RIDC NeuroMat

Third Report of Activities

July 2015 - July 2016

Contents

1 RIDC NeuroMat Identification

The Research, Innovation and Dissemination Center for Neuromathematics (RIDC NeuroMat) is a center of mathematics whose mission is to develop the new mathematics needed to construct a Theory of the Brain accounting for the experimental data gathered by neurobiological research. Established in 2013, the center is coordinated by mathematician Antonio Galves, hosted by the University of São Paulo, and supported by the São Paulo Research Foundation (FAPESP), grant 2013/07699-0.

The RIDC NeuroMat team is interdisciplinary, bringing together researchers in mathematics, computer science, statistics, neuroscience, biology, physics and communication, among other disciplines. NeuroMat leads a worldwide university network, composed of several high-level research institutions in Brazil, Latin America, the United States and Europe. Most research output has co-authors from more than one country, contributing to place NeuroMat at the center of a blossoming international scientific cooperation around Neuromathematics.

Alongside a research team that focuses on the scientific challenges pertaining to Neuromathematics, NeuroMat has active technology-transfer and dissemination teams.

The technology-transfer activities are driven by NeuroMat's scientific long-term objective, that is, to explain complex neuroscientific phenomena, with focus on plasticity mechanisms underlying learning and memory, neurorehabilitation and adapted rewiring. With this challenge as compass point, NeuroMat technology-transfer effort develops initiatives on neuro-rehabilitation and diagnosis, as well as on the development of open-source computational tools for neuroscience research.

The dissemination team has as guideline to work as a collaborative web-2.0 hub, that at the same time improves available scientific content to the general public and fosters a community for science. The dissemination effort makes its own media, working at the scientific frontier of science communication.

A.C. R. da Silva Filho (USP), C. D. Vargas (UFRJ), E. Hamburger (USP), F. da Paixão (UNICAMP), J. Stolfi (UNICAMP), P. A. Ferrari (USP), and Y. Kohayakawa (USP) are co-PIs, along with PI A. Galves (USP). B. Bollobás (Cambridge/Memphis), C. Newman (NYU), D. Brillinger (UC Berkeley), L. Cohen (National Institute of Neurological Disorders and Stroke) and W. Szpankowski (Purdue/NSF CSoI) take part in NeuroMat's International Advisory Board.

NeuroMat's main laboratory and offices are located on a three-story building with 800 square meters, at 1171 Prof. Luciano Gualberto Avenue, at USP's central campus in São Paulo. This building is currently going through an extension (+175 square meters) and renovation to support new laboratory facilities. The construction cost is estimated at BRL R$ 1,603,339 and is fully covered by USP, MaCLinC grant (recipient: Antonio Galves). NeuroMat's administrative staff is composed of an executive manager, two administrative assistants and an IT professional. These positions are supported by USP.

2 Scientific report

The RIDC NeuroMat's scientific mission is to build the new mathematical, statistical and computational framework which is necessary to address the challenges of neurobiology.

At its inception, NeuroMat submitted to FAPESP the document "Goals for the first two years", which announced the following scientific goals for the center's first two years of activities:

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

Detailed progress on these two goals was reported in the documents "First Report of Activities 2013-2014", "Second Report of Activities 2014-2015", "Complementary Form 2013-2015" and in the Evaluation by FAPESP International Committee in November 2015.

The progresses achieved in the first two years opened up the path for a new stage of development. In its third year, NeuroMat started the construction of innovative applications of the new stochastic models and statistical tools developed in the previous years, aiming at concrete questions of neuromathematics and computational modeling in neurobiology, electroencephalographic recordings analysis, and neurorehabilitative therapy.

2.1 A new stochastic model for biological neural networks: systems with interacting stochastic chains with memory of variable length

In the short report "Complementary Form 2013-2015", NeuroMat announced the successful fulfillment of the first goal, *Development of a new class of stochastic processes*, with the development of a new class of stochastic processes to model systems of interacting neurons. The starting point was the new model introduced in the article written by Galves and Löcherbach "Infinite Systems of interacting chains with memory of variable length - a stochastic model for biological neural nets" (see (1) in Annex 1d).

Until July 2015, the new direction of research initiated by this model had already given rise to five new scientific articles (see (11) and (28) in Annex 1a; and (2), (5) and (10) in Annex 1b), one postdoctoral project (detailed information is provided on Annex 8) and four PhD projects (detailed information is provided on Annex 9).

In this report period, since July 2015, this new direction of research originated four more new scientific articles (see (25), (28), (30) and (34) in Annex 1b), totalizing ten scientific articles that together sum up to more than 74 citations as compiled by the Google Scholar (until September 23, 2016). Eight new postdoctoral projects were started (detailed information is provided on Annex 8).

A worldwide reflect of this interest was the creation of a new research group within the International Neuroinformatics Coordinating Facility (INCF), the "Special Interest Group on Stochastic Modeling of

Neural Systems". This group, created and coordinated by NeuroMat, aims to serve as an international hub for researchers interested in mathematical issues in neuroscience involving models that are fully stochastic or that include some stochastic component.

2.2 Stochastic modeling of the statistician brain conjecture: stochastic processes driven by context tree models

Regarding the second goal *Development of the statistical tools required by this new class of stochastic processes*, in the short report "Complementary Form 2013-2015", NeuroMat had announced its successful progress with the development of a new statistical approach to address the conjecture that the brain operates as a statistician, assigning models to external stimuli by a procedure which is reminiscent of statistical model selection. A new experimental protocol to address this conjecture was designed, and empirical evidence was found that the brain does statistical model selection, a major breakthrough.

In this report period, since July 2015, a new article was written by Duarte, Fraiman, Galves, Ost and Vargas "Retrieving a hidden context tree model from EEG signals" (see (9) in Annex 1b), presenting this new statistical approach, experimental protocol and the results achieved. Advancements on *the Goalkeeper Game*, the NeuroMat computer game developed to addres this new experimental protocol, are presented in the *Technology transfer report* section of this report.

This line of research has produced until now three PhD dissertations and one post-doctoral project (detailed information is provided on Annexes 8 and 9).

Based on the theoretical results presented by Duarte et al, a new therapeutic prototype is presently being developed with brachial plexus lesion patients at UFRJ hospital Instituto de Neurologia Deolindo Couto, as part of NeuroMat's technology transfer iniciative on *Plasticity in brachial plexus avulsion*, coordinated by NeuroMat PI C. Vargas. Detailed information on this strategic initiative is provided in the *Technology transfer report* section of this report.

2.3 NeuroMat's scientific production

Since the last report "Second Report of Activities 2014-2015", the NeuroMat research team has:

- published or received acceptance for 29 papers;
- submitted or uploaded to arXiv 31 papers;
- 7 communications in meetings with referee.

Therefore, from its inception until July 2016, the NeuroMat team published or received acceptance for publishing of a total of 67 papers, submitted or uploaded to arXiv 31 papers and 15 communications in meetings with referee. This scientific papers sum up to 129 citations as compiled by Google Scholar

(until September 23, 2016). The complete lists of published, accepted, uploaded to arXiv or submitted papers and communications are provided in Annex 1.

In the Annexes, we also present updated information on:

- Annex 2 - NeuroMat's scientific publications citations
- Annex 8 - NeuroMat's post-doctoral fellows
- Annex 9 - NeuroMat's PhD dissertations
- Annex 10 - NeuroMat's MSc dissertations

2.4 NeuroMat new research facility: the High-Performance Computational Center

In April 2016, NeuroMat launched a new research facility: the NeuroMat High-Performance Computational Center. The simulation of large-scale network models remains a key activity to test analytical results, and the NeuroMat HPC will be a laboratory allowing for such tests, providing the NeuroMat team with a new experimental tool to test and construct large-scale computational implementations of NeuroMat newly developed models (over 100,000 neurons). The NeuroMat HPC is installed at the Laboratory of Neural Systems (SisNe) of the Department of Physics of USP Ribeirão Preto, under the direction of NeuroMat PI and Technology transfer coordinator A.C. R. da Silva Filho (USP-Ribeirão Preto).

To fully explore the scientific and experimental potential of this new facility, NeuroMat organized the Workshop "High-Performance Computing, Stochastic Modeling and Databases in Neuroscience" from April 25-29, 2016. The workshop had the participation of representatives of the main world brain initiatives - the BRAIN Initiative and the Allen Institute (USA), the Human Brain Project and the Virtual Brain (Europe), the Brain/MINDS (Japan) and the International Neuroinformatics Coordinating Facility. The program is available at neuromat.numec.prp.usp.br/hpcneuro, and a complete list of the lecturers and participants is provided in Annex 6.

2.5 NeuroMat's scientific meetings and schools

The model introduced in Galves and Löcherbach (2013) has as one of its components a graph of interactions between regions in the brain in several scales. The features characterizing the graph of interactions at different scales are one of the most important open questions in science. To address this question, NeuroMat organized the workshop "Random Graphs in the Brain," which took place from November 23-27, 2016. The workshop was coordinated by NeuroMat members C. Pouzat, A. Galves and C. Vargas, along with R. van der Hofstad. The program is available at neuromat.numec.prp.usp.br/rgbrain, and the complete list of the lecturers and participants is provided in Annex 6.

In January 2016, NeuroMat organized the VI Edition of the Latin American School on Computational Neuroscience (LASCON). LASCON is the first and foremost school of computational neuroscience in

Latin America. It is a biennial school aimed at introducing advanced undergraduate, graduate students and young researchers to the use of mathematical and computational methods for modeling neurons and neural networks of the brain. It is an intensive four-week school with morning, afternoon and evening activities. The faculty is composed of researchers with large experience in computational neuroscience and the use of these programs.

LASCON's creator and director is the NeuroMat PI and Technology Transfer Coordinator, A.C. R. da Silva Filho (USP-Ribeirão Preto). The full program can be seen at www.sisne.org/lascon, and the complete list of lecturers and participants is provided in Annex 6.

In April 2016, NeuroMat organized the Workshop "High-Performance Computing, Stochastic Modeling and Databases in Neuroscience", as detailed in the previous subsection *NeuroMat new research facility: the High-Performance Computational Center*.

In June 2016, NeuroMat organized the Second Thematic Day NeuroMat: "Statistic, probabilistic and computational methods in neurobiology". The program and complete list of lecturers is provided in Annex 6.

2.6 NeuroMat's global scientific research team

The scientific achievements reported here remain the expression of a cohesive and collaborative global network of research and exchange. This network brings together scientists from universities in Europe — France, Italy, Netherlands, United Kingdom —, Latin America —Argentina, Brazil, Uruguay — and the United States. The NeuroMat global network of scientific and institutional affiliations is provided in Annex 3.

A vast proportion of NeuroMat's research production has had co-authors from more than one country, thus contributing to put FAPESP's RIDC NeuroMat as a relevant player in the global field of Neuromathematics. An illustration of the international network that NeuroMat is embedded in and is fostering is provided in Annex 4, and information on the scientific missions undertook by the NeuroMat research team is provided in Annex 5.

3 Technology transfer report

NeuroMat's technology-transfer effort is intrinsically related to the scientific long-term objective stated in the original scientific project of NeuroMat:

"NeuroMat's long-term objective is to explain complex neuroscientific phenomena, with focus on plasticity mechanisms underlying learning and memory, neurorehabilitation and adapted rewiring."

"Post-injury plasticity state of art is still at a phenomenological stage."

To build a conceptual framework for this phenomenology has been the compass point of NeuroMat's technology-transfer activities.

In the document "Goals for the first two years", NeuroMat announced the following initial guidelines for the technology-transfer activities:

"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 usable product."

In accordance, NeuroMat's technology transfer activities can be divided in two fronts:

1. Neuro-rehabilitation and diagnosis front.
2. Computational tools front.

3.1 Neuro-rehabilitation and diagnosis

NeuroMat's current initiatives on Neuro-rehabilitation and diagnosis are:

- Plasticity in brachial plexus avulsion;
- Psychosis and psychiatric illnesses;
- Plasticity in Parkinson's disease.

3.1.1 Plasticity in brachial plexus avulsion

The initiative on "Plasticity in brachial plexus avulsion" has been successfully underway since the inception of the RIDC NeuroMat, coordinated by NeuroMat PI C. Vargas. This initiative is intrinsically associated to the development of the experimental protocol presented in the article by Duarte, Fraiman, Galves, Ost and Vargas (see (9) in Annex 1b).

Based on the theoretical results presented in this paper, a new therapeutical prototype is presently being developed. This prototype aims at estimating brain modifications after brachial plexus lesion and its surgical reconstruction employing EEG methods, and is based on a new computer game being

developed by NeuroMat since June 2015, *The Goalkeeper Game* (details on this game are provided in the subsection *The Goalkeeper Game*). This protocol will also be tested as a rehabilitation tool to contribute to functional gain.

During the last year, the associate NeuroMat laboratory of Neuroscience and Rehabilitation has shown that patients with brachial plexus injury (BPI) have altered upright balance (Souza et al., 2016 - see (17) in Annex 1a). Furthermore, in BPI patients the analysis of empirical functional correlations between neighbouring voxels in the primary motor cortex revealed faster correlation decay as a function of distance in the region corresponding to the arm as compared to the control group. This suggests that the lack of motor synergies induced by the total limb disconnection strongly disorganises the corresponding motor maps in the brain (Fraiman et al., 2016 - see (11) in Annex 1b) and also affects postural control (Souza et al., 2016 - see (17) in Annex 1a). We now seek to model these devastating plastic effects in the brain induced by peripheral lesions with mathematical tools.

3.1.2 Psychosis and psychiatric illnesses

The initiative on "Psychosis and psychiatric illnesses" has been successfully underway since the inception of the RIDC NeuroMat, coordinated by NeuroMat Distinguished Investigator S. Ribeiro. The use of Graph Theory on psychiatric research has as objective to describe and quantify the structure of the flow of thoughts, as expressed on verbal accounts, to help diagnosis.

This representation allows for mathematical features that successfully describe the typical speech structures from schizophrenia or bipolar mood disorder, with sensitivity and specificity above 90%. A similar analysis also separates with success Alzheimer's disease patients from other patients with less marked cognitive disorders. Currently, S. Ribeiro's team is applying this approach to map the cognitive decline that follows the first psychotic episode, still in the adolescence, in order to establish the early symptoms that allow for an early intervention.

3.1.3 Plasticity in Parkinson's disease

Since November 2015, NeuroMat has been developing a new research and technology transfer activity with the team led by the NeuroMat member M.E.P. Piemonte (USP Faculty of Medicine and Associação Brasil Parkinson), on the subject "Plasticity in Parkinson's disease".

This new initiative already produced concrete results that coherently meet NeuroMat's scientific ambitions:

1. Development of a new experimental protocol associated to Parkinson's disease plasticity mechanisms: this new experimental protocol aims to address the diagnosis and evaluation of the Parkinson's disease stage and progression. A pilot study associated to this protocol is underway with Parkinson's disease patients at Associação Brasil-Parkinson and USP Faculdade de Medicina, with the acquisition of data samples from these patients.

2. Creation of NeuroMat's Network of Support to Friends and People with Parkinson's Disease (Rede de Apoio NeuroMat a Amigos e Portadores de Doença de Parkinson - AMPARO): this network aims to promote health care and treatment in Parkinson's Disease. It has as main activities:

    - monthly health care trainings for people with Parkinson's Disease, relatives and caretakers.
    - monthly best practices lectures for Parkinson's Disease health professionals.
    - the establishment of a Brazilian network of Parkinson's Disease associations, health professionals and patients, to be extended to a Latin-American network in the medium term.
    - the development of a public health care line for Parkinson's Disease. Currently, there is no health care line for Parkinson's Disease at SUS - NeuroMat intends to develop a new public health care line for Parkinson's Disease.
    - the establishment of an on line platform to promote and organize the network's actions (amparo.numec.prp.usp.br).

Given the success of AMPARO, NeuroMat intends to expand this initiative to also embrace Brachial plexus avulsion patients. The creation of a NeuroMat network to support Brachial plexus avulsion patients is already being planned and underway.

3.2 Computational tools

The NeuroMat technology transfer effort on computational tools is focused on developing free and open-source software tools to manage and compile experimental and clinical neuroscience data, in order to enable scientists to store their data in a standardized and secure manner, and to provide retrieval facilities to the users who want to access these data.

This high-quality scientific data that is being collected and generated in the scope of the project, after the anonymization of the sensitive information, will feed an open database that will be made publicly available via a Web portal. While public scientific data repositories are common in other knowledge areas, they are still rare in neuroscience; thus, the NeuroMat technology-transfer effort aims at contributing to change this scenario.

The three mains initiatives on this front are:

- the Neuroscience Experiments System (NES);
- the Goalkeeper Game;
- the NeuroMat Open Database for neuroscientific data.

3.2.1 The Neuroscience Experiments System (NES)

The Neuroscience Experiments System (NES) is a free software for the collection and management of clinical and experimental neuroscience data. NES is, to the best of our knowledge, the only open source software for neuroscience data that:

- unifies data from different natures (clinical, electrophysiological, imaging, behavioral, etc.);
- allows for the verification and reproduction of experiments and its results;
- records provenance data from the experiment protocol until the generated experiment data.

In February 2016, NES team implemented a new software development management method called SCRUM, to speed up the creation of new functionalities and improve the development process. Progress on the development of new functionalities is provided in Annex 11.

Currently, NES Version 1.0 is installed in the Laboratory of Neuroscience and Rehabilitation (LNR) of the Institute of Neurology Deolindo Couto (INDC-UFRJ). In comparison to the previous version, which already supported features for patient clinical data, electronic questionnaires and the representation of research projects and experimental protocols, this new version offers the Electrophysiology Module, which allows for the collection, management and reproducibility of data from electroencephalography, electromyography and transcranial magnetic stimulation experiments. It also offers features for data export in a standardized format, and for search engine tools.

The NES development team, led by NeuroMat member K. Braghetto (USP), has been actively presenting these NES latest features in national and international congresses (see Annex 12).

It is also worth noting that in May 2016, NES was included among the INCF neuroscience computational tools (github.com/INCF/nes).

3.2.2 The Goalkeeper Game

The Goalkeeper Game is a computer game being developed by the NeuroMat team since June 2015, associated to the experimental protocol being developed in the“Plasticity in brachial plexus avulsion” initiative. In this game, brain signatures are evaluated through the performance of the participant in guessing the next direction chosen by the penalty-taker. The system records the sequence of guesses of the player, who must identify the context tree model used by a virtual penalty-taker.

In this way, the game allows for cheap and large-scale reaction time and error rate data collection, offering an alternative and complementary means to infer about brain functioning. The beta version is freely available at game.numec.prp.usp.br.

Alongside its experimental aspects, the game addresses a new mathematical challenge interesting by itself: the learning processes and decision-making models used by the player, and has been presented in dissemination events such as USP’s Virada Científica 2015.

Currently, the game is undergoing the development of new features to better address the therapeutic prototype associated with Brachial plexus lesion, and a new version is being developed to address the new experimental protocol on Plasticity in Parkinson's Disease. The game's homepage was reformulated to host this new fronts of the game (game.numec.prp.usp.br) and a new version for smartphone is being planned.

3.2.3 Open Database for neuroscience data

In NeuroMat's original scientific project, an open database for neuroscientific data was planned:

"a new Data Analysis Laboratory will be implemented."

This is being done with Brachial Plexus Avulsion, Psychosis and psychiatric illnesses and Parkinson's Disease data. The data generated and collected through these NeuroMat's initiatives are anonymised for sensitive information and feed a database that will be made publicly available via NeuroMat's Web portal. Currently, the new Web portal project is being developed to restructure NeuroMat's actual homepage to harbour this database, with open access and features for data retrieval and analysis.

4 Dissemination report

NeuroMat's dissemination activities have as guideline to work as a collaborative web-2.0 hub, developing web-2.0 media tools as a means of communicating on-the-go scientific endeavors as well as involving a scientific and broad community around the high-level science that this RIDC develops.

The dissemination team is committed on the development of a new language for NeuroMat's communication and education efforts, so as to bring the scientific frontier to general audiences. As part of this effort, the dissemination team creates its own media, like the Web Portal and the newsletter, promotes educational activities in schools and invests in the use of collaborative electronic platforms, like Wikipedia, to improve science contents available to the public. NeuroMat's dissemination activities are:

- the Wikipedia Initiative
- the Wikimedia Commons Initiative
- Training course for teachers
- Media Exposure and Newsletter
- Web resources: portal, Facebook page, dissemination blog
- NeuroCineMat
- Research on Communication Science
- Dissemination events
- Exhibitions

4.1 Wikipedia Initiative

NeuroMat's Wikipedia Initiative has become a strategic activity at the interface of communication and education. It has been recognized in Brazilian and foreign outlets as "success case" of the use of Wikipedia and other collaborative projects as a means of scientific dissemination. The project has been supported by seven scholarships and has been able to secure two small external grants, as described in Annex 13.

Achievements of this initiative from its inception om March 2016 to September 2016 are presented on Annex 14. Main achievements are:

- 44,413 content readers on Portuguese and English Wikipedias;
- 798,052 characters added to Portuguese and English Wikipedias;
- 22 entries created on Portuguese and English Wikipedias; and

- 32 entries improved on Portuguese and English Wikipedias.

The control panel of the NeuroMat Wikipedia Initiative is available at: goo.gl/v4Q1LD .

4.2 Wikimedia Commons Initiative

NeuroMat has been engaged in uploading media files to the open repository Wikimedia Commons. As of September 2016, 782 files had been uploaded by the NeuroMat team in this repository.

Files NeuroMat added to Wikimedia Commons were viewed 2,033,965 times in August. In July and June, views were respectively 1,810,954 and 2,084,925. These figures are obtained from the web visualization control tool GLAMorgan (goo.gl/obFhKV).

4.3 Training course for teachers

Since July 2015, the NeuroMat educational effort has been directed towards the development of new educational strategies to broaden its outreach and impact on the public education system. As an outcome, NeuroMat has established as the strategic guideline of its educational activities the development of free and widely available online materials and lectures to empower the public school teachers to understand the state of art in the scientific interface between neurobiology and mathematics, and to develop science related activities with students in their classrooms.

The development of these materials encompasses educational texts and videos, as well as lessons plans and classroom activities. This effort is being collectively thought and designed by the NeuroMat educational team with public school teachers from Escola de Aplicação of School of Education of the University of São Paulo and undergraduate students from the Institute of Mathematics and Statistics from University of São Paulo.

4.4 Media Exposure and Newsletter

Activities from FAPESP'S RIDC NeuroMat were featured in fifty three external media outlets since its inception, in 2013. Since July 2015, there have been twenty four media publications, including a four-part series on NeuroMat's innovative effort in scientific dissemination (Pensar a Educação, produced by the Federal University of Minas Gerais) and a general presentation of the exhibition "Body Maps in the Brain," at Museu do Amanhã. Coverage from FAPESP and USP media outlets have been continuous. NeuroMat's media clipping for this year is attached to this report as Annex 15.

NeuroMat's newsletter has had 32 issues since it was first released in February 2014. It runs monthly, generally being sent to subscribers at the end of each month. It is distributed to around 620 people, always in English. NeuroMat's newsletter compilation is attached to this report as Annex 16.

4.5 Web resources: portal, Facebook page, dissemination blog

NeuroMat's web portal was launched in early February 2014, and is thought of as the main official reference of the RIDC. It provides robust updates on research, technology transfer and dissemination activities. Publications are in English and Portuguese. Around 15,000 different users –55% of whom were identied as non-Brazilian users– have visited NeuroMat's webpage since its inception, with 80,568 page views, as of September 20, 2016. Average session duration is approximately 3 minutes and a half, with a bounce rate of 52,41%. A website analytics report is attached as Annex 17.

NeuroMat's Facebook page was launched in September 2014 to serve as a reference space for the diverse community that is involved with and interested in Neuromathematics. Since its creation (9/20/2014), the page has reached approximately 715 likes, as of September 20, 2016, with steady progress. The community growth has been organic.

Since April 2016, the NeuroMat dissemination team has sustained a blog on scientific challenges and activities pertaining to science communication, especially relying on web-2.0 platforms. The blog is called "Traço de Ciência." The blog has been viewed 1,819, since its inception as of September 20, 2016. Over 50 posts were published on this platform in the period of activities that is reported in this document; this figure is illustrated on Annex 18.

References are:

- web portal: neuromat.numec.prp.usp.br
- Facebook page: www.facebook.com/neuromathematics
- blog: difusaoneuromat.wordpress.com

4.6 NeuroCineMat

The NeuroMat dissemination team has fully produced two movies — on spike sorting (2015) and on the Latin American School on Computational Neuroscience (to be launched). Three other movies are under production: on open science, on an experiment on brain functioning and rhythms, and on the trajectory of Ernesto Hamburger. A movie on NeuroMat's initiative on Parkinson disease is being planned as of September 20, 2016.

4.7 Research on Communication Science

The NeuroMat dissemination team has produced one scientific publication and presented two conference papers, included in the annals of the Brazilian Congress of Communications Science (Intercom). A draft is being produced, and three research works are under progress. Details of the research activity of the NeuroMat dissemination team are described on Annex 19.

4.8 Dissemination events

In June 9, 2016, the NeuroMat dissemination team has directly organized the Roundtable: Challenges of Scientific Dissemination (University of São Paulo), with Antonio Galves, Marcos Nogueira Martins, André Frazão Helene, Fernando da Paixão, João Alexandre Peschanski, Mariluce Moura and Martha Marandino.

Reference: neuromat.numec.prp.usp.br/dc_hamburger.

4.9 Exhibitions

The exhibition "Inside the Brain," at the Museum of Veterinary Anatomy, is expected to be inaugurated at the end of 2016. This exhibition was the basis for an extended partnership between NeuroMat and the Museum of Veterinary Anatomy, that resulted in what is called a GLAM project, the publication on Wikimedia Commons of the museum image repository, photographed by a University of São Paulo journalism professor. This activity has sparked intense media interest.

NeuroMat PI C. Vargas has done the scientific coordination of the exhibition "Esporte Cérebro", at Museu do Amanhã, in Rio de Janeiro, from August 2 to October 2, 2016.

5 Annexes

Annex 1 - NeuroMat Scientific Publications

Annex 1a - Articles published or accepted for publication

Annex 1b - Articles submitted or uploaded to arXiv

Annex 1c - Communications in meetings with referee

Annex 1d - Articles published or accepted since NeuroMat's inception until July 2016

Annex 1e - Communications in meetings with referee since NeuroMat's inception until July 2016

Annex 2 - NeuroMat Scientic Publications: Citations

Annex 3 - NeuroMat global network of scientific, institutional affiliations

Annex 4 - Graph of Interactions of the NeuroMat Research Team

Annex 5 - Scientific missions

Annex 6 - Scientific meetings and Schools

Annex 7 - Seminars

Annex 8 - Post-doctoral fellows

Annex 9 - PhD dissertations

Annex 10 - MSc dissertations

Annex 11 - NES development report

Annex 12 - Communications in meetings with referee from the NES development team

Annex 13 - NeuroMat's Wikipedia Initiative scholarships and external grants

Annex 14 - NeuroMat's Wikipedia Initiative achievements

Annex 15 - NeuroMat's media clipping

Annex 16 - NeuroMat's newsletter

Annex 17 - NeuroMat's web portal

Annex 18 - NeuroMat dissemination blog "Traço de Ciência"

Annex 19 - NeuroMat Research on Communication Science

Annex 20 - Reports from FAPESP scholarships

Annex 20a - Aline Duarte de Oliveira

Annex 20b - Guilherme Ost de Aguiar

Annex 20c - Michelle Ferreira Miranda - I

Annex 20d - Michelle Ferreira Miranda - II

Annex 20e - Diogo de Carvalho Pedrosa

Annex 20f - Evandro Santos Rocha

Annex 20g - Margarita Ramona Ruiz Olazar

Annex 20h - Sueli dos Santos Rabaça

Annex 20i - David Fernando Levon Alves

Annex 20i-1 - David Fernando Levon Alves - annex 1

Annex 20i-2 - David Fernando Levon Alves - annex 2

Annex 20i-3 - David Fernando Levon Alves - annex 3

Annex 20i-4 - David Fernando Levon Alves - annex 4

Annex 20i-5 - David Fernando Levon Alves - annex 5