Introduction to Neuroinformatics   **HS 2018**
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Lecture 6
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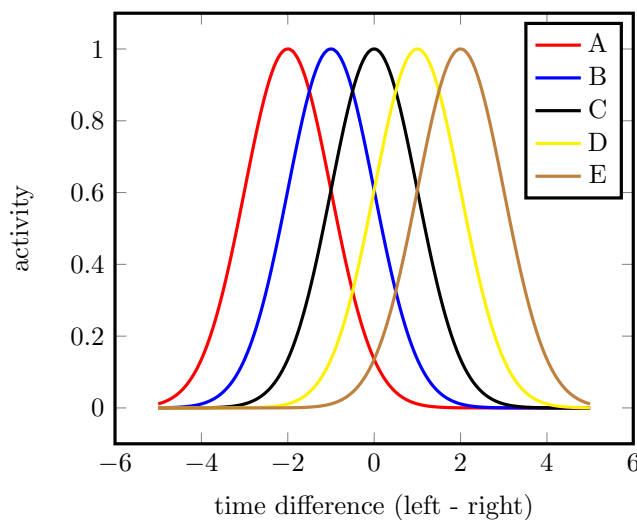
Solution 6.1: Interaural time differences

The neural network model in this exercise was proposed by Jeffress in 1948. Its main features are temporally coded input signals, delay lines, and coincidence detectors. It is an example of a theoretically postulated network for which experimental evidence has been found later on (about half a century later in the barn owl). In contrast to this, grid cells (in exercise 27) had never been theoretically postulated before their discovery.

1. It is a temporal code, since the difference in timing between the left and right spikes determines which neuron A-E gets excited the most.

2. The tuning curves which describe the dependence on the interaural time difference of the neurons A-E are bell-shaped:


3. The time difference for the signal to arrive at the left and right ear is about half the duration of an action potential:

$$t = \frac{x}{v} = \frac{0.15 \text{ m}}{350 \frac{\text{m}}{\text{s}}} = 0.43 \text{ ms.} \tag{1}$$

4. Points of equal interaural time differences have a constant distance difference to the ears, *i.e.*, the distance to the left ear minus the distance to the right ear is the same for all these points. Therefore, all the points with constant interaural time difference form a hyperbola.
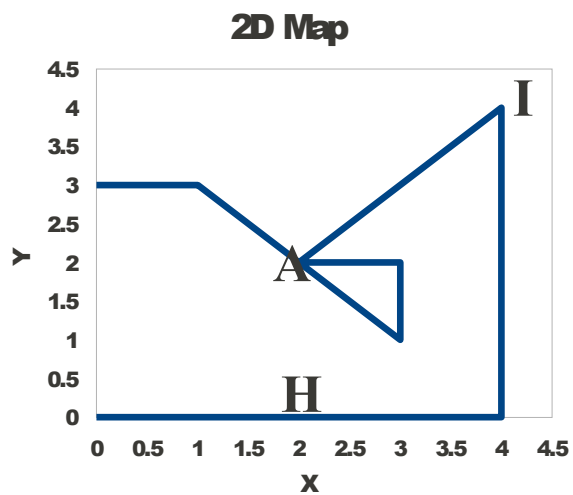
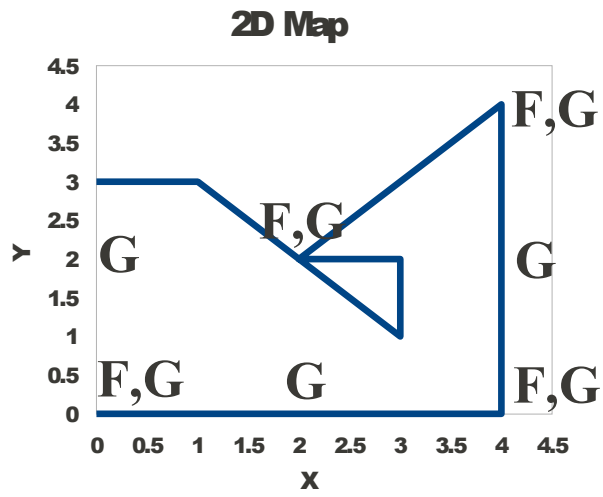# Solution 6.2: Interpreting multi-unit spike recordings

1. The trajectory:

2D Map
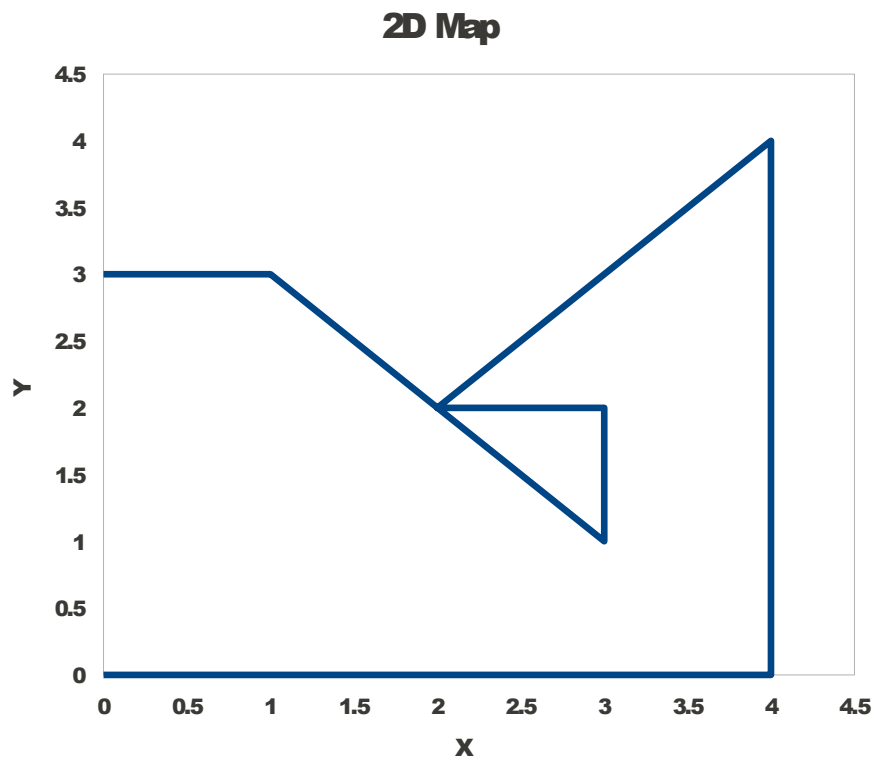
2.–3. We can identify four different types of neurons:

   (a) Place neurons fire at a certain location:
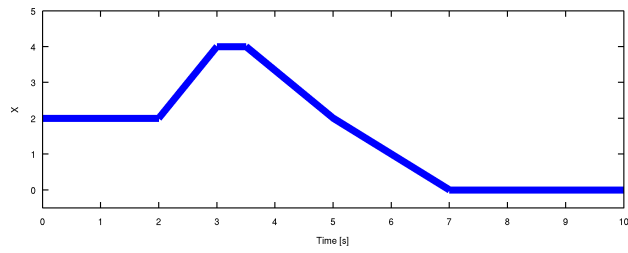

2D Map

    (b) Grid neurons fire at multiple places aligned on a grid:

2D Map

(c) Movement off- and on-set neurons (B, E) fire when the animal stops or starts moving.

(d) Head direction neurons (C left, J right, D up, and K down) indicate the orientation.

4. The trajectory can be reconstructed since we already know the features recognized by each neuron:
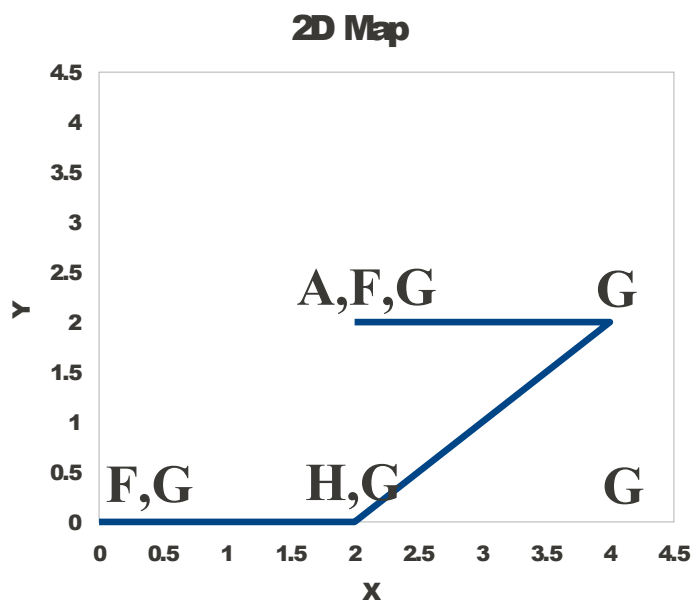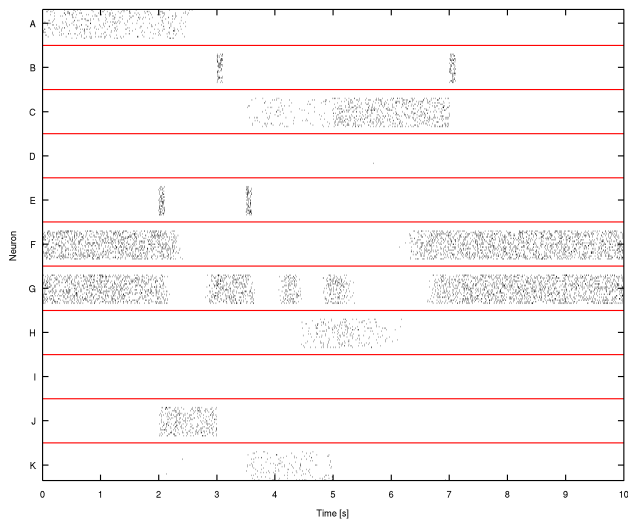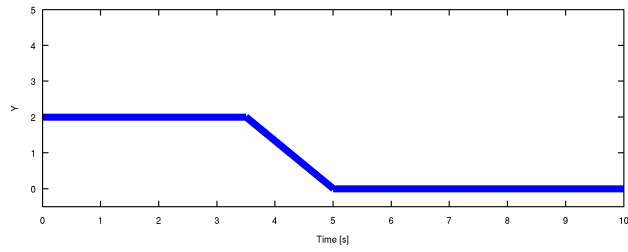
Note that the Nobel prize for Physiology or Medicine was awarded in 2014 for the discovery of place and grid cells.