A SEMINAR REPORT
ON

“Neuralink : The brain's magical future”

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CERTIFICATE

This is certify that the project entitled

"Neuralink : The brain's magical future"

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is a record of confide work carried out by them, in the partial fulfillment of the requirement for the award of Degree of Bachelor of Engineering (Computer Engineering) at Dhole Patil College of Engineering, Pune under the **Savitribai Phule Pune University. This** work is done during year 2024-2025.

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ABSTRACT

If the chip called Neuralink is realized and marketable then a wide spectrum of biomedical opportunities shall be available. One of them is the potential usage of chip as an implanted antenna. In fact, once the chip begins to be operative for biomedical purposes, then it might be a key piece in a prospective Internet of Brain Things (IBT).

This Internet would have a direct impact in all those patients that have lost domain in the nervous system. Thus, the scenario by which these patients have been injected of artificial neurotransmitters (ANT), the trajectory of them can be modified through the electromagnetic fields emitted by Neuralink. Thus, it is expected to have effect in the recovery of motility, speak and memory of affected patients. This paper explores the physics grounds of IBT and how communication between neurons might be improved under the synergy of ANT and IBT.

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Introduction

1.1 Introduction to Neuralink:

Neuralink is a neurotechnology company founded by Elon Musk with the ambitious goal of developing brain-machine interface (BMI) technologies. The company aims to create devices that can be implanted into the human brain, establishing a direct communication link between the brain and external computing devices.

The core objective of Neuralink is to enable bidirectional communication between neurons and computers, potentially revolutionizing the way humans interact with technology. By utilizing a matrix of ultrafine electrodes, Neuralink seeks to interpret and transmit neural signals, allowing for applications like restoring motor function in individuals with neurological disorders, facilitating communication for those with speech impairments, and potentially enhancing human cognition.

Ultimately, Neuralink's vision extends to leveraging brain-computer interfaces for a variety of purposes, ranging from healthcare solutions to augmentative technology. The company's endeavors aim to push the boundaries of human-machine interaction, potentially paving the way for a future where the human brain seamlessly integrates with advanced technology.

Neuralink Corp.[4] is an American neurotechnology company that has developed, as of 2024, implantable brain–computer interfaces (BCIs). It was founded by Elon Musk and a team of seven scientists and engineers (Max Hodak, Benjamin Rapoport, Dongjin Seo, Paul Merolla, Philip Sabes, Tim Gardner, Tim Hanson, and Vanessa Tolosa).[4][5][6][7] Neuralink was launched in 2016 and was first publicly reported in March 2017.[8][9][10][11] The company is based in Fremont, California with plans to build a three-story building with office and manufacturing space near Austin, Texas in Del Valle, located about 10 miles east of Tesla's headquarters and manufacturing plant that opened in 2022.[5]

Since its founding, the company has hired several high-profile neuroscientists from various universities.[12] By July 2019, it had received $158 million in funding (of which $100 million was from Musk) and was employing a staff of 90 employees.[13] At that time, Neuralink announced that it was working on a "sewing machine-like" device capable of implanting very thin (4 to 6 μm in width)[14] threads into the brain, and demonstrated a system that reads information from a lab rat via 1,500 electrodes. They had anticipated starting experiments with humans in 2020,[13] but have since moved that projection to 2023. As of May 2023, they have been approved for human trials in the United States.[6]

1.2 Mission & Vision

MISSION :

The mission of Neuralink is to "create a generalized brain-computer interface to restore autonomy to those with unmet medical needs today and unlock human potential tomorrow ." To create brain-machine interfaces (BMIs) to enhance human capabilites.

VISION :

Neuralink wants to connect humans and technology with brain-machine interfaces. This could let us control devices with our thoughts, or talk without words. Neuralink aims to revolutionize the way we interact with technology.

GOALS :

To build a system with at least 1000 times more communication channels (electrodes) than current clinically-approved devices. To create a BCI that can help people and enhance them. To make the BCI safe, invisible, and easy to use .To enable humans to communicate with technology and AI. Neuralink's mission revolves around creating cu³ng-edge brain-machine interface (BMI) technologies to augment human capabilities and improve quality of life.

The company's primary goals include:

1. *Advancing Brain-Machine Interfaces*: Neuralink aims to develop and implement advanced neural implant technologies that establish seamless communication between the human brain and computers.

2. *Revolutionizing Healthcare*: By leveraging BMI technology, Neuralink seeks to provide solutions for neurological disorders, spinal cord injuries, and other conditions, aiming to restore motor function and enhance overall well-being.

3. *Enabling Communication*: Neuralink's vision includes enabling direct brain-to-device communication, potentially aiding individuals with speech impairments or disabilities by offering alternative means of communication.

4. *Enhancing Human Capabilities*: The company envisions using BMI technology not only to restore lost functions but also to potentially augment human cognition, unlocking new levels of intelligence and capabilities.

5. *Pioneering Ethical and Safe Technology*: Neuralink emphasizes ethical considerations, privacy, and safety in the development and implementation of brain-computer interface devices, ensuring responsible and beneficial integration into society. Neuralink's overarching vision is to bridge the gap between the human brain and computing systems, paving the way for a future where the limitations of the human mind can be transcended through the seamless integration of advanced technology.

1.3 WHY ELON MUSK CREATED NEURALINK?

Elon Musk created Neuralink with the vision of advancing human capabilities through the development of brain-machine interface (BMI) technology. His motivations include:

1. *Advancing Technology*: Musk's overarching goal is to propel technological innovation. Neuralink represents a frontier where human consciousness meets artificial intelligence, aligning with Musk's vision of accelerating progress in groundbreaking fields.

2. *Addressing Human Limitations*: Musk aims to overcome human limitations, especially in the realm of cognitive abilities and neurological conditions. Neuralink's potential applications offer hope for improving the lives of people with disabilities or neurological disorders.

3. *Preparation for AI Integration*: Musk has voiced concerns about artificial intelligence surpassing human intelligence. Neuralink, in part, is seen as a proactive measure to ensure humans can keep pace with and potentially merge harmoniously with advanced AI.

4. *Long-Term Vision*: Musk's ambitious long-term vision involves establishing a symbiotic relationship between humans and technology, envisioning a future where the boundaries between biological and artificial intelligence are blurred.

Overall, Elon Musk's creation of Neuralink stems from a desire to push the boundaries of technology, enhance human capabilities, and prepare for a future where humans can seamlessly integrate with advanced AI systems.

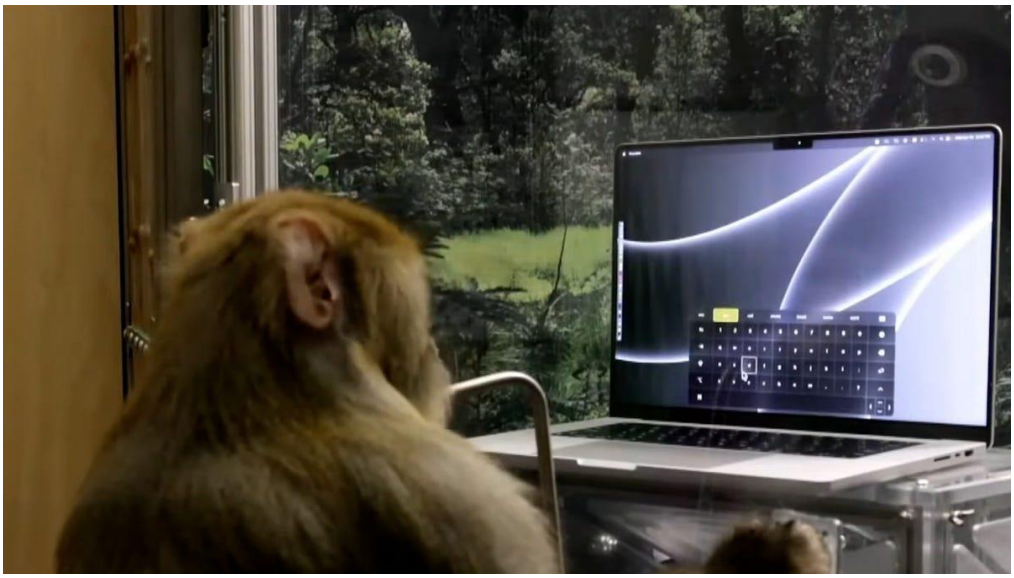

Fig 1.1 Successful Animal Trial

1.4 The TECH BCI

The Link: This is the main device that is implanted in the skull. It is a coin-sized chip that contains more than 1,000 electrodes that can record and stimulate brain activity.

The Threads: These are thin and flexible wires that connect the Link to different parts of the brain. Each thread has 32 electrodes that can detect and emit electrical signals from and to the neurons.

The Robot: This is a neurosurgical robot that can perform the implantation of the Link and the threads. The robot uses advanced imaging and precision techniques to avoid damaging blood vessels or brain tissue. The robot is designed to be fully automated in the future.

The App: The app can also display the data collected from the brain and allow the user to interact with various devices or applications using their thoughts.

Fig 1.2 Human Implant Overview

1.5 Brain Computer Interface

A brain-computer interface (BCI) is a system that allows a user to interact with a computer or another device using only their brain activity. BCIs are still in their early stages of development, but they have the potential to revolutionize the way we interact with technology. There are two main types of BCIs: invasive and non-invasive. Invasive BCIs involve implanting electrodes directly into the brain. Non-invasive BCIs use sensors that are placed on the scalp or near the eye.

Potential applications of BCIs::

- Treatment of neurological disorders
- Enhancement of human capabilities
- Control of devices
- Communication
- Entertainment

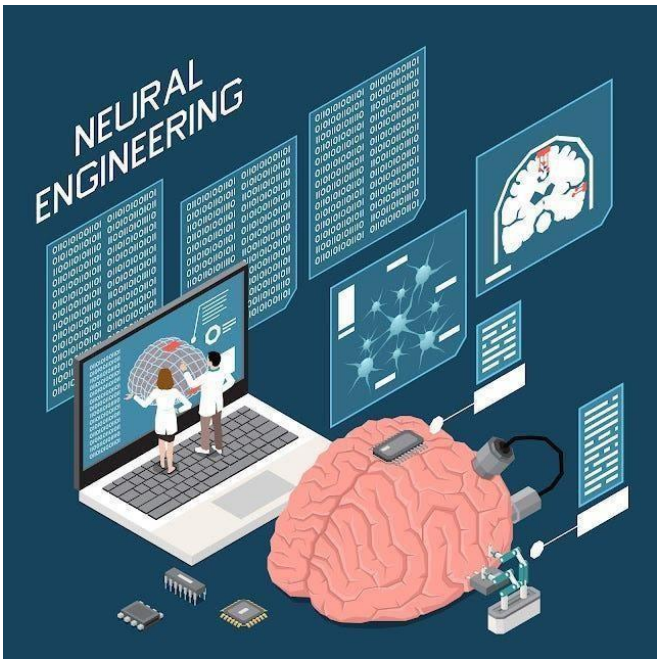

Fig 1.3 Neural Engineering

Chapter 2

DESCRIPTION

2.1 Animal Testing

ANIMAL TESTING Neuralink has conducted animal trials on monkeys. In 2020, Neuralink announced that it had successfully implanted a brain-computer interface in a monkey, allowing the monkey to control a computer cursor with its mind. The company also showed a video of the monkey playing a video game using its mind. Neuralink has conducted animal trials on pigs. In 2021, Neuralink announced that it had implanted its brain-computer interface in a pig. The pig was able to control a robotic arm using its mind. Neuralink also showed a video of the pig moving the robotic arm to pick up a treat.no infection is developed as monkey did Neuralink has conducted animal testing to develop and refine its brain-machine interface technology. These tests involve implanting the Neuralink devices into animals, typically rodents like mice and pigs, to evaluate the safety, efficacy, and functionality of the technology. The aim is to understand how the implants interact with the brain, how well they transmit and receive signals, and to ensure they don't cause harm or adverse effects. Animal testing plays a crucial role in validating and refining the technology before potential human trials. It helps researchers gather valuable data on the device's performance, safety, and potential impact on brain function. However, it's important to note that ethical considerations and animal welfare are fundamental aspects of these studies, and researchers must adhere to strict guidelines and regulations governing animal research.

2.2 CONTROVERSIES

In 2017, a year after the company's founding, Neuralink and University of California signed an agreement to test the company's brain chip at UC Davis's primate center in exchange for just under $800,000. According to internal documents obtained by the Physician's Committee for Responsible Medicine (PCRM), an advocacy group that works to eliminate animal testing, researchers "pried" and "drilled" open the animals's skulls in order to implant the chips, as well as used unapproved adhesive called BioGlue to seal the holes in their skulls. After the surgical procedures, the monkeys displayed signs of severe stress and exhaustion and a host of physical ailments, including diaríhea, open sores, vomiting, vaginal discharges and brain hemoírhaging. Neuralink ultimately ended its partnership with UC Davis in 2020 and moved its animal testing to internal departments. But between 2018 and 2022, the company experimented on and killed 1,500 animals, according to a report from Reuters. In the report, Neuralink employees explained how experiments involving 86 pigs and two monkeys had to be repeated as a result of various human errors. Though the company had passed USDA inspections, the agency ultimately opened a probe into Neuralink in December 2022.

Lawmakers Adam Schiff and Eaíl Blumenaur urged the Department of Agriculture to exact heightened scrutiny on Musk's company after learning of the allegations raised by PCRM. In February of this year, PCRM published emails showing improper handling of testing equipment, including transporting the remains of deceased monkeys without Disinfecting or sealing them. The equipment may have been contaminated with antibiotic-resistant pathogens that can be fatal foí humans, and a grave threat to public health. The U.S. Department of Transportation subsequently opened an investigation into Neuralink's improper handling of hazardous pathogens, the second independent federal investigation of the company since its founding.

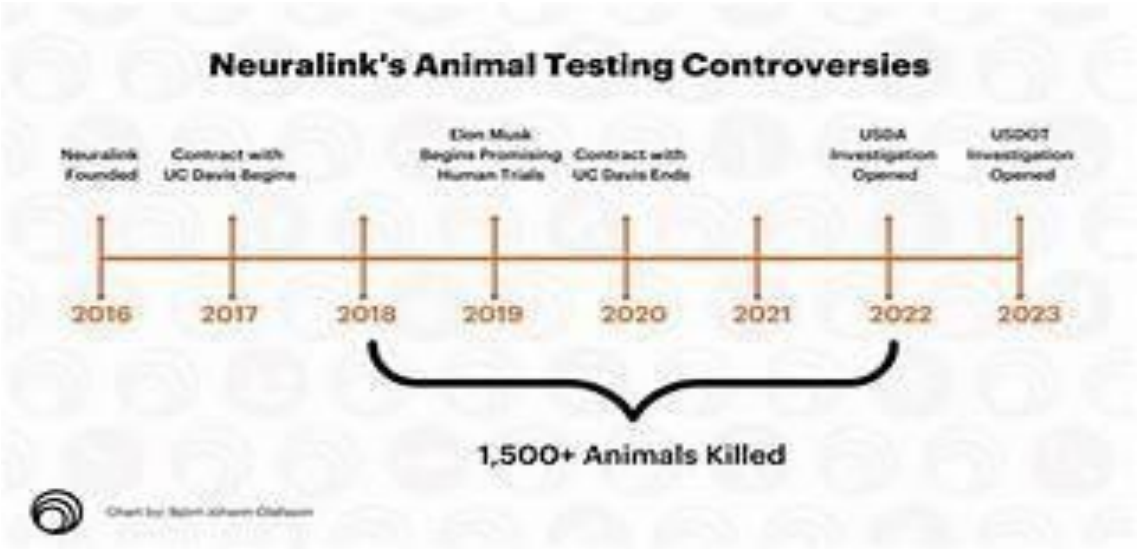

Fig 1.4 Controversies

2.3 CHALLENGES

Neuralink faces several challenges on its path toward developing viable brain-machine interface technology:

1. *Technical Hurdles:* Developing a high-bandwidth, safe, and reliable communication link between the brain and external devices is complex. Ensuring the longevity, accuracy, and stability of the implants while minimizing tissue damage or rejection is a significant technical challenge.

2. *Safety and Ethical Concerns:* Ensuring the safety of brain implants is paramount. Neuralink must address potential risks such as infection, tissue damage, or unintended side effects. Additionally, ethical considerations surrounding brain augmentation, privacy, and consent are crucial.

3. *Regulatory Approval:* Bringing a brain-machine interface technology to market involves navigating stringent regulatory pathways. Ensuring compliance with safety and efficacy standards set by regulatory bodies is a substantial hurdle.

4. *Public Perception and Acceptance:* Acceptance of brain implants, especially for non-medical purposes, might face skepticism or resistance from the public due to concerns about privacy, autonomy, and potential misuse.

5. *Integration and Functionality:* Integrating brain-machine interfaces seamlessly into daily life and ensuring their practical functionality, reliability, and user-friendliness is a significant challenge.

6. *Cost and Accessibility:* Making the technology affordable and accessible to those who need it most is crucial. Cost-effective production and ensuring accessibility for healthcare applications are ongoing challenges.

Addressing these challenges requires continuous research, collaboration across disciplines, rigorous testing, regulatory cooperation, and a balanced approach to ethical, societal, and technological considerations.

Chapter 3

FUTURE

The Future of Neuralink: Neuralink is a technology that connects the brain and computers. It could enable mind-controlled devices, telepathy, and brain enhancement. Neuralink could also help treat neurological diseases. Can Neuralink Affect Our Relationships? If someone you love loses the ability to talk, express themselves, or walk unaided - Musk's technology could be the key to bringing our loved ones back to us. However, as previously demonstrated in some films and books, if AI doesn't exactly replicate the person you miss, is it worth it in the end? If Musk's technology works well, the device could help bring back our relationships with people who we have lost through brain impairment - but who are physically still here. Many older people may age quietly, younger people with other issues could be brought back to us. For the people who lose their partners to early onset of Alzheimer's, tragic brain injuries, or even advanced cancers that damage the brain - this could be the technology to bring back people lost too soon. Whether it's a parent, a friend, or the love of your life - Neuralink is being tested to help bring those people back to themselves

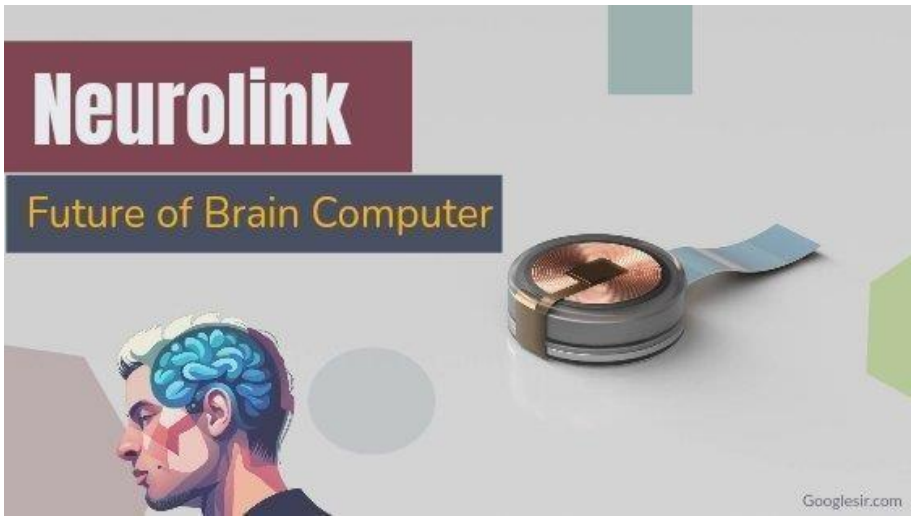

Fig 1.5 Future of Neuralinks

Implants vs Software

The key difference between Neuralink and OpenAI is that one requires brain implant surgery while the other purely develops software. Neuralink's brain chips aim to directly tap into our biological neural networks, while OpenAI's systems run on traditional computer hardware.
Implanting electrodes and other hardware into the brain provides more direct, high- bandwidth access to our neural activity. However, it is a much more invasive approach compared to software alone. OpenAI avoids the ethical issues and health risks of brain surgery. However, without a direct connection to the brain, external AI systems may not be able to match the seamless integration and capabilities Neuralink aims for. Enhancing Human Intelligence vs Artificial Intelligence Neuralink's goal is to enhance human intelligence and abilities by essentially merging biological and artificial computing. OpenAI, on the otheí hand, is focused on advancing AI itself - creating stand-alone systems that can interact with and assist people but not become fully integíated with the human mind. These different end goals lead to other philosophical differences between the technologies. Neuralink raises more direct ethical concerns regarding alterations of self identity and what is considered "natural." OpenAI's systems do not alter the brain itself so sidestep some of those issues, but they raise other concerns about AI capabilities getting ahead of human control and understanding

Chapter 4

Merits & Demerits

Merits:

1. *Medical Advancements:* Neuralink holds promise for treating neurological conditions. It could assist individuals with paralysis, spinal cord injuries, or conditions like Parkinson's disease by restoring movement or communication abilities.

2. *Enhancement of Human Abilities:* There's potential for augmenting human capabilities through brain- machine interfaces. This could lead to improved memory, faster information processing, or even direct interfacing with technology for enhanced communication and learning.

3. *Research and Understanding:* Neuralink's technology could deepen our understanding of the brain's functions, potentially unlocking breakthroughs in neuroscience and cognitive sciences.

Demerits:

1. *Ethical Concerns:* The potential for misuse, invasion of privacy, and ethical implications of augmenting human abilities raise significant concerns. Questions regarding consent, control over personal data, and the potential for coercion or exploitation must be addressed.

2. *Health Risks:* Implanting devices into the brain poses risks such as infection, tissue damage, or malfunction. Long-term effects on brain health and function also need careful consideration.

3. *Inequality and Accessibility:* Accessibility to such advanced technology could exacerbate existing social inequalities if it's only available to a select few due to cost or other barriers.

4. *Regulatory and Safety Challenges:* Ensuring the safety and efficacy of Neuralink's technology requires rigorous regulatory oversight and testing, which might slow down its availability.

Chapter 5

CONCLUSION AND FUTURE SCOPE

In conclusion, Neuralink is a revolutionary technology that has the potential to transform the way humans interact with technology. By connecting our brains directly to computers, we can achieve unprecedented levels of efficiency and communication. Neuralink represents a groundbreaking leap in brain-machine interface technology, holding immense potential for medical advancements and augmenting human capabilities. Its ability to establish communication between the brain and external devices opens doors for treating neurological conditions and potentially enhancing human cognition. However, ethical considerations, safety concerns, regulatory hurdles, and accessibility issues must be carefully addressed to ensure responsible development and widespread benefits.

Future Scope:

1. *Medical Applications:* Neuralink's future lies in revolutionizing healthcare by offering solutions for neurological disorders, paralysis, and brain injuries, potentially improving the lives of millions.

2. *Cognitive Enhancement:* Exploring ways to augment human abilities, such as memory enhancement or direct interfacing with technology, could redefine how we interact with the digital world.

3. *Advancements in Neuroscience:* Further research using Neuralink technology could deepen our understanding of the brain's complexities, leading to breakthroughs in neuroscience and cognitive sciences.

4. *Ethical and Regulatory Frameworks:* The future of Neuralink relies on developing robust ethical guidelines, ensuring privacy, consent, and addressing societal implications. Simultaneously, navigating regulatory pathways is crucial for safe and widespread adoption.

In conclusion, while Neuralink's potential is vast, its success hinges on responsible development, collaboration across disciplines, and addressing ethical, safety, and accessibility concerns. With careful navigation of these challenges, Neuralink could pave the way for transformative advancements in healthcare and human-machine interactions.

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