Technische Universität München

Neurowissenschaftliche Systemtheorie

Scientific Seminar Neuroengineering

Neural encoding schemes for spiking neural networks

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Problem description:

Spiking neural networks (SNN) are considered to be a promising way of reaching human-like flexibility to realize tasks such as opening doors that have handles in different shape, recognizing people by looking their childhood photos, etc. [1]. However, one of the challenges arose using SNN is that how the sensory information coming from the environment is represented in the brain [2]. Representation of the information is essential to close the loop between environment and processing unit (SNN) due to the dependence of SNN structure to the neural encoding scheme.

This seminar aims to review the hypothesized encoding schemes in the brain and their favorable use cases for the engineering tasks. Within this seminar, the student should provide a comprehensive survey of the existing ways to encode sensory stimuli such as temporal coding [3,4] and rate coding [5] to generate neural activity in spiking neural networks. The advantages of one scheme to another should also be provided in the survey considering the sensory devices used in robotics.

Task:

- Introduce hypothesized encoding types for sensory stimuli in the literature
- Determine in which aspects the encoding schemes can be compared regarding spiking neural networks
- Provide the advantages of the encoding schemes as well as weaknesses with the explanations considering the determined aspects
- Interpretation of the advantages of coding schemes regarding the robotics tasks
- Documentation and report.

Literature:

[1] Johansson, Roland S., and J. Randall Flanagan. "Coding and use of tactile signals from the fingertips in object manipulation tasks." *Nature Reviews Neuroscience* 10.5 (2009): 345-359.

[2] Rolls, Edmund T., and Alessandro Treves. "The neuronal encoding of information in the brain." *Progress in neurobiology* 95.3 (2011): 448-490.

[3] Vreeken, Jilles. "Spiking neural networks, an introduction." *Institute for Information and Computing Sciences, Utrecht University Technical Report UU-CS-2003-008* (2002).

[4] Gütig, Robert, and Haim Sompolinsky. "The tempotron: a neuron that learns spike timing–based decisions." *Nature neuroscience* 9.3 (2006): 420-428.

[5] Gerstner, Wulfram, and Werner M. Kistler. *Spiking neuron models: Single neurons, populations, plasticity*. Cambridge university press, 2002.

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