



Call 2021 Mid-term Evaluation

QOPT

Quantum algorithms for optimization

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CONCORCIUM



**UNIVERSITY
OF LATVIA**



**UNIVERSITÉ
LIBRE
DE BRUXELLES**



**INSTITUT
DE RECHERCHE
EN INFORMATIQUE
FONDAMENTALE**



COLLABORATION



GEOGRAPHICAL BREADTH

- Mostly old EU countries: France, Belgium, Germany.
- Except for Latvia (coordinator).



VARIETY OF SECTORS, DISCIPLINES

- Three partners with history of collaboration in quantum algorithms: LU, IRIF (CNRS), ULB.
- - having substantial contribution to quantum optimization as well.
- One partner with background on optimization: ZIB
- - having contribution to quantum computation as well.
- All partners with academic profile, no industry.



COLLABORATION



QUALITY OF COOPERATION

- Two project workshops have been organized:
 - - Brussels, Berlin.
- Several online seminars
 - - including the ones via EQSI colloquium series.
- Unfortunately, this does not give much impact in terms of joint publications between the partners.



PROJECT PROGRESS



CHALLENGE

- new quantum techniques for solving optimization problems
- applications to real life problems



SOLUTION

- Quantum algorithms for continuous optimization
 - - convex, linear, semi-definite, conic
- Quantum algorithms for discrete optimization
 - - exhaustive search, graph sparsification, quantum walks
- Bridging continuous and discrete optimization
 - - NISQ, mixed-integer, extended formulations
- Applications
 - - Machine Learning, Logistics, Big data, Physics

PROJECT PROGRESS



IMPLEMENTATION

- 26 papers related to the project.

PROJECT PROGRESS



- WP1 slightly behind the plan
 - - matrix scaling, computational complexity of Sum-of-Squares (SoS) hierarchy
- WP2 ahead the plan
 - - dynamic programming, divide-and-conquer; graph sparsification technique: matrix scaling and edge connectivity; electric flow sampling technique, variable-time quantum walks.
- WP3 slightly behind the plan
 - - low-depth amplitude estimation on NISQ computer, analysis of SoS relaxations.
- WP4 according to the plan
 - - reinforcement learning via policy iteration, training of neural networks using Fredholm networks, memory restricted algorithms (s-t-connectivity, collision finding), Low-Rank Tensor Decompositions.



PROJECT PROGRESS



HURDLES

- Not sufficient progress in WP1 Quantum algorithms for continuous optimization.
- Task 3.3. Bounds on extended formulations using quantum techniques.



NEXT STEPS

- Implementation of the missing points
- - WP1, Task 4.2.

IMPACT (RRI aspects)



GENDER

- At LU, two female and two male researchers are/were employed.
- Not so good at other groups.



OPEN SCIENCE

- Almost all papers have pre-prints.
- Many are published at open-access journals and proceedings
- - Quantum, LIPIcs series.



IMPACT (RRI aspects)



EDUCATION AND PUBLIC ENGAGEMENT

- 9 activities implemented
- Quantum Algorithms in Our Lives
- - 1-hour public lecture for high-school students during European Researcher's Night 2023. Attended by 40 students.



QUANTERA

ERA-NET Cofund in Quantum Technologies



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