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Smartphone and Wheelchair Control for Bedridden and Semi-Paralyzed People using Brain-Control Interface (BCI)

B. Vidya Sairam
bvidyasairam@gmail.com
Easwari Engineering College, Chennai, Tamil Nadu

N. Vijaykumar
vijay.nandakumar1990@gmail.com
Easwari Engineering College, Chennai, Tamil Nadu

Siddartha Addanki
siddartha.addanki@gmail.com
Easwari Engineering College, Chennai, Tamil Nadu

Sai Prapanch A
saiprapanch@gmail.com
Easwari Engineering College, Chennai, Tamil Nadu

Dr. Anand Kumar K. M
kmanandmss@gmail.com
Easwari Engineering College
Chennai, Tamil Nadu

ABSTRACT

The community of semi-paralyzed and bedridden people account for almost 35 million of the world's population. People with spinal cord injuries or nerve problems cannot live normal lives despite their minds remaining unaffected. They require constant attention and cannot be independent. They need assistance to even move around in a wheelchair or make use of ordinary devices like smartphones, which are an integral part of the modern world. The restrictions on the independent use of wheelchairs and smartphones do not allow the physically disabled people to contribute to the society effectively. Current technological solutions to help paralyzed and elderly people having physical disabilities require the use of custom-made devices, which use sensors to detect muscle movement to interpret actions and thus control their wheelchair and any computing device they use. They are however very expensive and cannot cater to a general population of physically disabled people. Our solution is the use of a Brain-Computer Interface, which is a novel technology that enables people to control devices using their brainwaves. An electroencephalography (EEG) headgear is used to capture the brainwaves and transmit it to a smartphone and Arduino board to be interpreted and thus control them. This project hopes to enable wheelchair movement using BCI-Arduino communication. A specialized smartphone interface will provide a cursor in the phone, which can be controlled using the BCI headgear. The smartphone interface and the Arduino-wheelchair will be compatible with a wide range of BCI headgear. The use of BCI technology in this project will provide an economical and generalized solution that will cater to the entire paralyzed and elderly community while opposed to the current solution, which is expensive and custom made for each individual.

Keywords: *BCI, OpenBCI, Physically challenged, EEG, EEG Headgear.*

1. INTRODUCTION

Over 35 million paralyzed and bedridden people (http://www.nytimes.com/2009/04/21/health/21para.html) who are physically incapable to interact normally with others and contribute to our society. We need an economical system that can benefit all paralyzed and Elderly People for interacting with Smartphone and their surroundings. The use a Brain-controlled Interface allows people with physical disabilities to control devices like wheelchairs and Smartphone by using their brainwaves. There are many issues present in the existing system, current devices read a person's head movements to navigate their phone or use joystick with their Mouth/Face to interface with the computer. A Mobile Application that receives the Command from human brain to interface and controls a Smartphone will be useful as there will be no need for any physical movement. A Head Band mounted on the user's head senses the Electromagnetic signals of the brain and transmits them to a mobile app. The signals received are translated to the CURSOR movement on the phone. A simple cursor will appear on the phone which will help them navigate. The same Electromagnetic signal can be used to control the movements of a wheelchair. Brain-controlled Interface (BCI) is used to develop the required application.

2. LITERATURE SURVEY

Fang, Gregory Francis, Xiao Zhang, Kan [1] Develops effective learning algorithms for continuous prediction of cursor movement using EEG signals is a challenging research issue in brain-computer interface (BCI). A novel statistical approach based on expectation-maximization (EM) method to learn the parameters of a classifier for EEG-based cursor control, train a classifier for continuous prediction, trials in training data-set are divided into segments. Therefore the proposed method can fully exploit the information contained in the BCI data and improve the performance of the cursor control system. Classification accuracy of the proposed algorithm is higher than the results of other widely used methods up to 4% and the information transfer rate is improved up to 19%.

Rui Zhang et al [2] is a Research into brain-computer interfaces (BCIs), which spell words using brain signals, has revealed that a desktop version of such a speller, the edges paradigm, offers several advantages: This edges paradigm outperforms the benchmark row-column paradigm in terms of accuracy, bitrate, and user experience. It has remained unknown whether these advantages prevailed with a new version of the edges paradigm designed for a mobile device. This paper investigated and evaluated in a rolling wheelchair a mobile BCI, which implemented the edges paradigm on small displays with which visual crowding tends to occur. How the mobile edge paradigm outperforms the mobile row-column paradigm has implications for understanding how principles of visual neurocognition affect BCI speller use in a mobile context. This investigation revealed that all the advantages of the edges paradigm over the row-column paradigm prevailed in this setting. However, the reduction in adjacent errors for the edges paradigm was unprecedentedly limited to horizontal adjacent errors. The interpretation offered is that dimensional constraints of visual interface design on a smartphone thus affected the neurocognitive processes of crowding.

Víctor Martínez-Cagigal et al [3] Is a investigates the effects of collaboration mode, luminance contrast and motor disability on task performance, brain activity and satisfaction of users with motor disabilities who performed a robot control task using a collaborative brain-computer interface (C-BCI) based on steady-state visually evoked potentials (SSVEPs). Users can perform the task by himself/herself (individual mode), working together (simultaneous mode), or taking turns (sequential mode). Fourteen amyotrophic laterals sclerosis (ALS) participants and fourteen able-bodied participants of similar age were recruited from local ALS association and local communities. This study investigated the effects of collaboration mode, luminance contrast and motor disability on task performance, brain activity and user evaluations. Results revealed significant main effects of collaboration mode and luminance contrast, while no effect of motor disability. These results could provide precious empirical data and invaluable insights to the real-world applicability of the SSVEP-based BCI applications for people with motor disabilities. A Two-way contingency analysis was conducted for user evaluations at first. Fisher's Exact Fisher Test was utilized because some cells had less than 5 observations. If there was no association between the two factors, a oneway frequency analysis was conducted

Anand Joshi, Parmar Prashant suggested that [4]One fundamental issue in human-computer interaction is that limitations exist on the communication between the human and the computer.That is, human-system interaction is still fundamentally bounded by the inherent capabilities of humans to absorb, analyze, store, and interpret information to create behavior; and by limitations in the ability of computers to predict human intentions, action, and communications.A brain-computer interface (BCI), also referred to as a mind-machine interface (MMI) or a brain-machine interface (BMI), provides a non-muscular channel of communication between the human brain and a computer system. With the advancements in low-cost electronics and computer interface equipment, as well as the need to serve people suffering from disabilities of neuromuscular disorders, a new field of research has emerged by understanding different functions of the brain. The electroencephalogram (EEG) is an electrical activity generated by brain structures and recorded from the scalp surface through electrodes. Researchers primarily rely on EEG to characterize the brain activity, because it can be recorded non-invasively by using portable equipment. The EEG or the brain activity can be used in real time to control external devices via a complete BCI system. A typical BCI scheme generally consists of a data acquisition system, pre-processing of the acquired signals, feature extraction process, classification of the features, post-processing of the classifier output, and finally the control interface and device controller. The post-processed output signals are translated into appropriate commands so as to control output devices, with several applications such as robotic arms, video games, wheelchair etc.

Martin Spuler suggested that [5] proposes a technique in Brain-Computer Interface (BCI) system to use arbitrary Windows applications by directly controlling mouse and keyboard. Code Modulation is used instead of frequency modulation to detect selection of characters. The c-VEP (Code modulation visual evoked potentials) BCI consists of 32 targets with the arrangements. The 32 targets are arranged as a 4*8 matrix and 28 complementary non-target stimuli are surrounding the targets. For modulation of the targets, a 63-bit binary m-sequence is used. For each target, the same sequence is used for modulation, but the sequence is circular-shifted for each target by a different number of bits. Based on the sequence flickering pattern the letter is selected. the EEG is first spatially filtered using CCA(canonical correlation analysis) and a one class support vector machine (SVM) is used to detect the corresponding time lag . Summation and averaging of the values are done to prevent errors and remove noise.The system works with average accuracies> 85% in a free spelling mode, which enabled the participants to write 21.3 error-free charactersper minute. The Code modulation VEP technique is used which is effective for large screen devices but not very conveying to small devices when compared to other techniques such as P300 speller. Improvement should be done is several corner cases. The keyboard interaction is fast compared to P300 BCI speller. A big advantage of this technique is that the same logic is used for both keyboard and mouse, and provides an option for the left, right and double-click. The sensitivity of the cursor movement can also be controlled.

Xiao Zhang et al [6] in some circumstances, people interact with a virtual keyboard by triggering a binary switch to guide a moving cursor to target characters or items. Such switch keyboards are commonly used by patients with severely restricted motor capabilities. The first step is to model the user's ability to use a switch keyboard correctly for different cursor durations. Once the model is defined, our optimization approach assigns characters to locations on the keyboard, identifies an optimal cursor duration, and considers a variety of cursor paths. Therefore an optimized keyboard with a linear cursor path is much faster than an optimized keyboard for other cursor paths and the cursor duration has to be made so long that the average entry time is quite large.

Yueqing Li, Chang S. Nam suggested that [7] is a Motion-onset visual evoked potential (mVEP) has been recently proposed for EEG-based BCI system. It is a scalp potential of visual motion response and typically composed of three components: P1, N2, and P2. Usually, several repetitions are needed to increase the signal-to-noise ratio (SNR) of mVEP, but more repetitions will cost more time thus lower the efficiency. Considering the fluctuation of subject's state across time, the adaptive repetitions based on the subject's real-time signal quality is important for increasing the communication efficiency of mVEP-based BCI. In this paper, the amplitudes of the three components of mVEP are proposed to build dynamic stopping criteria according to the practical information transfer rate (PITR) from the training data. During the online test, the repeated stimulus stopped once the predefined threshold was exceeded by the real-time signals and then another circle of stimulus newly began. Evaluation tests showed that the proposed dynamic stopping strategy could significantly improve the communication efficiency of mVEP-based BCI that the average PITR increases from 14.5 bit/min of the traditional fixed repetition method to 20.8 bit/min. The improvement has great value in real-life BCI applications because the communication efficiency is very important.

Qasem T et al [8] it presents an electroencephalographic (EEG) P300-based brain-computer interface (BCI) Internet browser. The system uses the "odd-ball" row-col paradigm for generating the P300 evoked potentials on the scalp of the user, which are immediately processed and translated into web browser commands. The aim of this study is twofold: 1) to test our web browser with a population of multiple sclerosis (MS) patients in order to assess the usefulness of our proposal to meet their daily communication needs; and 2) to overcome the aforementioned limitation by adding a threshold that discerns between control and non-control states, allowing the user to calmly read the web page without undesirable selections. The browser was tested with sixteen MS patients and five healthy volunteers. Both quantitative and qualitative metrics were obtained. MS participants reached an average accuracy of 84.14%, whereas 95.75% was achieved by control subjects. Results show that MS patients can successfully control the BCI web browser, improving their personal autonomy.

Ljiljana Seric Pero Bogunoyic suggested that [9] A human emotions classification technique based on EEG signals from a single electrode. (EEG experiment in which training data was collected.)They experimentally proved by getting a classification of human emotions based on the data they have collected by making people of different age groups to take the test.The collection of video clips gathered from various sources to elicit six potential emotions grouped on six videos and performed experiment on 25 subjects by and collected EEG signals of subjects exposed to different emotions.As a result, the spatial distribution of frequency band power by averaging epochs from all participants that are labeled with each emotion, obtaining six normalized histograms, was obtained.Based on the histogram and processing the data according to time-domain, certain key words were fixed for the data splits, these key-word were then collected as a bag of words, further the emotions could be identified by using these words.The proposed a Bag-of-words representation for EEG time series analysis and classifier for human emotion classification that is based on this representation. The proposed method treats a time series as a document and local segments extracted from the time series as words. The time series is represented as a histogram of codewords. Although the temporal order information of the local segments is ignored, both local structure and the global structure information of the time series are captured. Experimental results on datasets demonstrate that the bag-of-words representation is effective for characterizing EEG time series with satisfactory accuracy at natural positive and negative brain state caused by watching corresponds video clip. Soriani MH et al [10] extends the BCI technique of P300 speller. The paper test the usability of BCI on ALS (Amyotrophic lateral sclerosis) patients. P300 speller system consisted of EEG acquisition and real-time processing keyboard-display control software using the OpenVibe platform. P300 speller is equipped with the optimal stopping of flashes and word prediction this technique improves the performance in terms of information transfer rate (ITR).The flashing lights are random in nature to prevent flashing of the same character in succession. The keyboard had 43 symbols including punctuation marks and a backspace key. The keys are arranged in a matrix form in which the rows and columns are flashed at once. A row is first selected followed by column based on flashing. Each character that is obtained is used is used to predict full words. P300 speller does prediction based Presage library.Mean satisfaction score is 8.7/10 and average word count is about 3.4 per minute. P300 is an efficient technique that can be adapted to smaller devices as well.

3. COMPARATIVE ANALYSIS

S. No	Paper	Author	Approaches	Result	Issue
1	Expectation-Maximization Method for EEG-Based Continuous Cursor Control	Fang, Gregory Francis, Xiao Zhang, Kan	Expectation-maximization (EM) ,EEG-based cursor control, Training data-set.	Exploit information contained in the BCI data and improve the performance of the cursor control system.	The dependence between segments (or predictions) into our model to model the non-stationary property of the EEG signal.
2	An Adaptive Motion-Onset VEP-Based Brain-Computer Interface	Rui Zhang, Peng Xu, Rui Chen, Teng Ma, Xulin Lv, Fali Li, Peiyang Li, Tiejun Liu, and Dezhong Yao	BCI, Dynamic stopping, Motion-onset visual evoked potential (mVEP), Practical information transfer rate (PITR).	Reduces the cost of repetitions, which are required to increase the signal-to-noise ratio, Communication efficiency mVEP based BCI.	synchronous mode, dynamic stopping strategy
3	An Asynchronous P300-Based Brain-Computer Interface Web Browser for Severely Disabled People	Víctor Martínez-Cagigal, Javier Gomez-Pilar, Daniel Álvarez, Roberto Hornero	BCI,Electroencephalography,P300 event-related potentials,	Assistive context, It added a threshold which allowed that discerns between control and-control states	Results may not always be consistent
4	Brain-computer interface: A review	Anand Joshi, Parmar Prashant	Different functions of the brain, record scalp surface through electrodes	Output signals are translated into appropriate commands so as to control output devices, with several applications such as robotic arms, video games, and wheelchair.	limitations exist on the communication between the human and the computer
5	A Brain-Computer Interface (BCI) system to use arbitrary Windows applications by directly controlling mouse and keyboard	Martin Spuler	C-VEP for Mouse Mode and a keyboard Mode interface.	Code Modulation is used instead of frequency modulation to detect selection	It is suitable for only large display devices, bits transferred is comparatively less.
6	How to optimize switch virtual keyboards to trade off speed and accuracy	Xiao Zhang Kan Fang Gregory Francis	Switch keyboard correctly for different cursor durations, optimal cursor duration, cursor paths.	An optimized keyboard with a linear cursor path, the cursor duration has to be made long so that the average entry time is quite large.	The efficiency of a linear cursor path, Cursor duration.
7	Collaborative Brain-Computer Interface for People with Motor Disabilities.	Yueqing Li, Chang S. Nam	BCI, Collaborative BCIs, SSVEP-based BCI applications	Collaborative model, ALS patients, and able-bodied participants were shown to provide same results	The feasibility and sustainability of SSVEP-based collaborative BCI.

8	Spelling With a Small Mobile Brain-Computer Interface in a Moving Wheelchair	Qasem T. Obeidat, Tom A. Campbell, and Jun Kong	BCI,Edges Paradigm(EP), ,Event-Related Potentials (ERP) Row-column paradigm (RCP)	Edges paradigm outperforms the benchmark, Mobile edge paradigm.	Vertical Dimension is not solved, the relative horizontal spacing in landscape mode could leave the mobile EP less of a crowding problem to address
9	Human Emotions Classification using Bag-of-Words Method on Single Electrode Brain-Computer Interface	Ljiljana Seric ,Pero Bogunovic	Wavelet method , Histogram, Openvibe software pack to extract EEG signals, db8 wavelet function, Neurosky mind wave Eucledian distance equation	A human emotions classification technique based on EEG signals, training data is collected	Classification process and modeling responsiveness of the individual
10	Brain-computer interface with the P300 speller: usability for disabled people with amyotrophic lateral scleral sclerosis.	Soriani MH, Bruno M, Papadopoulo T, Desnuelle C, Clerc M.	P300 speller consists of electroencephalography acquisition used to identify characters.	An accuracy of 95% and 5.04 per min is achieved	Training model and self-learning not utilized

4. FUTURE SCOPE

The Interface can be expanded to IOS and Windows devices. Gamepads can also be controlled with BCI. Smart Home devices can be controlled with BCI. We can further simplify the daily activities of the disables.The idea of BCI for control of our environment has not seen many serious advancements in terms of direct consumer products. Bringing BCI to control home appliance sand mobile phones open a new window of opportunity for a wide range of developments. Mobile applications can be developed to take advantage of this mode of interaction. Cheaper and user-friendly devices to extract several brain waves can be developed. If a higher number of channels are used more data can be obtained by increasing the precision of the signal. Advance noise reduction technique should be presented in the form of simple API. Brain response to the different situation should be analyzed and presented in a simpler way for developers to focus on application development.

5. CONCLUSION

The Brain-computer Interface is used to solve the movemental problems faced by bedridden people and paralyzed people and also helps them for their basic needs. They can control the Smartphone using their brain waves and interact with apps present on the phone. We can further develop the system by making it more accurate and tailored to the user's brain waves by using learning algorithms and machine learning. Elaborate Noise reduction techniques can also be implemented on the system to get accurate data.

6. REFERENCES

[1]Xiao Zhang, Kan Fang, Gregory Francis, "Expectation-Maximization Method for EEG-Based Continuous Cursor Control ", EURASIP Journal on Advances in Signal Processing, 2007, Volume 2007, Number 1, Page 1, 19 October 2006.

[2] R. Zhang *et al*., "An Adaptive Motion-Onset VEP-Based Brain-Computer Interface," in *IEEE Transactions on Autonomous Mental Development*, vol. 7, no. 4, pp. 349-356, Dec. 2015.doi: 10.1109/TAMD.2015.2426176

[3] Víctor Martínez-Cagigal, Javier Gomez-Pilar, Daniel Álvarez, Roberto Hornero, an Asynchronous P300-Based "Brain-Computer Interface Web Browser for Severely Disabled People". Conf Proc IEEE Eng Med Biol Soc. 2015 Aug; 2015:1087-90. doi: 10.1109/EMBC.2015.7318554.

[4] P. Prashant, A. Joshi, and V. Gandhi, "Brain-computer interface: A review," *2015 5th Nirma University International Conference on Engineering (NUiCONE)*, Ahmedabad, 2015, pp. 1-6.

[5] Spuler M, 'A Brain-Computer Interface (BCI) system to use arbitrary Windows applications by directly controlling mouse and keyboard'. Conf Proc IEEE Eng Med Biol Soc. 2015 Aug; 2015:1087-90. doi: 10.1109/EMBC.2015.7318554.

[6] Xiao Zhang, Kan Fang, Gregory Francis ' How to optimize switch virtual keyboards to trade off speed and accuracy', Springer International Publishing, 22 September 2016 doi: https://doi.org/10.1186/s41235-016-0007-6

[7] Y. Li and C. S. Nam, "Collaborative Brain-Computer Interface for People with Motor Disabilities [Research Frontier]," in *IEEE Computational Intelligence Magazine*, vol. 11, no. 3, pp. 56-66, Aug. 2016.
doi: 10.1109/MCI.2016.2572558

[8] Q. T. Obeidat, T. A. Campbell and J. Kong, "Spelling With a Small Mobile Brain-Computer Interface in a Moving Wheelchair," in *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 25, no. 11, pp. 2169-2179, Nov. 2017.doi: 10.1109/TNSRE.2017.2700025.
[9] L. Seric and P. Bogunovic, "Human emotions classification using bag-of-words method on single electrode brain computer interface," *2017 25th International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*, Split, 2017, pp. 1-5.
[10] Guy V, Soriani MH, Bruno M, Papadopoulo T, Desnuelle C, Clerc M., ' Brain-computer interface with the P300 speller: usability for disabled people with amyotrophic lateral scleral sclerosis ' Ann Phys Rehabil Med. 2018 Jan;61(1):5-11. doi: 10.1016/j.rehab.2017.09.004. Epub 2017 Oct 10.

