Faiz Ahmed	Mithun Das	Mutasim Fuad Ansari	Mohammad Abir Reza
1152231	1151651	1152109	1151705
stu225473@mail.uni-kiel.de	stu225039@mail.uni-kiel.de	stu225365@mail.uni-kiel.de	stu225093@mail.uni-kiel.de

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.

There are 4 basic elements of biological neuron in a neural network.

1. **Cell body with nucleus (Soma)**
2. **Dendrites/ Denritic tree**
3. **One Axon with myelin sheath**
4. **Synapses**

Brief Description

1. **Cell body with nucleus (Soma)** : Neurons, like other cells, have cell body (call the **Soma**). The nucleus of the neuron found in the soma. Neurons need a lot of protein, and most neuronal proteins are synthesized in the soma as well. Various processes extend from the cell body. These include many short, branching processes know as Dendrites, a separate process that is typically larger than dendrites, known as the axon.
2. **Dendrites/ Denritic tree**: The first two neuronal functions,receiveing and processing incoming informations, generally take place in the dendrites and cell body. Incoming signal can be either *exicitatory* - which means they tend to make the neuron fire (generate and electric pulse) - or *inhibitory* - which means that they tend to keep the neurons from firing.

   Most neurons recieve many input signal throughout their dendritic trees. A single neuron may have more than one set of dendrites, and may receive many thousands of input signals. Whether or not a neuron is excited into firing an impulse depends on sum of all *exitatory* and *inhibitory* signals it receives.
3. **One Axon with myelin sheath:** Axon arises from the cell body at a specialized area called the axion hillock. Many axons are covered with special insulating substance called *myelin*, which helps them convey the nerve impulse rapidly. Towarads its end, the axon splits up into many branches and develops bulbous swellings known as *axon terminals*(nerve terminals). These terminals make connection with target cells.
4. **Synapses**: Neoron-to-Neuron connections are made onto the dendrites and cell body of other neurons. These connections are called **Synapses**. The first neuron from which the informations are carried called **presynaptic neuron** and the target neurons are called **postsynaptic neuron**. At most synapses and junctions, information is transmitted in the form of chemical messangers called **neurotransmitters**. A single neuron may receive inputs from many presynaptic neurons, it may also make synaptic connections on numerous postsynaptic neurons via different axon terminals.

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

At the **axons** and **dendrites** signals are ***electric pulses***. Whereas at the **synapses** the signal transmission can be both ***electrical*** and ***chemical***, depending on the type of synapses. Most synapses in our nervous system are of type chemical thus the signals transmit there as a ***chemical process*** whereas through the electric synapses the signal can be transmitted as ***electric impulse***.

The signal transmission through the axon which is basically *action potential* act as a binary event. Only if the depolarization of the membrane cell exceeds the threshold of -55v then this event will take place and transmit the signals through the axon to the axon terminal and there is no way that this signal could be lost in the way.

From the axon terminal this electric signal are being transmitted from the synapses to the next neuron through neurotransmitters as chemical signals. If the neurotransmitter is excretory it could polarized the membrane enough to cause action potential again or if this is a inhibitory neurotransmitter then it will cause a depolarization and the signal could be lost which is a analog system.

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

The basic neuronal event which is responsible for communicating to other neurons called **Action Potentials**. At the connecting point of two neuron which is called synapse one neuron transmit **Action Potentials** to another neuron to communicate.

The basic neural codes to represent meaningful information are :

- **Rate Coding**
- **Temporal Coding**
- **Population Coding**

Brief explanation of the neural codes :

Rate Coding : Rate coding which is also known as frequency coding is a regular or traditional coding that shows the information about stimulus is gathered in the firing rate(Action potentials) of the esteemed neuron. During the rate coding it is important to measure the firing rate accurately and counts information in average number of spikes per unit time.

Temporal Coding : Neuron shows high frequency or firing rates which could pass information or some sort of data. When high frequency firing rates are found carrying information are called Temporal coding. Rate coding suggest those high frequency can be noise but temporal code suggest that can be encoded and carry information.

Population Coding : Population coding is similar to the term distributed coding by which means it shows an output by using joint activity of various neurons taking a large set of inputs. Population coding is one of the few well-formed mathematical problem in the history of neuroscience. Population coding is fast and reflects the output instantly.

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 are -

- **Hodgkin- Huxley Model :** It explains the ionic mechanisms underlying the initiation and propagation of action potentials of axon membrane in detail. This explaines the Pumps and exchange of Na(Sodium) and K(Potassium) through channels .It also explaines about leakage of Cl and K Leak channels
- **Integrate-and-fire Model :** Integrate -and-fire model also describes membrane potential V(t) but more abstract than Hodgkin-Huxley model. Here in Integrate-and-Fire model there is no ion channels desscribed.
- **Renewal neuron Model :** Differential equation for postsynaptic potential.

Renewal Neuron(1) : This is differential equation for V(t) for postsynaptic potential h(t). Neuron state is defined as binary variable. If neuron emits action potential the state value is 1 and for no action potential the value is 0(zero).

Renewal Neuron(2) : Finds exact time of action potentials. This a simple equation for postsynaptic potential. In this model only last spike time is remembered.

- **Threshold element Model :** Unlike renewal neuron(2) model, threshold element model does not have memory for last spike. There is no refractory properties. But the computability of the model is simple. Postsynaptic potential only depends on current time.

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 : After repolarization there is a period during which a second action potential cannot be initiated, no matter how large a stimulus current is applied to the neuron. This is called the absolute refractory period.

Relative refractory period : Relative refractory period is the following period of absolute refractory period during which another action potential can be generated, but only by a greater stimulus current than that originally needed. This period is followed by the return of the neuronal properties to the threshold levels originally required for the initiation of action potentials.

Gain Function : Gain function is the number of spikes per unit time. It is also reffered to as spike frequency.

Interspike Interval Distribution : Time between two consecutive spike is called Interspike interval.