On the Role of Algorithms in Quantum Computing

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Abstract

In this note, the author proffers a view on the definition of algorithms, in the quantum context.

In [1], an algorithm is specified informally as any well-defined computational procedure that takes some value, or set of values, as input and produces some value, or set of values, as output. This places algorithms precariously close to functions, filter-banks, linear systems, feedback communication systems and many other objects with inputs and outputs related by computation. Nevertheless, if we take this as a heuristic for defining quantum algorithms, we may say that a quantum algorithm is any well-defined computational procedure that takes some quantum state, or set of quantum states as input and produces some quantum state or set of quantum states, as output. Each step of the procedure depends on one or more of the previous steps' quantum state result and in turn, the result of this step influences a later step's quantum state. We remark that this influence can be classical or quantum mechanical. For example, one can have an entangling relation between this step's final state and the next step's starting state. One may also have measurements in the final step, and these can be interaction-free [2].

Generally, we can draw a distinction between the algorithmic layer (pseudocode is usually initially handwritten on paper) and the actual physical layer or physical implementation of the procedure. This is analogous to the field of modern classical networks [3] where a distinction is drawn between the data layer and the physical layer.

References

[1] Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. *Introduction to Algorithms*. MIT Press, 2022.

[2] Avshalom C. Elitzur and Lev Vaidman. Quantum mechanical interaction-free measurements. *Foundations of Physics*, 23:987–997, 1993.

[3] D. Bertsekas and R. Gallager, *Data Networks*, 2nd ed., Athena Scientific, Belmont, MA, 2021.