# Neural Network In-Memory Computing

**A solution to the slow training speeds and other issues associated with synapses in Neural Network In-Memory Computing with practical applications in low-power edge devices like security cameras and drones, and high-performance computers.**

**Case ID:**
ID2021-014

**IP Position:**
Patent Pending

**Development Status:**
TRL 3: Concept demonstrated on lab platform - analytical models to support lab design

**Opportunity**
Partners sought for development and prototype testing.

**Category(s):**
Artificial Intelligence, Neural Networks, Memory Technology, Edge Computing, Energy Efficiency, Microprocessor, Semiconductor

**Keywords:**
Synapse, Nonvolatile memory cells, Resistance tuning, Real resistors, Quantized values, Programming speed

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**Inventor(s):**
Binh Quang Le

**Contact Information:**
Sandeep Mukkamala
Intellectual Property Specialist
Sandeep.Mukkamala@sjsu.edu
408-924-5462

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## Technology Overview

Existing synapses suffer from slow training speeds and various challenges due to their analog resistance tuning using nonvolatile memory cells. In contrast, our approach combines real resistors with non-volatile memory cells acting as digital switches. The real resistors are quantized in linear values, such as R, 2R, 4R, to achieve precise resistance levels.

By adopting this novel approach, several critical issues are resolved. Firstly, the programming speed is dramatically enhanced by utilizing non-volatile memory cells with only two levels, resulting in training speed improvements of up to six orders of magnitude compared to analog tuning. Secondly, the synapse resistance becomes linear and stable since it is determined by real resistors rather than the inherent variations in non-volatile memory cells. This ensures reliable and predictable synapse performance. By revolutionizing synapse design and operation, this technology paves the way for faster, more reliable, and power-efficient Neural Network In-Memory Computing systems.

## Key Features & Benefits

**Features:**
- Combination of real resistors with non-volatile memory cells acting as switches.
- Quantized linear values of resistors (e.g., R, 2R, 4R) for precise resistance levels.
- Utilization of non-volatile memory cells in digital mode with only two levels.

**Benefits:**
- Drastically improved programming speed, up to six orders of magnitude faster than analog tuning.
- Linear and stable synapse resistance determined by real resistors, eliminating variations.
- Mitigation of retention issues due to the digital mode with only two levels of resistance.

## Potential Applications

- Applied directly to a large range of low-power, high-performance artificial intelligent edge devices like security cameras, drones, and robots.
- High-performance computers on the Internet, enabling energy-efficient deep neural network microprocessors for services offered by leading companies such as Google.
- Can be used in a wide range of deep neural network microprocessors.

Fig 1.

Quantized synapse cell. RRAM write circuitry not shown. Can have more resistors.