GSJ: Volume 8, Issue 1, January 2020
ISSN 2320-9186

Physiological Computing | The What and How

Syed Atir Raza

SST Department

University of management and technology, Lahore Pakistan.

MS-IT

F2019108005@umt.edu.pk

Abstract:

Advancing world requires computer systems that are operated beyond hand-based or touch-based controls. The emerging technology that addresses this need of world is termed as "**Physiological Computing**" which sense, biocybernetic loop, bioelectrical,biomechanical, biophysical or biochemical signals from the human nervous system and decodes them into computer understandable instructions which are then processed by a computer machine and are executed to perform certain tasks. Physiological computing is now being used in medical sciences wildly. Here is the discussion about what is physiological computing? How it works? Where it is being used and it can be used.

Keywords

Physiological Computing, Categories of Physiological computing, BCI, Future directions.

Introduction

Computer Systems are now being used in almost every field of life due to advancements in the technology and ease of use. Due to the vast use of computers in every field of life, the user needs such systems which they can operate easily, effectively and timely when they need without any intervention of hard rules and regulations. With the advancements in the technology, people want to interact with the computer beyond "hand-based control" or "finger-based control". Now a time has come where everyone wants to operate a system without much physical interaction. The user needs such systems which they can easily control by their emotions, feelings or thoughts. They want something that they think, and it happens. The modern technology named this emerging field as "Physiological computing" which involves interaction with computer via human nervous system.

Physiological Computing | The What

"It may be any technological system that takes physiological data from human nervous system as input to control itself" (Physiological computing, 2018)

This technology comprises of such input devices that takes input, or it can be said that sense input from physical states of a person. These inputs can be in form of bioelectrical, biomechanical, biochemical or biophysical signal coming from human nervous system (HUGO PLACIDO DA SILVA, 2015). These inputs are taken by specialized sensors input devices, image capturing devices or scanning devices After taking inputs from these sensors, the physical data and/or instructions collected is then filtered and decoded using appropriate methods and finally are processed to get the desired output results (Jacucci, 2015). Different techniques and technologies are being used for this purpose. There are different categories of Physiological Computing. Each works on different principals. Some takes sensory inputs from states of mind, some involves inputs from physical interface, some takes inputs from muscles interfaces and others involves electrophysiological changes from the human nervous system.

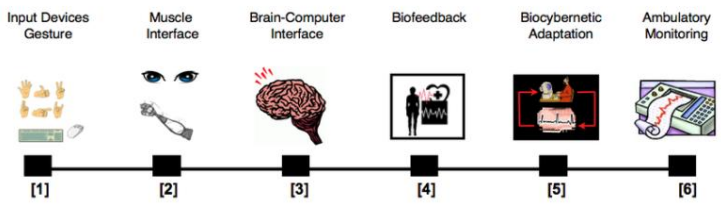

Figure 1: Categories of Physiological Computing(Badawi & El Saddik, 2020) (Physiological computing, 2018)

Biocybernetic loop plays an important in physiological computing which is the underlying mechanic behind physiological interactive systems which explains that how to collect a physiological information from a user, in which Passive Brain-Computer interfaces (pBCIs) are the important and helpful human-computer communication tool where the computer can detect from neuro physiological signals the current mental or emotional state of the user. The system can then adjust itself to guide the user toward a desired state. With pBCIs, the user's state is communicated to the computer without any conscious effort from the user and the system takes that into account to adapt itself to ultimately lead the user to an optimal state.(L. LeMoyne et al., 2018).

Physiological Computing | The How

In the past few years, great work has been done in the field of Physiological Computing. Such kinds of systems are becoming very popular especially in biomedical sciences.

Following work has been done in this field:

Biometric verification system introduced in medical science in a new way that to verifying a person identity using a medical device, medical diagnostic or therapeutic procedure, can be done easily particularly at home or at a remote location.(Kayyali, 2019)

Invention of remote sleep and signal analysis with biometric identification. The present invention is further related to the devices and sensors used in executing the method, and includes various embodiments of a method of inpatient and remote sleep analysis.(Kayyali, 2019)

Interaction between virtual reality (VR) and children with autism spectrum disorder (ASD) using physiological sensing of affective cues to investigate and to overcome the problem of autism spectrum disorder in children. Development of VR-based social communication system and then combine them into a physiological acquisition module to enabale and make it possible to capture the physiological responses in a timely synchronized way by the child who is suffering from (ASD) and then to find out the result of each response and to sort out that how to overcome or which changes should need to overcome the situation.(Welch, Lahiri, Warren, & Sarkar, 2019)

Designing Neuro Adaptive Technologies (NAT) which made enough easy now a days to estimate one's mental state using brain signals to understand that how a user will interact with the system , and then adapt that interaction as per the designed system.(Muñoz, Stephens, Velez, & Pope, 2019)

Identification of any person based on the shapes or appearances of his/her body parts or of using finger printing technology. .(Kayyali, 2019)

Brain computer interface systems introduced which are now a days very common in treatment of cognitive rehabilitation and neuroplasticity which are increasing in people now a days with dementia. New way of treatment introduced for the patients who are suffering from short tem memory, attention related cases are now a days being treated using physiological computing technologies.(da Silva-Sauer, L.,2019)

Design of block-based programming environment to create BCI based applications which make it easy to implement the physiological computing on BCI based hardware, which is also helpful in developing neurofeedback applications using various machine learning techniques to which helped alot in neuroscience.(Crawford, Chris S, G.,2019) (Muñoz et al., 2019)

CATEGORIES OF PHYSIOLOGICAL COMPUTING

There are five categories of physiological computing (Physiological computing, 2018)

i. Muscle Interaction (biophysical)

ii. Brain-Computer Interaction (BCI)

iii. Biofeedback

iv. Biocybernetic Adaptation (Machine Learning based intelligent systems)

v. Ambulatory Monitoring (Applications in Medical)

1 Muscle Interaction:

A computer-based system proposed for monitoring the heart muscle function of a patient, with contextual oversight, includes a sensor array for collecting physiological and environmental data that are pertinent to the patient.(DiPerna & Rose Jr, 2019). A context register is also included in the process which contains periodically updated patient specific data that establishes a relevant contextual oversight capability for the system to identify that where the problem is or where is the point that causing problem (Mannella et al., 2019). During operation, a computer identifies anomalies in the physical data i.e body and detects aberrations in the environmental data and then pass the feedback to the system. These anomalies and aberrations are then interactively evaluated together, to

get the result and helped a lot to find the actual reason of the disease and other problems in a human body to find out the solution, to determine whether clinical intervention for the patient is warranted and suggests that which treatment will good enough.(DiPerna & Rose Jr, 2019)

2 Brain Computer Interaction(BCI)

It is found that some diseases such as neurodegenerative diseases which directly attacks on peripheral and central motor system of the human and causes various further diseases in which a common disease is paralysis attack, in which a person is unable to move the body or sometimes unable to communicate with anyone, but it is found that in such condition the brain functions remains intact (Birbaumer & Rana, 2019). Patients just lose voluntary control over their bodies. To improve the lifestyle for such patients Brain computer interactions systems proposed (Mannella et al., 2019). BCIs translate brain activity into a command for an external device in order to perform a particular function for example, to control a prosthetic or to speak. BCI includes an electroencephalogram that records the alpha rhythm (13–15 Hz) over the motor cortex in stroke patients and gives a command to an artificial support that can help mobilize a paralyzed arm. Other BCIs are used to train participants to amplify or reduce certain brain activities in a process called neuro feedback (Birbaumer & Rana, 2019). BCIs were also introduced to overcome the situations which occur because of amyotrophic lateral sclerosis (ALS) (Birbaumer & Rana, 2019). Patients who have remaining control of their eyes can communicate and transfer their meanings , feelings and emotions using the special BCI devices that track their eye movements and select letters or commands on a computer screen(Caria et al., 2019).

3 Bio-Feedback

This category of physiological computing defines paradigm where electrophysiological changes from the human nervous system are used to interface with a computer system in real time (Fairclough, 2011). Home heart system proposed which purpose was to propose a system which monitors stress-related cardiovascular changes and triggers a biofeedback exercise as a stress countermeasure and which is a very useful proved stress released technique (DiPerna & Rose Jr, 2019). The concept of biofeedback is fundamental to all categories of physiological computing as users may use these systems to promote increased self-regulation with respect to input devices, can be used for emotional control and stress management (Caria et al., 2019), (Fairclough, 2011). Many bio-feedback-based health care systems propose in few past years which are very helpful now a days in the treatment of drugs, stress, and emotional controls, using these systems medical science is enough able now a days to understand the patient mental condition that what is the present condition of the person and what treatment will be suitable for the person biofeedback based health care systems revolutionized the medical science (Badawi & El Saddik, 2020), (Caria et al., 2019),(Fairclough, 2011). Cardiac biofeedback system proposed due to which medical science is enough able to investigate congruency of cardiac signals across two hierarchical levels: (i) the low-level congruency between a visual feedback and participant's own cardiac signal (ii) the high-level congruency between the participants' beliefs about the identity of the cardiac feedback and its true identity which is very helpful in stress management and heart diseases treatment (Hodossy & Tsakiris, 2020), (DiPerna & Rose Jr, 2019).

4 Biocybernetic Adaption

Development of machine learning based intelligent systems that are enough capable to understand the human mental condition and then suggest the treatment and drugs(medicine) for the patient as per the situation (L. LeMoyne et al., 2018). To overcome various cardiac and cerebral palsy diseases, system proposed which is enough able to capture the problem at initial stage, due to which it is easy to evaluate stress, mental fatigue, attentional engagement states, EEG system proposed to investigates the haptic control strategies which is good enough to overcome various mental problems with the help of some computational techniques and using machine learning algorithms, using BrainEx tool for exploration of brain data for neuroadaptive technology and detect mind wandering states to evaluate that ho much a person can bear stress (Muñoz et al., 2019). development of an artifact consisting on a physiological computing system for mental health only using mobile virtual reality (VR) and wearable devices which is useful in improving mental health (Quintero, 2019).

5 Ambulatory Monitoring

Using some computational, machine learning and artificial intelligence techniques an electrocardiography patch provided to measure the physiological data of different body parts of the human body using crypto circuits which helps a lot a doctor to understand the actual condition

and state of the body, to understand the problem and then as per the problem suggest the treatment and medicine for the patient (Felix, Bardy, Bishay, & Green, 2019). IOT based systems proposed for epilepsy monitoring and detection, to understand the various heart related, cardiovascular, malignancy illness, and in the treatment of seizures in which a patient may lose his/her memory(Nirmal Raj, Prabu, & Rohindh Kumar, 2019). Various activity monitoring systems proposed to monitor a baby during pregnancy to overcome the factors i.e. pre mature birth, to eliminate health risks associated with pregnancy(Howell, Hadiwidjaja, Thomas, & Tong, 2019b)(Howell, Hadiwidjaja, Thomas, & Tong, 2019a). To overcome postpartum depression states using some neuroadaptive and machine learning algorithms(Moreira, Rodrigues, Kumar, Saleem, & Illin, 2019).

Future Directions

In future, such progressing technology can be used for many useful purposes as like purely Brain-Controlled Intelligent Systems. There would be some technology that user only needs to think, and computer will sense the signals from brain and perform actions accordingly. This can only be done by connecting Physiological Computing Paradigm with Machine Learning Algorithms.

Human Physiology can be directly monitored and used as input to a technological system which will can also be helpful in curing and detecting various diseases before start of such disease or to control the disease at initial stage with the help of Machine Learning algorithms and artificial intelligence.

A system that can capture human digital memories and can be helpful in recalling memory can be produced using such progressing technologies.

Using such technology, medical science can be control on a human mind and can use to understand that what a human being is thinking or what the person actually want, which will be helpful in understanding the mental condition of the person and for the treatment of Psychomotor agitation, conduct disorder. But such kind of technology can also be dangerous as one can easily use them to take control on other mind and can be used it for any illegal purpose, such as brain washing etc as everything has both positive and negative side.

In near future, sensor input will be more reliable and accurate than before. Many researches are being done for this purpose and many new ways are being discovered that will improve sensing devices.

Applications of physiological computing can also be enhanced. It could be used by people for daily routine tasks. Based upon emotion predicted by a physiological computing system can be used.

Conclusion

Physiological computing is an emerging field in computer sciences. It is on its way to enhance user's experience of using computer technology by providing effective interfaces to the users for controlling the systems. The technology is making progress day by day and is helpful in treatment of various diseases specially depression and other physiological problems. one can use this technology to overcome on his/her emotions and can be used to control ones mind and can be useful in all fields. But , each positive thing has a negative side, it is concluded that using such technologies include usage of different other technologies which may lead toward the cancer, kidney failure as various rays are using in different ways which may include gamma rays and can cause cancer. However, overall this technology is very useful and helpful, but there is a need to take some precautionary measures to avoid other diseases which may cause because excessive usage of such advancing technologies.

REFERENCES

(2018, April). Retrieved from Physiological Computing: http://physiologicalcomputing.org/sample-page/

HUGO PLACIDO DA SILVA, S. F. (2015). Introduction to the Special Issue on Physiological Computing for Human-Computer Interaction. ACM Transactions on Computer-Human Interaction.

Jacucci, G. (2015). Physiological Computing. IEEE Computer Society, 12-16.

Badawi, H. F., & El Saddik, A. (2020). Biofeedback in Healthcare: State of the Art and Meta Review. In A. El Saddik, M. S. Hossain, & B. Kantarci (Eds.), *Connected Health in Smart Cities* (pp. 113–142). https://doi.org/10.1007/978-3-030-27844-1_6

Birbaumer, N., & Rana, A. (2019). Brain–computer interfaces for communication in paralysis. In *Casting Light on the Dark Side of Brain Imaging* (pp. 25–29). Elsevier.

Caria, A., da Rocha, J. L. D., Gallitto, G., Birbaumer, N.,

Sitaram, R., & Murguialday, A. R. (2019). Brain–Machine Interface Induced Morpho-Functional Remodeling of the Neural Motor System in Severe Chronic Stroke. *Neurotherapeutics*, 1–16.

DiPerna, P. M., & Rose Jr, F. H. (2019, January 31). *Computer-based systems and methods for monitoring the heart muscle of a patient with contextual oversight*. Google Patents.

Fairclough, S. H. (2011). Physiological Computing: Interfacing with the Human Nervous System. In J. Westerink, M. Krans, & M. Ouwerkerk (Eds.), *Sensing Emotions: The impact of context on experience measurements* (pp. 1–20). https://doi.org/10.1007/978-90-481-3258-4_1

Felix, J., Bardy, G. H., Bishay, J. M., & Green, J. D. (2019, April 11). *Extended Wear Ambulatory Electrocardiography And Physiological Sensor Monitor*. Google Patents.

Hodossy, L., & Tsakiris, M. (2020). Wearing your heart on your screen: Investigating congruency-effects in autonomic responses and their role in interoceptive processing during biofeedback. *Cognition*, *194*, 104053.

Howell, T. A., Hadiwidjaja, A., Thomas, C. D., & Tong, P. P. (2019a, January 15). *Activity monitoring system for pregnant women*. Google Patents.

Howell, T. A., Hadiwidjaja, A., Thomas, C. D., & Tong, P. P. (2019b, May 16). *Personal activity monitoring system*. Google Patents.

Kayyali, H. (2019, September 17). *Medical device and method with improved biometric verification*. Google Patents.

L. LeMoyne, E., Courtemanche, F., Louis, V., Fredette, M., Senecal, S., & Léger, P.-M. (2018). Dynamic Threshold Selection for a Biocybernetic Loop in an Adaptive Video Game Context. *Frontiers in Human Neuroscience*, *12*. https://doi.org/10.3389/fnhum.2018.00282

Mannella, C. A., Liu, Z., Hsieh, C., Afzal, N., Adams, R. A., Jafri, M. S., & Lederer, W. J. (2019). How the Nanoarchitecture of Cardiac Muscle Mitochondria Affects Function: Lessons from Computer Simulations. *Biophysical Journal*, *116*(3), 155a.

Moreira, M. W. L., Rodrigues, J. J. P. C., Kumar, N., Saleem, K., & Illin, I. V. (2019). Postpartum depression prediction through pregnancy data analysis for emotion-aware smart systems. *Information Fusion*, *47*, 23–31.

Muñoz, J. E., Stephens, C. L., Velez, L. E., & Pope, A. T. (2019). MODELING BIOCYBERNETIC ADAPTATION THROUGH FEEDBACK CONTROL SYSTEMS PRINCIPLES: IMPLICATIONS IN HUMAN-COMPUTER INTERACTION AND VIRTUAL REALITY APPLICATIONS. *The Second Neuroadaptive Technology Conference*, 39.

Nirmal Raj, M., Prabu, V., & Rohindh Kumar, M. (2019). *IOT BASED EPILEPSY MONITORING AND DETECTION USING AMBULATORY SYSTEM*.

Quintero, L. (2019). *Facilitating Technology-based Mental Health Interventions with Mobile Virtual Reality and Wearable Smartwatches*. Department of Computer and Systems Sciences, Stockholm University.

Welch, K. C., Lahiri, U., Warren, Z. E., & Sarkar, N. (2019). A system to measure physiological response during social interaction in VR for children with ASD. In *Computational Models for Biomedical Reasoning and Problem Solving* (pp. 1–33). IGI Global.

da Silva-Sauer, L., Torre-Luque, A. d. l., Silva, J. S. C., & Fernández-Calvo, B. (2019). New perspectives for cognitive rehabilitation: Could brain-computer interface systems benefit people with dementia? *Psychology & Neuroscience*, *12*(1), 25–37. https://doi.org/10.1037/pne0000154

Crawford, Chris S. and Gilbert, Juan E., Brains and Blocks: Introducing Novice Programmers to Brain-Computer Interface Application Development,ACM Trans. Comput. Educ, November 2019, 39. http://doi.acm.org/10.1145/3335815