

## Neurosciences, project I

1. Description of a neuron, numerical simulation of a model neuron: solving the system of differential equations using the Runge Kutta 4th order method, analyzing the correctness of choosing the time step.
2. Analyzing different regimes of a neuron dynamics, plotting time series and phase portraits of the signal, calculation of a regime map.
3. Adding Gaussian noise to the system, solving the system of differential equations with noise, analyzing the influence of noise amplitude on the system dynamics.
4. Adding the coupling between 2 neurons, analyzing synchronization between neurons for different values of the coupling strength.
5. Simulation of a neural network with global topology, analyzing the influence of external stimulus and noise amplitude by calculating characteristic correlation time.

### Variation 1

#### Hodgkin-Huxley model

1. Model: <https://sci-hub.si/10.1007/978-0-387-75847-3>, Pp. 205-206
2. Regime map <https://sci-hub.si/10.1007/978-0-387-75847-3>, P. 2103
3. Reference to a model with noise:  
<https://journals.plos.org/ploscompbiol/article/file?id=10.1371/journal.pcbi.1005646&type=printable>, eq. (4-7)
4. Reference to model with coupling:  
<https://journals.plos.org/ploscompbiol/article/file?id=10.1371/journal.pcbi.1005646&type=printable>, eq. (8)
5. Number of neurons  $N = 5$ , reference to characteristic correlation time:  
<http://www.math.pitt.edu/~cbsg/Materials/PhysRevLett.78.775.pdf>, eq. (3-4)

### Variation 2

#### FitzHugh-Nagumo model

1. Model: [https://ifisc.uib-csic.es/raul/publications/P/P97\\_tmg03.pdf](https://ifisc.uib-csic.es/raul/publications/P/P97_tmg03.pdf), eq. (1-2) without the last term
2. Regime map: <https://b-ok.cc/book/2104926/560800>, fig. 5.1.1a
3. Reference to model with noise:  
[https://ifisc.uib-csic.es/raul/publications/P/P97\\_tmg03.pdf](https://ifisc.uib-csic.es/raul/publications/P/P97_tmg03.pdf), eq. (2) - the last term
4. Reference to model with coupling  
[https://ifisc.uib-csic.es/raul/publications/P/P97\\_tmg03.pdf](https://ifisc.uib-csic.es/raul/publications/P/P97_tmg03.pdf), eq. (1) - the last term
5. number of neurons  $N = 25$ , reference to characteristic correlation time:  
<http://www.math.pitt.edu/~cbsg/Materials/PhysRevLett.78.775.pdf>, eq. (3-4)

### Variation 3

#### Hindmarsh–Rose model

1. Model: <https://sci-hub.si/10.1088/1009-1963/14/6/006>, eq. (1)
2. Regime map: <https://sci-hub.si/10.1088/1009-1963/14/6/006>, Fig. 1
3. Reference to model with noise:  
<https://sci-hub.si/10.1088/1009-1963/14/6/006>, eq. (2)
4. Reference to model with coupling:  
<https://sci-hub.si/10.1088/1009-1963/14/6/006>, eq. (5)
5. number of neurons  $N = 15$ , reference to characteristic correlation time:  
<http://www.math.pitt.edu/~cbsg/Materials/PhysRevLett.78.775.pdf>, eq. (3-4)

### Variation 4

#### Morris–Lecar model

1. Model: <https://link.springer.com/content/pdf/10.1007/s00422-013-0580-4.pdf>, eq. (1)
2. Regime map: <https://link.springer.com/content/pdf/10.1007/s00422-013-0580-4.pdf>, fig. 1
3. Reference to model with noise:  
[http://users.df.uba.ar/balen/Papers/PhysRevE\\_72\\_021901.pdf](http://users.df.uba.ar/balen/Papers/PhysRevE_72_021901.pdf), eq. (1)
4. reference to model with coupling

[http://users.df.uba.ar/balen/Papers/PhysRevE\\_72\\_021901.pdf](http://users.df.uba.ar/balen/Papers/PhysRevE_72_021901.pdf), eq. (1,8)

5. number of neurons  $N = 25$ , reference to characteristic correlation time:  
<http://www.math.pitt.edu/~cbsg/Materials/PhysRevLett.78.775.pdf>, eq. (3-4)

## Variation 5

### Izhikevich Neuron model

1. Model: <https://www.izhikevich.org/publications/spikes.pdf>, eq. (1-3)

2. Regime map:

[https://www.researchgate.net/publication/267480919\\_Bifurcation\\_analysis\\_of\\_Izhikevich\\_model](https://www.researchgate.net/publication/267480919_Bifurcation_analysis_of_Izhikevich_model), fig. 3

3. Reference to model with noise:

<http://www.readcube.com/articles/10.3389/fncom.2018.00059>, eq. (1-3,5)

4. Reference to model with coupling:

<https://www.ieice.org/nolta/symposium/archive/2016/articles/1135.pdf>, eq. (2)

5. number of neurons  $N = 25$ , reference to characteristic correlation time:  
<http://www.math.pitt.edu/~cbsg/Materials/PhysRevLett.78.775.pdf>, eq. (3-4)

## Variation 6

### Leaky integrate-and-fire model

1. Model: <https://www.nature.com/articles/s41598-017-07418-y.pdf>, eq. (1)

2. Regime map: <https://www.nature.com/articles/s41598-017-07418-y.pdf>, fig. 5 (b)

3. Reference to model with noise: <https://sci-hub.si/10.1103/PhysRevE.59.3427>, eq. (2.3) – the last term

4. Reference to model with coupling:

<https://link.springer.com/content/pdf/10.1140/epjb/e2017-80162-0.pdf>, 3(a) – the last term

5. number of neurons  $N = 50$ , reference to characteristic correlation time:  
<http://www.math.pitt.edu/~cbsg/Materials/PhysRevLett.78.775.pdf>, eq. (3-4)