**MAR ATHANASIUS COLLEGE OF ENGINEERING**

(Affiliated to APJ Abdul Kalam Technological University, TVM)

KOTHAMANGALAM

**Department of Computer Applications**

Seminar Report

# Neuralink : Merging Human Brain with AI

Done by

**SANDRA JOY**

**Reg No: MAC19MCA020**

**Under the guidance of**
**Prof. BEENA JACOB**

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# CERTIFICATE

**Neuralink : Merging Human Brain with AI**

Certified that this is the bonafied record of project work done by

**SANDRA JOY**

**Reg No: MAC19MCA020**

During the academic year 2019-2022, in partial fulfilment of the requirements for the award of the degree,

**Master of Computer Applications**
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**Thiruvananthapuram**

**Faculty Guide**

Prof.Beena Jacob
MCA Dept. MACE

**Head of the Department**

Prof Biju Skaria
MCA Dept. MACE

**Internal Examiner**

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# ABSTRACT

Can the mind connect directly with artificial intelligence, robots and other minds through brain-computer interface (BCI) technologies to transcend our human limitations? To achieve this, we can use the Neuralink technology as well as Brain-Machine Interface (BMI). Neuralink is a neurotechnology company that was founded in 2016 by Elon Musk., their goal was and is to develop implantable fully integrated high bandwidth brain-machine interfaces. The thought process behind this concept was that the brain could be interpreted and manipulated in real-time using technology. The device is a micro-computer chip that is implanted into the brain on a network of thousands of ultrathin electrode wires. These wires pick up the signals that the brain emits and translates them into motor control. It solves important brain and spine problems with a seamlessly implanted device. It aims to "understand and treat brainly disorders" along with "preserving and enhancing our brain" and "create a well aligned future". Brain-Machine Interfaces hold the power to help people with a wide range of clinical disorders such as dis-functional sensory and motor functions.BCI is being used to study how specific tissue systems respond to electrical stimulation and what that could mean at the cognitive level. This could be useful in various BCI use cases, including military operations, medical operations and Neuroscience. BCI translates brain signals into command outcomes using artificial intelligence algorithms. These commands can be used to control wheelchairs, prosthetic limbs or other assistive technologies. Neuralink is said to be able to cure Autism, Blindness, Paralysis, Depression, Memory loss, Anxiety, Insomnia, Brain Damage, Seizures, Strokes, Hearing Loss, Addiction, Extreme Pain.Initially, the person would be able to control a smart phone or computer by simply using their minds, but the long-term goal is much bigger than that. The Neuralink technology goes beyond that. With time, we could all be superhuman! Our vision would be incredible, we'd have telepathic powers and we could even listen to music right inside our heads. Humans would be able to communicate with each other without uttering a word and communication would be lightning fast. Neuralink can be one of the biggest invention of the century if everything goes right as their mission as well as vision.

# 1. INTRODUCTION

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 networks 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.

The Brain-machine interfaces (BMIs) have the potential to help people with a wide range of clinical disorders.For example, researchers have demonstrated human neuroprosthetic control of computer cursors, robotic limbs, and speech synthesizers using no more than 256 electrodes.While these successes suggest that high fidelity information transfer between brains and machines is possible, development of BMI has been critically limited by the inability to record from large numbers of neurons.Non invasive approaches can record the average of millions of neurons through the skull, but this signal is distorted and nonspecific.Invasive electrodes placed on the surface of the cortex can record useful signals, but they are limited in that they average the activity of thousands of neurons and cannot record signals deep in the brain.

An alternative approach is to use thin, flexible multi-electrode polymer probes.The smaller size and increased flexibility of these probes should offer greater bio compatibility.However, a drawback of this approach is that thin polymer probes are not stiff enough to directly insert into the brain; their insertion must be facilitated by stiffeners,injection or other approaches,all of which are quite slow. To satisfy the functional requirements for a high-bandwidth BMI, while taking advantage of the properties of thin-film devices, we developed a robotic approach,where large numbers of fine and flexible polymer probes are efficiently and independently inserted across multiple brain regions.

Here, we report Neuralink's progress towards a flexible, scalable BMI that increases channel count by an order of magnitude over prior work. Our system has three main components: ultra-fine polymer probes, a neurosurgical robot, and custom high-density electronics. Together, this system serves as a state-of-the-art research platform and a first prototype towards a fully implantable human BMI.

## 1.1 About Neuralink

Neuralink is a neurotechnology company that was founded in 2016 by Elon Musk. Based in San Fran, their goal was to develop implantable brain-machine interfaces.The thought process behind this concept was that the brain could be interpreted and manipulated in real-time using technology. The device is a micro-computer chip that is implanted into the brain on a network of thousands of ultrathin electrode wires. These wires pick up the signals that the brain emits and translates them into motor controls. Solve important brain and spine problems with a seamlessly implanted device. Aims to "understand and treat brainly disorders" along with "preserving and enhancing our brain" and "create a well aligned future".Initially, the person would be able to control a smart phone or computer by simply using their minds, but the long-term goal is much bigger than it. The Neuralink technology goes beyond that. With time, we could all be superhuman! Our vision would be incredible, we'd have telepathic powers and we could even listen to music right inside our heads.Humans would be able to communicate with each other without uttering a word and communication would be lightning fast.

# 2. WORKING ARCHITECTURE

## 2.1 Natural Neural Network

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.Neurons consist of dendrites, a cell body (known as Soma) which contains the nucleus and axon. Axon of one neuron is connected with the 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 between the neurons.

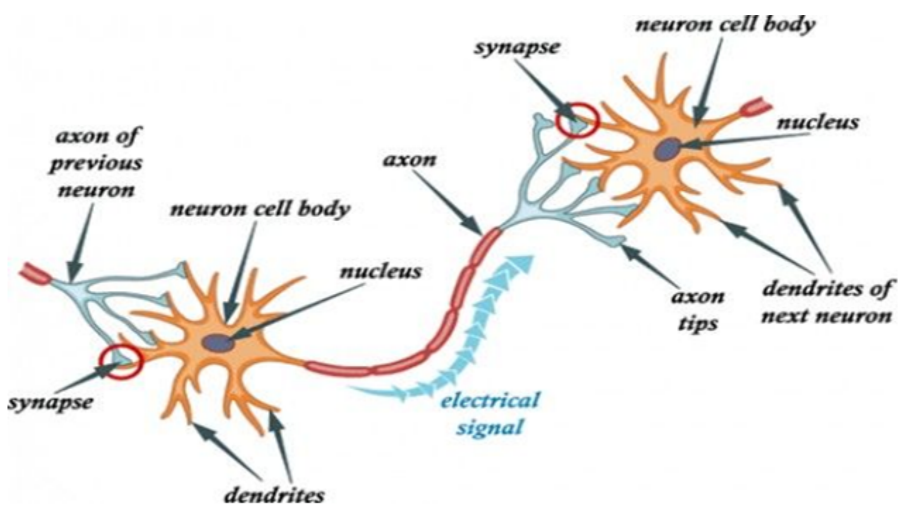


Figure 2.1: Neuron and Synapses

Neuralink will set up electrodes which will read those impulses, amplify them and send them to a machine which will then work accordingly. This way Neuralink will be able to read what you are thinking and find a way for you to talk to machines without even opening your mouth These electrodes support writing also which can help in treatment of brainly disorders

## 2.2 Brain-Computer Interface (BCI)

A Brain-Computer Interface (BCI) is a technology which allows a human to control a computer, peripheral, or other electronic device with thought. It does so by using electrodes to detect electric signals in the brain which are sent to a computer. The computer then translates these electric signals into data which is used to control a computer or a device linked to a computer. It 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.

This connection is a two-way link (a bidirectional interface). One direction involves a BCI sending brain activity to a computer, and the computer translating brain activity into motor commands.Communication can also happen in the other direction—where the computer sends information directly to the brain of the BCI user. This is called active BCI where there is a direct brain connection, compared to passive BCI which is non-invasive. We need to have a high bandwidth rate, but we have a very low bandwidth as we use only two of our thumbs to input into the machine or the smartphone. Even by using images, videos and audios we cannot get the same bandwidth as we can get by transferring directly from the brain to the machine 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.

The use of brain-computer interfaces in neurological rehabilitation. BCI is being used to study how specific tissue systems respond to electrical stimulation and what that could mean at the cognitive level. This could be useful in various BCI use cases, including military operations, medical operations and Neuroscience BCI translates brain signals into command outcomes using artificial intelligence algorithms. These commands can be used to control wheelchairs, prosthetic limbs or other assistive technology

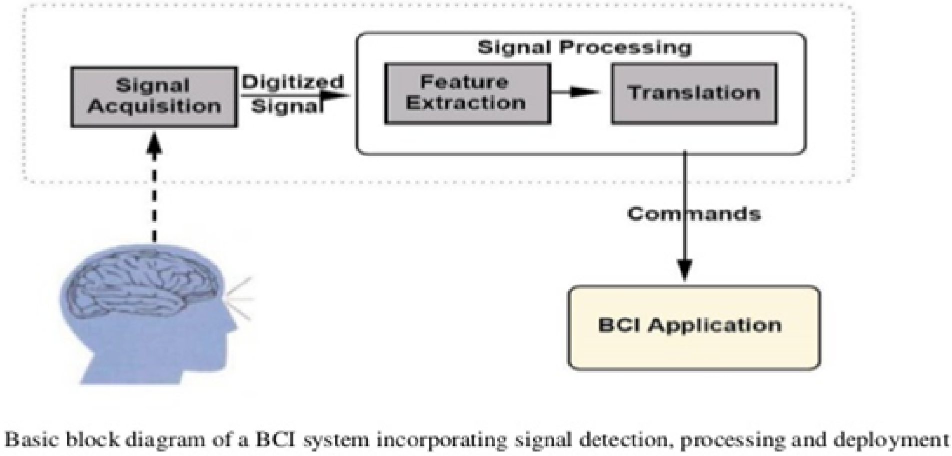


Figure 2.2: Block diagram of BCI

# 3. PROPOSED SYSTEM

Efforts to interpret brain waves began a few years ago in places such as Rischard Anderson's Caltech lab. Anderson's lab works with patients with severe physical disabilities. The lab's research found "inserting a few tiny electrode arrays into the brain enabled us to decode much of what a person intends to do" .Musk and his team believe that Neuralink represents a quantum leap in the technology and its potential applications, over cruder methods of the past. They say its significant potential as a medical device will include treatments for conditions ranging from disabled speech, to missing limbs, to more effective and less drastic treatment for medical issues such as seizures .

While Neuralink has most often emphasized the medical benefits of its technology, what makes Neuralink unique – and potentially much more controversial – is that Musk and the company have been clear that their aims do not end with medical applications. The ultimate goal of enhancing humans rather than merely treating them has been explicit. This focus on future enhancement awakens the greatest hopes of some, but the greatest fears and a generalized discomfort for many others.

"The quest for a fantastic future" is a succinct expression of Elon Musk's Brand. In the case of Neuralink, the positive vision includes medical applications but also encompasses additional goals. In interviews Musk has revealed his expectation that in a human the devices will allow for a far greater understanding of the brain simply by allowing a person to communicate what sensations, feelings, or memories are triggered when specific neurons or brain regions are stimulated. The motivation for Musk is to create a future in which humans are more likely to maintain their relevance as artificial intelligence becomes more sophisticated. According to Musk's logic, once computers can do everything better than humans, the only way humans will be able to keep up will be to have a way to expand our own capabilities . More mundane hopes include the possibility of fully immersive video games and simulations, and the ability to feel what it is like in another creature or person's body. Some techno-optimists even envision a future in which immortality can be achieved by downloading your mind into the virtual world . They are designing the first neural implant that will let you control a computer or mobile device anywhere you go. Micron-scale threads are inserted into areas of the brain that control movement. Each thread contains many electrodes and connects them to an implant, the Link.Neuralink contains mainly 3 components.They are ,

LINK

Sealed, implanted device that processes, stimulates, and transmits neural signals.Shown in figure(3.1)

Figure 3.1: Link

NEURAL THREADS

Each small and flexible thread contains many electrodes for detecting neural signals. Shown in figure(3.2)

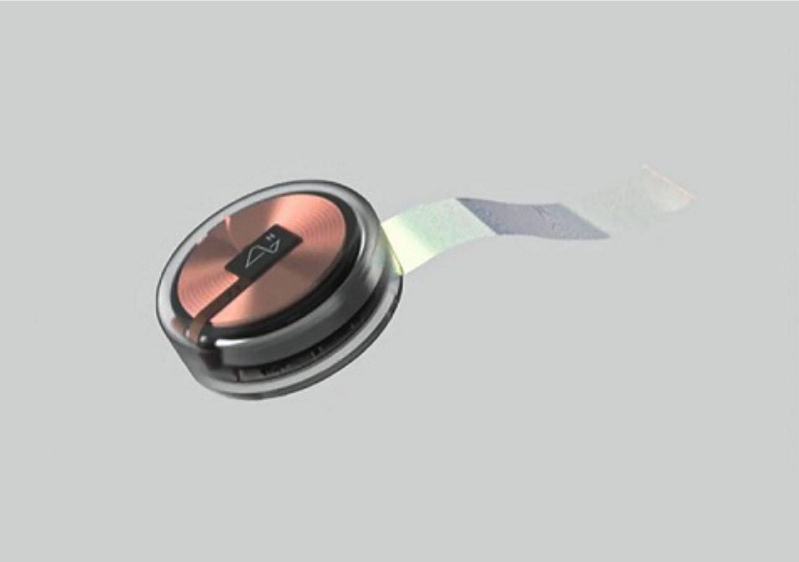

Figure 3.2: Thread

CHARGER

Compact inductive charger wirelessly connects to the implant to charge the battery from the outside.Shown in figure(3.3)

Precision automated neurosurgery, the threads on the Link are so fine and flexible that they can't be inserted by the human hand. Instead, we are building a robotic system that

Figure 3.3: Charger

the neurosurgeon can use to reliably and efficiently insert these threads exactly where they need to be.

The Neuralink App would allow you to control your iOS device, keyboard and mouse directly with the activity of your brain, just by thinking about it.

## 3.1 Neurosurgical Robot

The Robot is designed with a sole purpose of inserting the threads in least invasive manner.robot capable of inserting six threads (192 electrodes) per minute Each thread can be individually inserted into the brain with micron precision for avoidance of surface vasculature and targeting specific brain regions. The robotic insertion approach for inserting flexible probes (or threads), allowing fast and reliable insertion of large numbers of threads.

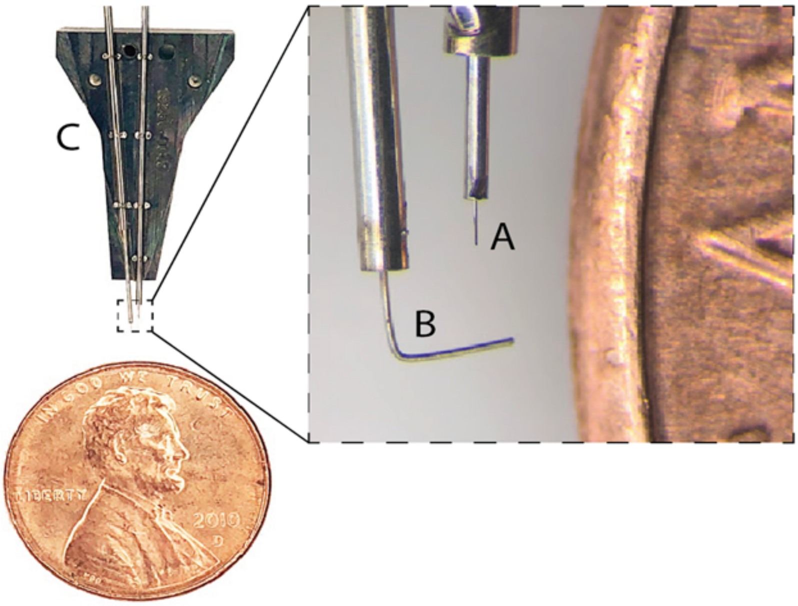


Figure 3.4: Needle pincher cartridge (NPC)

Needle pincher cartridge (NPC) compared with a penny for scale. A.Needle. B. Pincher. C. Cartridge

Thin-film polymers have previously been used for electrode probes, but their low bending stiffness complicates insertions. Neuralink has developed a robotic insertion approach for inserting flexible probes, allowing rapid and reliable insertion of large numbers of polymer probes targeted to avoid vasculature and record from dispersed brain regions. The robot's insertion head is mounted on a 10 m globally accurate, 400 mm 400 mm 150 mm travel three axis stage, and holds a small, quick-swappable, "needle-pincher" assembly. The needle is milled from 40 m diameter tungsten-rhenium wire-stock electrochemically etched to 24 m diameter along the inserted length. The tip of the needle is designed both to hook onto insertion loops—for transporting and inserting individual threads—and to penetrate the meninges and brain tissue. The needle is driven by a linear motor allowing variable insertion speeds and rapid retraction acceleration (up to 30;000 mm s2) to encourage separation of the probe from the needle. The pincher is a 50 m tungsten wire bent at the tip and driven both axially and rotationally. It serves as support for probes during transport and as a guide to ensure that threads are inserted along the needle path.

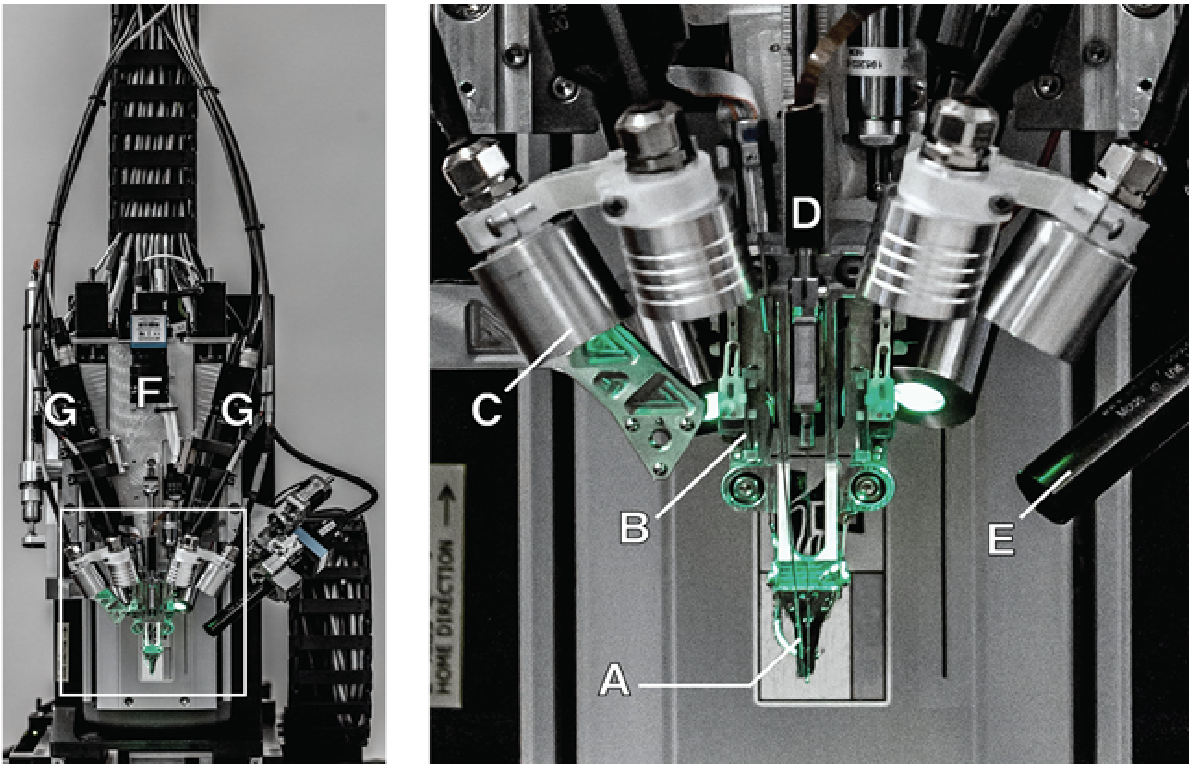


Figure 3.5: The robotic electrode inserter

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.

The inserter head also holds an imaging stack used for guiding the needle into the thread loop, insertion targeting, live insertion viewing, and insertion verification. In addition, the inserter head contains six independent light modules, each capable of independently illuminating with 405 nm, 525 nm and 650 nm or white light. The 405 nm illumination excites fluorescence from polyimide and allows the optical stack and computer vision to reliably localize the (16 50) m2 thread loop and execute sub-micron visual servoing to guide, illuminated by 650 nm the needle through it. Stereoscopic cameras, software based monocular extended depth of field calculations, and illumination with 525 nm light allows for precise estimation of the location of the cortical surface.

The robot registers insertion sites to a common coordinate frame with landmarks on the skull, which, when combined with depth tracking, enables precise targeting of anatomically defined brain structures. An integrated custom software suite allows pre-selection of all insertion sites, enabling planning of insertion paths optimized to minimize tangling and strain on the threads. The planning feature highlights the ability to avoid vasculature during insertions, one of the key advantages of inserting electrodes individually. This is particularly important, since damage to the blood-brain barrier is thought to play a key role in the brain's inflammatory response to foreign objects.

The robot features an auto-insertion mode, which can insert up to 6 threads (192 electrodes) per minute. While the entire insertion procedure can be automated, the surgeon retains full control, and if desired, can make manual micro adjustments to the thread position before each insertion into the cortex. The neurosurgical robot is compatible with sterile shrouding, and has features to facilitate successful and rapid insertions such as automatic sterile ultrasonic cleaning of the needle. The needle pincher cartridge (NPC) is the portion of the inserter head that makes direct contact with brain tissue and is a consumable that can be replaced mid-surgery in under a minute.

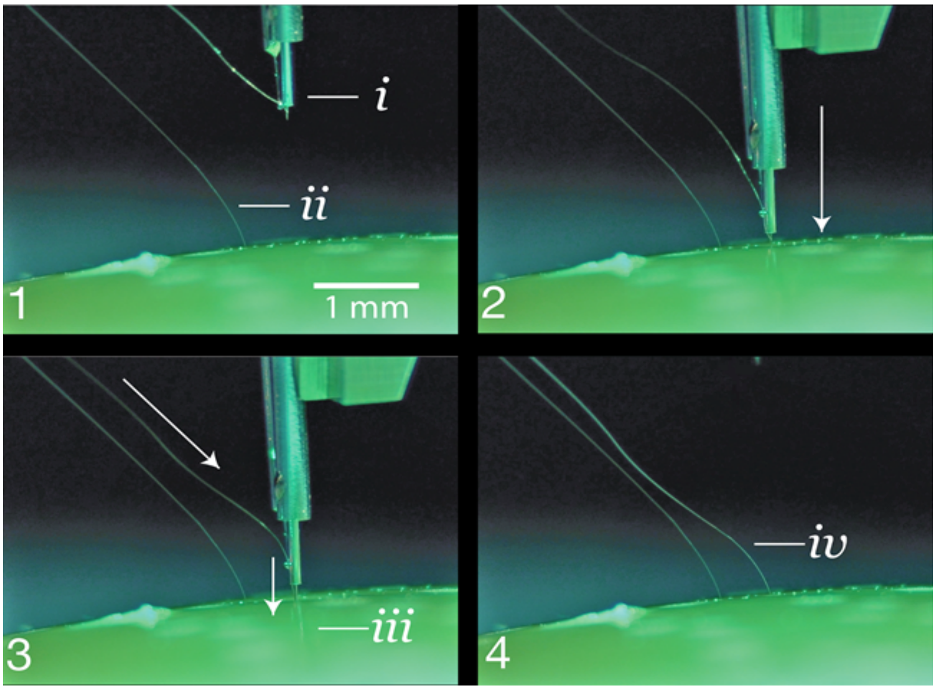


Figure 3.6: Robotic insertion of thin polymer

1. The inserter approaches the brain proxy with a thread. i. needle and cannula. ii. previously inserted thread. 2. Inserter touches down on the brain proxy surface. 3. Needle penetrates tissue proxy, advancing the thread to the desired depth. iii. inserting thread. 4. Inserter pulls away, leaving the thread behind in the tissue proxy. iv. inserted thread.

This demonstrates that robotic insertion of thin polymer electrodes is an efficient and scalable approach for recording from large numbers of neurons in anatomically defined brain regions.

# 4. EXPERIMENTS AND RESULTS

Of course, many of these ideas are far ahead of today's technology. One great weakness of the idea of a brain human interface completely understanding the human mind is its basis in the idea that electrical signals completely explain human thought. Even if we assume that the electrical signals from the brain are of primary importance to the human mind and what we might call consciousness (an idea even Musk admitted in a recent interview is uncertain), then the human body will still require more than a simple understanding of electrical signaling to truly comprehend. In computers the hardware and the software of the device are largely separate entities. The physical shell that runs the program is largely irrelevant to the computer programs. However, biology is different. In living organisms, the hardware and software are deeply integrated. Hormones, physical capabilities, and outside factors impact the way the brain reacts and performs in ways that even a near perfect understanding of electrical signaling may struggle to comprehend or explain. In humans, mind states like depression may have as much to do with the state of the physical body as the mind .

This leads to a basic question. How easy is it to simulate consciousness? Several projects are currently underway with the goal of simulating a human mind . If the answer is that it is very hard, or that consciousness depends on something that computers alone are not capable of, then we are likely headed for a future in which only a small amount of simulated consciousness will exist in the world controlled by large organizations. If it is very easy, then we are headed for a future in which simulated consciousness is a very common phenomena and full brain downloads will also become common. However, the easier it is to simulate the brain, the greater the potential for truly horrific nightmare scenarios.

## 4.1 Experiments on pigs

As a part of research Neuralink successfully completed animal testing in pigs. Recently They implanted a microchip into a pig and demonstrated how far the chip has already come!

The test is conducted using “Three Little Pigs” named Dorothy,Gertrude and Joyce. Joyce had no device. Gertrude had one that monitored neurons in her snout, Dorothy had one put in and removed. Dorothy behaved like a normal, happy pig – no problems. Great for humans if they want to take theirs out or upgrade. Gertrude walked on a treadmill and her limb functions and brain activity were all captured by the LINK. The team said there was great consistency between the predicted and actual outputs.Things of this nature will always have challenges,

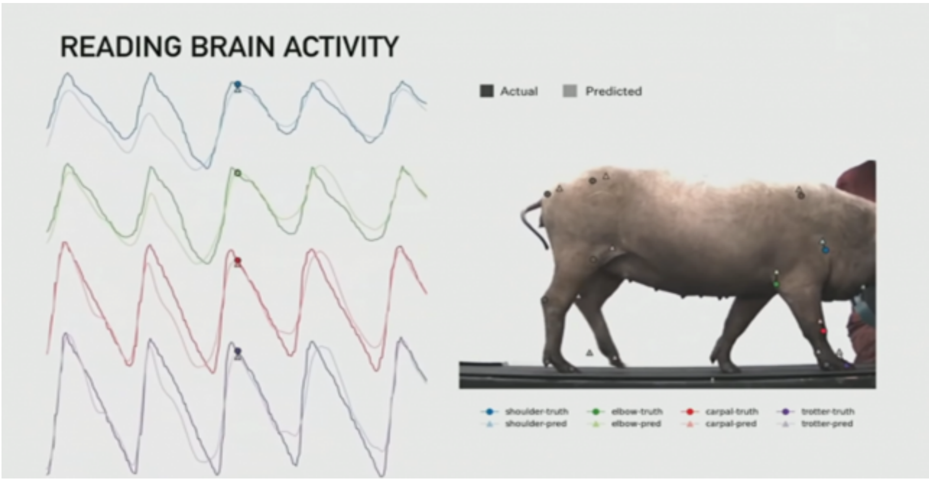


Figure 4.1: Experiments on pigs

Neuralink has been approved as an FDA Breakthrough Device, which speeds up the primary approval process with the agency. The company also stated that the Neuralink will be ready for the first patient by the end of the year 2020. This degree of understanding between a computer and the brain could prove instrumental in allowing an eventual ‘merge’ between human consciousness and an AI. Elon Musk has stated his fear of an eventual decline in importance of a human when AI will itself become capable of simulating all of our brainly functions. To not let that happen, humans must merge with artificial intelligence in order to become a more capable being. And according to Elon Musk, to save humanity’s future, we must see the importance of the Brain Machine Interfaces (BMI).

# 5. 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. With a highly skilled and intelligent team behind Neuralink micro-chip it does give hope and provide vision for what could be a great concept – if used correctly.As BCI technology further advances, brain tissue may one day give way to implanted silicon chips thereby creating a completely computerized simulation of the human brain that can be augmented at will. Futurists predict that from there, superhuman artificial intelligence won't be far behind. BCI is an advancing technology promising paradigm shift in areas like Machine Control, Human Enhancement, Virtual reality and etc. Several potential applications of BCI hold promise for rehabilitation and improving performance, such as treating emotional disorders (for example, depression or anxiety),easing chronic pain, and overcoming movement disabilities due to stroke. So, it's potentially high impact technology.

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