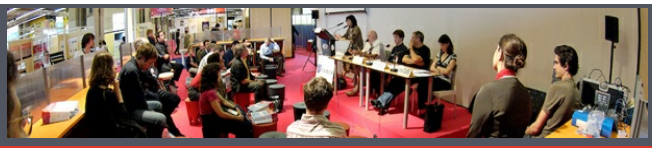
INTERNATIONAL RELATIONS



INTERNSHIP SUBJECT

2873 - Modeling experiments on the retinal network

Modeling experiments on the retinal network

Positioning. The retina, a sophisticated neural network for the visual system, plays a crucial role in the transduction of photonic signals from the external environment into a cascade of electrical impulses transmitted to the brain (Figure 1).
This complex organ, situated at the posterior segment of the ocular structure, is endowed with the capability to execute advanced tasks such as differential motion detection [1] and motion anticipation [2] with superior efficiency compared to contemporary computational devices. Despite these capabilities, comprehensive understanding of retinal functionality remains an enigma. A crucial challenge lies in elucidating the dynamics of the retinal network, particularly the response of retinal ganglion cells (RGCs)– the pivotal cells responsible for transmitting the retina's output to the brain – to diverse visual stimuli. This challenge crucially relies on experiments, as well as on modeling and simulation.
Current experimental setups use multi-electrode arrays (MEA). MEA are matrices of electrodes, plugged to the retina on the RGCs side. Each electrode records the electric activity of the retinal cells located in its neighborhood. This activity depends on the visual stimuli sent to the retina (Figure 2). By processing the electric signals sent by each electrode one obtains a spatio-temporal characterization of the retinal network response to visual stimuli.
Subject. Although there exist models of the retinal network, there is, to our best knowledge, no model of the *interplay* between the retina and the MEA. The goal of this internship is to develop such a model, using the software Macular https://team.inria.fr/biovision/macular-software/ developed in the Biovision lab https://team.inria.fr/biovision/research/ hosting the internship. Starting from a retinal model proposed in [3-7], the student will interface it with a simple model of the MEA device (passive electrodes) so as to be able to reproduce the electric profile observed in experiments and performed in Valparaiso, in A. Palacios team. This project stems indeed from a long lasted collaboration between A. Palacios, and B. Cessac (Inria). It emerged at the outcome of the associated team FUSION https://team.inria.fr/biovision/fusion-functional-structure-of-the-retina-a-physiological-and-computational-approach/. It involves interdisciplinary collaboration between experimental and theoretical teams. The expected results of this internship will up us better characterize the spatio-temporal response of the retinal network to complex stimuli. Indeed, the MEA provides a natural spatial grid which will be helpful to determine the spatial scales involved in the retinal response of spatially structured stimuli.
Involved teams. Dr. Palacios' laboratory was awarded in late 2022 an ANID project in Chile that will allow them to explore the use of various visual stimuli and the analysis of the Electroretinogram signal to estimate the complexity of the response using multiscale entropy methodologies to estimate entropy at different scales as a possible eye biomarker for Alzheimer's type pathologies in humans. This project could be complementary to future collaborative activities between our groups.
The Biovision team develops fundamental research as well as technology transfer around the central theme biological vision and perception, and the impact of low vision conditions. Bruno Cessac is a research director at INRIA, specialized in the modelling and analysis of neuronal models, especially, the retina.

References.

1. Gollisch T, Meister M. Eye smarter than scientists believed: neural computations in circuits of the retina. Neuron. 2010;65(2):150–64.
2. Menz, M. D., Lee, D., and Baccus, S. A. (2020). Representations of the amacrine cellpopulation underlying retinal motion anticipation.bioRxiv.
3. Souihel, S., & Cessac, B. (2021). On the potential role of lateral connectivity in retinal anticipation. The Journal of Mathematical Neuroscience, 11, 1-60.Cessac, B. (2022).
4. B. Cessac, Retinal processing: Insights from mathematical modelling. Journal of Imaging, 8(1), 14.
5. Kartsaki, E., Hilgen, G., Sernagor, E., & Cessac, B. (2024). How Does the Inner Retinal Network Shape the Ganglion Cells Receptive Field? A Computational Study.

Required Skills

We search for a student with a good level in mathematics and computer science, interested in neuroscience and ready to work in collaboration with neuroscience experimentalists.

General Information

- **Research Theme :** Computational Neuroscience and Medicine
- **Locality :** Sophia Antipolis
- **Level :** Master
- **Period :** 2nd February 2026 -> 30th April 2026 (3 months)

These are approximative dates. Please contact the training supervisor to know the precise period.

- **Deadline to apply :** 1st July 2025 (midnight)

Contacts

- **Training Supervisor :** Bruno Cessac / Bruno.Cessac@inria.fr
- **Second Training Supervisor :** Palacios Adrian / adrian.palacios@uv.c
- **Team Manager :** Bruno Cessac / Bruno.Cessac@inria.fr

More information

- **Inria Team :** BIOVISION
- **Inria Center :** Centre Inria d'Université Côte d'Azur

Neural Computation, 36(6), 1041-1083.
6. Ebert, S., Buffet, T., Sermet, B. S., Marre, O., & Cessac, B. (2024). Temporal pattern recognition in retinal ganglion cells is mediated by dynamical inhibitory synapses. Nature Communications, 15(1), 6118.
7. Emonet, J., Souihel, S., Di Volo, M., Destexhe, A., Chavane, F., & Cessac, B. (2024). A chimera model for motion anticipation in the retina and the primary visual cortex.