Mid-term Strategic Conference
Granada, November 13, 2019
QuantAlgo project

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Introduction
Quantum supremacy using a programmable superconducting processor

Frank Arute, Kunal Arya, [...] John M. Martinis

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Abstract

The promise of quantum computers is that certain computational tasks might be executed exponentially faster on a quantum processor than on a classical processor. A fundamental challenge is to build a high-fidelity
QuantAlgo: Quantum Algorithms and Applications

Foundations of quantum algorithms
- Algorithmic techniques
- Lower bounds
- Software tools
- etc.

Practical applications
- Big data
- Machine learning
- Communication
- Cryptography
Project structure

WP1
Techniques for quantum algorithms
Ronald de Wolf

WP2
Quantum algorithms for big data
Ashley Montanaro

WP3
Quantum algorithms for machine learning
Cyril Allouche

WP4
Quantum algorithms for interactive computation
Sophie Laplante
Main achievements
WP1 Techniques for quantum algorithms

- Quantum algorithms for optimisation problems (UPD, CWI, Latvia)
  - Linear and semidefinite programs
  - Minimisation of submodular functions
  - Finding a Hamiltonian cycle in a graph
- Quantum walk algorithms (CWI, Latvia)
  - Finding marked vertices in a graph
- Quantum algorithms in the CONGEST model (UPD)
- Resource optimisation (Bristol, ATOS)
  - Quantum constraint solvers for NP-hard problems
  - Space-efficient implementation of quantum backtracking
- Quantum-classical tradeoffs (Bristol)
  - Extension of the Gottesman-Knill theorem

Deliverables 2 / 4
Milestones 0 / 1
WP2 Quantum algorithms for big data

- Quantum protocols in the sketching model (Bristol)
  - Exponential speedups for problems relating large data sets
  - Computing Hamming distances
  - Distances between graphs
- Quantum property testing (Latvia)
  - Junta testing
- Quantum algorithms for mathematical finance (UPD)
  - Constrained portfolio optimisation
  - Polynomial speedup
  - Numerical simulation of quantum advantage

Deliverables

Milestones

1/3

1/1
WP3 Quantum algorithms for machine learning

- Framework of block-encoding for quantum machine learning (CWI, ULB)
  - Hamiltonian simulation
  - Weighted and generalised least squares
- Second order cone programs (UPD)
  - Quantum interior points method
  - Experimental evaluation of speedup for Support Vector Machine
- Clustering and dimensionality reduction (UPD)
  - Quantum analogue of k-means algorithm
  - Quantum analogue to Slow Feature Analysis
  - Benchmarked on MNIST handwritten digit dataset
- Deep learning (UPD)
  - Training and evaluating neural networks

Deliverables: 1/3
Milestones: 1/1
WP4 Quantum algorithms for interactive computation

• Communication (CWI, UCPH)
  • Channel capacities and decoherence times
  • Theoretical breakthrough about the log-rank conjecture

• Cryptography (UPD, Latvia, ULB)
  • Public-key cryptosystem based on Mersenne numbers
  • Improved security bounds on one-way to hiding
  • Quantum coin flipping

• Experimental validations (UPD, UCPH)
  • Sampling matching problem
  • Sensing averaged phase shift among distributed nodes in quantum network

Deliverables 2 / 3
Milestones 1 / 2
Dissemination
Dissemination

• Peer-reviewed articles
  • journals: 24 (published, accepted or under review)
  • conference proceedings: 15 (published or accepted)

• Oral presentations
  • Conferences: 13
  • Workshops: 14 international and 3 national
  • Seminars: 8 international and 8 national

• Organization of scientific events
  • Workshops: 2
  • Conferences: 2
  • Popularization conferences: 3