UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Innovations in In vitro Neuronal Engineering: bridging biology and technology"

Prof. Martina Brofiga

University of Genova - Italy

E-mail address: martina.brofiga@unige.it

Short Abstract: The PhD course is designed to provide students with a comprehensive understanding of in vitro neuroengineering, focusing on the principles, techniques, and applications of engineering approaches for studying and manipulating neuronal systems in vitro. The course will cover fundamental concepts, experimental methodologies, and cutting-edge advancements in the field, with an emphasis on multidisciplinary perspectives. Students will gain practical skills in designing and conducting experiments, and analyzing data.

Course Contents in brief:

The course is divided into four sections:

1. Introduction to In Vitro Neuroengineering
    a. Overview of in vitro neuronal systems
    b. Historical context and significance of in vitro neuroengineering
    c. Ethical considerations in in vitro experiments

2. Neuronal Cell Culture Techniques
    a. Cell culture fundamentals
    b. Primary neuronal culture techniques
    c. Induced pluripotent stem cell-derived neuronal cultures
    d. Co-culture systems and organoids

3. Microelectrode Arrays (MEAs)
    a. Principles of MEAs
    b. Fabrication and design considerations

c. Signal acquisition and data analysis
d. Applications in electrophysiology and neural interface development

4. Microfluidics and Brain-on-a-Chip Systems
    a. Microfluidic device fabrication and operation
    b. Integration of neuronal cultures in microfluidic platforms
    c. Advancements in drug delivery and chemical stimulation
    d. Disease modeling and high-throughput screening

Total # of hours of lecture: 16

References:

CV of the Teacher

Final Exam: project proposal (2 pages max) and presentation of it

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1 – 2nd September 2025- 09:00-13:00 (4 hours)

Day2 – 3rd September 2025 – 09:00-13:00 (4 hours)

Day3 – 4th September 2025 – 09:00-13:00 (4 hours)

Day4 – 5th September 2025 – 09:00- 13:00 (4 hours)

MARTINA BROFIGA

Ph.D., CTO & Co-founder of ScreenNeuroPharm

martina.brofiga@screenneuropharm.com +39 3880732345 Genova, Italy
martina-brofiga 0000-0003-2993-0597

RESEARCH ACTIVITY

I am an assistant professor in Bioengineering. My research activity fits into the field of neuroengineering, concerning both experimental and computational aspects. In this framework, my main research focus is to develop in vitro engineered neuronal networks made up of interacting sub-populations to recreate interconnected brain regions on chips. I am the co-founder and the Chief Technological Officer of ScreenNeuroPharm, an innovative startup, and spinoff of the University of Genova, aiming to improve the in vitro drug screening process.

TRACK RECORD

- **H-index = 7**, updated on 09/09/24, Scopus
- Number of citations = 129
- Co-author of 15 journal articles
- Co-author of 1 book chapter
- Co-author of 40 peer-reviewed conference proceedings
- 3 oral presentations at congresses and schools

EDUCATION AND RESEARCH EXPERIENCE

Assistant Professor - RTDa

DIBRIS - UniGe

Mar 2023 – ongoing Genova, Italy

Postdoctoral research

DIBRIS - UniGe

Feb 2022 – Feb 2023 Genova, Italy

- Project title: Modeling and characterization of heterogeneous, interconnected and 3D neuronal networks to study physiological and pathological conditions.
- Supervisor: Professor Paolo Massobrio

PhD Student in Bioengineering and Robotics

DIBRIS - UniGe

Nov 2018 – Gen 2022 Genova, Italy

- Project title: Brain-on-a-chip models to investigate the role of modularity, heterogeneity, and three-dimensionality on in vitro neuronal networks
- Visiting period: 3 months at NETRI, Lyon, France
- Supervisor: Professor Paolo Massobrio
- Final evaluation: Excellent

Master's degree in Bioengineering, Curriculum Neuroengineering and Bio-ICT

DIBRIS - UniGe

Sept 2016 – Oct 2018 Genova, Italy

- Thesis title: Characterization of the network dynamics of interconnected neuronal populations
- Final degree mark: 110/110 cum laude, "Right of Publication"

Bachelor's degree in Biomedical Engineering

DIBRIS - UniGe

Sept 2013 – Dec 2016 Genova, Italy

- Thesis title: How Alzheimer's disease changes the dynamic states of a cortical network, application of the SOC theory
- Final degree mark: 101/110

TEACHING ACTIVITY

- Co-advisor of 16 Bachelor's thesis
- Co-advisor of 12 Master's thesis
- Co-adivor of a PhD student
- Teaching assistant for "Approcci sperimentali alla Neuroingegneria" (CFU = 6, 2023-2025), 24 hours
- Teaching assistant for "Analysis of Biomedical Data and Signals" (CFU = 6, 2023-2025), 12 hours
- Holder of the doctoral course (39th cycle) "Advanced topics in in vitro Neuroengineering: techniques, applications, and future directions", 2023-2024
- Teaching Support in Computation Neuroscience (CFU = 6, 2021-2022), 18 hours
- Teaching Support in Neuroengineering and Neurotechnologies (CFU = 6, 2021-2022), 20 hours
- Teaching Support in Neuroengineering and Neurotechnologies (CFU = 6, 2018-2019), 20 hours
- Teaching Support in Computational Neuroscience (CFU = 6, 2019-2020), 15 hours
- Seminar on "Interconnected Neuronal Assemblies" at the University of Genova
- Seminar on "Brain-on-a-chip models" at the University of Genova

PUBLICATIONS

Journal Articles

- Callegari, F., Brofiga, M., Tedesco, M., & Massobrio, P. (2024). Electrophysiological features of cortical 3d networks are deeply modulated by scaffold properties. *APL Bioengineering*.
- Cerutti, L., & Brofiga, M. (2024). Unraveling brain diseases: The promise of brain-on-a-chip models. *Journal of Neuroscience Methods*.
- Brofiga, M., Poggio, F., Callegari, F., Tedesco, M., & Massobrio, P. (2023). Modularity and neuronal heterogeneity: Two properties that influence in vitro neuropharmacological experiments. *Frontiers in Cellular Neuroscience*.
- Callegari, F., Brofiga, M., & Massobrio, P. (2023). Modeling the three-dimensional connectivity of in vitro cortical ensembles coupled to micro-electrode arrays. *PLOS Computational Biology*.
- Parodi, G., Brofiga, M., Pastore, V. P., Chiappalone, M., & Martinoia, S. (2023). Deepening the role of excitation/inhibition balance in human ipscs-derived neuronal networks coupled to meas during long-term development. *Journal of Neural Engineering*.
- Poggio, F., Brofiga, M., Tedesco, M., Massobrio, P., Adriano, E., & Balestrino, M. (2023). Lack of epileptogenic effects of the creatine precursor guanidinoacetic acid on neuronal cultures in vitro. *Biomolecules*.
- Brofiga, M., & Massobrio, P. (2022). Brain-on-a-chip: Dream or reality? *Frontiers in Neuroscience*.
- Brofiga, M., Pisano, M., Tedesco, M., Boccaccio, A., & Massobrio, P. (2022). Functional inhibitory connections modulate the electrophysiological activity patterns of cortical-hippocampal ensembles. *Cerebral Cortex*.
- Callegari, F., Brofiga, M., F.Poggio, & Massobrio, P. (2022). Stimulus-evoked activity modulation of in vitro engineered cortical and hippocampal networks. *Micromachines*.
- Chiappalone, M., Cota, V. R., Carè, M., Florio, M. D., Beabois, R., Buccelli, S., … Levi, T. (2022). Neuromorphic-based neuroprostheses for brain rewiring: State-of-the art and perspectives in neuroengineering. *Brain Sciences*.
- Boschi, A., Brofiga, M., & Massobrio, P. (2021). Thresholding functional connectivity matrices to recover the topological properties of large-scale neuronal networks. *Frontiers in Neuroscience*.
- Brofiga, M., Pisano, M., F.Callegari, & Massobrio, P. (2021). Exploring the contribution of thalamic and hippocampal input on cortical dynamics in a brain-on-a-chip model. *IEEE Transactions on Medical Robotics and Bionics*.
- Brofiga, M., Pisano, M., Raiteri, R., & Massobrio, P. (2021). On the road to the brain-on-a-chip: A review on strategies, methods, and applications. *Journal of Neural Engineering*.
- Brofiga, M., Pisano, M., Tedesco, M., Raiteri, R., & Massobrio, P. (2020). Three-dimentionality and heterogeneity shape the dynamics of interconnected cortical ensambles. *Journal of Neural Engineering*.

Books

- Andolfi, A., Brofiga, B., Callegari, C., Dellacasa, E., Lisa, D. D., Massobrio, P., … Martinoia, S. (2021). *Brain-on-a-chip: Engineered neuronal populations and microtransducer arrays*. Patron editore.

Oral Presentations

- Brofiga, M., & Massobrio, P. (2022 **invited speaker**). *Brain-on-a-chip models to investigated the role of modularity, heterogeneity, and three-dimensionality on in vitro neuronal networks*. Berlin, Germany.
- Brofiga, M., Callegari, F., Cerutti, L., Tedesco, M., & Massobrio, P. (2024). *In vitro mea-based model to investigate the electrophysiological features of the cortical-striatal-thalamic (cst) circuit*. Zurich, Switzerland.
- Brofiga, M., Tedesco, M., & Massobrio, P. (2019). *Recreating in vitro the cortical-hippocampal system: Toward a brain-on-a-chip*. Montpelier, France.

AWARDS

- **Premio di dottorato Alberto Mazzoldi- University of Pisa- COntrubuted by the Mazzoldi family and the bioengineering group of the E. Piaggio Research Center of the University of Pisa**, Gruppo Nazionale di Bioingegneria (GNB), Scuola di Bressanone, 2023, first place nationally
- **Premio di Laurea IEEE Italy Section**, Gruppo Nazionale di Bioingegneria (GNB), Scuola di Bressanone, 9-12 September 2019
- **FENS-IBRO/PERC grant**, FENS Forum 2020, 11-15 July 2020
- **Premio Speciale ALTEROX**, Centro 3R, 30 September – 1 October 2021

TECHNOLOGY TRANSFER

- **CTO and Co-founder of SceenNeuroPharm s.r.l**, innovative start-up, established in 2021.
- **Inventor of Patent n° 102021000004313**, international publication number WO 2022/180187 A1, "Apparato biocompatible e sistema biocompatible per la creazione di culture cellular in vitro"
- **PCT n° PCT/EP2022/054715**, "Biocompatible apparatus and system for creating in vitro cell cultures"
- **Software IP D000017416, 'EasyPharm'**

EDITORIAL ACTIVITY

- Reviewer of **Journal of Neural Engineering**
- Reviewer of **Journal of Biosensors and Bioelectronics**
- Reviewer of **Journal of Neuroscience Methods**
- Reviewer of **Nature Communication**
- Reviewer of **Biofabrication**
- Reviewer of **Biochemistry and Biophysics Reports**
- Review Editor of **Frontiers in Computational Neuroscience**
- Review Editor of **Frontiers in Human Neuroscience**