

Note on Needle in a Haystack
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Abstract

Quantum search is applied to large amounts of binary data in a state vector.

Quantum Search

While thinking about how a quantum computer might search a database, Grover devised the concept of the oracle [1, 2]. The author interprets this to mean that there exists a certain black-box quantum function whose identity has been forgotten. The problem is to identify the function (and therefore all data that make the function true). Grover applied an iterative algorithm to give a high probability of identification. If he had chosen symmetric and anti-symmetric functions however, it would be possible to identify the function exactly, without iterations, using a single readout of qubits [3,4].

In perspective, it is more natural to store data temporarily in a state vector. Creation may be accomplished by initializing n qubits to combinations of (1 0), (0 1), or (1 1). Normalization is ignored for the moment. Let i be the number of (1 1) qubits. For a given combination of the (1 1) qubits in a group of n qubits, 2^{n-i} is the number of remaining binary codes. The number of combinations of (1 1) qubits equals n things taken i at a time, denoted as $C(n, i)$. Thus a state vector can hold any one of a huge number of combinations $> 2^n, < 2^{2^n}$

$$\sum_{i=0}^n C(n, i) 2^{n-i}$$

Using a decoding function (that is, a needle-in-a-haystack function $f(k_0) = 1$ and $f(k) = 0$ for any integer $k \neq k_0$, $0 \leq k \leq 2^{n-1}$) the bits in a state vector can be read out one at a time in any order. Hence random access memory (RAM) is possible. However, by using the other 2^{2^n} functions, any bit pattern (or word) can be recognized. Thus a content addressable memory (CAM) is possible. For example, let $|a\rangle \otimes |b\rangle \otimes |c\rangle = (1\ 0) \otimes (1\ 0) \otimes (1\ 1) = (1\ 1\ 0\ 0\ 0\ 0\ 0\ 0)$. The quantum function $a'b'$, generated in the usual way via a wiring diagram, will recognize only this vector. It signals recognition in the usual way, by setting a single auxiliary qubit.

[1] Lov Grover, "A fast quantum-mechanical algorithm for database search," in Proc. 28th Annual ACM Symposium on Theory of Computing, ACM, New York (1996).

[2] L. K. Grover, Phy. Rev. Lett. 79, 325 (1997).

[3] John Robert Burger, NOVEL IDENTIFICATION OF SYMMETRIC AND ANTI-SYMMETRIC QUANTUM FUNCTIONS, August 2003, <http://arXiv.org/abs/quant-ph/0308157>

[4] John Robert Burger, SYMMETRIC AND ANTISYMMETRIC FUNCTIONS, A NEW WAY TO TEST A QUANTUM COMPUTER, April 2003, <http://arXiv.org/abs/cs.CE/0304016>