Advances in Biomedical Sciences
2018; 3(1): 13-15
http://www.openscienceonline.com/journal/abs

Brief Review of Human Stress Detection Using the Processing of Physiological Signals

Luis Junqueira[1], Marta Cardoso Pina[2, *]

[1]Strategic Group of Technology, Research and Innovation (GETEPI), Sao Paulo, Brazil

[2]Federal Institute of Education, Science and Technology (IFSP), Sao Paulo, Brazil

Email address

profjunqueira@gmail.com (L. Junqueira), profmcpina@gmail.com (M. C. Pina)

[*]Corresponding author

To cite this article

Luis Junqueira, Marta Cardoso Pina. Brief Review of Human Stress Detection Using the Processing of Physiological Signals. *Advances in Biomedical Sciences.* Vol. 3, No. 1, 2018, pp. 13-15.

Received: September 24, 2017; **Accepted**: November 14, 2017; **Published**: January 26, 2018

Abstract

The identification of an alteration in biological signs related to presence of stress in the human organism can contribute to the awareness of individuals about their current status of stress, allowing them to take some preventive action against the worsening of their health conditions. This paper presents a brief review of the physiological variables generally used for stress detection and the most common methods and techniques used for analysis of the collected data by biofeedback devices.

Keywords

Stress Detection, Physiological Signals, Biofeedback Devices

1. Introduction

The use of computerized systems for acquiring biological signals has extended the possibilities for analysis of the collected physiological variables, in function of the increased storage and processing capacity of these systems and their ability to generate enhanced graphs from the recorded data.

Primarily, the development of biofeedback systems was due to the evolution of new computer systems and creation of new circuits for digital signal processing. Since then, biofeedback has increased its use in various fields, from those concerned to behavioral psychology and psychotherapy, as the traditional branch of the technique, to certain areas of medicine related to clinical intervention in cases of abuse and dependence on alcohol and drugs, memory disorders, high blood pressure, asthma attacks, hyperventilation, and others psychosomatic disorders originated from stress and anxiety [1].

A biofeedback device can be something as simple as a thermometer using a sensor in contact with the point where one wants to measure the temperature, usually the finger of one hand, and a display to show the measured grade [2]. The individual observing the change of temperature on the display becomes aware of which situation lets him stressed and which situation he stays relaxed. Once he knows which are the conditions causing stress, the individual may use some method of intervention to eliminate or reduce the stress when faced with such circumstances again [3].

Examples of specific application of biofeedback technique in both stress prevention and stress management can be found in several studies. For instance, there is a study that conducted a controlled and randomized clinical trial on the effectiveness of a stress management tool for medical professionals [2], a study that conducted a controlled and randomized clinical trial on interventions in situations of stress and anxiety for nursing students [4], and a case report of stress management in menopausal women [3].

2. Biological Data Acquisition

Besides the Skin Temperature (ST), other physiological variables generally used for biological data acquisition with biofeedback technique are the Blood Pressure (BP), the Galvanic Skin Response (GSR), the Respiration Rate (RESP), the Electromyography signs (EMG), the Electrocardiography signs (ECG) and the Heart Rate Variability (HRV) [5].

When biofeedback signals are related to the brain, the technique is known as Neurofeedback. In this case, the Electro encephalography signs (EEG) or the Hemoencephalography signs (HEG) are used to represent the brain activity and to train the individual in the self-regulation of his or her desired state of relaxation [6].

3. Signal Characteristics in Presence of Stress

The physiological signs have certain characteristics when the stress is present in human organisms. Thus, a measured temperature reflects the degree of relaxation or stress that the individual has, depending on the higher or lowers peripheral blood circulation. This characteristic is manifested by the activity of the autonomic nervous system (ANS) reflecting the state of his internal homeostasis. The stressed individuals tend to have a reduced skin temperature while the relaxed individuals tend to have their temperature increased, both of them when compared to the observed temperature of the individuals in a normal state [7].

The physiological principle associated with changes in the galvanic skin response values, as a function of stress, is similar to the behavior of the temperature. In an individual stressed the activity of sweat glands increases, resulting in increased skin moisture due to sweat in your hands. This sweat decreases the resistance to the passage of electric current, increasing the conductivity of the skin. The ANS is responsible for modulating the activity of the sweat glands, and its response is directly influenced by the action of stressors. Therefore, the higher the stress level, the lower the skin resistance.

Besides that, the ANS has the sympathetic and parasympathetic branches, and both influence on heart rate. The stimuli that occur in certain brain regions are responsible for the abnormal heart rhythm. When individuals are submitted to a stressor, they can have their heartbeat accelerated and the return to its normal values may depend on the removal of the stressor and even a period of time for subsequent recovery. Thus, stress can affect the normal rate of heart rate variability, causing a negative influence. Studies indicate that imbalances in the variability of indicators of heart rate, particularly with the reduction of this variability, may be related to the risk of cardiovascular mortality [8] and morbidity [9]. In this way, the stress factor contributes directly to the decrease of the heart rate variability.

4. Signal Processing

After the acquisition of the biological signals, the stress detection systems can adopt a variety of mathematical techniques to perform the analysis and interpretation of the signals and measurements that were made. Among the various possibilities, the following techniques have been most frequently cited: *Decision Trees*, *Bayesian Classification*, *Support Vector Machines*, *Hidden Markov Chains*, *k-Nearest Neighbor Classifier*, *Artificial Neural Networks* and the *Fuzzy Logic* [10]. The accuracy of those techniques varied from 76 to 90% [5], [10].

An example of such work can be found in [11], who described a study involving the collection of ECG, GSR, RESP and ST signals with the information extraction and the construction of the computational model based on the *Support Vector Machine*s. In [12] they used the *Hidden Markov Chains* technique to develop two models for continuous prediction of stress through physiological measures of ECG, ST and RESP. In [13] they developed a system for biomonitoring of stress with algorithms for the analysis of the ECG signal. In [14] they chose the *k-Nearest Neighbor Classifier* to classify the stress characteristics of EEG signals. In [15] they created a stress monitoring system based on signs of HRV and *Fuzzy Logic*. In [16] they conducted a study on stress detection based on signs of HRV with application of *Artificial Neural Network*. And in [17] they used the signs of GSR and ECG in a system for automatic stress detection based on subject dependent biosignal features.

Also, there is a promising work running in Brazil which adopted the evaluation of HRV measures together with the results of a psychological questionnaire to assess the stress level of patients in a Hospital [18].

The table 1 presents the main techniques and physiological variables used in some of the stress studies cited in this paper, with respective accuracy of each one.

Table 1. *Main techniques and physiological variables used in stress studies.*

Techniques	Physiological variables	Accuracy %
Fuzzy Logic	GSR, EMG, ECG, RESP	76.7
Bayesian Classifier	GSR, HRV, ST,	78.6
Support Vector Machine	GSR, EMG, ECG, RESP	79.3
Artificial Neural Network	EEG, GSR, BVP, RESP	82.6
Decision Tree	GSR, HRV, ST	88.0

5. Conclusion

There are a variety of biological signs and mathematical techniques that could be used for statistical analysis and for project modeling of stress detection systems. A fact noted is that even the sensors and the devices for the acquisition of signals vary in each study, without any standardization or consensus on the choice of the means and the devices to capture any of the various biological signals used. In addition, there is not standardization of the reference values for the variables evaluated or of the methods used to assess stress, hindering the adoption of this approach broadly by the medical community and the public health system. However, the technical study of stress detection by physiological signs may bring a great help in a more accurate assessment, thus contributing to a faster diagnosis of stress condition in the individuals, if compared only with the use of subjective methods of stress assessment, mainly based on the interview of the individuals and their reported symptoms. A particular approach, the HRV analysis, has been increased in its use for detection stress systems in recent studies, and represents a good promise for more reliable and affordable results.

Acknowledgements

This article is a cooperative effort under the sponsorship of the Strategic Group of Technology, Research and Innovation (GETEPI), Sao Paulo, Brazil. The authors would like to thank for the staff assistance and their institutional support during this work.

References

[1] O. JAFAROVA, M. SHTARK (1998). Computer Biofeedback: Trends of Development. In: *The 4th IEEE APEIE International Conference Proceedings*, pp. 162-164.

[2] J. LEMAIRE et al. (2011). The Effect of a Biofeedback-based Stress Management Tool on Physician Stress: A Randomized Controlled Clinical Trial. *Open Medicine*, 5(4), pp. 154-163.

[3] C. DUNSTER (2012). Treatment of Anxiety and Stress with Biofeedback. *Global Advances in Health and Medicine*, 1(4), pp. 76-83.

[4] P. RATANASIRIPONG et al. (2012). Biofeedback Intervention for Stress and Anxiety among Nursing Students: A Randomized Controlled Trial. *International Scholarly Research Network ISRN Nursing*, pp. 1-5.

[5] J. ZHAI, A. BARRETO (2006). Stress Recognition Using Non-invasive Technology. In: *Proceedings of the 19th International Florida Artificial Intelligence Research Society Conference*, pp. 395-400.

[6] C. YUCHA, C. GILBERT (2004). *Evidence-Based Practice in Biofeedback and Neurofeedback*. AAPB, Colorado Springs.

[7] S. REISMAN (1997). Measurement of Physiological Stress. In: *Proceedings of the IEEE 23rd Northeast Bioengineering Conference*, pp. 21-23.

[8] M. ROVERE et al. (2003). Heart Failure Patients Short-Term Heart Rate Variability Strongly Predicts Sudden Cardiac Death in Chronic. Circulation, Journal of The American Heart Association, 107, pp. 565-570.

[9] J. THAYER et al. (2010). The Relationship of Autonomic Imbalance, Heart Rate Variability and Cardiovascular Disease Risk Factors. *International Journal of Cardiology*, 141, pp. 122-131.

[10] N. SHARMA, T. GEDEON (2012). Objective Measures, Sensors and Computational Techniques for Stress Recognition and Classification. *Computer Methods and Programs in Biomedicine*, 108, pp. 1287-1301.

[11] Y. SHI et al. (2010). Personalized Stress Detection from Physiological Measurements. In: *Proceedings of the 2nd International Symposium on Quality of Life Technology*, Las Vegas, pp. 1-5.

[12] K. PLARRE et al. (2011). Continuous Inference of Psychological Stress from Sensory Measurements Collected in the Natural Environment. In: *The 10th Int. Conference on Information Processing in Sensor Networks*, pp. 97-108.

[13] N. CARBONARO et al. (2011). Wearable Biomonitoring System for Stress Management: A Preliminary Study on Robust ECG Signal Processing. In: *IEEE Int. Symposium on a World of Wireless, Mobile and Multimedia Networks*, pp. 1-6.

[14] N. SULAIMAN et al. (2011). EEG-based Stress Features Using Spectral Centroids Technique and k-Nearest Neighbor Classifier. In: *13th International Conference on Computer Modelling and Simulation*, pp. 69-74.

[15] M. KUMAR et al. (2012). Stress Monitoring Based on Stochastic Fuzzy Analysis of Heartbeat Intervals. *IEEE Transactions on Fuzzy Systems*, 20(4), pp. 746-759.

[16] P. KARTHIKEYAN et al. (2013). Detection of Human Stress using Short-Term ECG and HRV Signals. Journal of Mechanics in Medicine and Biology, 13(3), pp. 1-29.

[17] D. GIAKOUMIS et al. (2013). Subject-dependent Biosignal Features for Increased Accuracy in Psychological Stress Detection. International Journal of. Human-Computer Studies, 71, pp. 425-439.

[18] GLOBO (2014). Levantamento mostra que estresse atinge mais as mulheres. Available: http://g1.globo.com/jornal-hoje/videos/t/edicoes/v/levantamento-mostra-que-estresse-atinge-mais-as-mulheres/3245177.