Ayan Barui

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PhD Student at Inria

Research Experience

Introduction to Quantum Computing with Qiskit (IQCQ) 2024, *UPES*   *January 2024*

Took an interactive session on Quantum Image Processing and discussed various encoding schemes to store the informational content of an image in a quantum circuit. This workshop was organised by the Centre for Excellence in Quantum Technologies, UPES.

Womanium Global Quantum 2023, *Womanium*   *July 2023 - Sept 2023*
- Superconducting, Neutral-Atom, Trapped-Ion, Photonic, Silicon-based Quantum Computing; Quantum Annealing; Fiber Lasers in Quantum Optics
- Deutsch's Algorithm, Grover's Algorithm, Deutsch Jozsa, Bernstein Vazirani, Simon's Algorithm, Grover's Search, Max Cut and Adders, Quantum Cryptography Basics, Quantum Key Distribution with Noise, Entanglement-based Quantum Key Distribution, Quantum Error Correction
- Introduction to Quantum Machine Learning, Optimizing Quantum Circuits, Quadratic Unconstrained Binary Optimization, Quantum Computing with Neutral Atoms, Distributed Computing, Quantum Sensing

Qiskit Global Summer School 2023 - Quantum Excellence, *IBM*   *June 2023 - July 2023*
- Explore quantum computing and its applications with a focus on quantum algorithms using NISQ hardware
- Simulated Iterative Quantum Phase Estimation algorithm

Summer School on Quantum Information and Quantum Technology, *IISER Kolkata*   *June 2022 - July 2022*
- Focused on Quantum optics & information
- With broad perspective of Quantum sensing, communication, computing, metrology
- With researchers meet and industry-academia interaction

Protein Folding Using Quantum Computing, *Quantum AI*   *May 2023 - Aug 2023*

The protein folding problem has been an area of research for many years due to its pivotal role in Chemistry and medicines. Given a polymer model, its a NP-Hard problem for the classical algorithms to determine the number of ways a polypeptide chain will fold into a protein. However, quantum algorithms can optimize such problems with $O(n^4)$ scaling. In this project we extended the main chain and side chains, including more sub-sidechains. We customized this using the IBM research module, adding more penalty terms and using different interactions models such as the mj-interaction model, to setup the correct chirality.

Education

N/A	**PhD Student**, *Inria*	Valbonne, France	*November 2024 - Present*
N/A	**Research Project Fellow**, *IISER Kolkata*	Mohanpur, India	*June 23 - August 24*
6.74/10	**M.Sc in Physics**, *Central University of Haryana*	Haryana, India	*November 21 - July 23*
67.88%	**B.Sc. in Physics**, *University of Calcutta*	Kolkata, India	*June 17 - August 21*
69.33%	**High School (Class XI and XII)**, *ISCE*	Howrah, India	*July 15 - May 17*

Courses: Linear Algebra | Atomic and Molecular Physics | Solid State Physics | Semiconductor Devices | Electronics | Quantum Mechanics | Astrophysics | General Theory of Relativity | Computational Physics using Python

Skills

Programming	Python, C/C++, Java, Qiskit, Cirq, PennyLane, LaTeX
Technical	Quantum Algorithms, Quantum Simulations, VQE, CvaR, QAOA, Developer
Software	Linux, Tensorflow, Pytorch, OpenCV

Publications

A Novel Approach to Threshold Quantum Images by using Unsharp Measurements   *May 2023 - September 2023*

Advisors: Prof. Prasanta K. Panigrahi, *IISER Kolkata* & Dr. Mayukha Pal, *ABB*

Based only on image histograms, a novel method is developed to obtain thresholds of images using unsharp measurements. The mathematical formulations are constructed using Gaussian POVMs which convert the overlapping Gaussians present in image histograms into Dirac-delta functions that are treated as thresholds. Comparision metrics like PSNR and SSIM are used to evaluate the quality of compression ratio of different life-like pictures with well established thresholding algorithms. A quantum comparator, attached with a NEQR circuit, is used to apply the obtained threshold and binarize a given image. This work is accepted in the journal Quantum Information Processing. **DOI:10.1007/s11128-024-04282-4**

A Quantum Approach to solve N-Queens Problem   *June 2023 - November 2023*

Advisors: Prof. Prasanta K. Panigrahi, *IISER Kolkata*

The famous N Queens problem involves the arrangement of N queens on an $N \times N$ chessboard such that they are not under attack from each other on the same row, column and diagonal. In this work we have designed a quantum algorithmic framework to solve this NP-Complete computational problem. Along with the effective preparation of W states, two innovative quantum algorithms have been used to suitably find the solutions. This is an accepted work in the international conference COSMNETS 2024, held in Bangalore   **DOI:10.1109/COMSNETS59351.2024.10427458**

Research Projects

A Hybrid Quantum Algorithm to Binarize Grayscale Images - *Master's Thesis Project*   *Feb 2023 - May 2023*

Advisors: Prof. Prasanta K. Panigrahi, *IISER Kolkata* & Prof. Suneel Kumar, *Central University of Haryana*

Quantum Image Processing (QIP) is an emerging field that shows advantage over classical image processing owing to inherent quantum parallelism and quantum superposition. This work focuses on the determination of thresholds for effective multi-thresholding of images through Unsharp Measurements. The results show effective compression and object identification is demonstrated by the use of SIFT descriptor. A quantum circuit is made to binarize quantum images from a 4-level to a binarized image by the use of dynamic circuits implemented in IBM Qiskit

Extensice Review of Benchmarking Quantum Computers   *June 2022 - July 2022*

Advisor: Chetan Waghela, *IIT Ropar*

We implemented randomized benchmarking on 2-qubit simultaneous with 1-qubit, establishing a Error per Clifford (EPC) 1.320763e-02. In this particular experiment, we have 3 qubits Q0,Q1,Q2. We are running 2Q RB (on qubits Q0,Q2) and 1Q RB (on qubit Q1) simultaneously, where there are twice as many 1Q Clifford gates. We define a noise model for the simulator. To simulate decay, we add depolarizing error probabilities to the CNOT and U gates. We execute these sequences, but with a noise model extended with T1/T2 thermal relaxation error, and fit the exponentially decaying curve. We count the number of gates per Clifford, and calculate the two-qubit Clifford gate error, using the predicted primitive gate errors from the coherence limit.

Other Ongoing Projects   *October 2023 - Present*

IISER Kolkata

• Demonstrating Masking of Quantum Information
• A Review on Quantum Image Processing

Certificates

2022	**Quantum Computing: Introduction to the algorithms and implementation using Qiskit**, Qkrishi & IISER Tirupati	*Remote*
2023	**Third Workshop for Quantum Enabled Science and Technology**, IISER Kolkata, *QuEST*	*India*
2023	**Program Coordinator of the 4th International Conference on QIQT**, *IISER Kolkata & I-HUB*	*India*
2023	**IBM Quantum Challenge: Spring 2023 Achievement**, *IBM*	*Remote*
2023	**Quantum Measurement Theory and The Uncertainty Principle**, *GIAN & IISER Kolkata*	*India*

Languages

English	Professional proficiency
Bengali	Native proficiency
Hindi	Intermediate proficiency
German	Basic proficiency

Academic References

Prof. Prasanta K. Panigrahi

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