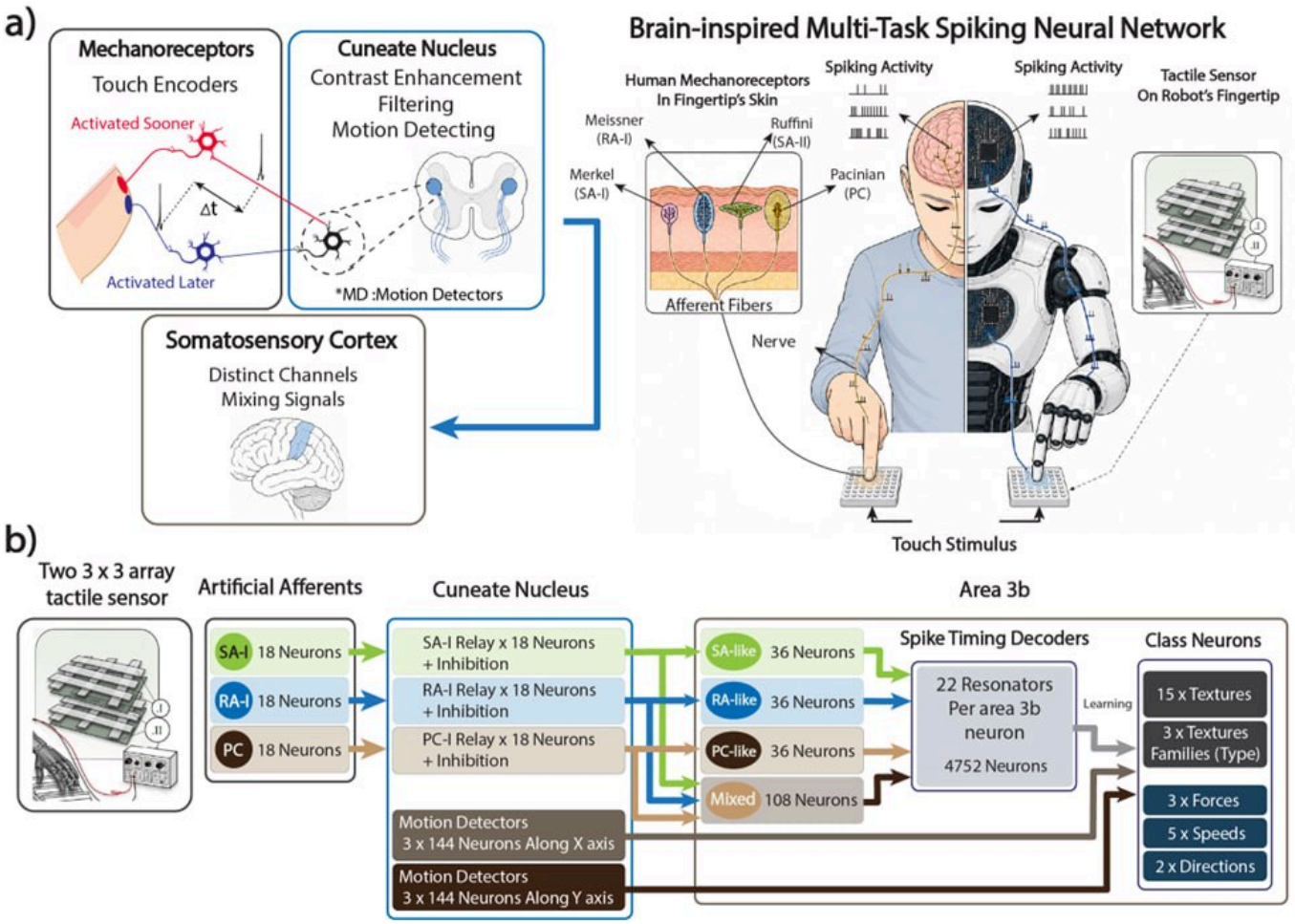
Master Thesis Description

Topic: Real-Time Biomimetic Tactile Perception on the SpiNNaker2 Neuromorphic Platform



Description: The aim of this work is to implement an existing brain-inspired spiking neural network for robotic touch on the SpiNNaker2 neuromorphic platform, and to determine whether it can reproduce its software results on real hardware. The network decodes multiple tactile properties from a single robotic fingertip through a shared hierarchical pathway. It includes mechanoreceptor-inspired afferents, cuneate nucleus-like processing, Area 3b-like populations, and resonate-and-fire neurons, with task-specific readouts for texture, texture family, scanning direction, scanning speed, and contact force. The core of the thesis is mapping the network onto the hardware, including its Izhikevich and resonate-and-fire neuron models and its spike-timing-dependent learning procedure. You will investigate how hardware constraints, such as numerical precision, memory, communication, and time resolution, affect the network's dynamics and performance. You will then repeat the original experiments on SpiNNaker2, including texture recognition across speeds and forces, generalisation to unseen speed-force combinations, and the multitask evaluations. The results will be compared directly with the software model in terms of neuronal responses, accuracy, and decision latency, while hardware performance will be measured through energy consumption and real-time capability. A central

question is whether the network can learn on the chip itself, allowing it to adapt during operation rather than relying only on weights trained offline. Depending on progress, you may also demonstrate the system with live tactile input on a robotic setup.

Motivation: Robots operating in daily life must perceive touch and adapt to new situations quickly, as humans do, within strict limits on latency and energy. A software simulation can show that a biologically structured network is capable of multitask tactile perception, but it cannot show whether that network can operate and learn in real time on a robot. Neuromorphic hardware such as SpiNNaker2 is designed for event-based, asynchronous computation with low energy use, which makes it a natural platform for this step.

Reference papers:

- Brain-Inspired Spiking Neural Network for Biomimetic Tactile Sensing: Motion, Direction, Speed, Force, and Texture Recognition.
- SpiNNaker2: A Large-Scale Neuromorphic System for Event-Based and Asynchronous Machine Learning.

Requirements:

- Programming: Strong proficiency in Python and experience with C or C++, preferably on embedded systems.
- Spiking Neural Networks: Good understanding of neuron models and synaptic plasticity.
- Neuromorphic Computing: Interest in neuromorphic hardware and robotics; prior experience is a plus.