Quantum Algorithms

Today:

Introduction

- Technicalities
- About the course

Background refresher

Introduction

Technicalities

- **Lecturer (docent): Vedran Dunjko**
  - all information googlable;
  - email subject: “QA: …”
  - http://liacs.leidenuniv.nl/~dunjkov/

- **Teaching assistant: Casper Gyurik**

Technicalities

- **Lecturer (docent): Vedran Dunjko**
  - all information googlable;
  - email subject: “QA: …”
  - http://liacs.leidenuniv.nl/~dunjkov/

- **Teaching assistant: Casper Gyurik**

- **Course website: http://liacs.leidenuniv.nl/~dunjkov/QAlg.html**

- Course will be given in English

- Make sure you are registered in uSis

- **More info in studiegids:** studiegids.universiteitleiden.nl/en/courses/96329/quantum-algorithms

Technicalities

- **Lecturer (docent): Vedran Dunjko**
  - all information googlable;
  - email subject: “QA: …”
  - http://liacs.leidenuniv.nl/~dunjkov/

- **Teaching assistant: Casper Gyurik**

- **Course website: http://liacs.leidenuniv.nl/~dunjkov/QAlg.html**

- **Study materials:**
  - Nielsen & Chuang “Quantum computation & quantum information”
  - Lectures will be done using writing pad, pdf’s available after lessons
  - Additional lecture notes:
    - Ronald de Wolf (https://arxiv.org/pdf/1907.09415.pdf)

- **Other online tutorials and materials:**
  - https://qiskit.org/
  - see e.g. https://qosf.org/learn_quantum/ for many links

Technicalities

Where and when:
Lectures: Mondays 11.15 - 13:00
“Tutorials”: Thursdays 16:15 - 18:00

- Why quotation marks? **“tutorials” not just exercises.**

- Tutorials will explain details from lecture, provide exercises, highlight “tips-and-tricks” and **provide background** (for those who need a reminder).

- Tutorials complementary, and as useful as lectures…

- **If possible, attend both.**

Technicalities

Grading… rather our objectives

- Not a seminar. Attendance not enough. **Independent work will be required**.
- Literacy in Quantum computing will be necessary within the next decade - **you will learn the theory behind quantum algorithms and how to apply them.**
- No exam.
- **50% grade homework**.
  - Individual work.
  - Handed out during lecture.
  - 1st homework ca. 21th Oct and 2nd homework ca. 18th Nov.
  - Deadline exactly two weeks after.
  - Every week your late: -1 on your grade per week.
- **50% grade mini-projects.**
  - Group work allowed.
  - ca. 25th Nov and has to be presented at the end of the course.

Prerequisites and what you will be doing

Prerequisites

- Linear algebra and complex numbers.
  - Matrix-vector and matrix-matrix multiplication.
  - Inner products and norms.
  - Multiplication, addition and norms of complex numbers.
- Probability theory.
- Complexity theory of classical algorithms.

This tutorial will serve as a refresher.

What you will be doing

- Understand theory behind quantum algorithms by doing pen and paper exercises and studying relevant complex linear algebra.
- Computing probabilities using rudimentary probability theory.
- Analyzing the complexity of a quantum algorithm and comparing it with classical algorithms.
- Learn how to apply quantum algorithms.
- **Not a programming course, most exercises will be with pen and paper.**

Technicalities

Course contents:

1. Technical introduction & background refresher
2. Introduction to Quantum computing (formalism, circuit model)
3. Deutsch-Jozsa (first algorithm, basic QC concepts)
4. Grover's algorithm (search), hybrid computation 1, applications
5. Quantum Fourier Transform, Phase estimation, applications
6. Shor's algorithm (factoring), generalizations
7. Intermezzo: Quantum complexity theory
8. Quantum backtracking and quantum walks
9. Applications of backtracking: real-world applications, hybrid computation 2
10. Quantum linear algebra algorithms
11. Intermezzo lecture: Quantum Machine Learning
12. Quantum algorithms for restricted devices: optimization, chemistry, supremacy

(Semester 2) **Advanced course: *Applied Quantum Algorithms***
https://studiegids.universiteitleiden.nl/en/courses/96393/applied-quantum-algorithms

Technicalities

Questions?

Quantum computing, computing, physics, linear algebra