

# Linking Neural Network to Neuron Network: Reinstating the Brain Mechanism of Language.

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**Abstract**—Artificial Intelligence has emerged prominent in the field of Neuroscience marking its significance in Brain Computer Interface and EEG Signal Processing. Broca's Area dysfunction causes speech impediment in people with Autism disabling speech and sentence formation. Through the ability of the third generation of Artificial Neural Network (ANN) providing an intrinsic mechanism of the brain reinstating auditory sentence comprehension improving articulation and intelligible speech processing. For coordinating the muscles of the throat, tongue and lips Artificial Spiking Neurons relays signals to unique neuron models processing complex information in the brain by replicating the functioning of biological neural clusters. Speech is the representation of the mind, here's promising a voice to communicate through AI.

**Keywords** Artificial Intelligence, Brain Computer Interface, Spiking Neural Network (SNN), Electroencephalography (EEG), Deep Neural Network (DNN), Brain Inspired Intelligence, Neuroscience, Broca's Area, Speech Impediment, Speech Production.

## I. INTRODUCTION

The human brain cells namely neurons, are similar to the artificial neural network, both are highly sophisticated complex interconnected network processing information system for humans via electrical signals. Brain- inspired intelligence aims to replicate structure, functions and the principles of the brain. The information stored in the sensory signal is vital in determining the role for engaging neural processes. The rich dynamics and behaviour of biological neurons is captured, analyzed, stimulated and represented by Spiking Neural Network (SNN) serving as a promising computational framework in integrating insights from the brain into artificial intelligence (AI).

SNN classifies different cognitive states and differentiates temporal sequences and spatial participation in Broca's Area exclusively supporting the simulation enabling them to learn complex strategies without explicit instructions. At the left hemisphere residing in left prefrontal cortex and cingulated cortex in the brain, Broca's Area is mainly responsible for articulating ideas, words

in both spoken and written language, most crucial for speech production. It coordinates processing of information from large neuronal networks to the motor cortex before articulation. The significance of neural networks and computational technology in the near future will enhance human performance but also develop advanced therapies to treat neurological disorders especially in cognitive impairment. In this research topic, we aim to contribute to eradicate speech impediment through brain inspired AI algorithms as a new computer vision task by analyzing biological mechanism of brain neural networks and providing new insights and functions in the field of neuroscience revolutionizing our understanding of the intrinsic brain mechanism.

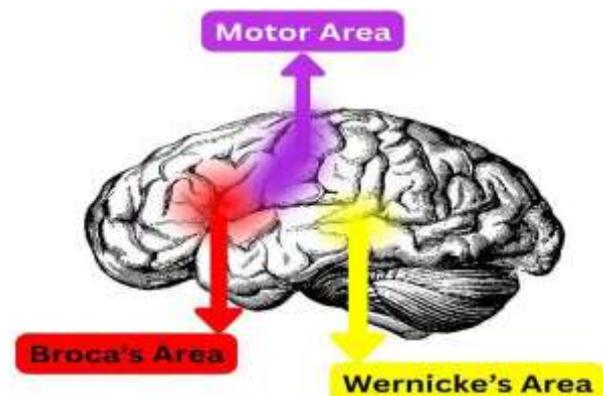


Figure 1.1 Broca's Area and Wernicke's Area in Brain.

## II. APPLICATION

First, establishing a computational neuronal network model of the human brain is extremely difficult due to its size, neuromorphic details and topological structure. The human brain is an immensely complex organ, with 86 billion neurons and 100 trillion synapses, which overshadows all man-made attempts at intelligence, such as large language models.

The development process has undergone three distinct phases which neuroscience and AI systems have worked together to achieve:

(1) Scientists in neuroscience field developed AI systems through their research. (2) AI model developers switched from neurobiological principles to engineering and mathematical approaches for their work. (3) Scientists evaluate how AI systems predict brain function patterns by matching them with actual brain operational processes which occur in human brains. The brain circuits of the prefrontal cortex (PFC) reveal their working memory process information through Multivariate pattern analysis which shows neural co-activation patterns that link to cognitive activities.

The process of building an AI system requires developers to choose hidden layer components which they use to determine how strong the synaptic connections between these components should be. Spatio and Spectro-temporal data (SSTD) represent the primary data types which scientists in various domains including neuroinformatics use for their research. BrainCog operates

SNN-based image classification and detection systems along with concept learning models which serve as computational tools for processing sensory information. BrainCog offers multiple training approaches for SNNs which include supervised and unsupervised learning through the biologically accurate spike-timing-dependent plasticity (STDP) system that works with short-term synaptic plasticity (STP) and adaptive synaptic filter and adaptive threshold balance to boost SNN performance during unsupervised learning tasks.

Combining information from multiple senses enhances perception, response times, and recognition capabilities. BrainCog provides a concept learning framework that generates integrated representations with five types of perceptual strength information. IM is a cognitive model that assumes that each type of sensory information for a concept is processed independently before being integrated. It uses a two-layer SNN model with five neurons in the first layer representing the five types of perceptual strength (visual, auditory, haptic, olfactory, and gustatory) and one neuron in the second layer for integration. AI enables individual predications to be compared with group-averaged analysis, strengthening the database system leading to reason and recognize a pattern between each individual and generalize a pattern involving system- across brain a network which captures real- world social perception and emotional responses thus achieving case-by-case modelling of precise diagnostics and treatment.

### III. DISCUSSION

AI systems experience ongoing operational problems in their everyday work despite their widespread industry support. The main obstacle emerges because cognitive neuroscience and AI systems maintain separate knowledge bases which researchers find challenging to connect. The AI technique breakthroughs do not always follow the same path as fundamental cognitive neuroscience progress.

The brain creates a time-based sequence of neural signals which start from word detection in the temporal cortex before moving to the motor cortex for speech execution. The process requires Broca's area to work with both temporal and frontal motor areas through bidirectional communication. The production of new articulatory sequences for unfamiliar strings activates Broca's area but does not affect motor cortex activity. The collected data set shows that Broca's area directs the process which transforms information between different brain networks that support spoken language tasks. In this role, Broca's area creates an appropriate articulatory code to be implemented by motor cortex. AI systems draw their core inspiration from brain biology but these brain-inspired models fail to deliver strong results because they simplify neural systems too much.

The evaluation process for intelligent systems distance usually focuses on behavioral data which assesses model performance through model-to-model and human behavior comparison. The neurobiological explainability function lets us determine model brain-likeness by assessing their ability to solve brain-related problems. The models can

predict brain responses during the same cognitive process even though their initial design did not focus on fitting brain signals. The research findings demonstrate that these models perform brain-like computations which produce neurobiological representations without needing any specific training. The models which have been modified will show their performance at the Speech behavioral level to determine which

brain-like models function at human-like levels. The modified models need to undergo Speech behavioral level testing because we want to determine if their performance will get better when we understand people with Speech Impediment.

### IV. CONCLUSION

The activation levels in Broca's Area might increase because this region handles complex functions which include managing multiple disrupted systems that affect planning and facilities and flexibility and data processing and goal-directed behavior and other elements. However, there is lack of methods for the efficient analysis of such data and for spatio-temporal pattern recognition (STPR). The brain functions as a spatio-temporal information processing machine and deals extremely well with spatio-temporal data.

It's organization and functions has been the inspiration for the development of new methods for SSTD analysis and STPR. Deep SNNs trained by surrogate gradient or converted from well-trained DNNs achieving remarkable progress in the fields of speech recognition, computer vision, and reinforcement learning. While it focuses on computational neuroscience research, it fails to consider the learning and optimization of deep SNNs. They currently lack in-depth inspiration from brain information processing information processing mechanisms and hence short at simulating large-scale functional brains.

Even with such shortcomings it integrates multiple brain areas and performs various brain cognitive functions, including image recognition, working memory, question answering, reinforcement learning, and fluid reasoning. As such, building generalizable AI models to demonstrate the "intrinsic" neural mechanisms of human cognition is a milestone achievement in the interface of cognitive neuroscience and AI. The advances of cognitive neuroscience, provides impetus to AI evolution as well as in the medical field.

## V. ABBREVIATIONS

AI- Artificial Intelligence

ANN- Artificial Neural Network SNN- Spiking

Neural Network BCI- Brain Computer Interface

EEG- Electroencephalography DNN- Deep Neural

Network

MVPA- Multivariate Pattern Analysis SSTD-

Spatio and Spectro-temporal Data

## VI. REFERENCES

[1] Applications of Spiking Neural Network in Brain Computer Interface. 2021 9<sup>th</sup> International Winter Conference on Brain-Computer Interface (BCI)

[2] Application of Neural Network in the Medical Field. Sofiene Mansouri, IEEE

[3] Brain inspired intelligence the deep integration of brain science and artificial intelligence. Zhaoyu Li, Xi Chen, Honggang Qi, Wei Lu

[4] On the role of generative artificial intelligence in the development of brain- computer interfaces. Seif Eldawlatly

[5] A new era in cognitive neuroscience: the tidal wave of artificial intelligence (AI). Zhiyi Chen and Ali Yadollahpour

[6] The mirror neuron system and the strange case of Broca's Area. Gabriella Cerri et al.

[7] Human brain computing and brain-inspired intelligence. Jianfeng Feng, Viktor Jirsa, Oxford University

[8] Redefining the role of Broca's Area in Speech. Adeen Flinker et al. 2015

[9] BrainCog: A spiking neural network based, brain-inspired cognitive intelligence engine for brain-inspired AI and brain simulation. Yi Zeng, Dongcheng Zhao, Brain science and IT.