CLAM: Neuromorphic Cognitive Localization and Mapping

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CLAM: Neuromorphic Cognitive Localization and Mapping The formation of rich cognitive maps for physical and conceptual spaces is a fundamental aspect of higher cognition and a key characteristic distinguishing human general intelligence from current machine learning approaches. As a step towards neuromorphic cognitive mapping, we propose a novel class of neuromorphic systems inspired by recent theoretical advances in hyperdimensional computing and evidence from the entorhinal cortex, a vital component of the brain's navigation system. The proposed approach uses a sparse, brain-inspired hyperdimensional encoding that reflects the geometry of the world and respects the topology of the neuromorphic chip. It also exploits parallelism, event-based processing, and in-memory computing - the unique features that make neuromorphic hardware more efficient. By defining an encoding and a small set of operations as an "instruction set" the hyperdimensional framework provides an abstraction layer between the hardware and the algorithm facilitating hardware-algorithm co-design. This allows us to design robust building blocks that are reusable by the community to build modular and scalable network architectures. We aim to benchmark and evaluate the proposed approach under real-world conditions, specifically in terms of performance, scalability, and power consumption on various tasks. In contrast to prior neuromorphic computing concepts focused on extreme edge applications and signal processing, we aim to address a challenging cognitive task laying the foundation for other forms of higher reasoning in neuromorphic systems. Our project has the potential to enable a fundamentally different type of neuromorphic system with applications in machine learning and autonomous robotics.

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