An Integrated Brain-Machine Interface Platform with Thousands of Channels

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Abstract

As the days are passing by, we come across new and latest inventions which use Artificial Intelligence to ease our usage of the devices. This sudden surge in the usage of AI has increased insecurity among humans that it can leave us of no use. This increased insecurity led people to think what can be done to make our future secure among the robots and artificial intelligence. And out came the solution, mix both the intelligences and achieve a symbiosis between human and AI. To achieve this, we can use the "Neural Lace" technology as well as Brain-Machine Interface (BMI). 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 startup which has a vision to cure the insecurity among us. Keywords—Artificial Intelligence, Brain-Machine Interface, Neural Network, Neuralink, Neural Lace, BrainGate

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an

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. Dr. AbhineetAnand Department of Computer Science Chitkara University Mohali, India abhineet.mnnit@gmail.com About Neuralink A start-up was registered by Elon Musk in 2016 named Neuralink which remained under the sheets till 2017 when 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 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 Figure 1:
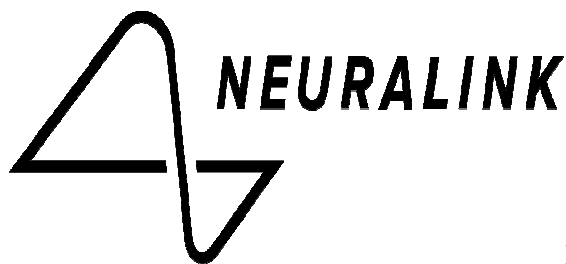
NEURALINK

Fig.2

TheNeuralink

Wikipedia 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. "We are already a cyborg. We are so well connected with our phones and computers that losing a phone feels like losing a limb."- ELON MUSK 2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS) 2 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. [1] 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. Figure 2: Neuron and Synapses 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 Synapse 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 1 The Culture is a futuristic interstellar utopian, post-scarcity space society of humanoids, aliens, and very advanced artificial intelligence living in socialist habitats spread across the Milky Way galaxy. 2 Damage to the central nervous system (CNS) results in a glial reaction, leading eventually to the formation of a glial scar. In this between the neurons. This is how neurons work and transfer information. 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. Neural Lace Neural Lace is a science-fictional concept introduced by Scottish author Iain M. Banks in his series of novels "The Culture"1 . Neural Lace is also a Brain-Machine Interface (BMI), which can help humans compete with Artificial Intelligence. This Neural Lace technology is currently being funded by Elon Musk as an effort to accomplish the same vision which is to make human brain able to compete with the AI in the future. An idea of how Neural Lace works can be taken from the movie Matrix in which one of its character (Neo) can be seen using a computer to acquire new information and learn new skills.

[2] Neural Lace is an ultra-thin mesh which will be implanted inside the skull and will form a body of electrodes which will be able to monitor the function of human brain. The ultra-thin mesh is inserted using a tiny needle which contains rolled up mesh. After the mesh is implanted inside the brain, it integrates itself with the human brain and "creates a perfect symbiosis between human and machine".

[3] A similar concept is being used by Neuralink to achieve symbiosis with AI, more of which will be explained later. Invasive and Non-invasive methods Our blood vessels are jelly-like substance which if tampered with can cause a brain disorder which in turn will cause Glial Scar to form which is the body's way of repairing the tissues in our brain. Invasive methods damage the tissues which start the formation of Glial Scar2 which can interfere with the transmission of impulses to the machine. While the non-invasive methods have the least amount of damage to the brain environment, axon regeneration fails, and remyelination may also be unsuccessful. The glial reaction to injury recruits' microglia, oligodendrocyte precursors, meningeal cells, astrocytes and stem cells.

2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS) 3 tissues which in turn will not influence the transmission of the signals.

[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. 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.

THE LINK

Figure 3:

 Threads are smaller than a finger |Source: Neuralink 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.

 3 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
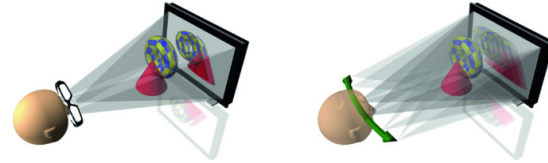
a) Loaded needle pincher cartridge.

 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.

: All the parts of the automatic Insertion Robot |Source: NeuralinkNeuralink 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 5: The size of needle and the pincher compared to a penny |Source: NeuralinkTo guide the needle, the Robot has four camera which are focused on the needle, the field of insertion, and stereoscopy. 2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS)

4 Electronics The electronics are built around Neuralink's custom application specific integrated circuit (ASIC), which consists of 256 individually programmable amplifiers (analog pixels), on-chip analog-to-digital converters (ADCs), and peripheral control circuitry for serializing the digitized outputs.

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

forms the core of a modular recording platform that allows for easy replacement of constitutive parts for research and development purposes. In the systems discussed here, several ASICs are integrated into a standard printed circuit board (PCB) using flip-chip integration. Each system consists of a field-programmable gate array (FPGA); real-time temperature, accelerometer, and magnetometer sensors; and a single USB-C connector for full-bandwidth data transfer. The systems are packaged in titanium cases which are coated with parylene-c, which serves as a moisture barrier to prevent fluid ingress and prolong functional lifetime."

Projects in working at Neuralink

Figure 7: N1 sensors implanted inside the skull along with the external device |Source: 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. 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. [1] Elon Musk also stated that

the Neuralink will be ready for the first patient by the end of next year i.e. 2020.

[5] 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). 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 2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS) 5 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. 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. Other BMI projects BrainGateBrainGate is another BMI initially developed by Brown University in 2006. It was even used on a patient named Matthew Nagle. Nagle had a spinal cord paralysis and was the first person to get the brain implant and control a computer using his mind. [6] BrainGate used Utah Array which consists of series of stiff needles that allows for up to 128 electrodes channels which can transfer less volume of data when compared to Neuralink's BMI. The stiffness of the needles could damage them when the brain shifts its shape which hinders in long-term functionality.

[6] Future for BMI and Neuralink 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.

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