When Turing Meets Deutsch: A Confrontation between Classical Computing and Quantum Computing

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Abstract

In this paper we try to construct a platform from which to bridge the gap between the two supporting pillars of quantum computation, namely theoretical physics and computer science. By confronting experts of both disciplines through the subject of quantum computation, a minimal common language is established; correspondences between the two disciplines as well as concepts that are hard to grasp and explain are identified. These insights are used to cut some corners and provide a tailored briefing on quantum computing through a particular case algorithm. Next to this, we provide some ideas as to where one should look in both disciplines in order to broaden this platform as quickly as possible. In our view, the most important problems as of now in developing new algorithms, and, further down the line, a decent quantum computational paradigm, is firstly that we do not know how to systematically exploit entanglement in quantum computational algorithms, and secondly, the lack of input to go from the limited number of isolated, handcrafted algorithms that exist now towards the abstraction levels that we are used to in classical computation. We discuss preliminary work which tackles these problems, using inspiration both from the physics community (for the former) and computer science (for the latter). Our results stress the importance of developing software and associated programming paradigms for quantum computing machines.