

**Université des Sciences et de la Technologie
Houari Boumediene (USTHB)**

Faculté d’Informatique

Master MIV – Année universitaire 2025/2026

Projet proposé par : Dr. Naoual MEBTOUCHE

Projet : Exploring Quantum Image Processing
From Fundamentals to Applications

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	<ul style="list-style-type: none">• 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?	<ul style="list-style-type: none">• a) Overview of qubits, superposition, entanglement and quantum 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

2025											
November						December					
21	22	23	24	25	26	27	28	29	30	01	02
Part 1											
Part 2											
Part 3											
Part 4											
Part 5											

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	<ul style="list-style-type: none"> • Group 1: Quantum computing principles • Group 2: Introduction to Qiskit
2	Part 2	<ul style="list-style-type: none"> • 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 implementation
3	Part 3	<ul style="list-style-type: none"> • Group 8: Enhancement and filtering techniques • Group 9: Quantum pixel transformation
4	Part 4	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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

Teams

Groupe	Titre du projet	Nom	Prénom
1	Quantum computing principles	Messerli	Yacine
		Aliouane	Hocine
		Benmati	Nour el Houda
		Bouzid	Sihem
		Chabani	Reda
		Abouriche	Louiza
		Touafek	Asma
		Amar Khodja	Mohamed Achour
2	Introduction to Qiskit	Djadi	Boudjemaâ
		Melouk	Dina Racha
		Boukaoula	Aymen
		Hamadi	Meriem
		Abdennour	Benjillali
		Abane	Mehdi Lamine
		Cherfaoui	Ismail
		Hebib	Nazim
3	How to represent an image in Quantum computing	Ounadji	Yaakoub
		Bouchakour Rahmani	Rafik
		Hamoudi	Abderezzak
		Trir	Aimen
		Ouahib	Elyes
		Younoussa	Houda
		Hammane	Mohamed Amine
		Refsi	Zineddine
		Tayebbey	Abdelhadi
		Aireche	Elounes
4	FRQI model implementation	Djaoud	Khadidja
		Guarbi	Feriel
5	NEQR model implementation	Kedjour	Chakib Abderrahmane
		Ferhat	Abderrahmane
		Sellami	Mohamed Amine
		Mansour	Mohamed Imad
		Bouchicha	Mourad
		Laama	Kaouther
		Nemiri	Lyna Ferial

Groupe	Titre du projet	Nom	Prénom
6	Comparative analysis FRQI vs NEQR	Nedjah	Youstra
		Mahdji	Ouafaa
7	Novel encoding model implementation	Boumaza	Imad Eddine
		Belkadi	Ilyes Islam
		Hattab	Omar Mourad
		Gueracha	Ramzi Wassim
		Merrouki	Yacine
		Heddouche	Mohamed Amine
		Ariba	Mehdi
		Chaaf	Mohamed
8	Enhancement and filtering techniques	Aouimer	Sabrine Fatma
		Bourouba	Rayan
		Dadi	Soumia
		Benkouider	Wissal
		Mazzouza	Sarah
		Matouk	Nour el Houda
		Bezri	Sarah
		Bouazza	Chaima
9	Quantum pixel transformation	Redjah	Youstra Sarah
		Saadoune	Sara
		Dekkiche	Nesrine
		Aliche	Zakaria
		Ferrani	Assia Lyna
		Derriche	Rania
		Deghbar	Djouhra
		Badada	Hadjer
10	Quantum clustering for image segmentation	Idjoudikene	Lounas
		Boukhatem	Mohamed Rafik
		Karballa	Chouaib
		Miloudi	Abdallah Redouane
		Khemissa	Ahmed
12	Implementation and evaluation on sample datasets	Rehal	Amel
		Challal	Saloua
		Ghemmour	Lehna
		Niati	Youstra
		Debbagh	Ilham
		Ouedfeul	Yasmine
		Benmahdi	Nadine
		Guebli	Fatima Ez-zahra

Groupe	Titre du projet	Nom	Prénom
14	Quantum encryption	Koudache	Lina
		Almadounas	Yasmine
		Cherfi	Farah Maria
		Gherib Djeffal	Lyna
		Ouaaz	Rania
		Belmehdi	Maria
		Aouadi	Asma
		Abdesselam	Meriem
15	Quantum image watermarking	Bouras	Mohamed Malik
		Hadj Aissa	Nadji
		Mohamedi	Anes
		Bouloufa	Tarek
		Remadhnia	Mohamed Yassine
		Djebara	Nadjib
		El Hadjen	Hamza Hocine
16	Quantum Cryptography	Fettal	Nesrine
		Zemmouri	Afnane
		Bouabache	Malak
		Feraï	Ikram
		Tahiri	Kaouther