

# The scientific project of NeuroMat

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Universidade de S.Paulo and NeuroMat

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1<sup>st</sup> Workshop RGBRain

## Research, Dissemination and Innovation Center for NeuroMathematics

- ▶ Research center funded by FAPESP
- ▶ established in August 2013 at the University of São Paulo
- ▶ integrating mathematical modeling and neurobiology.

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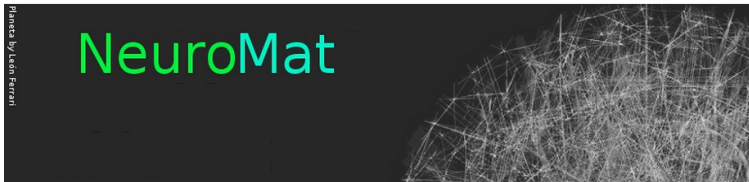
`neuromat.numec.prp.usp.br`

`www.facebook.com/neuromathematics`

`https://github.com/neuromat`

# NeuroMat

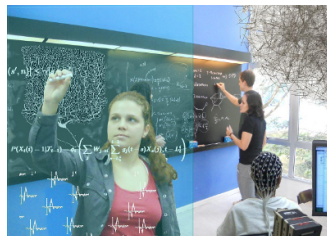
Research, Innovation and Dissemination  
Center for Neuromathematics

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## NeuroMat Project

This proposal concerns the creation of a mathematical Center aiming to integrate modeling with basic and applied research at the frontier of neuroscience. The goal of the Center is to develop a mathematical framework leading to the theoretical understanding of neural systems, fully integrated with experimental research in neuroscience. New models and theories will be developed in order to handle the huge quantity of data produced by concurrent experimental research and to provide a conceptual framework for the multiscale aspects displayed by neural phenomena.

Technology transfer and innovation will focus on products aimed at public health programs in re-habilitation and will be offered through the Lucy Montoro Rehabilitation Center of the São Paulo State Government. The USP FLOSS Competence Center will partner in producing high quality computational tools for neuroscience research and clinical use, all available



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I am quoting the Research Project we submitted to FAPESP

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- ▶ *This requires the definition of a full **new class** of **mathematical models** to describe and explain in a parsimonious way the different scales of neural activity and the relationship between them.*
- ▶ *The construction of these models should occur together with the development of suitable statistical and computational methods, including **model selection principles** (...)*

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- ▶ The mathematics required to address the issues associated to brain plasticity does not exist yet
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- ▶ We are **NOT** signal processors,
- ▶ even if part of our activities involves signal processing tasks.

# *Mutatis mutandis*

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in the Statistical Mechanics derivation of Thermodynamics.

# What are we doing to achieve these goals?



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We need to make progresses in the direction of these long term goals and steps.

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Recall the *The development of the long-term goal (. . .) requires the initial development of two foundational aspects:*

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I am quoting the text sent to FAPESP with our goals for the first two years.

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We propose a new paradigm based on the idea that neuronal activity must be described as a stochastic systems

- ▶ with a large number of interacting components,
- ▶ whose evolution depends on the history of the system.

# Basic features of these stochastic processes

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- ▶ The activity of each component depends on the past history of its interaction neighborhood.

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- ▶ The activity of each component depends on the past history of its interaction neighborhood.
- ▶ Both the size of the relevant past history and of the interaction neighborhood change as the process evolves.

# Double time evolution

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Therefore there is a double time evolution:

- ▶ one describing the changes in neuronal activity,
- ▶ and another one describing changes in the graph of interactions among components.



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Brain activity is underpinned by a double graph structure:

- ▶ physical graphs defined by connections between brain regions
- ▶ and functional graphs relating regions recruited for each particular activity.

While the physical graphs can be directly observed, functional interactions can only be inferred from data.

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- ▶ Traditionally, this has been done using descriptive statistical methods which give little insight on the mechanism underlying the dynamics of the neural activity.
- ▶ Alternative to this naive descriptive statistical approach: statistical model selection.
- ▶ Statistical model selection means: to assign models to samples following some optimality criterion.

Inference and model selection within this framework requires the development of new statistical methods.

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- ▶ *To be continued . . . .*