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Editorial: Quantum computing applications in computational engineering

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Editorial on the Research Topic

Quantum computing applications in computational engineering

Quantum computing research is a very active and diverse area of research, including work on creating quantum processing hardware in addition to investigations of applications with the potential for significant speed-up over simulations on classical (non-quantum) computers. The focus of this Research Topic is on applications in computational science and engineering. For these applications, the development of effective quantum algorithms with a significant speed-up over classical algorithms running on classical computers, has shown limited overall progress and is still in its infancy. However, this area of research has seen significant growth and progress in recent years, as illustrated by the three articles in this Research Topic.

The three articles in this Research Topic present advances in the development of quantum algorithms for applications in computational engineering, in particular computational fluid dynamics and structural mechanics. Two of the articles focus on original research in the area of computational fluid dynamics, while the third article provides a detailed review of existing work and prospects for quantum computing for partial differential equations in structural mechanics.

Focusing on the concept of quantum annealing, the article by [Ray et al.](#) explores the feasibility of using quantum annealers for the simulation of fluid flows. In the literature, this approach has not been widely investigated. In their article, [Ray et al.](#) consider the well-studied flow problem comprising the fully-developed pressure-driven flow between two infinite flat plates so that a linear, quasi-one-dimensional problem emerges. They then describe a framework to convert this type of problem in terms of an optimization problem suitable for use on quantum annealers. The D-Wave annealer ([D-Wave, 2022](#)) used in this work returns multiple states that sample the energy landscape of the problem and therefore the authors explore different solution selection strategies to approximate the solution of the problem. The obtained solutions are analyzed both qualitatively and quantitatively, showing, for example, the sensitivity to the precision used in the fixed-point representation of the velocity data.

In recent years, a major research focus in quantum computer applications to fluid dynamics has been lattice-based modeling, in particular approaches based on the Lattice Boltzmann method, e.g., [Todorova and Steijl \(2020\)](#); [Budinski \(2021\)](#); [Budinski \(2022\)](#). The article by [Moawad et al.](#) focuses on quantum circuit implementations of the one-dimensional

three-velocity (D1Q3) lattice model, in addition to efficient techniques for simulating and analyzing these circuits on classical computing hardware. With respect to circuit simulation, the authors focused on the feasibility of using hardware acceleration to perform such simulations with reduced energy consumption as compared to circuit simulation on CPUs. For the D1Q3 model, the nonlinearity of the model was represented in the collision term. For said collision term, novel quantum circuit implementations were presented along with quantum circuit reduction approaches to reduce the circuit width (qubit count), facilitating efficient simulation on classical hardware.

As mentioned earlier, the scope of this Research Topic was broader than Computational Fluid Dynamics, and the third article by [Tosti Balducci et al.](#) considered quantum computing applications to structural mechanics. Their study reviews previous work dealing with the application of quantum algorithms to solve partial differential equations (PDEs) in structural mechanics. Their review not only discusses the theoretical possibility and extent of advantage for a given PDE, boundary conditions, and input/output to the solver but also examines the hardware requirements of the methods proposed in the literature. In their review, fundamental building blocks of a wider range of quantum algorithms are discussed, including linear system solvers ([Harrow et al., 2009](#)), quantum amplitude estimation and quantum amplitude amplification ([Brassard et al., 2002](#)), and variational quantum algorithms ([Lubasch et al., 2020](#)). The review of these algorithms will certainly benefit a broader research community beyond computational structural mechanics.

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In summary, it is clear that the three articles cover a wide range of contributions in a very active area of research. We hope that readers will enjoy reading the articles and will find them useful and stimulating.

Author contributions

RS prepared the initial version of this editorial, with further additions and edits by RM. All authors contributed to the article and approved the submitted version.

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