# Position Decoding of Hippocampal Place Cells

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*Abstract*— **Place cells are pyramidal neurons located in the hippocampus of rats which action potential activities are in correlation with the position of the animal. The fact that different place cells are active at different locations (place fields) allows the reconstruction of the animal's position by the use of its brain waves. In the first step of this process the firing fields are localized by recording and merging action potentials (spikes) and position of the animal. In the second step the activity of unseen parts of the recording are compared with the data of step 1 and the position was reconstructed with the Bayesian 2-step algorithm. The decoded position agreed well with the real position of the animal.**

*Keywords*— **Place cells, position reconstruction, Bayesian 2-step;**

## I. Introduction

One of the most investigated neurons, the so-called place cells [1], are located in the Hippocampus [2], an important brain region for navigational skills. Place cell neurons have a background firing rate of about 0.1 Hz, but when the animal enters the neurons responsible location, the so-called place field, the firing rate goes up to about 10-20 Hz. These local fields can be stable of up to 150 days [3]. Recordings of place cell neurons of the hippocampus show their firing fields at different locations in space. The correlation of different neurons to different positions allows the reconstruction of the animal's position from their brain waves. The goal was to reconstruct the positions of rats in square open fields with sizes between 0.5 m x 0.5m – 1 m x 1 m.

## II. Methods

A pre-condition of neuronal decoding is the technology for single cell recordings. To be able to distinguish superimposed spikes [4] of different neurons, recordings were made with tetrodes [5]. These multiple wired electrodes dispose of four different channels with an inter-electrode distance of less than 40 µm. Every time the signal exceeds a given threshold the signals was recorded for 1 ms (200 µs before and 800 µs after the spike event) with a sampling rate of 48 kHz. Since the relative distance of each electrode-tip to the recorded cell will be different, the amplitude and spike duration differ. This allows the assignment of spike activities to specific neurons. For this purpose manual spike-sorting [4] was applied on the recordings. To be able to assign spike activities to the positions of the animal the trajectory of the rat was tracked with a video-tracking-system. After the action potentials and position were recorded two steps are necessary to reconstruct the position: encoding and decoding (see Figure 1). In the encoding step the arena is divided by software into 64 bins in X- and 64 bins in Y-direction. Every recorded spike is then assigned to the position (bin) the rat was at the moment of activity. The results of this process are matrices including the total amount of spikes of a neuron for every bin. The amount of spikes in each bin gets then normalized with the time the animal spent in this bin. This normalization leads to the so-called firing rate map – a map which represents the firing rate of a neuron over all bins the rat has visited during the recording. The firing rate maps of all neurons were then used to train three different algorithms.

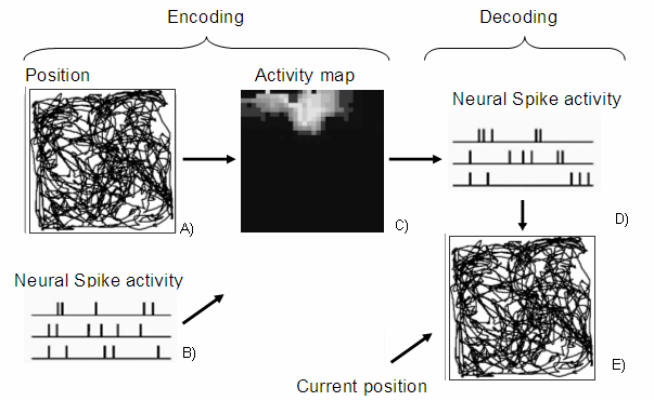


Fig. 1 Encoding and Decoding. The spikes of different neurons (B) are assigned to the position (A) of the animal acquired with a video tracking system. A shows the trajectory of the rat within the recording arena. B shows the spike activity over time for three different neurons. The result is a firing rate map (C) representing the individual firing rates of a neuron over position. Bright pixels are representing positions of high neuronal activity whereas dark pixels represent position of low or no activity. In the decoding step the firing rates within a time window of unseen recording parts (D) are compared with the positions of the firing rate maps and the position gets reconstructed (E).

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