Brain-Eye Connection

Project Description

• The main objective is to have a better model to understand the development of optical neurons between the eye and the brain.

• A Hamiltonian approach to modeling the connection between the eye and brain have been done previously [1], the Sperry-Hebb model.

• This project is important to understand how nerves grow and reach the visual cortex.

• The goal is to find a method that allow us to have a better understanding about the eye-brain connection and how the neuron regenerate.

Scientific Challenges

• The 3D case has complications related to coding the swirling mechanisms of each neuron, in addition to passing from one side of the brain.

• Developing the understanding of growth and repair of neurons can enable us to understand hidden biological factors that may have been previously ignored or not been well understood.

Potential Applications

• Can prevent or help cure many eye and brain related diseases upon understanding the connection process, i.e., blindness related diseases [3].

• Better understanding of the efficiency of genetic coding and the evolution process. Understanding the connection will be beneficial to understanding how the growth process is encoded in the genes.

Methodology

1. We introduced a sample potential for the chemical concentration of EphrinA/EphrinB. The Where the neurons try to follow the highest concentration of these proteins through out their development.

2. We use Matlab programming language to simulate the growth process of the neurons from the eye to brain. We set a single neuron and a single brain source as 1x2 matrix and measure the potential in multiple different angles and follows the highest potential with a constant step size.

3. Of course in real situations the chemicals are going to interact with other chemicals. Hence, for each step of the potential, the neurons experience noise we added some noise, in reality the noise are less effective near the source.

4. Each following neuron, must also avoid the highest potential if the location has already been passed by another neuron. This applies also in the 3D case.

Results

1. Each neuron grow toward the source, despite the starting point.

2. The repulsion between neuron is effective at short distances from each other.

3. The closer the neuron to the brain, the noise made by the other factors will be smaller.

4. No swirling neurons in 2D case.

References


4. Ilder R Gabitov, Simulation of 21 neurons and one source, (2020)

Acknowledgments

This project was mentored by Professor Ilder R Gabitov whose help is acknowledged with great appreciation.

Image 2. This figure is a simulation of 21 neurons and 1 source on the right. All the neurons are growing to the brain one by one. The brain is located get [10 0] and the starting position for the neurons is at x=0. 2D case. (From Professor Ilder R Gabitov)