Abstract

Spiking neural systems are based on biologically inspired neural models of computation since they take into account the precise timing of spike events and therefore are suitable to analyze dynamical aspects of neuronal signal transmission. These systems gained increasing interest because they are more sophisticated than simple neuron models found in artificial neural systems; they are closer to biophysical models of neurons, synapses, and related elements and their synchronized firing of neuronal assemblies could serve the brain as a code for feature binding and pattern segmentation.

Olfactory bulb (OB) processes molecular signals allowing the sense of smell. These chemical impulses are caused by buildup of neuronal signals consisting of electrical impulses, called a spike train, at olfactory sensory neurons in nasal cavity and discharge onto soma of mitral and tufted cells of olfactory cortex.

The goal of this research is to simulate and analyze neuronal responses of spiking neurons. The simulations are designed to exemplify certain properties of the olfactory bulb dynamics and are based on an extension of the integrate-and-fire neuron, and the idea of locally coupled excitation and inhibition cells. We introduce the background theory to making an appropriate choice of model parameters. The main purpose is to simulate certain dynamics within the olfactory bulb. It is shown how certain parameters of the spiking neuron model can be used to model these dynamics. The model is based on the two main cell types in the olfactory bulb, the mitral and granule cells. The dynamics that have been simulated include the reciprocal and lateral inhibition of mitral cells by granule cells, as well as the saturation of mitral cells. The simulations show how certain spike inputs to mitral cells correspond to odor recognition and discrimination in the olfactory bulb.

Our simulations showed that the inter-neuron transmission delay controls the size of spatial variations of the input and also smoothes the network response. Our integrate-and-fire extended model proves to be a useful basis from which we can study more sophisticated features as complex pattern formation and global stability and chaos of OB dynamics.