Université des Sciences et de la Technologie
Houari Boumediene (USTHB)
Faculté d'Informatique

Master MIV – Année universitaire 2025/2026

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Projet : Exploring Quantum Image Processing

From Fundamentals to Applications

Année universitaire 2025–2026

Project Description

Quantum computing represents a revolutionary paradigm that leverages the principles of **superposition** and **entanglement** to perform computations exponentially faster than classical systems for certain problems. This project explores how these principles can be applied to **image processing**, giving rise to the emerging field of **Quantum Image Processing (QIP)**.

Students will study how images can be represented, manipulated, and analyzed using quantum systems, and how quantum algorithms can outperform traditional approaches in speed, efficiency, and data security.

The project also investigates different quantum image representation models such as **FRQI (Flexible Representation of Quantum Images)** and **NEQR (Novel Enhanced Quantum Representation)**, as well as advanced applications like **quantum image compression** and **encryption**.

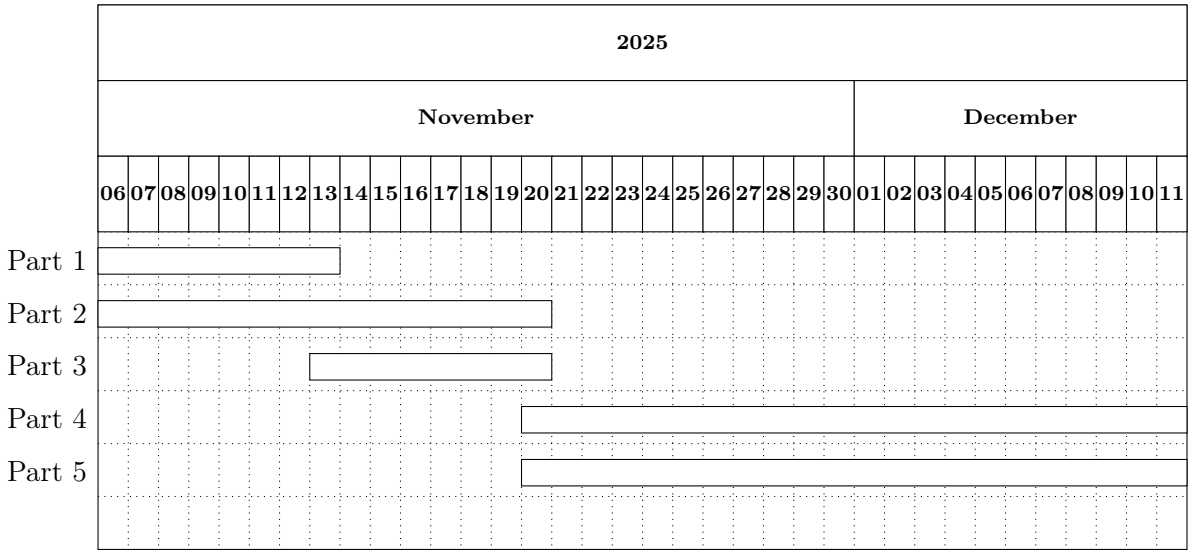
Objectives

1. Understand the fundamental concepts of quantum computing.
2. Explain the principles and architecture of Quantum Image Processing (QIP).
3. Compare classical and quantum image representations.
4. Explore quantum algorithms for image representation, manipulation, and segmentation.
5. Investigate applications such as quantum compression, segmentation, and encryption.
6. Discuss advantages, challenges, and future perspectives of QIP.

Project Structure

Part	Topic / Question	Expected Outcome
1	• a) What is quantum computing and how does it work? • b) What is Quantum Image Processing (QIP)? • c) Why is QIP useful? What are its applications?	• a) Overview of qubits, superposition, entanglement and quatum principles • b) Definition and conceptual difference with classical image processing. How does quantum image processing work • c) Real-world examples and potential use cases of quantum image processing
2	How is an image represented in quantum systems?	Study and implementation of FRQI, NEQR, and other models. comparing between the models
3	What kinds of image manipulation can be done?	Quantum operations, quantum enhancement and filtering
4	What quantum algorithms are used for segmentation?	Comparative analysis of existing methods. Implementation of a quantum segmentaiton algorithm
5	How does quantum compression and encryption work?	Study of emerging applications. Implementation of a quantum compression algorithm

Timeline (Until Mid-December)



Deliverables

For each part each group must submit the following:

- A written report (15–20 pages) summarizing the study and conclusions.
- A PowerPoint presentation explaining the main findings.
- A demonstration (for implementation part) using `Qiskit`, `QuTiP`.

Organization

Students are divided into groups. The project is structured into **5 main parts**, with **co-operative** groups working in parallel within each part. Each group focuses on a specific subtopic, implementation, or comparative study related to its part.

Each part aligns with the corresponding phase in the project timeline. Groups working within the same part operate in parallel and may later present a joint synthesis of their findings.

Part	Main Topic	Groups and Focus
1	Part 1	• Group 1: Quantum computing principles • Group 2: Introduction to Qiskit
2	Part 2	• Group 3 : How to represent an image in Quantum computing • Group 4 : FRQI model implementation • Group 5 : NEQR model implementation • Group 6 : Comparative analysis FRQI vs NEQR • Group 7 : novel encoding model impelmentation
3	Part 3	• Group 8: Enhancement and filtering techniques • Group 9: Quantum pixel transformation
4	Part 4	• Group 10: Quantum clustering for image segmentation • Group 11: Comparative study of segmentation algorithms • Group 12: Implementation and evaluation on sample datasets
5	Part 5	• Group 13: Quantum image compression techniques • Group 14: Quantum encryption • Group 15: Quantum image watermarking

Table 1: Group Distribution and Topics for the Quantum Image Processing Project