Control/Tracking Number: 2023-S-6965-SfN
Activity: Scientific Abstract
Current Date/Time: 6/14/2023 12:03:07 AM

Development of a biomimetic spiking neural network model for multidimensional tactile perception

AUTHOR BLOCK: *J. KIM, S.-P. KIM;
Ulsan Natl. Inst. of Sci. & Technol., Eonyang-eup, Ulju-gun, Korea, Republic of

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) to addresses this challenge. Designed to mimic the tactile pathway from cutaneous mechanoreceptors to S1 cortex, the proposed model utilizes a multi-layered SNN architecture, with each layer representing a distinct component in 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. This layer follows the neuronal circuit mechanisms intrinsic to the cuneate nucleus, particularly the dynamic interaction between excitatory and inhibitory neurons that facilitates lateral inhibition for minimizing noise accumulation and maintaining the fidelity of spatial information. The final layer, wherein inputs from SA-1 and RA-1 afferents converge, is constructed to emulate the S1 cortex. This layer utilizes a diverse combination of excitatory and inhibitory fields for the encoding of various stimulus properties. The layered organization of the proposed SNN is capable of the processing of multidimensional tactile features, thereby enhancing the efficiency of information processing. In the static perceptual dimension, the proposed SNN could distinguish two separate points of pressure stimulation at 3mm or greater, which is on par with human performance. It also accurately identified a tactile stimulus orientation, ranging from 0 - 170 degrees in 5 degrees increments. This was achieved using only four types of final layer neurons oriented to 0, 45, 90, and 180 degrees by decoding their activity into the stimulus orientation with 90.1% classification accuracy. In the dynamic perceptual dimension, the proposed SNN demonstrated the ability to rapidly detect the slip of an object within 5 ms. Furthermore, it could estimate the speed of the object with a resolution of 1 mm/s and discriminate vibration frequency of a stimulus in the range from 1 to 100 Hz. These results not only reinforce the proposed model's competency in mimicking biological tactile systems but also provide substantial implications for enhancements in the architecture and functions of tactile intelligence systems.

Author Disclosure Information:

J. Kim: None. **S. Kim:** None.
Presentation Preference (Complete): Poster Only
Linking Group Selection (Complete): None selected
Theme and Topic (Complete): A.08.b. Sensory systems ; D.03.e. Stimulus feature receptive fields and response properties
Linking Group and Nano Info (Complete):
Keyword (Complete): DEVELOPMENT ; TOUCH ; RECEPTIVE FIELD
Support (Complete):
Support: Yes
Grant/Other Support: : Brain Convergence Research Programs of the National Research Foundation (NRF2019M3E5D2A01058328)
Grant/Other Support: : National Research Foundation of Korea(NRF), under 2023 Project BK21 Four

Special Requests (Complete):
How do you plan to participate in Neuroscience 2023?: In-Person and Virtually
Religious Conflict?: No Religious Conflict
Additional Conflict?: No
Is the presenting author of this abstract a high school or undergraduate student?: None
Select: No preference

Status: Complete