way to separate groups or reject variables which are slight associate to group distinctions Discriminate function analysis is same as regression analysis. A discriminate score will be calculated supported the weighted combination of the freelance variables. Eun-Hye Jang, Byoung-Jun Park et al. underlying discriminant perform analysis is to see whether or not teams dissent with relation to the mean of a variable, so to use that variable to predict groupmembership^{8,12}.

Principal element Analysis (PCA) it's a applied mathematics analytical tool that's wont to explore, sort, and group knowledge. It takes an outsized no. of related variables and transforms this knowledge into a tiny low range of unrelated variable whereas retentive maximal quantity of variation, thus it's easier to control information and create prediction. PCA is employed to scale back dimensional knowledge to lower dimension whereas retentive most of the knowledge. Principal element analysis (PCA), conjointly called Karhunen-Loeve growth, may be a classical feature recognition and computer vision like face recognition¹⁹. PCA used for cut back dimension vector to higher acknowledge pictures²⁰. Advantage of exploitation this classification technique is PCA will be wont to compress knowledge, by reducing the no. of dimension, while not loss of any info. Reduction of noise since the almost variation basis is chosen and then the tiny variations within the background are neglected mechanically.

Fisher's Discriminant Analysis classifiers (FDA) classification is employed for every class (modality, valence, arousal), a categoryifier was trained for every class audio, visual, audiovisual, positive, negative, aroused, calm to supply a sign of whether or not it will or doesn't belong to it specific category. This technique had been used; classification results for every input can be obtained, while not having to coach on the input to be classified itself. Classification victimization agency leads to a orth between 0 and 1, whereas a worth over 0.5 is understood as instance happiness to the category that was classified. A classification for every check subject, separate classifiers was used, as a result of the variations between EEGs from totally different people.

Classification and regression tree (CART) is one in every of call tree and statistic techniques that may choose from among an oversized range of variables the foremost necessary ones in decisive the end result variable and given the info drawn at a node, either declare that node to be a leaf and state what class to assign thereto, or notice another property to use to separate the info into subsets²¹. This can be a generic tree-growing methodology referred to as CART. The elemental principle underlying tree creation is that of simplicity. We tend to like choices that result in a straightforward, compact tree with few nodes. Eun-Hye Jang et al. projected this for the analyses by mistreatment tree-building of CART is to see a group of logical conditions that let correct prediction or classification of cases. It's comparatively straightforward for non-statisticians to interpret call rules supported trees are a lot of probable to be feasible and sensible, since the structure of the rule and its basic logic are apparent⁸.

The Naive Bayes rule could be a classification rule supported applying Bayes' rule with study (naive) freelance assumptions²¹. In particularl, it's suited once the spatiality of the inputs is high. Naive Bayes classifier assumes that the presence or absence of a specific feature of a category is unrelated to the presence or absence of the other feature, given the category variable. This helps alleviate issues stemming from the curse of spatiality, like the requirement for knowledge sets that scale exponentially with the proper category chances, this could not be a demand for several application. Eun-Hye Jang et al. Naïve Bayes rule usually works quite well in follow, and it are often expressed by a really straightforward belief web. It's not one rule for coaching such classifiers, however a family of algorithms supported a typical principle⁸. All Naïve Bayes classifiers assume that the worth of a specific feature is freelance of the worth of the other feature, given the category variable.

Conclusion

Several existing methods have been reviewed for emotion recognition. In emotion recognition research, it is very important to collect meaningful data. This technique is an efficient method to determine the emotional states of human beings. One of the benefits of detecting emotions using

physiological signals is that these are automatic reactions of the body, and intrinsically very difficult to mask. From this research study it is concluded that the Empirical Mode Decomposition (EMD) is the methodology of breaking down a proof while not going away the time domain. Basically, the clear signal are going to be rotten into the Intrinsic Mode perform elements (IMFs). Once the creation decomposes the clear signal into its composing elements, all operations like analyzing, distinctive, and removing unwanted signals may be performed on these elements. Upon reworking the IMFs into Hilbert spectrum, the clear signal is also compared with alternative natural philosophy signals. The main benefit of using this technology produces a distributed or filtered sensor of original physical signal and eliminates undersigned intrinsic mode function (IMF) components. EMD technology also determines an analytic function which accurately represents the physically important components of the original signal.

References

1. Ekman E. and Davidson R.J. (1994). The nature of emotions, fundamental questions. Oxford: Oxford University Press, USA., 1-512, ISBN-10: 0195089448.
2. Scherer K.R. (2004). Which emotions can be induced by music? What are the underlying mechanisms? And how can we measure them?. *J New Music Res.*, 33(3), 239-251.
3. Arafat A. and Hasan K. (2009). Automatic Detection of ECG wave Boundaries using Empirical Mode Decomposition. Proc. IEEE Int'l Conf. Acoustics, Speech and Signal Processing, 461-464.
4. Frijda N. (1986). The emotions. Cambridge University Press Cambridge. UK Google Scholar, 1-544, ISBN: 0521301556.
5. Drummond P.D. and Quah S-H. (2001). The effect of expressing anger on cardiovascular reactivity and facial blood flow in Chinese and Caucasians. *Psychophysiology*, 38(2), 190-196.
6. Alaoui-Ismaili O., Robin O., Rada H., Dittmar André and Vernet-Maury Evelyne (1997). Basic emotions evoked by odorants: comparison between autonomic responses and self-evaluation. *Physiology and Behaviour*, 62(4), 713-720.
7. Ax A.F. (1953). The physiological differentiation between fear and anger in humans. *Psychosomatic Medicine*, 15(5), 433-442.
8. Jang Eun-Hye, Park Byoung-Jun, Park Mi-Sook, Kim Sang-Hyeob and Sohn Jin-Hun (2015). Analysis of physiological signals for recognition of boredom, pain, and surprise emotions. *Journal of Physiological Anthropology*, 34, 25.
9. Maaoui Choubeila And Pruski Alain (2010). Emotion Recognition through Physiological Signals for Human Machine Communication. INTECH Open Access Publisher, France, 317-332. ISBN: 9533070625.
10. Eun-Hye Jang and Byoung-Jun Park (2013). Classification of Human Emotions from Physiological signals using Machine Learning Algorithms. The Sixth International Conference on Advances in Computer-Human Interactions. Nice, France. 24th February – 1st March., 395-400.
11. Sanei Saeid and Chambers J.A. (2007). EEG Signal Processing. John Wiley & Sons, 1-312, ISBN: 978-0-470-02581-9
12. Baby shalini T. and Vanitha L. (2013). Emotion Detection in Human Beings Using ECG Signals. *International Journal of Engineering Trends and Technology*, 4(5), 1337-1342.
13. Bradley M.M. and Lang P.J. (2008). International Affective Digitized Sounds (IADS). Stimuli, Instruction Manual and Affective Ratings. The Center for Research in Psychophysiology, University of Florida, Gainesville, FL, USA, 40, 784-790.
14. Bradley M.M. and Lang P.J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of Behavioral Therapy and Experimental Psychiatry*, 25(1), 49-59.
15. Mallat S.A. (1989). A Theory for Multi resolution Signal Decomposition The wavelet Representation. *IEEE Transactions on Pattern Analysis And Machine Intelligence*, 11(7), 674-693.
16. Chanel Guillaume, Kierkels Joep J.M., Soleymani Mohammad and Pun Thierry (2009). Short term Emotion assessment in a recall paradigm. *International Journal of Human- Computer Studies*, 67(8), 607-627.
17. Okamura Shuhei (2011). The Short Time Fourier Transform and Local Signals. Dissertations. A Study, Doctorate Thesis. Department of statistics Carnegie Mellon University Pittsburgh, Pennsylvanian. 1-58.
18. Wasserman P.D. (1993). Advanced methods in neural computing. New York: Van Nostrand Reinhold., 1-250. ISBN:0442004613.
19. Li C., Diao Y., Ma H. and Li Y. (2008). A Statistical PCA Method for Face Recognition. *Intelligent Information Technology Application*, 3, 376-380.
20. Wang Z. and Li X. (2010). Face Recognition Based on Improved PCA Reconstruction. Intelligent Control and Automation (WCICA), 8th World Congress on, Jinan, China, 7-9 July, 6272-6276.
21. Duda R.O., Hart P.E. and Stork D.G. (2010). Pattern classification. 2nd edition. New York, NY: Wiley-Interscience, 1-635, ISBN: 0471056693.
22. Zhao Zhiqiang and Zhang Huiquan (2015). The methodology of ECG feature extraction based on empirical mode decomposition. Biomedical Research Center, Chongqing University of Posts and Telecommunications,

- Chongqing, China. *Journal of Chemical and Pharmaceutical Research*, 7(3), 321-324.
23. Lang P.J., Bradley M.M. and Cuthbert B.N. (2005). International Affective Picture System (IAPS): Affective Ratings of Pictures and Instruction Manual. *Technical report A-8*. The Center for Research in Psychophysiology, University of Florida, Gainesville, FL, USA.
24. Chanel Guillaume, Kronegg Julien, Grandjean Didier and Pun Thierry (2006). Emotion assessment: Arousal evaluation using eegs and peripheral physiological signals. International Workshop, MRCS, Istanbul, Turkey. 11-13 September, 530-537.
25. Petrantonakis P.C. and Hadjileontiadis L.J. (2009). Emotion Recognition from Brain Signals Using Hybrid Adaptive Filtering and Higher Order Crossings Analysis. *IEEE Transactions on affective computing*, 1(2), 81-97.
26. Kumari Pinki and Vaish Abhishek (2015). Brainwave based user identification system: A pilot study in robotics environment. *Robotics and Autonomous Systems*, 65, 15-23.