SCHOOL PROGRAM

Tramariglio (Alghero) 16-20 April 2018

April 16th

Morning sessions.

First lecture

Speaker: Dr. Paola Perin, University of Pavia, IT

Lecture: Quantifying shape in complex cells

Abstract:

Neural tissue contains cells which displays very complex shapes and interrelations. For neurons, shape strongly affects electrical properties; for glia, shape is related to functional states. In order to reconstruct shapes and spatial relations within the neural tissue, special tools in tissue labeling, stereology and morphological analysis are used. In this lecture we are going to introduce the more commonly employed techniques.

Second lecture

Speaker: Dr. Giuseppe Talani, Institute of Neuroscience CNR Cagliari, IT

Lecture: The knotty neuronal network: an electrophysiological vision

Abstract:

In this first section we'll discuss about how neuronal function and signaling may be addressed in an electrophysiological aspect. How do neurons work and how they talk with each other? What are the signals that can be observed experimentally and what are the laws that regulate their onset? We will review the various and most known electrophysiological techniques and how these can be used in order to understand the function of the mazy and fascinating neural network, surfing from the action potential to the main action of neurotransmitters.

Afternoon.

Hands-on time: The NEURON simulator and the SciPy ecosystem. Basic concepts.

Evening session.

Get together at the Blau Skybar.
Speaker: Dr. Jonathan Mapelli, University of Modena Reggio Emilia, IT
Presentation: Linear and Non-linear microscopy in Neuroscience

April 17th

Morning sessions.

First lecture
Speaker: Dr. Paolo Enrico, University of Sassari, IT
Lecture: From neurophysiology to math
Abstract:
Models are of central importance in many scientific contexts, and Neuroscience is no exception. We use models to describe our knowledge and beliefs about how a particular phenomenon functions. In mathematical modeling, we translate our (mostly qualitative) knowledge into the quantitative language of Mathematics. This has many advantages, in fact: 1) Math is a very precise and concise language, with well-defined rules for manipulations. This is very helpful to formulate ideas and identify underlying assumptions; 2) all the tools that mathematicians have develoed over hundreds of years are at our disposal; 3) computers can be used to perform numerical calculations. If your understanding of Math is less than rock solid, don't worry! The point here is to learn enough of the mathematics to understand what is going on, not necessarily how to do it yourself.

Second lecture
Speaker: Prof. Bruce Graham, University of Stirling in Scotland, UK
Lecture: From neurons and synapses to networks: Basics of computational neuroscience
Abstract:
Mathematical models and associated computer simulations of biological neurons and the networks they form are now (nearly) standard tools in the research neuroscientist's repertoire. Models and simulations are aids in validating the interpretation of experimental measurements of brain activity. They also enable predictions to be made at different levels, from molecular and cellular mechanisms underpinning learning

and memory, up to cognitive information processing by brain regions. This presentation and associated computer exercises will introduce the basic computational techniques developed for simulating the signalling activity within and between neurons. It will cover how to model the electrical activity of neurons, signaling between neurons via synapses, and the construction of neural network models.

Afternoon.

Hands-on time: Implementation of neural models using NEURON + Python: basics

Evening sessions.

Get together at the Blau Skybar.
Speaker: Dr. Saray Soldado Magraner, Institute of Neuroinformatics, CH
Presentation: Modeling the CA1 neuron

April 18th

Morning sessions.

First lecture
Speaker: Prof. Ausra Saudargiene, Vytautas Magnus University, LT
Lecture: Learning, memory and synaptic plasticity
Abstract:
The brain has an amazing ability to dynamically reorganize itself and adapt to the changing environment through synaptic plasticity, which is a modification of the synaptic connections between the neurons over time. Synaptic plasticity is believed to underlie the biological basis of learning and memory. In this presentation, the phenomena of long-term potentiation, long-term depression, spike-timing-dependent synaptic plasticity, neuromodulation of learning will be introduced, and the computational methods to model synaptic plasticity of at the molecular, cellular and circuit levels will be covered.

Second lecture
Speaker: Dr. Saray Soldado Magraner, Institute of Neuroinformatics, CH
Lecture: Unraveling neuronal plasticity rules through biophysical models
Abstract:
Neurons of the central nervous system present different firing patterns upon somatic injection of step currents. These responses have been cataloged among others, as adapting, bursting or regular spiking. In previous work we have characterized a novel form of plasticity, in which CA3 neurons in the hippocampus drastically change their firing pattern after a few minutes of subthreshold conditioning.

During this talk I will explain how we have used a model of a CA3 neuron in NEURON to estimate which underlying parameters are the responsible for the firing pattern transitions.

Afternoon.
Hands-on time: Implementation of neural models using NEURON + Python: more advanced topics

Evening session.
Get together at the Blau Skybar.
Speaker: Dr. Paolo Enrico, University of Sassari, IT
Presentation: How (not) to model a medium spiny cell of the nucleus accumbens

April 19th

Morning sessions.

First lecture
Speaker: Dr. Gabriela Michel, Institute of Neuroinformatics, CH
Lecture: Self-construction of the Brain using Cx3D
Abstract:
Conventional technology is constructed by engineers that have a clear view of the system that they want to built. In contrast, one fascinating aspect in biology is how individual cells interact with one another to assemble different structures. A few progenitors with the same genetic information replicate and generate specialized cell types that combine to form complex but coherent systems such as the cerebral cortex. We study self-construction using the Java-based simulation software Cx3D, which allows a physical representation of cortical development in a 3D environment. In this tutorial we will look at the biological principles of self-construction and I will show you how we study this with our software.

Second lecture
Speaker: Dr. Moritz Milde, Institute of Neuroinformatics, CH
Lecture: From modeling to real-world application. Abstracting neuronal computation to allow large-scale systems to interact with the world.
Abstract:
Modeling all physiological and computational properties of neurons and synapses in detail can be very resource intensive and due to the serial nature of conventional computers very inefficient. Furthermore, when using simulation of neural networks in real-world application additional constraints such as power-consumption and simulation time are two crucial factors. Especially when such networks are reasonable large, e.g. tens of thousands of neurons and even more synapses. I will introduce neuromorphic sensory-processing systems which consists of physical implementations of simplified neuron and synapse models, which can be emulated with extreme low power, in great quantity and operate, by

design, fully parallel. Further, I will present how in detail one can abstract biological neuronal computation and implement them in neuromorphic sensory-processing systems to perform real-world robotic tasks.

Afternoon.
Hands-on time: Advanced projects

Evening session.
Get together at the Blau Skybar:
Speaker: Dr. Giuseppe Talani, CNR Institute of Neuroscience, IT
Presentation: Synaptic plasticity and drug abuse

April 20th

Morning sessions.

First lecture
Speaker: Dr. Sergio Solinas, Institute of Neuroinformatics, CH
Lecture: Simulation and data processing workflow: from ideas to documented applications
Abstract:
Running computer simulations does not suffice to produce good science. Computational modeling can be a painstaking job if proper tools and care are not used in the process taking ideas from experimental design and data to neuron models and practical applications. The community of Computational Neuroscience has developed a set of tools to complete the neural simulators at its core. Revision control, data management and analysis, data visualization, progress report tracking, and last but not least standard representation of neuronal models can save your scientific life more than once. We will see how to use software as: Git, Sumatra, Neo, PytNN, Netpyne, Mozaik, NeuroML, Geppetto, and the OSB web portal.

Second lecture
Speaker: Plenary session
Lecture: Work you way in computational neuroscience
Abstract:
Computational neuroscience offers an enormous innovation potential in the quest to understand brain function, by combining the expertise of biologists, mathematicians, physicists, physicians, psychologists, computer scientists and engineers, in a true interdisciplinary approach. Models can be used to investigate many phenomena, including: neural dynamics, neuromodulation, neural coding, plasticity, vision, audition, and much more.

However, in such a large field of research is easy to get lost and waste too much time perusing things that are unimportant. Further, computer programming is a skill that can be learned in many way, and NEURON programming is no exception. On these basis one can be tempted to work his own way by just writing code. While there is considerable value in doing your own work privately, if you want to evolve you need to communicate with others. Doing research in computational neuroscience means not just dumping code, but actually being a scientist and do science within the scientific community.

Afternoon.
Hands-on time: Final discussion and results evaluation

Evening session.
Social dinner: