

2023-2024 ICS Internship Project: Electrical simulation of training RRAM neuromorphic systems using PySpice



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Project topics : Machine learning, Microelectronics, Electrical engineering

RRAM (resistive random access memory) is a promising technology for neuromorphic computing, which is a type of computing that is inspired by the human brain. Neuromorphic systems are able to learn and adapt to new information in a similar way to the human brain.

However, RRAM-based neuromorphic systems are still in their early stages of development, and there is a need for better simulation tools to help researchers design and optimize these systems.

This internship project is the continuation of the two mini-projects [Training memristive network with NeuroSim \(Project A\)](https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/NeuroSim.html) (<https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/NeuroSim.html>) [Simulation of an RRAM Device Using PySpice \(Project B\)](https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/PySpice-RRAM-simulation.html) (<https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/PySpice-RRAM-simulation.html>). The student that will be involved in this project will actually have to complete these two mini-projects (one during the mini-project period and the other during the internship period).

Project description

The goal of this project is to use PySpice to simulate the training of a memristive-based neural network. The simulation framework developed in this project will enable researchers to simulate the training process of RRAM neuromorphic systems and to evaluate the performance of different training algorithms. During the project, we will investigate the performance of the backpropagation algorithm, which is the simplest training algorithm in neural networks and the Equilibrium Propagation algorithm, which is an alternative to backpropagation.

In this project, the student will have the opportunity to learn how to use PySpice to simulate RRAM-based neuromorphic systems. This will be a valuable skill to have, as open source simulators and workflows are likely to play an increasingly important role in the development of electronics systems. Furthermore, this project will provide the student with the opportunity to develop a valuable new tool for the neuromorphic computing community.

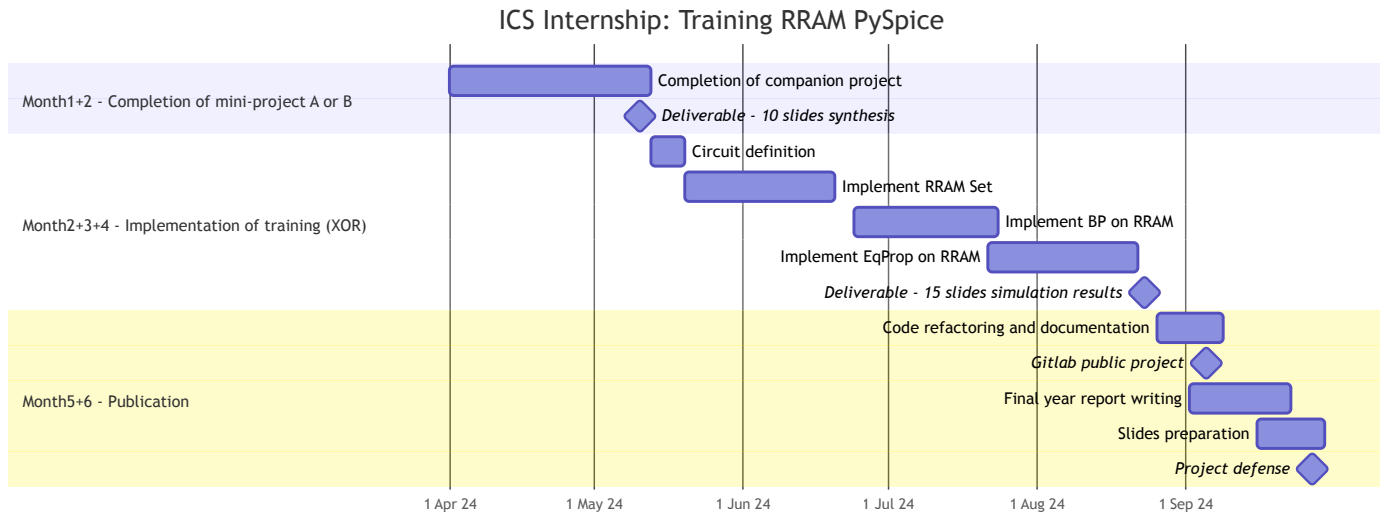
Required skills

This project requires a good knowledge of electrical engineering and Python programming.

- Mandatory
 - Python programming experience (setting a virtual environment or `LD_LIBRARY_PATH` or `PYTHONPATH`)
 - C++ programming experience (compiling with non-standard libraries)
 - practical elements of `git`
 - SPICE language (at least ability to read a *netlist*)

- Linux OS basics (usage of terminal command lines)
- Optional
 - Basic knowledge of Verilog-A
 - Basic knowledge of machine learning algorithms

Workplan (6 months)



Location

School

[Télécom Paris](https://www.telecom-paris.fr/) (<https://www.telecom-paris.fr/>) trains its students to innovate in today's digital world. Its training and research cover all fields of information and communication sciences and technologies with a strong societal foundation in order to address the major challenges of the 21st century. It offers engineering, PhD and professional degree programs, with international students accounting for 55% of its student body. Its research offers original, multidisciplinary world-class expertise in nine strategic areas: Data Science and Artificial Intelligence—Visual and Audio Computing, Interaction—Digital Trust—Innovation Regulations—Transformation of Innovative Firms—Cyber-Physical Systems—Communication Systems and Networks—Mathematics and Applications—Uses, Participation, Democratization of Innovation.

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Hosting laboratory

[Laboratoire Traitement et Communication de l'Information \(LTCI\)](https://www.telecom-paris.fr/fr/recherche/laboratoires/laboratoire-traitement-et-communication-de-linformation-ltci)

(<https://www.telecom-paris.fr/fr/recherche/laboratoires/laboratoire-traitement-et-communication-de-linformation-ltci>)

Research team

The [Circuits et Systèmes de Communication \(C2S\)](https://www.telecom-paris.fr/fr/recherche/laboratoires/laboratoire-traitement-et-communication-de-linformation-ltci/les-equipes-de-recherche/circuits-et-systemes-de-communication-c2s)

(<https://www.telecom-paris.fr/fr/recherche/laboratoires/laboratoire-traitement-et-communication-de-linformation-ltci/les-equipes-de-recherche/circuits-et-systemes-de-communication-c2s>)

team is internationally recognized for its ability to integrate digital intelligence into AMS and RF SoCs such as analog-to-digital converters (ADCs) or RF receivers for cognitive radio. By combining its expertise in the physical realization of the CMOS chip with its experience in signal processing and its knowledge of the other network layers for which LTCI's skills are recognized, the group designs high-performance AMS and RF SoCs. The aim is to develop elements or "building blocks", enabling the system of connected objects to be interfaced on one side with the physical world via sensors, and on the other side with the system core via communications, in particular RF.

References

The literature review for this project will elaborate on the one done during the mini-project period. Please refer to [mini-project A](https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/NeuroSim.html) (<https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/NeuroSim.html>) and [mini-project B](https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/PySpice-RRAM-simulation.html) (<https://c2s.telecom-paristech.fr/ICSProjectsInternships/Germain/projects/PySpice-RRAM-simulation.html>) for more details.

Last updated 2023-12-13 23:29:22 +0100