A Wireless approach towards the Neuralink Technology

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Abstract

This paper raises three questions regarding to the attribution and intentions to the Neuralink technology and brain-machine interface. The first one is whether Neuralink technology can be completely wireless. If it does this raises a second question: Whether it is safe from Cyber security threats and misuse? Both of these questions are empirical, and we author's will try out to make our research and evidence sufficient to answer them. Now if we assume that the answers to both questions is affirmative, a third and more important question arises if machines and chips start controlling human mind will it be worthy for us to trust machines. The paper will discuss the use of Brain-Machine Interface, Artificial Intelligence and Neural Network to achieve symbiosis with AI along with the company that is making all this possible, Neuralink, which is an Elon Musk start-up which has a vision to cure the insecurity among us and also if this particular technology can be completely wireless.

Keywords: Artificial Intelligence, Neuralink, Brain-Machine Interface, Neural Network, Wireless Neuralink, Neural Lace.

Introduction

In 1943, a neurologist Warren McCulloch and a young mathematician Walter Pitts wrote a paper on how neurons might work; they modelled a simple neural network with electrical circuits [1]. In 1957, John von Neumann suggested simple neuron functions by using telegraph relays and vacuum tubes. Recently, the studies related to neural networks have taken a sudden leap and it is being used to heal a person’s brainly disorders. Neuralink has gone out of the bounds of current studies in neural network and has started to not just cure the patients but also connect them to digital devices and help them use these devices without the need of using any of their body parts.[1]

About Neuralink

Neuralink is a gadget that will be surgically inserted into the brain using robotics by neurosurgeons. In this procedure, a chipset called the link is implanted in the skull. It has a number of insulated wires connected from the electrodes that are used in the process.[2]

Figure 1: The Neuralink Logo |Source: Wikipedia

Brain-Machine Interface (BMI)

A brain-computer interface (BCI) is a computer-based system that acquires brain signals, analyses them, and translates them into commands that are relayed to an output device to carry out a desired action. In principle, any type of brain signal could be used to control a BCI system. Brain-Machine Interface (BMI) or Brain to Machine

Interface (B2M) is an interface through which we can connect ourselves to any machine which is capable of reading the inputs from our brain Brain-Machine Interfaces hold the power to help people with a wide range of clinical disorders such as dis-functional sensory and motor functions [12]. BMI hasn't been widely popular with clinical disorders as they had a modest number of channels to transfer signals but Neuralink has taken its first step into creating a scalable high-bandwidth channel to transfer the signals using arrays of threads and electrodes.[12]

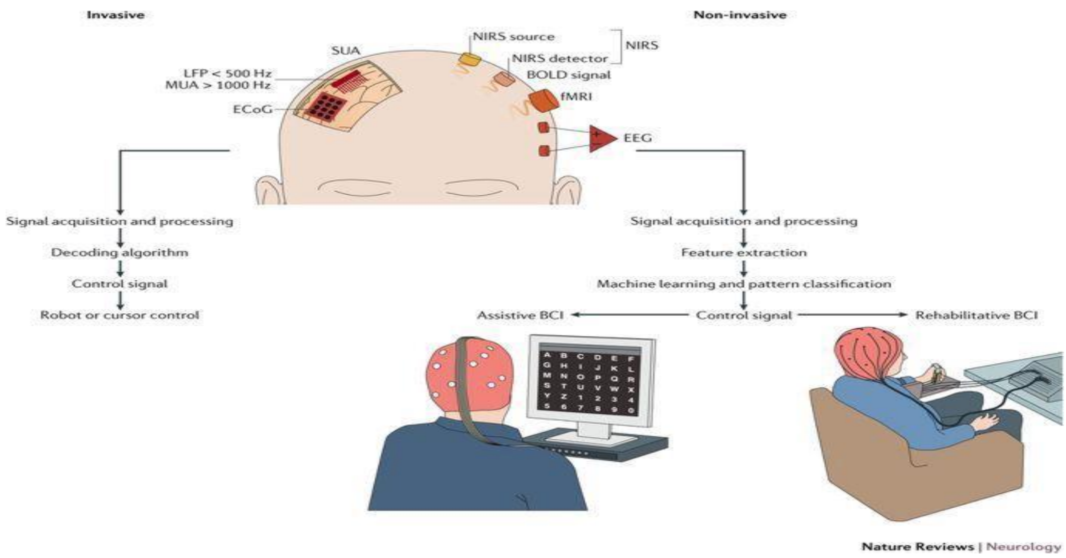

Figure 2: The working of the Brain Machine Interface|Source: Google Chrome

Natural Neural Network

How our brain works is quite interesting. Neurons are like the transport system for our thoughts and actions. Everything we feel, see, sense, touch, taste and think goes through Neurons for further processing. There is an estimate of 100 billion neurons in a human brain which govern the working of the brain.[4] Neurons consists of dendrites, cell body (known as Soma) which contains the nucleus and axon. Axon of one neuron is connected with Dendrite of another neuron through Synapsis which contains Neurotransmitters. The neurotransmitters are triggered by electrostatic impulse known as the Action Potential. When the right kind of impulse is sent through the synapses, a chain reaction is initiated.[10]

Your nervous system uses specialized cells called neurons to send signals, or messages, all over your body. These electrical signals travel between your brain, skin, organs, glands and muscles. The messages help you move your limbs and feel sensations, such as pain.[1]

The four main functions of the nervous system are:

- Control of body's internal environment to maintain 'homeostasis' An example of this is the regulation of body temperature.
- Programming of spinal cord reflexes. An example of this is the stretch reflex.
- Memory and learning.
- Voluntary control of movement.

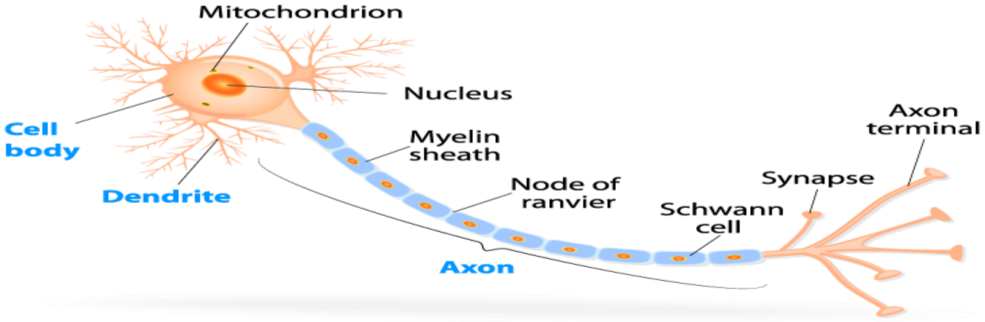

Figure 3: Neuron and Synapse|Source: Biological Neural Network

How Neuralink will use neurons?

Neuralink will setup electrodes which will read those impulses, amplify them and send them to a machine which will then work accordingly. These electrodes support writing also which can help in treatment of brainly disorders.[13]

Structure of a Neuralink chip

What exactly is a Neuralink chip?

Neuralink is Musk's neural interface technology company. It's developing a device that would be embedded in a person's brain, where it would record brain activity and potentially stimulate it. Musk has compared the technology to a "Fitbit in your skull."[7]

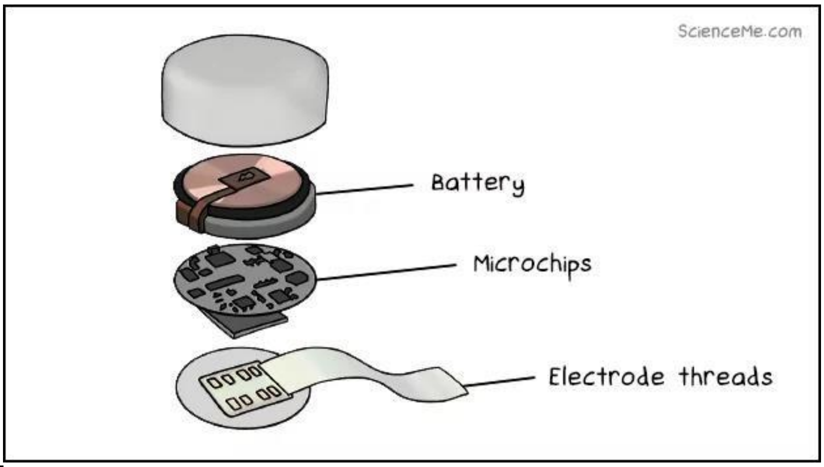

Figure 4: Diagrammatic representation of a Neuralink Chip|Source: Neuralink Official Page

Battery

The probes, composed mostly of polyimide, a biocompatible material, with a thin gold or platinum conductor, are inserted into the brain through an automated process performed by a surgical robot.[6] The difference that the N1 has with Neuralink, it's fully implantable, it is battery-powered, it is wireless. Computers need power, and Neuralink's in-skull chip gets it by charging wirelessly through the skin, Musk said.29-Aug-2020

Microchips

What Is a Microchip? A microchip is a radio-frequency identification transponder that carries a unique identification number, and is roughly the size of a grain of rice. When the microchip is scanned by a vet or shelter, it transmits the ID number. There's no battery, no power required, and no moving parts.[11]

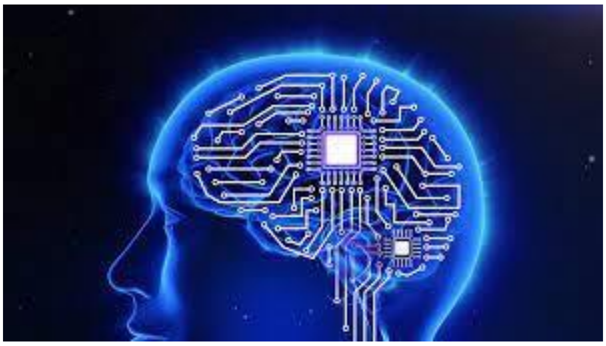

Figure 5: Brain Chip Implementation in a Human Brain

CHARGER

Compact inductive charger wirelessly connects to the implant to charge the battery from the outside.[12]

Threads

"Threads" are the ultra-thin, flexible polymer which will contain the electrodes and will transfer the information and signals to the transmitter.[6] 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 highvolume of data possible with just one array.[1] 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. We're aiming to design a fully implantable, cosmetically invisible brain-computer interface to let you control a computer or mobile device anywhere you go.[12]

Micron-scale threads would be inserted into areas of the brain that control movement. Each thread contains many electrodes and connects them to an implant called the "Link."[1]

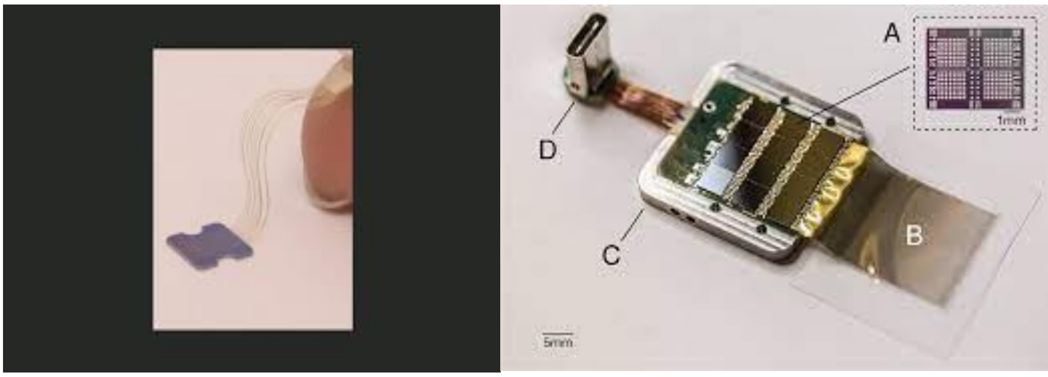

Figure 7: Sensor device: A- ASIC, B-Threads, C- Titanium enclosure (without lid), D- USB-C port for power and data transmission |Source: Neuralink

Robot

The “Robot” is designed with a sole purpose of inserting the threads in least invasive manner. The Robot consists of seven parts.[1]

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. (Cameras which create an illusion of depth when viewed on appropriate displays)

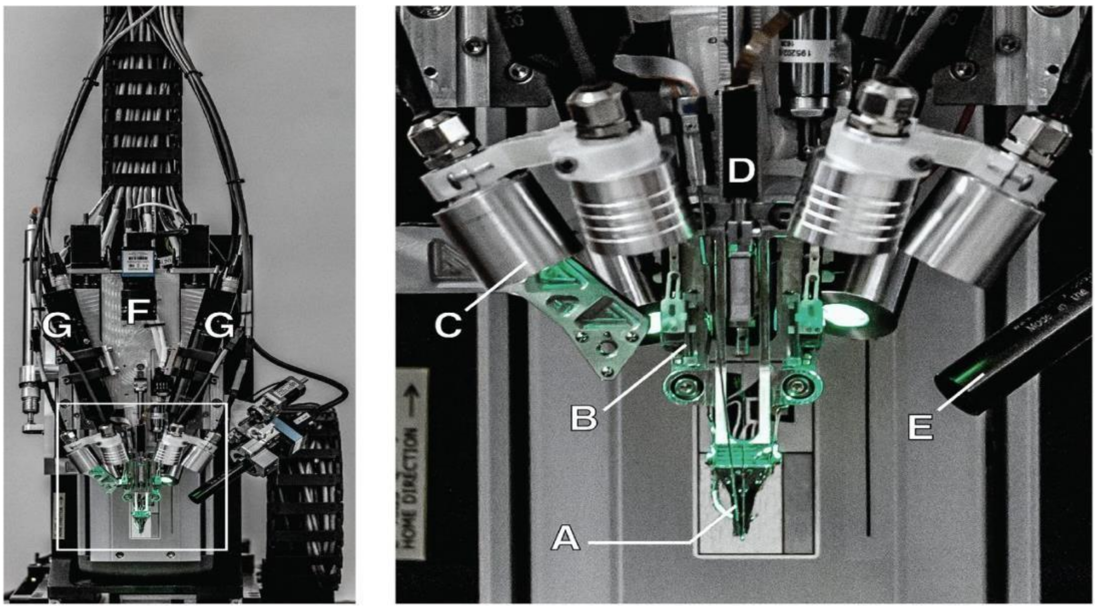

Figure8: All the parts of the automatic Insertion Robot |Source: Neuralink

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. [1] For the insertion, the Robot has a "needle pincher" assembly which inserts the thread, stitches it and releases it rapidly.

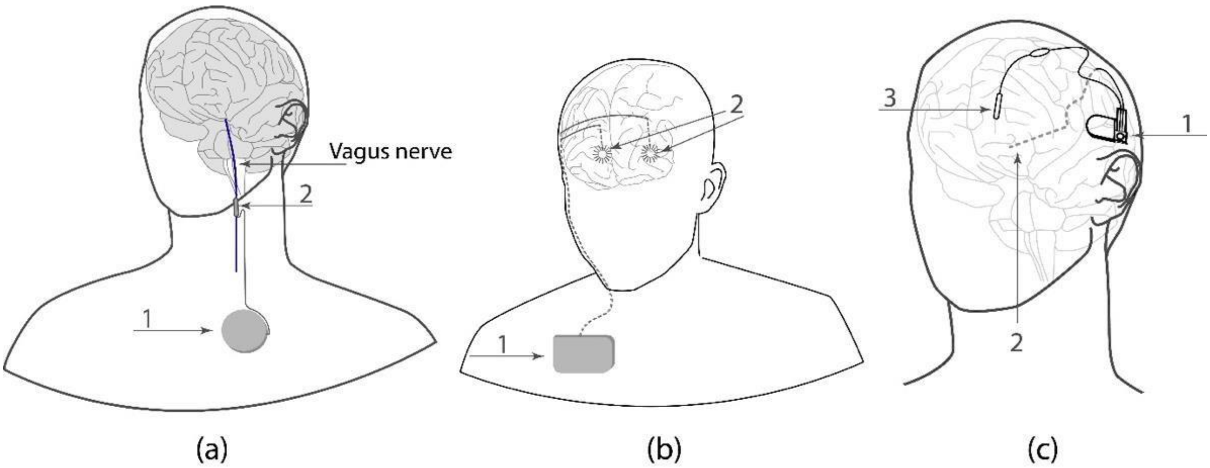

Figure 9. The schematic illustration of brain-machine interface prototypes to suppress epileptic seizures using electrical stimulation. (a) Vagus nerve stimulator containing (1) an implantable pulse generator and (2) a stimulation lead. (b) Stimulator of the anterior nucleus of the thalamus in epilepsy containing (1) an implantable pulse generator and (2) intracranial electrodes placed in the anterior thalamic nuclei bilaterally. (c) Responsive neurostimulator containing (1) implanted deep electrodes for recording electroencephalography signals, (2) an implantable device for processing electroencephalography signals from electrodes, and (3) strip electrodes receiving an electrical stimulation signal generated by the device to stop seizures|Source:[6]

The chip Neuralink is developing is about the size of a coin, and would be embedded in a patients' skull. From the chip an array of tiny wires, each roughly 20 times thinner than a human hair, fan out into the patient's brain.[14]

The wires are equipped with 1,024 electrodes which are able to both monitor brain activity and, theoretically, electrically stimulate the brain. This data is all transmitted wirelessly via the chip to computers where it can be studied by researchers.[14]

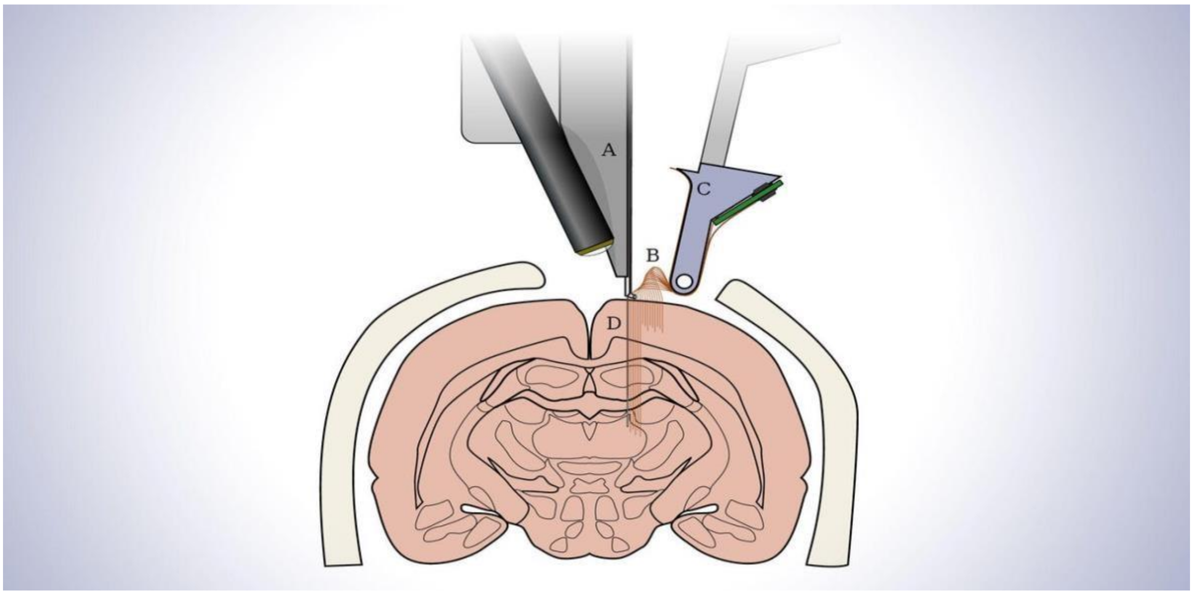

Figure 10: Surgical Implementation of Neuralink|Source: Implant od Brain Chips

One possible approach involves an array of flexible probes inserted into the brain with a system resembling a sewing machine, an idea described by researchers reportedly associated with Neuralink. That's a lot cruder than the organically grown nanotechnological neural laces you'll find inside the brains of sci-fi characters, but it's remarkable that the technology is even under discussion. Neuralink has developed an Application-Specific Integrated Circuit (ASIC) to create a 1,536-channel recording system. This system consists of 256 amplifiers capable of being individually programmed ("analog pixels"), analogtodigital converters within the chip ("ADCs") and a peripheral circuit control to serialize the digitized information obtained.[9] It aims to convert information obtained from neurons into an understandable binary code in order to achieve greater understanding of brain function and the ability to stimulate these neurons back. With the present technology, electrodes are still too big to record the firing of individual neurons, so they can record only the firing of a group of neurons; Neuralink representatives believe this issue might get mitigated algorithmically, but it is computationally expensive and does not produce exact results.[10]

In July 2020, according to Musk, Neuralink obtained a FDA breakthrough device designation which allows limited human testing under the FDA guidelines for medical devices.

Author's Research & Solving the Disadvantages

Whether Neuralink technology can be completely wireless ?

An example of a Fitbit

A Fitbit is an activity tracker worn on the wrist just like a watch. It tracks your day-to-day activity automatically across a range of exercises like walking, running, swimming, cycling, or gym activity, and then stores this information in an easily-accessible app on your phone. Fitbit trackers are equipped with photoplethysmography sensors, which is the small green light you see blinking on the tracker's underside. This light essentially monitors the volume of blood in your wrist and uses that to calculate the number of heartbeats in a minute. How does my Fitbit device count steps taken? Fitbit devices use a 3-axis accelerometer to count your steps. This sensor also allows your device to determine the frequency, duration, intensity, and patterns of your movement.[10]

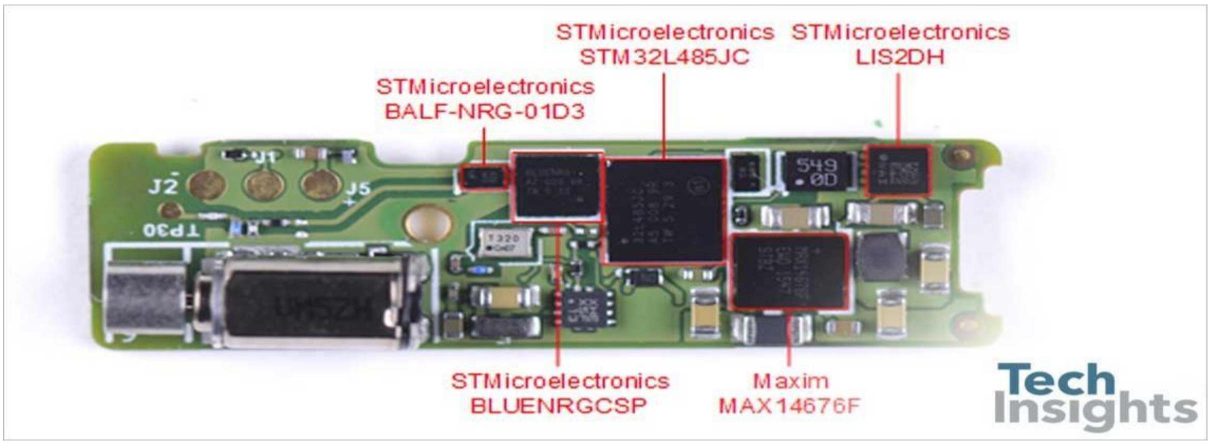

Figure 11: A Diagrammatic Representation of a Fitbit|Source: TechInsights

The Actual Research

A group of KAIST researchers and collaborators have engineered a tiny brain implant that can be wirelessly recharged from outside the body to control brain circuits for long periods of time without battery replacement. The device is constructed of ultra-soft and bio-compliant polymers to help provide long-term compatibility with tissue. Geared with micrometre-sized LEDs (equivalent to the size of a grain of salt) mounted on ultrathin probes (the thickness of a human hair), it can wirelessly manipulate target neurons in the deep brain using light. This study, led by Professor Jae-Woong Jeong, is a step forward from the wireless head-mounted implant neural device he developed in 2019. That previous version could indefinitely deliver multiple drugs and light stimulation treatment wirelessly by using a smartphone.[5]

For the new upgraded version, the research team came up with a fully implantable, soft optoelectronic system that can be remotely and selectively controlled by a smartphone. This research was published on January 22, 2021 in *Nature Communications*.[5]

The new wireless charging technology addresses the limitations of current brain implants.[14] Wireless implantable device technologies have recently become popular as alternatives to conventional tethered implants, because they help minimize stress and inflammation in freelymoving animals during brain studies, which in turn enhance the lifetime of the devices. However, such devices require either intermittent surgeries to replace discharged batteries, or special and bulky wireless power setups, which limit experimental options as well as the scalability of animal experiments.

"This powerful device eliminates the need for additional painful surgeries to replace an exhausted battery in the implant, allowing seamless chronic neuromodulation," said Professor Jeong. "We believe that the same basic technology can be applied to various types of implants, including deep brain stimulators, and cardiac and gastric pacemakers, to reduce the burden on patients for long-term use within the body."[5]

To enable wireless battery charging and controls, researchers developed a tiny circuit that integrates a wireless energy harvester with a coil antenna and a Bluetooth low-energy chip. An alternating magnetic field can harmlessly penetrate through tissue, and generate electricity inside the device to charge the battery. Then the battery-powered Bluetooth implant delivers programmable patterns of light to brain cells using an "easy-to-use" smartphone app for real-time brain control.[5]

"This device can be operated anywhere and anytime to manipulate neural circuits, which makes it a highly versatile tool for investigating brain functions," said lead author Choong Yeon Kim, a researcher at KAIST.

Neuroscientists successfully tested these implants in rats and demonstrated their ability to suppress cocaine-induced behaviour after the rats were injected with cocaine. This was achieved by precise light stimulation of relevant target neurons in their brains using the smartphone-controlled LEDs.[14] Furthermore, the battery in the implants could be repeatedly recharged while the rats were behaving freely, thus minimizing any physical interruption to the experiments.

Whether it is safe from Cyber security threats and misuse?

Almost anything can be hacked. So, when Neuralink announced that it is pursuing human trials for its brain-machine interface, its security was always going to fall under scrutiny.

The company, founded by Elon Musk in 2016, aims to help people with "a wide range of clinical disorders", such as those who have been paralysed, by allowing them to interact with a computer using their mind via a brain implant.[8]
Such brain-machine interfaces have been around since the mid-2000s, albeit with varying degrees of sophistication. But Neuralink appears to have built on existing research in the field, bringing in leading neuroscientists to work in relative secrecy until Musk revealed Nueralink's progress during a recent presentation to the California Academy of Sciences.During this presentation, Neuralink said it is looking to start human trials in 2020, something that is likely to face many hurdles. Beyond the technological difficulties, it will need to convince regulators such as the US Food and Drug Administration (FDA) that the device is safe for human use.Part of that will include Neuralink's security, the details of which – so far at least – are scarce. In its white paper, there isn't a single mention of the word 'security': the focus is on the how, not the what if.[9]
What we do know, thanks to Neuralink's president, Max Hodak, is that "it'll be controlled by an iPhone app"."You won't have to go to a doctor's office and have them have a programmer configure it," he said during the presentation.We also know that it will use Bluetooth to connect to your device. And there will be a battery and radio worn behind the ear, rather than those components being in the implant.[8]

"The interface to the chip is wireless, so you have no wires poking out of your head. That's very important," said Musk.
Well, It's not confirmed yet. Since neuralink is just building prototypes that are tested on animals only. Neuralink has yet to be tested on humans. So in theory there is no definitive answer. Since, People all over the internet are giving their own theories like if someone in the future will hack neuralink then all of us will be controlled by him. This is not confirmed yet. So, Even if a hacker will hack into the neuralink. He won't be able to have any real benefits from it till the year 2026 or maybe more because Neuralink is still developing and also Neuralink is designed to benefits humans who are paralyzed or who are blind. Some say that It's actually not made to hack people actions. no, you cant hack neuralink, because neuralink can only transmit code and not receive code.[15]

If machines and chips start controlling human mind will it be worthy for us to trust machines

Instead of thinking of the human-machine relationship as a zero-sum game, we should shift our mindset and think about ways to work with machines and make the pie bigger together! This is a great opportunity for us to think deeply about what we are good at, what we really want to do, how we can better leverage machines! Oliver Tavakoli, chief technology officer at cybersecurity firm Vectra, compares Neuralink's potential to change our bodies to gene-editing tool CRISPR, in that both "can be good and for evil".

"Our experience with CRISPR has shown us that we're not prepared to have wide-ranging and serious discussions of this sort yet. But even beyond the ethics of legitimate use, the fact that we potentially enable third parties to use this technology on individuals without their permission should give us pause. "Over the past few decades, we have created computer architectures, operating systems and applications without considering security first. We can see where that has led us in our daily news cycle. Interfaces like Neuralink should be designed from the ground up with fail-safes and peer reviews of the technology to ensure a high level of safety."
Notably, Neuralink is yet to be peer-reviewed, which is seen as a crucial step in a technology progressing to the next phases of trials. Verdict asked Neuralink about the steps it would take to ensure Neuralink security is of the highest standards, but did not receive a reply at the time of publication.

The human brain is the most complex machine in the known universe. Pulling off its ambitious goals will be an impressive scientific feat, but one that cannot afford to overshadow a security-first approach, warned Rios. "Obviously, anything that touches your brain has to be SOLID from a cybersecurity standpoint," said Rios.
"I hope the Neuralink team has built their system from the ground up with security in mind, otherwise, they will be putting their patients at serious risk."

Conclusion

This technology is very young at this stage and can have a bright future depending upon how well it is being received by the consumers. The vision of this technology can be fulfilled if it works properly without glitching otherwise it can become a disaster which wouldn't create a great image. For it to work, the technology must become reliable and shouldn't have a price which could be paid by some affluent persons. Neuralink can be one of the biggest inventions/researches of the century if everything goes right as their mission as well as vision can be felt by most of us. The need of time will only decide. Inserting a computer chip inside the brain might sound something fancy but is it that worthy to be drilled for (as of now, laser to be introduced later). Even to get yourself drilled and have a chip inserted you might need to pay a large amount. For all the affluent personalities, it might become an option if they face some rare brain disorder or neural disorder, but still getting drilled cannot be worth anything. Meddling or interfering in any process is always devastating and shouldn't be done but trying a new technology for medical purposes can be beneficial for the human race.

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