RIDC NeuroMat

Eighth Report of Activities

Nov 1, 2020 - Aug 30, 2021

Contents

1 Highlights of the period

- **Progress in the Statistician Brain conjecture** Hernández *et al.* (2021), published in *Nature*'s journal *Scientific Reports*, appears to be an important step forward in one of the main axes of the NeuroMat scientific project, that is, the investigation of the classical conjecture that claims that the brain assigns probabilistic models to samples of stimuli. Using an innovative statistical procedure this article shows that electrophysiological signatures of the sequences of auditory stimuli generated by stochastic chains can effectively be extracted from the EEG data. This paper is an example of a virtuous cycle: starting with neurobiological questions, to produce new mathematical objects and developments, then to rely on these mathematical objects and developments to retrieve valuable information from neurobiological data.

- **Impact of COVID-19 on people with Parkinson's disease** The NeuroMat-led AMPARO initiative conducted a study to assess the impact of COVID-19 in people with Parkinson's disease. This research was headed by NeuroMat associate investigator Maria Elisa Pimentel Piemonte, relying on data collected from 14 centers distributed over all regions of the country under the coordination of AMPARO. This work has led to the publication Silva-Batista et al. (2021).

- **NeuroMat Thematic Program at Institut Henri Poincaré** NeuroMat PIs Antonio Galves and Claudia D. Vargas, jointly with associate investigators Eva Löcherbach and Christophe Pouzat, have successfully led an application for the Institut Henri Poincaré Thematic Program. From February 27 to April 7, 2023, NeuroMat will gather hundreds of scientists from around the world to discuss "Random Processes in the Brain: from Experimental Data to Math and Back", including NeuroMat International Advisory Board members. This event is an opportunity for consolidating in a global context the research agenda NeuroMat has put forward with support from FAPESP and sparking affiliated centers in other contexts, such as the the recently established Université Côte d'Azur NeuroMod Institute led by NeuroMat team member Patricia Reynaud-Bouret and in which NeuroMat PI Antonio Galves acts as a member of the think tank.

- **A new journal dedicated to the mathematical modeling of neurobiology** The scientific direction the NeuroMat team has worked on has contributed to inform the onset of a new international open-access journal called *Mathematical Neuroscience and Applications*. The chief editor is Olivier Faugeras (INRIA Sophia Antipolis) and three members of the NeuroMat scientific team have taken up the role of editors. The video that is featured on the journal front page, an interview in which Faugeras presents *MNA*'s scope and policies, was produced by the NeuroMat dissemination team.

- **Advances in TMS technology** The project led by NeuroMat PI O. Baffa Filho (USP) and R.

Ilmoniemi (Aalto) of developing a robot arm to deliver transcranial magnetic stimulation with the InVesalius neuronavigator is progressing smoothly, despite the restrictions of the pandemic. The robotic arm arrived last March 2020 when restrictions to access the laboratories were already in effect. Nevertheless, we managed to assemble the robotic arm in accordance with standards we designed and constructed. Another camera system (Polaris) was adapted to control the robot, that now accepts Polaris, Polhemus and Claron systems to record position of the head and coil. Moreover, all the routines to interface the robotic arm with the InVesalius were developed and tested. First results are impressive and performance tests are being done at the moment.

- **94,000 views on NeuroMat YouTube channel** The NeuroMat dissemination team released 173 YouTube videos in 2020 and 2021 (until July). Content on the NeuroMat YouTube channel was seen 94,000 times from October, 2020 to July, 2021. The NeuroMat investment in video making, and the associated production and view figures, was a means of spreading and deepening science dissemination in a context of new social practices and sociabilities that have emerged with the COVID-19 pandemic.

2 RIDC NeuroMat Identification

RIDC: Research, Innovation and Dissemination Center for Neuromathematics (NeuroMat)

Grant number: 2013/07699-0

Host institution: Instituto de Matemática e Estatística da Universidade de São Paulo

Associated institutions: Aalto University; Centre National de la Recherche Scientifique - CNRS (Strasbourg); Forschungszentrum Jülich; Gran Sasso Science Institute (GSSI); IBM Thomas J. Watson Research Center; Instituto de Matemática Pura e Aplicada (IMPA); National Institute of Neurological Disorders and Stroke (NIH); New York University Shanghai; Universidad de Buenos Aires; Universidad de la Republica; Universidad de San Andrés; Universidade Estadual de Campinas (UNICAMP); Universidade Federal do ABC (UFABC); Universidade Federal de Ouro Preto (UFOP); Universidade Federal de Pernambuco (UFPE); Universidade Federal do Rio de Janeiro (UFRJ); Universidade Federal do Rio Grande do Norte (UFRN); Universidade Federal do Rio Grande do Sul (UFRGS); Universidade Federal de São Carlos (UFSCar); Università di Roma "La Sapienza"; Université Côte d'Azur; Université Paris 1 (Pantheon-Sorbonne); University of California, Berkeley; Faculdade Cásper Líbero.

Webpage: http://neuromat.numec.prp.usp.br

Principal Investigator/Center Director: Jefferson Antonio Galves

Vice Director: Pablo Augusto Ferrari

Co-Principal Investigators: Antônio Carlos Roque da Silva Filho; Claudia D. Vargas; Ernst Hamburger (*in memoriam*); Fernando da Paixão; Jorge Stolfi; Oswaldo Baffa Filho; Pablo Augusto Ferrari

Education and Knowledge Dissemination Coordinator: Fernando Jorge da Paixão Filho

Technology Transfer Coordinator: Antônio Carlos Roque da Silva Filho

RIDC Executive Manager:

System analyst:

Administrative assistant: Lourdes Vaz da Silva Netto - IME/USP; Vera Lúcia Ribeiro - IME/USP

Manager of Education and Dissemination of Knowledge:

Manager of Technology Transfer:

The Research, Innovation and Dissemination Center for Neuromathematics (RIDC NeuroMat) is a center of mathematics which has as mission to develop the new mathematics needed to construct a Theory of the Brain accounting for the experimental data gathered by neuroscience research. Mathematician Antonio Galves coordinates this center. Hosted by the University of São Paulo, the RIDC NeuroMat was established in 2013, with support from the São Paulo Research Foundation (FAPESP), grant 2013/07699-0, which will last until July 2024.

The RIDC NeuroMat has an interdisciplinary team, bringing together researchers in mathematics, computer science, statistics, neuroscience, biology, physiotherapy, medicine, physics and communication, among other disciplines. RIDC NeuroMat leads a worldwide university network, with ramifications that sprawl to several high-level research institutions in Brazil, Latin America, the United States, Europe and China (Annex 1). Most research output has had co-authors from more than one country, thus contributing to put 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 effort is concentrated on devising tools for diagnosing and clinical guidelines for neurological conditions, and on developing free, open-source computational tools to manage and compile experimental and clinical data. This development team is part of a joint effort to create an international open database for neuroscientific data. The dissemination-team effort includes a nonstatic web portal (Creative Commons license), open multimedia productions and training projects with public-school teachers. A distinctive feature of this effort is that it relies on 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 bridging the high-level science that this RIDC develops and general audiences.

Pablo Augusto Ferrari (UBA and USP), Antonio Carlos Roque da Silva Filho (USP), Fernando Jorge da Paixão Filho (UNICAMP), Ernst Wolfgang Hamburger (USP, *in memoriam*), Jorge Stolfi (UNICAMP), Claudia Domingues Vargas (UFRJ), and Oswaldo Baffa Filho (USP) remain co-principal in-

vestigators, along with PI Antonio Galves (USP). David Brillinger (UCBerkeley), Francesco Guerra (Universita di Roma "La Sapienza"), Leonard Cohen (National Institute of Neurological Disorders and Stroke), Markus Diesmann (Jülich Institute of Neuroscience and Medicine), and Wojciech Szpankowski (Purdue and NSF Center for Science of Information) take part in NeuroMat's International Advisory Board. NeuroMat's main laboratory and offices are located on a three-story building, with approximately 1,000 square meters, at 1171 Prof. Luciano Gualberto Avenue, at USP's central campus, in São Paulo. NeuroMat's main building has recently gone through an extension (+175 square meters) and renovation to support new laboratory facilities; the construction cost was BRL R$ 1,603,339 and was fully covered by USP, MaCLinC grant (recipient: Antonio Galves). NeuroMat has set up a Simulation Laboratory (SimLab) at the USP's Ribeirão Preto campus. NeuroMat's administrative staff team is composed of two administrative assistants and an IT professional. These positions are supported by USP.

3 Scientific report

3.1 Mission

The mission of NeuroMat is to develop the new mathematics which is deemed necessary to account for 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 neuroscientific phenomena, with focus on plasticity mechanisms underlying learning and memory neurorehabilitation and rewiring. This Neuromathematics is envisioned, at this time, as conjoining probability theory, combinatorics, statistics, and neuroscience. This requires the definition of a full new class of mathematical models to describe and explain in a parsimonious way the different scales of neural activity and the relationship between them. The construction of these models should occur together with the development of suitable statistical and computational methods, including model selection principles and results.

3.2 Executive summary

The main goal of NeuroMat is to build the new mathematical, statistical and computational framework which is necessary to address the challenges of neurobiology. Activities presented in this report strictly relate to the goals announced in the document submitted to FAPESP in November 2012, in the third and final step of the selection process. The general goals of this research project are the following:

- Development of new classes of stochastic processes which are necessary to model brain functioning;
- Development of the statistical tools required by this new class of stochastic processes.

Detailed progresses on these two goals were exhaustively reported in the documents "First Report of Activities 2013-2014", "Second Report of Activities 2014-2015", "Complementary Form 2013-2015",

the Evaluation by FAPESP International Committee in November 2015, "Third Report of Activities 2015-2016," the "Complementary Form 2015-2017," "Fourth Report of Activities 2016-2017," the presentation "NeuroMat: first 5 next 6" to FAPESP's International Assessment Committee, the 2018 Statement of Impact (SoI), "Fifth Report of Activities 2017-2018," "Sixth Report of Activities January 2019-July 2019," and "Seventh Report of Activities August 2019-October 2020." These documents were carefully reviewed by FAPESP. The SoI is a summary of main activities and highlights our main achievements. This statement is still up-to-date and informs substantially this report, along with relevant parts of the document for the renewal of the RIDC NeuroMat by FAPESP, the "Project for the period 2018-2024."

The progresses achieved in the first term of the RIDC have opened up the path for a new stage of development. In the last year, the object of this report, in spite of all the challenges posed by the COVID-19 pandemics, NeuroMat continued with 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. Research highlights and corresponding published works are listed below, in the appropriate section. Since the "Seventh Report of Activities August 2019-october 2020", the NeuroMat research team has:

- published 57 papers;
- published pre-prints 17;
- presented 2 communications in meetings with referee;
- published 1 book;
- had 2 PhD dissertations concluded and 12 in progress;
- had 1 MA thesis concluded and 1 in progress.

NeuroMat scientific publications in the period being assessed in this report are listed on Annex 2. A full list of publications since the inception of NeuroMat can be viewed at NeuroMat's Google Scholar (`https://goo.gl/LvZV4f`). Citations to these publications across the years are available on Annex 3.

In parallel to the mathematical and theoretical biological developments which are necessary to foster the scientific project of NeuroMat, the RIDC has also sustained two laboratories. In April 2016, NeuroMat launched a new research facility: the NeuroMat Simulation Laboratory (SimLab). The simulation of large-scale network models remains a key activity to test analytical results, and the NeuroMat SimLab allows for such tests, providing the NeuroMat team with a new experimental tool to test and construct large-scale computational implementations of NeuroMat's newly developed models. The SimLab

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). In July 2017, NeuroMat launched an Electroencephalography Laboratory, with an EEG DC actiCHamp 128CH System. The creation of NeuroMat's EEG lab was made possible by the expansion of the building, through a grant from the University of São Paulo (value of support: BRL R$ 1,603,339).

3.3 Research results highlights

There are two main axes in the NeuroMat research agenda, which follow:

- the development of a new class of stochastic processes aimed at a realistic description of nets of spiking neurons;
- the introduction of a new mathematical approach to address the classical conjecture that the brain retrieves statistical regularities from sequences of stimuli.

The first axis appears to be by now a well-established area of research in Probability Theory. For instance, according to Google Scholar, there have been around 100 papers with direct references to the paper (Galves and Löcherbach, 2013). A notable illustration is the 2019 paper "Replica-Mean-Field Limits for Intensity-Based Neural Networks" by the important mathematician François Baccelli and co-author, which is dedicated to the study of a linear version of the model introduced by Galves and Löcherbach (2013). In particular, this paper has coined the name Linear Galves-Löcherbach Network (LGL). In Baccelli and Taillefumier (2020), the Galves-Löcherbach model is indicated as a keyword. In a subsequent article, Yu and Taillefumier (2021) claimed in the introduction: "Our goal is to characterize the typical distribution of $\lambda(t)$ for certain intensity-based model of neuronal networks, referred to as Exponential Galves-Löcherbach (EGL) Networks".

The second research axis reached a milestone in 2021, with the publication of "Retrieving the structure of probabilistic sequences of auditory stimuli from EEG data", published in *Nature*'s journal *Scientific Reports*. This work builds upon the NeuroMat paper by Duarte et al. (2019), to investigate a classical conjecture that claims that the brain assigns probabilistic models to samples of stimuli. If this is true, then sequences of auditory stimuli generated by stochastic chains should be encoded in the brain activity. Using an innovative statistical procedure this article shows that electrophysiological signatures of the sequences of auditory stimuli generated by stochastic chains can effectively be extracted from the EEG data. This series of papers is an example of a virtuous cycle: starting with neurobiological questions, to produce new mathematical objects and developments, then to rely on these mathematical objects and developments to retrieve valuable information from neurobiological data.

A complete list of papers is available as Annex 2.

3.4 Scientific meetings organized by NeuroMat in the period

An important aspect of the work NeuroMat produces depends on fostering a tight relationship among members of the NeuroMat worldwide. As emphasized in our interaction with FAPESP International Committee, we are especially aware of this challenge, and we have sustained partnerships among scientists from different parts of the world —of which the high rate of papers with co-authors from different countries is an evidence. The fostering of a tight community around Neuromathematics strongly meets the expectations of FAPESP's Committee.

A key part of the community-building entrepreneurship NeuroMat has sustained relates to organizing frequent conferences and meetings on topics pertaining to Neuromathematics. In the period covered by this report, we continued with this endeavor and were not stopped by the COVID-19 Pandemics. The meetings organized in the period are listed below.

During the period of activities being reported in this document, the NeuroMat team has organized the following seminars:

- The retina as a dynamical system, with Bruno Cessac (INRIA);
- Introducing elementary neurocognitive mechanisms in AI models, with Alexandre Muzy (Université Côte d'Azur).

More details on these events are available as Annex 8.

4 Technology transfer report

The main focuses of this area have been the development of supporting tools for the diagnosis and neuro-rehabilitation researches being conducted by the AMPARO and ABRAÇO initiatives on Parkinson's Disease and Brachial Plexus Injury, respectively. These tools are the Goalkeeper Game, a robot arm for accurate real-time positioning of a transcranial magnetic stimulator on the head, and the Neuroscience Experiments System (NES).

The highlight of the period was related to the robot arm development. The communication and closed-loop control systems were constructed, and now the robot can be instructed to move to a desired place on the scalp and apply the stimulation while keeping the coil on the same position even if the head moves.

4.1 Neuro-rehabilitation and diagnosis

4.1.1 ABRAÇO Initiative

NeuroMat's Brachial Plexus Injuries focus area is called ABRAÇO Initiative, or Ação NeuroMat para a Lesão do Plexo Braquial. The website of ABRAÇO is abraco.numec.prp.usp.br. This website is the first worldwide platform devoted to this health condition and is aimed at being both a source of help and support for patients, caregivers, students and professionals, and a powerful scientific knowledge sharing platform.

4.1.1.1 Assessing plasticity associated to Brachial Plexus Injuries The team led by NeuroMat CO-PI Claudia Domingues Vargas (INDC/UFRJ) is using the Goalkeeper Game (Section 4.2.1) to study mechanisms of plasticity in the brain after a brachial plexus injury aiming at developing new tools to assess plastic changes in the brain induced by this traumatic injury. In the motor context, prediction can be seen as an automatic process of choosing and implementing a next step in a sequence of events. Tests are being conducted with human subjects playing the Goalkeeper Game to determine which parameters of the context tree generating stochastic sequences of events in the Goalkeeper Game are best associated with the optimal processing of sequences of motor events. The objective is to check the possibility of using the Goalkeeper Game as a tool for rehabilitation of brachial plexus injury patients.

4.1.1.2 New transcranial magnetic stimulation protocol This endeavor involves a collaboration between Neuromat CO-PI Oswaldo Baffa Filho (FFCLRP/USP), Neuromat CO-PI Claudia Domingues Vargas (INDC/UFRJ) and R. Ilnomiemi (Aalto) for the development of a closed-loop robotic system for the positioning of a transcranial magnetic stimulation (TMS) coil on a subject's scalp (see Section 4.3.1). Besides the technological aspects of this initiative, a team of researchers led by NeuroMat CO-PI Claudia Domingues Vargas (INDC/UFRJ) is developing a new protocol to test whether the primary motor cortex

(M1) holds the memory of a sequence of TMS pulses driven by a stochastic chain. If so, it should be possible to recover in the motor evoked response (MEP) a signature of a sequence of TMS pulses applied in M1. In other words, can a sequence of TMS pulses generated by a stochastic chain be recovered on the MEP response? If so, then it would be interesting to test if this recovered signature is affected by a brachial plexus lesion.

4.1.2 AMPARO Initiative

The NeuroMat focus area towards Parkinson's Disease is called AMPARO Initiative, or Rede de Apoio NeuroMat a Amigos e Pessoas com Doença de Parkinson. The link to the website of AMPARO is amparo.numec.prp.usp.br.

4.1.2.1 A tool for early Parkinson's Disease diagnosis The team led by NeuroMat researcher Maria Elisa Pimentel Piemonte (FM-USP) is using the Goalkeeper Game (see Section 4.2.1) to study putative novel relationships between the main cardinal Parkinson's Disease symptom, bradykinesia, and implicit probabilistic learning and lack of ability in automatic motor control. The study aims at developing a new measure and typology to establish the limits between normal decline associated to aging process and abnormal alterations associated to the onset of the pathological process of Parkinson's disease. The clinical implication of this work is to offer a free and friendly test to early diagnosis of Parkinson's disease by e.g. cell phones using the Goalkeeper Game.

4.1.2.2 Collaborative network for Parkinson's disease clinical guideline AMPARO Initiative organizes monthly meetings with NeuroMat members, professionals, patients and caregivers. The goal is to share knowledge towards the collaborative building of guidelines for Parkinson's disease in Brazil, especially for the public health system. An important achievement in the period was the publication of the first multicenter trial assessing the impact of the COVID-19 pandemics on people living with Parkinson's disease in Brazil. This pioneering study involved 14 centers distributed over all regions of the country under the coordination of AMPARO.

4.2 Computational tools

4.2.1 Goalkeeper Game

NeuroMat researchers devised experimental protocols to test the performance of human subjects in identifying sequences of stimuli represented by context trees. An innovation spin-off from NeuroMat's research project is the "Goalkeeper Game". It is an online game with desktop and mobile device versions in which the player, taking the role of a goalkeeper in a penalty shootout, guesses the position in the goal where the ball will hit (left side, right side or center) after being kicked by the opponent. The game consists in a sequence of penalty kicks in which the ball positions are generated by a context tree model. As

the player (the goalkeeper) succeeds in guessing the right sequence, the complexity of context tree model increases and the game becomes more difficult. The goalkeeper game has potential to be used as diagnosis and rehabilitation tool in neurology, and the NeuroMat technology transfer team is currently testing its applicability in its two main clinical development fronts: Parkinson's Disease and Brachial Plexus Injuries (see Sections 4.1.2.1 and 4.1.1.1). The game is openly, freely available at: game.numec.prp.usp.br and also at Apple Store and Google Play. The development team of the Goalkeeper Game is led by the Associate Investigator M. D. Gubitoso (IME/USP).

4.2.2 Neuroscience Experiments System

The Neuroscience Experiments System (NES) is a free software to manage data and metadata from neuroscience experiments. It integrates data records from different types such as clinical, electrophysiological, and behavioral. NES is currently being used by the teams involved in both ABRAÇO (Section 4.1.1) and AMPARO (Section 4.1.2) initiatives. NES is integrated to the Goalkeeper Game (Section 4.2.1) and to the NeuroMat Open Database (Section 4.2.3). The main functionalities, which include Electrophysiology and Export modules, were improved in the period, and modules that deal with the data using machine learning are being developed. The development team of the Neuroscience Experiments System is led by the Associate Investigator K. R. Braghetto (IME/USP).

4.2.3 NeuroMat open database

The NeuroMat open database provides an open-access platform for sharing and searching data and metadata from neuroscience experiments. The platform is constituted by a web portal and a REST (Representational State Transfer) API (Application Programming Interface). The web portal was designed to have a user-friendly interface. The REST API is used to feed the open database with experimental data generated by NeuroMat's researchers. Currently, the API intermediates the receiving and retrieving of data from research laboratories which use NES (Section 4.2.2). It can be can easily adapted to receive (or transfer) data from (for) other client systems. The development team of the NeuroMat open database is led by K. R. Braghetto.

4.3 Hardware tools

4.3.1 Closed-loop system of robotic stimulator positioning in the brain

The effect of transcranial magnetic stimulation (TMS) on the brain is highly specific; variations of the order of 1 mm in the positioning of the coil evoke substantially different responses. Currently, the coil is positioned manually through neuronavigation, which causes variations in the observations according to the experimenter. In addition, the patient being awake throughout the procedure performs small involuntary movements, even with the head secured on a support. If the patient moves during stimulation, the stimulator must be repositioned. As a solution to this problem, robotic arms have been used to help

position the TMS coil. Robotic positioning also enables the development of new methods for automated motor mapping. However, the combination of TMS and the robotic arms is not yet commonly used by the clinical and scientific communities due to three main factors. The first is low portability, that is, the systems are fixed and cannot be transported between rooms and clinics. The second is the high cost of commercial equipment. And the third is that commercial navigation programs are closed, making it impossible for new tools to be developed. A closed-loop system is a set of mechanical or electronic devices that automatically regulates a variable to a desired state, without human interaction. Closed-loop systems are designed to automatically achieve and maintain a desired condition (exit condition), comparing it to its condition at the given moment (real condition). The comparison is made using an error signal, which is the difference between the output and the reference input.

In the period, the team led by NeuroMat PI O. Baffa Filho and R. Ilmoniemi finished the assembling of two robot arms in their stands. The first set-up was a table like stand and the second used a wheeled stand with a wider free area. The main achievement was the construction of communication protocols within the InVesalius software to operate the robot arms. It is now possible to instruct the robot to move to a certain position in the scalp and to stimulate a specific area of the brain in an open loop configuration. The first version of the closed loop control was also tested, and it is possible to keep the coil in the same position even if the head moves. This step is now being refined with developments in the instrumentation and in the software. From the instrumental side it is necessary to add a new safety layer using an external force sensor that will disengage the robot arm if the coil touches the head and exerts a force greater than 1 N. From the software side it is needed to test stability and other issues.

5 Dissemination report

NeuroMat's dissemination activities have as a compass point working as a collaborative 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. Activities are envisioned to use innovative means to transform scientific culture, overcoming artificial field boundaries and contributing to foment an integrated and genuinely multidisciplinary approach to the study of the brain. These activities have seen a significant increase in production and viewers in the context of the pandemic.

NeuroMat's milestone dissemination activities include in the period of interest:

- the *A Matemática do Cérebro* podcast
- the Wikipedia Initiative
- the Wikimedia Commons Initiative
- Media Exposure and Newsletter
- Web resources: portal, Facebook page, dissemination blog
- NeuroCineMat
- the Introduction to Science Journalism course

5.1 The *A Matemática do Cérebro* podcast

The RIDC NeuroMat launched in August 2019 the podcast "A Matemática do Cérebro" – in Portuguese, Mathematics of the Brain. This resource is available on the most important podcast technologies and also hosted on its own website. The production of the podcast is led by NeuroMat director Antonio Galves and NeuroMat associate investigator Eduardo Vicente.

NeuroMat's podcast is aimed at covering three main topics: the model for systems of spiking neurons that the research team developed; the Statistician Brain conjecture; and pertaining institutional aspects of doing research in Brazil. The overall goal is to bring public awareness on work that is being done within the NeuroMat community.

Four episodes of the podcast were produced in the period covered by this report
and may be found at: https://podcast.numec.prp.usp.br/.

5.2 The 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 a "success case" of the use of Wikipedia and other collaborative projects as a means of scientific dissemination.

In the period covered by this report, an on-wiki portal for the Wikipedia Initiative has been launched at: https://pt.wikipedia.org/wiki/Wikipédia:GLAM/CEPID_NeuroMat

Main achievements are:

- 151 million content viewers in Wikimedia;
- 175 million words added to Portuguese Wikipedia and related projects;
- 99.4 thousand entries created on Wikimedia projects; and
- 196 thousand entries improved on Wikimedia projects.

The control panel of the NeuroMat Wikipedia Initiative is available at: https://outreachdashboard.wmflabs.org/campaigns/neuromat/programs.

5.3 The Wikimedia Commons Initiative

NeuroMat has been engaged in uploading media files to the open repository Wikimedia Commons. At the end of July, 53.8 thousand files had been uploaded by the NeuroMat team in this repository.

Files NeuroMat added to Wikimedia Commons were viewed 15,901,323 times in July 2021.

This figure is obtained from the web visualization control tool of the Dashboard (aforelinked).

5.4 Media Exposure

Activities from FAPESP'S RIDC NeuroMat were featured in around a hundred external media outlets since its inception in 2013. NeuroMat's media clipping for this year is attached to this report as Annex 4.

NeuroMat's newsletter has had 71 issues since it was first released in February 2014. Due to the pandemic, there has been a temporary interruption of the newsletter.

The important article on "Retrieving the structure of probabilistic sequences of auditory stimuli from EEG data" was the object of an article at *Pesquisa FAPESP*.

5.5 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. There have been 14 thousand pageviews in the period of interest of this report different users — around 53% of which did not come from Brazil.

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 1,612 followers, as of July, 2021, with steady progress. The community growth has been organic.

Since April 2016, the NeuroMat dissemination team has maintained 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 47,102, since its inception as of September, 2016.

Posts on this resource have been published continuously; a detailed report is provided on Annex 6.

References are:

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

5.6 NeuroCineMat

The NeuroMat dissemination team has fully produced 289 movies. A full list is available on the NeuroMat Youtube channel. There has also been continuous streaming of activities on YouTube, which have attracted almost 4,000 subscribers and 94,000 views from October 2020 to July 2021. A full list is available on:

https://www.youtube.com/user/neuromathematics

5.7 The Introduction to Science Journalism course

The NeuroMat dissemination team launched in 2021 an Introduction to Science Journalism course to contribute to capacity building of communications professionals who are interested in specializing in science coverage. The course strictly abides to curriculum expectations of the Mídia & Ciência call.

The course has been developed under the supervision of NeuroMat PI Fernando J. Paixão, supported by NeuroMat team members and FAPESP science-journalism fellows.

The course is available freely on Wikiversity:

https://pt.wikiversity.org/wiki/Introdução_ao_Jornalismo_Científico.

6 Annexes

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Annex 2 - NeuroMat scientific publications

Annex 3 - NeuroMat Scientific Publications: Citations

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Annex 5 - Website's analytics

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Annex 6 - NeuroMat dissemination blog "Traço de Ciência"

Annex 7 - Scientific Missions

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- Annex 15f - Fernanda Volchan Cruz - BJC2
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