Introduction

Brain-Computer Interface is a bridge between the brain and the external device; it can be used in therapeutic areas to cure the affected ones. According to sources, about 82 million people would be affected by dementia by the year 2030 and would rise up to 152 million by 2050. This gives us the perspective or an overview as to how the demand in the Brain-Computer Interface market is expected to rise in the near future.

The document highlights the BCI overview, applications and the classifications, market analysis with competitive landscape with companies currently operating in this field to give the reader the idea about the scope of the products and services that are currently being offered.

What is BCI?

The brain-computer interface (BCI), also referred to as the neural-control interface (NCI), the mind-machine interface (MMI), the direct neural interface (DNI), or the brain-machine interface (BMI), is a direct communication pathway between the enhanced or wired brain and the external unit. BCI differs from neuromodulation in that it enables a bi-directional flow of information. BCIs are directed to the study, mapping, assistance, enhancement, or repair of cognitive or sensory-motor functions of humans.
Brain-Machine Interface Systems base its functionality on either observing the state of the user or enabling the user to deliver his or her ideas. The BCI system tracks the brain waves and sends them to the computer system to complete the expected tasks. For this function, transmitted waves are used to communicate an idea or influence an entity. The following subsections include a brief reference to these BCI operations.

a. Classification
i. Communication and Control
The BCI systems create a communication bridge between the human brain and the outside world, removing the need for traditional information delivery methods. They manage to transmit messages from human minds and decipher their silent thoughts. They can allow people with disabilities to express and write their thoughts and ideas through many approaches, such as spelling, semantic categorization, or silent speech communication. BCIs may also promote hands-free applications that offer ease and comfort to human beings through the mind control of machines. They only need the integration of brain signals to execute a series of commands, and no involvement of muscles is required. BCI assistive robots may assist disabled users in their everyday and professional life, increasing their cooperation in building their communities.

ii. User State Monitoring
Early BCI applications target disabled users who have mobility or speech problems and seek to provide an alternate communication platform for those users. Later, it joins the realm of healthy people as well as serving as a physiological measurement tool that retrieves and uses information about an individual's emotional, cognitive, or emotional state. The goal of brain signal utilization expanded beyond regulating any entity or

Figure 1: BCI System (German Rodriguez-Bermudez1, *, Alejandro Lopez-Belchí1, Arnaud Girault, 2019)
Approaches in Brain-Computer Interface

a. Non-Invasive Techniques
Seriously and partially paralyzed patients to reacquire essential means of communication and to monitor neuroprosthetics and wheelchairs have successfully used non-invasive techniques. Despite the excellent use of non-invasive methods in BCI applications, engine recovery has been limited due to the need for higher resolution brain signals.

b. Partially Invasive Techniques
Partially invasive BCI instruments are inserted inside the skull but rest outside the brain rather than inside the gray matter. Signal intensity using this form of BCI is slightly lower as compared to Invasive BCI. They provide higher resolution signals than non-invasive BCIs. Partially invasive BCIs have a lower
chance of scar tissue development relative to Invasive BCI.

c. Invasive Techniques

Invasive modalities need to insert microelectrode arrays within the skull, which pose substantial health risks, which limit their use to experimental settings. Two intrusive modalities can be used in BCI research: electrocorticography, which positions electrodes on the cortex surface, either outside the dura mater (epidural electrocorticography) or under the dura mater (subdural electrocorticography), and intracortical neuron recording, which inserts electrodes within the cortex.

- The risk of infection should be minimized. Harm to tissue, constant stress on the person by plugging and unplugging the recording device.

Neuroimaging

There are two activities in the brain that are monitored namely Hemodynamic and Electrophysiological.

a. Electrophysiological

Electrophysiological activity is produced by electrochemical transmitters, which exchange information between neurons. Neurons produce ionic currents that circulate inside and through neuronal assemblies. Current flows, known as secondary currents. Electrophysiological behavior is measured by electroencephalography, electrocorticography, magnetoencephalography, and the acquisition of electrical signals in single neurons.

b. Hemodynamic

Hemodynamic response is a process in which the blood releases glucose to active neurons at a higher rate than in the area of inactive neurons. Glucose and oxygen distributed through the blood...
stream result in an excess of oxyhemoglobin in the veins of the active region and a major change in the local ratio of oxyhemoglobin to deoxyhemoglobin. These improvements can be quantified by neuroimaging techniques such as functional magnetic resonance and near-infrared spectroscopy. (Nicolas-Alonso & Gomez-Gil, 2012)

Most widely, the modality for neuroimaging is Electroencephalography:
- High temporal resolution
- Few risks the user
- High Portability
- Relative low cost

<table>
<thead>
<tr>
<th>Neuroimaging methods</th>
<th>Activity Measured</th>
<th>Risk</th>
<th>Portability</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEG</td>
<td>Electrical</td>
<td>NI</td>
<td>P</td>
</tr>
<tr>
<td>MEG</td>
<td>Magnetic</td>
<td>NI</td>
<td>NP</td>
</tr>
<tr>
<td>ECoG</td>
<td>Electrical</td>
<td>I</td>
<td>P</td>
</tr>
<tr>
<td>Intracortical neuron recording</td>
<td>Electrical</td>
<td>I</td>
<td>P</td>
</tr>
<tr>
<td>fMRI</td>
<td>Metabolic</td>
<td>NI</td>
<td>NP</td>
</tr>
<tr>
<td>NIRS</td>
<td>Metabolic</td>
<td>NI</td>
<td>P</td>
</tr>
</tbody>
</table>

(N: Non-Invasive, I: Invasive, P: Portable, NP: Non-Portable)

Figure 4: Neuroimaging Methods

Industry Overview
The Market which was at $1.36 billion in 2019 is expected to grow at a CAGR of 14.30% (2019 to 2027) at touch $3.85 billion by 2027.

Figure 5: Brain Computer Interface Market Size for BCI. (in US $ bn)

Drivers
- Increased incidence of neuroprosthetic disorders/conditions. A rise in the geriatric population.

Restraints
- Ethical issues faced during study/research & cybersecurity threats.

Opportunities
- Integration of Artificial Intelligence with BCI.

Industry
Competitive Landscape
OpenBCI – The Company specializes in developing low-cost, high-quality biosensing hardware for brain-machine interfaces. OpenBCI headphones, boards, sensors, and electrodes allow anyone interested in biosensing and neurofeedback to purchase high-quality equipment at accessible prices.
Advanced Brain Monitoring – The Advanced Brain Monitoring Business, and over the last 20 years, our team has challenged traditional wisdom by designing groundbreaking medical technologies that offer superior patient service, lower healthcare costs, and improved quality of treatment.

NeuroPace, Inc. - NeuroPace was developed to design, develop, produce, and market implantable devices for the treatment of neurological disorders with responsive stimulation. The company's initial focus is on the treatment of epilepsy, a crippling neurological condition affecting about 1% of the world’s population.

MindMotion – MindMaze develops products for MindMotion. MindMaze technology is based on a decade of rigorous healthcare research. The company's first drugs benefit people with stroke and have also proven helpful for other neurological disorders such as Parkinson's disease, traumatic brain injury, multiple sclerosis, and cerebral palsy.

Emotiv Systems, Inc. - EMOTIV is a bioinformatics company that advances the understanding of the human brain through electroencephalography (EEG). Their goal is to inspire individuals to understand their brains and to promote brain science globally.

Cadwell Industries, Inc. – Company’s entire focus is providing innovative and easy-to-use neurodiagnostic, neuromonitoring, and sleep solutions.

NeuroSky, Inc - NeuroSky technology enables low-cost EEG-linked research and products using low-cost dry sensors; older EEGs require the use of a conductive gel between the sensors and the head. The systems also have built-in electrical noise reduction software/hardware and use embedded (chip level) solutions for signal processing and performance.

Artinis Medical Systems B.V. – They aim to make optical imaging easier. Artinis provides a broad range of NIRS devices, all of their devices can be mixed and matched to create your ideal setup according to the client’s needs.

ANT Neuro B.V. – Comprehensive strategies for clinical neuro diagnostics & neuroscience study. The company’s products and services are aligned for the same. The key company
focused on complete solutions for capturing and interpreting neurophysiological signals in neurological, psychological, physiological and associated clinical applications.

Nihon Kohden Corporation - Nihon Kohden Corporation is a Tokyo-based leading manufacturer, developer, and distributor of medical electronic equipment, including EEGs, EMG measurement devices, ECGs, patient monitors, and clinical information systems.

Blackrock Microsystems, LLC - Blackrock Microsystems provides enabling tools for neuroscience, neural engineering, and neuroprosthetics research and clinical communities worldwide.

Conclusion
After understanding the brain-computer interface concept with the classification of the same with its applications, this document highlights the area where BCI is being used currently. As the technology advances, BCI then could be used for enhancing medical care, which is currently not possible. This market would grow and shows promise even though there are a lot of challenges and hurdles that are visible or yet to be unearthed.

References

Glossary
ANN: Artificial Neural Network
EEG: Electroencephalography
MEG: Magnetoencephalography
ECoG: Electrocorticography
Brain Computer Interface