

# Neuromorphic-based evolutionary algorithms for combinatorial optimization

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This work introduces NEVA (Neuromorphic Evolutionary Algorithm), a novel optimization framework that bridges the gap between evolutionary computation and neuromorphic computing. Neuromorphic computing, inspired by the structure and functioning of the human brain, relies on Spiking Neural Networks (SNNs), which process information through discrete spike events, enabling highly parallel, energy-efficient, and real-time computation. Despite its growing relevance, this paradigm has not been extensively explored in the context of evolutionary algorithms, an area this work aims to address.

We propose a fundamentally new approach in which an evolutionary algorithm is fully embedded within a neuromorphic architecture. Unlike traditional implementations that run on conventional digital hardware, NEVA is designed directly using the principles of SNNs. This involves defining neuron dynamics, synaptic interactions, and learning mechanisms that collectively emulate evolutionary processes such as selection, variation, and adaptation. As a result, the algorithm operates in an event-driven and distributed manner, aligning naturally with the strengths of neuromorphic systems, particularly their low power consumption and scalability.

A key contribution of the work is demonstrating how evolutionary computation can be reformulated within a spiking neural framework. We detail the mapping of evolutionary operators onto neural components, effectively transforming populations and fitness evaluation into neural activities and synaptic updates. This reinterpretation allows optimization processes to benefit from the inherent parallelism and temporal dynamics of SNNs. To validate the effectiveness of NEVA, we conduct experiments on several well-known combinatorial optimization problems, including Quadratic Unconstrained Binary Optimization (QUBO), 3-SAT, and the knapsack problem. The implementation under the LAVA software framework shows that NEVA is capable of producing high-quality solutions efficiently, confirming its viability as a new class of metaheuristic algorithms. Furthermore, the paper extends NEVA into a neuromorphic memetic algorithm, incorporating local search techniques to enhance performance. This hybrid approach significantly improves both solution quality and convergence speed, highlighting the flexibility of the neuromorphic framework in integrating multiple optimization strategies.

In conclusion, this work represents a pioneering step in combining evolutionary algorithms with neuromorphic computing to solve combinatorial optimization problems. By leveraging the advantages of SNNs, NEVA opens new avenues for designing energy-efficient, scalable, and high-performance optimization methods, particularly suited for next-generation hardware systems.

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