Brain Machine Interface

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***Abstract*—Weallknowthattechnologyhasevolved alotin the recent years. Let us take a moment to visualize the massive change in our lifestyle and see if this has anything to do wi th the technology. . There was a time when the computers we are using was a great deal and being able to use Internet Explorer a mark of a true geek but now there are over 4 Billion searches performed e ver y single day! Hence, to know about emerging technologies in computing is not only essential for our knowle dge and interests but also survi val. Whene ver we use emerging technologies in computing, the techgiant Google tops the list and just analyzing Google's project fillsus with half of the knowle dge, we want. In this paper, we will be discussing the most exciting emerging technology i.e. Brain-ComputerInterface.**

***Keywords*—BCI (Brain computer interface), EEG (Elec tro encephalogram), EPOC (Excess Post-Exercise Oxygen Consumption).**

I. INTRODUCTION

Not even a decade ago among the coolest stuffs in technology was a mobile phone with a keypad from NOKIA and wireless landlines from TATA. There was a time when the computers we are using was a great deal and being able to use Internet Exp lorer a mark of a true geek but now there are over 4 Billion searches performed every single day! Google's recent product and experiment that is Google's Cardboard, is an approach to utilize the smart phones we carry all the time and ever aspiring virtual reality e xpe rience in one; Big Dog a quadruped robot designed for the U.S. military is among the best known realistic human stimulation by Boston Dynamics; Google 's self-driving car in itself is among the best merge of software and human needs one can witness along with the Google 's glass which has already became a sensation

II. THE EMERGINGTECHNOLOGIES

It is highly critical to know about what are the various products and projects that are being worked upon before even

that all the technologies we have seenor will comeare talkingabouttheemergingtechnologies,as"atechnologythat can't produce a desirable product, is not a technology but mereanexperiment".So, nowletus comestraighttothetopic that what are the latest technologies we need to be aware of : *Immersive Virtual Reality* – it is an art ificial computer world whichgives the impression to the user that he/she is e xperienc ing a real or believable world in a synthetic or virtual world, *Artificial intelligence* - it is the intelligence in which any problem solving concept or any function is being performed by machine or computers rather than human source, *Augmented reality* - it uses the existing environment instead of artificial and superimpose the user views and new information on top of it, thus providing a composite view and smart glass and Pokémon Go being its biggest exa mples , device. If some technology is able to excite the world to such an e xtent, then it indeed is an emergingtechnology.

III. BIRTH OF BRAIN COMPUTERINTERFACE

We can't stop thinking about what could the world be if the devices start operating with our mind! Just thought of switching off the light, made it do it could be incredible, but even more e xc it ing is the fact that although being an emerging technology brain-human interface is in talks for hundreds of years now. To know about a current technology, it is equally important to know how come one come up with it? There is in fact not one person, but all of us who must once said and wondered to do anything via thinking or wished to be God and control everything with our minds. But in the physical world, the thought of Brain-computer interface could be evident from the films we all have grown up watching. Most of us have seen the movie 'Spiderman 2' which was released twelve years ago, and we all remember the famous 'Dr. Octopus' who built four artificial hands and controlled it by his brain by attaching it to the spinal cord. Not only the thought of the writer to think about something like this was unbelievable, but the convincingpowerofitbeingpartoftherealitywas.

Now, the point comes why does it matter? The answer is emergent of human's unlimited ability, power and rightto

think. That one thought leads to the origin of a technology, revolution and an ultimate era and brain-computer interface being a part of the same. An e xt reme recent news in the newspaper and television this year in March was the one which talked about world's first mind-controlled wheelchair and in that the biggest highlight was that it was made by Indians. So, this technology has not only spread in the world, but has conquered Indian market too.

IV. SOME ONGOINGBRAIN-COMPUTERINTERFACEPROJECTS

Mind controlled wheelchair has gotten into the limelight but there are amazing other gadgets also on which the work is going on and among them some popular ones are *emotive EPOC* -device which helps control the character movement in the game with just thought; *MUSE* which is now at the initial stage which guides the user to relax or concentrate, but is destined for controlling smart phones *; NeuroSky mindwave* is made to train the brain ;Brain Driver helping to control the movement of cars with thoughts; *DARPA's Prosthetic Arm* is made especially for people with disability to have their own arm controlled by the brain cells, *Neromimi and Shippo* are the cutest utilization of this technology to tell the group when you are happy or concentrating leading to rise of ears or movement of tail respectively; *neuro turntable mobile* is among the gadgets we have always wished for as it plays the music from your smartphone when you just think about it and lastly *orbit helicopter* to lift loads of your mind and help to relax which in itself could be a great solution to problems such as depression [1].

Beforetalkingaboutthesepro jectsin detailletusknowabout the million-dollar question about what exactly the technology Brain-Computer Interfaceis!

V. EVOLUTION OF BRAIN-COMPUTERINTERFACE

A *BCI* is a direct pathway between the wired brain and an external device. This is something which has not come into existence today but dates back in 1970s which is around forty years from now aiming to restore damaged hearing, sight and movement via corticalplasticity of the brain. Signals from implanted prostheses after adaptation can be handled by the brain like natural sensors [2].

Knowing about the technology itself is not sufficient until we know who e xactly is using the technology. Although the state of development for BCI devices is really pretty primitive but there are many big names involved in it. And if we are talking about big names and technology how come there is no talk about Google. Google is working on an electrocorticography-based brain computer interface (BCI).Google's work comprises of an output device communicatively coupled to the BCI computer, the BCI computer further configured to generate a device command from the intent of the user. Google is working in extreme disciplined manner in this field with a lot of research and patents goingon.

VI. BRAIN COMPUTER INTERFACE GADGETS

A. MIND CONTROLLEDWHEELCHAIR

People with severe disabilities can depend on this technology. Technology depending on visual or auditory input may not be feasible therefore the feasibility of a BCI has been validated based on tactually-evoked event-related potentials (ERP) [3].

B. EMOTIVE'STECHNOLOGY

EMOTIVE is a bioinformatics company working e xtensively on advancing the understanding of human brain using electroencephalography (EEG) with the mission to empower individuals to understand their own brain and accelerate brain research globally. Emotive aims to track cognitive performance, monitor emotions, and control both virtual and physical objects via machine learning of trained mental commands[4].

C. EPOC

It is a product of Emotive that is a headset which reads brain waves. These brain waves tell the system to what to do in virtual reality. It is generally used in providing unbelievable virtual reality gaming e xpe rience [5].

D. INSIGHT

Is yet another Emotive's product which is essentially a Brainwear that allows you to monitor your cognitive health and wellbeing and optimize your performance [6].

E. MUSE

It is the brain sensing headband helps you get the most out of your meditation practice by giving you real t ime biofeedback of what's going on in your mind.

It is a product not only available in market, but also selling at $249. Marking the presence of BCI technology in the world apart from Emotive's one [7].

E. NEUROSKYMINDWAVE

It includes many devices and kits made for various activities of brain. Some of them are-Brain Link Pro: It is a mobile brainwave sensing headset with fun brain training apps that teach you how to meditate, focus and understand your mind by connecting to your smartphone and tablet via Bluetooth wireless (iOS and Android). Brainwave Starter Kit: It helps in Brainwave Visualizer, SpeedMath, and MindWave Mobile Tutorials. Play Bundle: It offers a wide assortment of games and mobile apps[8].

F. ORBITHELICOPER

The Puzzlebox Orbit is a brain-controlled helicopter.Operated with an EEG headset, users can fly the Orbit by focusing their concentration and clearing their mind. Colourful visuals and physical feedback help provide positive reinforcement while developing skills of attention and mental relaxation. What makes the Puzzlebox Orbit truly unique however is the open release of all source code, hardware

schematics, 3D models, and the step-by-step hacking instructions which are published freely online. Puzzlebox seeks to aid the pursuit of science and education by inviting its users to modify their products and make them their own [9].

VII. Involvement of India in Brain-Computer Interface

In India itself, awareness of BCI has increased tremendously which can be seen by research by individuals, universities and funding and support by the government.

There are many workshops being conducted throughout the country regarding the awareness of same by Dr. Alejandro Riera who graduated in Physics (Astrophysics) at the Complutense University of Madrid and came back to Barcelona where he joined Neuroelectrics, Starlab's spinoff that produces and commercialises Neuroscientific products. There has been tremendous researching going in the related fields such as EEG, MEG, FMRI, FNIRS etc signals for neuroscientific investigations. Currently research is going on e xtracting the best features from an EEG wave which more or less reflects the characteristics of the signal. Features could be in time or in frequency domain, but should be able to provide an identity to a particular signal. Typical methods like spectral transforms, time-frequency analysis are experimenting on various datasets. The research investigates various pattern recognitionalgorithmstogetthebestsignalgrouping.Different clustering and classification techniques are experimented for performanceevaluation.

Currently, there are faculty members those who have registered for PhD and are working on the following problem statements in BCI:

1) Design, Modeling and Performance Analysis of Novel Algorithms for EEG based Brain Control Interface for ParalyticPatients.
2) Design, Modeling and Va lidation of Novel Algorithms for Emotion Detection and Classification using EEG signals in Normal and AbnormalPatients.
3) Design, Modeling and Va lidation of BCI for non-medical application areas such as driving and traffic monitoring.
4) Design of low cost embedded systems for BCI module for elderlypersons.

There has been extensive collaboration in this field too. The Centre will collaborate with DRDO organization (DEBEL), Nimhans (Bangalore) and MS Ramaiah Memorial Hospital (Neuro Science Department) for jo int research activities. The centre will also collaborative with Weldon School of Biomedical Engineering, Purdue University, US and University ofToronto,CanadaforcollaborativeresearchinBCI.Hence,full credit to the country for working hard in this field and being at par with theworld.

VIII. Future Scope of Brain-ComputerInterface

If the present itself is unbelievable, we can think what future could behold.

Thinking strategies: "Participants have been able to navigate a robot and control a camera and to enter a virtual reality that enables them to meet and talk to other people using BrainAble." BCIs will fit into the Internet of Things by including chips and implants in people and animals - everything will be connected by default. If your brain and nervous system get connected onto the net then they are automatically a part of it - in effect, you become your own cloud. So, the whole prediction can be divided into three stages:

A. EarlyBCI/BMI

Signal splicing into human sensory nerve pathways, most importantly the visualnerve.

B. Mid-termBCI/BMI

More direct links into the brain with the ability to read certainthoughtsandcopyawiderangeofdataandinformation into various parts of thebrain.

C. Final BCI/BMI

Direct control over the activities of all individual neurons by means of Nano robots. Arbitrary read/write access to the whole brain. The line between the mind and the computer is blurred. Partial or full uploading is possible and inevitable at the same time [10].

IX. The Benefits of Advancement inBrain-Computer Interface Technology

1) *Allows paralyzed people to control prosthetic limbs with theirmind*:Wecan'tevenimaginetolivewithoutahandorleg, but there are millions of people who are facing this difficulty every second of their lives. Just a swell in the feet or a minor fracture, becomes the lowest point of our life and then what about the people who don't even have a limb. Technology is providing them with art ificial limbs, but they can't if real and make them feel as a part of their own. But, what BCI could do to them can't be understated. Losing a limb and getting back could reduce suicide rates, depression rates upto 50%. Hence itwould provetobeablessing forthemankind.

2) *Transmit visual images to the mind of a blind person, allowing them to see:* What worse than losing a limb is to not be abletoevenseetheworld.Andforgetabouttheworldbutnotbe able to see yourself and even imagine! No Braille could do that, what BCIcould.

3) Hearing is not just among five major senses, but something our smile, life and world is associated with. Think about guessing what the world is saying to actually know is remarkable. BCI is the only hope forthem.

4) Allow gamers to control video games with their minds. Have played games on screen with keys, joystick andeven

touch screen and shake. What else we could want, but to control the player with our mind. C'mon this is what we waited for our entire lives!

5) *Allow a mute person to have their thoughts displayed and spoken by a computer*: No better exa mple of it then Stephen Hawkings. He is the man behind BCI. This technology has been introduced to the world by him which could give lives and voice to millions. It is a reality of some, but need to become reality of many!

6) *Employment and job opportunities*: The entire world is going through crisis of lack of jobs, making thousands of people to commit suicide everyday. With jobs disappearing so fast, having an entire field of new technology opens job and employment opportunities at every stage. Not just technology in itselfisboomforpeoplewhoneedit butprovidingfacilityto others for many things. This BCI has really came to empower our lives[11].

X. MajorConcernsinBrain-ComputerInterface Technology

Like everything in the world, like every technology Brain Computer Interface too has its dark side. Some of the facts are pretty obvious, but some could only be stated in the long run, so below are some key points which must be addressed before accepting BCI as a blessing.

- *Research is still in beginning stages*: We can build anything in our mind, but need to have current facts to make it into a future reality. We can't absolutely deny that BCI is at its primitive stage, hence the term emerging is used throughout in thecontext.
- *The current technology is crude*: It has taken over a century to come with the technology which we are using. We have seen everything with our eyes and taken our own time with each phase and BCI being emergent of another era would definitely require a lot of time and effort inacceptance.
- *Ethical issues may prevent its development* : This is somethingwecanforeseefromtheverybeginningofthe time. Tampering with someone's brain could actually not only damage that individual, but who knows Dr. Octopus of Spiderman could actually be born among us and this time we definitely do not have aSpiderman!
- *Electrodes outside of the skull can detect very few electric signals from the brain*: This is themajor technical concern with the BCI and it is definitely not easy to solve too.
- *Electrodes placed inside the skull create scar tissue in the brain*: It is among the concerns where a being can be damage for the sake of technology and we all know it is absolutelynot worthit.
- *Involvement of huge amount of capital*: This is not only a technology, but a revolution. And this is not multi-millionaire project, but requires Billions of dollars, huge land, huge sacrifice of animal species which in itself requires involvement of many big names, which is not at all an easytask.

XI. Conclusion

Brain Computer Interface is the technology which we actually need to change lives of millions, and for which it feels like we have been waiting for ages now. And the fact that from thought stage, it has actually reached to developingstageand inmanycasestoevenproductstageis in itself an over-whelming e xperience. The world is in its full swing and what better than our country being a part of thisrevolution.Notjustbeingapart,ourcountryhasshown tremendous promise by building world's first mind-controlled wheelchair. There is no doubt that BCI has a very long way to go and thousands of obstacles in its way where concern for environment, life and involvement of huge investment being primarily. BCI has to overcome these obstacles and provide the experience for paralyzed, handicapped people they ever wishedfor!

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