ESILV – Research Project 2026

January 3, 2026

1 Project guidelines

Report guidelines: The report should contain a maximum of 15 pages. An introduction, a methodological section, results & discussion section and a conclusion are expected. The introduction must be composed of a presentation of the context with a literature review, an explanation of the project, and the plan of the report. The methodology section must present the technical and theoretical aspects that are used for this project, so that a reader unfamiliar with the topic can understand the report. For this project, you must use an AI platform (ChatGPT, Copilot...) and explain why and when you used this platform and what were the advantages and disadvantages. If many plots, tables and figures must be present, an appendix is highly recommended. There is no page restriction regarding the appendix.

The report must be sent to gabriel.breuil@ext.devinci.fr by February 27^{th} **at** 16:00**, at the latest**.

The presentation guidelines: The presentation should last 15 minutes ±1 min. An explanation of the project must be given in order to present it to the rest of the class. The presentation will be followed by a round of questions for 5 minutes. The presentation must answer the following questions:

- What is your project about?
- What were the objectives of the project and how did you achieve them?
- What recommendations would you make to extend this project?

This will be done on March 2^{nd} **from** 10:00 **to** 13:15**. All presentations must be sent before** 10:00 **on the same day.**

The report and presentation must be done in English.

2 Goal

Bored during one of the many quantum computing lectures, you and your teammate decide to play tic-tac-toe. However, after a few games, you both know how to play and the pattern is always the same. Now each match ends in a draw. So now, you have to go back to the quantum computing lecture and listen. After some time, you start thinking: What if you could have a superposition of positions for your crosses and circles? This would definitely change the outcome of a match.
One last issue remains. You think and behave classically, like your teammate. How would you be able to have a quantum opponent? The answer is straightforward. You need to code your opponent.
A quantum tic-tac-toe captures three quantum phenomena:

1. The superposition of states: the ability of a quantum particle to be characterized by several states
2. The entanglement: the correlation between two different particles such that the state of one of them is directly linked to the state of the second and vice versa
3. The collapse of the wave-function: after a measurement, all states of particles collapse such that they are now in a single state.

It remains, however, one major challenge. How can we play to quantum tic-tac-toe?

In the 1^{st} round, the cross player has to put two crosses in two different boxes. Let us name the boxes A and B. We have a superposition such that we have X_A and X_B in the 1^{st} round. In the 2^{nd} round, the circle player can now put two circles in two different boxes as well. Let us assume the circles are in boxes B and C. The second superposition occurs then with O_B and O_C. In the 3^{rd} round, it is now the turn of the cross-player and so on. When entangled states are created, one can assume that a measurement is performed in order to "*provoke*" the collapse of the wave function.
The game ends when three circles or crosses make a straight line. However, due to entanglement and collapse of the wave function, the two players can sometimes both be winners or losers.

The first goal of your project is to code an interface against which you can play tic-tac-toe. Then, create your own quantum algorithm which plays the role of your quantum opponent.

3 Tasks

- By using the language of your choice, program your classical tic-tac-toe. Your opponent must be optimized such that the algorithm tries to find the most suitable position for the crosses and circles.
- By using `Qiskit` or `Pennylane`, code your own quantum tic-tac-toe. For this, you must use the quantum property of state superpositions and develop or use a quantum algorithm if needed.
- Feel free to add any additional details in the description. The core idea of this project is that you try altogether to go beyond the asked tasks.

Good luck and enjoy!