Paulo Ricardo Protachevicz

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Google Scholar | Loop | ResearchGate | SciProfile
arXiv | WebOfScience | ORCID | FAPESP | GitHub

Academic Education

2010 - 2013 - Bachelor Degree in Physics
Universidade Estadual de Ponta Grossa, UEPG, Ponta Grossa, Brazil
Research Topic: Methods to Calculate Lyapunov Exponent to Detect Chaos in Non-Linear Dynamic System
Supervisor: Prof Dr José Danilo Szezech Jr
Scholarship: National Council for Scientific and Technological Development - Brazil
Thesis: *Methods to Calculate Lyapunov Exponent to Detect Chaos in Non-Linear Systems*
Keywords: Chaos Detections - Numerical Simulation - Data Analysis - Data Visualization - Analytical Analysis Complex Systems - Big Data Analysis - Multivariate Diagnostics - Algorithms Development

2014 - 2016 - Master of Science/Concentration area: Physics
Universidade Estadual de Ponta Grossa, UEPG, Ponta Grossa, Brazil
Title: Study of the Dynamic Range in Neural Networks Modeled by Cellular Automaton
Supervisor: Prof Dr Antonio Marcos Batista
Scholarship: Brazilian Federal Agency for Support and Evaluation of Graduate Education
Keywords: Cellular Automata Machine - Discrete Math - Linear Algebra - Dynamic Range - Neuronal Topology Chemical Synapses - Sensory Detection - Activation Functions - Time Delayed Systems - ETL.

2016 - 2020 - Ph.D. in Sciences/Concentration area: Physics
Universidade Estadual de Ponta Grossa, UEPG, Ponta Grossa, Brazil
Title: Firing Patterns in Neuronal Networks
Supervisor: Prof Dr Antonio Marcos Batista
Scholarship: Brazilian Federal Agency for Support and Evaluation of Graduate Education
Keywords: Neural Networks - Nonlinear Dynamics - Epileptic Seizures - Computational Modeling
Firing Pattern Classification - Prediction Dynamic Behavior - Computational Modelling
Detection of Seizures - Coefficient of Variation - Synchronization - Spike Frequency - Neuronal Adaptation

Postdoctoral and Work Experiences

2025 - Current - Project Coordinator - Computational Neuroscience, Data Analysis, and AI
State University of Ponta Grossa (UEPG), Ponta Grossa, Paraná, Brazil
Project Title: Analysis and Prediction of Neuronal Activity Using Artificial Intelligence Techniques
Keywords: Computational Neuroscience - Brain Criticality - Neural Networks - Epilepsy - Artificial Intelligence - Unsupervised Learning - Bayesian Inference - Time Series Analysis - Stochastic Modeling - Hodgkin-Huxley - AdEx - Neural Synchronization - Kuramoto Order Parameter - Neuronal Avalanches - Signal Processing - Predictive Modeling - Data Science - Python/C/C++.

- Developing computational models of neuronal networks operating near critical regimes.
- Applying unsupervised learning and dimensionality reduction techniques to identify patterns in neural activity data.
- Designing probabilistic models to predict pathological transitions, including epileptic seizures.
- Simulating biologically realistic neuronal models (Hodgkin-Huxley, AdEx) with stochastic inputs and synaptic plasticity mechanisms.
- Analyzing synchronization, neuronal avalanches, and dynamical regimes using different metrics.
- Integrating machine learning with large-scale simulations to improve early diagnosis and understanding of neurological disorders.

2020 - 2024 - Postdoctoral Research Fellow - Applied Physics
University of São Paulo, USP, São Paulo, Brazil
Project title: Synaptic Plasticity in Neuronal Network
Scholarship: São Paulo Research Foundation (FAPESP), Brazil
Supervisor: Prof Dr Iberê Luiz Caldas
Keywords: Synaptic Plasticity - Machine Learning - Statistical Analysis - Nonlinear Dynamics - Model Development - Data Analysis - Data Minning - Data Vizualization - Hypothesis Testing - Methods of Artificial Intelligence - Causual Interference - K-Nearest Clustering - Python - R - Forecasting Models.

- Designed and implemented models to investigate synaptic plasticity and neuronal network dynamics.
- Conducted predictive analyses and applied machine learning to uncover patterns in neural data
- Collaborated with interdisciplinary teams to integrate insights from computational and experimental neuroscience
- Developed data visualization tools to communicate findings effectively to multidisciplinary teams
- Published high-impact research on synaptic behavior and its influence on network stability
- Developed data visualization tools to communicate findings effectively to multidisciplinary teams

2022 - 2023 - Honorary Research Fellow - Physics
University of Aberdeen, UOA, Aberdeen, United Kingdom
Project title: Neuronal Networks with Short-term Synaptic Plasticity
Scholarship: São Paulo Research Foundation (FAPESP), Brazil
Supervisor: Prof Dr Murilo da Silva Baptista
Keywords: Short-Term Synaptic Plasticity, Nonlinear Systems, Data Mining, Neural Simulations - Computational Neuroscience - Applied Physics - Nonlinear Dynamics - Testing and Causal Inference - Advanced Analytics - PCA method - Linear and Logistic Regression Models - Analytical and Numerical Solutions - Quantitative and Qualitative Diagnostics Analysis - Development of C and Python codes - Development of Data Analysis - Multivariate Diagnostics - Predictive Models - Reinforcement Learning.

- Modeled the dynamics of short-term synaptic plasticity and its effects on neuronal synchronization
- Applied advanced statistical methods and causal inference to analyze neural network data
- Optimized algorithms for large-scale simulations, significantly reducing computational costs

2023 - 2024 - Visiting Scientist - Physics
Potsdam Institute for Climate Research Impact, Postdam, Germany
Project title: Synchronization in Neuronal Networks with Long-Term Synaptic Plasticity
Scholarship: São Paulo Research Foundation (FAPESP), Brazil
Supervisor: Prof Dr Jurgen Kurths
Keywords: Synchronization - Probabilistic Models - Computational Neuroscience - Long-Term Synaptic Plasticity Probability - Statistics - Data Cleaning - Data Mining - Data Wrangling - Models of Prediction - Artificial Intelligence - Causal Interference - Statistical Model - Python - Model Deployment

- Investigated synchronization phenomena in neuronal networks under varying external conditions
- Developed probabilistic models to simulate and predict long-term neuronal dynamics
- Collaborated with international researchers to advance knowledge in network theory and dynamics

2025 - 2026 - Postdoctoral Research Fellow - Electrical Engineering and Industrial Informatics
Federal University of Technology – Paraná, Curitiba, Paraná, Brazil
Project Title: Detection, prediction and prevention of epileptic seizures in a neuronal network model
Scholarship: Federal Agency for Support and Evaluation of Graduate Education (CAPES).
Supervisor: Prof. Dr. Paulo José Abatti
Keywords: Epilepsy Prediction - Brain Dynamics - Machine Learning - Signal Processing - Statistical Modeling - Time Series Analysis - Stochastic Processes - Algorithm Development - Machine Learning - Predictive Analysis - Regression Analysis - R/Python/SQL - Data Analysis - Optimization Techniques Big Data - Modeling - Bayesian Inference - Deep Learning - A/B Testing - Data Visualization.

- Leading a project focused on the detection, prediction, and prevention of epileptic seizures.
- Developing and refining neural network models to simulate pathological brain activity.
- Implementing machine learning algorithms for real-time seizure detection and prevention.

Complementary Training

2025 - Applied Machine Learning: Algorithms. LinkedIn Learning, 2025.
2024 - Training Neural Networks in C++, **Deep Learning: Model Optimization and Tuning**, and **Machine Learning with Scikit-Learn.** LinkedIn Learning.
2024 - Data Science Tools. IBM - DS0105EN.
2024 - ML and AI with Python and **Introduction to Data Science with Python.** HarvardX.
2024 - The Complete Python Developer. Udemy.
2024 - Introduction to Data Science. IBM DS0101EN.
2024 - XLIV Dynamics Days 2024 Europe. Constructor University, Bremen, Germany.
2024 - XXII Conference On Non-equilibrium Statistical Mechanics and Nonlinear Physics. Brazil.
2024 - School on Modeling Infectious Disease Dynamics. Institute of Theoretical Physics, Brazil.
2024 - Workshop on Dynamical Processes on Complex Networks. ICTP - Brazil.
2023 - Non-autonomous Dynamics in Complex Systems. Max-Planck-Institut-Magdeburg, Germany.
2022 - Certificated Machine Learning Course. Stanford University. Professor Andrew Ng.
2022 - C Standard Library. LinkedIn Learning.
2022 - C Programming for Embedded Applications, **Level Up: C Programming**, and **Complete Guide to C Programming Foundations.** LinkedIn Learning.
2021 - Simulating a Hippocampus Microcircuit. EPFL - Switzerland.
2021 - International Conference on Mathematical Neuroscience.
2020/2021/2024 - 29th/30th/33th Annual Computational Neuroscience Meeting.
2020/2021 - Bernstein Conference & **Canadian Computational Neuroscience Spotlight.**
2018 - Nonlinear Time Series Analysis and Complex Networks in the Big Data Era. IFT, Brazil.
2018 - LASCON - VII Latin American School on Computational Neuroscience.
2017 - Online Course Simulation Neuroscience. EPFL, Switzerland.

Complete Articles Published in Journals

1. **Protachevicz, P.R.**; Borges, F.S.; et al. How synapses can enhance sensibility of a neural network. Physica A - Statistical Mechanics and its applications, 492, 1045-1052, 2017. Published manuscript link.

2. Borges, R.R.; Borges, F. S.; Lameu, E. L.; **Protachevicz, P.R.**; Iarosz, K. C.; Caldas, I. L.; Viana, R. L.; Macau, E. E. N.; Baptista, M. S.; Grebogi, C.; Batista, A. M. Synaptic plasticity and spike synchronisation in neuronal networks. Brazilian Journal of Physics, 47, 678-688, 2017. Published manuscript link.

3. Borges, F.S.; **Protachevicz, P.R.**; Lameu, E.L.; Bonetti, R.C.; Iarosz, K.C.; Caldas, I.L.; Baptista, M.S.; Batista, A.M. Synchronised firing patterns in a random network of adaptive exponential integrate-and-fire neuron model. Neural Networks, 90, 1-7, 2017. Published manuscript link.

4. Lameu, E.L.; Macau, E.E.N.; Borges, F.S.; Iarosz, K.C.; Caldas, I.L.; Borges, R. R.; **Protachevicz, P.R.**; Viana, R.L.; Batista, A.M. Alterations in brain connectivity due to plasticity and synaptic delay. European Physical Journal-Special Topics, 227, 673-682, 2018. Published manuscript link.

5. Borges, F.S.; Lameu, E.L.; Iarosz, K.C.; **Protachevicz, P.R.**; Caldas, I. L.; Viana, R.L.; Macau, E.E.N.; Batista, A.M.; Baptista, M. S. Inference of topology and the nature of synapses, and the flow of information in neuronal networks. Physical Review E, 97, 022303, 2018. Published manuscript link.

6. Lameu, E.L.; Yanchuk, S.; Macau, E.E.N.; Borges, F.S.; Iarosz, K.C.; Caldas, I.L.; **Protachevicz, P.R.**; Borges, R. R.; Viana, R. L.; Szezech Jr, J. D.; Batista, A.M.; Kurths, J. Recurrence quantification analysis for the identification of burst phase synchronisation. Chaos, 28, 085701, 2018. Published manuscript link.

7. **Protachevicz, P. R.**; Borges, R. R.; et al. Synchronous behaviour in network model based on human cortico-cortical connections. Physiological Measurement, 39, 074006, 2018. Published manuscript link.

8. Kan, M. T. V.; Trobia, J.; **Protachevicz, P. R.**; Santos, M.; Ferrari, F. A. S.; Bonetti, R. C.; Costa, D. R.; Szezech Jr, J. D.; Caldas, I. L.; Batista, A. M.; Iarosz, K. C. Synchronization of coupled neurons in a master-slave configuration. Mathematics in Engineering, Science and Aerospace: The Transdisciplinary International Journal, 10, 55-64, 2019. Published manuscript link.

9. **Protachevicz, P. R.**; Borges, F. S.; e al. Bistable firing pattern in a neural network model. Frontiers in Computational Neuroscience, 13, 1-8, 2019. Published manuscript link.

10. Santos, M. S.; **Protachevicz, P. R.**; Iarosz, K. C.; Caldas, I. L.; Viana, R. L.; Borges, F. S.; Ren, H-P; Szezech Jr, J. D.; Batista, A.M.; Grebogi, C. Spike-burst chimera states in an adaptive exponential integrate-and-fire neuronal network. Chaos, 29, 043106-1-6, 2019. Published manuscript link.

11. Borges, F.S.; **Protachevicz, P. R.**; Lameu, E. L.; Iarosz, K.C.; Caldas, I.L.; Kihara, A.H.; Batista, A.M. Bistable firing patterns: one way to understand how epileptic seizures are triggered. 28th Annual Computational Neuroscience Meeting: CNS*2019. BMC Neuroscience, 20, 56, 2019. Published manuscript link.

12. **Protachevicz, P.R.**; Iarosz, K. C.; Caldas, I.L.; Antonopoulos, C. G.; Batista, A. M.; Kurths, J. Influence of autapses on aynchronization in neural networks with chemical synapses. Frontiers in Systems Neuroscience, 14, 1 - 13, 2020. Published manuscript link. **Highlights of Research in the Medias**: News 1, News 2, News 3, News 4, News 5.

13. **Protachevicz, P. R.**; Borges, F.S.; et al. Influence of delayed conductance on neuronal synchronization. Frontiers in Physiology, 11, 1-9, 2020. Published manuscript link.

14. Borges, F.S.; **Protachevicz, P.R.**; Pena, R.F.O.; Lameu, E.L.; Higa, G.S.V.; Kihara, A.H.; Matias, F.S.; Antonopoulos, C.G.; de Pasquale, R.; Roque, A.C.; Iarosz, K.C.; JI, P.; Batista, A.M. Self-sustained activity of low firing rate in balanced networks. Physica A, 537, 122671, 2020. Published manuscript link.

15. Lameu, E.L.; Borges, F.S.; Iarosz, K.C.; **Protachevicz, P.R.**; Antonopoulos, C. G.; Macau, E.E.N.; Batista, A.M. Short-term and spike-timing-dependent plasticity facilitate the formation of modular neural networks. Communications in Nonlinear Science and Numerical Simulation, 105689, 2020. Published manuscript link.

16. Santos, M. S.; **Protachevicz, P. R.**; Caldas, I. L.; Iarosz, K.C.; Viana, R.L.; Szezech Jr, J. D.; Souza, S. L. T.; Batista, A.M. Spiral wave chimera states in regular and fractal neuronal networks. Journal of Physics: Complexity, 2, 015006-0150006, 2020. Published manuscript link.

17. Trobia, J.; Gabrick, E. C.; Seifert, E. G.; Borges, F. S.; **Protachevicz, P.R.**; Szezech Jr, J. D.; Iarosz, K.C.; Santos, M.; Caldas, I. L.; Tian, K.; Ren, H-P; Grebogi, C.; Batista, A.M. Effects of drug resistance in the tumour-immune system with chemotherapy treatment. Pramana Journal of Physics, 2020. Published manuscript link.

18. Borges, F.S.; **Protachevicz, P.R.**; Santos, V.; Santos, M.; Gabrick, E.C.; Iarosz, K.C.; Lameu, E.L.; Baptista, M.S.; Caldas, I.L.; Batista, A.M. Influence of inhibitory synapses on the criticality of excitable neuronal networks. Pramana Journal of Physics, 2020. Published manuscript link.

19. **Protachevicz, P.R.**; Santos, M.S.; et al. Noise induces continuous and noncontinuous transitions in neuronal interspike intervals range. Pramana Journal of Physics, 2020. Published manuscript link.

20. Silveira, J.A.P.; **Protachevicz, P.R.**; Viana, R.L.; Batista, A.M. Effects of burst-timing-dependent plasticity on synchronous behaviour in neuronal network. Neurocomputing, 433, 126-135, 2021. Published manuscript link.

21. **Protachevicz, P.R.**; Hansen, M.; Iarosz, K.C.; Caldas, I.L.; Batista, A.M.; Kurths, J. Emergence of neuronal synchronization in coupled areas. Frontiers in Computational Neuroscience, 15, 1-12, 2021. Published manuscript link.

22. Trobia, J.; Tian, K.; Batista, A.M.; Grebogi, C.; REN, H.; Santos, M.S.; **Protachevicz, P. R.**; Borges, F. S.; Szezech Jr, J.D.; Viana, R.L.; Caldas, I.L.; Iarosz, K. C. Mathematical model of brain tumour growth with drug resistance. Communications in Nonlinear Science and Numerical Simulation, 106013, 2021. Published manuscript link.

23. **Protachevicz, P.R.**; Hansen, M.; Iarosz, K. C.; Caldas, I.L.; Batista, A.M. Influence of the connectivity on the synchronization of two coupled neuronal networks. 30th Annual Computational Neuroscience Meeting: CNS-2021-Meeting Abstracts. Journal of Computational Neuroscience, 49, 3-208, 2021. Published manuscript link.

24. Mugnaine, M.; Gabrick, E.C.; **Protachevicz, P.R.**; Iarosz, K.C.; Souza, S.L.T.; Almeida, A.C. L.; Batista, A.M.; Caldas, I.L.; Szezech Jr, J. D.; Viana, R. L. Control attenuation and temporary immunity in a cellular automata SEIR epidemic model. Chaos, Solitons & Fractals, 155, 111784, 2022. Published manuscript link.

25. Hansen, M.; **Protachevicz, P.R.**; Iarosz, K. C.; Caldas, I.L.; Batista, A.M.; Macau, E.E.N. Dynamics of uncoupled and coupled neurons under an external pulsed current. CSF, 155, 111734, 2022. Published manuscript link.

26. Gabrick, E.C.; **Protachevicz, P.R.** ; Batista, A.M.; Iarosz, K.C.; Souza, S. L. T.; Almeida, A.C.L.; Szezech Jr, J.D.; Mugnaine, M.; Caldas, I.L. Effect of two vaccine doses in the SEIR epidemic model using a stochastic cellular automaton. Physica A - Statistical Mechanics and Its Applications, 127258, 2022. Published manuscript link.

27. **Protachevicz, P.R.**; Bonin, C.A.; Iarosz, K.C.; Caldas, I.L.; Batista, A.M. Large coefficient of variation of inter-spike intervals induced by noise current in the resonate-and-fire model neuron. Cognitive Neurodynamics, 1-10, 2022. Published manuscript link.

28. Trobia, J.; Souza, S.L.T.; Santos, M.A.; Szezech JR, J.D.; Batista, A.M.; Borges, R.R.; Pereira, L.S.; **Protachevicz, P. R.**; Caldas, I.L.; Iarosz, K. C. On the dynamical behaviour of a glucose-insulin model. Chaos, Solitons & Fractals, 155, 1-8, 2022. Published manuscript link.

29. Hansen, M.; **Protachevicz, P.R.**; Iarosz, K.C.; Caldas, I.L.; Batista, A.M.; Macau, E.E.N. The effect of time delay for synchronisation suppression in neuronal networks. Chaos Solit. Fractals, 2022. Published manuscript link.

30. Yang, C.; Santos, M.S.; **Protachevicz, P.R.**; Reis, P.D.C.; et al. Chimera states induced by spike timing-dependent plasticity in a regular neuronal network. AIP Advances, 2022. Published manuscript link.

31. Borges, F.S.; Gabrick, E.C.; **Protachevicz, P.R.**; Higa, G.S.V.; Lameu, E.L.; Rodriguez, P.X. R.; Ferraz, M.S.A.; Szezech Jr, J.D.; Batista, A.M.; Kihara, A.H. Intermittency propertiers in a tempral lobe epilepsy model. Epilepsy & Behavior, 139, 109072, 2023. Published manuscript link.

32. Gabrick, E. C.; Sayari, E.; **Protachevicz, P. R.**; Szezech, J. D.; Iarosz, K. C.; Souza, S. L. T.; Almeida, A. C. L.; Viana, R. L.; Caldas, I. L.; Batista, A. M. Unpredictability in seasonal infectious diseases spread. Chaos, Solitons & Fractals, 166, 113001, 2023. Published manuscript link.

33. Sayari, E.; Batista, A.M.; Gabrick, E.C.; Iarosz, K.C.; **Protachevicz, P.R.**; Szezech Jr., J. D.; Borges, F. S. Analysing bursting synchronization in the structural connectivity matrix of a human brain under external pulsed currents. Chaos, 33, 033131, 2023. Published manuscript link.

34. **Protachevicz, P.R.**; Borges, F.S.; et al. Plastic neural network with transmission delays promotes equivalence between function and structure. Chaos, Solitons & Fractals, 171, 113480, 2023. Published manuscript link.

35. Iarosz, K. C.; Gabrick, E. C.; Trobia, J.; Borges, R. R.; **Protachevicz, P. R.**; Bonetti, R. C.; de Souza, S. L. T.; Batista, G. L., Szezech Jr, J. D., Caldas, I. L.; Batista, A. M. Chaotic dynamics in memristive circuits. Revista Brasileira de Ensino de Física, 45, 2023.Published manuscript link.

36. Boaretto, B. R. R.; **Protachevicz, P.R.**; Hansen, M.; Oliveira, J., Andreani, A. C., Macau, E. E. N. Phase synchronization in a sparse network of randomly connected neurons under effect of Poissonian spike inputs. Chaos, 33, 123115, 2023. Preprint link. Published manuscript link.

37. Borges, F. S., **Protachevicz, P. R.**, Souza, D. L. M., Bittencourt, C. F., Gabrick, E. C., Bentivoglio, L. E., Szezech Jr, J. D., Batista, A. M., Caldas, I. L., Dura-Bernal, S., Pena, R. F. O. The roles of Potassium and Calcium currents in the bistable firing transition. Brain Science, 3(9), 1347, 2023. Preprint link. Published manuscript link.

38. Gabrick, E. C.; **Protachevicz, P. R.**, Lenzi, E. K; Sayari, E.; Lenzi, M. K.; Borges, F. S.; Caldas, I. L.; Batista, A. M. Fractional diffusion equation under general kernel and its stability. Fractal and Fractional, 7(11), 792, 2023. Published manuscript link.

39. Souza, D.L.; Seifert, E.G.; Gabrick, E.C.; Borges, F.S.; Lenzi, E.K.; Trobia, J.; Iarosz, K. C.; Batista, A.M.; Caldas, I.L.; **Protachevicz, P. R.** Adaptive exponential integrate-and-fire model with fractal extension. Brain Science, 34(2), 2024. Published manuscript link.

40. Gabrick, E.C.; **Protachevicz, P.R.**; de Souza, D.L.M.; Sayari, E.; Lenzi, E.K.; Lenzi, M.K.; Trobia, J.; Borges, F.S.; Caldas, I.L.; Batista, A.M. Transient dynamics of fractional Fisher equation. Fractal and Frational, 8(3), 143, 2024. Published manuscript link.

41. **Protachevicz, P.R.**; Batista, A.M.; Caldas, I.L.; Baptista, M.S. Analytical solution to short-term plasticity. Chaos, Solitons & Fractals, 181, 114678, 2024. Preprint link. Published manuscript link.

42. Souza, D.L.M.; Borges, F.S., Gabrick, E.C.; Bentivoglio, L.E. **Protachevicz, P.R.** Dos Santos, V; Viana, R.L.; Caldas, I.L.; Iarosz, K.C.; Batista, A. M.; Kurths, J. Spiral wave dynamics in a neuronal network model. Journal of Physics: Complexity, 5, 025010, 2024. Preprint link. Published manuscript link.

43. da Silva, S.T.; Gabrick, E.C.; **Protachevicz, P.R.**, Iarosz, K. C.; Caldas, I.L.; Batista, A.M.; J. Kurths. When climate variables improve the dengue forecasting: a machine learning approach. EPJ Special Topics, 2024. Published manuscript link. Highlights of the Research in the Medias: Link 1, Link 2.

44. Gabrick, E. C.; Brugnago, E. L.; de Moraes, A.L.R.; **Protachevicz, P.R.**; da Silva, S.T.; Borges, F.S.; Caldas, I.L.; Batista, A.M.; Kurths, J. Control, bi-stability and preference for chaos in time-dependent vaccination campaign. Chaos, 34, 1-13, 2024. Published manuscript link.

45. Bentivoglio, L. E.; Souza, D. L. M.; Gabrick, E. C.; **Protachevicz, P. R.**; Sousa, G. A.; Caldas, I. L.; Viana, R. L.; Iarosz, K. C.; Batista, A. M.; Borges, F. S. Collapse of multi-headed chimera states in neuronal networks. Chaos: An Interdisciplinary Journal of Nonlinear Science 35 (9). Published manuscript link.

46. Boaretto, B.R.R.; **Protachevicz, P. R** , Hansen, M.; Medrano, R. O.; Macau, E.E.N.; Grebogi, C. Complex Bifurcation Structures in a Hodgkin–Huxley Model of Thermally Sensitive Neurons under Periodic Perturbation. Physical Review E 111 (5), L052203, 2026. Published manuscript link..

47. Pirola, J. P.; DeForest, P.; **Protachevicz, P.R.**; Fontenas, L.; Ferreira, R. F.; Pena, R.F.O. Astrocytic Signatures in Neuronal Activity: A Machine Learning-Based Identification Approach. Cognitive Neurodynamics 19 (1), 89. Published manuscript link.

48. **Protachevicz, P.R.**; Santos, M. S.; et al. Synaptic potentiation dependence on spike variability. European Physical Journal - Special Topics. Published manuscript link.

49. Souza, D. L. M.; Bentivoglio, L. E.; Gabrick, E. C.; **Protachevcz, P. R.**; Caldas, I. L.; Iarosz, K. C.; Dura-Bernal, S.; Batista, A. M.; Borges, F. S. Neuronal silence as a predictive biomarker and target for epileptic seizures suppression. *Scientific Reports*, 16, 16732, 2026. Published manuscript link..

50. Santos, M.S.; Trobia, J.; Ferreira, J. Z.; **Protachevicz, P. R.**; Iarosz, K.C.; Caldas, I. L.; Rizzo, L. V.; Quiles, M. G.; Macau, E. N. M.; Zou , Y.; Batista, A. M. Seasonality-induced riddling in conceptual model for global changes. Frontiers in Forest Global Change - Sec. Tropical Forests, Volume - 2026. Published manuscript link..

Invited talks and presentations

1. **The Influence of Chemical Synapses in Neuronal Synchronization**. Laboratory of Functional and Molecular Imaging. National Institute of Healthy. National Institute of Neurological Disorders and Stroke. Research Group of Prof. Dr. Jeff Duyn (2024).

2. **Synchronization in Neuronal Networks**. Department of Neurobiology and Neuroscience Institute. Grossman Center for Quantitative Biology and Human Behavior. University of Chicago. Group of Prof. Jorge Jaramillo (2024).

3. **Influence of Chemical Synapses on Neuronal Synchronization**. Laboratory of Biosensors and Bioelectronics. Swiss Federal Institute of Technology Zurich. University of Zurich. Research Group of Prof. Dr. Janos Vörös (2024).

4. **Past research achievements and outlined his future research interests**. Group Leader in Neuronal Systems Theory. Max Planck Institute for Dynamics and Self-Organization and Georg August University. Research Group of Prof. Dr. Viola Priesemann (2023).

5. **Synchronization and Synaptic Plasticity**. Department of Medicine, Institute for Neural Computation, University of California, San Diego. Research Group of Prof. Dr. Maxim V. Bazhenov (2023).

6. **Synchronization in neuronal networks with long-term synaptic plasticity.** School of Mathematical Sciences. University College Cork, Ireland. Research Group of Prof. Dr. Serhiy Yanchuk (2023).

7. **A model for epileptic seizures.** Department of Physics, Institute for Complex Systems and Mathematical Biology, University of Aberdeen, Scotland . Research Group of Prof. Dr. Murilo da Silva Baptista (2023).

8. **Influence of the connectivity on the synchronization of two coupled neuronal networks**. 30th Annual Computational Neuroscience Meeting. Organization for Computational Neuroscience, Online (2021).

9. **How epileptic seizures are generated in a neuronal network model**. Conference on Perspectives in Nonlinear Dynamics. University of São Paulo and Institute of Theoretical Physics (2019).

10. **Synchronized firing patterns in a random network of adaptive exponential integrate-and-fire neurons**. First Applied Course of Computational Neuroscience. Physics Department of Ribeirão Preto, Brazil (2017).

11. **Synchronised firing patterns in a neuronal network based on cortico-cortical connections of human brain** Dynamics Days Latin America and the Caribbean, Universidad de la Republica Uruguay, Uruguay (2018).

12. **Perspectives on the field of Computational Neuroscience: insights into my previous research**. Donders Institute, Radboud University, Netherlands. Research Group of Prof. Dr. Fleur Zeldenrust (2024).

13. **Synchronous behavior in a neuronal network model**. São Paulo Scholl of Advanced Sciences on Nonlinear Dynamics, University of São Paulo (2019).

14. **Study of dynamic range in neuronal networks modeled by cellular automaton.** Post-Graduation Program in Science - Physics, State University of Ponta Grossa, Brazil (2016).

15. **Spike and bursting synchronization in a random network of adaptive exponential integrate-and-fire**. Applied Physics Department, University of São Paulo, Brazil. Research Group of Prof. Dr. Iberê Luiz Caldas (2016).

Selected Abstracts

1. **P. R. Protachevicz**; D. L. M. Souza, L. E. Bentivoglio, E. C. Gabrick, I. L. Caldas, K. C. Iarosz, S. Dura-Bernal, A. M. Batista , F. S. Borges. Silence Before Synchronisation Predicts Seizure-Like Activity. In: XLVI Dynamics Days, 2024, Lisbon, Portugal, Dynamics Days, 2026.
2. **P. R. Protachevicz**; D. L. M. Souza; L. E. Bentivoglio; E. C. Gabrick; I. L. Caldas, K. C. Iarosz; S. Dura-Bernal; A. M. Batista; F. S. Borges. Neuronal Silence as a Predictive Biomarker for Epileptic Seizures. FENS FORUM 2026, Barcelona, Spain, 2026.
3. **P. R. Protachevicz**; F. S. Borges; A. M. Batista; M. S. Baptista; I. L. Caldas; E. E. N. Macau; E. L. Lameu. Synchronized firing patterns shape topology in neuronal networks. In: XLIV Dynamics Days, Bremen, 2024.

4. **P. R. Protachevicz**; M. Hansen; K. C. Iarosz; I. L. Caldas; A. M. Batista; J. Kurths. How synchronized firing patterns emerge and shape neuronal network connectivity. In: Workshop on Dynamical Processes on Complex Networks, 2024, São Paulo. Workshop on Dynamical Processes on Complex Networks, 2024.

5. **P. R. Protachevicz**; M. Hansen; K. C. Iarosz; I. L. Caldas; J. Kurths. Emergence of synchronization between neuronal areas. In: Conference on Non-Equilibrium Statistical Mechanics and Nonlinear Physics, Medyfinol, 2024.

6. **P. R. Protachevicz**; A. M. Batista; I. L. Caldas; M. S. Baptista. Exploring neurotransmitter release in a model of synaptic dynamics. In: 33rd Annual Computational Neuroscience Meeting, 2024, Natal. CNS - 2024.

7. **P. R. Protachevicz**; M. Hansen; K. C. Iarosz; I. L. Caldas; A. M. Batista; J. Kurths. Influence of connectivity on the synchronization of a sender-receiver neuronal network. In: Non-autonomous Dynamics in Complex Systems: Theory and Applications to Critical Transitions, Dresden, Germany, 2024.

8. **P. R. Protachevicz**; F. S. Borges; K. C. Iarosz; I. L. Caldas; A. M. Batista; M. S. Baptista. Emergence of highly synchronized firing patterns in neuronal networks. In: Nonlinear Data Analysis and Modeling: Advances, Applicati-

ons, Perspectives, 2023, Berlin. Nonlinear Data Analysis and Modeling: Advances, Applications, Perspectives, 2023.

9. **P. R. Protachevicz**; F. S. Borges; K. C. Iarosz; A. M. Batista; R. L. Viana; I. L. Caldas. Influência do atraso e das conexões não locais na faixa dinâmica de uma rede neural. In: XX Semana da Física da UEPG, 2018, Ponta Grossa. Anais da XX Semana da Física, 2017.

10. **P. R. Protachevicz**; F. S. Borges; K. C. Iarosz; I. L. Caldas; R. L. Viana; E. L. Lameu, E. E. N. Macau; A. M. Batista. Comportamento biestável em uma rede com sinapses elétricas e químicas. In: XX Semana da Física da UEPG, 2018, Ponta Grossa. Anais da XX Semana da Física, 2017.

11. **P. R. Protachevicz**; F. S. Borges; K. C. Iarosz; I. L. Caldas; R. L. Viana; E. L. Lameu; E. E. N. Macau; A. M. Batista. Interações de múltiplas escalas em redes neurais. In: XX Semana da Física da UEPG, 2018, Ponta Grossa. Anais da XX Semana da Física, 2017.

12. **P. R. Protachevicz**; R. R. Borges; A. S. Reis; F. S. Borges; K. C. Iarosz; I. L. Caldas; E. L. Lameu; E. E. N. Macau; R. L. Viana; I. M. Sokolov; F. A. S. Ferrari; J. Kurths; A. M. Batista; C. Z. Lo; Y. He; C. Lin. *Firing patterns of synchronisation in a neuronal network based on cortico-cortical connections of human brain.* In: *Dynamics Days Latin America and the Caribbean*, Puntal del Este, 2018.

13. **P. R. Protachevicz**; F. S. Borges; K. C. Iarosz; A. M. Batista; I. L. Caldas; R. L. Viana. *Effect of plasticity on the neuronal firing.* In: *6th International Conference on Nonlinear Science and Complexity*, 2016, São José dos Campos. *6th International Conference on Nonlinear Science and Complexity*, 2016.

14. **P. R. Protachevicz**; R. C. Bonetti; F. S. Borges; R. R. Borges; K. C. Iarosz; A. M. Batista. *Effects of synaptic plasticity on the synchronisation in neural network.* In: *6th International Conference on Nonlinear Science and Complexity*, 2016, São José dos Campos. São José dos Campos, 2016.

Grants

2010-2012 Undergrad Fellowship to Research
The funding was received to technical support - State University of Ponta Grossa.
Source: National Council for Scientific and Technological (CNPq), Brazil.

2012-2013 Undergrad Fellowship to Research
The funding was received to research the neuronal Hodgkin-Huxley model - State University of Ponta Grossa.
Source: National Council for Scientific and Technological (CNPq), Brazil.

2014-2016 Master Fellowship in Science/Physics
Topic of research: Study of the dynamic range in neural networks modeled by cellular automaton - State University of Ponta Grossa. Source: Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), Brazil.

2016-2020 PhD Fellowship in Science/Physics
Topic of research: Firing patterns in neuronal networks - State University of Ponta Grossa.
Source: Brazilian Federal Agency for Support and Evaluation of Graduate Education, Brazil.

2020-2024 Postdoc Research Fellowship
Topic of research: Synaptic Plasticity in Neuronal Networks
Funding to post-doctorate fellowship in Physic at the University of São Paulo, São Paulo, Brazil.
Source: São Paulo Research Foundation (FAPESP), São Paulo, Brazil.

2022-2023 Honorary Research Fellowship
Topic of research: Short-term Plasticity in Neuronal Networks
University of Aberdeen, Aberdeen, Scotland, UK
Source: São Paulo Research Foundation (FAPESP), São Paulo, Brazil.

2023-2024 Visiting Scientist Fellowship
Topic of research: Long-term Plasticity in Neuronal Networks
Potsdam Institute for Climate Impact Research, Potsdam, Germany
Source: São Paulo Research Foundation (FAPESP), São Paulo, Brazil.

2024-2025 Potsdoc Research Fellow
Topic of research: Detection, prediction and prevention of epileptic seizures in a neural network model
University: Federal University of Technology - Paraná, Curitiba, Paraná, Brazil
Source: Federal Agency for Support and Evaluation of Graduate Education (CAPES)

2025-2029 - Research Funding Fellow
Topic of research: Analysis and prediction of neuronal activities using techniques of Artificial Inteligence
University: State University of Ponta Grossa, Ponta Grossa, Paraná, Brazil
Source: National Council for Scientific and Technological Development (CNPq)

Advisory Committee Member

2022 - Currently - Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil

Summary of Scientific Projects and Collaborations

2024 - Current - Detection, prediction and prevention of epileptic seizures in a neural network model
This project aims to develop a computational neural network model inspired by biological networks to simulate both healthy and pathological brain activity. The primary goal is to explore the dynamic properties of these networks, uncover the mechanisms behind transitions to abnormal states, and propose methods for early seizure detection and prevention. Additionally, control strategies, such as targeted neuronal stimulation, will be implemented to prevent seizures. Ultimately, the project aims to propose non-invasive, preventive clinical devices based on the developed methods. By integrating computational modeling, real data analysis, and practical interventions, this initiative seeks to offer innovative solutions for epilepsy prevention while advancing the understanding of neural network dynamics. Collaborator: Prof. Dr. Paulo José Abatti.

2023 - Current - Synchronization in Neuronal Networks with Long-Term Synaptic Plasticity
Investigate of neuronal networks submitted to random and periodic input currents since these two types of input are observed in the brain and can induce distinct patterns of neuronal activity depending on the synaptic coupling intensities. To achieve the goals, computational models of neuronal networks that in-corporate biologically plausible neuronal dynamics and synaptic plasticity rules will be considered. Is expected that random synaptic currents can lead to predominant asynchronous firing patterns in the network, while periodic ones may induce a predominance of synchronous firings. Collaborator: Prof. Dr. Jürgen Kurths.

2022 - Current - Neuronal Networks with Short-Term Synaptic Plasticity
One objective of this project is to understand how these different STP regimes are related to normal and abnormal synchronization of the neuronal network. Another objective is to analyse how external signal inputs can affect neuronal dynamics, aiming at a better understanding of the influence of STP on the capacity of neuronal networks to detect, process and encode stimuli. Collaborator: Prof. Dr. Murilo da Silva Baptista.

2020 - Current - Synaptic plasticity in neuronal networks
In this project will be investigated the influence of synaptic plasticity to obtain synchronous and asynchronous firing patterns. The proposal foresee study of long and short term plasticity, evaluated for individual and conjoint case. Although these two types of plasticity act at the same time, the influence of each one occurs at different time scales. This study is justified due to the fact that abnormal synchronized states of activities are directly related to several neurological diseases such as Parkinson's disease and epilepsy. Otherwise, normal firing patterns of synchronization have been identified as a fact that benefits the formation of memories. Collaborator: Prof. Dr. Iberê Luiz Caldas.

2019 - Current - Synchronous behaviour in stochastic neuronal networks
Despite enormous knowledge on how complete synchronisation emerges in homogeneous complex networks composed of equal nodes, the appearance of weak synchronisation (i.e. not complete synchronisation) in clustered networks of heterogeneous nodes and heterogeneous connections is still far from being fully understood. This proposal aims at contributing to this highly multi- disciplinary challenge, i.e. the study of the relationship between weak synchronisation and network structure, and its suppression, in clustered networks modelling the cerebral cortex, a network with heterogeneous coupling behaving far from being completely synchronous. Collaborators: Prof. Dr. Kelly C. Iarosz and Prof. Dr. Chris Antonopoulos. Coordinator: Antonio M. Batista.

2018 - Current - Coupled System Dynamics Analysis
The study will focus on the dynamics of complex systems, particularly coupled nonlinear systems. A system is considered complex when its characteristics cannot be derived solely from its individual components, as these interact in a nonlinear way to form the entire system. The system to be analyzed is a neural network, which can be modeled mathematically through cellular automata, coupled maps, or differential equations. The goal is to examine the synchronization of neural firing in network clusters. Neural synchronization is linked to brain disorders like epilepsy and Parkinson's disease, so understanding it may help develop methods for suppression and control of such conditions. Collaborators: Dr. Fernando da Silva Borges, Prof. Dr. Iarosz C. Kelly, Dr. Ewandson Luiz Lameu, Prof. Dr. Rafael R. Borges, Prof. Dr. Fabiano A. S. Ferrari, Prof. Dr. Jose Danilo Szezech Jr, Prof. Dr. A. M. Batista.

2014-2016 - Study of Dynamic Range in Neuronal Network Modeled by Cellular Automaton
In this project, I considered a model of Cellular Automata to model the activity of a neuronal networks and investigate how the topology influence the dynamic range. Dynamic range is characterized by the capacity of a biological system to discriminate the intensity of an external stimulus. It is a range of intensities for which receptors can encode stimuli. I verify the topologies and intensities of neuronal connections that maximize the dynamics range of neuronal networks. Collaborators: Dr. Fernando da Silva Borges, Prof. Dr. Iarosz C. Kelly, Dr. Ewandson Luiz Lameu, Prof. Dr. Rafael R. Borges, Prof. Dr. Fabiano A. S. Ferrari, Prof. Dr. Jose Danilo Szezech Jr, Prof. Dr. A. M. Batista.

2012-2013 - Single Neuronal Dynamics of a Hodgking-Huxley model
In this project, I investigated the mechanisms of generation action potentials in a single neuron due to different intensities of external current applied in the neuron. To do that, I simulate the neuronal dynamics in a C code, and analysis the firing activities exhibited by the neuron. Collaborator: Prof. Dr. A. M. Batista.

Organization of Scientific Events

1. R. L. Viana; A. M. Batista; E. D. Leonel; K. C. Iarosz; F. A. S. Ferrari; **P. R. Protachevicz**; M. Hansen. 1st Perspectives on Oscillation Control, 2019.

2. A. C. Roque; C. Romaro; F. S. Borges; F. Dellajustina; M. Girardi-Schappo; N. L. Kamiji; R. O. Shimoura; R. P. Rocha; R. F. O. Pena; V. L. Cordeiro; **P. R. Protachevicz.** *PratiCoNeuro 2018 - II Curso Prático de Modelagem Computacional em Neurociência.* II Practical Course of Computational Neuroscience Modeling.

3. 30th Annual Computational Neuroscience Meeting: CNS*2021-Meeting, 2021.

4. E. Brugnago; **P. R. Protachevicz;** K. C. Iarosz; S. L. T. Souza; J. D. Szezech Jr; R. L. Viana; I. L. Caldas. 3rd Perspectives on Oscillation Control (POC 2024).

Member of the Editorial Board

2022 - Currently - Frontiers in Physics (2296–424)
2022 - Currently - Frontiers in Network Physiology - Networks in the Brain System
2023 - Currently - Brain Sciences - MDPI
2023 - Currently - Frontiers in Network Physiology - Networks of Dynamical Systems
2023 - Currently - Frontiers in Network Physiology - Systems Interactions and Organ Networks

Proposed Topic Issues

2023 - Recent Advances in Neuroinformatics - Brain Sciences - MDPI
2023 - Chaotic Firing in the Brain and Their Effects on Collective Brain Behavior - Frontiers in Network Physiology

Per review activity

2019 - Currently - Review of Scientific Instruments - Applied Physics Letters (on-line)

2020 - Currently - IEEE Access - Shock and Vibration - Journal of Marine Science and Engineering

2021 - Currently - Cognitive Neurodynamics - Frontiers in Physiology- Journal of Applied Physics

2022 - Currently - Frontiers in Electronics - Mathematics - EPL (Europhysics Letters) - Physica A-Statistical Mechanics And Its Applications - Frontiers in Integrative Neuroscience - Qeios - Sustainability - Journal of Zhejiang University-Science A

2023 - Currently - Frontiers in Synaptic Neuroscience - Scientific Reports Sensors - Journal of Neuroscience Methods - Frontiers in Computational Neuroscience - Machines - Journal of Biological Physics - Chaos - Applied Sciences - Frontiers in Human Neuroscience - Frontiers in Neuroinformatics - Physical Biology - Chaos, Solitons, and Fractals - European Biophysics Journal - Neural Processing Letters - IEEE Transactions on Neural Systems & Rehabilitation Engineering - Micromachines - AIP Advances - Chaos, Solitons, and Fractals

2024 - Currently - Non-linear Dynamics - Biochemical and Biophysical Research Communications - Biomimetics - Applied Biosciences - Brain Sciences - Electronics - Fractional Calculus and Applied Analysis - Physical Review E - Mathematical Biosciences and Engineering - Brain Research