

Neural Interfaces Project – Fall 2024

Context:

Neural interfaces are artificial electronic systems designed to communicate with the nervous system. The latter orchestrates and controls our movements, thoughts and automatic responses to our surrounding world. Damage to the nervous system due to diseases, trauma or genetic conditions, leads to impairments that may be diagnosed or treated using a neural interface. Many people worldwide already benefit from medical neural interfaces but today, we are at a technological turning point in the development of neural technology.

You are part of the R&D department of a MedTech company. Your management asks your team to explore opportunities in the neurotech domain. Your team is composed of **4 experts** in Engineering and Life Sciences and specializes in Neural Interfaces. The focus of its activity can be Medical devices, Wearable devices, Internet of Things (IoT) and/or Implantable systems. Your company produces devices in-house, and your team is given 9 weeks to come up with an innovative yet concrete idea for a new neural interface.

Your tasks include:

- (1) defining the anatomical area of the nervous system your neural interface will target, its medical application, and the general context (what similar products or technologies already exist? How do they work, how are they made?)
- (2) outlining the neural interface, including all its building blocks (which type of electrodes/transducers are suitable? Is signal amplification and digitization necessary? If so, at what gain levels or with how many bits? Is DC offset a critical consideration in your design? Do you require on-device processing, battery/wireless powering, or data telemetry, among other specifications? etc.)
- (3) defining the interface function
- (4) selecting the relevant materials and manufacturing process or circuit design to produce the device
- (5) defining its characterization and validation methods
- (6) summarizing the added value of the novel interface.

Innovation in your neural interface may come from one or multiple fronts, including the choice of materials, its application, its mechanical footprint, miniaturization, electronic circuits, on-device intelligence, packaging and integration, among others. You should **focus on the hardware side** of the neural interface.

You have 9 weeks to design the product by selecting a reliable technological route and planning its manufacturing and validation steps. You will share your idea with a coaching committee (TAs) in a two-page draft on October 11, 2024. Next, you will prepare a technical report for December 20, 2024.

Project registration - by September 20, 2024, midnight:

Teams of 4 students will be formed: each team must include students with different backgrounds (at least 3 EPFL sections represented per team).

By September 20, 2024 - midnight, each team will register on a Google sheet, which will be made available on Moodle. When signing up, each team will propose a tentative project title.

In the following week, the teams' list will be reviewed by the TAs; each team will have a reference TA but questions during the semester will be handled across the TA team. The project is designed to promote your own thinking, & ideas, in a technological sound context.

Two-page draft - due on October 11, 2024, midnight:

The document (**1-page, single column text + 1-page for figures**) must include the following sections: General context and proposed device / Design concept, specifications and building blocks / Feasibility assessment (materials, manufacturing, integration) / Conclusion.

The report will be handed out via Moodle to the TAs who will assess them and provide feedback the following week.

Project presentation and Q&A session, December 13-14, 2024

Each team will share its concept and device design with the whole class via a presentation and Q&A session.

Given the large number of groups, the groups will be split into two large groups and presentations will run in 2 parallel sessions. Each session will be chaired by a group of one professor and TAs.

First, your team will be asked to present in **12 min** your project and its key concepts. You may wish to use a **maximum of 6 slides** without heavy animations!

Next, there will be a 5+ min Q&A session addressing the materials and technology choices, the novelty of your product/device/technology, the feasibility of the proposed invention/product/technology, and your teamwork and organization.

The final timing and schedule will be shared during the semester, once we have a complete list of projects.

Technical report, due on December 20, 2024, noon:

Each team prepares a technical document describing its product/device in more detail. Experts in Materials Science, Microengineering, Microelectronics and Neural engineering will assess the documents.

The report should follow the format below, **12 pages maximum** excluding the cover page and eventual annexes. Each section is mandatory.

- **Cover page.** Your team name, authors' names and EPFL section, date and place.
- **Summary (1 page).** A summary of the main points of the document.
- **State-of-the-art review (2 pages).** Describe the background of your invention/product/technology. What similar products or technologies already exist? How do they work, how are they made, what problems do they solve? You should reference sources from the scientific literature, existing patents, and industry websites.
- **Your product/device (2-6 pages).** A clear and concise description of the invention/product/technology. How does it work, what problem does it solve, how is it different from existing products/inventions/technologies? This should be documented with precise and quantitative information. This section includes: a block diagram of the entire system proposed, the fabrication process flow for the device, its electrochemical characterization, any electrical/mechanical considerations if needed, a block diagram of the electronic system (hardware architecture) along with its specifications.
- **Feasibility assessment (1 page).** Resources you need to produce a prototype: which technologies, which materials, how long would it take? Are there any regulatory bodies that need to approve your product/device? How realistic is the proposed solution?
- **Conclusion (1 page).**
- **Appendix (1 page).** Describe how you worked as a team to ensure everyone contributed to the project.

Important

The final report should be no more than 12 pages long, in standard single-column format, with 2.5cm margins with 12-point font Title and 11-point font Main text. Pages should be numbered. Diagrams, graphs, photographs, and tables should be used where appropriate. Figures should have captions and be clearly labeled and referenced in the text. References should mainly include papers from peer-reviewed journals and conference proceedings, books, and patent citations. Your report should not rely on information taken from websites. References will be numbered throughout the report and listed at the end of the report.

Any report that does not follow these guidelines will not be marked, and will be assigned a grade of 1. Ask early in the semester if you are unsure of the format.

Useful information

- Each team should meet weekly with their TA in the semester.
- Once the team and project are selected, students should establish regular meeting times to progress throughout the semester on the project.
- The time taken to write the project will vary between groups but this will need coordination among the 4 members and during the semester.
- All group members share responsibility for the project's success. As tasks may be assigned to each student, make sure the team understands the entire content of the project.
- The reports must be original, reflecting your own thinking and analysis.

Deliverables per team

- **September 20, 2024:** Team-project groups are available.
- **October 11, 2024, midnight:** 2-page project summary of your project. Your main TA will provide feedback during the following TA session.
- **December 13-14, 2024:** group presentation project. The list and timetable will be established mid-semester and posted on Moodle.
- **December 20, 2024, noon:** 12-page project report. The report should be uploaded on Moodle. One paper copy of the report can be handed out to the TAs during class.