**Title:** Development of a Biomimetic Spiking Neural Network Model for Multidimensional Tactile Perception

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**Abstract:** Implementing an artificial tactile system that approaches the human perception level has proven to be a formidable challenge. This work proposes a biomimetic tactile perception model based on a Spiking Neural Network (SNN) that addresses this challenge. Designed to mimic the tactile pathway from fingertip mechanoreceptors to primary somatosensory cortical neurons, the proposed model utilizes a multi-layered SNN architecture, with each layer representing a distinct component of the tactile pathway.

The first layer comprises Slowly Adapting-1 (SA-1) and Rapidly Adapting-1 (RA-1) afferent neurons, which receive tactile stimuli from mechanoreceptors stochastically. The second layer processes the information derived from SA-1 and RA-1 afferents in separate streams, simulating the functions of the cuneate nucleus (CN). This layer investigates the neuronal circuit mechanisms intrinsic to the cuneate nucleus, particularly the dynamic interaction between excitatory and inhibitory neural circuits that facilitate lateral inhibition. This lateral inhibition mechanism is fundamental for minimizing noise accumulation and maintaining the fidelity of spatial information, crucial for accurate tactile perception.

The final layer, wherein inputs from Slowly Adapting-1 (SA-1) and Rapidly Adapting-1 (RA-1) afferents converge, is constructed to emulate the primary somatosensory cortex. This layer utilizes a diverse combination of excitatory and inhibitory fields for the encoding of various stimulus properties. The layered organization of the SNN enables simultaneous processing of multiple physical features of tactile information, thereby enhancing the efficiency of information processing.

To evaluate the model's performance, separate experiments were conducted, wherein it was tasked with the representation of an extensive variety of both static (e.g., pressure and shape) and dynamic (e.g., vibration frequency and slip) tactile stimuli. The subsequent analysis focused on two aspects: the classification accuracy achieved by the model, and its ability to identify tactile features within the output layer in response to various stimuli. The results validate the model's ability to replicate the intricate process of biological tactile information processing, as demonstrated by a broad spectrum of neural responses to various tactile features. These findings not only enhance the current state of artificial tactile systems but also hold significant implications for the future design and development of tactile intelligence.