

Neuron Block: Towards a Modular and Efficient AI Computing Architecture

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Abstract

Neuron Block introduces a novel bio-inspired computing architecture that enhances AI efficiency in energy consumption, memory management, and reasoning capabilities. Unlike traditional Large Language Models (LLMs), Neuron Block utilizes dynamic feedback mechanisms, multi-layer neural structures, and dimension reduction to optimize AI operations. Additionally, by integrating the Smart Cone Model (SCM), this framework aims to equip AI with innovative reasoning capabilities, potentially bridging artificial intelligence and neuroscience.

1 Introduction

Traditional Large Language Models (LLMs), such as Transformers, face several critical challenges:

- High computational cost due to extensive matrix multiplications.
- Inefficient memory management, leading to limited long-term recall.
- Proneness to hallucinations and model drift, reducing reliability.

Neuron Block addresses these limitations by simulating biological neurons' operational logic through matrix-based frequency-triggered synaptic activations. This approach ensures computational efficiency, enhances memory capabilities, and improves adaptability.

2 Mathematical Framework of Neuron Block

Neuron Block is based on the mathematical modeling of individual neuron behaviors:

$$S(t) = W \cdot I(t) \tag{1}$$

where $S(t)$ represents the neuron activation signal, W is the synaptic weight matrix, and $I(t)$ denotes input signals. A neuron is activated if $S(t)$ exceeds

the activation threshold T :

$$\Theta(t) = 1 \quad \text{if } S(t) > T, \quad \Theta(t) = 0 \text{ otherwise.} \quad (2)$$

To prevent overfitting and ensure adaptability, a feedback mechanism dynamically adjusts the threshold:

$$T_{new} = T_{old} + \alpha \cdot \Theta(t) - \beta \cdot (1 - \Theta(t)) \quad (3)$$

where α and β represent up-regulation and down-regulation factors.

3 Advantages Over Traditional LLMs

3.1 Energy Efficiency

Neuron Block reduces computational power requirements by introducing a "cool-down" mechanism that suppresses redundant activations, mimicking biological neurons' energy-saving strategies.

3.2 Memory Management and Dimensional Reduction

Neuron Block converts dynamic information into lower-dimensional representations through:

- Multi-layer neural structures for progressive dimensionality reduction.
- Mathematical integration and differentiation techniques to compress and reconstruct complex data representations.

This ensures long-term memory retention without excessive computational costs.

3.3 Adaptive Reasoning and Reduced Hallucinations

By integrating self-regulating activation thresholds and feedback loops, Neuron Block minimizes the risks of data drift and hallucinations, improving AI reliability in critical applications such as medicine, finance, and legal advisory.

4 Neuron Block and the Smart Cone Model (SCM)

Neuron Block can enhance AI innovation capabilities by integrating the Smart Cone Model (SCM), a framework designed to explain biological neural segmentation. Through pattern matching and dimensional reduction, SCM allows AI to:

- Induce new knowledge from limited data.
- Extend reasoning beyond direct pattern recognition.
- Potentially validate biological theories about cognitive functions.

This cross-disciplinary approach might contribute to both artificial intelligence and neuroscience research.

5 Applications of Neuron Block

- **AI Memory Optimization:** Enhancing LLM recall capabilities while reducing computational costs.
- **Personal AI Assistants:** Improving long-term user interaction and contextual adaptation.
- **Risk Mitigation in AI Decision-Making:** Reducing AI-generated misinformation and hallucinations.
- **Dynamic Data Analysis:** Ensuring AI adaptability in financial markets, weather predictions, and cyber-security.
- **Energy-Efficient AI Computing:** Lowering power consumption for large-scale AI inference tasks.

6 Future Research Directions

Future research will focus on integrating Neuron Block with SCM to enhance AI innovation. Additionally, validating whether Neuron Block can be used to model biological cognition could advance both artificial intelligence and neuroscience.

7 Conclusion

Neuron Block presents a novel approach to AI computing that optimizes energy efficiency, memory management, and reasoning adaptability. By leveraging feedback regulation, dimensional reduction, and biologically inspired computational logic, Neuron Block not only improves LLM capabilities but also paves the way for AI-driven innovation and potential neuroscience breakthroughs.

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References