Journal of Computer Science and Technology Studies
ISSN: 2709-104X
DOI: 10.32996/jcsts
Journal Homepage: www.al-kindipublisher.com/index.php/jcsts

JCSTS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Elon Musk's Neuralink Brain Chip: A Review on 'Brain-Reading' Device

Mujiba Shaima[1] ✉ Norun Nabi[2], Md Nasir Uddin Rana[3], Md Tanvir Islam[4], Estak Ahmed[5], Mazharul Islam Tusher[6], Mousumi Hasan Mukti[7] and Quazi Saad-Ul-Mosaher[8]

[13456]*Department of Computer Science, Monroe College, New Rochelle, New York, USA*

[2]*Master of Science in Information Technology (MSIT)- Washington University of Science and Technology (WUST), Alexandria, Virginia, USA*

[78]*Department of Computer Science and Engineering, Bangladesh Army International University of Science and Technology, Academic Block, Cumilla, Chittagong, Bangladesh*

Corresponding Author: Mujiba Shaima, **E-mail**: mshaima6806@monroecollege.edu

| ABSTRACT

With its novel bidirectional communication method, Neuralink, the brain-reading gadget created by Elon Musk, is poised to transform human-machine relations. It represents a revolutionary combination of health science, neurology, and artificial intelligence. Neuralink is a potentially beneficial brain implant that consists of tiny electrodes placed behind the ear and a small chip. It can be used to treat neurological conditions and improve cognitive function. Important discussions are nevertheless sparked by ethical worries about abuse, privacy, and security. It is important to maintain a careful balance between the development of technology and moral issues, as seen by the imagined future in which people interact with computers through thinking processes. In order for Neuralink to be widely accepted and responsibly incorporated into the fabric of human cognition and connectivity, ongoing discussions about ethical standards, regulatory frameworks, and societal ramifications are important. Meanwhile, new advancements in Brain-Chip-Interfaces (BCHIs) bring the larger context into focus. By enhancing signal transmission between nerve cells and chips, these developments offer increased signal fidelity and improved spatiotemporal resolution. The potential revolutionary influence of these innovations on neuroscience and human-machine symbiosis raises important considerations about the ethical and societal consequences of these innovations.

| KEYWORDS

Neuralink, Brain-Chip-Interfaces (BCHIs), Neurology, Brain-Reading Device.

| ARTICLE INFORMATION

ACCEPTED: 02 February 2024 **PUBLISHED:** 23 February 2024 **DOI:** 10.32996/jcsts.2024.6.1.22

1. Introduction

Humans have been trying to uncover the brain signal for a very long time. Researchers were attempting to establish communication with the brain, which is our body's power source. Neuralink, which was incredibly unrevealing, finally shines some light to connect the globe with something new. Brain-computer interface (BCI) technology has gained prominence in scientific and technological discourse since the launch of Elon Musk's Neuralink, an innovative project at the intersection of neuroscience and AI. Established in 2016, the goal of the Neuralink project is to create a cutting-edge brain chip that will allow for direct brain-to-device connection. This technology has potential uses in both medical and cognitive domains. Neuralink's mission, driven by the goal of attaining human-machine symbiosis, has generated enthusiasm as well as ethical questions. This introduction explores the technological underpinnings of Neuralink, its possible uses, and the moral questions raised by this revolutionary project.

2. Methodology

Elon Musk's plan to develop Neuralink involves a multifaceted approach combining materials science, neurosurgery, and computational neuroscience and develop the brain-computer interface (BCI). The central element of Neuralink's methodology is the implantation of ultra-thin electrodes, referred to as "threads," that connect or go directly into the brain. These threads are finer than human hair and are designed to penetrate neural tissue with minimal damage, enhancing precision and reducing the risk of adverse reactions.

The surgical procedure for implantation is a critical aspect of the methodology. The aims of Neuralink are to minimize invasive approaches and utilize a robotic system that ensures precision during the placement of electrodes. Musk has emphasized the importance of developing a surgical technique that is both safe and efficient, minimizing trauma to the brain and enabling a faster recovery process for the patient.

Materials science plays a crucial role in Neuralink's methodology to ensure the longevity and biocompatibility of the implanted device. Musk has highlighted the use of biocompatible materials and advanced encapsulation techniques to address concerns related to the long-term effects of implantation, reducing the risk of tissue damage or rejection.

The computational aspect involves the development of sophisticated algorithms for decoding neural signals. Neuralink aims to create a system capable of accurately translating the complex patterns of neural activity into meaningful information. Hence, a lot of effort needs to be included to understand and interpret the neural code associated with different thoughts, sensations, interpretations, and movements.

3. Structure of Neuralink

3.1 Threads

Neuralink contains a gold thin-film trace encapsulated in a polyimide primary substrate and dielectric. The two main sections of the thin film arrays are the "sensor" area, which interfaces with custom chips for signal amplification and acquisition, and the "thread" area, which houses electrode contacts and traces. High-throughput production is made possible by wafer-level microfabrication, which patterns ten thin-film devices with 3072 electrode contacts in each wafer [Musk et al. 2019].

There are 48 or 96 threads in each array, and each thread has 32 separate electrodes. Flip-chip bonding is the method used to attach integrated chips to the contacts in the sensor area. The goal is to achieve a high channel count while minimizing tissue displacement in the brain through the maintenance of a small thread cross-sectional area. Stepper lithography and other microfabrication techniques are used to form metal films with submicron resolution [Musk et al. 2019].

More than 20 different thread and electrode configurations are included in the arrays, including "on-probe references" designs that place reference electrodes either on different threads or on the same threads as recording electrodes. The thread dimensions, which include multiple insulation and conductor layers, range from 5 μm to 50 μm in width and a nominal thickness of 4-6 μm. For pre-insertion handling, threads of about 20 mm in length are coated with parylene-C, which forms a film that is later removed by the surgical robot (Figure 1). Every thread ends with a $16\times50\ \mu m^2$ loop to make threading the needle easier. Optimizing probe performance for neural recording in the brain is the main goal of the design [Musk et al. 2019].

3.2 Technical Overview

The current device called the 0.9 version, consists of an array of 92 threads in input lines. Each of these threads is made up of 32-electrodes to receive brain electrical signals from 32 different regions. A 20-nanometer single electrode works electrical signal receptors and propagates the electrical signal to a single channel. So 92x32, a 3072 channel analog electrical signal converted to a digital signal. These digital signals of 20000 samples per second from the channels could be written into the external disk simultaneously [Musk et al. 2019].

3.3 Neural Data Repository

Modern devices like smart watches and hand-held gadgets can understand and track down some physical movements such as walking, running, sleeping etc. The data generated by these devices are stored in the cloud computer. Alongside, Neuralink recordings data could be written down into disk in real-time in conjunction with action tracking by smart devices. Not just smart devices, data also could be amassed from medical reports and patient devices. All these collected data could be simultaneously mapped as label data and stored in secondary storage. A comprehensive data repository architecture is needed to collect, store, and distribute data to help build not only different AI models but also to serve various medical purposes [Musk et al. 2019].

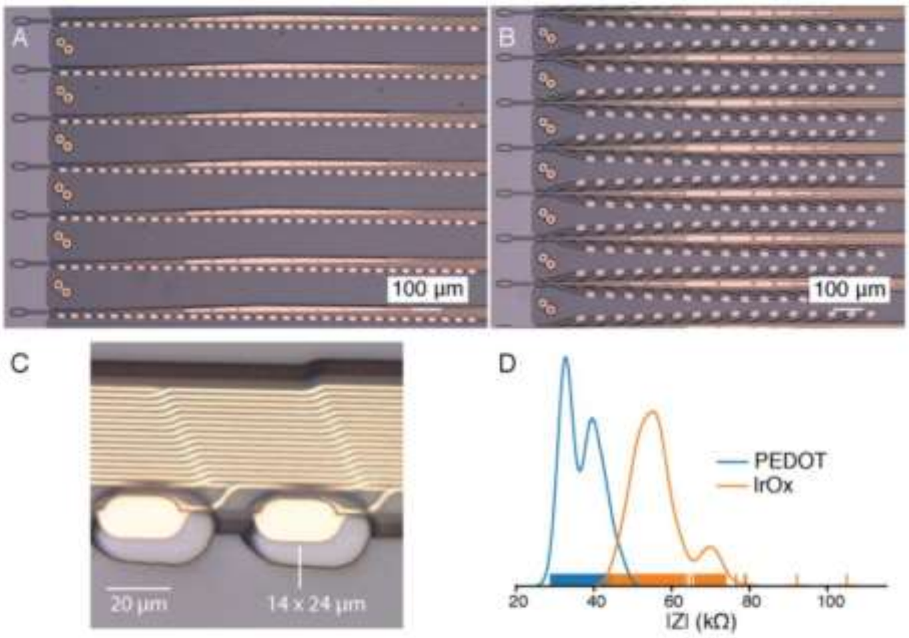

Figure:1 our cutting-edge polymer probes. (A) Probes with "Linear Edges," with 32 electrode connections separated by 50 µm. (B) "Tree" probes placed 75 µm apart and featuring 32 electrode connections. (C) A larger magnification of each electrode to highlight their tiny geometric surface area for the thread design in panel A. (D) Electrode impedance distribution (measured at 1 kHz) for PEDOT (n = 257) and IrOx (n = 588) surface treatments. IrOx stands for iridium oxide, PCB for printed circuit board, and PEDOT for poly-ethylenedioxythiophene [Musk et al 2019].

3.4 Building A Brain Model

Musk's Neuralink device, neuro spike detection based on emotional behavior, became materialized. These digital spike analyses could be a game changer for future human behavioral interpretation. Managing and storing these outputs of the device is worth future work. Machine learning algorithms could be fed with such neuro data repositories to develop an emulation to mimic human intelligence. The black box analysis of complex human neural networks could be expressed in terms of deep neural networks using machine learning algorithms.

4. The Future of Neuralink brain chip

With expected advancements that could drastically change the fields of neuroscience and human-machine interaction, Brain-Chip-Interfaces (BCHIs) have a very bright future ahead of them. Advances in signal fidelity and spatiotemporal resolution are anticipated to boost the precision and effectiveness of neural interfacing technologies as scientists work to perfect bidirectional communication between chips and nerve cells [Hodak et al. 2019]. Advances in oxide-insulated chips featuring large-scale, high-resolution arrays present a singular chance to capture and initiate brain activity at never-before-seen levels of detail [Neuralink Corporation n.d]. Furthermore, new insights into understanding and managing neurological functions other than electrical impulses are offered by the study of chemical signaling in BCHIs [Hodak et al. 2019]. As these technologies develop, BCHIs could be crucial in medical applications like the treatment of neurological diseases, as well as in improving human cognitive abilities and opening up new possibilities for human-machine symbiosis [Neuralink Corporation n.d].

We now have great hope that the field of neurological disease research and rehabilitation can greatly benefit from the application of brain-chip interfaces, or BCHIs. Advances in BCHIs are expected to lead to more effective treatment approaches for diseases like paralysis, Parkinson's disease, cancer cell pre-detection, and other various cases. Paralyzed people can control their internal parts by using wireless communication if the scientists can implement Neuralink technology [Flesher et al. 2016]. It accomplishes this by utilizing cutting-edge circuitry and incredibly thin electrodes [Musk et al. 2019]. As BCHIs continue to improve in signal fidelity and spatiotemporal resolution, this could further our understanding of brain circuits and lead to the development of more individualized and flexible treatment plans [Hodak et al. 2019]. Moreover, adaptive brain activity modulation and real-time monitoring may be made possible by the integration of BCHIs with machine learning algorithms to provide a flexible and dynamic method of managing disease [Musk et al. 2019]. Though morality remains a crucial factor, there appears to be a bright future for BCHI application in illness rehabilitation. The lives of those suffering from neurological disorders can be greatly enhanced by them.

5. Future implementation in Criminal Detection

The emergence of Brain-Chip-Interfaces (BCHIs), as demonstrated by Neuralink and Brain-Chip-Interfaces (BCHIs) could potentially play a role in criminal detection by providing insights into neural processes associated with deceptive behavior, memory recall, or emotional responses. While this application raises ethical and privacy concerns, the technology could be explored for forensic purposes under strict legal and ethical frameworks.

1. Memory Recover and Truth Verification: BCHIs can be used to examine the brain activity linked to recalling memories. Evaluating brain patterns associated with memory recall may help evaluate the veracity of witness statements and identify dishonest behavior [Farahany et al. 2014].
2. Identification Brain Response: Using BCHIs to analyze emotional responses may be helpful for criminal investigations. An individual's responses to interrogation or confrontation may be revealed by alterations in brain activity linked to emotions such as stress, anxiety, or fear. Again, hopefully, successful implementation can cure psychological patients.
3. Analize Particular Brain Patterns: Studies aimed at identifying brain patterns connected to deceit or criminal intent may aid in the creation of prediction models. Also, this can be used to detect some birth faults. However, care must be taken to prevent biases and incorrect interpretations of brain data [Greely et al. 2013].

If scientists can successfully implement Neuralink, it could have a significant impact in the future. However, legal frameworks need to be considered in order to guarantee the ethical and open application of this technology in the criminal justice system. In addition, the long-term effects must be considered.

6. Conclusion

The researchers have made an attempt to project and portray how Elon Musk's Neuralink installation is integrated with state-of-art technologies and some possible future research areas, for instance emulation of the brain using machine learning from neural device data. Such development would give some food for thought to what would happen next in terms of understanding neuro sensation. Consequently, an aggressive research market would gain confidence and momentum to further deep down into neuro analysis and its applications.

There are some key findings regarding the technical review of Elon Musk's Neuralink in possible ways of how data generated by the device could be manipulated so machines could be fed them in a structured way. The orchestration of data generated by brain chips, smart watches, and medical devices is crucial for the future emulation of the human brain.

However, the technical analysis and prediction of Brain-Chip-Interfaces (BCHIs) were brainstormed in a limited way because there was no real access to such devices. The analysis assumed some future security concerns due to the implication of BCHIs, but there is no such real life example of it.

Overall, these findings would carry a crucial role when it comes to having a simplistic interpretation of how spike based data drive Brain-Chip-Interfaces (BCHIs) could leave the layouts for potential AI applications.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Flesher, S. N., Collinger, J. L., Foldes, S. T., Weiss, J. M., Downey, J. E., Tyler-Kabara, E. C., ... & Boninger, M. L. (2016). Intracortical microstimulation of human somatosensory cortex. Science Translational Medicine, 8(361), 361ra141. https://pubmed.ncbi.nlm.nih.gov/27738096/

[2] Farahany, N. A. (2014). Neuroprivacy: A challenge for the criminal justice system. *The Journal of Neuroscience, 34(33)*, 10577-10586.

[3] Greely, H. T. (2013). Neuroscience and criminal justice: not responsibility but treatment. *Kansas Law Review*, 62, 1045.

[4] Hodak, A. (2019). White paper: Neuralink's neurosurgical robot. https://www.neuralink.com/docs/neurosurgical-robot-whitepaper.pdf

[5] Musk, E. (2019). An integrated brain-machine interface platform with thousands of channels. *bioRxiv*, 703801. https://doi.org/10.1101/703801

[6] Neuralink Corporation. (n.d.). https://www.neuralink.com/

[7] Naci, L., et al. (2014). An agenda for open science in the field of cognitive neuroscience. *Royal Society Open Science, 1(2)*, 140095.