CEPID Neuromat
First Report of Activities

August 2013 - September 2014

Contents

1 Introduction

This document presents a report of the activities developed by the Research, Innovation and Dissemination Center for Neuromathematics (CEPID Neuromat) during its first year. This report has three parts:

- Scientific report
- Dissemination report
- Technology transfer report

The report shows an impressive amount of activities in the three levels aforementioned. These activities are strictly related to the goals announced in the document submitted to FAPESP in November 2012, in the third and final step of the selection process. This document which title is "Goals for the first two years" appears in the Appendix.

In the above mentioned document, the scientific goals for the first two years are described in the subsection *A new mathematical framework for neuroscience*. They are the following:

- Development of a new class of stochastic processes
- Development of the statistical tools required by this new class of stochastic processes

The following articles are steps towards the achievement of these goals.

1. **Infinite Systems of Interacting Chains with Memory of Variable Length—A Stochastic Model for Biological Neural Nets.** *Galves, A. and Löcherbach, E.* Journal of Statistical Physics June 2013, Volume 151, Issue 5, pp 896-921
2. **Hydrodynamic limit for interacting neurons.** *De Masi, A. ; Galves, A. ; Löcherbach, E. and Presutti, E.* Mar 10, 2014 arxiv:1401.4264v1
3. **Identifying interacting pairs of sites in Ising models on a countable set.** *Galves, A.; Orlandi, E. and Takahashi D.Y..*
4. **Predicting upcoming actions by observation: some facts, models and challenges.** *Vargas, C. D.; Rangel, M. L.; Galves, A..*
5. **Spike process.** *Pablo Ferrari, Ilie Grigorescu.*
6. **Brain death in a simple model for neuronal systems.** *Duarte, A.; Ost, G..*
7. **Classifying EEG data driven by stochastic rhythmic stimuli.** *Ost,G.; Duarte, A.; Vargas C.D.; Fraiman, R.; Galves A..*

The second article is the first co-authorship of the eminent probabilists Anna De Masi and Errico Presutti who joined the team of the CEPID NeuroMat.

The other articles produced within NeuroMat, mentioned in the Scientific report, constitute the theoretical framework, both mathematical and neurobiological, which provides the necessary foundation for our research.

The section *Education and Knowledge Dissemination* in the Appendix "Goals for the first two years" announces the following goals:

- Interactive contents for the web portal of the Center;
- Communication channels with researchers, students, teachers and other interested parties
- Videos on neuromathematical issues;
- Exhibitions and shows on Neurosciences;
- Organization of courses for teachers of mathematics and science to allow for future inclusion of neuromathematical topics in school curricula.

In the first year we concentrated our dissemination activities in the first three items of the above list. They are described in the details in Section 3. The workshop *New Forms of Scientific Journalism and the CEPID NeuroMat Work* is the first activity organized by Dulcilia Buitoni within NeuroMat. Dulcilia Buitoni, who is a professor at the Faculdade de Jornalismo Casper Libero, has just joined the dissemination team of NeuroMat. She will lead a discussion on the scientific journalism activities that the Center intends to develop.

The section *Technology transfer* in the Appendix "Goals for the first two years" announces the following goals:

- Data normalization within the project, with adoption of international open standards wherever applicable;
- Surveying existing products that may provide hooks and interfaces to the project yield;
- implementing algorithms and incorporating the ensued software into the research cycle;
- disseminating this production as free and open software, scientific and technical papers and workshops for medical and therapy personnel.

The progress achieved with respect to these goals are described in Section 4. We are developing data management computational tools for basic and clinical data. The data generated by the Center are being stored in a database that will be made publicly available for the scientific community. It is important to stress that all the legal requirements of privacy for sensitive data are being taken into account.

In the fourth point, the tutorials or workshops for medical and therapy personnel offered by the Center are described in Subsection 3.3 in the Dissemination report.

An important outcome of the activities developed by Cepid NeuroMat is the proposal of a National Institute of NeuroMathematics, coordinated by Antonio Galves, which is already the coordinator of Cepid Neuromat, and the eminent neurophysiologist Ricardo Gattass. With the agreement of Fapesp, this proposal was recently submitted to CNPq in the framework of the INCT program 2014. This project expands and reinforce the already blossoming activities of CEPID NeuroMat both at national and international levels. The proposal of the National Institute of Neuromathematics can de downloaded at http://neuromat.numec.prp.usp.br/relatorio/INNeuroMat.

In addition, all the documents cited in this report can be accessed at:
http://neuromat.numec.prp.usp.br/relatorio/

2 Scientific report

The scientific activities developed by the Research, Innovation and Dissemination Center for Neuromathematics are presented in this Section. The team of the Center is contributing with high quality original work in the new area of neuromathematics. This fact is reflected in its production, which sums up to

- 17 published or accepted papers,
- 14 submitted papers,
- 7 papers under preparation,
- 3 communications in scientific meetings, 2 of them with referee.

Many young researchers and students have joined the Neuromat team and are being formed in the core of the project. The Center is succeeding in its goal of training researchers in the specialized area of neuromathematics as can be confirmed by the following numbers.

- 2 postdoctoral fellows,
- 2 concluded PhD Thesis,
- 3 concluded Master dissertations,
- 12 PhD thesis in progress,
- 5 Master dissertations in progress.

Scientific missions, organization of meetings, training programs, scientific and dissemination seminars are key activities for the growth of scientific areas, allowing the interaction among members of the team and communication with society. In its first year of activities the Center organized the following activities.

- 102 scientific missions,
- 2 scientific meetings,
- 3 training programms,
- 18 seminars on Stochastic Processes and their Applications.

The detailed list of research activities developed within NeuroMat in the first year are described below.

2.1 Research results

2.1.1 Publications

Published or Accepted

1. **Tight Hamilton cycles in random hypergraphs, Random Structures Algorithms.** *Allen, P.; Böttcher, J.; Kohayakawa, Y. and Person Y..* DOI: 10.1002/rsa.20519
2. **On the number of orientations of graphs with no directed cycles of a given length.** *Allen, P.; Kohayakawa, Y.; Mota,G. O.; and Parente, R. F..* Electron. J. Combin. 21 (2014), no. 1, Research Paper 1.52, 13pp (electronic).
3. **Powers of Hamilton cycles in pseudorandom graphs.** *Allen, P.; Böttcher, J.; Hàn; H., Kohayakawa, Y.; and Person, Y..* LATIN 2014: Theoretical informatics (Montevideo, 2014) (A. Pardo and A. Viola, eds.). Lecture Notes in Computer Science, vol. 8392, Springer-Verlag, 2014, pp. 355-366.
4. **An investigation of Hebbian phase sequences as assembly graphs.** *Almeida-Filho DG, Lopes-dos-Santos V, Vasconcelos NA, Miranda JG, Tort AB, Ribeiro S..* Front Neural Circuits. 2014 Apr 8;8:34. doi: 10.3389/fncir.2014.00034. eCollection 2014.

5. **Increase in hippocampal theta oscillations during spatial decision making.** *Belchior H, Lopes-Dos-Santos V, Tort AB, Ribeiro S.*. Hippocampus. 2014 Jun;24(6):693-702. doi: 10.1002/hipo.22260. Epub 2014 Feb 24.

6. **Graph analysis of verbal fluency test discriminate between patients with Alzheimer's disease, mild cognitive impairment and normal elderly controls.** *Bertola L, Mota NB, Copelli M, Rivero T, Diniz BS, Romano-Silva MA, Ribeiro S, Malloy-Diniz LF.*. Front Aging Neurosci. 2014 Jul 29;6:185. doi: 10.3389/fnagi.2014.00185. eCollection 2014.

7. **Loss of memory of hidden Markov models and Lyapunov exponents.** *Collet, P.; Leonardi, F.*. The Annals of Applied Probability 24 (2014), no. 1, 422–446. doi:10.1214/13-AAP929. **An improved upper bound on the density of universal random graphs, Random Structures Algorithms**. *Dellamonica Jr., D.; Kohayakawa, Y.; Rödl, V.; and Rucinski, A.*. DOI: 10.1002/rsa.20545

8. **Aggregated functional data model for Near-Infrared Spectroscopy calibration and prediction.** *Dias, R.; Garcia, N.L.; Ludwig, G.; Saraiva, M.A.*. Journal of Applied Statistics, 2014.

9. **Biological Motion Coding in the Brain: Analysis of Visually Driven EEG Functional Networks** *Fraiman D, Saunier G, Martins EF, Vargas CD* (2014) PLoS ONE 9(1): e84612. doi: 10.1371/journal.pone.0084612

10. **Rumor Processes on** *mathbbN* **N and Discrete Renewal Processes.** *Gallo, S.; Garcia, N.L.; Junior, V.V.; Rodriguez, P.M.*. Journal of Statistical Physics, 2014.

11. **Infinite Systems of Interacting Chains with Memory of Variable Length—A Stochastic Model for Biological Neural Nets.** *Galves, A. and Löcherbach, E.* Journal of Statistical Physics June 2013, Volume 151, Issue 5, pp 896-921

12. **Independence tests for continuous random variables based on the longest increasing subsequence.** *García, J. E. , González-López, V.A.* Journal of Multivariate Analysis, Volume 127, May 2014, Pages 126-146, ISSN 0047-259X, http://dx.doi.org/10.1016/j.jmva.2014.02.010.

13. **Modeling of Acoustic Signal Energies with a Generalized Frank Copula. A Linguistic Conjecture is Reviewed.** *García, J. E. , González-López, V.A.* Communications in Statistics - Theory and Methods Vol. 43, Iss. 10-12, 2014

14. **On an anti-Ramsey threshold for random graphs.** *Kohayakawa, Y.; Konstadinidis; P. B. and Mota G. O.*.European J. Combin. 40 (2014), 26-41.

15. **Graph analysis of dream reports is especially informative about psychosis** *Mota, N. B., Furtado, R., Maia, P. C. P., Copelli, M. and Ribeiro, S.* Scientific Reports 4, Article number: 3691 15 January 2014. doi:10.1038/srep03691

16. **The onset of data-driven mental archeology.** *Ribeiro S.*. Front Neurosci. 2014 Aug 13;8:249. doi: 10.3389/fnins.2014.00249. eCollection 2014.

17. **Undersampled Critical Branching Processes on Small-World and Random Networks Fail to Reproduce the Statistics of Spike Avalanches.** *Ribeiro, T. L. ; Ribeiro, S. ; Belchior, H. ; Caixeta, F. and Copelli, M.* Apr 24, 2014 PloS ONE 9(4): e94992 DOI: 10.1371/journal.pone.0094992

Submitted

1. **Powers of Hamilton cycles in pseudorandom graphs.** *Allen, P.; Böttcher, J.; Kohayakawa, Y. and Person Y.*.

2. **Potential well spectrum and hitting time in renewal processes.** *Abadi, M.; Cardeño, L.; Gallo, S.*. Journal of Statistical Physics.

3. **Synaptic homeostasis and restructuring across the sleep-wake cycle.** *Blanco, W.; Pereira, C.M.; Cota, V.M.; Souza, A.C.; Rennó-Costa, C.; Santos, S.; Dias, G., Guerreiro A.M.G.; Tort, A.B.L.; Neto, A.D.; Ribeiro, S.*.

4. **Guidelines for Developing Electronic Questionnaires to Collect Experimental Data.** *Braghetto, K.R.; Nascimento, A.S.*.

5. **On the number of Bh-sets**. *Dellamonica Jr., D.; Kohayakawa, Y.; Lee, S. J.; Rödl, V.; and Samotij, W.*.

6. **The number of B3-sets of a given cardinality.** *Dellamonica Jr., D.; Kohayakawa, Y.; Lee, S. J.; Rödl, V.; and Samotij, W.*.

7. **Hydrodynamic limit for interacting neurons.** *De Masi, A. ; Galves, A. ; Löcherbach, E. and Presutti, E.* Mar 10, 2014 arxiv:1401.4264v1

8. **Statistics of Dynamic Random Networks: A Depth Function Approach.** *Fraiman, D.; Fraiman, N.; Fraiman, R.*.

9. **Identifying interacting pairs of sites in Ising models on a countable set.** *Galves, A.; Orlandi, E. and Takahashi D.Y.*.

10. **Combining multivariate Markov chains.** *Garcia,J.*.

11. **Stochastically Perturbed Chains of Variable Memory.** *Garcia, N. L. and Moreira, L.*. Jul 17, 2014 arxiv:1305.5747v1

12. **Predicting upcoming actions by observation: some facts, models and challenges.** *Vargas, C. D.; Rangel, M. L.; Galves, A.*.

13. **Finite cycle Gibbs measures on permutations of Z^d.** *Armendáriz,I.;Ferrari,P.; Groisman, P. and Leonardi, F.*. arXiv:1407.6542 [math.PR]

14. **Nonparametric statistical inference for the context tree of a stationary ergodic process.** *Gallo, S. and Leonardi, F.*.

Drafts

1. **A non-parametric test of hypotheses for random graph distributions with application to EEG data.** *Cerqueira, A.; Fraiman, D.; Leonardi, F. and Vargas, C.*

2. **Product Context Trees and Statistical Selection of Interacting Graphs.** *Ost, G.; Galves A.; Duarte A.*

3. **Classifying EEG data driven by stochastic rhythmic stimuli.** *Ost,G.; Duarte, A.; Vargas C.D.; Fraiman, R.; Galves A.*.

4. **Transições ictais nas epilepsias límbicas: uma análise de grafos.** *Claudio M Queiroz, Kelly S Farias, Roberto Imbuzeiro.* Laboratório de Redes Neurais e Epilepsia - Instituto do Cérebro (UFRN); IMPA, Rio de Janeiro.

5. **Spike process.** *Pablo Ferrari, Ilie Grigorescu.*

6. **Brain death in a simple model for neuronal systems.** *Duarte, A.; Ost, G.*.

7. **Fast implementation of the Smallest Maximizer Criterion for unbounded context tree model selection.** *Montoro, A.M.G.; Mandel, A.; Galves, A.*.

Communications in Neuroscience meetings with referee

1. **Construindo um Banco de Dados Digital no Instituto de Neurologia Deolindo Couto da UFRJ.** *Ramalho, B.; Rangel M.L.; Silva, L.S.; Peixoto, T.; Maia, J.; Frare, S.L.; Lazary, E.; Martins,J.V.; Tavares, P.L.; Erthal, F.S.; Vargas, C.D.; Braghetto, K.R.; Nascimento, A.; Correa, J.F.G.*. SBNEC 2014.

2. **Controle postural em pacientes com lesão traumática do plexo braquial.** *Silva,L.S.; Carvalho, T.L.; Silva, D.C.L.; Oliveira, L.A.S.; Tavares, P.L.M.S.; Correa, J.F.G.; Rodrigues, E.C.; Vargas, C.D.*. SBNEC 2014.

Other communications

1. **Effect of synaptic plasticity on functional connectivity and global activity of a cortical network model.** *Shimoura, R.O., Pena, R.F.O., Roque, A.C.*. I International Workshop on Synaptic Plasticity (IWSYP'14), September 8-9 2014, Ribeirão Preto-SP, Brazil. Online abstract: http://iwsyp14.thiagomatospinto.com/renan-shimoura.html

2.1.2 Post-doctoral fellows

In progress

1. **Modeling Complex Datasets: association between high-dimensional imaging data, clinical variables and genetic information.** *Michelle F. Miranda.* Universidade de São Paulo (NeuroMat).

2. **Representing Brain Activity through Statistical Model Selection in the Class of Systems of Interacting Variable Memory Chains.** *Aldana M. González Montoro.* Universidade de São Paulo (NeuroMat).

2.1.3 PhD theses

Concluded

1. **Modelagem estocástica de uma população de neurônios.** *Karina Yuriko Yaginuma.* Orientador: Antonio Galves

2. **Processos de renovação obtidos por agragação de estados a partir de um processo Markoviano.** *Walter Augusto Fonseca de Carvalho.* 2014. Tese (Doutorado em Estatística) - Universidade Estadual de Campinas. Orientador: Nancy Lopes Garcia.

In progress

1. **Mecanismos de propagação de atividade epileptiforme em um modelo cortical de grande porte.** *Rodrigo Felipe de Oliveira Pena.* Orientador: Antônio Carlos Roque da Silva Filho

2. **Plasticidade cerebral após lesao do plexo braquial: efeitos sobre a ressonância motora.** *Maria Luiza Salles Rangel.* Instituto de Biofísica Carlos Chagas Filho. Orientadora: Claudia Domingues Vargas.

3. **Conectividade funcional após lesão do plexo braquial.** *Lidiane Souza.* Instituto de Biofísica Carlos Chagas Filho. Orientadora: Claudia Domingues Vargas.

4. **Simulação perfeita para redes probabilísticas.** *Andressa Cerqueira.* Orientadora: Florencia Leonardi.

5. **Inferência estatística para modelos gráficos.** *Iara Moreira Frondana.* Orientadora: Florencia Leonardi.

6. **Modelos produtos de alcance variável e seleção estatística de grafos de Interações.** *Guilherme Ost de Aguiar.* Orientador: Antonio Galves.

7. **Processos de Saltos com Memória de Alcance Variável e Sistemas Pontuais Interagentes.** *Aline Duarte de Oliveira.* Orientador: Antonio Galves.

8. **Modelo de Evolução de Grafos.** *Bruno Monte de Castro.* Orientador: Antonio Galves.

9. **Sistemas com memória de alcance variável e aplicações à modelagem estocástica de redes neurais.** *Douglas Rodrigues Pinto.* Orientador: Antonio Galves.

10. **Detecção de assembleias neuronais em registros eletrofisiológicos do rato.** *Vitor Lopes dos Santos.* Orientador: Sidarta Riberito. Universidade Federal do Rio Grande do Norte.

11. **Modelos autoregressivos com memória variável.** *David Henriques da Matta.* Início: 2013. Doutorado em Estatistica - Universidade Estadual de Campinas. Orientador: Nancy Garcia.

12. **Calibração e predição simultâneas para dados de espectroscopia do infra-vermelho próximo.** *Alex Rodrigo dos Santos Souza.* Início: 2013. Doutorado em Estatistica - Universidade Estadual de Campinas. Orientador: Nancy Garcia.

13. **Envolvimento do córtex orbitofrontal no processo de tomada de decisão, em ratos.** *Cyrus Antonio Villas-Boas.* Orientador: Gilberto Fernando Xavier.

14. **Atenção sustentada envolvendo a modalidade auditiva, em ratos.** *Leopoldo Francisco Barletta Marchelli.* Orientador: Gilberto Fernando Xavier.

2.1.4 MSc dissertations

Concluded

1. **Teste de hipóteses para grafos aleatórios com aplicação à neurociência.** *Andressa Cerqueira.* Orientadora: Florencia Leonardi.

2. **Controle postural em pacientes com lesão do plexo braquial.** *Lidiane Souza da Silva.* Orientadora: Cláudia Domingues Vargas. Co-Orientadora: Erika de Carvalho Rodrigues.

3. **Uma investigação das sequências de fase hebbianas descritas como grafos de assembleias neuronais.** *Daniel Gomes de Almeida Filho.* Orientador: Sidarta Ribeiro.

In progress

1. **Plasticidade em modelo de circuitaria local do córtex: caracterização da reorganização funcional da rede após lesões focais.** *Renan Oliveira Shimoura.* Orientador: Antônio Carlos Roque da Silva Filho

2. **Alterações sensoriais após avulsão do plexo braquial**. *Bia Ramalho.* Instituto de Biofísica Carlos Chagas Filho. Orientadora: Claudia Domingues Vargas

3. **Famílias de esquemas de bancos de dados para experimentos de neurociência.** *Larissa Cristina Moraes.* IME-USP. Orientadora: Kelly Braghetto.

4. **Modelo de proveniência de dados para processos de análise em neurociência.** *André de Camargo Fernandes.* IME-USP. Orientadora: Kelly Braghetto.

5. **Estimulação optogenética in vivo do septo medial no rato anestesiado e em livre comportamento.** *Annie da Costa Souza.* Orientador: Sidarta Ribeiro.

6. **Orientação encoberta da atenção em ratos.** *Mateus Torres Cruz.* Orientador: Gilberto Fernando Xavier.

2.1.5 Work in progress

Experimental data collection Throughout the last year, EEG data was collected at *Instituto de Neurologia Deolindo Couto - UFRJ* from more than 40 volunteers by means of a 128 channels system (Geodesic HidroCel GSN 128 EGI, ElectricalGeodesic Inc.). The signal was amplified through an optic isolated system of high impedance (200 MΩ) with a converter A/D of 24 bits, and nominal gain of 20x. The acquisition was performed in a sampling frequency of 500Hz, and the signal was analogically filtered (Butterworth first order low-pass filter of 0.1-200Hz; Geodesic EEG System 300, ElectricalGeodesic Inc.). The system impedance was maintained below 50 kΩ during all the recordings. The electrode positioned on the vertex (Cz) was used as reference during the acquisition.

Experimental data analysis

- Michelle Miranda is currently developing a Bayesian Spatial EEG Modeling Framework to establish associations between a matrix/array covariate, which is formed by the EEG source signals, and clinical outcomes. The proposed model is a generalization of the voxel-wise models that are widely used for fMRI data. The key idea comes from two main components. First, we model each electrode signal at a given time, as a function of signals within a fixed time window, and additional clinical variables. Second, we combine all electrodes by considering spatial priors in a Bayesian paradigm. The proposed methodology will be applied to a dataset generated by experiments that are under way at *Instituto de Neurologia Deolindo Couto - UFRJ.*

- Dário Oliveira is currently working on classifiers for identifying Evoked Potentials in EEG exams using a set of different descriptors. The analysed experimental data was collected at the *Instituto de Neurologia Deolindo Couto - UFRJ*, where patients were exposed to rhythmically structured audio stimuli during an EEG recording session. The descriptors used range from morphological ones to spectral ones, and different classifiers were tested such as Support Vector Machines and Random Forests.

- Aldana Gonzáalez Montoro is currently working in collaboration with Michelle Miranda and Sergio Neuenschwander on context tree models for spike train data. The aim of this project is to use stochastic chains with memory of variable length to model spike trains obtained by means of multichannel recordings from the visual cortex of behaving and anesthetized monkeys and cats (experiments performed in Vislab, Instituto do Cérebro - UFRN, Natal). We intend to test whether these models reflect the various stimulus properties under different experimental settings. Models for different experimental conditions will be estimated using context tree model selection techniques which are also being developed by the Neuromat team. This study may provide important insights about mechanisms related to feature encoding and binding.

2.2 Project activities

2.2.1 Meetings

NeuroMat's Workshop Researchers from eight countries attended the First Workshop of FAPESP's Center for Neuromathematics, from January 20 to 25, 2014, in São Paulo, Brazil. This event brought together mathematicians, neurobiologists, physicians and investigators from other fields to discuss ongoing research at the frontier of mathematics and neuroscience. Scientists from different backgrounds and institutions, in Brazil and abroad, were able to know from each other what their research plans and results were and how they could work together.

During the workshop, there were thirteen sessions and guest talks by Prof. Martijn van den Heuvel (Utrecht University), Prof. Leonardo G. Cohen (National Institute of Neurological Disorders and Stroke), Prof. Guillermo Cecchi (IBM) and Prof. Angel Caputi (Instituto de Investigaciones Biológicas Clemente Estable). The full program and slide presentations may be found at: neuromat.numec.prp.usp.br/first-workshop-neuromathematics. A revised version of Prof. Cohen's concluding remarks at the workshop may be found at: neuromat.numec.prp.usp.br/leonardo-cohen-concluding-remarks-neuromats-first-workshop, and are quoted below.

> "The first point I would like to make is that in my view the meeting was highly successful. Now, everybody knows what everybody else in the program is doing or thinking, regardless of the opportunity to interact with each other you had before.
>
> The second point. In my view the meeting has been highly educational. All presentationseducated the audience on what investigators in their different disciplines are doing, on how they are doing it, how they are thinking, their language and their priorities. An important aspect of this educational process is the sense that, in order to advance from a scientific point of view and to generate the best science, it is crucial to develop productive interdisciplinary interactions. Science cannot advance in the absence of productive interdisciplinary interactions, like those discussed along the meeting. The comfort area for each of us is to do what we know, do it the best way we can, go straight where we want to go in terms of results, publications and so on, and try to use as few resources as we can manage because such approach allows faster processing. The heart of the issue is that nowadays, following this limited approach and in the absence of an interdisciplinary effort, it would be very hard to do the best science.
>
> The third point. Another educational aspect is the need to pay attention, understand and empathize with psychology of investigators in each discipline. How does a scientist that is taking measures of cell activity in three monkeys for years feel about sharing data? Knowing that if suddenly one of the monkey dies, he cannot publish a paper after years of effort. This is a psychological frame of mind, and in this kind of project in which you are involved in you should be aware of this. How does a statistician or mathematician feel knowing the wonders he can advance research and science if he had access to the proper data? Knowing that such data may be already available but neglected or just lying in a CD without being used? I believe this is something to which the coordinating committee of Neuromat should be very attentive and empathetic with. The committee could thus generate the best safeguards to allow the most freely interactive and productive coordination across researchers and specialties.
>
> The fourth point. The interaction between biological data and complex analysis or modeling. I believe the interaction between both is required for scientific advance. Biologists collect data that, when analyzed by mathematicians/statisticians contribute to create models of biological processes. Such

models require further biological testing which eventually lead to more sophisticated and realistic models. Alternatively, models should be tested in real biological settings and data generated in such way permits modifications that enrich new models. These cycle: data - model - data. This cycle assumes prospective planning when we go from model to data, and it assumes retrospective work when we look at the data that leads to the model. Productive generation of these cycles is, from my point of view, what will allow this group to generate the very best science. Most importantly, there has been a lot of discussion on how the collection of data may generate interesting models, but at the same time there was little discussion on how we go back to the biologists, for example, to help them produce new and more exciting data based on testing more sophisticated models. This will engage biologists to be more successful in their own science.

The fifth point in my mind is the connection between different level of activities. The first level is what I call (probably incorrectly) basic research on cell components, proteins, genes, etc. The second level gathers people who are working at a system-level, which can be clinical or not clinical (multicell recordings, imaging in humans or primates, behavioral studies in either animal or human models). The third level gathers mathematicians, statisticians and "modellers" if you allow me this terminology. I felt that most of the emphasis in the discussions has been placed on trying to connect the first and third level, and the second and third level. For instance, an issue we discussed was how to bring data back and forth from the math level to the systems level, and so on. Perhaps the links between the more basic science level and the systems science levels could develop as well in the future.

The sixth point relates to the presentation of several ideas on collaboration that emergedduring discussions. This has been thought-provoking and has triggered in all possible ways my imagination, but the real challenge is: how to anchor this? How to translate the idea of "Oh, let's collaborate" to the creation of new and significant biological hypotheses of multidisciplinary interest? In the absence of these biological hypotheses, that you may all consider meaningful from the scientific standpoint, it is going to be difficult to obtain the most exciting science. I had wonderful discussions, full of ideas, so: which idea are you going to pursue? What hypotheses will you test? When are you going to start? Who is going to do what, where and when?

My final consideration is about the issue of data sharing, partially addressed in my third point. I feel that this should be considered carefully by the leadership. I do not think the project as a whole depends on this. Data sharing is going to come naturally, when collaborations starts to flow. People will understand that the best science is dependent on collaborating with the data and that the data will come back with new directions to whom has collected it, and this will move forward the best science.

All in all, thank you for allowing me to share your wonderful discussions, plans and concerns."

Workshop Mathematics and Neuroscience: a Dialogue" The workshop was funded by STAR cluster, Utrecht University, Eindhoven University and took place in Uthrect (the Netherlands) from the 3rd of September to the 5th of September at Utrecht University.

The recent extraordinary progress in data collection and empirical evidence on neural phenomena calls for a deeper theoretical understanding of the processes involved. Mathematics offers both a language and a general frame to achieve this understanding.

Conceptual understanding —and predictive power— can only come from a close collaborations between researchers in mathematical models and structures and experts in applied areas of neuroscience.

This workshop intends to bring together researchers of different areas to exchange ideas, learn from each other, and identify priority directions where joint research is both needed and feasible. It proposes an informal and unassuming environment with expositions geared towards an interdisciplinary audience, focused on central issues and notions and leaving technical details for private discussions.

The workshop was free and open to all. The participant teams were:

- Brazil:
  - Federal University of Rio de Janeiro, Institute of Biophysics (Claudia Vargas)
  - University of Sao Paulo, Institute of Mathematics and Statistics/Numec (Antonio Galves)
- Denmark:
  - University of Copenhagen, Mathematics Institute (Susanne Ditlevsen)

  - University of Copenhagen, Department of Neuroscience and Pharmacology (Rune W. Berg, Henrik Linden)

- France:
  - University of Cergy Pontoise, Mathematics Department (Eva Loecherbach, Pierre Hodara)
  - University Paris-Descartes (Paris 5), Applied Maths Laboratory (Christophe Pouzat)
  - University Pierre et Marie Curie (Paris 6), Group of Probability, Statistics and Biology (Michèle Thieullen)
  - University of Sophia Antipolis, INRIA Neuromathcomp team (Bruno Cessac, Rodrigo Cofré)

- Netherlands:
  - Eindhoven Univesity, Mathematics Department (Remco van Hofstad)
  - Leiden University, Mathematics Department: Evgeny Verbitskiy
  - Leiden University Medical Center, Brain Function and Dysfunction (Serge Rombouts)
  - Leiden University Medical Center, Division of Neurosurgery (Martijn Malessy)
  - Leiden Universtity Medical Center, Neurophysiology (Gert van Dijk)
  - Utrecht Medical Center, Brain changes in developmental disorders (Martijn van den Heuvel, Guusje Collin, Siemon de Lange, Marcel de Reus, Ruben Schmidt)
  - Utrecht Medical Center, Dept. of Neurology and Neurosurgery (Nicolas Ramsey)
  - Utrecht University, Mathematics Department (Roberto Fernandez, organizer)

2.2.2 Training Programs

Since June 2013, there were three training programs on open databases provided by NeuroMat's researcher Kelly Rosa Braghetto. These programs reached an estimated audience of 100 people. The dates and details of the courses are presented below:

06/05/2013 – "Data Provenance, Neuroscience Data, Scientific Workflow Management (and Questionnaires)": the program aimed to introduce techniques and tools for the management of scientific data, in special Neuroscience data. Duration: 2h.

06/13/2013 – "An Introduction to LimeSurvey": at NeuroMat there are questionnaires specifically designed for different studies. As a way of dealing and preserving the data of these forms, the team suggested the use of LimeSurvey. So the goal of the course was to present the software in a practical way. Duration: 3h.

07/16/2013 – "Data Provenance, Neuroscience Data, Scientific Workflow Management (and Questionnaires) and an Introduction to LimeSurvey": the two courses above were presented to the team of researchers of INDC/UFRJ. Duration: 5h.

Other informal meetings between Braghetto and the team occurred for knowledge transfer. Besides, NeuroMat organized 18 seminars on Stochastic Processes and their Applications, which were attended by a high qualified audience. The themes, speakers and dates are presented in the table that follows.

Theme	Speaker	Date
Universality and Scaling in brain dynamics in vivo	Mauro Copelli - UFPE	9/4/2014
Spectral dimension of trees with a unique infinite spine	Stefan Zohren - PUC-RJ	6/26/2014
Nonparametric inference for neural synchrony under spontaneous activity	Aldana González - IME/USP	5/22/2014
Statistical methods for graphs with applications in biological data	André Fujita - IME/USP	5/15/2014
Proofs of two new correlation inequalities	Vladimir Blinovsky - IME/USP	4/3/2014
Context tree model selection using the Smallest Maximizer Criterion	Arnaldo Mandel - IME/USP	11/14/2013
Mimicking martingales with given marginals	Fima Klebaner - Centre for Modelling of Stochastic Systems / Monash University	11/7/2013

Parsimony-inducing prior in high-dimensional Cholesky stochastic volatility modeling	Hedibert Freitas Lopes - University of Chicago	10/31/2013
A martingale approach to waiting time problems in Markov chains	Renato Gava - UFSCar	10/24/2013
The WR model and allelopathy	Yuri Suhov - IME/USP and University of Cambridge, UK	10/17/2013
The Contact Process on Power Law Random Graphs	Daniel Valesin - University of British Columbia	10/10/2014
Lower and upper bounds to critical curve for Ising model coupled to causal dynamical triangulations	José Javier Cerda Hernández - IME/USP	10/3/2013
On the Location of the Maximum of a Continuous Stochastic Process	Leandro Pimentel – UFRJ	9/19/2013
Modeling of socio-economic phenomena with interacting particle systems and their extensions	Vladimir Belitsky - IME/USP	9/12/2013
From single neurons to global activity	Daniel Fraiman, Universidad de San Andrés, Argentina	8/29/2013
A branching process for virus survival	Rinaldo Schinazi - Department of Mathematics -University of ColoradoColorado Springs	8/19/2013
The first exit problem for gradient and non-gradient systemsperturbed by Gaussian and stable Lévy diffusions	Michael Högele - Institut für Mathematik, Universität Potsdam, Germany	8/18/2013
Zero Range Process with Site wise Disorder	K. Ravishankar - SUNY-Newpaltz	8/15/2013

Additionally, from September 7th through September 10th of the present year, the 18th EEGLAB Workshop took place at the Neurology Institute Deolindo Couto of the Federal University of Rio de Janeiro, with the support of NeuroMat. The workshop introduced and demonstrated the use of EEGLAB and EEGLAB plug-in tools for performing analysis of EEG and related data, with detailed method expositions and practical exercises.

2.2.3 General Events

During its first year of existence, NeuroMat has taken part in a sequence of events, generally open to a general audience. To some respect, the First Workshop of FAPESP's Center for Neuromathematics, in January, 2014, could be considered a general event, since it was open to the public and was spread out in media channels. Small-scale events are part of the routine of NeuroMat researchers, including lectures on Neuromathematics and pertaining topics in universities and conferences, dissemination activities and talks in different venues. Illustrations of forthcoming activities open to a general audiences are a set of presentations in the context of USP's Virada Científica, called "Computational and Mathematical Challenges of Neuroscience", and two keynote lectures at an undergraduate program on Mathematics at UNESP-Rio Claro, in October.

NeuroMat promoted an important seminar on scientific dissemination in September, 2014. This event, open to the public, was called "New Forms of Scientific Journalism and the CEPID NeuroMat Work" and discussed renewed means of disseminating science and science-oriented journalism produced in Brazil, on the 25th of September. The seminar brought together renowned scientists, communications researchers, journalists, and enthusiasts of the subject. Key speakers were Antonio Galves (coordinator of the CEPID NeuroMat/USP), Carlos Vogt (president of UNIVESP and coordinator of Labjor/Unicamp), Denis R.Burgierman (managing editor of the science magazine Superinteressante), Dulcilia Buitoni (professor of Cásper Libero's PPGCOM and former faculty at ECA/USP), Ernst Hamburger (physicist and science disseminator) and Sergio Neuenschwander (neuroscientist and documentarian/UFRN). Main objectives of the event were:

1. To give visibility to research and technological transfer developed by NeuroMat;

2. To harness advances in Neuromatemathics to develop creative ways to foster scientific knowledge among specialized and general audiences;

3. To develop new languages and scientific-communication tools; and

4. To contribute to the multiplication of scientific disseminators.

More details on this event may be found at: http://neuromat.numec.prp.usp.br/content/new-forms-scientific-journalism-and-cepid-neuromat-work. This event was broadly disseminated on the internet, including at the FAPESP Agency and USP Agency agenda pages.

2.2.4 Scientific missions

To fulfil the international inter-institutional profile of CEPID Neuromat, a number of short-period scientific missions were undertaken within the project scope in this first year, as seen below.

1. Adriane Ribeiro Rosa – UFRGS – 04 a 08 de dezembro de 2013 - desenvolvimento de pesquisa.

2. Adriane Rosa - UFRGS – Participação no First NeuroMat Workshop - 20 a 23 de janeiro de 2014.

3. Aldana González – Universidad de Coruña, Espanha - desenvolvimento de pesquisa em São Paulo – 06 a 28 de março de 2014.

4. Aldana González - IME-USP - visita a UFRN para desenvolvimento de pesquisa – 14 a 22 de julho de 2014.

5. Aldana González – IME-USP – 10 a 17 de agosto de 2014 – Natal, RN – participação do Summer School on "Physics and Neuroscience", de 11 a 17 de agosto de 2014.

6. Aline Duarte de Oliveira-IME-USP – desenvolvimento de pesquisa - Roma, Itália, 1 a 22 de dezembro de 2013.

7. Aline Duarte de Oliveira – IME-USP – visita a UFRJ de 12 a 18 de maio de 2014 – desenvolvimento de pesquisa.

8. Amanda Silva - Bolsista TT5 – CEPID-NeuroMat - 16 a 20 de dezembro de 2013 - visita a UFRJ

9. Amanda Sávio Nascimento e Silva - UFOP – 10 a 17 de setembro de 2014 – participação na XXXVIII Reunião Anual da SBNeC – Sociedade Brasileira de Neurociências e Comportamento.

10. Amanda Sávio Nascimento e Silva – UFOP – 16 a 18 de maio de 2014 e de 29 de maio a 1 de junho de 2014 – Visita a São Paulo para desenvolvimento de pesquisa

11. Ana Carolina Simões - UFABC – 21 a 22 de outubro de 2013 – desenvolvimento de pesquisa – UFRJ

12. Ana Carolina Simões – UFABC – 22 de novembro de 2013 – desenvolvimento de pesquisa na Sede do CEPID-NeuroMat.

13. Ana Carolina Simões – UFABC – 20 a 22 de janeiro de 2014 – participação no First NeuroMat Workshop.

14. André Frazão Helene – IBUSP – desenvolvimento de pesquisa na UFRJ – 18 a 20 de dezembro de 2013.

15. André Peres - UFRN - participação no First NeuroMat Workshop - 19 a 22 de janeiro de 2014.

16. Angel Caputi - Instituto Clemente Estable, Montevideo, Uruguai – Participação no First NeuroMat Workshop - 20 a 25 de janeiro de 2014.

17. Antonio Carlos Roque Silva Filho - USP - Ribeirão Preto – Participação no First NeuroMat Workshop - 19 a 21 de janeiro de 2014.

18. Antonio Galves - IMEUSP– 01 a 02 de outubro de 2013 – Rio de Janeiro – Reunião IMPA.

19. Antonio Galves - IMEUSP – 9 a 10 de outubro de 2013 – Desenvolvimento de pesquisa

20. Antonio Galves - IMEUSP – 29 a 30 de outubro de 2013 – Reunião na Academia Brasileira de Ciências

21. Antonio Galves – IMEUSP – 13 a 17 de agosto de 2014. Natal – Desenvolvimento de pesquisa

22. Antonio Galves – IMEUSP – participação como conferencista em congresso na Argentina de 27 de julho a 2 de agosto de 2014.

23. Antonio Galves - IMEUSP - – Montevideo – 27 a 30 de novembro de 2013 –apresentação de resultado do CEPID NeuroMat.

24. Antonio Galves - IMEUSP - – USP – 1 a 21 de dezembro de 2013 - desenvolvimento de pesquisa – Paris, França e Roma – Itália.

25. Antonio Galves - IMEUSP –25 a 26 de novembro de 2013. Conferência "Avanços e Perspectivas da Ciência no Brasil, América Latina e Caribe", da Academia Brasileira de Ciências e apresentação de conferência "Problemas que a Neurociência sugere para a Matemática".

26. Antonio Galves - IMEUSP - Amsterdam, Holanda – 1 a 8 de setembro de 2013 – desenvolvimento de pesquisa.

27. Antonio Galves - IMEUSP - 11 a 17 de agosto de 2014 – desenvolvimento do pesquisa.

28. Antonio Pereira Junior – UFRN – 19 a 26 de janeiro de 2014 – participação no First NeuroMat Workshop.

29. Arnaldo Mandel - IMEUSP – 27 de novembro a 1 de dezembro de 2013 – participação em congresso, WORKSHOP ON STOCHASTIC MODELING OF BRAIN ACTIVITY, NOVEMBER 28 TO 30, 2013 - FACULTAD DE CIENCIAS, MONTEVIDEO, URUGUAY.

30. Bia Ramalho - UFRJ – participação no First NeuroMat Workshop - 20 a 25 de janeiro de 2014.

31. Bruno Monte de Castro - IMEUSP – 10 a 16 de agosto de 2014 – Natal, RN – participação do Summer School on "Physics and Neuroscience", de 11 a 17 de agosto de 2014.

32. Bruno Monte de Castro – IME-USP – participação em evento – 6 a 10 de setembro de 2014.

33. Cecilia Hedin Pereira - UFRJ – participação no First NeuroMat Workshop - 20 a 23 de janeiro de 2014.

34. Cecilia Hedin-Pereira– UFRJ – para desenvolvimento de pesquisa - 20 a 21 de agosto de 2014.

35. Claudia Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa - 14 a 15 de novembro de 2013

36. Claudia Domingues Vargas - UFRJ – 27 a 30 de novembro de 2013 - apresentação de resultado do CEPID NeuroMat.

37. Claudia Domingues Vargas – UFRJ – visita a USP – desenvolvimento de pesquisa -7 a 9 de maio de 2014.

38. Claudia Domingues Vargas - UFRJ – participação no First NeuroMat Workshop - 19 a 25 de janeiro de 2014.

39. Claudia Domingues Vargas – UFRJ – 25 a 26 de setembro de 2013 – visita a USP para desenvolvimento de pesquisa.

40. Claúdia Domingues Vargas – UFRJ – 28 a 30 de agosto de 2013 – visita a USP para desenvolvimento de pesquisa.

41. Claudia Domingues Vargas - UFRJ - visita a USP para desenvolvimento de pesquisa - 3 a 4 de fevereiro de 2014

42. Claudia Domingues Vargas - UFRJ - visita a USP para desenvolvimento de pesquisa -13 a 14 de fevereiro de 2014

43. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 18 a 20 de março de 2014.

44. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 9 a 11 de abril de 2014.

45. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 05 a 09 de maio de 2014.

46. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 20 a 22 de maio de 2014.

47. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 9 a 11 de junho de 2014.

48. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 23 a 25 de julho de 2014.

49. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa - 27 a 29 de agosto de 2014.

50. Claudia Domingues Vargas – UFRJ – visita a USP para desenvolvimento de pesquisa – 24 a 25 de setembro de 2014.

51. Claudio Queiroz - UFRN – participação no First NeuroMat Workshop - 19 a 26 de janeiro de 2014.

52. Daniel Fraiman Borrazas – Universidad de San Andrés, Argentina – 28 a 30 de agosto de 2013 – desnvolvimento de pesquisa.

53. Daniel Fraiman Borrazas - Universidad de San Andres, Argentina – participação no First NeuroMat Workshop - 19 a 26 de janeiro de 2014.

54. Daniel Takahashi - Princeton University –participação no First NeuroMat Workshop - 19 a 26 de janeiro de 2014.

55. Dario Augusto Borges Oliveira – UFRJ - desenvolvimento de pesquisa – 21 a 30 de abril de 2014

56. Dario Augusto Borges Oliveira - UFRJ – desenvolvimento de pesquisa – 18 a 30 de maio de 2014

57. Dario Augusto Borges Oliveira – UFRJ - desenvolvimento de pesquisa – 15 a 27 de junho de 2014

58. Dario Augusto Borges Oliveira – UFRJ - desenvolvimento de pesquisa – 15 a 30 de julho de 2014

59. Erika Lazary - UFRJ – participação no First NeuroMat Workshop - 20 a 25 de janeiro de 2014.

60. Eva Löcherbach (Mathematics Department, University of Cergy Pontoise, France) – desenvolvimento de pesquisa - 26 de agosto a 6 de setembro de 2014.

61. Eva Loëcherbach (Mathematics Department, University of Cergy Pontoise, France) – participação no First NeuroMat Workshop - 19 a 26 de janeiro de 2014.

62. Fátima Cristina Erthal - UFRJ –participação no First NeuroMat Workshop - 20 a 24 de janeiro de 2014.

63. Gilberto Xavier – IBUSP – Participação no evento sobre CEPID's – Ribeirão Preto, SP – 23 a 25 de abril de 2014.

64. Guilherme Ost de Aguiar – desenvolvimento de pesquisa - Roma, Itália, 1 a 22 de dezembro de 2013

65. Guilherme Ost de Aguiar – IME-USP – visita a UFRJ de 12 a 18 de maio de 2014 – desenvolvimento de pesquisa.

66. Guillermo Cecchi – IBM, USA –participação no First NeuroMat Workshop - 20 a 25 de janeiro de 2014.

67. Jerome Baron – UFMG – visita a USP para desenvolvimento de pesquisa – 31 de agosto a 6 de setembro de 2014.

68. Jesus Enrique Garcia – UNICAMP – participação no First NeuroMat Workshop – 19 a 25 de janeiro de 2014.

69. Jesus Enrique Garcia – UNICAMP – visita a USP para desenvolvimento de pesquisa – 12 de setembro de 2014.

70. Jorge Stolfi – IC – UNICAMP – participação no First NeuroMat Workshop – 23 a 25 de janeiro de 2014.

71. José Vicente Martins - UFRJ - participação no First NeuroMat Workshop - 23 a 25 de janeiro de 2014.

72. Kelly Rosa Braghetto –RJ - 21 a 22 de outubro de 2013 - desenvolvimento de pesquisa.

73. Kelly Braghetto - IME-USP - 16 a 20 de dezembro de 2013 - visita a UFRJ para desenvolvimento de pesquisa.

74. Kelly Braghetto -IMEUSP – 10 a 13 de setembro de 2014 – participação na XXXVIII Reunião Anual da SBNeC – Sociedade Brasileira de Neurociências e Comportamento.

75. Leandro Pimental – UFRJ – 19 de setembro de 2013 – apresentação de seminário.

76. Leonardo Cohen – National Institute of Health - NIH – participação no First NeuroMat Workshop - 19 a 25 de janeiro de 2014

77. Marcel de Reus, Utrecht University - participação no First NeuroMat Workshop - 19 a 26 de janeiro de 2014.

78. Martijn van den Heuvel - First NeuroMat Workshop - 19 a 23 de janeiro de 2014.

79. Mauro Copelli – UFPE – visita a SP para desenvolvimento de pesquisa - 3 a 6 de setembro de 2014.

80. Michelle Miranda – IME-USP – visita a UFRJ para desenvolvimento de pesquisa – 18 a 24 de julho de 2014.

81. Michelle Miranda – 10 a 16 de agosto de 2014 – Natal, RN – participação no Summer School on "Physics and Neuroscience", de 11 a 17 de agosto de 2014.

82. Michelle Miranda – participação em evento, RJ - de 06 a 14 de setembro de 2014.

83. Nancy Garcia Lopes – UNICAMP – participação em Congresso EBEB 2014 – 13 a 14 de março de 2014 – Atibaia, SP

84. Nancy Garcia Lopes – UNICAMP – Encontro dos CEPID's na FAPESP – 20 de março de 2014 – Atibaia, SP

85. Nancy Garcia Lopes – UNICAMP – 22 a 27 de junho de 2014 – Cabo Frio, RJ - participação em Congresso.

86. Ricardo Fraiman – Universidad de la Republica – Montevideo – 19 a 26 de janeiro de 2014 – participação no First NeuroMat Workshop.

87. Ricardo Fraiman – Universidad de La Republica, Uruguai - visita a USP para desenvolvimento de pesquisa de 18 a 21 de maio de 2014.

88. Roberto Fernandez - Utrecht University - 13 a 28 de janeiro de 2014 - visita a USP para desenvolvimento de pesquisa e participação no First NeuroMat Workshop.

89. Roberto Imbuzeiro de Oliveira - IMPA – participação no First NeuroMat Workshop - 20, 23 a 25 de janeiro de 2014.

90. Roberto Imbuzeiro de Oliveira – IMPA – 21 a 22 de agosto de 2014 – visita a USP desenvolvimento de pesquisa.

91. Samuel Frare - UFRJ – participação no First NeuroMat Workshop - 20 a 25 de janeiro de 2014.

92. Sergio Neuenschwander - UFRN – participação no First NeuroMat Workshop - 19 a 24 de janeiro de 2014.

93. Sergio Neuenschwander – ICe – UFRN – 6 a 9 de maio de 2014 – visita a USP para desenvolvimento de pesquisa.

94. Sergio Neuenschwander – ICe – UFRN – 24 a 29 de maio de 2014 – visita a USP para desenvolvimento de pesquisa.

95. Sergio Volchan - UFRJ – participação no First NeuroMat Workshop - 20 a 24 de janeiro de 2014.

96. Sidarta Ribeiro – ICe – UFRN — participação no First NeuroMat Workshop – 19 a 22 de janeiro de 2014.

97. Sidarta Ribeiro - UFRN - visita a SP para desenvolvimento de pesquisa – 01 a 9 de setembro de 2014.

98. Susanne Ditlevsen (Mathematics Institute, University of Copenhagen, Denmark) – participação no First NeuroMat Workshop – 19 a 25 de janeiro de 2014.

99. Verónica Andrea González-López – UNICAMP – participação no First NeuroMat Workshop – 19 a 25 de janeiro de 2014.

100. Vitor Santos - UFRN - participação no First NeuroMat Workshop - 19 a 22 de janeiro de 2014.

101. Wojtek Samotij - Tel Aviv University, Tel Aviv, Israel - desenvolvimento de pesquisa de 5 a 7 de dezembro de 2013.

102. Yury Person - Goethe-Universität - Institute of Mathematics – visita a USP para desenvolvimento de pesquisa – 23 a 29 de março de 2014.

3 Dissemination report

FAPESP's CEPID NeuroMat (the Research, Innovation and Dissemination Center for Neuromathematics) has become a general reference center for scientific dissemination in its first year of activity. In this sense, NeuroMat has accomplished three interconnected objectives: (1) substantial media exposure; (2) intensive, crossmedia communication through NeuroMat's web portal and newsletter, via web-2.0 connections; (3) interdisciplinary training programs, workshops and events on Neuromathematics and pertaining topics to specialized and public audiences. The subsequent sections bring a general overview, a set of quantifiable metrics and descriptive elements and a strategic plan of forthcoming activities of each of the accomplishments.

Two interconnected groups take part of activities pertaining to scientific dissemination within NeuroMat. The Scientific Dissemination coordinator and his appointees are involved with establishing general guidelines of communication and education and facilitating such guidelines. A professional dissemination team –including two media attachés and an IT specialist– is responsible for daily communication and education activities in accordance to the general guidelines for NeuroMat's scientific dissemination.

Key challenges to any communication on Neuromathematics relate to its novelty, its high level of abstraction and to its character of being science in-the-making. Neuromathematics is a renewed interdisciplinary scientific domain, and any communication enterprise is at such a presentation and introduction to this domain. A mathematical theory of neural functioning, as NeuroMat is doing, involves making science at a high level of abstraction, and it may be challenging to express advances in such level of abstraction in media reports. As a new science, Neuromathematics are still in the making, and any report on its work takes the form of reporting on work that is still being done. Challenges in communicating Neuromathematics have led the NeuroMat scientific-dissemination team and interested journalists to understand the endeavor of making sense of the mathematical theory of the brain as needing innovative means of reporting. These new means would include a language and narrative that could deal with the levels of abstraction, and a style and technology that could make sense of processes in the making. The development of these new means of communication has informed the work of the NeuroMat scientific-dissemination team and its deliverables.

3.1 Media Exposure

Public awareness remains a key aspect of building a new scientific domain such as Neuromathematics, and media exposure comes up as a bridge between high level and geared scientific production and knowledge dissemination. To bridge research and dissemination –a foundational goal of all FAPESP's CEPIDs, particularly NeuroMat that is involved in the creation of renewed conceptual frameworks of neuroscience based on mathematical approaches– remains akin to developing a well-informed community of peers and interested audiences as well as to perpetuating a resourceful flow of ideas among NeuroMat members, media professionals and the general public.

Moreover, scientific dissemination also involves establishing bridges and fair exchanges with media professionals. Journalists that show an interest in neuromathematics have been invited to take part in the process of scientific dissemination, so to give them a solid ground to understand the renewed scientific domain that NeuroMat works on. In order to establish such bridges and fair exchanges, it was also important to stress media coaching among the NeuroMat scientific team, which has been conducted by the scientific-dissemination professional staff.

3.1.1 Milestone: NeuroMat clipping

NeuroMat has been the object of media coverage eighteen times since its creation. These references to NeuroMat have been related to the actual creation of center (4), the development of a mathematical theory of the brain (6), the work on neuroscientific public databases within NeuroMat (4), the work on NeuroMat's scientific dissemination including the NeuroMat Wikipedia Initiative (4). This media clipping brings together material that was produced by professional journalists outside NeuroMat as well as news pieces that were produced by NeuroMat members and published in mainstream media. The NeuroMat clipping is available at: http://neuromat.numec.prp.usp.br/news.

Figure 1: Copy of a page of "Neuromatemática, a nova ciência do cérebro," by Aline Naoe, USP online, 04/14/2014.

NEUROMATEMÁTICA

Conexões dinâmicas

Matemáticos e neurocientistas se unem para entender e predizer o funcionamento do cérebro

Igor Zolnerkevic

Os dois desenhos animados que Ghislain Saunier mostrou a seus voluntários num experimento feito em 2008 na Universidade Federal do Rio de Janeiro (UFRJ) não eram nenhuma obra de arte. Com alguns segundos de duração, cada sequência de imagens mostrava 10 pequenos círculos brancos se deslocando sobre um fundo preto. Em uma delas, o movimento dos círculos formava figuras que lembram uma pessoa caminhando – os círculos brancos, na realidade, marcavam as articulações das pernas, dos braços e do tronco de alguém filmado enquanto andava. Na outra, os círculos se moviam de maneira embaralhada.

Os dois filmes, criados por Saunier durante seu doutorado no laboratório da neurocientista Cláudia Vargas na UFRJ, foram exibidos dezenas de vezes, em ordem aleatória, a 16 participantes do estudo. Os voluntários assistiam às animações enquanto um aparelho de eletroencefalografia registrava a atividade elétrica do cérebro. Os participantes em geral reconheciam a primeira sequência de imagens rapidamente, mas tinham dificuldade de dar sentido ao que viam no segundo filme. Com esse experimento, Saunier e Vargas tentavam descobrir se o processamento cerebral das duas imagens diferia significativamente. "Um debate-chave da neurociência é entender como o cérebro codifica e segmenta os objetos em uma cena visual por meio da combinação dos atributos que os compõem", comenta Sergio Neuenschwander, pesquisador da Universidade Federal do Rio Grande do Norte (UFRN) que estuda a resposta de pequenos conjuntos de neurônios de animais expostos a diferentes estímulos visuais.

Hoje é cada vez mais comum experimentos como esse, que começam com o registro da atividade cerebral de animais e de voluntários em laboratório, prosseguirem em uma simples sala de reuniões onde neurocientistas, matemáticos e especialistas de outras áreas discutem, com o auxílio de papel e caneta, a melhor forma de processar, analisar e explicar os dados. Um prédio de três andares no Instituto de Matemática e Estatística da Universidade de São Paulo (IME-USP) tornou-se nos últimos anos a sede de uma rede multidisciplinar

ILUSTRAÇÃO JANIO OTUKI

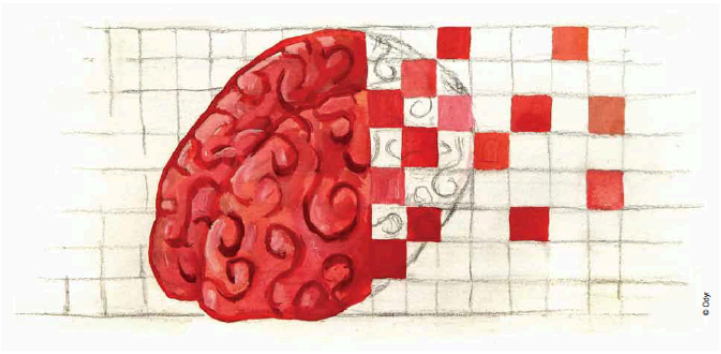
Figure 2: Copy of a page of "Conexões dinâmicas," by Igor Zolnerkevic, Revista Pesquisa FAPESP, 04/2014.

CIÊNCIA ABERTA

Em defesa do compartilhamento público de dados científicos

O movimento da ciência aberta preconiza que as ferramentas e os dados utilizados pelos cientistas sejam disponibilizados publicamente para ampliar seus benefícios a toda a sociedade. Embora haja inegáveis avanços nos últimos anos, ainda há forças que resistem a essa ideia

POR CLAUDIA DOMINGUES VARGAS E FABIO KON*

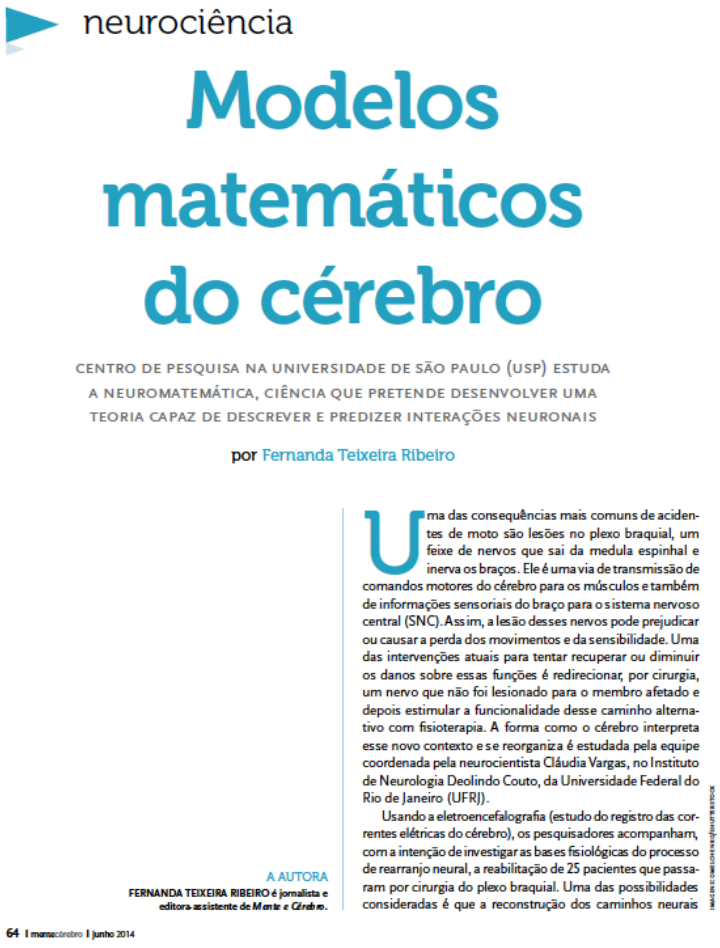


A ideia de que o conhecimento deveria estar ao alcance de todos aqueles que quisessem apreciá-lo é uma questão recorrente na história da humanidade. Ela está presente desde os filósofos gregos da Antiguidade até os cientistas da Renascença, dos trovadores medievais aos grandes compositores eruditos do século XIX. Ao mesmo tempo, mecanismos de controle do conhecimento, proteção da informação e até criptografia existem há algumas centenas de anos. No século XX, houve um movimento na direção de restringir o acesso ao conhecimento como forma de gerar receita financeira ou vantagem comercial. Desse modo, apenas quem pagasse pelo direito de executar uma peça musical receberia autorização para sentar-se ao piano em um concerto público e somente quem pagasse pelo acesso a um artigo científico teria direito de lê-lo. Uma parte significativa dos avanços científicos do século foi motivada por fins militares, cuja prática de esconder as descobertas do inimigo é compreensível. No entanto, o que podemos observar a longo prazo é que, de maneira geral, quando há um nível maior de compartilhamento de ideias e abertura do conhecimento, o avanço da ciência é mais rápido e as sociedades tornam-se mais avançadas, ricas e democráticas.

Nos últimos anos, boa parte da comunidade científica internacional, com apoio de órgãos de fomento governamentais tais como a Fundação da Ciência Nacional (NSF) dos Estados Unidos, a Comissão Europeia e a Fundação de Amparo à Pesquisa do Estado de São Paulo (Fapesp), no caso do Brasil, tem defendido o que se conhece como "ciência aberta". Esse novo modelo de compartilhamento da informação científica está baseado em três fundamentos. Primeiro, os resultados científicos devem ser divulgados em veículos de "acesso aberto", para que qualquer cientista ou cidadão tenha fácil acesso a essas descobertas, independentemente de sua origem ou situação financeira. Segundo, as ferramentas utilizadas no processo científico devem também ser compartilhadas abertamente; como boa parte da ciência hoje em dia depende de ferramentas computacionais, isso indica que elas devem ser disponibilizadas como "software livre". Finalmente, os dados utilizados nas pesquisas devem ser compartilhados como "dados abertos": não só os dados brutos e processados devem ser disponibilizados abertamente, mas também descrições do formato e significado desses dados (chamados metadados) devem ser distribuídas publicamente. Quando essas informações são coletadas em seres humanos, especial atenção é necessária para que a distribuição seja feita de forma criteriosa, respeitando a privacidade e o anonimato dos envolvidos. Um dos pilares da ciência experimental é sua reprodutibilidade. E a ciência só se torna reprodutível se os dados e ferramentas utilizados nos experimentos, simulações e análises forem também disponibilizados de forma aberta e livre.

A ideia de ciência aberta tem avançado em diferentes velocidades em distintos ramos. Em áreas como Ciência da Computação, Genética e Química, por exemplo, esses conceitos têm sido muito bem recebidos. Na Neurociência, o compartilhamento não é a praxe. Tanto a coleta como o armazenamento de dados ainda se fazem, de modo geral, de maneira artesanal. Há grande variabilidade nos tipos de dado que se coletam. Bancos de dados nessa área do conhecimento deverão contemplar desde informações sobre a forma e o comportamento de neurônios individuais, passando por medidas de funcionamento cerebral, até medidas comportamentais. Essa grande quantidade e variedade de informações requer um tipo de banco de dados desenhado especialmente para tal. Além disso, há, ainda hoje, grande desinformação na comunidade sobre mecanismos públicos de compartilhamento de dados.

Figure 3: Copy of page of "Em defesa do compartilhamento público de dados científicos," by Claudia D. Vargas e Fabio Kon, Le Monde Diplomatique Brasil, 05/2014.



neurociência

Modelos matemáticos do cérebro

CENTRO DE PESQUISA NA UNIVERSIDADE DE SÃO PAULO (USP) ESTUDA A NEUROMATEMÁTICA, CIÊNCIA QUE PRETENDE DESENVOLVER UMA TEORIA CAPAZ DE DESCREVER E PREDIZER INTERAÇÕES NEURONAIS

por Fernanda Teixeira Ribeiro

Uma das consequências mais comuns de acidentes de moto são lesões no plexo braquial, um feixe de nervos que sai da medula espinhal e inerva os braços. Ele é uma via de transmissão de comandos motores do cérebro para os músculos e também de informações sensoriais do braço para o sistema nervoso central (SNC). Assim, a lesão desses nervos pode prejudicar ou causar a perda dos movimentos e da sensibilidade. Uma das intervenções atuais para tentar recuperar ou diminuir os danos sobre essas funções é redirecionar, por cirurgia, um nervo que não foi lesionado para o membro afetado e depois estimular a funcionalidade desse caminho alternativo com fisioterapia. A forma como o cérebro interpreta esse novo contexto e se reorganiza é estudada pela equipe coordenada pela neurocientista Cláudia Vargas, no Instituto de Neurologia Deolindo Couto, da Universidade Federal do Rio de Janeiro (UFRJ).

Usando a eletroencefalografia (estudo do registro das correntes elétricas do cérebro), os pesquisadores acompanham, com a intenção de investigar as bases fisiológicas do processo de rearranjo neural, a reabilitação de 25 pacientes que passaram por cirurgia do plexo braquial. Uma das possibilidades consideradas é que a reconstrução dos caminhos neurais

IMAGENS: CAMILLO CHAVES/ISTOCK

A AUTORA

FERNANDA TEIXEIRA RIBEIRO é jornalista e editora-assistente de *Mente e Cérebro*.

Figure 4: Copy of page of "Modelos matemáticos do cérebro," Fernanda Teixeira, Mente e Cérebro, 06/2014.

Title, author	Media outlet	Date	Topic	Link
"Wikipédia pode reinventar as provas escolares", André Jorge de Oliveira	Revista Galileu	9/11/2014	NeuroMat Wikipedia Initiative	http://neuromat.numec.prp.usp.br/content/wikipedia-may-invigorate-educational-activities
"Ciência para todos: entrevista com o Prof. Ernst Hamburger", Antonio Augusto Passos Videira e Sofia Moutinho	Ciência Hoje	8/1/2014	NeuroMat and scientific dissemination	http://neuromat.numec.prp.usp.br/content/science-all-interview-prof-ernst-wolfgang-hamburger
"A Wikipédia, um bem público global", João Alexandre Peschanski	Boletim Grupo de Cidadania	8/1/2014	NeuroMat Wikipedia Initiative	http://neuromat.numec.prp.usp.br/content/neuromathematics-through-new-technologies
"A ciência precisa ser aberta", Kelly Rosa Braghetto	A Rede	8/1/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br/content/science-must-be-open
"Centro de pesquisa da USP investe em difusão científica 'wiki'"	Wikinews	7/16/2014	NeuroMat Wikipedia Initiative	http://neuromat.numec.prp.usp.br/content/research-center-invests-wiki-scientific-dissemination
"NeuroMat estuda como cérebro processa estímulo externo", Aline Naoe	Agência USP de Notícias	7/16/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br/content/neuromat-investigates-how-brain-processes-external-stimuli
"Open Source, Open Skies, Open Stadium"	Imagine Science Films	6/26/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br/content/open-source-open-skies-open-stadium
"Modelos matemáticos do cérebro", Fernanda Teixeira	Mente e Cérebro	6/1/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br/content/mathematical-models-brain
"Em defesa do compartilhamento público de dados científicos", Claudia D. Vargas e Fabio Kon	Le Monde Diplomatique Brasil	5/1/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br/content/defense-public-scientific-data-sharing
"Professora do Departamento de Computação integra projeto de pesquisas em neuromatemática", Tamara Pinho	Portal UFOP	4/23/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br/content/computer-science-professor-takes-part-research-project-neuromathematics

"Conexões dinâmicas", Igor Zolnerkevic	Revista Pesquisa FAPESP	4/1/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br/content/dynamic-connections
"Neuromatemática, a nova ciência do cérebro", Aline Naoe	USP online	4/14/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br/content/neuromathematics-new-brain-science
""A ciência traz valores fundamentais à sociedade": entrevista com Claudia Domingues Vargas", Pedro Motta Gueiros	O Globo	4/10/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br/content/ciência-traz-valores-fundamentais-à-sociedade-entrevista-com-claudia-domingues-vargas
"Discurso sobre sonho pode ajudar no diagnóstico de doenças mentais", Elton Alisson	Jornal do Brasil	3/18/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br/content/discurso-sobre-sonho-pode-ajudar-no-diagnóstico-de-doenças-mentais
"Nas fronteiras do conhecimento"	Jornal da USP	7/4/2013	Creation of NeuroMat	http://neuromat.numec.prp.usp.br/content/nas-fronteiras-do-conhecimento
"Com novos Cepids, FAPESP busca ampliar interação com empresas", Karina Toledo	Agência FAPESP	6/7/2013	Creation of NeuroMat	http://neuromat.numec.prp.usp.br/content/com-novos-cepids-fapesp-busca-ampliar-interação-com-empresas
"A expansão do conhecimento", Fabrício Marques	Revista Pesquisa FAPESP	6/4/2013	Creation of NeuroMat	http://neuromat.numec.prp.usp.br/content/expansão-do-conhecimento
"FAPESP anuncia 17 novos CEPIDs com investimentos de US$ 680 mi", Claudia Izique	Agência FAPESP	5/15/2013	Creation of NeuroMat	http://neuromat.numec.prp.usp.br/content/fapesp-anuncia-17-novos-cepids-com-investimentos-de-us-680-mi

3.1.2 Milestone: Videos on NeuroMat

NeuroMat was featured in two videos that were released on the internet. Both videos have dealt with NeuroMat's core work: the building of a conceptual framework to make sense of neural functioning. In the movie "On Mind and Motion," Claudia Domingues Vargas, a NeuroMat co-principal investigator, talked on how brain and body communicate. The movie was produced by Imagine Science Films, in June 2014, and is available at: http://neuromat.numec.prp.usp.br/content/neuromat-investigator-movie-mind-and-motion. "Dynamics Connections" has focused on the combining of neuroscience and mathematics, NeuroMat's cornerstone. This movie was produced by the Pesquisa Fapesp crew, in May 2014, and is available at: http://neuromat.numec.prp.usp.br/content/dynamic-connections-movie-neuromat. The latter was embedded in NeuroMat's web portal, with English subtitles, and has had in this embedded version at least 4,000 visits.

NeuroMat expects to release two more videos in 2014. These videos have had direct involvement in their production of the scientific dissemination team.

3.2 NeuroMat's web portal and newsletter

NeuroMat's web portal and newsletter remain communication tools created and updated by the center's scientific dissemination team. The web portal was launched as soon as NeuroMat was created, in 2013, and is designed with an innovative programming language called Drupal (to see the web portal go to http://neuromat.numec.prp.usp.br/). Currently, its main tab sections are: Project, which gives access to the research, technology-transfer and scientific-dissemination projects upon which the CEPID rests and other pertaining documents; Research, that lists NeuroMat's publications and should soon also have a sub-tab on lectures; In the Media, with the media and streaming clipping as well as the newsletter; Events; and Opportunities. There should soon be a tab with Tools, where programming technology and tutorials will be available freely. NeuroMat's web portal is connected to web 2.0 technologies, so to allow dynamic exchanges and interactions with users.

Goals of NeuroMat's monthly newsletter are at least threefold. Firstly, it gives evidence of developments and news from the perspective of NeuroMat. Reports that appear on the newsletter are meant to be in-depth accounts of work that has appeared within the center. Examples of this way of accounting for what NeuroMat members are working on are "Data-management tools to help treating neurological injuries", "NeuroMat mathematical models yield basic clues to neural functioning" and "In Neuromathematics, the reaching of a frontier of science means 'courageous' software development." These pieces cover respectively NeuroMat's development of open-access, data-sharing computational tools, that could lead to progress in understanding and treating neurological lesions, a new class of mathematical models that could eventually lead to a general theory of the brain, and the creation of operational neuromathematical softwares. Secondly, the newsletter contributes to strengthening bonds and interests among the interdisciplinary and globally distributed research team that integrates the center. Lastly, the newsletter is also a resource for journalists and educators who want to build upon concepts and ideas that have been elaborated within NeuroMat.

3.2.1 Milestone: NeuroMat's web portal

NeuroMat's new web portal was launched in early February, 2014. Since then, the web portal received a total of 2,057 users and 19,531 pageviews (up to September, 24). Half of these users are new visitors, which suggests that the portal has reached new audiences.

The web site was built in two languages: Portuguese and English. The effort of translating the texts is based on the principle of the internationalization of science, in special mathematics, neuroscience and Neuromathematics produced in Brazil. The main results of this communication outlet are:

- 2,057 users
- 19,531 pageviews
- 3,897 sessions
- 5.01 pages per session

An important fact to be registered is that the audience is highly qualified. This can be presumed by the average time spent by the visitor on each session –5 minutes and 33 seconds, which is a significant duration for internet.

The original language of access is also a key feature of NeuroMat's web portal: almost half of the sessions occurred in Portuguese (46.11%) and half in English (44.32%). This is certainly associated to the principle cited before, of showing NeuroMat's production and framework to an international audience.

NeuroMat has already accomplished two goals with this portal: on one hand, it remains a point of reference to all documents we release; on another hand, it strengthens bonds among the large, diverse research team we bring together and provides access to research material and technological tools. The next actions will be the bettering of NeuroMat's web portal, in order to reach a more varied audience and to generate more interest in Neuromathematics.

3.2.2 Milestone: NeuroMat's newsletter

NeuroMat's newsletter has had seven issues, since February, 2014. It is generally released at the end of each month. All issues may be read at: http://neuromat.numec.prp.usp.br/newsletter/neuromat. The general structure of the newsletter remains having two core articles that show aspects of research in the making or important initiatives that NeuroMat is involved with, a list of new media references to NeuroMat and scientific publications, and position opportunities and other pertaining information.

NeuroMat's newsletter is distributed to around 400 people, who have subscribed to receiving it. The subscription may be done at NeuroMat's web portal frontpage. Besides members of the center, the newsletter also reaches journalists and educators. Topics that are covered in special articles are at the forefront of what NeuroMat achieves, including advances in research, technological transfer and scientific dissemination.

Key articles that were produced exclusively to the newsletter are:

Title	Date	Topic	Link
"NeuroMat launches Wikipedia initiative"	7/1/2014	NeuroMat Wikipedia Initiative	http://neuromat.numec.prp.usp.br /content/neuromat-launches-wikipedia-initiative
"A call to duty: NeuroMat and the Wikipedia Initiative"	7/1/2014	NeuroMat Wikipedia Initiative	http://neuromat.numec.prp.usp.br /content/call-duty-neuromat-and-wikipedia-initiative
"Open Data in Science: a NeuroMat op-ed"	6/1/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br /content/open-data-science-neuromat-op-ed
"In defense of public scientific-data sharing: a NeuroMat op-ed"	5/1/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br /content/defense-public-scientific-data-sharing-neuromat-op-ed
"In neuromathematics, the reaching of a frontier of science means 'courageous' software development"	4/1/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br /content/neuromathematics-reaching-frontier-science-means-'courageous'-software-development
"NeuroMat mathematical models yield basic clues to neural functioning"	3/1/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br /content/neuromat-mathematical-models-yield-basic-clues-neural-functioning
"NeuroMat mathematicians and physicians collaborate to improve rehabilitation questionnaires"	3/1/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br /content/neuromat-mathematicians-and-physicians-collaborate-improve-rehabilitation-questionnaires

"Data-management tools to help treating neurological injuries"	2/1/2014	Neuroscientific public databases: NeuroMat technological transfer	http://neuromat.numec.prp.usp.br /neuromat-data-%C2%ADmanagement-tools-help-treating-neurological-injuries
"Challenges ahead of NeuroMat: remarks by Prof. Leonardo G. Cohen"	2/1/2014	Mathematical theory of the brain: NeuroMat model	http://neuromat.numec.prp.usp.br /leonardo-cohen-concluding-remarks-neuromats-first-workshop

3.2.3 Milestone: NeuroMat's Wikipedia Initiative

NeuroMat has chosen as a core activity what has been called the NeuroMat Wikipedia Initiative. Launched in July, 2014, this Initiative aims at ensuring that articles on neuromathematics (research, terminology, theory) are up-to-date, complete, and written in a style that is neutral and appropriate for the general public, as well as based on reliable sources, and assessing neuromathematics-related articles and tagging them appropriately when problems are found. Members and supporters of NeuroMat were called on to realize these aims.

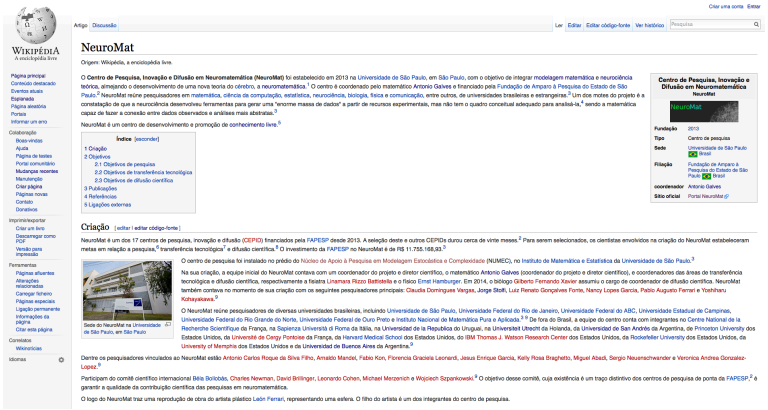
The general justification for the NeuroMat Wikipedia Initiative are at least threefold. Firstly, the global encyclopedia has become one of the most widely read content outlets and to take it seriously within scientific communities is to reach social groups that are often disconnected to high-level scientific enterprises. Secondly, the NeuroMat Wikipedia Initiative remained deeply connected to NeuroMat'seffort to spread open science. This general understanding, that has been expressed in media op-eds, rests upon the idea that science will not advance as fast as it could without radical scientific collaboration and has led NeuroMat to become a reference center to scientists and students who want to collaborate to opening science, especially related to the specific goal of creating a public, open-access neuroscientific database. Thirdly, the practical task of writing encyclopaedic entries pertaining to Neuromathematics proves to be a genuinely efficient strategy to clarify and sharpen newly conceived concepts in the realm of a newly designed scientific area. In this sense, NeuroMat encouraged members and followers to make updating and creating Wikipedia entries part of coursework. The general justification has been put forward in the open letter "A call to duty: NeuroMat and the Wikipedia Initiative," that is available at: http://neuromat.numec.prp.usp.br/content/call-duty-neuromat-and-wikipedia-initiative.

In this Initiative, the NeuroMat team has taken a leading role in the writing and editing of thirty encyclopaedic entries, both in Portuguese and in English. These entries may be seen at: http://neuromat.numec.prp.usp.br/content/neuromat-launches-wikipedia-initiative. An example of work that has been accomplished is the actual entry of NeuroMat in Portuguese: $https://pt.wikipedia.org/wiki/NeuroMat$, which was first created by members of NeuroMat and subsequently edited by Wikipedia volunteers. As an illustration, this NeuroMat entry has had around 1,000 visits, since its creation at the end of June, 2014.

3.3 Training Programs and Workshops

Educational activities to disseminate Neuromathematics have generally been training programs and workshops, as well as general events. The rationale was to provide opportunities to engage with conceptual frameworks and tools that have been developed within NeuroMat both to specialized and general audiences. Sequences of such activities provide grounds to foster and strengthen a community around topics pertaining to a renewed theory of the brain and tools to analyze and invigorate such theory, which includes computational tools. A general trend in educational activities has been its reliance on what has been called "open science," an understanding that science ought to be deeply public: freely and generally available, so to stimulate new advances and remain accountable to the general public. This has been considered especially important in the case of NeuroMat, a cutting-edge research center that is financed by FAPESP, a public foundation.

Figure 5: Copy of the frontpage of NeuroMat's web portal.



NeuroMat

Origem: Wikipédia, a enciclopédia livre

O **Centro de Pesquisa, Inovação e Difusão em Neuromatemática (NeuroMat)** foi estabelecido em 2013 na Universidade de São Paulo, em São Paulo, com o objetivo de integrar modelagem matemática e neurociência teórica, almejando o desenvolvimento de uma nova teoria do cérebro, a *neuromatemática*.[1] O centro é coordenado pelo matemático Antonio Galves e financiado pela Fundação de Amparo à Pesquisa do Estado de São Paulo.[2] NeuroMat reúne pesquisadores em matemática, ciência da computação, estatística, neurociência, biologia, física e comunicação, entre outros, de universidades brasileiras e estrangeiras.[3] Um dos motes do projeto é a constatação de que a neurociência desenvolveu ferramentas para gerar uma "enorme massa de dados" a partir de recursos experimentais, mas não tem o quadro conceitual adequado para analisá-la,[4] sendo a matemática capaz de fazer a conexão entre dados observados e análises mais abstratas.[5]

NeuroMat é um centro de desenvolvimento e promoção de conhecimento livre.[5]

Centro de Pesquisa, Inovação e Difusão em Neuromatemática
NeuroMat

Fundação	2013
Tipo	Centro de pesquisa
Sede	Universidade de São Paulo, Brasil
Filiação	Fundação de Amparo à Pesquisa do Estado de São Paulo, Brasil
coordenador	Antonio Galves
Sítio oficial	Portal NeuroMat

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2 Objetivos
2.1 Objetivos de pesquisa
2.2 Objetivos de transferência tecnológica
2.3 Objetivos de difusão científica
3 Publicações
4 Referências
5 Ligações externas

Criação [editar | editar código-fonte]

NeuroMat é um dos 17 centros de pesquisa, inovação e difusão (CEPID) financiados pela FAPESP desde 2013. A seleção deste e outros CEPIDs durou cerca de vinte meses.[2] Para serem selecionados, os cientistas envolvidos na criação do NeuroMat estabeleceram metas em relação a pesquisa,[6] transferência tecnológica[7] e difusão científica.[8] O investimento da FAPESP no NeuroMat é de R$ 11.755.168,93.[2]

Sede do NeuroMat na Universidade de São Paulo, em São Paulo

O centro de pesquisa foi instalado no prédio do Núcleo de Apoio à Pesquisa em Modelagem Estocástica e Complexidade (NUMEC), no Instituto de Matemática e Estatística da Universidade de São Paulo.[3]

Na sua criação, a equipe inicial do NeuroMat contava com um coordenador do projeto e diretor científico, o matemático Antonio Galves (coordenador do projeto e diretor científico), e coordenadores das áreas de transferência tecnológica e difusão científica, respectivamente a físatra Limamara Rizzo Battistella e o físico Emel Hamburguer. Em 2014, o biólogo Gilberto Fernando Xavier assumiu o cargo de coordenador de difusão científica. NeuroMat também contava no momento de sua criação com os seguintes pesquisadores principais: Claudia Domínguez Vargas, Jorge Stolfi, Luiz Renato Gonçalves Fonte, Nancy Lopes Garcia, Pablo Augusto Ferrari e Yoshiharu Kohayakawa.[9]

O NeuroMat reúne pesquisadores de diversas universidades brasileiras, incluindo Universidade de São Paulo, Universidade Federal do Rio de Janeiro, Universidade Federal do ABC, Universidade Estadual de Campinas, Universidade Federal do Rio Grande do Norte, Universidade Federal de Ouro Preto e Instituto Nacional de Matemática Pura e Aplicada.[3][9] De fora do Brasil, a equipe do centro conta com integrantes no Centre National de la Recherche Scientifique da França, na Sapienza Università di Roma da Itália, na Universidad de la República do Uruguai, na Universiteit Utrecht da Holanda, da Universidad de San Andrés da Argentina, de Princeton University dos Estados Unidos, da Université de Cergy Pontoise da França, da Harvard Medical School dos Estados Unidos, do IBM Thomas J. Watson Research Center dos Estados Unidos, da Rockefeller University dos Estados Unidos, da University of Memphis dos Estados Unidos e da Universidad de Buenos Aires da Argentina.[9]

Dentre os pesquisadores vinculados ao NeuroMat estão Antonio Carlos Roque da Silva Filho, Arnaldo Mandel, Fabio Kon, Florencia Graciela Leonardi, Jesus Enrique Garcia, Kelly Rosa Braghetto, Miguel Abadi, Sergio Nasuncshwander e Veronica Andrea Gonzalez-Lopez.[9]

Participam do comitê científico internacional Béla Bollobás, Charles Newman, David Brillinger, Leonardo Cohen, Michael Merzenich e Wojciech Szpankowski.[4] O objetivo desse comitê, cuja existência é um traço distintivo dos centros de pesquisa de ponta da FAPESP,[2] é garantir a qualidade da contribuição científica das pesquisas em neuromatemática.

O logo do NeuroMat traz uma reprodução de obra do artista plástico Laon Ferrari, representando uma esfera. O filho do artista é um dos integrantes do centro de pesquisa.

Figure 6: Copy of NeuroMat's Wikipedia entry.

4 Technology transfer report

The creation and availability of open data is a pillar of Open Science [18], advocated by various governments and some of the largest research financing agencies in the world, such as NSF and FAPESP. While public scientific data repositories are common in other knowledge areas, they are still rare in neuroscience. One of the main goals of NeuroMat is to contribute to change this scenario by proposing a conceptual data model for neuroscience data, the implementation of a database and computational tools for management, curation and sharing of scientific data.

The representation and storage of data from experiments in neuroscience impose several challenges. The main one is the great variability that may exist in the structures of the experimental protocols. Furthermore, there is no consensus in the scientific community about the type of data required to document and report an experiment in neuroscience. There is also the difficulty in defining a model of data representation in digital format which affords efficient physical storage while being at the same time, easy to be adopted by neuroscientists. To the best of our knowledge, there are no proposals in the related literature for appropriately dealing with all these challenges.

As the initial step in the building of the NeuroMat computational data and software resources, we have identified and characterized the data gathered in experiments conducted by the researchers of the project. Gathering a large team of researches and professionals, we have created a conceptual database model for neuroscience experimental data. At this first stage of the project, we have focused on experiments involving electrophysiological, behavioral, and clinical data acquisition. For the collection of study-specific data, we have also introduced the use of electronic questionnairesso as to guarantee some standardization and consistency for unstructured data too. More details about the developed database model and the use of electronic questionnaires in the project are provided in Section 4.1.

Data management software tools are being developed in the project in order to enable scientists to store their data in the NeuroMat database and to provide recovery facilities to the users who want access these data. In particular, in this first year of the project, the Neuromat development team has devoted its efforts to the design and development of software tools for clinical and experimental data management, based on requirements collected at INDC-UFRJ. The software is being developed in such a way that it can be directly installed and used in other neurological rehabilitation centres and neuroscience research laboratories. Section 4.2 describes the main characteristics of the software.

In NeuroMat, computer scientists have engaged in ever-evolving, innovative strategies to create operational softwares. The development team of the project has progressively become a central player in the overall scientific project of combining mathematical and neuroscientific research agendas. The main activities that the software development team has been involved with in NeuroMat are at least twofold. First, they are responsible for translating and operationalizing needs of scientific groups that work in the frontier between neuroscience and mathematics. Secondly, NeuroMat computer scientists have had to come up with programming methodologies and designs that are compatible with this evolving and exploratory aspect of neuromathematical research projects; this has led to an outlook of scientific advances within Computer Science. The NeuroMat software development team and the working methodology that it employs (the *Extreme Programming* – XP) are described in further details in Section 4.2.3.

Finally, the planned activities related to database and software development for the next stage of the project are briefly described in Section 4.3.

4.1 The NeuroMat Database

In order to make a correct analysis of experimental data, scientists needs to know the details of the experimental protocol used in the data acquisition. Furthermore, there are other orthogonal information which are important indicators of the quality of the collected data. As an example, one can cite information about the research laboratory where the data were collected and people responsible for the collection, and publications or other results derived from the data. In this text, all information about experimental protocol and other orthogonal information of data collected in a neuroscience experiment is referred as *provenance information*.

In addition to collecting data (often called "raw data"), an experiment in neuroscience may also involve the generation of new data – referred in this text as *derived data*. Derived data may be generated through the computational processing of raw data. This processing generally consists of a sequence of data manipulations, such as filtering, transformation and analysis. Storing provenance information of derived data is as important as storing provenance information of raw data. The provenance information of derived data must associate them with their source data and with the manipulation processes they passed through.

Often scientists digitally store the data of their experiments as unstructured files, kept in the file system of a computer system, with no standard format. This storage structure hinders the maintenance, retrieval (search), sharing and reuse of data, especially when the amount of collected data grows.

To address this problem, we are developing a database to store neuroscience experimental data. In addition to promoting standardized formats forexperiments and analyses reporting, this database supports the reproducibility of experiments, enables comparison of data across studies, and keeps data provenance. And the usage of a *Database Management System* (DBMS) in the implementation of the database improves the efficiency and security of the data storage.

There are other projects/consortia (such as *Human Brain Project* [6], *International Consortium for Brain Mapping* [7], *Biomedical Informatics Research Network* [2]) worldwide also engaged in data storage and distribution for the neuroscience research field, but they are also facing the challenge of standardization of formats to report experiments and analyses.

In the modelling of the NeuroMat database, we are following other well-succeeded initiatives related to the representation and storage of neuroscience data. In particular, the NeuroMat database is in accordance with the recommendations of MIBBI guidelines to report data em neuroscience domains. The *Minimum Information for Biological and Biomedical Investigation* project (MIBBI) is considered a pioneering project that aims to coordinate guidelines for reporting of scientific metadata across domains [16]. Under the MIBBI project, there are three guidelines for neuroscience domains:

- *Minimum Information about a Neuroscience Investigation* (MINI) [14] – to report the use of electrophysiology in a neuroscience study;
- *Minimal Information for Neural Electromagnetic Ontologies* (MINEMO) [13] – to report event-related potential ERP/EEG data;
- *Minimum Information about an fMRI Study* (MIfMRI) [15] – for fMRI studies.

4.1.1 Database Modules

The NeuroMat database is being designed to store both experimental data and their provenance information (i.e., experimental protocol data and other orthogonal information). There are different types of experiments in neuroscience, e.g., behavioral, cognitive, electrophysiological and neuroimaging. The experimental protocol comprises all the definitions of an experiment, including the statement of the objectives, the description of the groups of subjects to be tested, the experimental conditions to which groups will be submitted, the types of data acquisition that will be carried out, and the equipment settings used in the data acquisition. The data acquisition can be, for example, signals or images captured from the experiment subjects and digitally recorded by equipments such as electroencephalography (EEG) and magnetic resonance imaging (MRI), or measurements or manual notes on the observed behavior of subjects.

In order to accommodate all these data with so varied nature and facilitate the evolution of the database, we divided the database structure in modules. Currently the database has five modules:

- Organizational Structure – to store data about the researchers, laboratories and projects that conduct the experiments;
- Experiment Protocol – to store data describing the experiments, their overall goals and their design (including the experimental conditions, stimuli and tasks);
- Electrophysiological Data Acquisition – to store data acquired by electrophisiology equipments such as EEG, EMG and stabilometry machines;
- Behavioral Data Acquisition – to store data from behavioral responses collected from the subjects in the experiments;
- Documents – to store papers, articles, reports, and other documents that are direct products of the analyses made over the experimental data.

The conceptual schema of NeuroMat database is described as a diagram in the Extended Entity-Relationship (EER) model. Figures from 7 to 9 show a simplified view of the structure of the main designed modules. The complete EER schema of the modules has more than fifty entity types and relationships among them. Figure 10[1] shows the complete EER schema of the database, designed in an open-source modelling tool called *pgModeler* [10].

The Neuromat database is being implemented as a relational database in the open-source DBMS *PostgreSQL* [11]. Software tools that enable users to interact with this database are being developed, as described in Section 4.2.

[1] A figure in higher resolution is attached to this report.

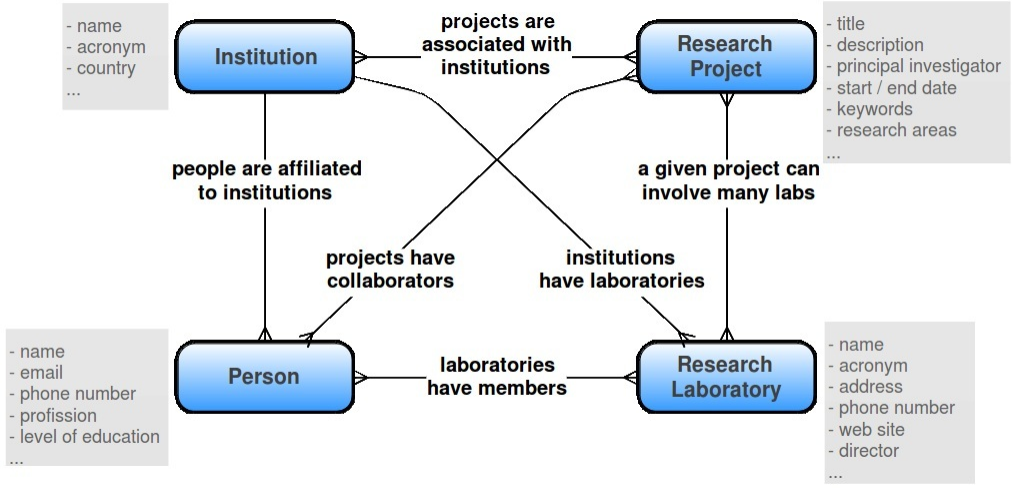

Figure 7: General view of Organizational Structure database module.

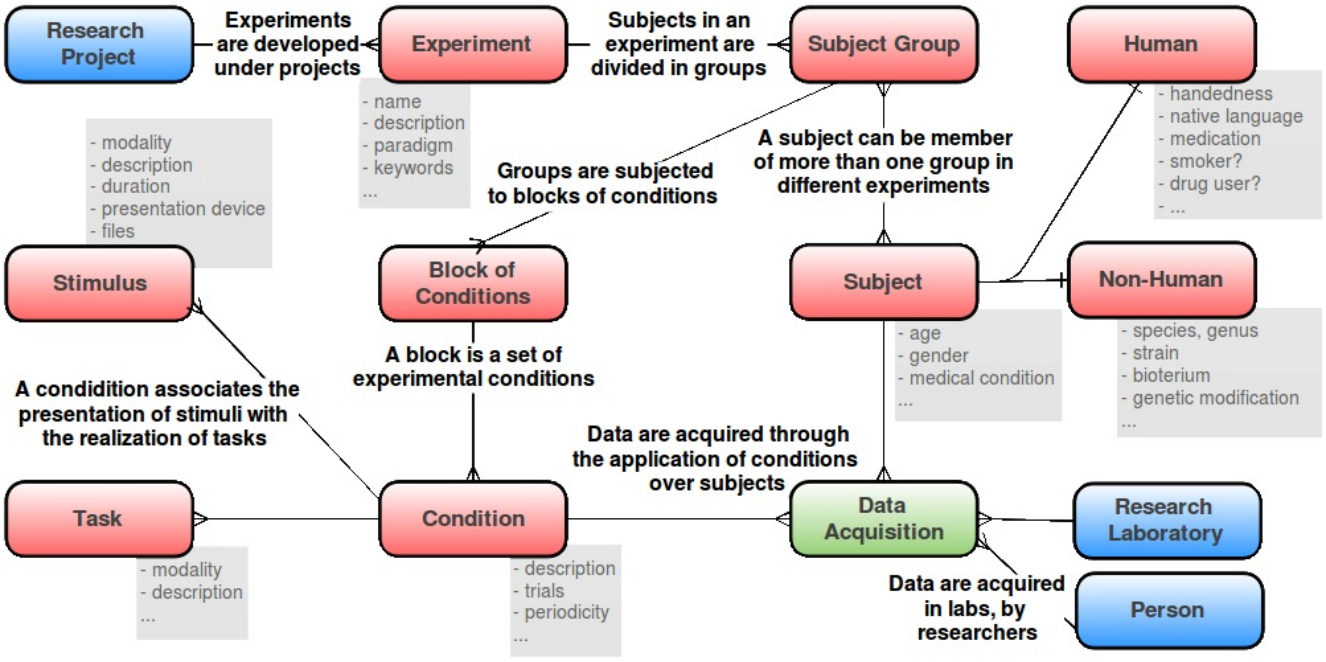

Figure 8: General view of Experiment Protocol database module.

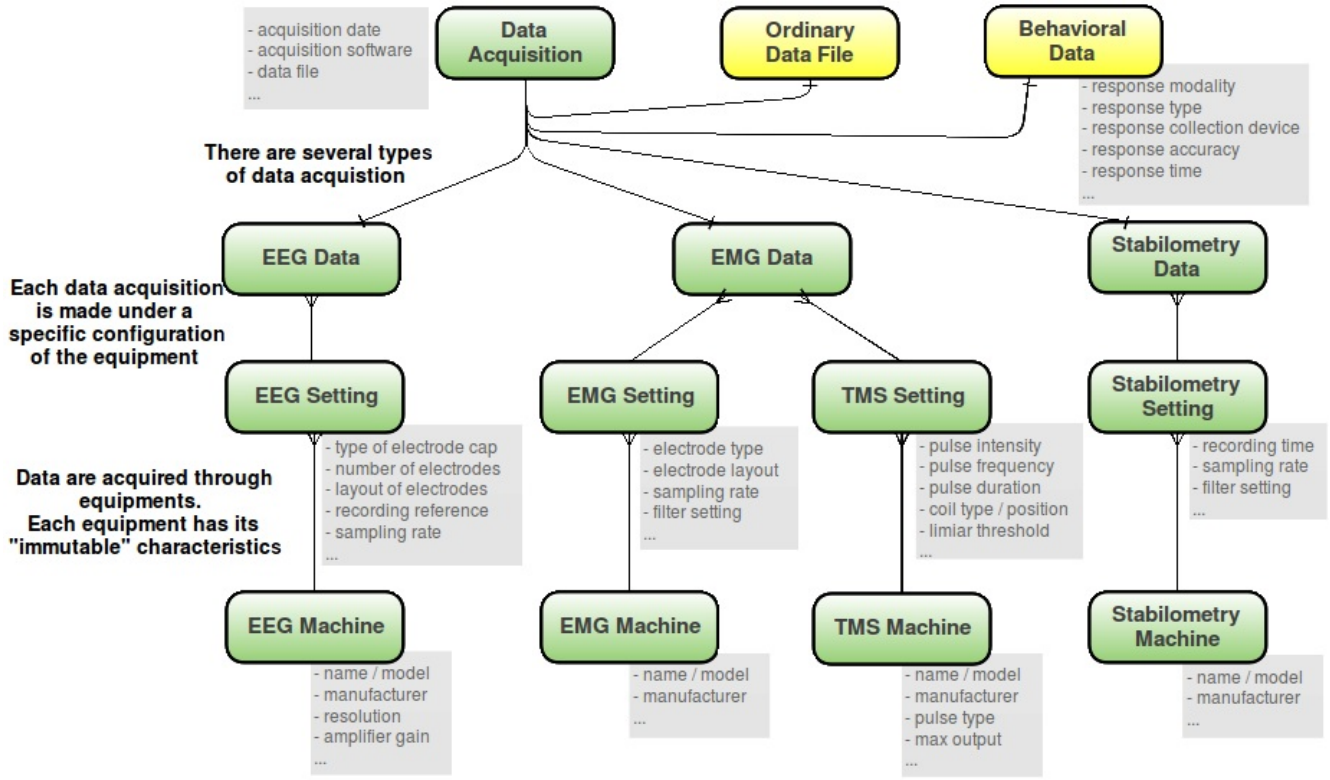

Figure 9: General view of Electrophysiological Data Acquisition database module.

Figure 10: Current conceptual model of NeuroMat database (figure in small resolution).

4.1.2 Using Electronic Questionnaires to Collect Experimental Data

The structure of the database modules described in Section 4.1.1 can accommodate an important portion of all data that can be collected in an electrophysiological experiment. These modules were developed for data whose structure is common to all experiment or, in other words, data that can be described in terms of the standardized structure defined by the database model.

A considerable part of the data analyzed in neuroscience experiments is collected by means of paper-based questionnaires. These ad-hoc questionnaires are generally designed by the scientists specifically for the studies that they are conducting. As these questionnaires vary from study to study, they do not have a fixed structure. For this reason, we are not able to store these data in the same "rigid" structure presented in Section 4.1.1. To deal with this problem and also to provide more quality and security to data collected through questionnaires, we have introduced in the project the use of *electronic questionnaires management systems*. These systems allow users to quickly create intuitive, powerful, electronic question-and-answer surveys [17].

In the project, we have adopted *LimeSurvey* [9] to create and manage the electronic questionnaires. LimeSurvey is an open-source, web server-based software that enables users to develop and publish on-line surveys and collect responses. It supports advanced question types, including *multiple answers* question, *date* question, and file submission. When defining multiple answers, LimeSurvey also allows respondents to provide additional comments with their submissions. To ensure integrity of the collected data, LimeSurvey allows the definition of constraints on answers (e.g., minimum values, valid intervals, etc). Preselected questions can be defined as required.

On LimeSurvey, we can also design logical branching based on answers and scores. In this way, it is possible to define a condition or a set of conditions on each question of the target survey, such as if the condition is met, the question will be displayed.

To define the look and feel of a questionnaire, LimeSurvey provides generic templates, so that the layout can be customized without interfering with the structure of the questionnaires. Furthermore, LimeSurvey allows the creation of multilingual surveys. The administrator is in charge of translating the survey and respondents can choose among available languages.

In LimeSurvey, a user can export the collected data into an Excel spreadsheet (or CSV file, or Microsoft Word file). Alternatively, by using the embedded statistics feature, it is possible to filter the collected data and retrieve numbers and summaries of different fields from it. LimeSurvey allows the definion of general survey security settings, by means of which it is possible to support single or multiple users and roles, thus being able to guarantee data integrity and confidentiality.

A very important feature of LimeSurvey is that it enables us to store all data collected through the questionnaires in a "private" server. It relies on an underlying database management software, which can be deployed on a server that is deemed appropriate to store the target data and customized to support different data access policies. To have full control over data storage and access policies is a desirable feature due to the nature of experiments in biological and medical sciences, which usually include sensitive data. Some other questionnaire systems rely on cloud computing technology and, therefore, their users are not able to fully manage data storage and access.

Electronic Questionnaires at LNR-INDC-UFRJ The *Laboratory of Neurocience and Rehabilitation* (LNR) of the *Institute of Neurology Deolindo Couto* (INDC), at Federal University of Rio de Janeiro (UFRJ) is conducting, in the context of NeuroMat project, a study to leverage a better understanding of brain plasticity and, hence, to support a more efficient treatment for neurological lesions related to the network of nerves called *brachial plexus*. In order to achieve this, the LNR-INDC team needs to develop the adequate descriptors of neural functioning, a very challenging task since there is no consolidated parameters to report features of neurological lesions and other related patient data.

The LNR-INDC team with support of IME-USP team has developed a set of electronic questionnaires to collect patient life-history, medical and physiotherapeutic data over long periods of time. The electronic questionnaires were implemented after a six month work of data requirement analysis – in which the LNR-INDC team has identified and characterized the data involved in the brachial-plexus study. The questionnaires reflect the consensus reached by the LNR-INDC team on what data should be collected and stored. The team includes professionals such as physicians, physiotherapists, biologists, and physical educators.

The set of electronic questionnaires developed by the LNR-INDC team includes not only those specifically designed for its studies, but also some clinical standard questionnaires. These questionnaires can be divided in the following categories, according to the data type they refer to: *(i)* admittance (patient personal information); *(ii)* clinical evaluation (data collected by experimenters, neurosurgeons, and physical therapists); *(iii)* post-surgery (data collected by experimenters and neurosurgeons); *(iv)* longitudinal evaluation (data collected by experimenters

and physical therapists); *(v)* standard questionnaires frequently used in neuroscience studies: *Oldfield*, *Berg*, *DN-4* and *DASH*; and *(iv)* other more specific standard questionnaires, such as the ones to evaluate *phantom limb sensation*, *posttraumatic stress disorder*, *depression*, and *rhythm complexity*.

This experience at INDC resulted in a proposal of guidelines to support the development of electronic questionnaires in biological and medical domains and analyzes open-source survey tools that can be used to create and manage these questionnaires. The guidelines account for important issues such as privacy, security, and data quality, and are presented in the paper titled "Guidelines for Developing Electronic Questionnaires to Collect Experimental Data" (to be submitted), attached to this report.

4.1.3 About the NeuroMat Database Development Team

The database model presented in this work was developed by professors Ana Carolina Q. Simões (UFABC) and Kelly R. Braghetto (IME-USP). The data requirements considered in the modelling were collected through frequent meetings and discussions with professors Claudia D. Vargas (INDC-UFRJ) and André Frazão Helene (IB-USP) and their research teams.

The activities related to the study and use of electronic questionnaires to collect experimental data were developed by the INDC-UFRJ research team, leaded by professors Claudia D. Vargas and Kelly R. Braghetto. Prof. Braghetto provided training courses on the use of *LimeSurvey*, while prof. Vargas' team designed and implemented the questionnaires.

4.2 The NeuroMat Software Tools

The software tools that are being developed in the NeuroMat project can be divided in three categories:

1. Web Portal Application – public online tools to query and analyse the experimental data stored in the NeuroMat database;

2. Laboratories Local Infrastructure – tools used in the laboratories of the project, to locally store and manage data collected and generated in their experiments;

3. Data integration tools – tools that carry the data transfers from laboratories local databases to NeuroMat central database. These tools will perform the filtering and anonymization of sensitive data. Sensitive content will always be kept under the responsibility of the laboratory which collected it.

Figure 11 shows the interactions that exist among theses categories, the NeuroMat database and the laboratories local databases.

In this first phase of the project, we are focusing on the development of software tools for Laboratories Local Infrastructure, since these tools are essential for the collection of the data that will feed the NeuroMat database. In particular, our primary aim is to attend the systemic needs of the Institute of Neurology Deolindo Couto (INDC). The first application being developed is the **Laboratory Web Application**, a web system for clinical and experimental data management.

Initially, some functionalities were prioritized in the development of Laboratory Web Application. The goal of this prioritization was to build a functional software (to be put in production) in a short time. The prioritized functionalities were: *i)* patient registration, with social-demographic and social history information; *ii)* medical evaluation record, using the International Classification of Diseases (ICD) to register patients diagnosis; *iii)* simple experimental data management, interfacing the use of LimeSurvey to handle electronic questionnaires.

The Laboratory Web Application is an open-source software and its source-code is available on the NeuroMat github account: `https://github.com/neuromat`. Also, on the NeuroMat github repository can be found some screenshots and a link to the demonstration website. The next subsections provide further details involved in the development of this software.

4.2.1 About the Architecture Description

The architecture consists of the description of software components, the existing layers, external properties, and relationships with others software needed. In addition, the architecture provides an abstraction in a software overview, describing also the possible connections between the components and design patterns used. This description aims to a high level of abstraction and, consequently, it facilitates the communication between the software different stakeholders.

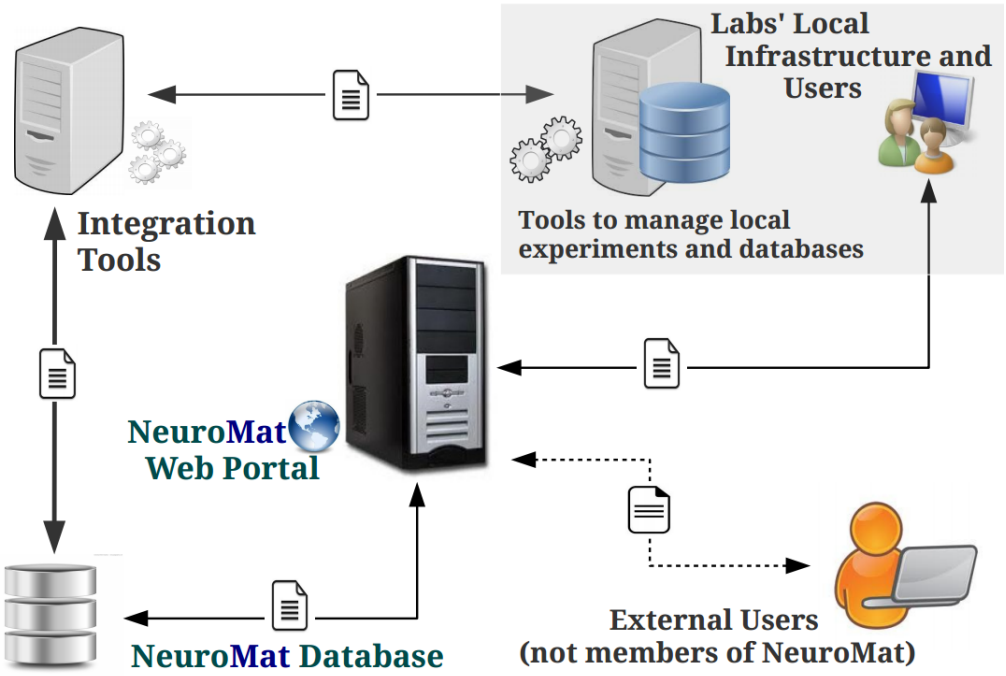

Figure 11: Macro view of NeuroMat Web Portal and laboratories integration.

In our case, we split the architecture into two parts: *i)* Software Architecture; *ii)* Development Environment. The first aims to define the internal architecture of the software that will be run in the laboratories. More details about this architecture are described on Section 4.2.1. The second presents the elements of the network and the provision of computers, providing a basis for the understanding of continuous integration, automated tests, fault monitoring, presentation of results and code version control. Details about this architecture are described on Section 4.2.1.

Software Architecture The technical team defined that the *Model-View-Controller* (MVC) design pattern would be the most appropriate to develop the Laboratory Web Application. To support the implementation of the pattern, the chosen web framework was Django Web [4], written in Python[2]. The Django Framework was chosen because *"Django is a high-level Python Web framework that encourages rapid development and clean, pragmatic design(...)"* [5]. Figure 12 presents the architecture of the MVC design pattern based on Django Web framework.

Notice in Figure 12 that the architecture is divided into three layers: client, server and third party server. In the client layer, the client accesses the application via Browser. In the server layer, we have an Apache 2 [1] server waiting for requests, which will be passed to the application. Note that the Django Web framework has a component for access to the PostgreSQL database [11], the Django Object-Relational Mapping (ORM). Also in Figure 12, the Twitter Bootstrap [3] framework is used to generate the application layout and make it responsive, adjusting the web pages dynamically according the device used (desktop, mobile, tablet). In the third party server layer, the questionnaires are maintained in the LimeSurvey application, which is integrated with the Laboratory Web Application through an Application Programming Interface (API) provided by the LimeSurvey itself.

In short, these are the technologies adopted in the project:

- Programming language – *Python 2.7*
- Web framework – *Django 1.6*
- Front-end framework – *Twitter Bootstrap*
- Database Management System – *PostgreSQL 9.3*
- Web Server Application to Production Environment – *Apache Web 2*

[2]python

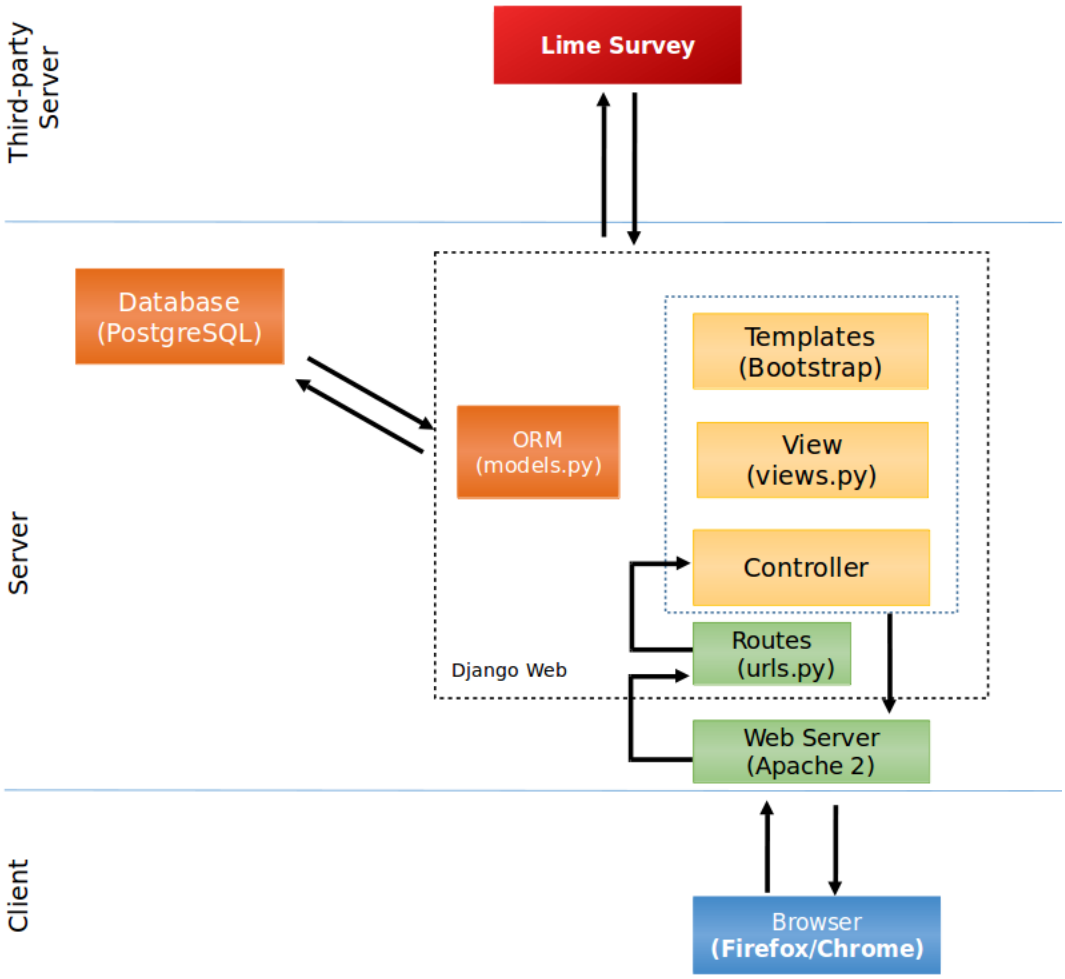

Figure 12: Django Python Software Architecture.

- Electronic Questionnaire System – *LimeSurvey*

Development Environment The architecture is designed to support an easy integration among the developers, controlling and versioning of their source-codes, and preview the results generated by the team during the development. As part of this development process, the supporting architecture is shown in Figure 13.

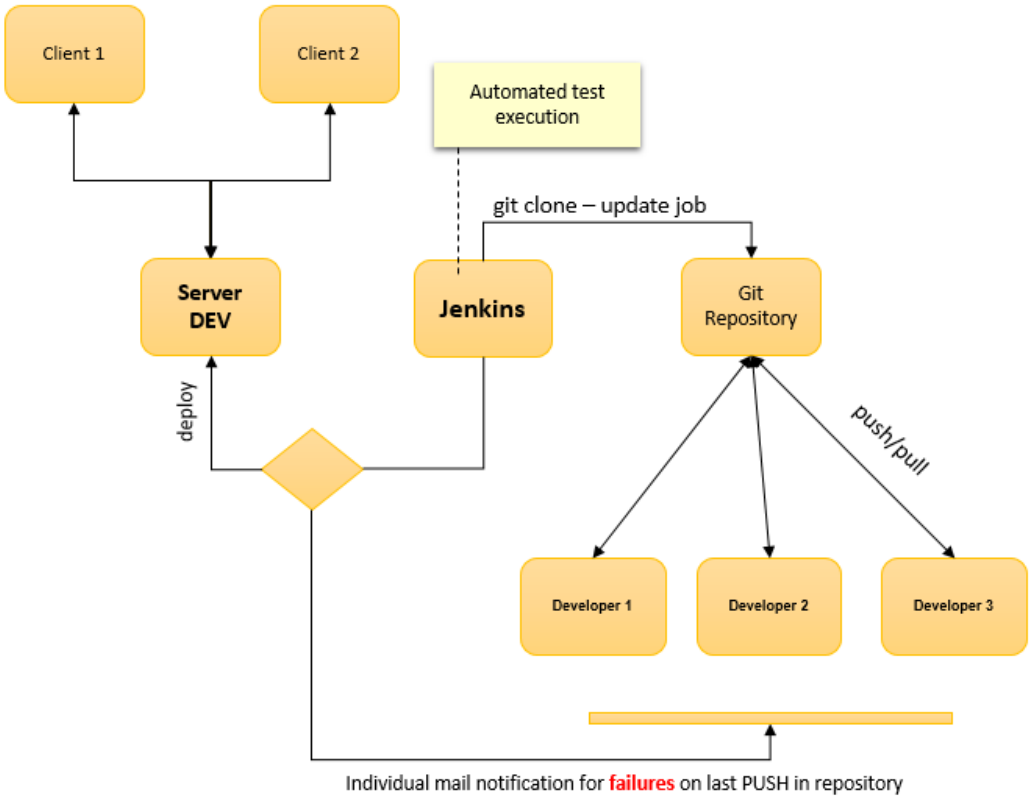

Figure 13: Overview of Development Architecture Support.

Also in Figure 13 the development integration process can be seen, where central control is in Jenkins [8] that get the latest source-code version from the Git repository. Once obtained such sources, a build to be deployed in the appropriate server is be generated. During this process, a verification step through the execution of automated tests is performed. Other verification steps related to the quality of the source-code are also performed at this stage. If a failure happens to occur during the generation process build, a mail notification is triggered to the developer responsible for the failure.

Infrastructure as a Service and Additional Resources The Development Architecture Support described here uses the computing infrastructure present in the NUMEC / CEPID NeuroMat building. The laboratory used by the team is equipped with iMAC computers from Apple.

The team also uses the University of São Paulo's Cloud. This cloud delivers Infrastructure as a Service (IaaS) to faculties, departments, special projects and research groups using Cloud Platform orchestration. The NeuroMat project has an account in this cloud and it is used to host the virtual machines used by the software development team, e.g. Server DEV, Jenkins and Database. Git repository for a while is part of this infrastructure such as described in Figure 13. However, we are moving the current repository to the GitHub, a git repository web-based hosting service, to share the project source-code with public access for collaborative revision control.

Additionally, software tools are necessary to support the development team. Developers use the same Integrated Development Environment, PyCharm [12], a Python IDE that allow code analysis besides support to the Django framework and other productive tools, e.g., test coverage report. In short, these are the technologies adopted for the project:

- Integrated Development Environment (IDE): *PyCharm*

- Source code management: *Git*
- Continuous integration tool: *Jenkins*
- Automated tests: *Djanjo unittest*

Continuous Integration The Jenkins tool attends on the main needs for continuous integration and development support. This tool has a lot of resources, that can be added by means of Plug-ins.

The following configurations were made to offer us support during the project development:

- Creating *Jobs* (item project) for continuous integration for *branch* repository
- Mail notification when failures occurs during the build generation/automated tests
- Run automated tests
- Statistic of code coverage, amount of tests, etc.
- Statistics of amount of builds generated to failed and normal
- Statistics of lines of code
- Statistics of code violations based on *PEP8*
- Deploy in development/homologation/production environments

Figure 14 shows the Jenkins dashboard, containing the list of Jobs created. For each Job, a summary of certain information about the build generation is presented, e.g. test coverage, violations, stability, etc.

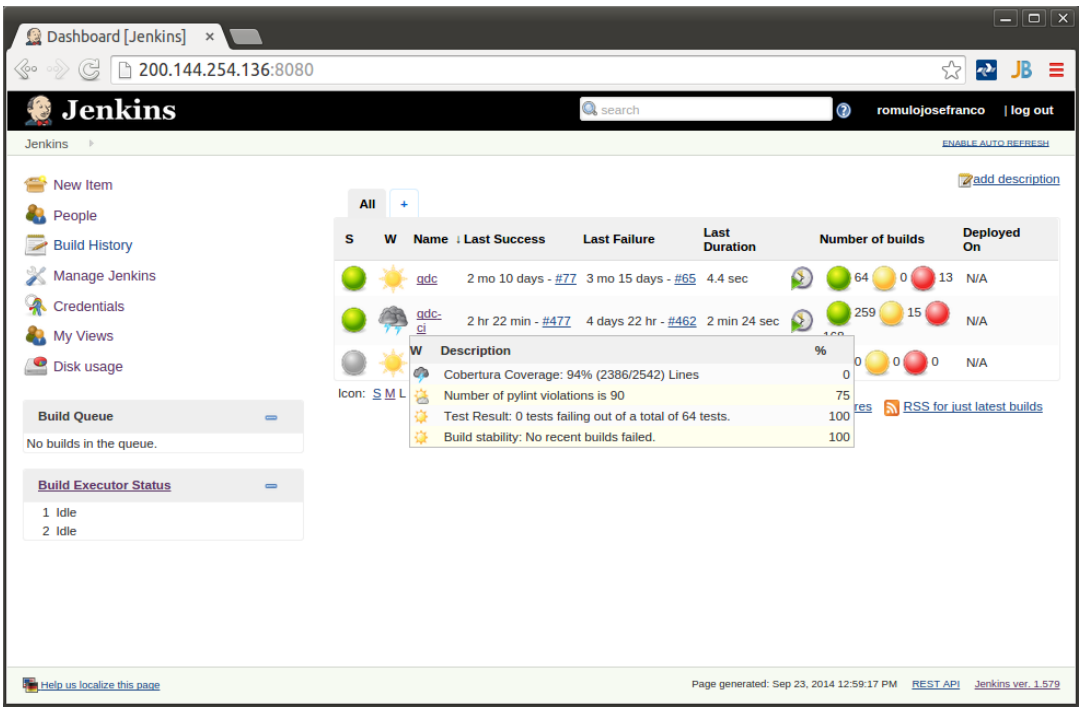

Figure 14: Jenkins - Main screen containing the Jobs set and some statistics

Figure 15 presents the screen of one Job, where information about the builds, statistics and reports can be obtained.

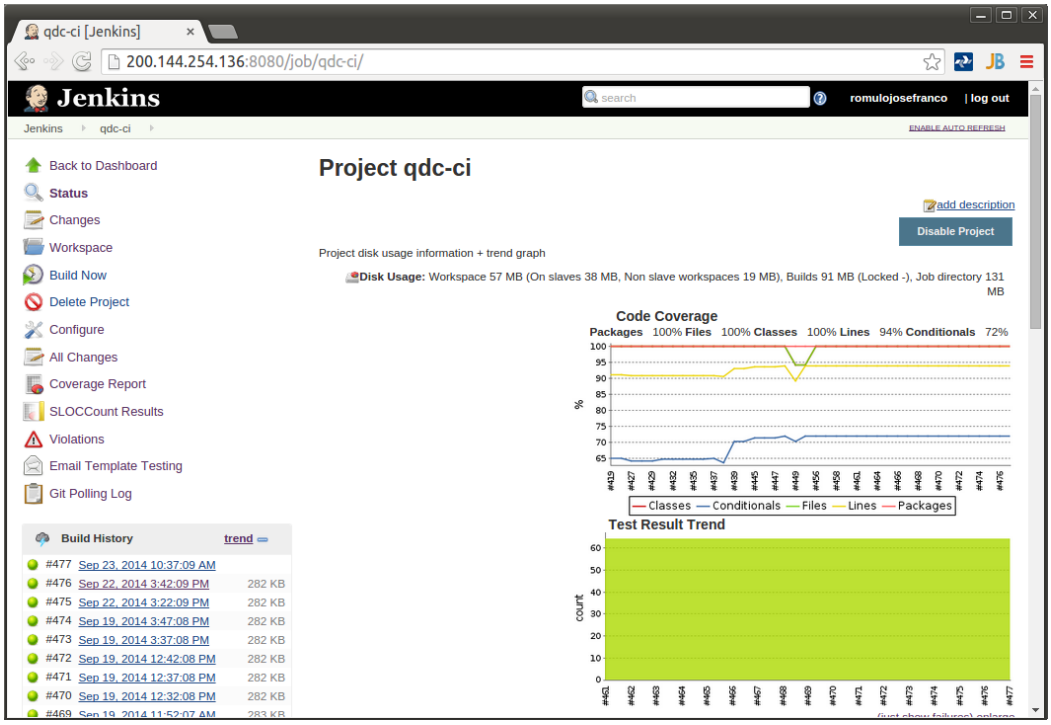

Figure 15: Jenkins - Detail about Job selected

Automated Tests Automated tests implemented for the project were based on the testing framework provided by Django – Unittest [4]. This framework is similar to the popular testing framework for the Java language – JUnit.

The 64 automated tests (94% lines of code coverage) separated into three modules were implemented: *i)* Quiz Module; *ii)* Users Module; *iii)* Experiments Module.

When running the automated test, the database is created at runtime without affecting data already created in the database used by the application in development or production environments. In addition, test execution ensures validation of the data model.

PyCharm supports the development, debugging and visualization of statistical test coverage, as shown in Figure 16. Note that in Figure 16 is also presented information about the test coverage, that is the same presented in the Jenkins when it executes the tests from the Git repository.

4.2.2 Developed Features

This section describes the functionalities that were developed to attend the initial needs of INDC, involving patient registration and basic experiments management with electronic questionnaires.

Functionalities

1. **Patient Registration Module**: identification; localization with search by zip-code; social-demographic data with social class calculation; and social history information.

2. **Medical Record Registration**: diagnosis registration using the International Classification of Diseases (ICD) and possibility to include details, clinical analysis results and medical report.

3. **Experiment Management**: experiment registration and configuration of the electronic questionnaires from the LimeSurvey.

4. **Fill Management Questionnaire**: integration with LimeSurvey to manage the filling of patient questionnaire.

5. **User Management**: user registration based on groups and permissions configuration.

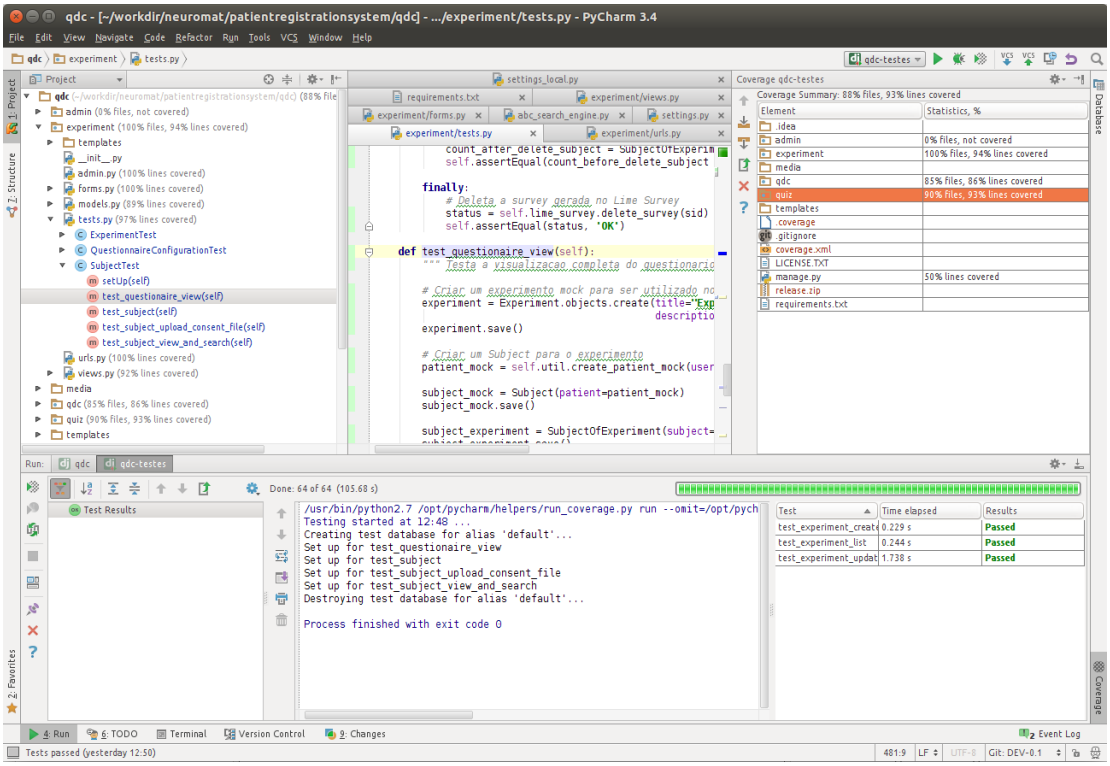

Figure 16: IDE PyCharm presented the order of execution of tests and coverage data of the last run.

Quality requirements Some extra features have been implemented in this first phase of the project in response to non-functional requirements and to promote improvement in the software quality. These features are described below:

1. **Access control** – Full software access control by users management provided by Django Admin package.
2. **Auditing log and change history** – Interface to changes management in records on database for some types of data objects (e.g. patients, diagnosis history). This feature allows auditing database tables for suspicious use of the system and support the recovery of accidental recordings.
3. **Design for tablet and smartphones usage** – Feature developed with the support of Bootstrap, to make the layout of the application portable to be accessed via tablets and smartphones.
4. **Automated tests** – This feature has been applied in development phase to validate application before to put on production environment and improve quality of source code. This feature was described on Section 4.2.1

Screenshots Figures from 17 to 19 show screenshots of the interface of some of the functionalities developed in the Laboratory Web Application. Other screenshots can be found on the NeuroMat github account: `https://github.com/neuromat`.

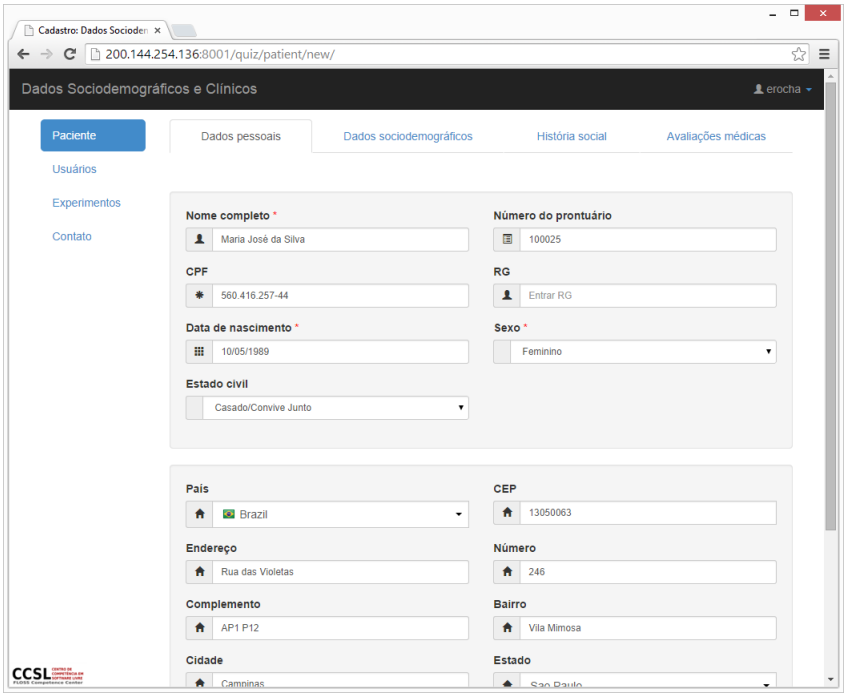

Figure 17: Patient registration – identification and localization.

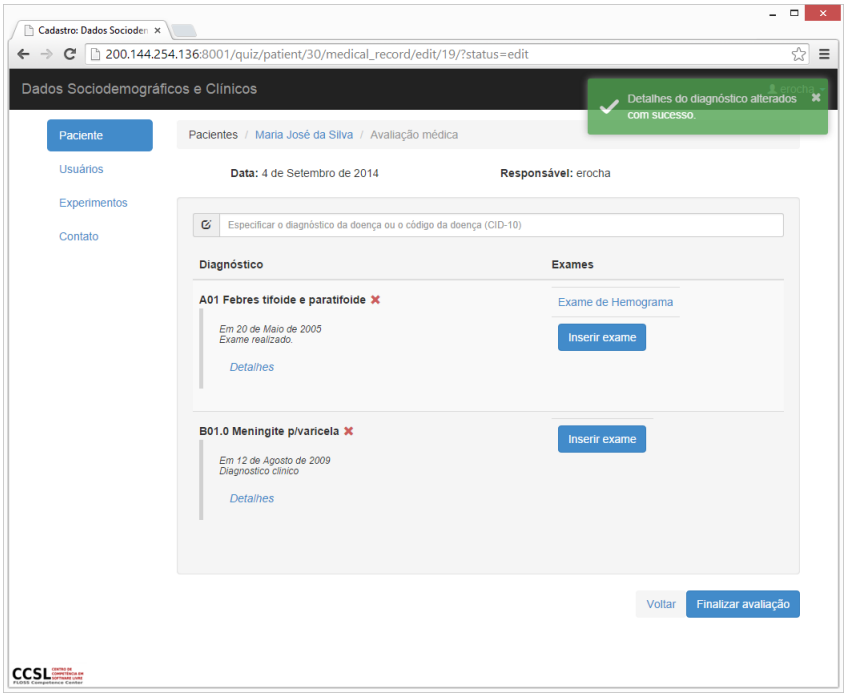

Figure 18: Patient medical record view with diagnosis history.

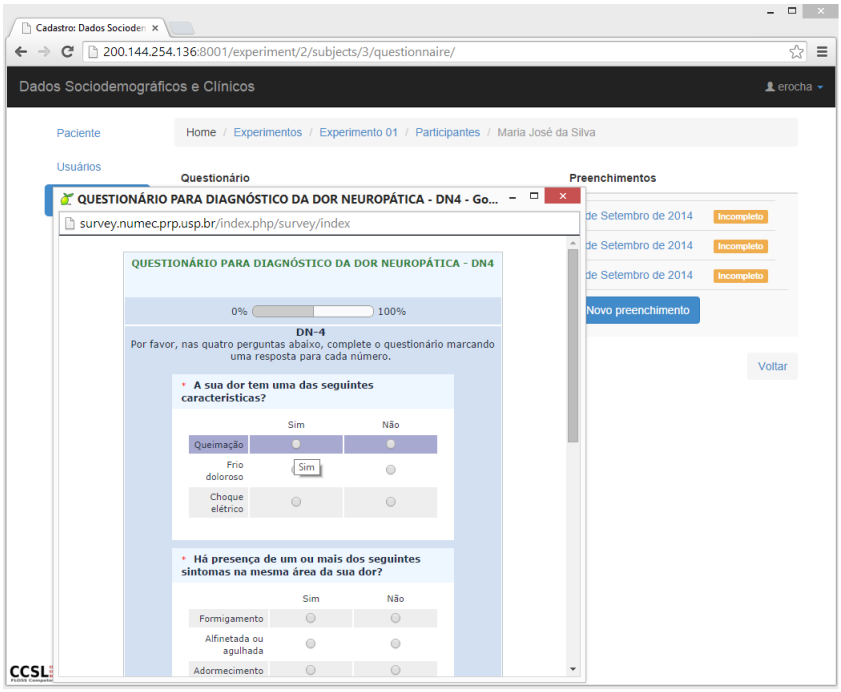

Figure 19: Experiment management – LimeSurvey integration.

Applying a questionnaire to a subject Figure 20 shows a process diagram of applying a questionnaire to a subject.

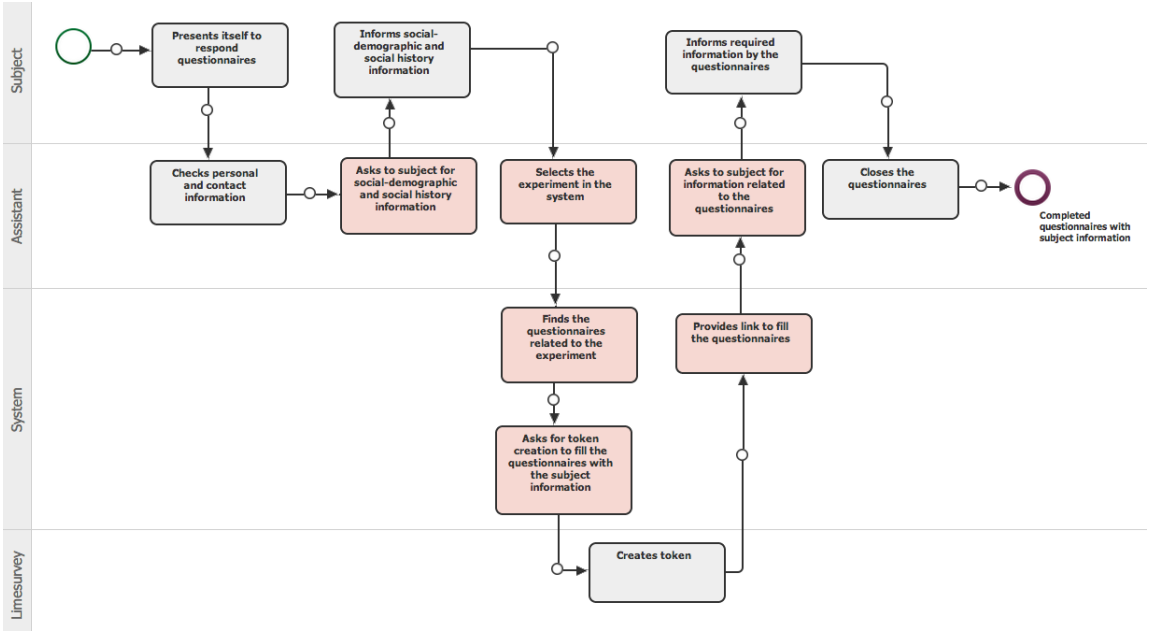

Figure 20: Applying a questionnaire to a subject.

4.2.3 About the NeuroMat Software Development Team

Several developers are currently involved in the NeuroMat software development team:

- Yoshio Mori – undergraduate student on Computer Science at IME-USP;
- Larissa Cristina Moraes – master-degree student on Computer Science at IME-USP;
- Carlos Eduardo Ribas – expert in architecture and software development (USP employee);
- Evandro Santos Rocha – expert in architecture and software development (NeuroMAT FAPESP TT5 grant);
- Rômulo José Franco – expert in architecture and software development (NeuroMat FAPESP TT5 grant).
- Amanda Nascimento – Received TT5 grant from Nov/01/2013 to Mar/31/2014. Currently, she holds a professor position at the Federal University of Ouro Preto (UFOP).
- Dário Augusto Borges Oliveira – expert in pattern recognition and image/signal processing (NeuroMAT FAPESP TT5 grant [3]);

These professionals work under the supervision of Prof. Fabio Kon and Prof. Kelly R. Braghetto from IME-USP, and Prof. Amanda S. Nascimento, from DCC-UFOP. This team has progressively grown in the last months; in December 2013, only four people (including professors) were working with software development within NeuroMat.

The growth of the software development team may be explained partially by an increasing complexity of needs related to NeuroMat's scientific projects. Initially, there was only one main software project: the modelling and implementation of a public, open-access neuroscientific database. However, when the data requirements started to be collected, we identified the need for the creation of smaller databases and software tools to locally store and manage the data collected in the research laboratories in the project, so that they could be transferred to NeuroMat data repository posteriorly. This need conduced to the development of the clinical database for the Institute of Neurology Deolindo Couto at the Federal University of Rio de Janeiro (INDC-UFRJ) and the Laboratory Web Application.

[3]The work plan of the TT5 software engineers are attached to this report.

Extreme Programming The NeuroMat software development team has adopted a working methodology that is called Extreme Programming (XP), which is one of the best known agile development methodologies. XP was originally created by the software engineer Kent Beck in the late 1990s and is dependent on frequent exchanges between the development team and "clients," people and organizations that will effectively use the software that are being created in their work. Characteristics of XP are minimizing bureaucratic efforts, increasing flexibility, intensifying internal communication and speeding up feedbacks. The general idea is that programmers split the overall product they are developing in as many small products as possible that are continuously submitted and evaluated by the software clients; this splitting of activities rest upon an efficient planning of steps to be sequentially achieved. This programming strategy is especially suitable for small and medium-sized programming groups, since it requires intense, regular training and meeting.

Extreme Programming, as it is used within NeuroMat, puts a lot of emphasis on strong internal communication, constant feedbacks and more importantly courage. Researchers of NeuroMat have been studying this programming methodology and designed its application within the research center. Furthermore, initial training of the software development team was also conduced. In particular, courage in software development relates to acknowledging the fact that the best way to produce the best possible products is to be honest and transparent on all the possible levels, from customer communication to the way you type code despite how uncomfortable the idea of high transparency might look like at the beginning. The implementation of this value in a working group depends on having frequent meetings, that are of uttermost importance for sustaining a good and updated technical level within the team and for strengthening our bonds. The current training schedule include weekly workshops and every-other-week planning sessions.

Final Remarks In the short term, the software development team hopes to build a coherent group identity. The team is still at an initial stage, in which they are having a first contact with procedures and values of Extreme Programming. A long-run challenge is the improving of the development team within a scientific research program, in which needs, demands and priorities are evolving, and in which the actual programming and developing accrue innovation of Computer Science. Computational tools that are being developed within NeuroMat are not simply ad-hoc solutions, and there are expectations that they could lead to substantial scientific improvements and submitted for publication.

4.3 Work Plan for the Next Activities

4.3.1 Database Modelling

As the next steps in the development of the NeuroMat database, we have the modelling of four additional modules:

- Neuroimaging Data Acquisition (for MRI and fMRI studies)
- Histopathology Data Acquisition
- Molecular Data Acquisition
- Derived Data and their Provenance Information

For the modelling of these database modules, we will have to conduct a new round of interactions and discussions among project members, in order to identify and characterize the data that are worth to store.

Special attention will be given to the neuroimages and derived data, since these kinds of data are already being produced in considerable volumes in the project. In particular, we will evaluate the use of *scientific workflow management systems* (SWfMS) to design and automatize the analysis processes used to generate derived data. Some SWfMS automatically record provenance information about the analysis processes managed by them.

4.3.2 Software Development

As next steps regarding software development in NeuroMat, we have two main sets of planned activities:

1. the extension of the Laboratory Web Application, and
2. the development of the NeuroMat Data Repository (including the Web Portal Application).

For the Laboratory Web Application, the planned activities are the development of new functional features (such as the support to advanced data searches) and the implementation of software interfaces for the database modules of organizational structure, experimental protocol and electrophysiological data acquisition.

For the NeuroMat Repository and Web Portal, the planned activities are the development of data integration tools (to extract data from local laboratory databases and feed the NeuroMat central database) and web interfaces that will enable the public access to the repository data. This involves the study of tools, architecture definition, interfaces definition, development of tools and routines to support data integration and data search in large volumes of data.

In addition, since a new module will be included in the NeuroMat database to store neuroimaging data, there are also planned activities regarding the study and development of software architectures and tools to support the efficient storage and manipulation of medical images.

To support the development of the planned activities, we would like to have a new senior IT expert, as a FAPESP TT4 software engineer, in the development team. The work plan for this new expert is attached to this report.

A CEPID Neuromat goals for the first two years

The mission of the Center is to develop the new mathematics needed to construct a Theory of the Brain accounting for the full experimental data gathered by neuroscience research. The long-term objective is to understand and explain complex neuronal phenomena, with focus on plasticity mechanisms underlying learning and memory, neurorecovery and adapted rewiring. This calls for the development of a new approach —*neuromathematics*— conjoining probability theory, combinatorics, statistics, computer science and neuroscience. In this approach, a new class of mathematical models must be introduced to describe and explain in a parsimonious way the different scales of neural activity and their relationship. The construction of these models, however, should marry the simultaneous development of suitable statistical and computational methods, including model selection principles and results.

The main strength of the Center relies on its innovative combination of scientific expertise. The prospect of very successful interactions among team members is guaranteed by the recognized scientific level of the participants. In particular the Center includes a team of first-level national and international neuroscientists, mathematicians, physicists, computer scientists, statisticians and clinicians. The Center is also connected to international institutions such as the NSF Science and Technology Center for the Science of Information and the Center of Cognitive Neurosciences of the CNRS, at Lyon. This team has been reinforced by a recently awarded Capes-Nuffic agreement with M. Malessy, Professor of Nerve Surgery at the Leiden University Medical Center in the Netherlands (LUMC). Collaborative interdisciplinary partnership in progress is described in Sections 2.7–2.8 (p. 10) of the Research Project of our proposal.

The following summarizes the activities planned for the first two years.

A new mathematical framework for neuroscience

In basic mathematical research it is unrealistic to establish concrete deadlines for particular results. Rather, research plans must refer to general objectives and directions of investigation. Success in this type of research comes from the careful combination of relevant research lines with qualified teams of mathematicians. The design of the Center is based on such a combination.

The development of the long-term goal of providing encompassing mathematical bases for neuroscience research requires the initial development of two foundational aspects, which will be addressed in the first two years:

Development of a new class of stochastic processes. We propose a new paradigm for Neuromathematics based on the idea that neuronal activity must be described as a stochastic process. This approach requires the development of a new class of process. Owing to the multiscale character of neural phenomena, these stochastic processes are systems with a large number of components, linked by interactions that evolve in time and depend on the history of the system. They are not Markovian in time, the activity of each component depending on the past history of its interaction neighborhood. Moreover, both the size of the relevant past history and of the interaction neighborhood change as the process evolves. 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.

The mathematical models of these evolving interaction graphs must access both "low dimensional" and "high-dimensional" aspects of neural systems, and lead to a revealing description of brain plasticity. In particular, models should provide appropriate degree distributions, clustering coefficients, average inter-vertex distance, as well as scale-free properties of the neural networks. Furthermore, evolutions should illustrate "repair mechanisms" of the brain, that is, change in graph properties due to localized destruction and the transitions leading to (partially) restored functionality.

The development of this new probabilistic theory is essential for a mathematical description of brain plasticity. A fundamental objective of the Center in the first two years is to lay down its foundations.

Development of the statistical tools required by this new class of stochastic processes. Brain activity is underpinned by a double graph structure: physical graphs defined by actual connections between neurons and brain regions, and functional graphs relating regions recruited for each particular activity. While the physical graphs can be directly observed, interactions between neural structures can only be inferred from data. Traditionally, this has been done using descriptive statistical methods which give little insight on the mechanism underlying the dynamics of the neural activity. The alternative to this naive descriptive statistical approach is to assign models to samples of neural data at different scales. Inference and model selection within this framework requires the development of new statistical results.

From a practical point of view, an inference problem can only be considered to be effectively solved if the resulting estimator is computationally efficient as well as theoretically sound. Progress in these directions will require cooperative work of computer scientists, mathematicians and statisticians. The NeuroMat team has the right blend of expertise needed to face this challenging issue. In the first two years, the Center aims to make noticeable progress in this direction.

A São Paulo School on Advanced Sciences on Neuromathematics. A proposal for a FAPESP advanced school will be submitted in the second year of the project. The research developed in the Center will require a new combination of skills, and the school will play an important role in attracting and giving the initial training to talented young researchers that will be able to join the team.

Technology transfer in years 1 and 2

The first activity of the Center in technology transfer will be the development of a collection of open source tools for basic neuroscience research, databases handling and clinical practice, in particular with respect to diagnostics and rehabilitation of stroke patients. These will evolve in tandem with the theory up to a point where sufficient utility can be amassed into an useable product.

The initial stage will be gathering typical data, in order to design, implement and test fundamental algorithms for data handling. These will be packaged into reusable containers, mostly libraries and possibly plug-ins for existing software products. The construction of test drivers will yield some experience on the useful characteristics of a productive user interface. The technology produced by the project will be released as free and open source software in all stages.

The initial two years will be highly experimental in the software front, and will comprise: (1) Data normalization within the project, with adoption of international open standards wherever applicable; (2) surveying existing products that may provide hooks and interfaces to the project yield; (3) implementing algorithms and incorporating the ensued software into the research cycle; (4) disseminating this production as free and open software, scientific and technical papers and workshops for medical and therapy personnel of Lucy Montoro and other rehabilitation centers, and to interested professionals.

Education and knowledge dissemination in years 1 and 2

The Center will produce instructional tools for general audiences, students at several levels and researchers in mathematics and neuroscience. These include: (1) Interactive contents for the web portal of the Center (already under construction), including texts, demonstrations, kits, exhibitions and videos; (2) communication channels with researchers, students, teachers and other interested parties; (3) videos on neuromathematical issues, made available on internet and exploiting the agreement with public TV channels of Fundação Padre Anchieta, TV Cultura and UNIVESP; (4) exhibitions and shows on Neurosciences at Science Centers and Museums of USP and UNICAMP, schools, Lucy Montoro Rehabilitation Network and other health centers and public places; (5) organisation of courses for teachers of mathematics and science to allow for future inclusion of neuromathematical topics in school curricula.

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