NeuroMat: first 4 next 7

Antonio Galves

October 17, 2017

NeuroMat

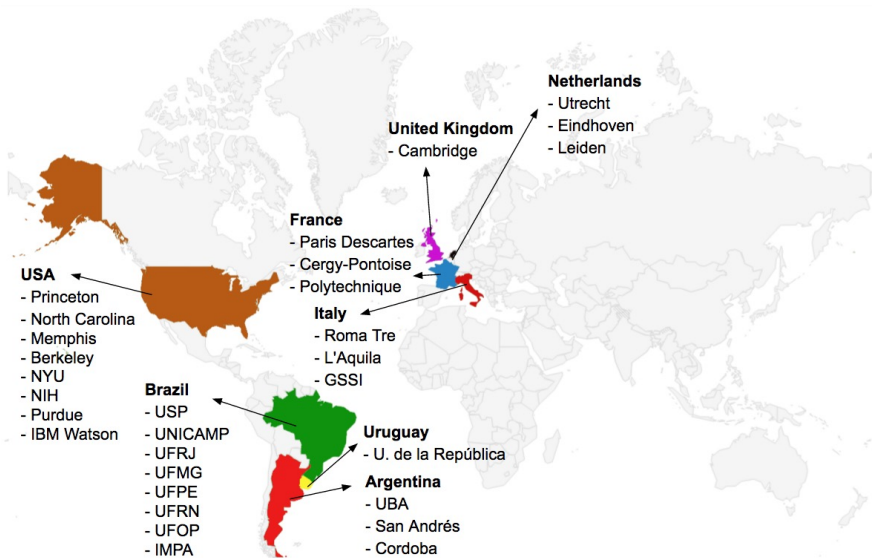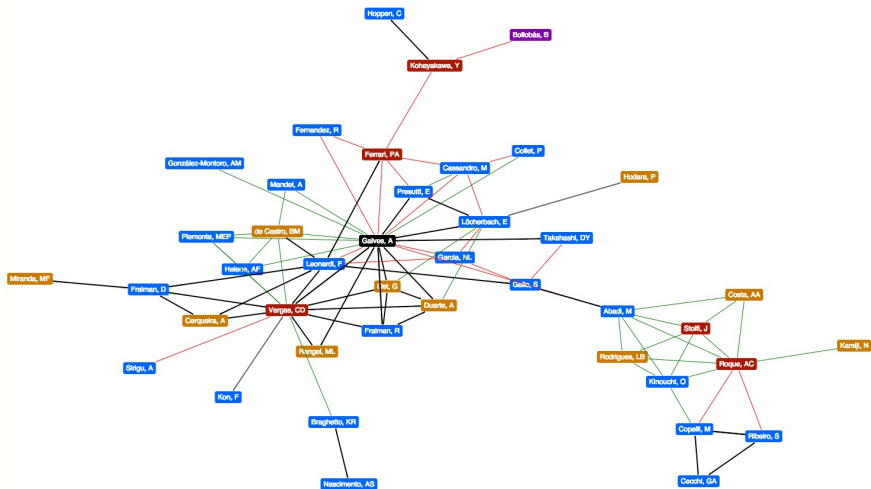- ▶ Research center integrating mathematics and neurobiology.

NeuroMat

- Research center integrating mathematics and neurobiology.
- Hosted at University of São Paulo

NeuroMat

- ▶ Research center integrating mathematics and neurobiology.

- ▶ Hosted at University of São Paulo

- ▶ Vertices in departments of
    - ▶ Mathematics, Statistics, Computer Science, Physics and Neurobiology

NeuroMat

- ▶ Research center integrating mathematics and neurobiology.
- ▶ Hosted at University of São Paulo
- ▶ Vertices in departments of
    - ▶ Mathematics, Statistics, Computer Science, Physics and Neurobiology
- ▶ in several universities and institutions: UNICAMP, UFRJ, UFRN, UFPE, UFMG, UFSCar, IMPA, UBA, Cergy-Pontoise, Berkeley, Cambridge, Centre de Neuroscience Cognitive (CNRS, Lyon), GSSI, Montevideo, NIH, Paris Descartes, IBM, Purdue, NIH, Nice-Sophia-Antipolis, San Andres, ...

Netherlands
- Utrecht
- Eindhoven
- Leiden

United Kingdom
- Cambridge

France
- Paris Descartes
- Cergy-Pontoise
- Polytechnique

Italy
- Roma Tre
- L'Aquila
- GSSI

USA
- Princeton
- North Carolina
- Memphis
- Berkeley
- NYU
- NIH
- Purdue
- IBM Watson

Brazil
- USP
- UNICAMP
- UFRJ
- UFMG
- UFPE
- UFRN
- UFOP
- IMPA

Uruguay
- U. de la República

Argentina
- UBA
- San Andrés
- Cordoba

NeuroMat facilities and associated laboratories

- Facilities
  - HPC center launched in April, 2016
  - EEG lab launched in October, 2017
- Associated laboratories at UFRJ and UFRN

USP counterpart support

- four-floor building - 1,175 m^2
  - recently renovated and extended $\sim$ \$ 500,000
- 3 staff members
- 1 assistant professor position

Mission

The main goal of NeuroMat is to build the new mathematical framework deemed necessary to address the challenges of neurobiology.

Mission

The main goal of NeuroMat is to build the new mathematical framework deemed necessary to address the challenges of neurobiology.

This required the construction of new classes of stochastic processes to

- model huge systems of spiking neurons
- describe statistical model selection in the brain
- address the issue of the *statistician brain*

What we have done

We introduced two new classes of stochastic processes:

- ▶ Systems of interacting chains with memory of variable length
- ▶ Context tree driven stochastic processes

Modelling huge systems of spiking neurons

- ▶ The model is a huge system of interacting chains with memory of variable length
- ▶ Introduced in Galves and Löcherbach (2013)
- ▶ This paper gave rise to a sustained mathematical research agenda (not only from our team).

Outcomes of this research line

- 33 new scientific articles
- 125 citations
- 10 postdoctoral projects
- 6 PhD dissertations

Stochastic processes driven by context tree models retrieved from EEG data

Duarte, Fraiman, Galves, Ost and Vargas (2017):

- ▶ a new statistical approach to address the conjecture that the brain operates as statistician, assigning models to external stimuli.
- ▶ a new experimental protocol to test this conjecture.
- ▶ a new mathematical object: stochastic processes driven by context tree models.
- ▶ a new statistical model selection procedure for functional data.

Goalkeeper Game

- New computer game associated to the experimental protocol developed in the article by Duarte, Fraiman, Galves, Ost and Vargas (2017).
- The game allows for inexpensive and large-scale neuroscience data collection.
- Alongside its experimental aspects, the game addresses a new mathematical challenge interesting by itself: the learning processes and decision-making models used by the player.
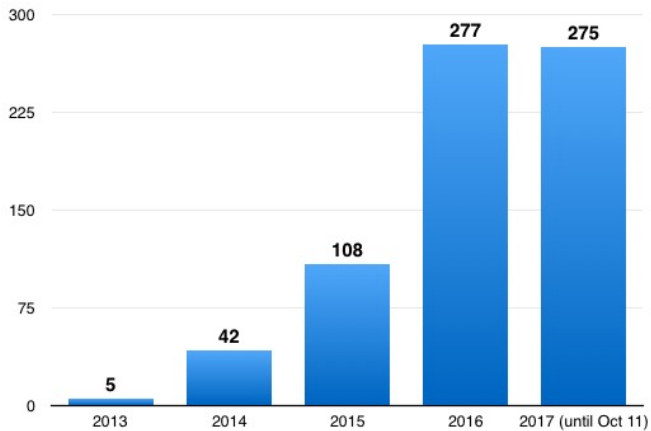- This has become a compass point for technology transfer

THE GOALKEEPER GAME

Soccer – Mathematics – Cognition

2 PhD dissertations

1 postdoctoral project

Near future

- ▶ Modeling brain plasticity
- ▶ Phase transitions, criticality and oscillations in stochastic neural networks
- ▶ Continuing mathematical research and computational simulation of large-scale stochastic neural networks

Technology transfer and innovation

Innovation mission

- To develop innovative tools and applications based on the new conceptual framework to approach the brain being constructed at NeuroMat

- This is different from applying existing mathematics-based tools to neuroscience

NeuroMat innovation

- Clinical applications: diagnosis and neuro-rehabilitation
- Computational tools: free and open source software tools

Clinical applications under development

- Parkinson disease (AMPARO initiative)
  - Free and friendly test for early differential PD diagnosis
- Brachial plexus injury (ABRAÇO initiative)
  - Predictors of rehabilitation after peripheral injury
- Psychosis and psychiatric disorders
  - Prediction and diagnosis through speech analyses

Computational tools - now available

- Goalkeeper game
  - online game with desktop and mobile device versions
- NeuroMat Experiments Database
  - data and metadata sharing and searching
- Neuroscience Experiments System (NES)
  - data and metadata management
  - unifies data from different provenances (clinical evaluation, electrophysiological, imaging, behavioral, ...)

NeuroMat — Research, Innovation and Dissemination Center for Neuromathematics

Log In   English ▾

Neuroscience Experiments Database

Open Platform for Experiments in Neuroscience

Type key terms/words to be searched

Select one or more data collection types   ▾   **Search**

List of Experiments

Title	Description	Participants	Version	
EEG register and stochastic auditory stimuli	The experiment consisted in exposing volunteers to sequences of auditory stimuli defined as strong beats, weak beats and silent units, indicated respectively by symbols 2, 1 and 0. The sequence of auditory stimuli were produced by two the context tree models called Ternary and Quaternary random sources and a Independent random source in which each symbol appears independently with probability 1/3. Each volunteer was exposed to two 12 min blocks of samples generated by each of the random sources. The blocks were separated from each other by a period of time ranging from 5 to 10 min, during which data collection was interrupted. Each sample was a concatenation of three 1 min sequences of auditory units generated independently by the same random source. Each sequence of auditory units was separated from the next one by a 15 seconds silent interval. All volunteers were exposed to two different orderings, either Ternary, Independent, Quaternary or Quaternary, Independent, Ternary. For half of the volunteers the starting block was Ternary, Independent, Quaternary and the second block was Quaternary, Independent and Ternary. The inverse ordering was used with the other half, to balance possible order effects.	20 in 1 groups	4	View
Cerebral Dynamics during the Observation of Point-Light Displays Depicting Postural Adjustments	Design: We registered the EEG activity of 12 volunteers while they passively watched point light displays (PLD) depicting quiet stable (QB) and an unstable (UB) postural situations and their respective scrambled controls (QS and US). In a pretest, 13 volunteers evaluated the level of stability of our two biological stimuli through a stability scale.	12 in 1 groups	6	View

NeuroMat   FAPESP

Dissemination

Dissemination Mission

To propose radical innovations to improve public scientific culture about NeuroMathematics

FAPESP's expectations are to be met under structural, institutional constraints

- ▶ Stable scientific illiteracy
- ▶ Continuously insufficient, inefficient investment to public school system
- ▶ General lack of interest in science news in broad-public media outlets
- ▶ Little incentives for professors and researchers in universities to get involved in programs of "culture and extension"

CEPID **NeuroMat** discute

Cultura Matemática no Brasil: diagnósticos e perspectivas

16 de maio de 2017

15h–17h30 Mesa-redonda:
Diagnósticos sobre a situação da cultura
matemática no Brasil: o que dizem as avaliações?
debatedores:
Esther Carvalhaes (OCDE)
Claudio Landim (OBMEP/IMPA)
Nancy Lopes (UNICAMP/FAPESP/NeuroMat)
Ocimar Alavarse (FEUSP)
moderador: **Fernando J. da Paixão (UNICAMP/NeuroMat)**

18h–20h30 Mesa-redonda:
Impacto das avaliações nas políticas públicas
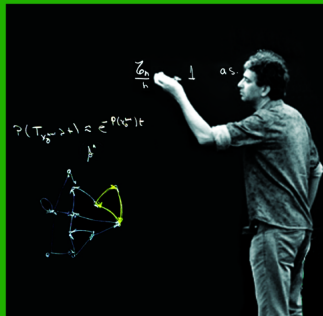**e na formação de professores.**
debatedores:
Otaviano Helene (USP)
Hilário Alencar (UFAL/SBM/PROFMAT)
Manoel Oriosvaldo (FEUSP)
moderadora: **Martha Marandino (FEUSP/NeuroMat)**

neuromat.numec.prp.usp.br/cmb

Auditório da Faculdade de Educação USP
Av. da Universidade, 308

apoio: **FAPESP** · **FEUSP**

NeuroMat Wikimedia Initiative

NeuroMat Wikimedia Initiative

- $\sim$ 2,000 Wikipedia entries in Portuguese (and hundreds in English)

NeuroMat Wikimedia Initiative

- $\sim$ 2,000 Wikipedia entries in Portuguese (and hundreds in English)
  - over 10M views since January 2016

NeuroMat Wikimedia Initiative

- ∼ 2,000 Wikipedia entries in Portuguese (and hundreds in English)
  - over 10M views since January 2016
- 2,334 media files (pictures, GIFs, videos, audio files)

NeuroMat Wikimedia Initiative

- ∼ 2,000 Wikipedia entries in Portuguese (and hundreds in English)
  - over 10M views since January 2016
- 2,334 media files (pictures, GIFs, videos, audio files)
  - near 11M views in September'17 alone

NeuroMat Wikimedia Initiative

- $\sim 2,000$ Wikipedia entries in Portuguese (and hundreds in English)
  - over 10M views since January 2016
- 2,334 media files (pictures, GIFs, videos, audio files)
  - near 11M views in September'17 alone
- Systematic effort to disseminate our approach

NeuroMat Wikimedia Initiative

- $\sim$ 2,000 Wikipedia entries in Portuguese (and hundreds in English)
    - over 10M views since January 2016
- 2,334 media files (pictures, GIFs, videos, audio files)
    - near 11M views in September'17 alone
- Systematic effort to disseminate our approach
    - other RIDCs

NeuroMat Wikimedia Initiative

- $\sim$ 2,000 Wikipedia entries in Portuguese (and hundreds in English)
    - over 10M views since January 2016
- 2,334 media files (pictures, GIFs, videos, audio files)
    - near 11M views in September'17 alone
- Systematic effort to disseminate our approach
    - other RIDCs
    - USP museums and departments

NeuroMat Wikimedia Initiative

- $\sim$ 2,000 Wikipedia entries in Portuguese (and hundreds in English)
    - over 10M views since January 2016
- 2,334 media files (pictures, GIFs, videos, audio files)
    - near 11M views in September'17 alone
- Systematic effort to disseminate our approach
    - other RIDCs
    - USP museums and departments
    - general outreach (UNICAMP, UFABC, Prefeitura de São Paulo, CGI.br, ABCiber, Campus Party, INTERCOM, ...)

Other activities

- Communication
  - website
  - Facebook
  - Blog
- Training/Education
  - LASCON
  - Extension to secondary teachers

Near future

Goal: to consolidate our impact on neuromathematical culture we need

- ▶ reach the school system
- ▶ influence public policies

New generation

Mentorship

- Antonio Galves - USP

- Errico Presutti - GSSI - Italy

- Eva Löcherbach - UCP - France

- Pablo Ferrari - USP

- Ricardo Fraiman - UdeLAr - Uruguay

- Claudia Vargas - UFRJ

Mentorship

- Antonio Galves - USP - Mathematician

- Errico Presutti - GSSI - Italy - Physicist

- Eva Löcherbach - UCP - France - Mathematician

- Pablo Ferrari - USP - Mathematician

- Ricardo Fraiman - UdeLAr - Uruguay - Statistician

- Claudia Vargas - UFRJ - Neurobiologist

Mentorship

- Antonio Galves - USP - Mathematician

- Errico Presutti - GSSI - Italy - Physicist

- Eva Löcherbach - UCP - France - Mathematician

- Pablo Ferrari - USP - Mathematician

- Ricardo Fraiman - UdeLAr - Uruguay - Statistician

- Claudia Vargas - UFRJ - Neurobiologist

In different frameworks

- Probability theory

- Applied statistics

- Experimental protocols

- Data analysis

Young researchers

- ▶ 10 Technical training (7 in progress)
- ▶ 6 Scientific journalism (4 in progress)
- ▶ 7 MSc (3 in progress)
- ▶ 18 PhD (12 in progress)
- ▶ 11 Post-doc (7 in progress)

Young researchers

- ▶ 10 Technical training (7 in progress)
- ▶ 6 Scientific journalism (4 in progress)
- ▶ 7 MSc (3 in progress)
- ▶ 18 PhD (12 in progress)
- ▶ 11 Post-doc (7 in progress)

Working on

- ▶ Probability theory
- ▶ Statistics
- ▶ Simulations
- ▶ Software development
- ▶ Neurobiology
- ▶ Dissemination

"Por mares nunca de antes navegados,
Passaram inda além da Taprobana"