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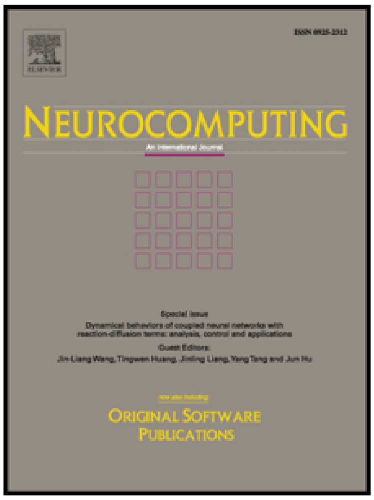

Recognizing tactile surface roughness with a biomimetic fingertip: a soft neuromorphic approach

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Recognizing tactile surface roughness with a biomimetic fingertip: a soft neuromorphic approach

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Abstract: Surface roughness is an important object property and can significantly affect the friction characteristics, wear resistance, and fatigue life of components. Although some work has been done on demonstrating the capability of specific tactile sensors for surface roughness discrimination, the soft neuromorphic approach by taking inspirations from neuroscience for tactile surface roughness discrimination is exceptionally rare. This paper aims to fill this gap, and presents a soft neuromorphic method for tactile surface roughness discrimination with a biomimetic fingertip. The analog tactile signals generated from polyvinylidene difluoride (PVDF) films are fed as input to the Izhikevich neurons in order to obtain spike trains. Two distinct decoding schemes based on *k*-nearest neighbors (*k*NN) in both spike feature space and spike train space are used for surface roughness discrimination. We thoroughly examined the different spike train distance based *k*NN (STD-*k*NN) algorithms for decoding spike trains. Eight standard rough surfaces with roughness values (Ra) of 50 μm, 25 μm, 12.5 μm, 6.3 μm 3.2 μm, 1.6 μm, 0.8 μm, and 0.4 μm are explored. The highest classification accuracy of (77.6 ± 13.7) % can be achieved with *k*NN (k = 11) classifier and the Victor-Purpura distance ($q = 0.024\ \mathrm{ms}^{-1}$).

Keywords: soft neuromorphic approach; spike train distance; biomimetic fingertip; tactile sensing; surface roughness recognition

1. Introduction

Neuromorphic engineering is an interdisciplinary domain that takes inspirations from neuroscience. It aims to mimic the neuronal architectures and function of nervous systems by the aid of electronic devices [1]. The past decade has witnessed tremendous efforts and progress made by the industry and academia with many neuromorphic designs and hardware developments. For instance, the address event representation (AER) is used as a signal transmission scheme in recent neuromorphic systems, which addresses the connectivity challenge of a large number of neurons on a silicon chip [2]. Neuromorphic scientists have also developed silicon retinas and silicon cochleas to replicate the functionality of retina and cochlea [3,4]. These systems have been demonstrated to possess biological properties such as local processing and local gain control. In addition to the surge in hardware development, there is another branch of neuromorphic engineering called soft neuromorphic engineering [5], which focuses on spike-