EOP ASEE 2022
Final Presentation

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Introduction to Quantum Computing with Implications of Sustainability

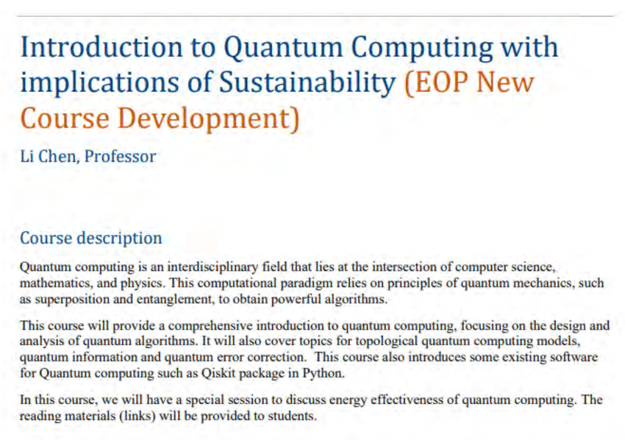
Summary:

The main goal of this project is to prepare a syllabus for a quantum computing class at undergraduate level. I have completed the Initial Syllabus for it. I also gave two testing lectures to UDC Students to collect some information of teaching. I also prepared over 50 pages lecture notes. In addition, I convinced our department to offer this class for undergraduate and graduate students this Spring semester. I have sent a proposal to DIMACS at Rutgers to have a seminar for quantum computer education for HBCUs. Plan to submit a proposal to NSF or other grant agencies.

Completed Procedure/Methods:

Syllabus development

- Met with EOP advisor
- Met with EOP mentors and discussed with other team members.
- Attended EOP Meetings
- Submitted progress report and gave presentations.
- Gave testing lectures to Senior Students (Two Lectures)


Introduction to Quantum Computing with implications of Sustainability (EOP New Course Development)

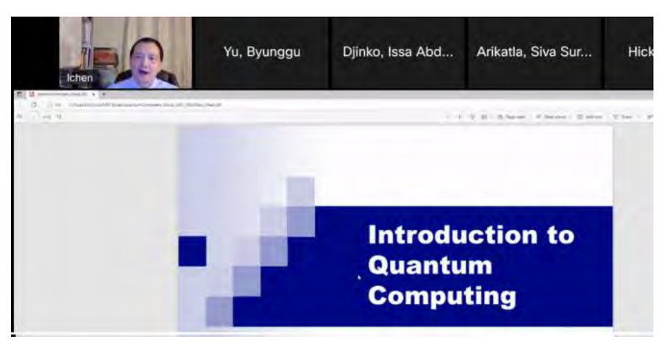
Li Chen, Professor

Course description

Quantum computing is an interdisciplinary field that lies at the intersection of computer science, mathematics, and physics. This computational paradigm relies on principles of quantum mechanics, such as superposition and entanglement, to obtain powerful algorithms.

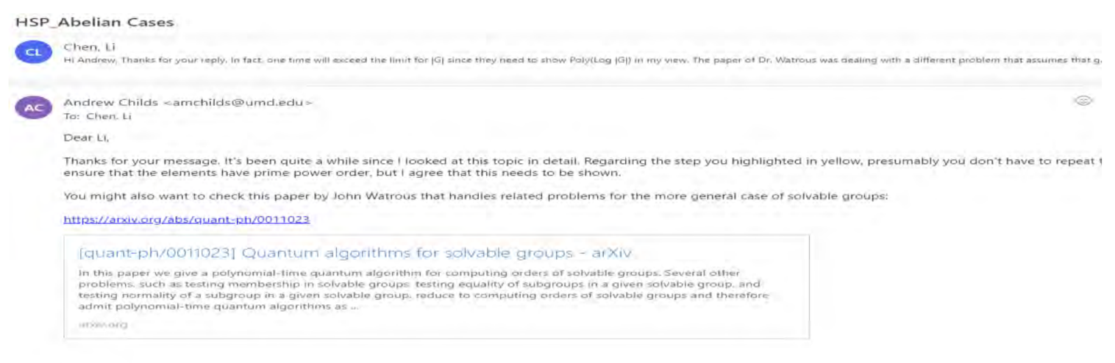
This course will provide a comprehensive introduction to quantum computing, focusing on the design and analysis of quantum algorithms. It will also cover topics for topological quantum computing models, quantum information and quantum error correction. This course also introduces some existing software for Quantum computing such as Qiskit package in Python.

In this course, we will have a special session to discuss energy effectiveness of quantum computing. The reading materials (links) will be provided to students.



Progress and Future Plans:

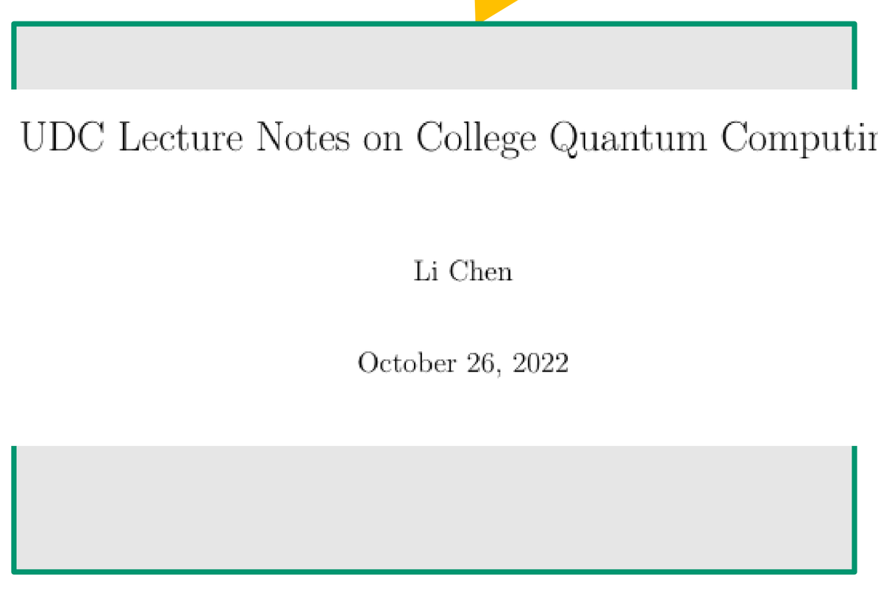
- Write Lecture Notes (50+ pages Completed)
- Ask experts for help of some topics



- Get departmental support for offering the class this Spring
- Propose to have seminars for quantum computer education for HBCUs
- Plan to provide teaching experiences to HBCUs for quantum computing related courses.

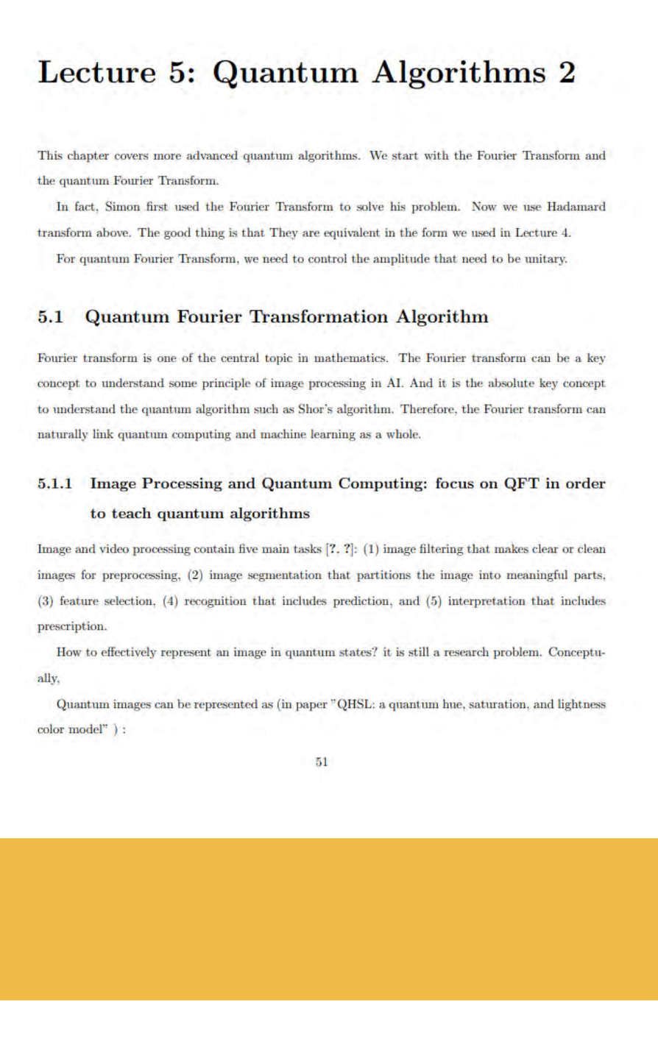
Course and Lecture Notes

Lecture Notes


UDC Lecture Notes on College Quantum Computing

Li Chen

October 26, 2022


Lecture 5: Quantum Algorithms 2

This chapter covers more advanced quantum algorithms. We start with the Fourier Transform and the quantum Fourier Transform.

In fact, Simon first used the Fourier Transform to solve his problem. Now we use Hadamard transform above. The good thing is that They are equivalent in the form we used in Lecture 4.

For quantum Fourier Transform, we need to control the amplitude that need to be unitary.

5.1 Quantum Fourier Transformation Algorithm

Fourier transform is one of the central topic in mathematics. The Fourier transform can be a key concept to understand some principle of image processing in AI. And it is the absolute key concept to understand the quantum algorithm such as Shor's algorithm. Therefore, the Fourier transform can naturally link quantum computing and machine learning as a whole.

5.1.1 Image Processing and Quantum Computing: focus on QFT in order to teach quantum algorithms

Image and video processing contain five main tasks [?, ?]: (1) image filtering that makes clear or clean images for preprocessing, (2) image segmentation that partitions the image into meaningful parts, (3) feature selection, (4) recognition that includes prediction, and (5) interpretation that includes prescription.

How to effectively represent an image in quantum states? it is still a research problem. Conceptually,

Quantum images can be represented as (in paper "QHSL: a quantum hue, saturation, and lightness color model") :

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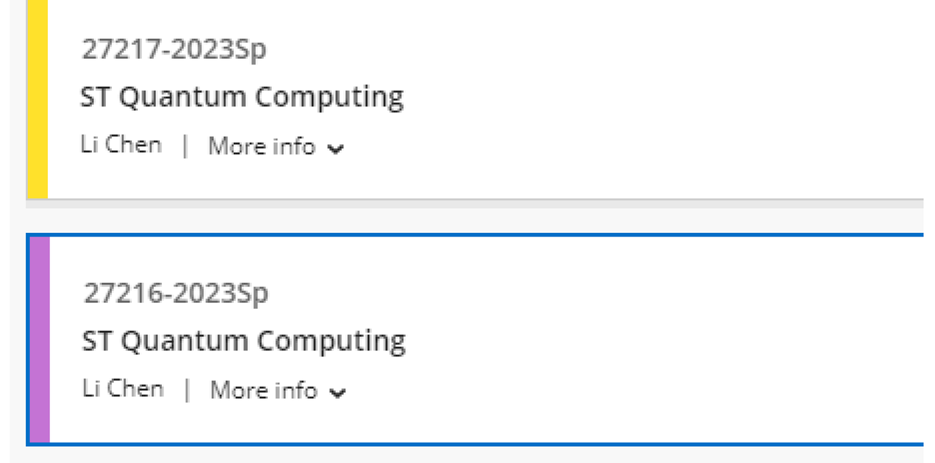
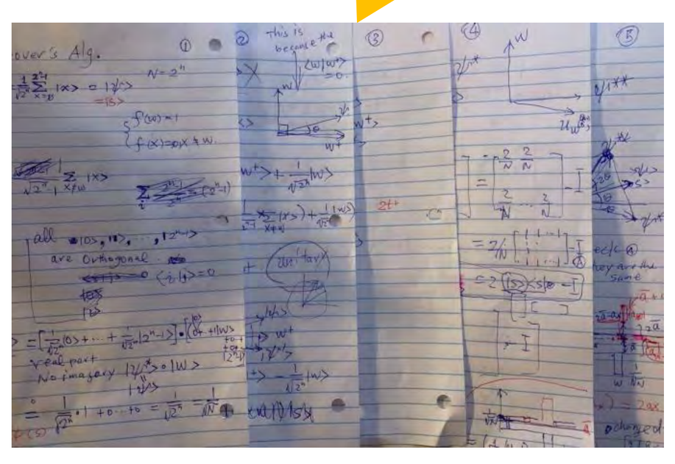
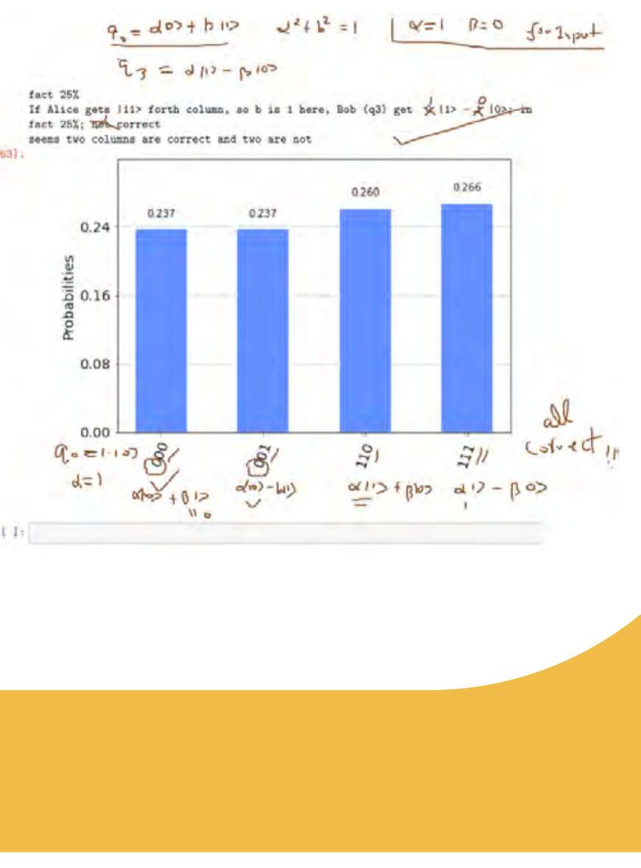


Class Offering this semester

Working on difficult topics For teaching





Qiskit Programming

Evaluation/Impact

- DIMACS is in the process of considering the special seminar for Quantum Computing for HBCU faculty.
- UDC leadership supported this syllabus development by offering a course in quantum computing for undergraduate students this Spring.
- Students will learn programming in quantum computing. Help them to find industry jobs.

References

- *Ikonen, J., Salmilehto, J. & Möttönen, M. Energy-efficient quantum computing.*
- *M Martin et al, Designing Energy-Efficient Quantum Computers Through,Prediction and Reduction of Cooling Requirements for Cryogenic Electronics*
- *Preskill, J. Notes on Quantum Computation.*
- *EOP-ASEE: https://eop-mgp.asee.org/*
- *DIMACS: Center for Discrete Mathematics and Theoretical Computer Science. http://dimacs.rutgers.edu/*

Acknowledgements:

Team 13 would like to thank EOP-ASEE for providing the Mini-grant to UDC. Many thanks to Drs. D. Sanchez, B. Ogundipe, and A. Welker for their mentorship. I would like to thank Professors Yu and Kacem to organize Lecture sessions in their class-time.