

# Introduction to Computational Neuroscience

## Practice I: Structure of the Brain

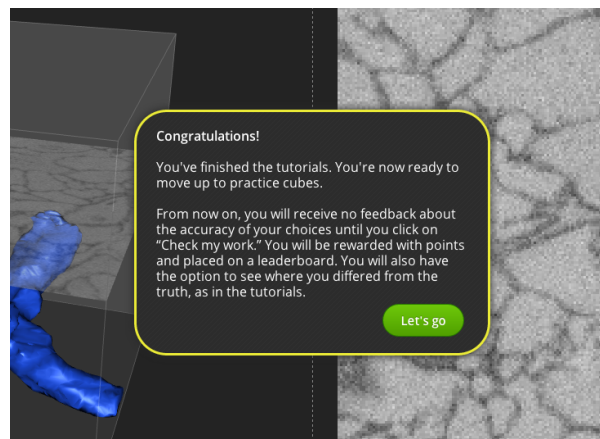
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As you might have heard before, structure of the brain is extremely complex. There are lots of neurons next to each other, tangled with each other, forming one, almost gapless mass. In pursuit of understanding any complex system, one thing you try to learn is its structure. Once you see the structure you get insights about the purpose of the system. Same, hopefully, stands for our brain. Brain structure consist of neurons, their *dendrites* (input channes), *axons* (output channes) and *synapses* (connections points). Eventually we would like to see this system in some structured and normalized form. The whole map of the brain (or part of it) is called *connectome*. Building a connectome might reveal an information essential for understanding the inner workings of that part.

### Exercise 1: EyeWire (0.5pt)

One project aimed at creating a connectome of human brain is called EyeWire<sup>1</sup>. The idea is similar to FoldIt<sup>2</sup> or GalaxyZoo<sup>3</sup>: use human abilities and processing power to solve tasks where artificial intelligence fails. Read about this project's goals and motivation and start playing. In order to get points for this exercise complete the tutorial (first 6 cubes) and submit screenshot like the one below.



### Exercise 2: Questionnaire (0.5pt)

Q<sub>1</sub> : Question one

Q<sub>2</sub> : Question two

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<sup>1</sup><http://www.eyewire.org>

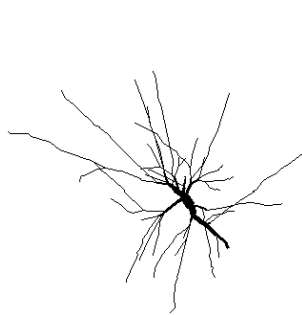
<sup>2</sup><http://fold.it>

<sup>3</sup><http://www.galaxyzoo.org>

Q<sub>3</sub> : ...

### Exercise 3: Model of a neuron (1.5pt)

There are lot of different types of neurons in our nervous system. They have different size, structure and functional role. Let us have a look at some of them:



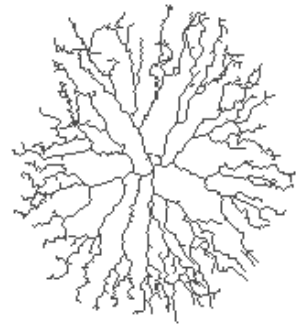
**Pyramidal cell in layer 2 or 3**



**Purkinje cell**



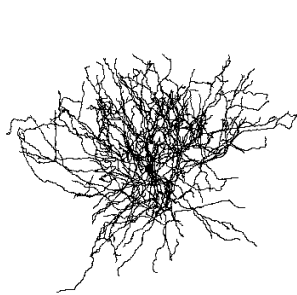
**Spindle neuron**



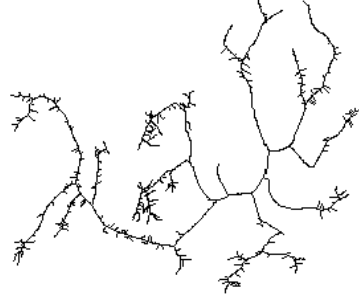
**Amacrine cell**



**Pyramidal cell in layer 5**



**Bascet**



**Sensory**

In the **data** folder of this assignment you will find three **.swc** files. Each file describes reconstructed structure of a neuron. Neuron can be classified by different parameters, such as size, bifurcation, size of some, etc. In general this task is quite hard<sup>4</sup>. When looked at, different types of neurons have distinguishable shapes. This is what we will try to use in this exercise. Your task is to plot neurons from the data files and guess which of the above-mentioned types each of them belongs to.

1. Have a look inside an **.swc** file. Each line describes small piece of the neuron (*compartment*), space-separated values are:
  - (a) ID of the compartment
  - (b) Type of the compartment:
    - 0 – undefined
    - 1 – soma
    - 2 – axon

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<sup>4</sup>M. Bota, L. W. Swanson, **The neuron classification problem**, 2007, <http://www.sciencedirect.com/science/article/pii/S0165017307000768>

- 3 – basal dendrite
  - 4 – apical dendrite
  - (c) X coordinate (in  $\mu\text{m}$ )
  - (d) Y coordinate
  - (e) Z coordinate
  - (f) Radius of the compartment
  - (g) ID of parent compartment (-1 for root compartment)
2. Import coordinate data into your program (or **Matlab**, **R** environment)
  3. Plot data in 3D (for example using **scatter3** in **Matlab**)
  4. Look at resulting 3D image and try to guess type of the neuron

In your report please tell type of neuron for each of the files, include visualizations and the code to reproduce them. You can use **Matlab/Octave**, **Python** or any other programming language you like. During the course we consider **Matlab** our primal tool, so if you don't have any strong preferences, try using **Matlab/Octave**.

#### **Exercise 4: Brain lesions (0.5pt)**

Brain *lesions* are abnormalities in the structure of the brain. Some lesions lead to interesting effect, which gives us information about functional role of the damaged region. Read about brain lesions and possible effects. Find one lesion, which triggers your interest and:

- describe the nature of the lesion
- find a picture of the structure it appears in
- tell about its characteristics, e.g. is it temporal or permanent
- describe the effect it causes
- speculate on how the effect is related to the functional role of that region

Please submit a **pdf** report with answers to the questions and comments about your solutions. Also submit a code for the programming exercise(s). Pack those into **zip** archive and upload to the course web page.