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Poster presentation

Spiking neural network models for memorizing sequences with forward and backward recall

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Introduction

It has been reported that when a rat reaches the end of a track, the hippocampal place cells, which spike sequentially during the run, can generate spikes in a short time window in the reverse order [1,2]. Also, a forward replay has been recorded from the place cells in a short time interval prior to the run [2]. A recently published model [3] uses phases in the theta cycle to code different locations of the rat. A disadvantage of such an approach is that a frequency of the theta rhythm changes in a wide range and it is not clear whether the phase coding can be reliable under condition of the variable theta-frequency. Here, we present an oscillatory neural network model that can memorize sequences by adapting their synaptic weights during the memorization period. The model includes Hodgkin-Huxley type spiking elements arranged in small groups with excitatory and inhibitory connections. These groups can generate a rhythmic activity in the theta range. Excitatory elements in different groups are coupled by plastic excitatory connections. We propose that each group of rhythmic elements includes two subgroups of excitatory neurons. For the first sub-group, the modification of inter-group excitatory connections is according to the Spike Timing Dependent Plasticity (STDP) learning rule and for the second group the modification is according to the anti-STDP learning rule [3,4]. Also, these learning rules are adjusted to the cycles of the theta rhythm. This approach allows us to memorize locations in the track during the running stage and replay them in forward order by the first sub-network and in the reverse order by the second sub-network (Figure 1). To initiate forward (backward replay we use a group of neurons corresponding to the beginning (end) of the track. In both cases the duration of replay is short and takes one cycle of the theta rhythm, in accordance with experimental results [1,2].

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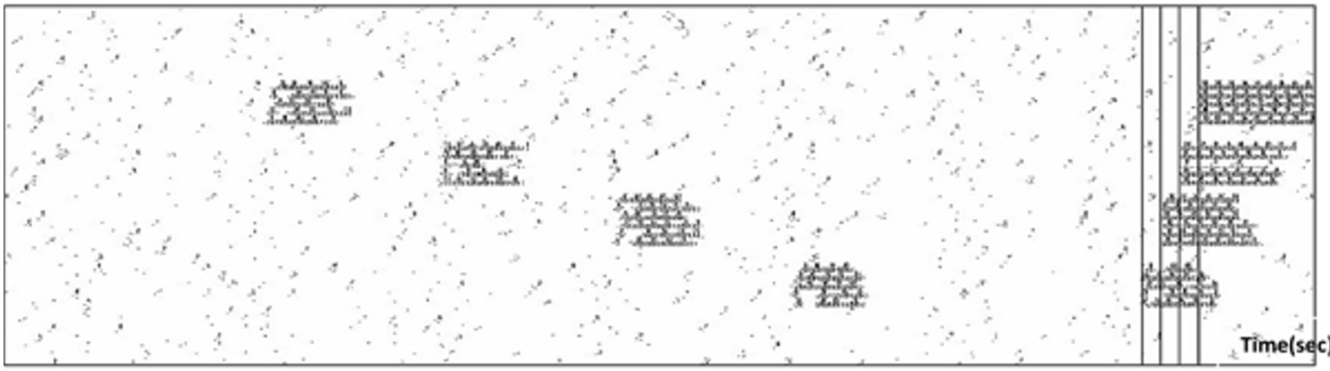

Figure 1
Simulations show the memorizing of four activity patterns corresponding to a sequence of four rat positions along the track. Each pattern contains five groups of interactive excitatory and inhibitory neurons. The right part corresponding the time window of 200 msec shows the backward recall initiated by the activity pattern corresponding to the end of the track.