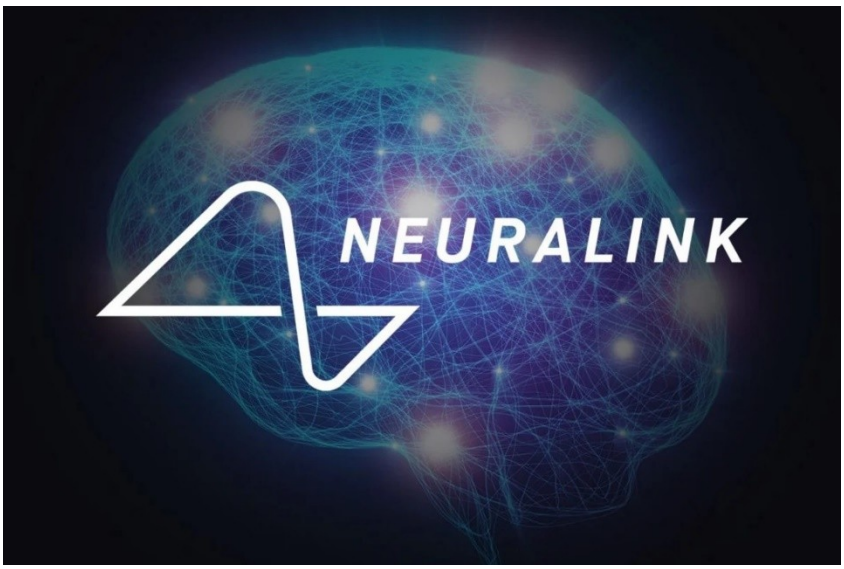
1. INTRODUCTION

Since 2017, Elon Musk's project Neuralink and brain-machine interfaces have received a lot of attention. Neuralink is a brain machine interface (BMI) company that creates devices designed to be implanted in human brains "to eventually improve memory and interface with computer systems". On August 28, 2020, billionaire entrepreneur Elon Musk presented his pig Gertrude and the chip implanted in the animal's brain. The chip retransmits Gertrude's neurological signals. From this information, a computer can predict at any time where each of Gertrude's members is, giving hope to restore mobility to paraplegic people. Elon Musk is brilliant at marketing his ideas on a large scale and creating enthusiasm and fascination for his various projects. Never short of vivid images, Elon Musk claimed that having the interface is comparable to have a smartwatch in your brain. Science expands and brings new technologies, which leads to benefits, but also threats, as society's relationships are reshaped. For this study, it was of interest to investigate Neuralink, BMIs, and transhumanism, which are both fascinating and frightening. Scientists need to ensure that the benefits are maximized while minimizing the threats. The fusion of human beings and machines naturally raises a plethora of ethical questions. Will a brain-machine interface redesign humanity? What are the impacts? This study is a literature review, followed by an evaluation of the impacts of brain-machine interfaces on humanity's future. Data types are mostly secondary qualitative data from peer-reviewed scientific papers, which provide a solid basis of knowledge. It gives a well-grounded foundation to my methodological choices. My personal evaluations are also supported by meta-models, such as the Spiral Dynamics.



1.Neuralink

1.1 DEFINITION

Neuralink is a brain chip, which is specifically called as Brain Machine Interface (BMI). The chip contains long and thin wires with electrodes and it also fitted correctly to removing the piece of skull. The

threads will detects neural signals and ultimately these transmitted by the link. It is used to communicate with machines and even control them. It helps to study and cure various medical problems

2. LITERATURE SURVEY

Neuralink was co-founded in 2016 by Elon Musk, Max Hodak and Paul Merolla. The group of initial hires consisted of experts in areas such as neuroscience, biochemistry and robotics. The trademark "Neuralink" was purchased from its previous owners in January 2017.

In April 2017, Neuralink announced that it was aiming to make devices to treat serious brain diseases in the short-term, with the eventual goal of human enhancement, sometimes called transhumanism. Musk had said his interest in the idea partly stemmed from the science fiction concept of "neural lace" in the fictional universe in The Culture, a series of 10 novels by Iain M. Banks.

Musk defined the neural lace as a "digital layer above the cortex" that would not necessarily imply extensive surgical insertion but ideally an implant through a vein or artery. He said the long-term goal is to achieve "symbiosis with artificial intelligence", which he perceives as an existential threat to humanity if it goes unchecked. He believes the device will be "something analogous to a video game, like a saved game situation, where you are able to resume and upload your last state" and "address brain injuries or spinal injuries and make up for whatever lost capacity somebody has with a chip."

As of 2020, Neuralink is headquartered in San Francisco's Mission District, sharing the Pioneer building with OpenAI, another company co-founded by Musk. Jared Birchall, the head of Musk's family office, was listed as CEO, CFO and president of Neuralink in 2018. As of September 2018, Musk was the majority owner of Neuralink but did not hold an executive position.

By August 2020, only three of the eight founding scientists remained at the company, according to an article by Stat News which reported that Neuralink had seen "years of internal conflict in which rushed timelines have clashed with the slow and incremental pace of science."

In April 2021, Neuralink demonstrated a monkey playing the game "Pong" using the Neuralink implant. While similar technology has existed since 2002, when a research group first demonstrated a monkey moving a computer cursor with neural signals, scientists acknowledged the engineering progress in making the implant wireless and increasing the number of implanted electrodes.

In May 2021, co-founder and President Max Hodak announced that he no longer works with the company. As of January 2022, of the eight cofounders, As we probably aware currently moving innovations which is Artificial Intelligence. While using man-made reasoning need to utilize robots, controlling robots it prompts colossal issues for people. So need to survive or control the issue and furthermore in some cases confronting issues to the mind in like feelings of anxiety, fervor all brain work.

3. NEURALINK

3.

Neuralink is a neurotechnology company which is enhancing by the Brain Machine Interfaces (BMI), founded by the ELON MUSK, launched in the year 2016 at San Francisco

Neuralink aim initially was to understand and treat brain disorders

It is building a technology that could be embedded in a person's brain, where it could both record brain activity and potentially stimulate it.

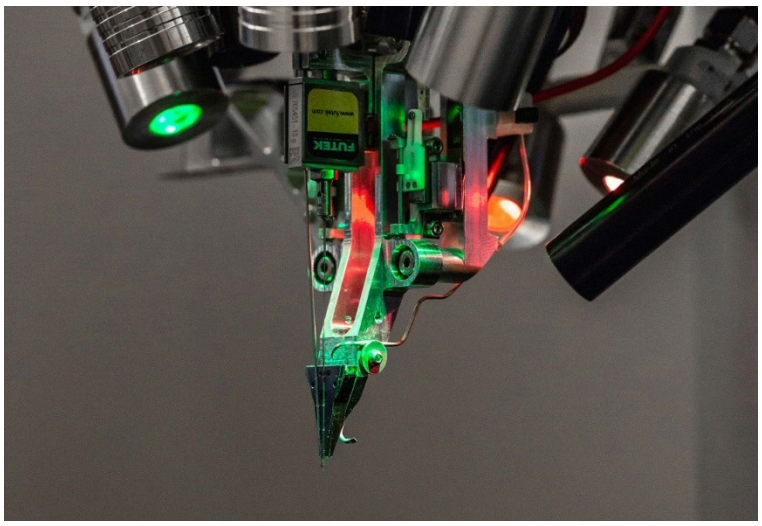
Neuralink is a device that will be surgically implanted into your brain and with it, you'll be able to communicate with machines and even control them. The Neuralink system is said to potentially provide treatment for Alzheimer's, paralysis, spine issues etc.

To any machine which is capable of reading the input from our brain Concept used is Brain Machine Interface (BMI) through which we can connect ourselves

3.1 HOW DOES NEURALINK BE INSTALLED?

3.1.1 Surgical Robot

Since we're talking about drilling a hole into your skull and inserting wires into your brain there are a lot of reservations among people. Musk has said that the procedure is complex and beyond the capabilities of even skilled human hands. Which is why Neuralink will be using its specially developed robots to carry out the quick and precise insertion of the device into the cortex. The company said it will work in accordance with the regulations by health ministries while carrying out the operation to ensure it is safe. The Neuralink robot will insert the module into your brain using a microscope and needles the size of 24 microns (a micron is one-millionth of a meter). These needles are so small that you can't easily spot them with the naked eye.



3.1.2 Loaded needle pincher cartridge

As per the company, there could be 10,000 electrodes inserted into the brain. The robot has been designed to ensure that the device is inserted into the brain without touching any veins or arteries. Each electrode will be inserted specifically bypassing any kind of blood vessel.

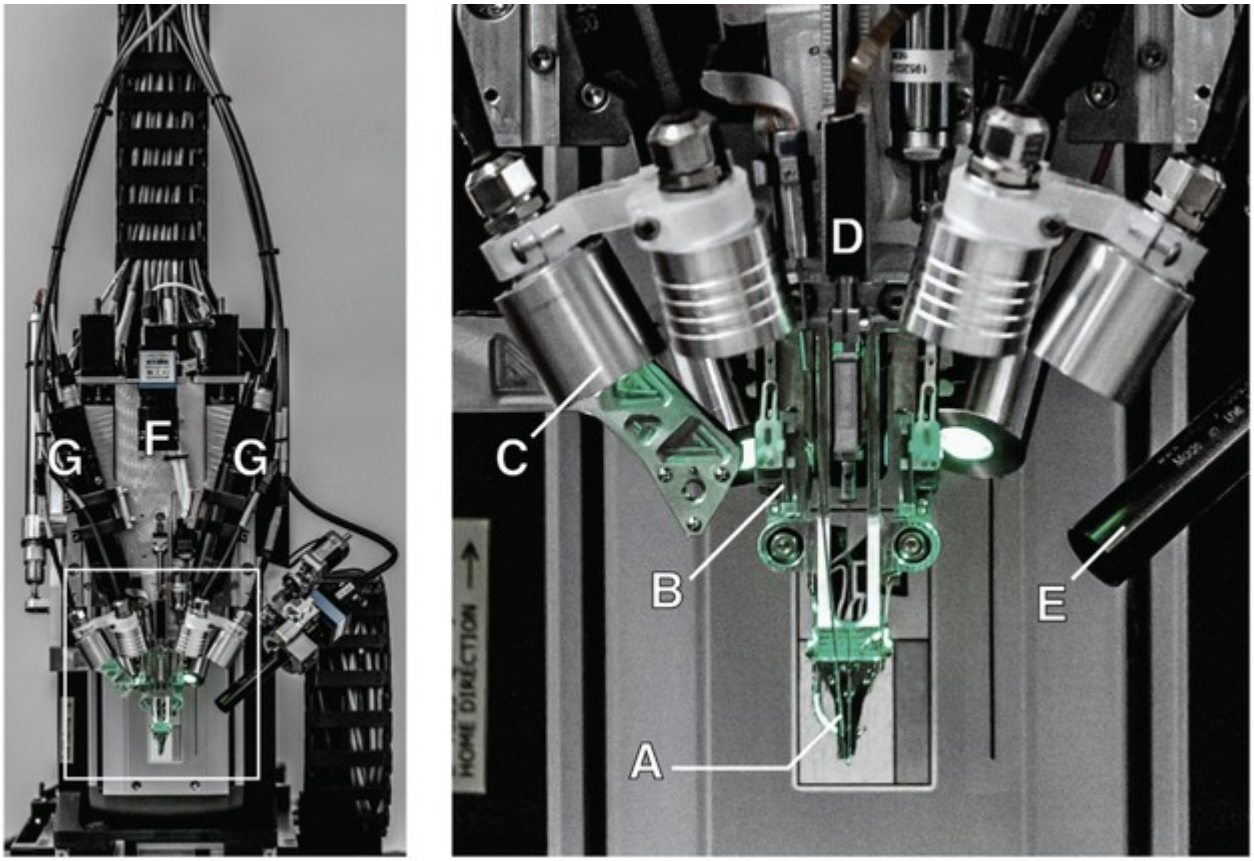
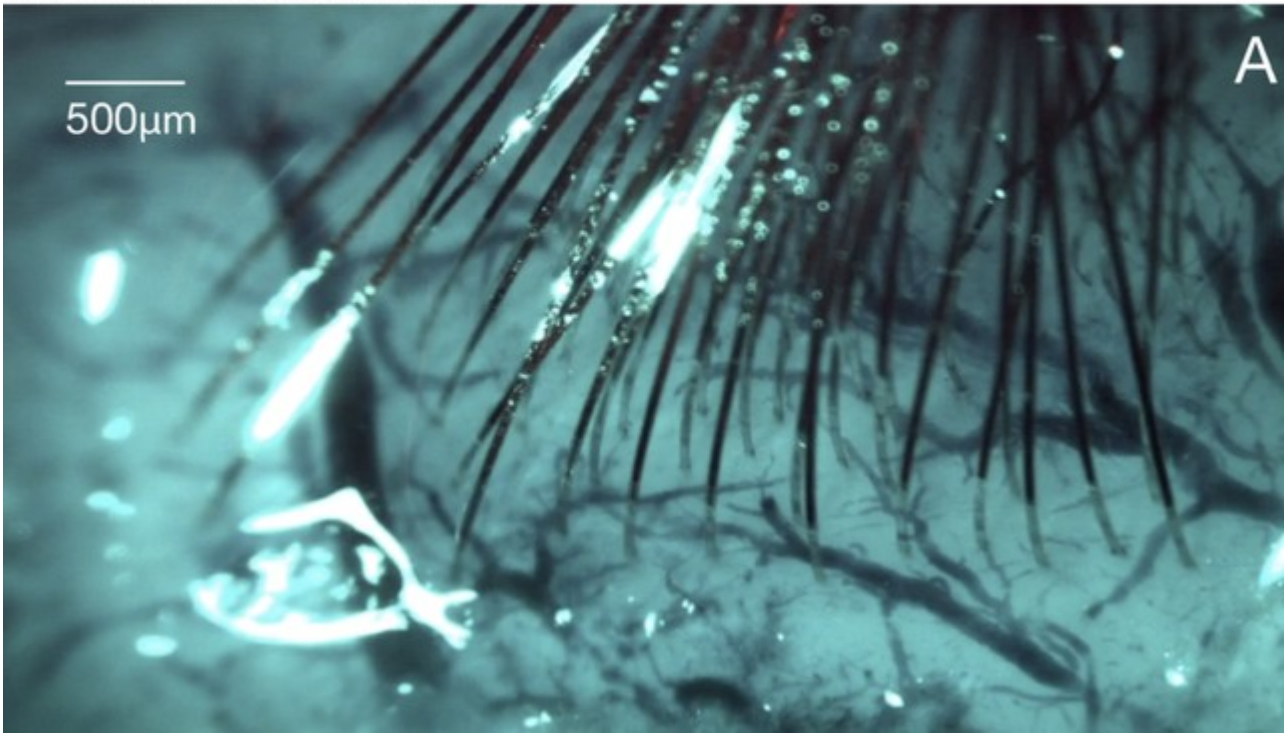


Figure 3: The robotic electrode inserter; enlarged view of the inserter-head shown in the inset. **A.** Loaded needle pincher cartridge. **B.** Low-force contact brain position sensor. **C.** Light modules with multiple independent wavelengths. **D.** Needle motor. **E.** One of four cameras focused on the needle during insertion. **F.** Camera with wide angle view of surgical field. **G.** Stereoscopic cameras.



3.1.3 Cortical surface with implanted threads

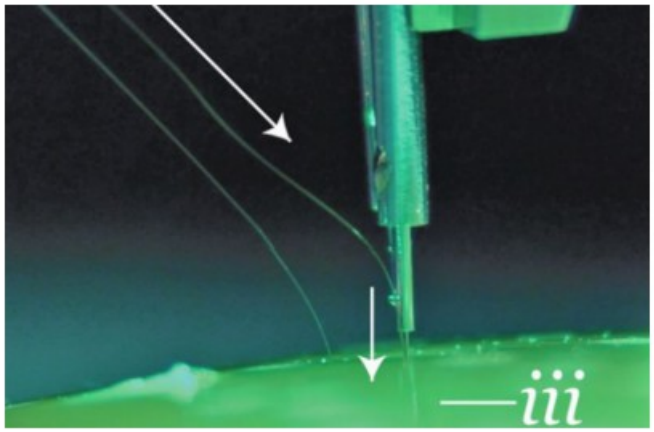


Figure 2: Needle penetrating tissue proxy [17]

3.1.4

Like artificial intelligence, the idea of inserting a device into the brain that would allow speedy communication between humans and computers veers quickly into science fantasy.

The company says surgeons would have to drill holes through the skull to implant the threads. But in the future, they hope to use a laser beam to pierce the skull with a series of tiny holes.

A stereoscope is a device for viewing a stereoscopic pair of separate images, depicting left-eye and right-eye views of the same scene, as a single three-dimensional image.

Robot

The "Robot" is designed with a sole purpose of inserting the threads in least invasive manner. The

Robot consists of seven parts-

a) Loaded needle pincher cartridge.

b) Low-force contact brain position sensor.

c) Light modules with multiple independent wavelengths.

d) Needle motor.

e) One of four cameras focused on the needle during insertion.

f) Camera with wide angle view of surgical field.

g) Stereoscopic3 cameras.

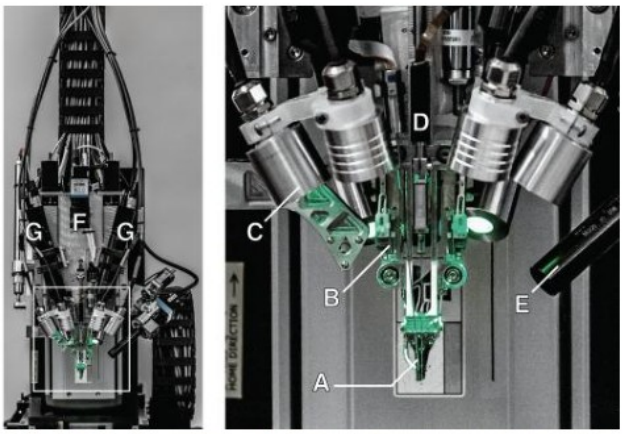


Figure 4: All the parts of the automatic Insertion Robot |Source: Neuralink

3.1.5

Neuralink has developed a robotic insertion approach for inserting flexible probes (or threads), allowing fast and reliable insertion of large numbers of threads targeted to avoid vasculature and record from dispersed brain regions.

For the insertion, the Robot has a “needle pincher” assembly which inserts the thread, stitches it and releases it rapidly.

To guide the needle, the Robot has four camera which are focused on the needle, the field of insertion, and stereoscopy.

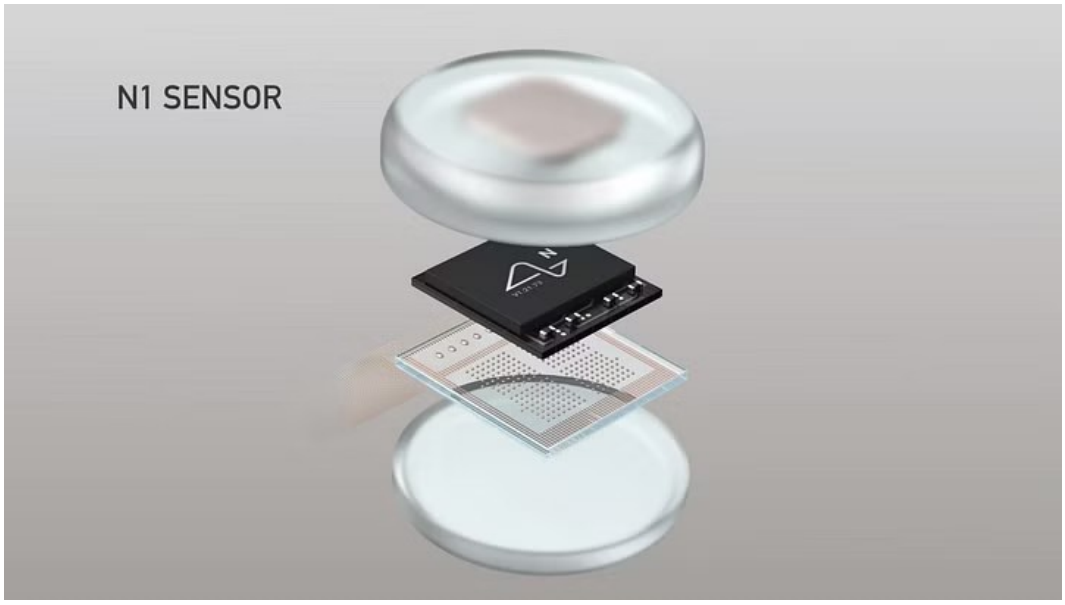
4. ARCHITECTURE/WORKING PRINCIPLE

4.1 How Does Neuralink Work?

Have you seen the Hollywood action flick The Matrix? Remember the scene where Neo (played by Keanu Reaves) learns martial arts just by loading a computer program into his brain?

Neuralink might not be able to teach you martial arts but it will be able to send and receive electrical signals through your brain to control machines.

4.1.1 N1 Chipset



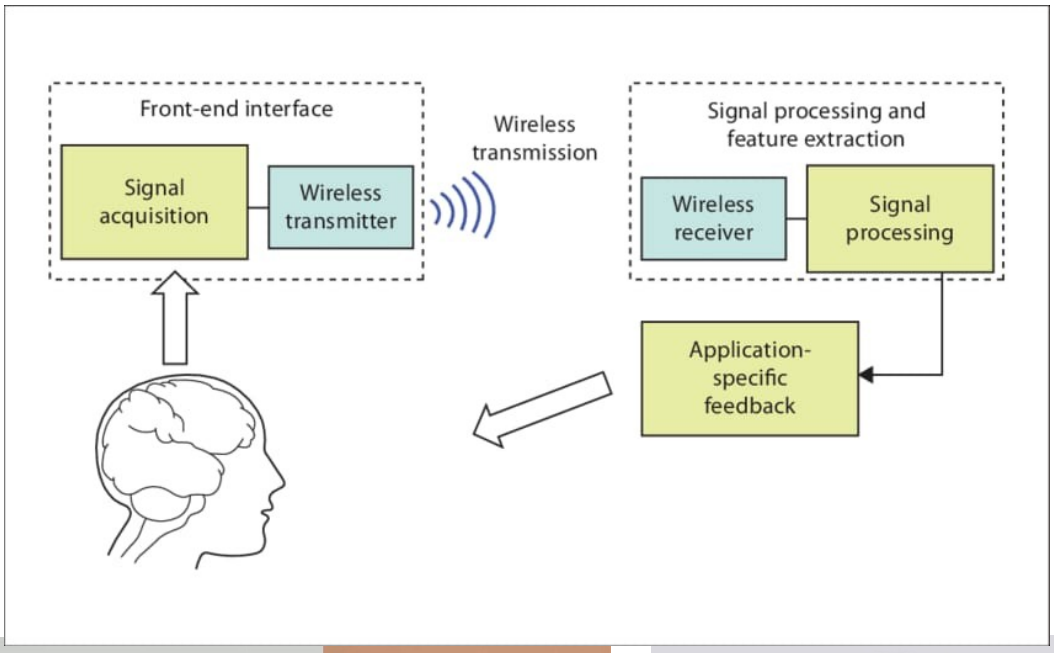
Right now, the company has said that you will be able to control basic devices like your smartphone, computer and maybe even type using thoughts.

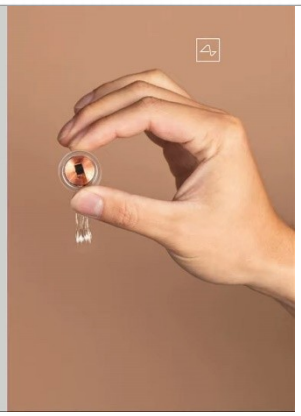
The sensor will be inside a casing that houses the wires and insulation for the module. (Photo: YouTube/Neuralink)

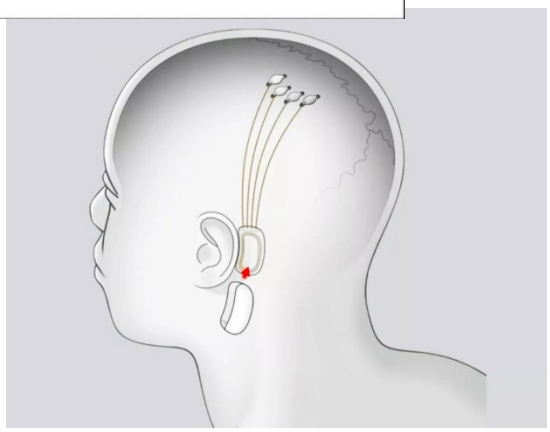
In order to understand how Neuralink works you must understand that your brain sends information to different parts of your body using neurons.

These neurons in your brain connect with each other to form a large network and communicate using chemical signals called neurotransmitters. This reaction generates an electric field and you can record these reactions by placing electrodes nearby.

4.1.2 BMI Representation







Working of the Neuralink is one of the best understanding of the science which is behind the human brain. The human consists of neurons which transmits signals to cells in the body by including muscle, nerve, gland and remaining neuron cells. Each neuron is consists of three parts called as the dendrite, the soma and the axon. Every part has its own functionality. The Dendrite are used to receive the signals. The soma processes signals. The axon transmits the signals to the remaining cells. The neurons which are connected to one another by the synapses which release the neurotransmitters. Electrodes are the part of the Neuralink which reads the electrical signals it produced by different neurons in the brain. Neuralink device is implanted directly in the brain. Because we are not able to detect accurately if the signals outside of the head. Neuralink probably used to operate encephalopathy. It is a connection between human brain and technology. It comes to people with paralysis which can easily operate computers and phones directly with the brain. The main aim is communicating with text or voice messages to help the people. Neuralink can also perform many other activities too like photographs and all.

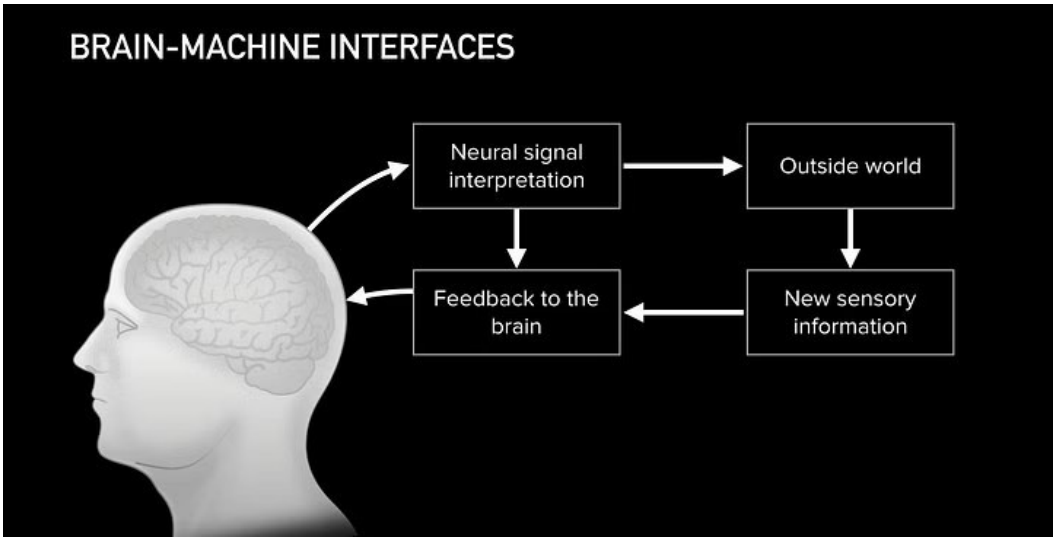
4.1.3 Neuralink device 4.1.4 Implantation of Neuralink device

Neuralink won't have any other option to show combative techniques yet it just actually want to convey and get electrical messages through mind to control the machines. Neuralink functions should comprehend that brain sends data to various pieces of body using neurons. The neurons in brain interface with one another to shape a huge arrange and impact utilizing compound signs which is called as synapses. These

response produces an electric field and also record the responses by setting a nodes. These node would be able comprehend the electrical sign in mind and also make an interpretation of them into a calculation that machine can pursue. This way Neuralink will actually want to understand opinion and discover a way to converse with machines without opening mouth. No need to call out Alexa. The objective N1 chip is to record and animate the electrical signals inside the brain. Here is the Option will acquire various abilities utilizing application.

4.2 Brain-Machine Interfaces:

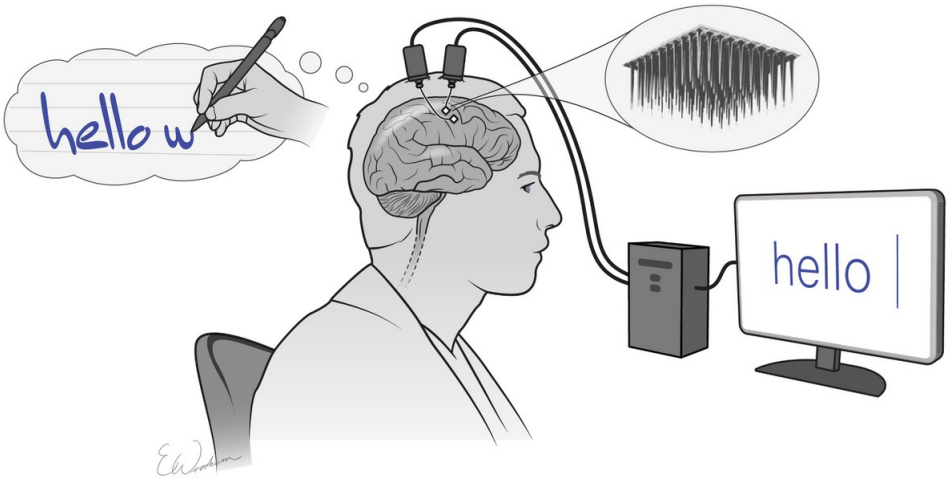
Generally, a brain-machine interface is a link between a brain and a machine. The first attempts to translate neuronal activity into commands to control external devices were made in monkeys in the 1960s. In the 1970s, electroencephalography (EEG) was used to link brain activity with computers directly. The term "brain-computer interface" appeared in the 1970s. Brain-machine interface research and its applications are considered as the most exciting interdisciplinary fields of science. Similar to computers' evolution, neural interfaces will become smaller and more powerful. Today, BMIs allow controlling a cursor on a screen. BMIs are particularly promising for neurorehabilitation of sensory and motor disabilities, neuro communication, and cognitive state evaluation. Furthermore, better neuronal activity analyses hold out hope for the use of BMIs daily in the future. BMIs can bring huge benefits to society, such as novel therapies, or social and cognitive enhancement.



4.2.1 Structural representation of BMI

Many people already benefit from medical BMIs. Generally, the main goal of BMIs is to repair and/or increase human performance. One could consider that the gap between human and machine needs to be reduced. Our brains are not prepared to deal with the considerable volume of information brought by pervasive technologies and the Internet of Things (IoT). In addition, the limits of personal and professional life will be increasingly blurred. Niforatos et al. affirm that ", our cognitive capacities cannot simply rely on natural evolution to keep up with the immense advancements in the field of Ubiquitous technologies, which remain largely uninformed about our cognitive states". Niforatos et al. have presented a software architecture for developing cognition-aware applications that adjust user presentation to user's current cognitive state. Generally, there is a will to increase human efficiency by reducing the human-machine gap.

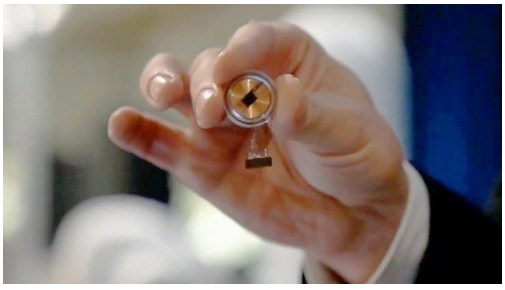
As the influence of modern computers grows alongside with our understanding of the human brain, we are moving closer to make some pretty spectacular science fiction into reality. For example, just imagine transmitting signals directly to someone's brain that would allow them to see, hear or feel specific sensory inputs, how much spectacular that would be. This means you have the potential of manipulating the machine or the computer with your own brain just by giving sensory inputs.



4.2.2 BCI Article

Development of a Brain-machine interface (BCI) could be the most important technological breakthrough in decades not just for the convenience of disabled people. Our brains are filled with neurons, individual nerve cells connected to one another through dendrites and axons. Each time we think, move, feel and remember something, our neurons are at work. Brain-Machine Interface research is an area of high public awareness. Videos on YouTube, as well as reported news in the media, indicates intense curiosity and interest in a field that hopefully one day soon will dramatically improve the lives of many disabled persons affected by a number of different diseases.

4.3 Neuralink:



4.3.1 Neuralink Chipset

Neuralink is a device that will be surgically implanted into your brain and with it, you'll be able to communicate with machines and even control them. It will also help study the electrical signals in the brain and arrive at solutions that can help cure various medical problems.

According to Elon Musk, the team is optimistic of introducing the technology by the end of 2020, although human trials have not yet started.

With Neuralink a chipset, called N1 chipset, will be installed in your skull which is 8mm in diameter and has multiple wires housing electrodes and insulation for the wires.

The size of a Neuralink link chip compared to the little finger of the hand.

These wires will be surgically placed inside your brain using a robot. As per the company, the wire is as thick as the neurons in your brain and thinner than a strand of hair at 100 micrometres. To compare, imagine the diameter of your hair, and then divide that diameter by ten.

You can place more than one device inside your skull.

Max Hodak, the president of Neuralink, says that you can place more than one device to target different sections of your brain.

4.4 How will it work?

Neuralink will work in five major steps-

• Creation of threads

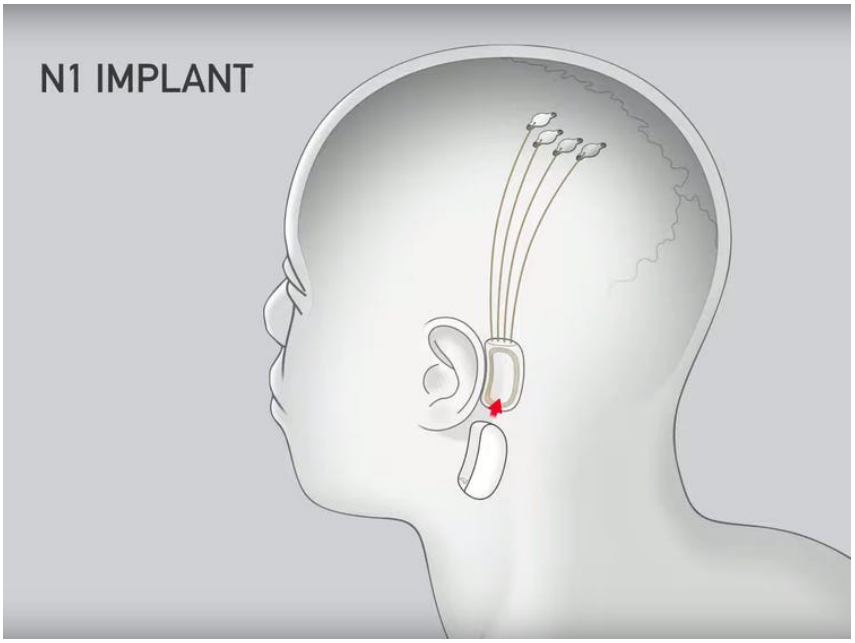
• Stitching of threads into the tissues

• Reading the signals and cleaning them

• Transmission of signals to amplifier

• Amplification of signals and transmission to the machine.

As of now the amplification and transmission of the signals happen via a USB-C port which is installed on a chip which is fitted into the brain of the subject (patient) along with a sensory device.

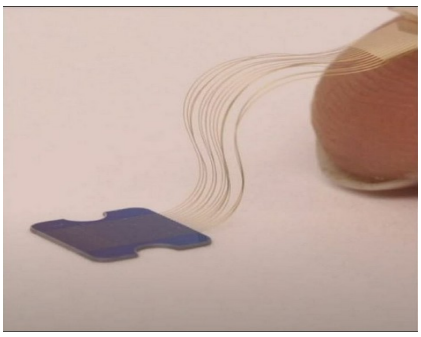


4.4.1 The chip sits behind the ear, while electrodes are threaded into the brain

4.5 Threads:

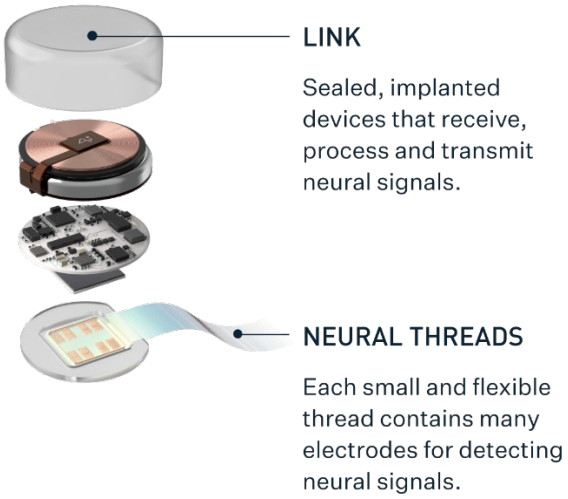
"Threads" are the ultra-thin, flexible polymer which will contain the electrodes and will transfer the information and signals to the transmitter. These threads (4-6 μm) are thinner than a human hair (17 μm) and have a length of 20 μm. An array will contain 96 threads which will have 32 independent electrodes which means that an array of threads contains 3,072 electrodes which makes transfer of high-volume of data possible with just one array. A human brain also shifts its shape which can cause damage to these threads, but the flexible nature of these threads makes them shift accordingly.

But with all the advantages, there lies a disadvantage i.e. these threads are very delicate and can break if not stitched carefully. Just for that purpose, Neuralink has created a Robot which can automatically insert the threads into the brain causing very less amount of damage to the tissues.



4.5.1 Threads are smaller than a finger |Source: Neuralink

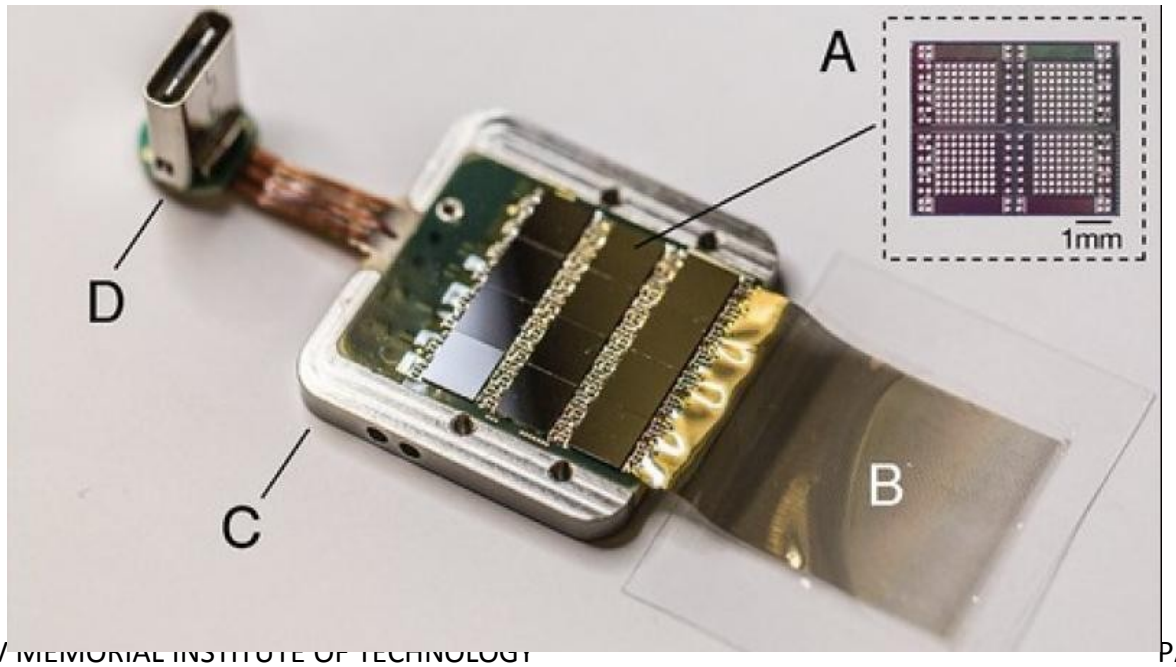
4.5.2 Internal structure of chipset



4.6 NEURAL THREAD:

- Each small and flexible thread contains many electrodes for detecting neural signals
- Thread thickness is nominally 4 to 6 pm.
- Typical thread length is approximately 20 mm.
- The main substrate and dielectric used in these probes is polyimide.
- Each array has 48 or 96 threads, each of those containing 32 independent electrodes.
- Metal film are at sub-micron resolution.

4.6.1Elon Musk unveils chip implant to make brain smarter



- Application specific integrated circuit (ASIC) is used.
- A number of ASICs are integrated into a standard printed circuit board (PCB).
- Each system consists of a field-programmable gate array (FPGA)
  - real-time temperature
  - Accelerometer
  - Magnetometer sensor
  - single USB-C connector
- The systems are packaged in titanium cases which are coated with parlene-c

4.7 CAN NEURALINK HACKED?

Musk cleared that currently high level hacking are severe but never having computers connection to brains which gives possibility for the hackers.

➢ Using brains itself not computers so it won't be able to hack.

➢ Brain linked into the computer AI that is BCI which leads to eliminate the barrier to the brain.

➢ Major evolution of hacking is via BCI but it won't.

➢ Musk broadly contrasted AI innovative work and gathering the evil presence. In this case constrain governments to administer severe powers over AI improvements.

➢ The Artificial intelligence could force a slave relationship, then could people turn into the multitude of robots. The man-made brainpower represents an existential danger to humankind.

5. ADVANTAGES

While the broad aim of developing such a brain-computer interface (BCI) is to allow humans to be competitive with AI, Musk wants Neuralink to solve immediate problems like the treatment of Parkinson's disease and brain ailments from depression and anxiety, dementia and even paralysis

It allows people to send and receive information between their brain and a computer wirelessly. One of the big benefits of this technology, according to the company, is, for example, a paralyzed person who has a Neuralink chip implanted could control a mouse and keyboard without ever removing their limbs.

It can be used to operate encephalopathy.

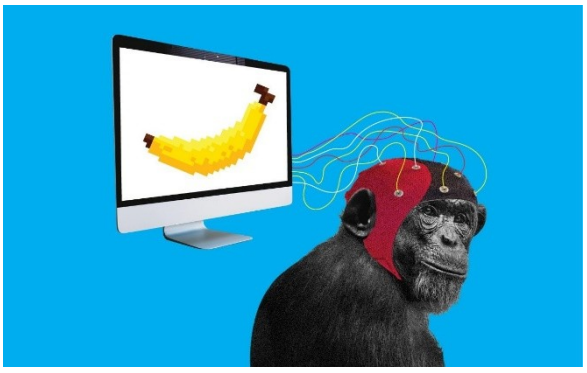
It could also be used as a connection between the technology and humans.

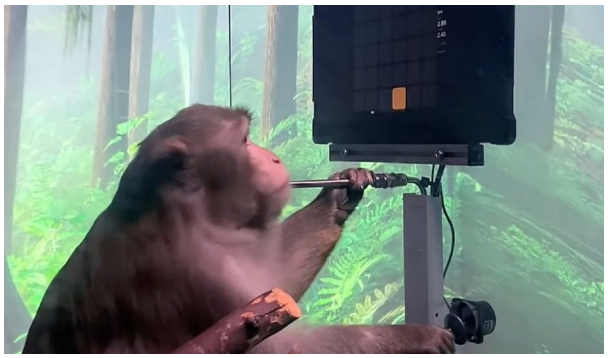
The people with paralysis may benefit by easily operating their phones directly through their brains.

It can also be used to draw pictures, take photographs etc.

This technology can be a breakthrough for various neuro disease patients and also brain disorders.

The world would be greatly ordered in case Elon Musk succeeds in this venture. Many patients hit by paralysis have also reached out to him asking him to use them as a subject of his study but Musk insists on first using it on monkeys.





5.1Elon Musk claims that his wired-up Neuralink monkey is happy and enjoys playing video

6. DISADVANTAGES

According to "bio-conservatives", the "Neuralink"' brain implant suppresses the frontier between natural/artificial, human/machine, living/no-living. Thus, the merger of human intelligence and artificial intelligence sought by Musk would be as much an artificialization of the human as a humanization of the machine

Invasion of privacy.

Unintended negative consequences of BCIs, such as addiction, anxiety, or depression.

Difficulty in removing or repairing BCIs if they malfunction.

Increased risk of brain injury or infection.

High cost of BCI technology.

Limited research on the long-term effects of BCIs.

7. APPLICATIONS

Neuralink is currently focused on developing medical devices. We believe these devices have the potential to help people with a wide range of injuries and neurological disorders, and we hope to develop treatments for many of these conditions in the coming years.

1. **Telepathy**

As per the lead chip designers at Neuralink, there is a possibility of telepathy potential as the next frontier for Neuralink.

The lead chip designers explain that it is an incredible effort to put thoughts into words and helps share the actual thoughts and interact appropriately.

So the words are a compressed form of our extensive thinking capabilities.

2. **Eliminate Pain**

In-house neurosurgeons present at the event told that pain is the basis of human sufferings.

Today there are several diseases causing pain, and the treatments are also painful.

In case, the pain can be reduced then the perception of ailments will alter considerably. Neuralink devices will play a significant role in it.

3. **Solve Mental Illnesses**

The device can ascend to more channels and regions. It goes deeper to resolve problems concerning fear, anxiety, and depression.

If you have a fear of heights, and still want to enjoy rock climbing. Musk suggests that fear might be helpful.

Every invention at its inception feels impossible but might be possible.

7.1 THERAPEUTIC APPLICATIONS

Medical applications are presented, along with a succinct and specific evaluation. We will devote a dedicated, more complete, and more global part to an evaluation.

Spinal Cord Injuries

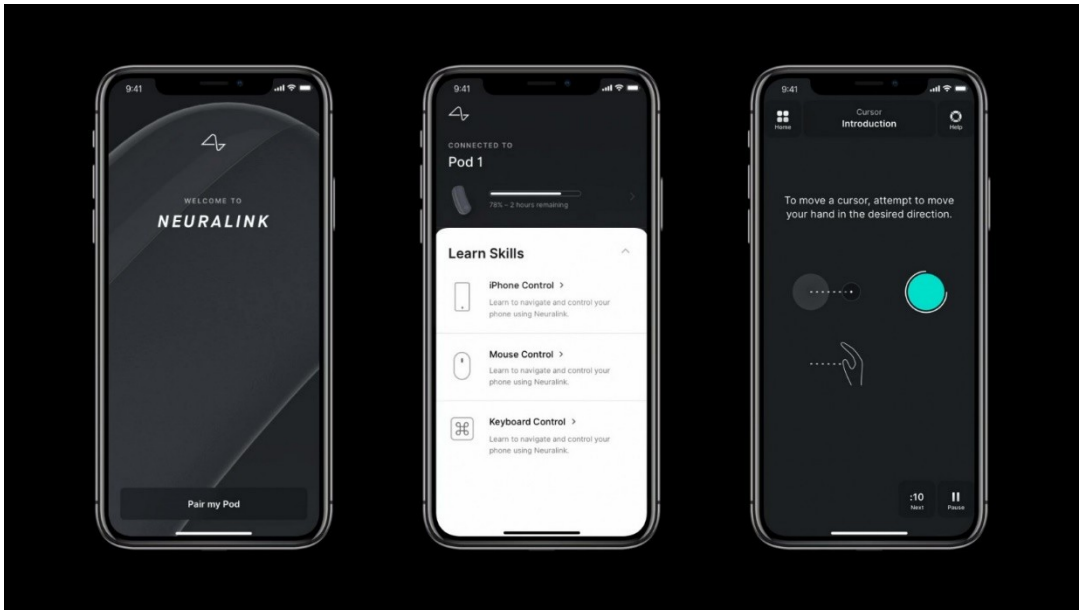
Spinal cord injury is the showcase application of Neuralink. The goal is to help people with spinal cord injury by allowing them to dexterously control a digital mouse and keyboard directly with their brains. Combined with spinal stimulation techniques, it is hoped that this approach could restore motor functions. Using BMIs to control a device by thought has been studied since the 1960s.

However, Musk's companies benefit from significant fundraising and extensive media coverage. On the website of Neuralink, the latest versions of the project are presented. The link is a sealed and implanted device that processes, stimulates, and transmits neural signals. The Neuralink app would allow controlling an iOS device, keyboard, and mouse directly with brain activity, just by thinking about it.

Other Applications

Generally, novel therapeutic possibilities are expected with BMIs. We will present some of them here.

Replacement of body parts. Bionic limbs are not new, and the classical approach does not need BMIs. A bionic limb, e.g., an arm, detects small naturally generated signals when the user flexes



7.1.1 Neuralink app their residual limb muscles.

The bionic limb is then able to convert them into hand movement. However, BMIs can push this approach a step further and allow to directly use "the brain to convey our intentions, rather than having an extra,

physical step translating those intentions to text, speech, or gestures". The interactions can be made easier, faster, and more natural.

Epilepsy: BCIs can be used to treat neurological disorders and reveal about brain functions. Karageorgos et al. have presented HALO (Hardware Architecture for Low-power BCIs), an architecture for implantable BCIs, that allows the treatment of disorders, such as epilepsy. HALO also records/processes data that can be used for a better understanding of the brain. Epilepsy is characterized by epileptic seizures defined by uncontrolled and excessive electrical activity of neurons. Neuronal signals are processed to predict seizures. When an increase in brain excitation occurs, "the brain needs inhibitory synapses to tone down and regulate the activity of other cells". BCIs then electrically stimulate neurons to mitigate the severity of the seizures. However, the time between seizure onset and stimulation must be very short, i.e., tens of milliseconds. Also, low-power hardware is needed for a safe and chronic implantation. HALO is inspired by previous approaches but offers higher bandwidth brain communication in real time at low-power. Non-invasive approaches can also be considered, such as tDCS and TMS

Parkinson:

Parkinson, as well as epilepsy, can be treated by deep brain stimulation (DBS). DBS belongs to invasive BMIs. Surgery is required to implant a thin electrode wire in the part of the brain responsible for abnormal movement. A second surgical intervention is then necessary to implant an impulse generator battery (IPG) in the abdomen or under the collarbone. The IPG can then give electrical impulses to the brain to help control some motor symptoms.

Autism:

In recent years, important funding has been allocated to the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) to understand better the origins of cognition and other brain activities. It is hoped that more effective treatments can be found for conditions like autism and mood disorders. With the TMS approach we were able to show an improvement in social skills in people with autism.

Depression:

Depression is the most common mental health condition. About one-third of cases of depression are treatment resistant. BMI therapies are regarded as hope for people that drugs have failed to treat. While drugs could be ineffective because they affect the whole body, BMIs can precisely target relevant regions of the brain. Mental health medications have side effects, such as weight gain and decreased libido. BMIs can have side-effects as well, but they might be less severe than drugs

Diagnosis of Brain Diseases:

In addition, brain diseases that promote dysfunction of the synaptic communication system may be better diagnosed with BMIs [27]. Generally, BMIs can be viewed as alternatives or competing approaches to traditional medicine in specific areas. This trend is expected to intensify in the future.

8. SUCCESSFUL EXPERIMENT

So recently Elon musk make an experiment by the monkey on April 19, 2021. Only surgical robot make a chip inside the brain. A coin-sized disc which is called a Link implanted by a surgical robot into the pagers brain, here it connecting thousands of micro threads from the chip to neurons for controlling motion.

➢ The nine-year old male monkey, named as a pager which has a Neuralink embedded in the 2 sides of its brain.

➢ Now Neuralink is creating Bluetooth -empowered implantable chips which can communicate with PCs by using a little collector and these innovation proved by pigs experiment.

➢ Pager moves the onscreen cursor by using joystick. Enjoying with banana after ping pong game

➢ Two Neuralink chips record the brain activity via in excess of 2,000 minuscule terminals embedded in pagers engine cortex, which controls hand and arm developments.

➢ Neuralink totally takes care of the data from monkey's neurons into a decoder, it would be used to foresee pagers expected hand developments and model the connection between mind action and joystick developments.

➢ After some period of time yield from the decoder used to move the cursor rather than a pager controlling the joystick.

8.Enjoying with banana after ping pong game

➢ Ultimately Joystick is seperated and pager is shown moving the cursor by using the mind.

➢ The principal of the chip will empower somebody with loss of motion to use a cell phone with their brain quicker than somebody using thumbs.

➢ This is the Neuralink manner empowering, after makes added the paraplegics to walk once more.

9. CONCLUSION

The Neuralink implant and its potential for neuro amplification and treatment modalities bring a hopeful advancements to enhancing the people lives with spinal cord injuries, neurodegenerative disorders, and also neurobiological deficiencies. Anyways Neuralink technology and early testing results seems promising, the necessity of neurosurgical robots to implant the devices magnitude of electrodes raises the wellbeing and training concerns. Until this point no one but this makes regards to the safety and adequacy of the device. Also clinical preliminary are central for Neuralink to be acknowledged and incorporated into the front line of future neurosurgical practice.

Neuralink has developed advanced solution to existing medical problems.

It will surely create a well aligned future.

Implantation will be done in less than an hour and leave hospital the same day.

Neuralink is still at an early stage (it's at version 0.9).

We have no current idea of how much the brain chips will cost..

10. REFERENCES

[1] Hassan Akbari, Bahar Khalighinejad, Jose L. Herrero, Ashesh D. Mehta, and Nima Mesgarani. 2018. Towards reconstructing intelligible speech from the human auditory cortex. (2018). https://doi.org/10.1101/350124

[2] Thomas Baldwin, Jonathan Cole, Maria Fitzgerald, Jenny Kitzinger, Graeme Laurie, Jack Price, Nikolas Rose, Steven Rose, Ilina Singh, Vincent Walsh, and Kevin Warwick. 2013. Novel Neurotechnologies: Intervening in the Brain. Nuffield Council on Bioethics.

[3] DE Beck and CC Cowan. 1996. Spiral dynamics: mastering values, leadership, and change. Blackwell Business.

[4] Oğuz 'Oz' Buruk, Oğuzhan Özcan, Gökçe Elif Baykal, Tilbe Göksun, Selçuk Acar, Güler Akduman, Mehmet Aydın Baytaş, Ceylan Beşevli, Joe Best, Aykut Coşkun, Hüseyin Uğur Genç, A. Baki Kocaballi, Samuli Laato, Cássia Mota, Konstantinos Papangelis, Marigo Raftopoulos, Richard Ramchurn, Juan Sádaba, Mattia Thibault, Annika Wolff, and Mert Yildiz. 2020. Children in 2077: Designing Children's Technologies in the Age of Transhumanism. In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (Honolulu, HI, USA) (CHI EA '20). Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3334480.3381821

[5] Laura Cabrera. 2012. Social Enhancement: Re-Thinking the Role of Emerging Technologies. In Proceedings of the 2012 Virtual Reality International Conference (Laval, France) (VRIC '12). Association for Computing Machinery, New York, NY, USA, Article 7, 6 pages. https://doi.org/10.1145/2331714.2331723

[6] Tommaso Carella, Matteo De Silvestri, Mary Finedore, Isaac Haniff, and Hananeh Esmailbeigi. 2018. Emotion Recognition for Brain Machine Interface: Non-linear Spectral Analysis of EEG Signals Using Empirical Mode Decomposition. 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (2018). https://doi.org/10.1109/embc.2018.8512228

[7] Liam Drew. 2019. The ethics of brain–computer interfaces. Nature 571, 7766 (2019). https://doi.org/10.1038/d41586-019-02214-2

[8] Ragnar Fjelland. 2020. Why general artificial intelligence will not be realized. Humanities and Social Sciences Communications 7, 1 (2020). https://doi.org/10. 1057/s41599-020-0494-4