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Brain Computer Interfaces:
The New Dynamics of VR Gaming

Brain-controlled Virtual Reality Games hold the future of gaming. Move, throw, and perform all possible actions just with a thought!

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Introduction

A thought leads to an action. When the brain thinks, its neurons guide and control the actions and functions of the body.

BCI (Brain-Computer Interface) technology has turned science fiction into reality and defies the usual way people and technologies communicate. As per market studies from KBV Research and Allied Market Research, BCI market is expected to grow at an approximate CAGR of 12% for the time period of 2016 -2022 and most of the users might be from North American region. The usage of BCI technology in gaming and entertainment market by North America and APAC region is expected to generate around $197.8 million for the same time period.

BCI-VR (Brain-Computer Interface-Virtual Reality) market holds the future of gaming and at present it has been analysed that the VR gaming market size is expected to reach USD 45.09 billion by 2025. Several companies are trying to develop some BCI-VR gaming products or BCI-VR influenced healthcare gadgets.

How BCI Works

Neurons act as intermediaries between the brain and body muscles. The Brain generates electric signals that pass through neurons and instruct our body muscles to perform an action. BCI (brain-computer interface) technology uses electrodes to detect electric signals generated by the brain and then connects these signals with a computer to generate device commands.

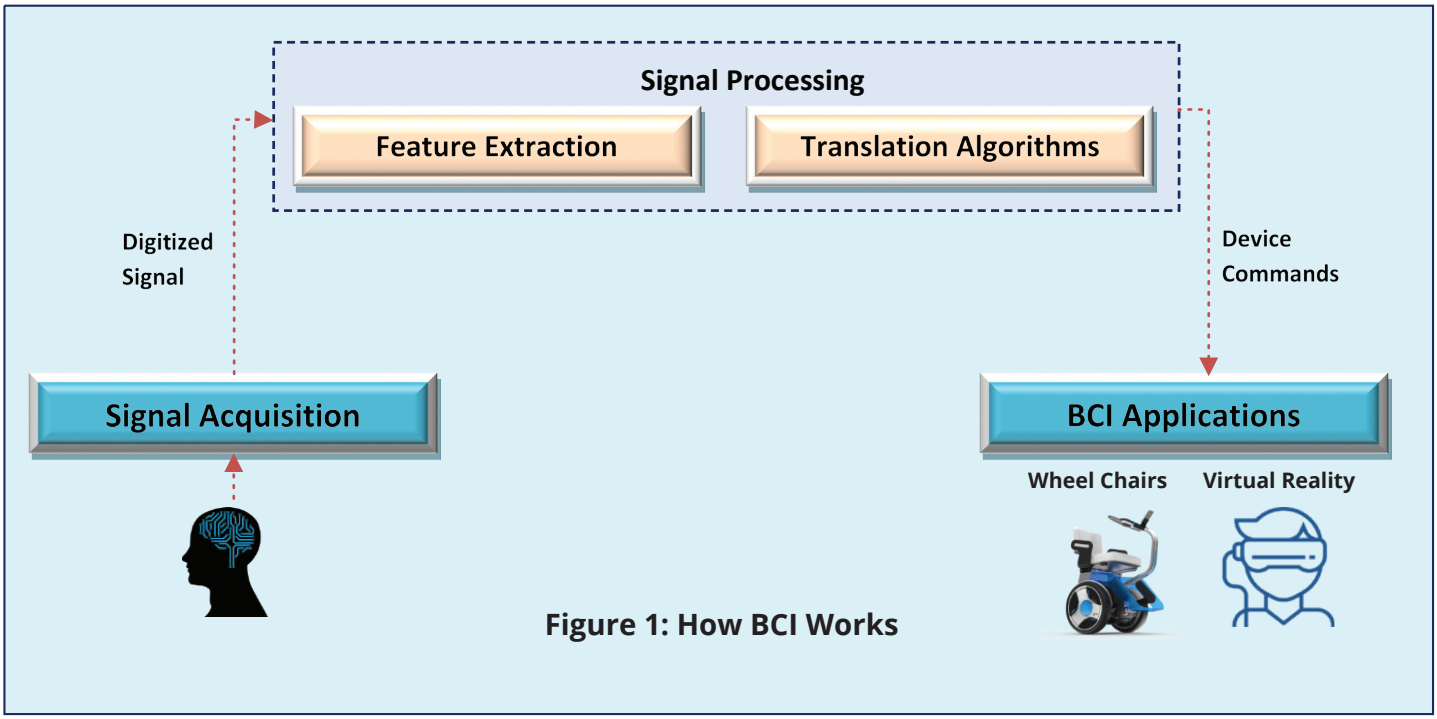


Figure 1: How BCI Works

Technology Overview of Brain-Computer Interfaces

Key parts of BCI

- **Signal Acquisition:** The signal acquisition method includes 'the interface' and isolated electronic amplifiers.
  - **'The Interface':** Comprises of the easiest and least invasive method which includes a set of electrodes - a device known as an electroencephalograph (EEG) –
    - The device is attached to the scalp such that the electrodes can read brain signals.
    - To get a higher-resolution signal, scientists can implant electrodes directly into the grey matter of the brain itself, or on the surface of the brain, beneath the skull.
  - **'Signal Transmission':** Wires from each electrode transmit their measurements to a computer/electronic device. The electrodes measure minute differences in the voltage between neurons.
- **Signal Processing Unit:**
  - The signal received from 'the interface' goes through the feature extraction system, which includes algorithms for linear prediction of the signal.
  - The signal is further amplified and filtered.
  - They produce readable graphs on a computer/electronic device, showing the readings from each electrode.

Types of BCI

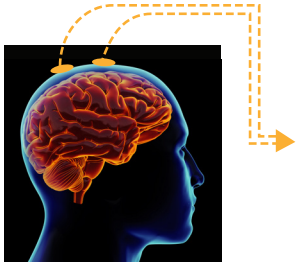
There are currently three types of BCI in the market –

Invasive:

- They are implanted directly into the grey matter of the brain by neurosurgery
- Embedded within the grey matter, the invasive devices produce the highest quality signals out of all BCI devices
- Prone to scar tissue build-up which makes signals weaker or even lost as the body reacts to a foreign object in the brain

Partially Invasive:

- They are implanted inside the skull but outside the grey matter
- In this case, the electrode grid is being implanted by surgical incision
- Electrocorticography (ECoG) is the example of partially invasive BCI
- Electrocorticograph (ECoG) records the activity of the brain inside the skull, but from the surface of the membranes that protects it



Non-Invasive:

- One of the most useful neuron imaging methods - In this case the device is applied on the scalp
- Existing techniques that leverage this type of BCI devices are Electroencephalography (EEG); Magnetoencephalography (MEG); functional Magnetic Resonance Imaging (fMRI)

Virtual Reality Gaming Landscape

Virtual reality gaming offers an interactive experience and reinvigorates the sub-industries that help produce the peripherals for enhancing gaming experience. In the last couple of years it has been observed that the gaming experiences have evolved from 2D and 3D landscapes to virtual reality. As per recent technological developments the conventional 2D and 3D games pale in comparison to the interactive and immersive experiences offered by VR gaming platforms. In 3D games the entire field of view isn't overlapped, which massively limits the gamers' visual involvement. But virtual reality provides gaming experiences in a three-dimensional environment that allows them to interact with the surroundings.

Virtual reality games have improvised in recent times with the launch of some BCI-VR headsets like HTC Vive and Oculus Rift. The basic functionality of these headsets is similar to that of Electroencephalogram (EEG). The VR headsets are comprised of EEG Sensors which allows players to play a game with their mind.

The Evolving Gaming landscape

The Evolution of BCI-VR Games

1968	'Sword of Damocles' was the first functioning computer-generated VR environment. It was the first working model which could have materialized into commercial virtual reality.
1987	Head-mounted 3D video and haptic response through a custom controller came into existence. This gave a major push to virtual reality experiments.
1991	Arcade based virtual reality setup was the only medium to experience a virtual reality environment. But the hardware costs were extremely high and unaffordable.
1995	Virtual reality gaming controllers had many side effects on players making them difficult to use. One such example is Nintendo's Virtual Boy.
2013	An attempt to bring back VR gaming to arcades and attractions was made which includes the launch of 'VirtuSphere'
2016	The Oculus VR headset came into the market and created massive buzz. It brought in a better VR experience in the market.
2017	Neurable's VR headset with HTC vive has marked a proper entry of 'mind controlled VR games' in the VR gaming market

Major components of a BCI-VR Game

BCI-VR games in the market today mostly require a VR headset and a virtual environment. The VR headset is comprised of EEG sensors which help in understanding human brain activity. The key components that contribute to the functioning of a BCI-VR game are as follow:

- **The VR Headset:** EEG based VR headsets measure electrical activity generated by the synchronized activity of thousands of neurons (in voltage), which provides excellent time resolution, allowing you to analyse which brain areas are active at a certain time – even at sub-second timescales.
- **The Virtual Environment:** In BCI-VR based games, the player is made to wear the VR headset which allows the player to experience a virtual world by becoming part of that world. For instance, a player can impersonate a character within a game and do some activities and experience supernatural kind of powers.

The Technical Mechanism Involved

The EEG sensors implanted by headsets start reading one's mental states as the individual starts getting a variety of visual experiences.

The games work on two parameters: 'Concentration' and 'Distraction'. A player can move or throw an object at a specific position only when he concentrates well enough.

If a player fails to concentrate, then in some gaming methods the objective of the game is not met. In such situations, the player mostly 'lacks concentration' or is not focussing enough to aim and throw an object in the game.

Popular Brain-Computer Interfaces/EEG Head Gear — Uplifting VR Gaming

Many companies have been developing BCI-VR games and gear, accelerating development in the field of mind-controlled gaming. Some of the headsets creating innovative Virtual Reality gaming experiences are:

Neurable's EEG Headset

Neurable has launched one of the world's first mind-controlled virtual reality games called Awakening. The game has been developed on a storyline similar to that of the Netflix series, Stranger Things, and shows users what it's like to have telekinetic abilities. The game is supposed to be played with its EEG headset and HTC VIVE.

Neurable worked in collaboration with a Madrid-based company named Estudiofuture to eliminate the need for controllers and hand movements. While this technology was mainly used by the disabled until now, Neurable's game has started making it mainstream.

Emotiv's Headset called EPOC

Emotiv Systems released a headset called the EPOC that allows the user to play video games with only their brainwaves. The device can read 4 mental states, 13 conscious states, facial expressions, and head movements. The EPOC is the first commercial BCI to use dry sensor technology, which can be dampened with a saline solution for a better connection.

InteraXon's Headband called Muse

Muse is a headband that **comprises of 4 EEG** sensors that measure the patterns of electrical activity in the brain. It measures two of the better-understood frequency tiers – alpha waves (8–12 Hz) associated with relaxation and restfulness, and beta waves (12–30 Hz) which correlate with alert or attentive mental states.

VR Headband Oculus Rift

The OpenBCI Community has allowed people to create different interactive BCI gaming environments using their platform. One such game has been created for the Oculus Rift using OpenBCI's Unreal Engine 4 with Leap Motion controller. In the game, the player can change the gaming environment using different powers activated by thought.

Conclusion

The rising popularity of Brain Controlled Virtual Reality might be a boon for the future owing to the fact that Brain-Computer Interface (BCI) and Virtual Reality (VR) are natural companions. BCI provides a new interaction technique for controlling VR, and VR provides a rich feedback environment for BCI while retaining a controlled and safe environment. Thus, the overall environment created via BCI-VR is capable of providing human beings with novel experiences that are impossible otherwise. This whitepaper aims to showcase the basic functioning of Brain-Controlled Virtual Reality and how market players are innovating currently in this technology space.

The clientele of Course5 Intelligence includes technology giants, chip makers, industry leaders and other research companies, who can harness this technology for their business needs and are interested in knowing the innovation landscape including current use cases, market data and other aspects. We help businesses vault ahead on the innovation curve with research data and live market insights on important technology developments.

References:

1. *Global Brain Computer Interface Market, Dec, 2016, https://kbvresearch.com/news/global-brain-computer-interface-market/*
2. *The First Mind Controlled Virtual Reality Game Has Arrived, 2017, https://futurism.com/the-first-mind-controlled-virtual-reality-game-has-arrived/*
3. *Mind-Controlled VR Game Really Works, 2017, https://www.technologyreview.com/s/608574/mind-controlled-vr-game-really-works/*
4. *Throw Trucks With Your Mind demonstrates the power of calm and focus, https://www.polygon.com/2013/6/8/4366188/throw-trucks-with-your-mind*
5. *How Mind-Controlled Games Work – And Why It's Way, Way Bigger Than That, https://readwrite.com/2013/01/10/ces-2013-muse-mind-control/*
6. *Can A Virtual Reality Game Make You Forget You're In Pain? http://www.iflscience.com/healthand-medicine/can-virtual-reality-game-make-you-forget-you-re-pain/*
7. *Playtest is Black Mirror's terrifying glimpse at the future of gaming, https://www.theverge.com/2016/10/25/13401020/black-mirror-season-3-episode-2-playtest-recap*
8. *Five Ways Elon Musk's Brain-Computer Interface Could Transform the World, https://futurism.com/five-ways-elon-musks-brain-computer-interface-could-transform-the-world/*
9. *EEG-based "Serious" Games Design for Medical Applications, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.458.2971&rep=rep1&type=pdf*
10. *Invaders Reloaded, https://store.neurosky.com/products/invaders-reloaded*
11. *Neurosky MindWave Mobile EEG Headset, http://www.titan-commerce.com/images/downloads/MWM_en.pdf*
12. *Heads-on: mindwave lets you control mobile games with brain waves, https://www.wired.com/2012/05/mindwave-mobile-hands-on/*
13. *28 Spoons Later Your Brain Might be Eaten, First Brainwave-Controlled Zombie Game's Crawling to Your iPhone, https://neurogadget.net/2012/01/11/28-spoons-later-your-brain-might-be-eaten-first-brainwave-controlled-zombie-games-crawling-to-your-iphone/3444*
14. *EEG Games Top 5 List: Playing with Your Brainwaves, http://neurosky.com/2015/09/eeg-games-top-5-list-playing-with-your-brainwaves/*
15. *A BCI-responsive game environment in VR by Juris, http://openbci.com/community/a-bci-responsive-game-environment-in-vr-by-juris/*
16. *Mind-Controlled VR Game Coming to Arcades 2018, https://vrscout.com/news/mind-controlled-vr-game-arcades-neurable/*
17. *The First Mind-Controlled VR Game Will Hit Arcades in 2018, https://spectrum.ieee.org/semiconductors/devices/the-first-mindcontrolled-vr-game-will-hit-arcades-in-2018*

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