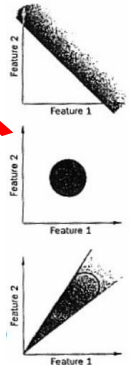
13th December

Computing with spike timing and delays

Types of neuronal pattern recognition

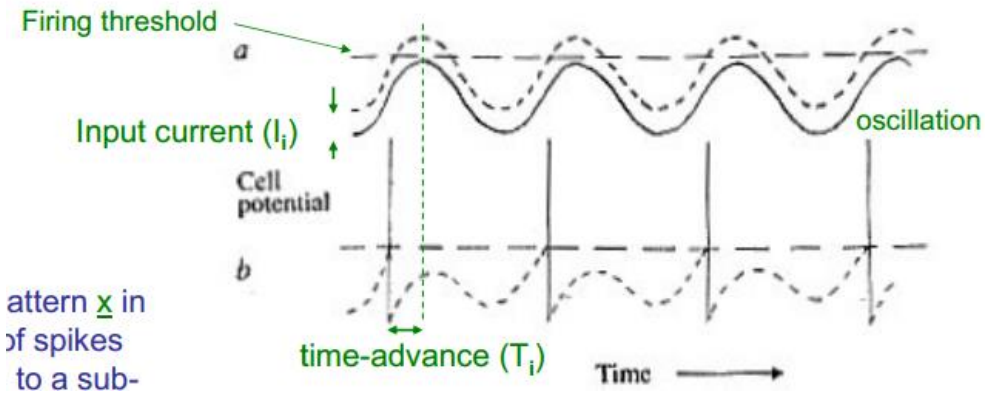
Scale-invariant recognition

- E.g. in speech recognition, loudness is not a variant in recognition. Doesn't matter if the person speaks softly or loudly, the identity of the speaker can still be recognised
- E.g. scent, either weak or smell, still recognisable
- Pattern of activity in input neurons is a vector, $\underline{x}$. The size of $\underline{x}$ doesn't matter. To recognise input pattern of activity $\underline{x}$ as similar to stored pattern $\underline{x}^*$, i.e. $\underline{x} \approx \lambda\underline{x}^*$. The scale factor shouldn't come into play, they are the same input pattern, and the relative firing rate of the neurons will be same.
- Standard neural networks have to normalise inputs to do scale-invariant recognition
    - Normalisation could be achieved by feedback inhibition
    - But this still poses a problem as standard neural networks are strength dependent rather than pattern dependent. A strong input neuron would usually have a strong connection and a weak input neuron would have a weak connection and make less of a difference. This weak input is not fundamental in deciding what the outcome is. However if the network is pattern based, then the weak input would be crucial in identifying the identity of the input.
- Linear pattern separation (perceptrons: weighted sum of firing rates and threshold) are not suitable for scale invariant recognition
- Tuning to respond at a given absolute value (e.g. head direction and place cells, radial based functions) are not suitable for scale-invariant recognition either
- Tuning to respond to given relative values are suitable for scale invariant recognition.



<u>Hopfield's 1995 time-advance coding network</u>

Described a computational model in which the sizes of variables are represented by the explicit times at which action potentials occur, rather than by the more usual 'firing rate' of neurons. This model of computation explains how one scheme of neuroarchitecture can be used for very different sensory modalities and seemingly different computations. E.g. Olfactory bulb has theta oscillation frequency (10 Hz) due to inhibitory input from medial septum.



"When there is no input current, the sub-threshold cell potential oscillation (solid line) never exceeds the firing threshold (horizontal broken line). When an input current is added, the cell potential (neglecting currents which flow during an action potential) will cross threshold, as shown by the broken curve. The cell potential corresponding to the broken curve in a, including the effect of the currents which flow during action potentials, which leave the cell in a depolarised state from which it slowly recovers. The cell potential never again exceeds the threshold for spike generation until the next cycle of the periodic oscillation. Thus the cell fires only on the upward threshold crossings of the broken line in a."