**Title:** Development of a Biomimetic Multimodal Tactile Perception System for Robots via Spiking Neural Networks

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**Abstract:** Despite significant advancements in robotics, one persisting challenge is the realistic simulation and understanding of the human tactile pathway, crucial for enhancing user interactions. This study addresses this challenge by presenting a biomimetic model, employing a Spiking Neural Network (SNN), designed to mimic the tactile pathway from fingertip mechanoreceptors to primary somatosensory cortical neurons, responsive to a diverse range of tactile stimuli.

The model utilizes an SNN architecture with multiple layers, each 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, receiving stimuli from mechanoreceptors stochastically. The subsequent layer, representing the cuneate nucleus (CN), integrates and categorizes the incoming data. This process involves a lateral inhibition mechanism, facilitated by central excitatory and peripheral inhibitory connections, enhancing the spatial tactile information transmission. The final layer, symbolizing the primary somatosensory cortex, models the inhibitory receptive fields of neurons, leading to distinct output layers for decoding various physical properties of stimuli. This stratified configuration allows the SNN to process different tactile characteristics concurrently, thereby improving the efficiency and realism of tactile information processing.

We conducted two separate experiments, employing a broad range of static and dynamic tactile stimuli. Our analysis focused not only on the classification performance but also on identifying the tactile features recognized by the model's output layer in response to stimuli. The results affirm the model's capacity to effectively simulate the complex nature of biological tactile information processing, demonstrating a comprehensive range of tactile features in response to diverse stimuli.

Our research suggests that this biologically-inspired model can significantly improve the realism and accuracy of tactile information processing in robotics. A key advantage of our model is its ability to represent diverse tactile features, such as pressure, vibration frequency, slip, and shape, simultaneously within a single model. By offering a robust method for processing a vast array of tactile information, our model may pioneer new paradigms of more natural and intuitive human-robot interaction. This advancement holds profound implications for the design and development of future tactile-sensitive robotic systems.