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Mind-Reading Computers: Towards A New Horizon in Medical Science

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Abstract- Mind reading is the ability to infer other people's mental state and use that to make sense of and predict their behaviour and intensions. Though it seems impossible to read someone's mind, the modern neuroscience is able to do just that with the help of Mind Reading Computers. Over the years, many Brain Machine Interface (BMI) tools have been invented and they have been put to use in different areas of research, but the most effective and useful applications of mind reading computers probably have been in the field of medical science. Starting from mind controlled robotic arms for disabled persons to today's 'Neuralink' which is expected to treat serious brain diseases, scientists have always been up to create better replacement for the current, conventional way of treatment in neurology with the help of mind reading computers. In the present paper the author discusses about how mind reading computers are being used in development of human health and wellness and also about the future scopes of the on-going researches in this field. The author has also tried to find out the risks related to BMI devices.

Keywords: electroencephalogram, Mind-Controlled Robotic Arm, locked-in syndrome, Emotiv EPOC, deep brain stimulation

I. INTRODUCTION

Mind reading is the ability to discern the thoughts of others without the normal means of communication, especially by means of a preternatural power. The history of mind reading goes back a long way. Accounts of mind-readers can be found in works by the ancient Greeks and in the Old Testament of the Bible. Throughout the ages, legions of science-fiction authors have imagined a future that includes mind-reading technology. But thanks to advances in neuroscience and computer coding, mind reading is no longer a fantasy.

Research on mind-reading has been vigorously pursued by government agencies and various academic centres since the 1970s, and continues to this day. Since 1973 DARPA has been studying mind-reading technology using scientists at the University of Illinois, UCLA, Stanford Research Institute, Massachusetts Institute of Technology, and the University of Rochester.[1] Very recently, some of the biggest IT corporations (like Facebook, Microsoft, Elon Musk's Neuralink etc.) have started working on projects related to this field too.

Facial movements and eye language in play a important role in recognizing basic emotions such as happiness, sadness, disgust and fear and also the complex mental states like distrust, recognize, scheme, admire, interest, thoughtfulness etc.[2] With a special camera, the computer observes a person's emotions through facial expressions. That can be combined with electroencephalogram (EEG) and similar technologies which read brain activity through sensors on a person's head.

Mind reading by a computer can provides us many applications in various fields of one's everyday life, especially in medical treatment. This technology has far-reaching implications for medical science and has the ability to improve the lives of individuals suffering from various conditions, from paralysis to autism. Various research projects and experiments have been successful to the extent of interpreting the brain's signals through brain–computer interfaces, thus helping those patients to carry out some physical movements that they are unable to perform.

The paper concentrates on applications of mind reading computers are in development of human health and wellness. It also includes the future scopes of the on-going researches in this field and the risks related to BMI devices.

II. MIND READING COMPUTERS

A. Definition of Mind-Reading Computer

Drawing inspiration from psychology, computer vision and machine learning, mind-reading machines – computers has been developed that implement a computational model of mind-reading to infer mental states of people. The goal is to improve the productivity of the user and to enable applications to initiate interactions with and on behalf of the user, without waiting for explicit input from that user.

B. Types of Mind Reading Computers

1) Brain-Computer Interfaces (BCIs) and Neuroprosthetics

Brain Computer Interface (BCI) technology is a powerful interaction tool between users and systems. It does not require any external device or muscle intervention to assign commands and complete the communication.[3] BCI system records the brain waves and sends them to the computer system to complete the intended task. The transmitted waves are therefore used to express an idea or control an object.

Neuroprosthetics is an area of neuroscience concerned with neural prostheses, i.e., using artificial devices to replace the function of impaired nervous systems and brain related problems, or of sensory organs. The difference between BCIs and neuroprosthetics is: the first one connects the nervous system to a device, while the later usually connects the brain or the central nervous system with a computer system.

Neuroprosthetics and BCIs engage in restoring sight, hearing, movement, ability to communicate, and even cognitive function. Both technologies use similar experimental methods and surgical techniques. Measuring brain generated oscillations is one of the main components of these techniques. There are two types of brain-signal acquisition methods: invasive techniques and non-invasive techniques.

a) Invasive techniques

Invasive recording methods implant electrodes under the scalp. They measure the neural activity of the brain either intracortically from within the motor cortex or on the cortical surface (electrocorticography (ECoG)). Their advantage is that they give high temporal and spatial resolution, increasing the quality of the acquired signal and its signal to noise ratio.[4]

b) Non-invasive techniques

These methods do not require implanting of external objects into the user's brain. Thus it avoids the surgery or permanent device attachment needed by invasive methods. These methods are based on Neuroimaging or brain imaging. Various assessment methods for different types of measured brain signals are functional magnetic resonance imaging (fMRI), functional nearinfrared spectroscopy (fNIRS), magnetoencephalography (MEG), and electroencephalogram (EEG).[4]

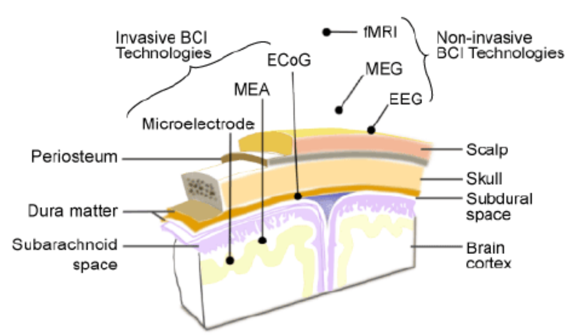

Figure 1: Typical electrode placement locations for various brain acquisition technologies [5]

2) Whole brain emulation (WBE)

Whole brain emulation (WBE), mind upload or brain upload (sometimes called "mind copying" or "mind transfer") is the suppositional futuristic process of scanning the mental state of a particular brain substrate and copying it to a computer. The computer could then run a simulation model of the brain's information processing such that it responds in the same way as the original brain and experiences having a conscious mind of its own.

Mind uploading focuses on acquisition of data and not on the maintenance of the data of the brain. A method, called loosely coupled off-loading (LCOL), is sometimes used in the attempt to characterize and copy the mental contents of a brain. This may use self-reports life-logs and video recordings, analyzed by artificial intelligence. [6][7]

Another bottom-up approach focuses on the specific resolution and morphology of neurons and the spike times of neurons. [8]

3) Recommended methods

Among these mind-reading computers, EEG based BCI is the most appropriate techniques for mind-reading applications because of its non-invasive and easy to use nature. The EEG system acquires the electrical brain signals from the scalp using the surface electrodes. It can be classified into different types, among them EEG MI-based BCI is commonly used.

The input signals used for this type of BCI system is a motor imagery signal. This system involves a BCI user to concentrate on a MI task in order to produce a characteristic brain pattern that identifies with the desired control. The block diagram of EEG MI-based BCI system is shown in Figure 2.

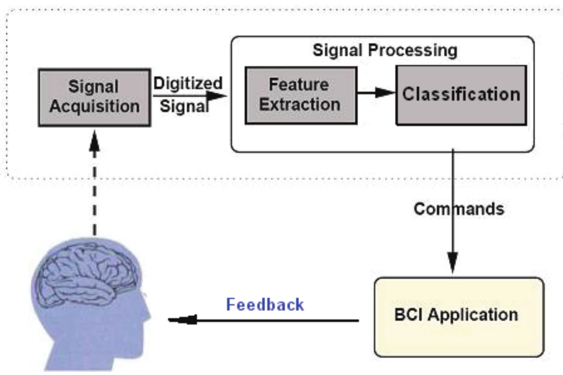

Figure 2: Generic Scheme of a BCI system compound [10]

EEG signals are captured by multiple-electrode EEG machines either from inside the brain, from the cortex under the skull, or some perticuler locations over the scalp. There are five main brain-signal waves distinguished by their different frequency ranges. These frequency bands from low to high frequencies, respectively, are typically categorized in specific bands such as 0.5–4 Hz (delta, δ), 4–8 Hz (theta, θ), 8–13 Hz (alpha, α or mu, μ), 13–30 Hz (beta, β) and >30 Hz (gamma, γ). For BCIs employing MI, EEG signals are typically filtered in the 8–30 Hz band (μ and β rhythms). The acquired signals are then given to the signal processing unit that consists of the pre-processing, feature extraction and classification.

a) Feature extraction algorithm

Among the other feature extraction techniques, common spatial pattern filtering (CSP) is probably the most effective algorithm. The spatial filters are calculated from a set of data by the method of common spatial patterns and reflect the specific activation of cortical areas.

CSP optimizes the spatial filters ω by minimizing and maximizing the following function:

$$J_{CSP}(\omega) = \frac{\omega X_1 X_1^T \omega^T}{\omega X_2 X_2^T \omega^T} \quad ..... (1)$$

Or, $$J_{CSP}(\omega) = \frac{\omega C_1 \omega^T}{\omega C_2 \omega^T} \quad .....(2)$$

Where T is the transpose matrix, X_i is EEG signals for class i, which were previously bandpass filtered (matrix with EEG samples as columns and sensors as rows) and C_i the spatial covariance matrix for class i. Here, the covariance matrix C_i is defined as the average of the covariance matrices of each example of the class i. In equation (1), ωX_i is the spatially filtered EEG signal for class i, and $\omega X_i X_i^T \omega^T$ is therefore the variance of the spatially filtered signal.

$J_{CSP}(\omega)$ is in the form of a generalized Rayleigh quotient. Therefore, maximizing and minimizing this function can be solved by Generalized Eigen Value Decomposition (GEVD). The spatial filters, ω, that maximize or minimize $J_{CSP}(\omega)$ are therefore the eigenvectors corresponding to the largest and smallest values of the GEVD of matrices C_1 and C_2. Typically, three pairs of filters are used, which correspond to the three largest and three smallest eigenvalues. Once the filters have been obtained, a CSP feature, f, is calculated by taking the log variance of the filtered signals.[9]

b) Classification algorithm

Linear discriminant algorithms (LDA) are probably the most popular algorithms for BCI applications.

LDA uses hyperplanes to separate the data representing the different classes. For a 2-class problem, the class of a feature vector depends on which side of the intersecting hyperplane the vector is.

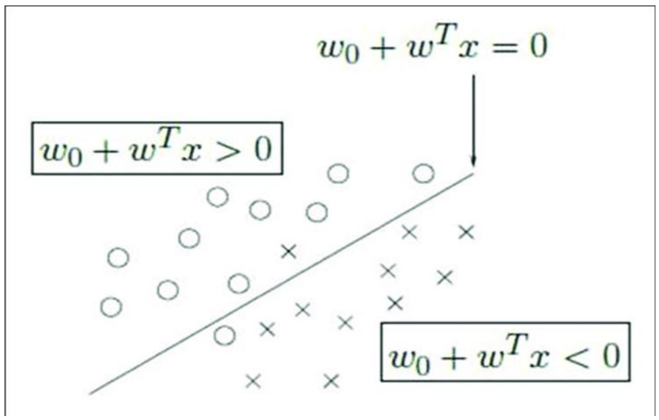

Figure 3: A hyperplane which separates two classes: the “circles” and the “crosses”[11]

The hyperplane, separating the classes, is obtained by seeking the projection that maximize the distance between the two class means and minimize the interclass variance. To solve an N-class problem, where N > 2, more than one hyperplanes are used. The strategy generally used for multiclass BCI is the “One Versus the Rest” (OVR) strategy which consists in separating each class from all the others.[12]

III. MIND-READING COMPUTERS IN MEDICAL SCIENCE

A recent report by the World Health Organization (WHO) pointed out that neurological disorders (including neuropsychiatric conditions) constitute 6.3% of the global burden of disease.[13][14] Neurological disorders represent the most invalidating clinical condition, exceeding HIV, malignant neoplasm, heart ischemia, respiratory and digestive diseases. Among neurological disorders, more than half of the burden in disability-adjusted life years (DALYs) is constituted by cerebrovascular diseases, such as stroke (55%), followed by Alzheimer’s disease and other dementias (12%), migraine (7.9%) and epilepsy (7%).

The number of people affected by stroke and dementia is likely to increase in the coming years, because of the rapidly ageing population, while some other disorders can affect people at any age and may be so severe to compromise the patient’s ability to work. Therefore, enhancing recovery of cognitive, sensory and motor functions in these conditions has become a global priority in healthcare.

From the scenario depicted above, it is clear that brain disorders represent one of the biggest challenges for healthcare and society and that the lack of effective treatments demands for innovative interventions.[15]

Thankfully, in recent years, mind-reading computers have proven to be able to target different neurological disorders successfully. There are variety of health issues that could take advantage of brain signals in all associated phases including prevention, detection, diagnosis, restoration and even treatment and rehabilitation.

A. Prevention

1) Sopite syndrome

The sopite syndrome is a neurological disorder that associates with symptoms of fatigue, drowsiness, and mood changes to prolonged periods of motion. Persons, who operate automobiles, airplanes, et cetera, may experience impaired motor function due to the motions of the vehicle and may therefore contribute to motor vehicle accidents.[16]

Sopite syndrome can be avoided with the help of mind reading computers. Jaguar Land Rover has been working on a project called Mind Sense that will monitor a driver's heart-rate, respiration and levels of brain activity constantly, and throw up warnings if it detects stress, fatigue or a lack of concentration. Mind Sense will include brainwave sensors fitted into the steering wheel of the sedan.

Figure 2 : Sopite Syndrome[17]

2) Sleep inertia

Sleep inertia is a state of impaired cognitive and sensory-motor performance that is present immediately after awakening. Humans sleep in stages or cycles. Scientists found that when people were woken during deep sleep, it produces sleep inertia which can affect short-term memory, cognitive abilities and even counting skills.

The conventional alarm clocks awaken people from their night's sleep exactly at the scheduled time irrespective of their sleeping stages. This problem can be solved with mind reading alarm clocks. Sleepsmart, a smart alarm clock invented by the students of Brown University, wakes people up only from light sleep. In order to do that, user wears a soft headband in bed which enables the clock to monitor brain activity and pick the right moment to wake them up.

B. Detection and Diagnosis

1) Intracranial Diseases

Cranium is the top portion of the skull, which protects the brain. An intracranial disease is any disorder that happens within the cranium. It includes brain tumour, cerebral atherosclerosis, intracranial haemorrhage etc.

These diseases can be detected with the help of non-invasive brain-computer interfaces like MRI (Magnetic Resonance Imaging), Computed tomography or CT scan, Positron emission tomography (PET) or PET-CT scan, etc, easily.

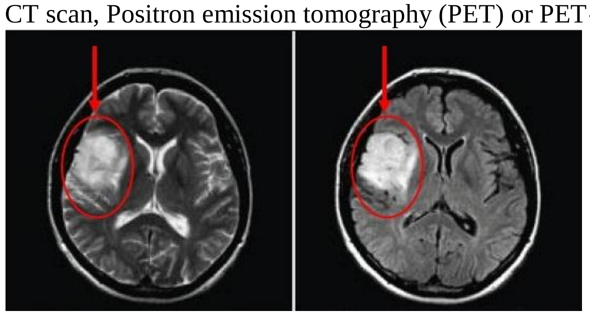

Figure 3: MRI scan of Brain tumour[18]\

2) Neurodegenerative diseases

Neurodegeneration is the progressive damage of structure or operation of neurons, including death of neurons. Some neurodegenerative diseases are Alzheimer's disease (a loss of brain function that affects memory, thinking, language, judgment and behaviour), Huntington's disease (an inherited disease that causes the progressive breakdown of nerve cells in the brain) etc.

Alzheimer's disease and Huntington's disease can be detected with the help of non-invasive brain-computer interfaces like MRI (Magnetic Resonance Imaging), Computed tomography or CT scan, Positron emission tomography (PET) or PET-CT scan, etc.

3) Sleep disorders

Some common types of sleep disorders include: Insomnia (having difficulty falling asleep or staying asleep throughout the night), Sleep apnoea (experiencing abnormal patterns in breathing while asleep), Narcolepsy (a condition characterized by extreme sleepiness during the day and falling asleep suddenly during the day), etc.

To detect these disorders, the patient's brain activity, heart rate, heart rhythm and blood pressure are recorded digitally while he is sleep. EEG or electroencephalogram (a non-invasive BCI) is used to measure and record brain wave activity.

4) Smoking and Alcoholism

EEG technique has been widely used in nicotine and alcohol addiction detection to relate specific sensory and cognitive event to specific cues. Abundant fMRI evidences also have suggested that cue-induced reactivity among nicotine or alcohol addicts is different from the healthy ones which shows functional and structural abnormalities in the brain of addicts.[19]

5) Dyslexia and ADHD

Dyslexia is a learning disorder that involves difficulty reading due to problems identifying speech sounds and learning their relation to letters and words. Attention-deficit/hyperactivity disorder (ADHD) is a neurological disorder featuring an ongoing pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development.

According to University of Amsterdam researchers, dyslexia could be diagnosed before kids even learn to read by analyzing their brain waves with electroencephalogram (EEG). An EEG helmet has also been approved recently by the FDA, which is being used to test kids for ADHD.[20]

C. Restoration

There are several conditions that can cause people disabilities like congenital disorders, autism, locked-in syndrome, Parkinson's disease, stroke paralysis etc and even by the removal of a limb by trauma, medical illness, or surgery.

When a person suffers with a disability, their ability to do everyday tasks is hampered. Rehabilitation technology helps them overcome the limitations that come with physical and mental disabilities, allowing them to lead a life of comfort and integrity. These disabilities can be restored to some extent with the help of neuroprosthetics and other mind-reading computers.

1) Mind-Controlled Robotic Arm

This is a prosthetic that is controlled by neural activity in the brain to restore motor function to people who are disabled to move their arm or a leg or have had amputated them. In particular, the researchers focus on the motor cortex, the part of the brain that takes care of the movement. When a person moves or merely thinks about making a movement, the neurons in this area of the brain will generate an electrical current that can be measured with EEG tools. Using advanced signal processing and machine learning, these thoughts are then translated into commands that will control the robotic arm.

To track the electrical activity of the brain, either an EEG cap with 64 electrodes or with electrodes that have been surgically implanted on the surface or within the depth of the brain.[21] Scientists have also created prosthetic hands which connect directly to the remaining nerves in the upper arm. That means the hand is able to send sensations of touch back through the arm and into the brain.

Figure 4: Mind-Controlled Robotic Arm[22]

2) Mind-controlled wheelchair

A mind-controlled wheelchair is a brain-machine interfacing device that uses thoughts or neural impulses to command the motorised wheelchair's motion. A mind-controlled wheelchair functions using a brain–computer interface where an electroencephalogram (EEG), worn on the user's forehead, detects neural impulses that reach the scalp allowing the micro-controller on board to find out the user's thought process, interpret it, and control the wheelchair's movement. These wheelchairs come with many different types of sensors, like temperature sensors, sound sensors and an array of distance sensors which detect any unevenness in the surface. The chairs automatically avoid stairs and steep inclines. They also have a "safety switch" for in case of danger, the user can close his eyes quickly to trigger an emergency stop.

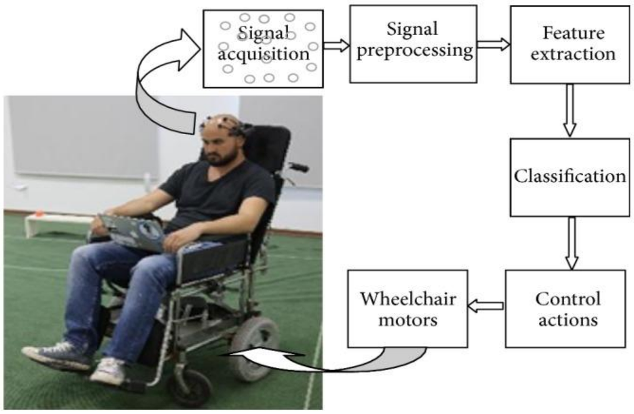

Figure 5: Mind-Controlled wheelchair[23]

3) Thought Identification system

A team from Carnegie Mellon University (CMU) has developed a way to accurately read complex concepts from a brain scan, and even piece together entire sentences. They have developed a way to see thoughts of high complexity in the fMRI signal. The discovery of this correspondence between thoughts and brain activation patterns indicates what the thoughts are built of. [24]

4) Restoring communicative disability of patients with Locked-in syndrome

Niels Birbaumer, a neuroscientist at the Wyss Centre for Bio and Neuroengineering in Geneva, designed a brain-computer interface to communicate with patients of locked-in syndrome in a binary yes or no fashion. The brain-computer interface measures changes in electrical waves flowing from the brain as well as blood flow using functional near-infrared spectroscopy (fNIRS). [25]

An Austrian organization, g.tec medical engineering, has developed a similar BCI system called mindBEAGLE, which relies on electroencephalogram (EEG) to give people with locked-in syndrome, the ability to answer yes or no questions using only their thoughts. [26]

5) Restore Hearing

A brain implant called a cochlear implant is a common neuroprosthetic that replaces the malfunctioning ear to restore hearing for certain deaf people.

It captures sound with a microphone and then impulses the auditory nerve through electrodes, allowing the brain to approximate hearing.[27]

6) Emotiv EPOC

Emotiv Systems is an Australian electronics innovation company which produced the EPOC near headset, a peripheral targeting mainly the gaming market for Windows, OS X and Linux platforms. But recently, Student team of Ben-Gurion University of the Negev announced a new application for the Emotiv EPOC which turns the biosensor headset to a unique computer pointing device, or mouse/keyboard replacement for disabled people. [28]

Raúl Rojas, an AI professor at the Freie Universität Berlin, and his team also have used an Emotiv Headset to steer a vehicle using only thoughts. Their "BrainDriver" application lets the driver's thoughts control the engine, brakes, and steering in their research car, named "MadeInGermany". This type of cars can allow disabled and paralyzed people to gain more mobility in the future.

D. Treatment and Rehabilitation

1) Neuromodulation therapy

Neuromodulation is the alteration of nerve activity to normalize or modulate nervous tissue function. We can benefit more from this technology by implementing BCI in Neuromodulation. One example of brain-machine interface neuromodulation, deep brain stimulation (DBS), has proven to be the greatest advance in the treatment of Parkinson's disease, dystonia or essential tremor.[29]

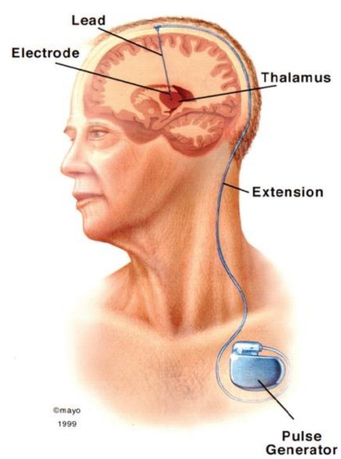

Figure 6: Deep brain stimulation [30]

2) Functional electrical stimulation

Functional electric stimulation is based on the principle that one can artificially compensate for the loss of voluntary motor control by means of stimulating the paralyzed muscles of the affected limb.

Meng et al. verified the feasibility of an EEG-based BCI-FES system in chronic post-stroke patients. They asked two post-stroke participants to imagine repetitive wrist extension/flexion. When subjects successfully imagined this movement, which was reflected by a cursor moving towards and hitting a target on a computer screen in front of the participant, the FES system was activated. The size of target was dependent on the imagery performance of the participant, with smaller targets for better imagery encouraging them to achieve better levels of neural control. [31]

Figure 7: EEG-based BCI-FES system in chronic post-stroke patients[31]

3) Improvement in mental focus for ADHD patients

The startup company NeuroPlus has developed games that can actually improve attention deficit hyperactivity disorder (ADHD) symptoms in kids.

4) Reality approaches for BCI-based rehabilitation

Various reality-based approaches for rehabilitation training using BCIs such as real, virtual, and augmented approaches have been presented.

Real rehabilitation approach exploits brain signals generated from healthy people along with the decoded kinematic parameters.[32] It assists stroke patients modifying their thinking behaviour to match the recorded signals and retraining healthy, unaffected areas of the brain to take over.

Virtual reality could also help restore mobility in paraplegic patients, according to 2016 research from Duke University, North Carolina. In this training system, there is an immersive virtual reality environment in which patients employed his/her brain activity. This brain activity is recorded via a 16-channel EEG, to control the movements of a human body avatar, while receiving visuo-tactile feedback. [33]

Scientists have also combined BCIs and AR feedback in order to train surgeons for Human-Robot Interaction based surgeries. The goal of the system is to teach surgeons keep their concentration during the whole time of the operation. Another therapy that has been improved by combining AR and BCI is the “exposure therapy”. To cure patients from phobias and anxieties, Acar et al. developed an EEG based system to help patients overcome their fear.[34]

IV. SOME ONGOING RESEARCHES

A. Neuralink

This is one of the leading neuroprosthetics companies owned by Elon Musk. The company aims to make devices that intially would treat serious brain disease and brain damage that was caused by a stroke in the short-term. In the long-term, the company's goal is to advance the technology for human enhacement.

B. Kernel

This is another neuroprosthetic company founded by Bryan Johnson with the goal of retaining the human brain vitality while unleashing its full potentials and capabilities. The company’s target is to repair damaged neurons generated by certain diseases like Alzheimer’s and other neurodegenerative diseases. The implantation chips being built by the company is expected to boost memory and enhance human intelligence.

C. Neurable

This is a neuroprosthetic company that is focused on confiding existing electroencephalogram instead of building new hardware, unlike many other startups. The company utilizes this platform to interpret neural activities and assist people with acute disabilities.

D. Delta Brain Inc

The Delta Brain Inc is a startup in the neuroprosthetic field that researches on improving heart health. This company has helped a lot of people with heart and liver problems.

E. Novela

This is another renowned company in the neuroprosthetic field that developed a flexible electrode array that successfully created a closed loop system for the detection and stoppage of seizures.

F. Brains view

This startup company has been involved in the development of certain MATLAB-based software that is able to predict the outcomes of paediatric traumatic brain injuries.

G. Eyewink

This is another startup in the neuroprosthetic field that has been able to design a system that gives humans the ability to control electronic devices with the wink of the eye.

H. Restoring Active Memory (RAM) and SUBNETS

The Defense Advanced Research Projects Agency (DARPA) is developing neuroprosthetic devices that can directly interface with the hippocampus, and can restore memory loss and repair brain damage by using electrodes to stimulate neural tissue. This project is called Restoring Active Memory (RAM). In project SUBNETS, researchers are trying to use neuroprosthetics and electric currents to cure PTSD, depression, and pain.

V. RISKS AND CHALLENGES OF USING MIND-READING COMPUTERS

A. Lengthy training process

Training the user is a time-consuming activity either in guiding the user through the process or in the number of recording sessions. The user is taught to work with the system as well as to manage his or her brain feedback signals in the preliminary phase. In the calibration phase, the trained user's brain signal is used to learn the applied classifier. This process can seem to be very lengthy and irritating to the user.

However, some solutions to this time-consumption problem are to employ single trial instead of multi-trial analysis, which is used for enhancing signal to noise ratio,[35] and placing the burden of small training size on subsequent BCI system components to handle.[4]

B. Technical challenges

1) Noise

Noise is one of the significant challenges in analysis and interpretation of brain signals. It includes undesired signals caused by alterations in electrode placement, and environmental noise.
A solution to the noise problem is improving the signal to noise ratio (SNR) of EEG signals by increasing the signal level and/or decreasing the noise level.[4]

2) Risks with implantation

Invasive recording methods implant electrodes under the scalp. Making holes in the skull to implant electrodes is risky, difficult, and potentially damaging to extremely important parts of the brain. There is also a chance of implants slipping out of place. Implants also need to be made of nontoxic materials that won't cause human bodies to reject them as foreign, and they need to be tiny and rechargeable.

3) Data acquisition and interpretation

The relatively low ability to extract the relevant information from the brain is a key challenge to overcome. The present method used in brain data collection from the invasive to the non-invasive methods only produces partial and unclear data on the user's intention. This has been an obstacle to the success of the technology.

C. Ethical challenges

1) Cyber security threat

The ever-increasing cyber threat is a major challenge to this industry because there is the continuous fear of data theft which may cause severe damage to the industry's reputation. Some people have been opposed to the brain-computer interfaces on the basis that some private and personal data about them can be accessed by unauthorised persons.

2) Legality

There is also the challenge of legality and regulations which the industry has been trying to overcome. There are basic human right laws that must not be violated by the use of this technology.

D. Social Challenge

According to a recent survey conducted in USA,[36] most of the population is not interested in a brain implant that could improve memory or mental capacity, and some of the people even think it'll be a change for the worse if most people wear implants that provide them with information about the surrounding world. So, getting people interested in this technology can be a challenge.

VI. OUTCOMES OF SOME SIGNIFICANT EXPERIMENTS

A. The Thought Identification system developed by Carnegie Mellon University (CMU) was able to predict the missing sentence from a brain activation pattern with 87 percent accuracy.[24]

B. Wyss Centre for Bio and Neuroengineering's brain-computer interface to communicate with sufferers of "locked-in syndrome" is claimed to get the binary answers, consistent 70 percent of the time, substantially better than chance.[25]

C. In a pilot study, kids with ADHD showed better focus and attention after 10 weeks of playing the games, developed by NeuroPlus, while wearing a brain-sensing headset.

D. After 10 training session, the error rate of the BCI-FES system by Meng et al. became less than 20%, showing that chronic post-stroke patients could learn to improve their motor imagery actions, based on the closed loop sensori-motor control, via the BCI-FES system.[31]

E. Following 12 months of training with VR based paradigm, all patients experienced neurological improvements in somatic sensation (pain localization, fine/crude touch, and proprioceptive sensing) in multiple dermatomes. Patients also regained voluntary motor control in key muscles below the SCI level, as measured by EMGs, resulting in marked improvement in their walking index. [33]

VII. Results and Discussion

Mind-reading computer is an evolving technology that implements a computational model of mind-reading to infer mental states of people. The main objective of this paper is to find out how mind reading computers are being used in development of human health and wellness.

There are variety of health issues that could take advantage of brain signals in all associated phases including prevention, detection, diagnosis, restoration, treatment and rehabilitation. Sopite syndrome and sleep inertia can be prevented using mind-reading computer. Several diseases can be detected and diagnosed with this technology including intracranial diseases like brain tumour, cerebral atherosclerosis; neurodegenerative diseases like Alzheimer's disease, Huntington's disease etc; Sleep disorders; Smoking and Alcoholism; Dyslexia and ADHD etc.

Restoration of disable body parts are important application of this technology. Mind-Controlled Robotic Arm, Mind-controlled wheelchair, Thought Identification system, restoring communicative disability of patients with Locked-in syndrome, restore hearing with cochlear implant are all successful invention of this field.

Treatment and Rehabilitation are also popular using mind-reading computers. Deep brain stimulation (DBS), i.e., brain-machine interface combined with neuromodulation, , has proven to be the greatest advance in the treatment of Parkinson’s disease, dystonia or essential tremor. Feasibility of an EEG-based BCI-FES system for chronic post-stroke patients has been proven. NeuroPlus’s games can improve ADHD symptoms in kids. Various reality approaches for BCI-based rehabilitation training such as real, virtual, and augmented approaches have also been presented.

Some ongoing researches have also been discussed in this paper. There is Neuralink which would treat serious brain disease and brain damage that was caused by a stroke. Kernel is hoped to repair damaged neurons occasioned by certain diseases like Alzheimer’s and other neurological damaging diseases. Delta Brain Inc would improve heart health. DARPA’s project Restoring Active Memory (RAM) which could restore memory loss and SUBNETS which would cure PTSD, depression, and pain have been mentioned.

There are various risks and challenges of using Mind-reading computers. Apart from lengthy training process, there are technical challenges like noise problem, non-linearity of the brain, risks with implantation, low ability to extract the relevant information from the brain etc. There are Ethical challenges also which includes fear Cyber security threat, challenges regarding legality and regulations etc. Getting people interested in this technology can be a challenge too.

VIII. Conclusion and Future Scopes

Over the years, many Brain Machine Interface tools have been invented and their most effective and useful applications probably have been in the field of medical science which includes prevention, detection and treatment of severe diseases and even restoring disabilities which were otherwise impossible.

There is wide variety of future scopes of this technology. For example, Scientists are already developing contacts that can zoom. Combined with implants, we could control them with the brain, allowing us enhance the zoom at will and eventually be able to search the Web for information on what we see. This technology will be helpful to the whole mankind including the doctors and patients. The thought identification system also can be combined with a speech synthesizer to create a voice output to aid people with severe speech impairment.

Although, there are some risks of using mind-reading computers, we hope that these will be eradicated gradually with the growth of this industry. As for now, we can rightfully say that mind-reading computers are leading us towards a new horizon in medical science as well as in our everyday life.

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