POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 39th cycle

Research Area n. 1 - Computer Science and Engineering

PNRR 118 PNRR Research Field: QUANTUM COMPUTING FOR COMPUTATIONAL FLUID DYNAMIC PROBLEMS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Computational Fluid Dynamics (CFD) holds great importance in various industries such as energy, hydrology, environment, aerospace, and medicine. However, its potential is limited by the significant computational cost required for simulations. Quantum Computing (QC) provides a potential solution to this issue, while also presenting new research questions regarding how to effectively utilize this new computational paradigm for CFD problems. The objectives of this project are: to develop and enhance quantum algorithms specifically for CFD, explore the advantages of QC in CFD that go beyond what is currently possible with classical computing, perform experiments that measure the effectiveness of quantum CFD algorithms and compare them to classical methods, and identify the limitations and challenges associated with utilizing QC for CFD problems and suggest potential solutions to overcome them.
Methods and techniques that will be developed and used to carry out the research	The design of quantum algorithms for CFD requires a strong collaboration between QC and CFD experts in order to identify key features of CFD simulations that could be optimized using quantum computing. Possible approaches will be the usage of quantum Fourier transforms, quantum walks, and quantum lattice-gas models to simulate the dynamics of a fluid. Moreover,

	quantum optimization algorithms will be exploited to optimizing parameters and variables in CFD models, such as the mesh size, boundary conditions, initial conditions, etc. The results from quantum CFD simulations will be analyzed and compared with classical methods to determine the advantages and limitations of using QC for CFD, both in terms of speedup and accuracy of simulations.
Educational objectives	The PhD student will learn how to develop and run CFD algorithms for quantum computers, as well as how to use quantum computers for CFD problems effectively given their strengths and limitations.
Job opportunities	With the rapid advancements being made in quantum computing and the widespread impact of innovations in computational fluid dynamics (CFD), there is an increasing demand for individuals who can bridge the gap between these two fields. The available job opportunities span from aerospace, energy, and environmental engineering to contribute to the development of cutting-edge research and development of new applications. As quantum computing becomes more mainstream, the opportunities in this field are only expected to grow, with many companies and organizations investing heavily in quantum computing research and development.
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Maurizio Ferrari Dacrema

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	University: Chalmers University of Technology, Sweden
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	University: Chalmers University of Technology, Sweden
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

CFD simulations powered by QC can help industries optimize production processes, thanks to its ability to solve complex problems more quickly and efficiently. This will allow the simulation of systems that were previously intractable, improving both productivity and competitiveness, and enabling the development of new technologies in several fields, from energy and aerospace to medicine. Furthermore, quantum CFD can be used to improve the design of wind turbines, cooling systems, or vehicle aerodynamics, fostering the development of sustainable infrastructures better suited for the challenges of the future.

This proposal is consistent with Mission 1 ?PNRR: digitalizzazione, innovazione, competitività, cultura e turismo? and in particular with component M1C2 ?Digitalizzazione, innovazione e competitività nel sistema produttivo?.

Furthermore, this proposal is aligned to Goal SGD 9 ?Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation?, in particular, with the indicator 9.4 ?By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes? .

Computational Fluid Dynamics (CFD) holds great importance in several industries, but its potential is limited by the high computational cost. This project aims to develop and enhance Quantum Computing (QC) algorithms for CFD, explore the advantages of QC in CFD that go beyond what is currently possible with classical computing, compare experimentally quantum CFD algorithms against classical methods, identify the limitations and challenges of utilizing QC for CFD and suggest potential solutions.

EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid

per PhD student
5.707,20 Euro per student

TEACHING ASSISTANTSHIP: availability of funding in recognition of supporting teaching activities by the PhD student There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.