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NEURALLINK

Martin Jacob [1],Cini Joseph [2] , Arun Kumar R[3] , M B Abin [4], Antony John [5]
[1](MCA) Department of Computer Application Kristu Jyoti College of Management and Technology, Changanassery, Kerala, India
[2] (Assistant Professor) Department of Computer Application Kristu Jyoti College of Management and Technology, Changanassery, Kerala, India
[3] (MCA) Department of Computer Application Kristu Jyoti College of Management and Technology, Changanassery, Kerala, India
[4] (MCA) Department of Computer Application Kristu Jyoti College of Management and Technology, Changanassery, Kerala, India
[5] (MCA) Department of Computer Application Kristu Jyoti College of Management and Technology, Changanassery, Kerala, India

ABSTRACT
Brain-computer interfaces (BCIs) hold promise for the restoration of sensory and motor function and the treatment of neurological disorders, but clinical BCIs have not yet been widely adopted, in part because modest channel counts have limited their potential. Inthis white paper, we describe Neuralink's first steps toward a scalable high-bandwidth BCI system. We have built arrays of small and flexible electrode "threads", with as manyas 3,072 electrodes per array distributed across96 threads. We have also built a neurosurgical 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 electrode array is packaged into a small implantable device that contains custom chips for low-power on-board amplification and digitization: the package for 3,072 channels occupies less than (23 × 18.5 × 2) mm3. A single USB-Cable provides full-bandwidth data streaming from the device, recording from all channels simultaneously. This system has achieved a spiking yield of up to 85.5 % inchronically implanted electrodes. Neuralink's approach to BCI has unprecedented packaging density and scalability in a clinically relevant package.

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. 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. A start-up was registered by Elon Musk in 2016 named Neuralink which remained under the sheets till 2017 then it was revealed to the world. Neuralink as the name suggests creates a link between the Neurons inside our brain and a machine (smartphones or computers). On 16th July 2019, a white paper was published under the name, "ELON MUSK AND NEURALINK" which told about what the

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company was up to and how will it be possible to create a general symbiosis between man and a machine or the artificial intelligence (AI). Elon Musk in the launch event of the Neuralink told that the company aims to "understand and treat brainly disorders" along with "preserving and enhancing our brain" and "create a well aligned future". Elon Musk in an interview also talked about how the company will try to recreate "the Neural Lace", a fictional way/method of transferring brain's content to a machine and vice-versa.

- **Brain-Machine Interface (BMI)**

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. For this, 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.

Brain-Machine Interfaces hold the power to help people with a wide range of clinical disorders such as dis-functional sensory and motor functions. 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.

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.

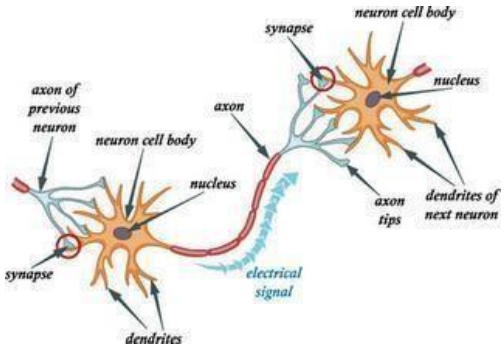

Figure1: Neuron and Synapses

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

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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.

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.

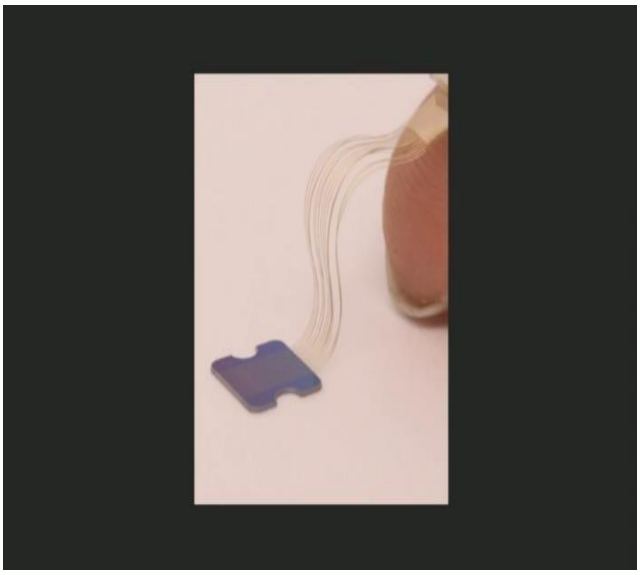

Figure 2: Threads are smaller than a finger

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.

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) Stereoscopic[3] cameras.

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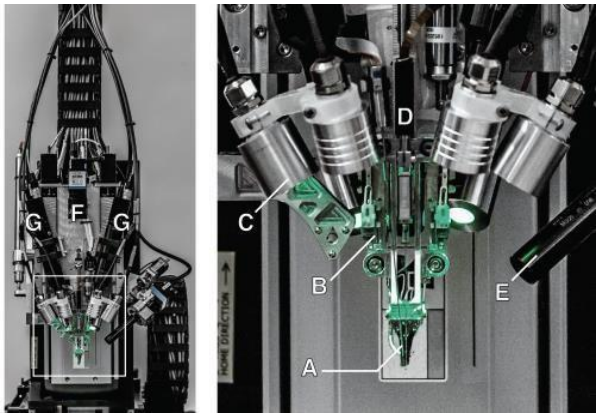

Figure3 : All the parts of the automatic Insertion Robot

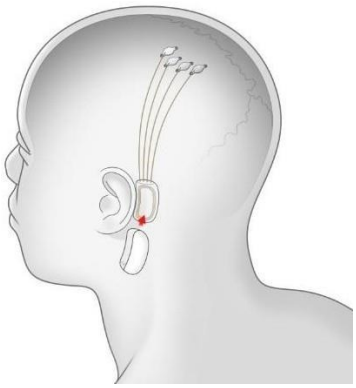

Figure 4: N1 sensors implanted inside the skull along with the external device

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]

Projects in working at Neuralink

- Neuralink uses a USB-C port as a wired medium to provide power and to transfer the data. But for the future it plans on to provide a wireless method for the same. This wireless goal will be achieved by something Neuralink calls as "N1 sensors". "Four of these N1 sensors will be placed inside our skull (three in motor areas and one in somatosensory area). The sensors will connect wirelessly to an external device mounted behind our ear which can connect to iPhones through an app.", said Max Hodak, President of Neuralink, at the Introductory Presentation for Neuralink
- Neuralink also plans to use laser technology (like the laser eye surgery) to get through the skull as opposed to drilling holes in it which they are performing now. It will also help in decreasing the damage to the tissues.

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Ethical or not

Humans have always been trying to move forward without thinking of the consequences. Over the course of time, it has become very evident that meddling in a natural process can cause a huge amount of destruction. There are processes that have been going on for ages and interfering with them can cause repercussions which can be very harmful if gone wrong.

Such is in the case of human body. We have always been adapting ourselves to the environment. A kid of today knows how to use a smartphone better than a computer professional. Thinking that we can't adapt to the increasing artificial intelligence around ourselves can be just a fear which we can overcome if we see what changes the human brain has gone through to adapt to the changes around us. So, we can probably say that even though we as of now can't become as intelligent or powerful as Artificial Intelligent, but it is safe to say that the future generation can be.

"**Being the creator of artificial intelligence, we shouldn't hold ourselves lowly than the creation.**" Because even though it is learning new things, we are the one who made it and it will always remain as a helper to us if used in a constructive way.

"I don't think artificial intelligence is a threat, or something terrible, and we are smart enough to learn that."-JACK MA

Our body even has a healing mechanism which can be accelerated but just using this device can be a bit uncomfortable for the patient and/or can make the situation worse.

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.

Present and Future

At present the company is using this technology to serve two purposes which are-

- As a research project for rodents and Lab Rats
- As a prototype project for human clinical implants

As of now the device is being used on Lab Rats to analyse the results and make refinements in the device to read the correct input. As opposed to the previous projects, Neuralink uses ultra-thin and flexible threads which are much more capable for a long-life and a greater volume of data transferring. Even the composition of the material used is biocompatible so is non-harmful for the brain.

The vision of the company is to achieve symbiosis with 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).

CONCLUSION

This technology is very young at this stage and can have a bright future depending upon how well it

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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.

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