Abstract

The design of efficient quantum circuits is an important issue in quantum computing. It is in general a formidable task to find a highly optimized quantum circuit for a given unitary matrix. We propose a quantum circuit design method that has the following unique feature: It allows to contruct efficient quantum circuits in a systematic way by reusing and combining a set of highly optimized quantum circuits. Specifically, the method realizes a quantum circuit for a given unitary matrix by implementing a linear combination of representing matrices of a group, which have known fast quantum circuits. We motivate and illustrate this method by deriving extremely efficient quantum circuits for the discreter Hartley transform and for the fractional Fourier transforms. The sound mathematical basis of this design method allows to give meaningful and natural interpretations of the resulting circuits. We demonstrate this aspect by giving a natural interpretation of known teleportation circuits.