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Exercise 1 (Structure of a neuron)

Name the basic elements of a biological neuron in a neural network and briefly summarize the functional role of each element.

Answer

There are Four basic elements of a biological Neuron:

1. Cell body

   It produces all the proteins for the dendrites, axons and synaptic terminals. It is also responsible for patiotemporal integration of incoming impulses (PSPs) of all dendrites

2. Dendrites

   These fibrous branches that come out of cell body acts as a medium of signal passing from one neuron to another.

3. Axon with the myelin sheath

   An axon is a long, tail-like structure which joins the cell body at a specialized junction called the axon hillock and transmits the neural signal.Many axons are covered with a fatty substance called myelin, which helps axons to conduct an electrical signal.

4. Synapses

   The synapse is the chemical junction between the axon terminals of one neuron and the dendrites of the next. It is a gap where specialized chemical interactions can occur

Exercise 2 (Type of signal transmission in neuronal components)

Name the type of signal transmission (electrical, chemical, wireless, …) at the axon, the synapses and the dendrites. Indicate whether it is a binary or an analog event. Explain your choice.

Answer

There are two types of singnal transmission

1. Chemical(synapses)
2. Electrical(axon, denderite, synapses)

The signal generated at axon is binary in sense that the signal will be passed through only if the action potential is generated.

Exercise 3 (Neural codes)

What is the basic neuronal "event" of a neuron to "communicate" to other neurons? What are the basic neural codes to represent "meaningful information"? Give a brief explanation of the neural codes.

Answer

Basic neural event of a neuron to communicate with other neurons is action potential.

There are three basic neural codes to represent “meaningful information”:

1. **Rate coding**: information represented in the average number of spikes per unit time. Temporal structure of a spike train ignored. In rate coding, learning is based on activity-dependent synaptic weight modifications.
2. **Temporal coding**: precise spike timing, timing fluctuations carry information.
3. **Population coding**: information represented in averaging over a number of neurons. Population coding is also much faster than rate coding and can reflect changes in the stimulus conditions nearly instantaneously.

Exercise 4 (Neuron models and neuron properties)

a) Name the neuron models mentioned in the lecture in the order of descending model complexity (from complex to simple). Briefly summarize their main characteristics.

Answer

The neuron models in the order of descending model complexity:

1. Hodgkin-Huxley model

   describes axon membrane potential V(t) in detail. uses Na and K ion channels.mention of leakage terms

2. Integrate-and-fire model

   describes membrane potential V(t) more abstractly.no mention of ion channels.

3. Renewal neuron

   Differential equation for V(t). Introduces Introduce explicit memory(time since last spike)

4. Threshold element / perceptron

   More simplified version. There is concept of no refractory properties and no memory of last spike.Neuron state represented as binary variable.

b) Explain the following terms characterizing the behavior of a neuron:

- Absolute refractory period
- Relative refractory period
- Gain function
- Interspike interval distribution

Answer

Absolute refractory period: The absolute refractory period is a period where it is completely impossible for another action potential to be activated,, no matter how large the applied stimulus is. This is because the sodium channels are inactivated and remain that way until hyperpolarization occurs.

Relative refractory period: The relative refractory period is the period that occurs during the undershoot phase; where an action potential can be activated but only if the trigger (stimulus) is large enough.his is because some of the sodium channels have been reactivated and have recovered but it is a difficult process due to the counter-acting potassium flow as some potassium ion channels are still open.

Gain function:Gain function (spike frequency):

– Function of input current I

– and refractory strength c

It descirbes the relation between input current and refactory strentgh.

Interspike Interval distrbution:Interspike interval T (time between two consecutive spikes) depends on

– Input current I : larger I -> smaller T

– Refractory function : larger c -> larger T