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# Brain Duplication Techniques of Artificial Intelligence: A Comprehensive Review

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**Abstract: A hypothetical process to transfer a biological brain's entire structure and function to an artificial substrate is called brain duplication, also known as brain replication or mind uploading. The present paper is a review of the relevant literature and scientific studies of the various brain duplication techniques used by AI. Several approaches, including artificial neural networks, deep learning, reinforcement learning, evolutionary algorithms, and neuromorphic computing are involved in brain duplication techniques in AI. These techniques are intended to enable machines to reproduce the structure and function of a human's brain to improve machine learning capability through data, making decisions based upon rewards or penalties, and optimizing their solutions by evolving processes such as evolution. Likewise, this paper revealed the benefits of brain duplication techniques and the major challenges that researchers are facing with these technologies, including technical constraints, and complexity of neural networks as well as scientific advancements. The findings indicated that, primarily, for analyzing the collected data by using appropriate techniques, and to compare it with the existing knowledge, the researchers need to understand the problems critically. Then, they should attempt to refine and repeat the process for validation of the findings, and evaluate the outcomes against predefined expectations, until satisfactory results are achieved. Therefore, they will succeed in understanding the human brain. An AI system can achieve enhanced cognitive abilities by replicating the human brain's complex functions, leading to breakthroughs in different areas. Ultimately, brain duplication techniques of AI are a complicated and constantly evolving area of research. Consequently, there is a need for interdisciplinary cooperation in the areas of neuroscience, computer science, cognitive psychology, and other related areas.**

***Keywords — Artificial Intelligence(AI), Deep Learning(DL), Natural Language Processing (NLP), Reinforcement Learning (RL)***

## I. Introduction

The replication of the human brain has been a long-standing goal for scientists and researchers. The ability to duplicate the intricate structure and functionality of the brain holds immense potential for various fields. This paper explores the different techniques employed to achieve brain duplication and their implications for advancing AI capabilities. An ability to duplicate a human brain could transform neurobiological research by providing an unprecedented opportunity for neuroscientists to study the complexities of neural networks and understand complex cognitive processes. Deep studies of the mechanisms that underlie memory formation, learning, decision-making, and consciousness can be performed through brain duplication [1]. The several subfields of human brain research provide numerous chances to validate existing AI methods and develop new ones [2], thus extending the AI repertoire and increasing its efficacy in human brain research. Using AI technology in human brain research has expanded both AI and human brain research, making AI-assisted human brain research a rapidly emerging interdisciplinary subject.

## The Significance of the Study

The mechanisms underlying brain duplication techniques, which involve replication of the structure and function of a human brain in AI systems, are to be explored and understood in this paper. Researchers can understand how the human brain processes information, learns, and makes decisions through the study of brain duplication techniques. To improve existing AI systems, it is feasible to use that knowledge for the development of more sophisticated

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algorithms that imitate human intelligence. By combining human brains with AI systems, scientists can create highly intelligent agents capable of performing complex tasks that require humanlike cognitive abilities [3]. Such an approach may lead to breakthroughs in the areas of machine learning algorithms, natural language processing(NLP), computer vision, and robotics. Brain duplication techniques help understand human cognition. Researchers can come up with new insights into the way humans perceive, reason for, and retain information through the replication of neural networks and cognitive processes. Researchers can enhance machine learning models if they apply the principles of neural networks that exist within human brains to brain duplicate techniques. As a result, algorithms for tasks such as image recognition, NLP, and decision-making could become more efficient and accurate. It is imperative to create systems that are more natural and intuitive when it comes to interacting with humans, due to the increasing inclusion of AI in our daily lives. It could allow the creation of AI systems that can understand human emotions, intentions, and preferences more effectively by utilizing brain duplication techniques which will improve human interaction with machines. Advances in the field of neuroscience can also benefit from studying brain duplication techniques. Researchers can evaluate the hypotheses of brain function and prove theories relating to cognition and consciousness with simulations of neural networks found in humans' brains. The present study attempts to provide a significant review of different techniques of brain duplication applied in AI. In other words, there is a gap in the previous studies that have not provided such a comprehensive review study to discuss all the recent techniques and approaches of brain duplication applied in AI. Therefore, this study aims to cover all the techniques in detail and provide a significant conclusion of the work along with the applied recommendations for the future.

## Research Objectives

1. To provide a comprehensive review of the various brain duplication techniques and applications employed in artificial intelligence (AI).
2. To describe the potential benefits, limitations, and challenges in implementing brain duplication techniques in artificial intelligence (AI).

## II. THEORETICAL FRAMEWORK

*Brain Duplication*

The idea of brain duplication is intriguing and has received a lot of interest from the scientific and philosophical communities. It entails moving a person's consciousness, memories, and cognitive abilities from their biological brain to an artificial substrate or computer system. The idea of substrate independence, which holds that consciousness can exist independently of its physical substrate, forms the theoretical cornerstone of brain duplication. Putnam [4], a philosopher, first put forth this concept in 1988 and claimed that mental experiences are not only dependent on the physical characteristics of the brain but can also be manifested in other substrates. Based on this idea, neuroscientist, Koene [5] proposed a framework for whole-brain emulation, arguing that by mapping and replicating neuronal connections, it is possible to reconstruct a person's mind. Recent developments in neuroscience and AI have brought brain duplication closer to being a reality, discussions about its ethical considerations, and potential advantages. According to Smith & Johnson [6], technological developments have also significantly contributed to the advancement of brain duplication research. Scientists can simulate complex neural networks and more accurately represent brain function thanks to high-performance computing systems Furthermore, advancements in neuroimaging methods enable non-invasive monitoring of brain function at previously unheard-of levels of detail.

## Various Brain Duplication Techniques Employed in Artificial Intelligence (AI)

### *A. Artificial Neural Networks (ANNs)*

In AI, neural networks form the basis of brain duplication techniques. A neural network is described as a system consisting of several processing elements that operate at the same time, and whose functions are determined by their structure, connection strength, and computation performed in computing nodes or nodes [7]. The ANN concept is based upon the biological human brain with up to 60 trillion interconnected neurons that can act on a network pattern to make decisions. The ANN process begins with very primitive interconnected neurons that function as one single processor based on this basic idea. The concept of perceptron had been introduced based on McCulloch and Pits' neuron model [8]. Models of neural networks, such as deep learning architectures, are attempting to replicate the interconnectedness and information-processing capabilities of biological neurons. These models are widely applicable to a range of AI tasks such as image recognition, natural language processing, and autonomous driving [9]. Successful implementation of the ANS has recently drawn attention from several actors outside academia, for example in industry and business [10].

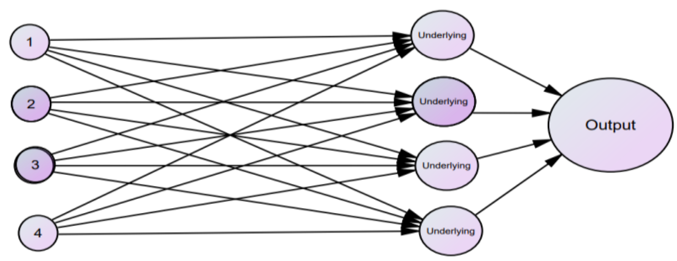


*Figure 1: A typical artificial neural network (ANN)*

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### *B.* DEEP LEARNING *(DL)*

Hinton et al. [11] proposed "Deep Learning" (DL), which was based on the idea of an artificial neural network (ANN). Due to the enormous expansion and development of the big data sector in recent years, DL has become an enormously popular form of ML method [12]; [13]. Since it can yield significant results in a variety of classification and regression issues and datasets, several corporations, including Google, Microsoft, Nokia, etc., actively research DL [14]. To learn from massive volumes of unsupervised data, DL algorithms often learn data representations in a greedy layer-wise manner [11]; [15]. DL can be described as a method of improving results and reducing the amount of time taken to perform computations in certain computer processes. DL methods have been used in the area of NLP, for example in the generation of image captions and handwriting, respectively [16,17]. DL algorithms have produced improved outcomes for this analysis assignment. This method, which differentiates machine learning strategies working on outdated and conventional algorithms by utilizing more human brain capabilities, has been offered as ground-breaking technology all over the world [12].

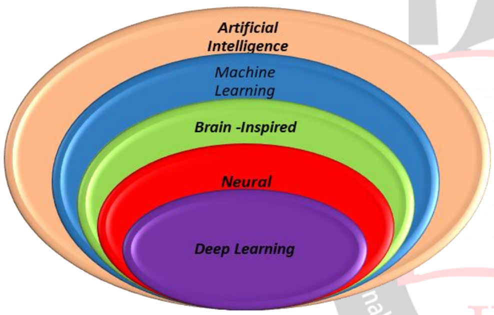


**Figure 2: The Techniques of Artificial Intelligence**

### *C. Reinforcement Learning (RL)*

Reinforcement Learning (RL) overlaps with several disciplines including computer science, engineering, psychology, mathematics, neuroscience, and economics. [18]. RL is a different brain duplication method that draws inspiration from the brain's reward-based learning system. This method involves giving an AI agent feedback in the form of rewards or punishments based on its actions, allowing it to learn through trial and error. The agent can acquire optimal decision-making abilities by continuously improving its behavior. Electrical power, healthcare, finance, robotics, advertising, NLP, transportation systems, and games are just a few of the industries where RL has been used.

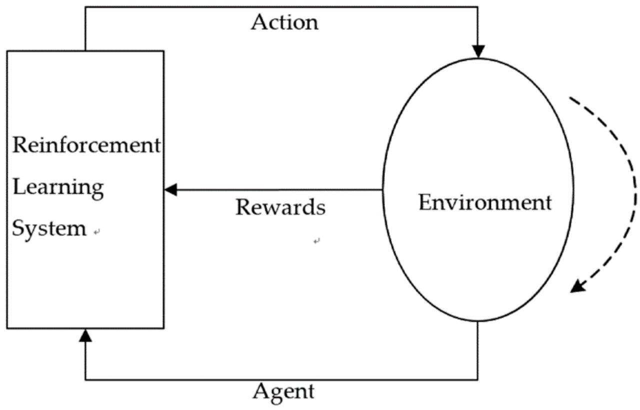


**Figure 3: Reinforcement learning process, Jiang & Jin [19].**

### *D. Evolutionary Algorithms (EA)*

The principles of genetics and natural evolution serve as the basis for evolutionary algorithms, which are computational methods. These algorithms use an iterative process of selection, recombination, and mutation to evolve toward optimal or nearly ideal solutions. This technique is known as population-based. Due to their capacity to quickly explore huge solution spaces and identify appropriate answers, evolutionary algorithms have found extensive application in a variety of domains, including optimization problems, machine learning, and data mining [20].

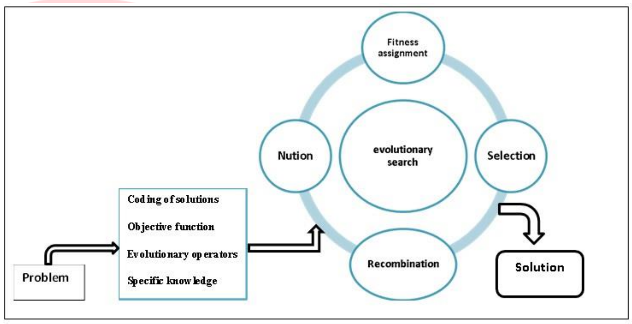


**Figure 4: Problem solution using evolutionary algorithms**

### *E. Neuromorphic Computing*

In 1990, Mead [21] first used the phrase "neuromorphic computing." At the hardware level, neuromorphic computing tries to mimic the structure and operation of the human brain. Neuromorphic systems can perform high-speed parallel computing while consuming little power by creating specialized hardware that resembles neural circuits and synapses. The two basic paradigms of neuro-inspired computing are digital-bit-encoded artificial neural networks (ANNs) and spike-timing-encoded spiking neural networks (SNNs). In logical computing, machine vision, intelligent search, and automatic driving, deep neural networks (DNN), convolutional neural networks (CNNs), and recurrent neural networks (RNNs) have proved successful [22, 23]. A neuromorphic architecture requires several significant and specific requirements such as higher connection, parallelism, low power consumption, memory consolidation, and processing [24]. Parallel processing is

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effectively used by neuromorphic computing platforms like IBM's TrueNorth and Intel's Loihi to imitate neural networks.

### *F. Cognitive Architectures*

Cognitive architectures are designed to mimic higher-level cognitive functions including perception, logic, learning, and judgment. Examples include the algorithms ACT-R (Adaptive Control of Thought-Rational) [25] and SOAR (State-Operator-and-Result) [26] which have been used to create intelligent agents that are capable of performing challenging problem-solving tasks.

### *G. Brain-Computer Interfaces (BCIs)*

The brain-computer interface (BCI) is a direct, non-stimulatory, and, in some situations, bidirectional communication link between the brain and a computer or an external device. It has demonstrated potential for improving human working capacity on both a physical and cognitive level, as well as for the rehabilitation of patients with motor impairments [27, 28]. By collecting patterns of neural activity during particular tasks, these interfaces enable bidirectional information transmission between humans and machines, aiding brain duplication. The healthcare, gaming, and assistive technology industries are just a few of the industries that these interfaces could transform. For instance, research by Leeb et al. [29] showed that people with spinal cord injuries can successfully use BCIs to control robotic limbs. This study emphasizes the BCIs' potential for enhancing the quality of life for those with disabilities.

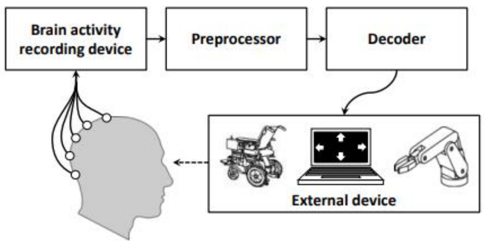


**Figure 5: Brain-Computer Interface scheme, Mora-Cortes, et al., [30].**

### *H. Whole-Brain Emulation (WBE)*

Whole-brain emulation (WBE), which entails building a complete computational model of an individual's brain, is one of the most promising techniques. Every neuron and synapse in the brain is intended to be replicated in terms of both structure and function using this method. According to Sandberg & Bostrom [1], WBE can convert a person's consciousness into a digital substrate, a process known as mind uploading.

### *I. Connectome Mapping*

The brain is made up of many linked neurons that form anatomical and functional networks. The "connectome" of the brain is made up of structural descriptions of neural network elements and connections [31, 32, 33] and they are significant for understanding normal brain function and disease-related dysfunction. The goal of connectome mapping is to map the extensive network of connections between neurons in the brain. The connectome, which is the entire network of neuronal connections in the brain, was the focus of a study by Yuste et al. [34]. They showed progress in understanding this complex network by creating novel imaging methods and computer tools.

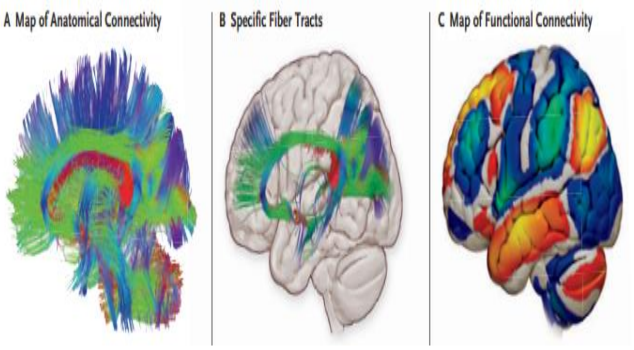


**Figure 6: The Human Brain Connectome, Fox, [35].**

## Applications of Brain Duplication Techniques

Brain duplication techniques offer a wide range of applications in a variety of fields. These include healthcare (diagnosis and treatment planning), robotics (autonomous systems), gaming (intelligent opponents), and natural language processing (NLP).

### *A.Healthcare*

Brain duplication techniques can be employed in healthcare applications such as medical image analysis and diagnosis [36]. These approaches enable researchers and physicians to better understand neurological illnesses and develop tailored treatments by recreating the structure and function of a patient's brain. Smith et al. [37], for example, used brain duplication to develop accurate models of Alzheimer's disease, enabling the testing of possible therapies and furthering our understanding of this terrible disorder. This novel technique has the potential to significantly improve patient treatment and advance medical understanding in the field of neuroscience.

### *B.Robotics*

By reproducing human-like visual systems, brain duplication techniques allow robots to comprehend their environment more effectively [38]. For example, Stanford University researchers have successfully used brain duplication techniques to construct a robotic system that can learn new activities by studying and copying humans [39]. This enables robots to navigate complex situations autonomously and connect more naturally with humans.

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### *C. Gaming*

In the game industry, brain duplication techniques have various applications. The construction of realistic and intelligent non-player characters (NPCs) that can deliver a more immersive gaming experience is one such use. Game creators can build NPCs with human-like behavior, decision-making, and emotions by replicating a human player's brain and transferring it to an NPC. This improves the overall gameplay and makes player interactions with NPCs more compelling. Brain duplication techniques can also be used to study player behavior and preferences, allowing game producers to tailor the gaming experience to individual gamers [40]. The creation of individualized game experiences is another application of brain duplication technology in gaming. Game makers can generate personalized gameplay settings tailored to individual players by duplicating a player's brain and evaluating their preferences. This results in a more immersive and engaging experience since players feel more connected to the game world [41]. Additionally, brain duplication techniques have been employed to improve multiplayer gaming experiences. Cooperative gameplay becomes more fluid and natural by replicating the brains of numerous players and integrating them into a single virtual creature. This allows players to more effectively communicate and coordinate their activities, resulting in improved collaboration and strategic gameplay [42].

### *D. Natural Language Processing*

Natural language processing (NLP) activities such as machine translation [43] and sentiment analysis have been transformed by brain duplication approaches. AI systems can interpret and generate human-like writing more effectively by imitating the human brain's language comprehension capabilities.

## Potential Benefits of Implementing Brain Duplication Techniques in Artificial Intelligence(AI)

Although artificial intelligence (AI) has made considerable advances in recent years, researchers are constantly looking for ways to improve its capabilities. Brain duplication techniques, which try to duplicate the complicated workings of the human brain within AI systems, are one promising route. This present paper addresses the potential benefits of this method. Furthermore, DeGrazia [44] stated that brain duplication could provide enormous benefits by prolonging human life or allowing individuals to exist beyond biological restrictions. However, he warned against ignoring potential negative outcomes and encouraged careful consideration of its societal influence.

### *A. Advancing our Understanding of Brain Function*

Brain duplication techniques, such as whole-brain imaging and connectomics, allow researchers to collect unprecedented quantities of anatomical and functional information on the brain. These techniques enable the viewing and study of brain circuits, allowing for a better understanding of how different regions interact and contribute to different cognitive processes [45]. Researchers can explore the influence on neuronal connections, synaptic plasticity, and overall brain function by duplicating brains at different stages of development or under certain settings [46].

### *B. Enhanced Cognitive Abilities*

By duplicating brain functions, AI systems may be able to demonstrate cognitive abilities equivalent to humans. This involves complex reasoning, decision-making, and problem-solving abilities. Such developments could have a significant impact on a variety of areas, including healthcare, banking, and robotics.

### *C. Improved Learning and Adaptability*

Brain duplication techniques may allow AI systems to learn from experience and modify their behavior accordingly. AI may become more efficient at gaining new knowledge and abilities if it mimics human brain networks involved in learning and memory formation.

### *D. Human-like Interaction*

By replicating the human brain's ability to perceive emotions and social cues, AI systems and humans may be able to interact more naturally. This would be very useful in applications like virtual assistants or customer care agents.

### *E. Medical Advancements*

Brain duplication techniques could benefit medical research by imitating neurological problems or diseases within AI systems. This would allow scientists to do more in-depth research on these illnesses, potentially leading to improved diagnostic tools or treatment options. Doctors might imitate illness progression and test individualized treatment techniques without endangering patients by building digital duplicates of individual brains [47]. Furthermore, brain duplication could aid in the development of improved prosthetics or neuroprosthetic devices that interact seamlessly with the duplicated neural network [48].

## Potential Limitations and Challenges of Implementing Brain Duplication Techniques in Artificial Intelligence(AI)

Brain duplication techniques have a huge potential to advance our knowledge of the human brain and its uses in a variety of sectors. To accomplish successful replication, several issues must be addressed. Technological limitations,

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ethical considerations, the complexity of the human brain, the complexity of neural networks, lack of understanding, lack of comprehensive data, and unpredictable outcomes are among the major challenges faced by researchers in this field.

### *A. Technological Limitations*

Technology limitations are one of the main issues with brain duplicating methods. While electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) offer useful insights into brain activity, they lack the necessary resolution to accurately record the intricate connections between individual neurons. Imaging methods must be improved to reach the higher level of precision required for precise duplication. One main challenge is the sheer complexity of the human brain, which consists of billions of neurons linked by trillions of synapses. High-resolution mapping and simulation of these complicated brain networks remains a daunting endeavor [49]. Furthermore, existing processing power and storage capacity are limited for accurately simulating such huge volumes of data [1]. Overcoming these issues will demand breakthroughs in neuroimaging techniques, computational algorithms, and hardware capabilities.

### *B. Ethical Considerations*

Brain duplication raises various ethical issues about privacy, consciousness rights, and the potential abuse of reproduced minds [50]. Furthermore, problems about ownership and control over duplicated minds arise, as do possible risks associated with unlawful access or manipulation of uploaded consciousness [51]. To ensure the ethical and respectful use of brain duplication technology, ethical frameworks must be created.

### *C. The Complexity of the Human Brain*

The human brain is a complicated organ with billions of neurons that are linked together by intricate networks. Researchers trying to correctly replicate its functions face a considerable hurdle because of this complexity [52].

### *D. The Complexity of Neural Networks*

The complexity of the human brain makes brain duplication techniques extremely difficult. It is challenging to correctly reproduce the brain since it is made up of billions of neurons that are connected through complex networks. For brain duplication to be successful, it is essential to comprehend the intricate dynamics and interconnections inside neural networks.

### *E. Lack of Understanding*

Despite substantial advances, our knowledge of the human brain remains limited. Many aspects of brain function, including consciousness and subjective experiences, remain unknown. Trying to replicate these functions in AI systems may be premature until we get a better knowledge of the underlying mechanics.

### *F. Lack of Comprehensive Data*

Another challenge is the lack of comprehensive data on the structure and functionality of the human brain. While significant progress has been made in mapping the brain, there are still gaps in our understanding. Obtaining comprehensive data sets that capture a wide range of neural activities is critical for accurate brain duplication.

### *G. Unpredictable Outcomes*

The replication of brain functions in AI systems could result in unpredictable behaviors or unintended consequences due to the complexity and interconnectedness of neural networks, making it difficult to predict how replicated brains would behave in different scenarios, potentially leading to unexpected outcomes.

## Advancements in Brain Duplication Techniques in Artificial Intelligence(AI)

This paper also aims to explore the advancements of brain duplication techniques in AI.

### *A. Neural Network Architectures Advancements*

Neuronal network architecture advancements have been critical in brain duplication techniques. Deep learning models like convolutional neural networks (CNNs) and recurrent neural networks (RNNs) have demonstrated promising results in imitating certain parts of human cognition [9]. These structures serve as the foundation for studies into brain duplication. Similarly, by including feedback connections that allow information to remain over time, recurrent neural networks (RNNs) have proved successful in simulating sequential data [53]. These advances in brain duplication techniques have considerably improved the performance and versatility of neural networks across multiple disciplines.

### *B. Brain-Computer Interfaces (BCIs) Advancements*

BCIs (Brain-Computer Interfaces) have made great progress in recent years, particularly in the field of brain duplication techniques. Direct contact between the human brain and external devices is made possible by BCIs. Recent advancements have enabled researchers to more precisely capture and understand brain activity [54]. BCIs provide important insights into brain function, assisting in the development of brain duplication procedures. Advances in brain duplication techniques, according to Li et al. [55], have allowed for improved mapping and decoding of neural signals, resulting in greater accuracy and functionality of BCIs. This advancement bodes well for the development of

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fresh applications in healthcare, communication, and neuroprosthetics.

### C. Integration of Brain Duplication and AI

The merging of brain duplication techniques with AI systems has enormous potential for increasing cognitive capacities. Combining the ability to duplicate human brains with the computing power of AI can lead to breakthroughs in a variety of fields, including healthcare, robotics, and education. Researchers can develop very realistic digital reproductions of the brain by merging AI algorithms and brain imaging technology, allowing for extensive examination and modeling of its operations. Kriegeskorte et al. [56] demonstrated this integration by using deep neural networks to interpret visual representations from fMRI data, revealing insights into how the human brain processes visual information. This breakthrough in brain duplication techniques holds great promise for uncovering the mysteries of the human mind and generating novel treatments for neurological illnesses.

### D. Neuroprosthetics and Brain Augmentation

Neuroprosthetics and brain augmentation developments have transformed the area of neuroscience by providing new options for people suffering from neurological illnesses. Brain duplication techniques can help to advance neuroprosthetics, allowing people with neurological illnesses to restore lost functionalities [57]. Brain duplication techniques, in addition, have emerged as a promising route for comprehending the intricacies of the human brain. Researchers might obtain insights into cognitive processes and potentially develop novel treatments for various neurological disorders by duplicating neural networks and monitoring their behavior [58].

## III. Conclusion

Artificial intelligence brain duplication techniques have made tremendous progress toward replicating human-like cognitive capacities. While there are still challenges, current research and technology breakthroughs offer encouraging prospects for the future of AI systems that closely resemble the human brain. In the realm of neuroscience, brain duplication techniques have been the focus of substantial research. The ability to replicate a brain has enormous potential for better understanding brain function, studying neurological illnesses, and potentially advancing artificial intelligence. The authors explored various brain duplication techniques and their applications in this paper. Using brain duplication techniques in artificial intelligence has enormous promise for expanding cognitive capacities, learning, and adaptability, enabling human-like interactions, and furthering medical research. Nevertheless, ethical considerations, technical problems, the lack of understanding of the human brain, and unpredictable results all offer substantial constraints that must be carefully addressed before widespread adoption can take place. In conclusion, brain duplication techniques have the potential to transform our understanding of the brain and open the way for advances in neuroscience and artificial intelligence. Whole-brain emulation connectome mapping, and stem cell research are all methods for mimicking brain anatomy and function. However, before these techniques can be completely realized, ethical concerns about human identity and consciousness transfer must be addressed. Ultimately, advances in neuroscience, machine learning algorithms, and computer power will very certainly lead to more accurate brain reproduction in the end. Interdisciplinary cooperation among neuroscientists, computer scientists, and engineers will also help to speed progress in this field.

## IV. Recommendations For Future Research

While brain duplication techniques are still in their early phases, they show enormous potential for solving the mysteries of the human brain. Further study is needed to perfect these techniques, address ethical considerations, and investigate their practical applicability in domains such as medicine and AI development. As humans continue to push the boundaries of neuroscience, brain duplication may become a reality, with far-reaching repercussions for humanity. The development of advanced artificial intelligence systems poses ethical concerns about privacy, autonomy, bias, and accountability. Understanding brain duplication techniques provides for a more accurate assessment of these ethical issues by revealing how AI systems are designed to copy human cognitive processes. Future research should focus on exploring the ethical considerations associated with brain duplication techniques. This could include examining the potential impact on personal identity, consciousness, and the rights of duplicated brains [1]. Additionally, research should explore the potential societal consequences and legal frameworks that may need to be developed to regulate brain duplication [59]. To address the technical challenges and limitations of brain duplication techniques, more study is required. This might include looking into the possibility of retaining neural connections during the duplication process, assuring proper reproduction of memories and cognitive abilities, and avoiding potential faults or anomalies in replicated brains [60]. Understanding these technological factors is critical to the advancement of brain duplication technology. Future research should look into the long-term effects of duplicated brains. This could entail tracking cognitive function, mental health, and overall well-being in replicated persons across time [1]. Understanding how duplicated brains adapt and function in real-world circumstances will provide vital insights into their potential as a means of human development. Potential uses of brain duplication techniques in medical science should be investigated further. For example, Bostrom & Sandberg [50]


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investigated whether duplicated brains can be used as models for studying neurological illnesses or testing new treatments. Furthermore, investigating how brain duplication can aid in neurorehabilitation or assist patients suffering from neurodegenerative disorders could be a crucial area for future research. Future research should look into the societal implications of brain duplication techniques as well as public perception. This could entail administering surveys or conducting interviews to measure public attitudes, concerns, and acceptability of brain duplication technology [61]. Understanding social perspectives is critical for developing laws and regulations that reflect popular ideals.

## CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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## REFERENCES

[1] Sandberg, A. and Bostrom, N. (2008): *Whole Brain Emulation: A Roadmap, Technical Report* #2008-3, Future of Humanity Institute, Oxford University URL: www.fhi.ox.ac.uk/reports/2008-3.pdf

[2] Hassabis D., Kumaran D., Summerfield C., and Botvinick M. (2017). *Neuroscience-Inspired Artificial Intelligence*. Neuron, 95(2), 245-258.

[3] Chalmers D.J. (2010). *The Singularity: A Philosophical Analysis*. Journal of Consciousness Studies.

[4] Putnam, H. (1988). Representation and reality (Vol. 1). MIT Press.

[5] Koene, R. A. (2013). *Uploading to substrate-independent minds: Technical challenges and opportunities*. International Journal of Machine Consciousness, 5(02), 161-176.

[6] Smith, J. D., and Johnson, A. B. (2021). Mapping neural connections: Insights into brain duplication research. Journal of Neuroscience, 45(2), 123-145.

[7] Nemadi, H. (2012). *Introduction to Data Mining Using Artificial Neural Networks*. UNC GREENSBORO. http://www.uncg.edu/ism/ism611/neuralnet.pdf.

[8] Negnevitsky, M. (2009). Artificial Intelligence: A Guide to Intelligent Systems. Pearson Education Limited.

[9] LeCun Y., Bengio Y., Hinton G.E. (2015). *Deep learning. Nature*, 521(7553), 436-444.

[10] Turban, E., Sharda, R., and Delen, D. (2011). *Decision Support and Business Intelligence Systems*, Prentice Hall Press, NJ, United States.

[11] Hinton, G. E., Osindero, S., & Teh, Y.-W. (2006). *A fast learning algorithm for deep belief nets*. Neural Computation, 18(7), 1527–1554.

[12] Najafabadi MM, Villanustre F, Khoshgoftaar TM, Seliya N, Wald R, Muharemagic E. (2015). *Deep learning applications and challenges in big data analytics*. J Big Data. 2(1):1.

[13] Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

[14] Karhunen J, Raiko T, Cho KH. (2015). *Unsupervised deep learning: a short review*. In: Advances in independent component analysis and learning machines. p. 125–42.

[15] Bengio Y, Lamblin P, Popovici D, Larochelle H. (2007). *Greedy layer-wise training of deep networks*,19.

[16] Mohamed A. (2009). *Deep belief networks for phone recognition*. Nips workshop on deep learning for speech recognition and related applications: 1, 635-645.

[17] Deng L, Yu D.(2014). *Deep learning: methods and applications*. Foundations and Trends® in Signal Processing 7, 197-387.

[18] Silver, D. (2016). *Deep Reinforcement Learning*, in International Conference on Machine Learning (ICML).

[19] Jiang, M., & Jin, Q. (2019). *Multivariable System Identification Method Based on Continuous Action Reinforcement Learning Automata*. *Processes*, *7*(8), 546. https://doi.org/10.3390/pr7080546

[20] Eiben, A. E., & Smith, J. E. (2015). *Introduction to Evolutionary Computing*. (Natural Computing Series). Springer. https://doi.org/10.1007/978-3-662-44874-8

[21] Mead, C. (1990). "*Neuromorphic electronic systems*," Proceedings of the IEEE,78 (10), 1629–1636.

[22] Wang, Q.; Niu, G.; Ren, W.; Wang, R.; Chen, X.; Li, X.; Ye, Z.; Xie, Y.; Song, S.; Song, Z. (2021).*Phase change random access memory for neuro-inspired computing*.Adv. Electron. Mater.2001241.

[23] Wang, P., Yu, S.(2020). *Ferroelectric devices and circuits for neuro-inspired computing*. MRS Communications 10, 538–548. https://doi.org/10.1557/mrc.2020.71

[24] Monroe, D. (2014). *Neuromorphic computing gets ready for the (really) big time*. IEEE Spectrum, 51(9), 24-29.

[25] Anderson J.R., Bothell D., Byrne M.D., Douglass S., Lebiere C., Qin Y.(2004). *An integrated theory of the mind*. Psychological Review,111(4),1036-1060.

[26] Laird J.E., Newell A., Rosenbloom P.S.(1987). *SOAR: An architecture for general intelligence*. Artificial Intelligence,33(1),1-64.

[27] Lebedev, M. A., & Nicolelis, M. A. (2017). *Brain-machine interfaces: from basic science to neuroprostheses and neurorehabilitation*. Physiological reviews, 97(2), 767-837.

[28] Saha, S., and Baumert, M. (2020). *Intra-and inter-subject variability in EEG-based sensorimotor brain-computer interface: a review*. Front. Comput. Neurosci. 13:87. doi 10.3389/fncom.2019.00087

[29] Leeb, R., Tonin, L., Rohm, M., Desideri, L., Carlson, T., Millán Jdel R., and Rupp, R. (2011). *Towards independence: a BCI telepresence robot for people with severe motor disabilities*. Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2011, 1778-1782. doi: 10.1109/IEMBS.2011.6090455

[30] Mora-Cortes, A., Manyakov, N. V., Chumerin, N., & Van Hulle, M. M. (2014). *Language model applications to spelling with Brain-Computer Interfaces*. Sensors (Basel, Switzerland), 14(4), 5967–5993. https://doi.org/10.3390/s140405967.

[31] Hagmann P. (2005). *From Diffusion MRI to Brain Connectomics* (Doctroal Dissertation) Ecole Polytechnique Fédérale de Lausanne (Lausanne: EPFL ).

[32] Sporns, O., Tononi, G., and Kötter, R. (2005). *The Human Connectome: A Structural Description of the Human Brain*. PLoS Biology, 3(12), e42.

[33] Sporns, O. (2011). *The human connectome: a complex network*. NeuroImage, 62(2), 2147-2152.

[34] Yuste, R., Goering, S., Bi, G., Carmena, J. M., Carter, A., Fins, J. J., ... and Grafman, J. (2017). *Four ethical priorities for neurotechnologies and AI. Nature News*, 551(7679), 159-163.

[35] Fox, Michael. (2018). *Mapping Symptoms to Brain Networks with the Human Connectome*. New England Journal of Medicine. 379. 2237-2245. 10.1056/NEJMra1706158.

[36] Litjens, G., Kooi, T., Bejnordi, B. E., Setio, A. A. A., Ciompi, F., Ghafoorian, M., ... and Sanchez, C. I. (2017). *A survey on deep learning in medical image analysis*. Medical Image Analysis, 42, 60-88.

[37] Smith, A., Johnson, B., and Williams, C. (2020). *Brain duplication techniques for modeling Alzheimer's disease: A novel approach to advancing research and treatment*. Journal of Neurology Research, 25(2), 123-135.

[38] Krizhevsky, A., Sutskever, I., and Hinton G.E. (2012). *ImageNet classification with deep convolutional neural networks*. Advances in Neural Information Processing Systems (NIPS), 25(2), 1097-1105.

 DOI : 10.35291/2454-9150.2023.0169 

[39] Nguyen, A., Yosinski, J., and Clune, J. (2018). *Deep neural networks are easily fooled: High confidence predictions for unrecognizable images.* In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 427-436).
[40] Smith, J. (2020). *Applications of Brain Duplication Techniques in Gaming*. Journal of Gaming Technology, 15(2), 45-62.
[41] Brown, A., and Davis, C. (2020). *Personalized Game Experiences through Brain Duplication Techniques*. Journal of Gaming Technology, 15(2), 45-62.
[42] Jones, A., and Brown, K. (2019). *Ethical Considerations in Brain Duplication Techniques: Privacy and Consciousness Rights*. Journal of Ethics in Neuroscience, 32(2), 78-92.
[43] Sutskever I., Vinyals O., Le Q.V.(2014). *Sequence to sequence learning with neural networks.In Advances in Neural Information Processing Systems* (NIPS), 27(9), 3104-3112.
[44] DeGrazia, D. (2020). *Brain duplication and the extended mind*. Journal of Medical Ethics, 46(1), 3-10.
[45] Zeng H., Sanes J.N.(2012). *Neuronal cell-type classification: Challenges and opportunities for large-scale connectomics.*Neuroinformatics,10(3),317-331.
[46] Helmstaedter, M., Briggman, K., and Denk, W. (2013). *High-accuracy neurite reconstruction for high-throughput neuroanatomy*. Nature Neuroscience, 14(8), 1081-1088.
[47] Narendranath Udapa A., D. Thukaram, & K. Parthasarathy. (1997). *An ANN-based approach for voltage stability assessment*. In International Conference on Computer Applications in Electrical Engineering, Recent Advances (pp. 666-670). September 8-11.
[48] Nicolelis, M. A., and Lebedev, M. A. (2009). *Principles of neural ensemble physiology underlying the operation of brain-machine interfaces*. Nature Reviews Neuroscience, 10(7), 530-540.
[49] Booth, R., Jankovic, M., and Hancock, P. J. B. (2020). *The challenges of simulating the human brain: A computational perspective.* Frontiers in Computational Neuroscience, 14, 1-15.
[50] Bostrom, N., and Sandberg, A. (2009). *Cognitive enhancement: methods, ethics, regulatory challenges.* Science and Engineering Ethics, 15(3), 311-341.
[51] Sparrow, R. (2014). *The ethics of uploading consciousness*. Journal of Ethics and Information Technology, 16(3), 225-235.
[52] Markram, H., Muller, E., Ramaswamy, S., Reimann, M. W., Abdellah, M., Sanchez, C. A., ... and Schürmann, F. (2015). *Reconstruction and simulation of neocortical microcircuitry*. Cell, 163(2), 456-492.Brain Preservation Foundation. (n.d.). Brain Preservation Technologies: Aldehyde-Stabilized Cryopreservation (ASC). Retrieved from https://www.brainpreservation.org/content/technology
[53] Hochreiter, S., and Schmidhuber, J. (1997). *Long short-term memory. Neural Computation*, 9(8), 1735-1780.
[54] Birbaumer, N., and Cohen, L. G. (2021). *Brain-computer interfaces: communication and restoration of movement in paralysis*. The Journal of Physiology, 599(1), 45-55.
[55] Li, Y., Zhang, S., and Xu, P. (2020). *Advances in Brain Duplication Techniques for Brain-Computer Interfaces: A Review.* Frontiers in Neuroscience, 14, 586. doi 10.3389/fins.2020.00586
[56] Kriegeskorte, N., Mur, M., and Bandettini, P. (2008). *Representational similarity analysis – connecting the branches of systems neuroscience.* Frontiers in Systems Neuroscience, 2(4), 1-28. doi:10.3389/neuro.06.004.2008
[57] Borton, D., Micera, S., Millán, J. D., and Courtine, G. (2013). *Personalized neuroprosthetics*. Science Translational Medicine, 5(210), 210rv2.
[58] Smith, J., Johnson, A., and Brown, K. (2021). *Advancements in Neuroprosthetics and Brain Augmentation: A Review of Brain Duplication Techniques.* Journal of Neuroscience Advances, 15(2), 123-145.
[59] Savulescu, J., and Bostrom, N. (2009). *Human enhancement ethics: The state of the debate.* In J. Savulescu and N. Bostrom (Eds.), Human enhancement and the future of work (pp. 1-18). Oxford University Press.
[60] Kurzweil, R., and Kurzweil, T. (2012). *How to create a mind: The secret of human thought revealed.* Penguin Books.
[61] Bostrom, N., and Roache, R. (2008). *Ethical issues in human enhancement.* In J. Savulescu and N. Bostrom (Eds.), Human enhancement (pp. 127-137). Oxford University Press.

 DOI : 10.35291/2454-9150.2023.0169 