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Implementation of Brain Computer Interface for Stress Management

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***Abstract*— This paper presents a stress identification system implementation, which contains an EEG Headset, a non-invasive type of brain – to – machine interfacing on which the brainwave patterns such as attention, meditation, and eye blink is acquired directly on the person's scalp. Electroencephalography (EEG) is also being examined at the time of detection where the Gamma, Beta, Alpha, Theta, and Delta brain waves are considered. The system implementation consists of two main functional modules: stress detection unit and stress visualization unit. The stress detection unit based on the analysis of EEG waves using Neurosky Mindwave EEG headset. The captured waves are then transferred to the stress visualization unit where it displays the signals in the form of a virtual fish tank, programmed to change the swimming position of a fish according to the stress levels. The development of this type of system is not only convenient but also it is portable and affordable.**

Keywords*— Brain Computer Interaction, stress, EEG

I. INTRODUCTION

Stress has turned into a key source among populace which has made various negative effects on the society and of overall associations, and they are relied upon to end up a noteworthy wellbeing peril in the prospective decades. Nearly everybody is presented to an extensive variety of stress in both individual and work life. Some person's adapt exceptionally well to these weight, then again, some person's think that it's hard to deal with the circumstance and that is when people fall into the "stress". As indicated by International Labor Organization, idiocies caused by stress cost up to 10 percent of a nation's Gross National Production. At an individual level, word related pressure causes an adverse effect on both work life and individual life influencing the quality and prosperity. These disarranges affect the financial and social condition of the individual and society. There are many traditional and modern stress management techniques applied in order to manage stress levels. Considering the current healthcare industry and social scale there is a huge trend towards ICT supported stress management techniques. ICT Supported health intervention can be considered as a phenomenon that has grown stronger in recent years. Many web and mobile-based health communities/applications has contributed to a shift: from formal healthcare providers being the one and only source of support for most patients to a situation in which patients take an active role in each other's struggle for health and recovery. Also, for people with different lifestyle issues, the health communities have become widely used for advice and support. Through the interaction with others, patients and other people with health concerns can get help to access relevant resources, develop their ability to make personal decisions and exercise critical thinking. They get support to develop skills and abilities along with a more positive self-image. This is also referred to as 'patient empowerment.' Thus, this research work also contribute to expand the horizons of ICT supported stress management interventions through brain computer interfacing approach.

II. THEORETICAL BACKGROUND

A. Brain Computer Interface (BCI)

BCI is also known as Mind Machine Interface because it is a direct communication pathway between the brain and an external device. As the power of modern computers improves understanding of our human brain. This brings closer to making some fascinating science fiction into reality. BCI could be the most important technological breakthrough in decades. BCIs are directed at assisting, augmenting or repairing human cognitive or sensory motor functions. One of the reasons that BCI works well is the way of brain usually functions. Our brain is filled with neurons, each nerve cell us connected to one another by dendrites and neurons. Every time we think, move, remember or feel something our neurons are carrying electrical signals from one to another. The simpler and less invasive method is to attach a device known as EEG to the scalp. The electrodes have the ability to read brain signals. The electrodes measure differences in voltage between neurons and the signal is then amplified and filtered. It will also be interpreted by a computer program at the end. The field of BCI research and development has primarily focused on neuro prosthetics applications that aim at restoring damaged hearing, sight and movement. Thanks to the remarkable cortical plasticity of the brain, signals from implanted prostheses can, after adaptation, be handled by the brain like natural sensor or effector channels.

B. Eelectroencephalogram (EEG)

EEG is a test used to evaluate the electrical activity in the brain by measuring brain's voltage fluctuations as detected from scalp[1]. Brain cells communicate with each other through electrical impulses. An EEG can be used to help detect potential problems associated with this activity. It is generally is an approximation of the cumulative electrical activity of neurons. An EEG tracks and records brain wave patterns. Small flat metal discs called electrodes are attached to the scalp with wires[1]. The electrodes analyze the electrical impulses in the brain and send signals to a computer that records the results. EEG is known as the most studied non- invasive interface due to its fine temporal resolution, ease of use, portability and low testing or set us costs. The electrical impulses in an EEG recording look like

wavy lines with peaks and valleys which allow doctors or specialists to quickly assess whether there are abnormal patterns. According to the BCI used that is used to analyze results, people are required to be trained appropriate to use BCI who can work the technology.

C. Brin waves

Basically all over the time in our waking state, our EEG will display five types of brain waves at the same time[1]. However one particular brain wave will be dominant dependent on the state of awareness that we are in. As an example if we are awake, but have really bad Attention deficit hyperactivity disorder (ADHD), we may have slower wave activity of alpha and theta than beta waves. While sleeping frequently there are combinations of the rapid eye movement (REM) [6].

Gamma Waves: In a complex processing tasks as well as a cognitive functioning these can be involved [6]. These waves are very important for the learning, processing of the information and memory. It is known that the 40 Hz gamma wave is very important for the binding of our senses with regard to perception and concerned in learning new materials. It has been found that people who are individually mentally challenged and have learning disabilities tend to possess lower gamma activity than average.

Beta waves: These waves can be defined as high frequency low amplitude brain waves [6]. These are usually observed while we are awake. They are concerned in aware thought, logical thinking and tend to have a stimulating affect. To complete work based tasks, projects easily, right amount of the beta waves helps much more. Having an excessive amount of beta could result in US experiencing excessive stress or anxiety. The higher beta frequencies square measure related to high levels of arousal. When someone take caffeine or some other stimulant, their beta activity can be naturally increased. Think of these as being in no time brain waves that the majority individuals exhibit throughout the day so as to complete aware tasks such as: important thinking, writing, reading, and socialization.

Alpha Waves: This frequency range avoid the gap between human's conscious thinking and sub conscious mind [6]. In other words, alpha is in the middle frequency range in the beta and theta. It will be helped to humans to be calm down when necessary and promotes feelings of deep relaxations. If human become stressed, a phenomenon called "alpha blocking" may occur. Which involves deep beta activity and very little of alpha. Basically the beta waves "block" the production of alpha, because human become too aroused.

Theta waves: This frequency range is mostly involved in sleep and daydreaming [6]. When feeling deep and raw emotions this waves are connected to us. People prone to bouts of depression, too much theta activities. The main benefits of the theta frequencies are, improve human's creativity, institution and make them feel more natural. It is also direct people to restorative sleep. In our working hours theta isn't produced excess. So it can be defined very helpful brain wave range.

Delta waves: This is slowest brain frequency in human beings. These are mostly in the babies and young children [6]. In this age human are tendency to make less delta during the sleep. They are related with deepest level of restorative and relaxation, medicinal sleep. They have additionally been found to be concerned in unconscious bodily functions like control heart beat and digestion. Adequate production of delta waves helps humans to feel fully rejuvenated once humans tend to awaken from good night's sleep. If there's unnatural delta activity, a personal could expertise learning disabilities or have difficulties maintaining aware awareness such as brain damages.

TABLE1: BRAIN WAVE FREQUENCIES AND MENTAL CONDITIONS

Brainwave Type	Frequency range	Mental state and condition
Delta	0.1 Hz to 3 Hz	Deep, dreamless sleep, unconscious
Theta	4 Hz to 7 Hz	Creative, recall, dream, Fantasy, Imaginary
Alpha	8 Hz to 12 Hz	Relaxed, conscious
Low Beta	12 Hz to 15 Hz	Formerly SMR, relax yet
Midrange Beta	16 Hz to 20 Hz	Linking aware of self
High beta	21 Hz to 20 Hz	Alertness, agitation

D. Neurosky Mindwave EEG headset

The brainwaves can be observed with an EEG (electroencephalograph) headset. This allows researchers to identify brainwaves patterns. During this project researcher used Neurosky Mindwave (MW003) headset as EEG headset. In Neurosky EEG headset product, basically there have two types of headset called MindWave (MW001) and MindWave mobile (MW003). Both headsets compatible with developer tools properly. But MindWave (MW001) headset is communicate via RF (Radio Frequency) and MindWave mobile (MW003) communicate via Bluetooth. When considering EEG headset, Neurosky Mindwave (MW003) EEG headset easy to calibrate and communicate.

E. eSense

eSense™ is a NeuroSky's proprietary algorithm for characterizing mental states. To calculate eSense, the NeuroSky thinkGear technology amplifies the raw brainwave signal and removes the ambient noise and muscle movement. the eSense algorithm is then applied to the remaining signal, resulting in the interpreted eSense meter values. The eSense meters are a way to show how effectively the user is engaging Attention (similar to concentration) or Meditation (similar to relaxation). For each different type of eSense (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. On this scale, a value between 40 to 60 range is considered "neutral" and is similar in notion to "baselines" that are established in conventional brainwave measurement techniques.

ATTENTION eSense: the eSense Attention meter indicates the intensity of a user's level of mental "focus" or "attention", such as that which occurs during intense concentration and directed (but stable) mental activity. Its value ranges from 0 to 100. Distractions, wandering thoughts, lack of focus, or anxiety may lower the Attention meter level[2].

MEDITATION eSense: the eSense Meditation meter indicates the level of a user's mental "calmness" or "relaxation". Its value ranges from 0 to 100. Note that Meditation is a measure of a person's mental states, not physical levels, so simply relaxing all the muscles of the body may not immediately result in a heightened Meditation level. However, for most people in most normal circumstances, relaxing the body often helps the mind to relax as well. Meditation is related to reduced activity by the active mental processes in the brain [2].

F. ThinkGear Packets

ThinkGear components deliver their digital data as an asynchronous serial stream of bytes [3]. The serial stream must be parsed and interpreted as thinkGear Packets in order to properly extract and interpret the thinkGear Data Values. Each Packet begins with its Header, followed by its Data Payload, and ends with the Payload's Checksum Byte.

III. METHODOLOGY

The system implementation consists of two main functional modules: stress detection unit and stress visualization unit. The stress detection unit based on the analysis of EEG waves using Neurosky Mindwave EEG headset [4]. The captured waves are then transferred to the stress visualization unit where it displays the signals in the form of a virtual fish tank, programmed to change the swimming position of a fish according to the stress levels.

A. Data capturing Unit

This is the main window of bio feedback desktop application. Basically this form consists with main functionality of the system. These are as follows,

- Connect headset: Connect Neurosky EEG headset with desktop application.
- Disconnect headset: Disconnect Neurosky EEG headset from desktop application.
- Record EEG returns values: Use to record EEG headset returns values to the text file. When accessing EEG headset for the particular user. Application provide functionality to record their alpha, beta, gamma, meditation and attention values.
- Stop record EEG: helps users to stop recording, while there recording EEG values.
- Enable Blink: Enable blink detection using EEG headset.
- Disable Blink: This function helps to disable blink detection using EEG headset.
- Select Com port: User can assign particular port to connect headset, by default it is setup to the COM port 4.
- Select Baud rate: User can assign particular baud rate when the connect headset with desktop, by default it is setup to the 56000 baud rate.

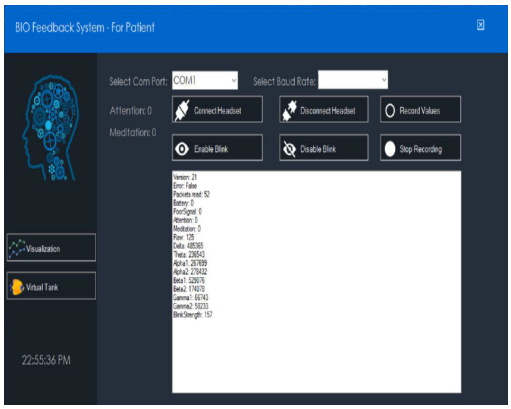


Fig. 1. Data capturing unit main window

B. Visualization Unit: Chart Form

Basically this form consists of chart representation where the EEG returned attention and meditation values are used to generate chart X and Y axis (attention and meditation axis). Using these two values program will calculate the stress level, productivity level, engagement level of the brain. Then it will display on the visualization form. The window primarily consists of 3 buttons and 3 labels. One is used for display relax level of the user, 2nd one is used for display engagement level of the user and last one is used to display the productivity level of the brain in particular user.

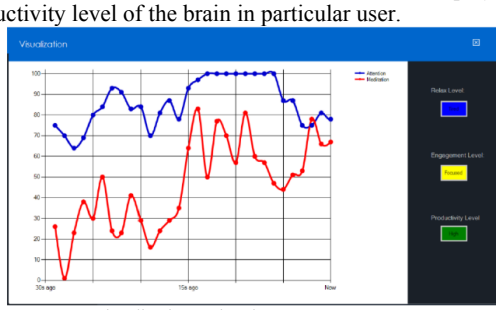


Fig. 2. Data Visualization Unit: Chart Form

C. Visualization Unit: Virtual Tank Form

Virtual tank form used to display humans stress level, productivity level, engagement level, meditation level and attention level in form of a fish tank. Which means, this especially designed virtual fish tank (relaxation scenery) is programmed to identify different levels of stress according to the swimming position of a certain fish. They are all designed in different color codes in order to minimize confusion. The red colored fish usually swims at top level of the tank if your stress levels increased. If his or her stress levels are low, the yellow colored fish tends to swim at the bottom of the tank. Also, if your stress levels are not too high or low, the green colored fish is likely to swim in the middle of the tank. The other reason for using a virtual fish tank for the experiment is that as we are all aware fish swimming is widely used in the health sector as a scenery for cardiac patients and also for ordinary people like ourselves. It is a well-known and evidence based mind focused method of reducing anxiety and stress in people.

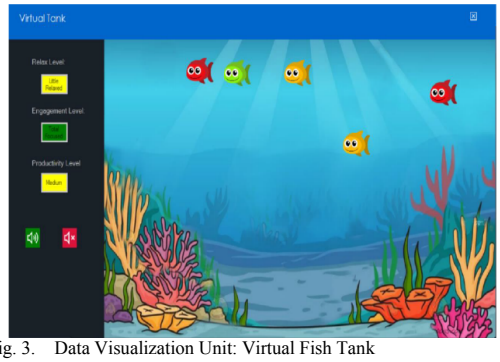


Fig. 3. Data Visualization Unit: Virtual Fish Tank

IV. DISCUSSION

We are currently living a world where our lives are busier working or with other commitments you have in life. If you think about a work place such as garment factory in the clothing industry, we often know employees are working with strict time scales for certain orders or productions to be

completed. You may find their stress levels as high. Stress related psychological conditions can possibly cause employees to go on long term sick leave and therefore efficiency levels of the company can be reduced. In such working environments if you were to perform this experiment on randomly selected employees you'll be able to figure out employees stress levels thereby implement suitable stress management strategy minimize their stress levels at workplace. Use of biofeedback technology is widely spread approach of health care providers which are often performed by psychiatrists, psychologists and other physicians. Considering the experimental outcome biofeedback can be considered as an excellent therapy that is delivered to patients with the use BCI technology. It may appeal in situations where all other treatments have been ineffective for certain health conditions or where patients are not able to take oral medications. The fascinating about biofeedback is that it teaches you how to keep their own natural responses in stressful situations in life. That may makes you give more control over yourself in relation to handling or face situations in the way you want to be.

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