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Research on quantum computing with logic gate

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ABSTRACT: *This essay summarizes some of the current investigation on quantum computing. It covers the quantum logic gates and the matrix form of them and some information about quantum computation.*

KEYWORDS: *Quantum, logic gate*

Introduction

Quantum mechanics has been around for exactly 100 years since Planck came up with the idea. In the past 100 years, quantum mechanics has brought great changes to human life, especially in the second half of the 20th century, with the commonly use of lasers and the rapid development of the semiconductor industry, the power of science has become even more prominent. But for any successful theory, the debate over it has inevitably raised. There are many pioneers in this field, such as Schradinger, Einstein, etc., and the advocators of quantum mechanics are Bohr and Heisenberg represented by the Copenhagen School. They argue that studying the number of physical descriptions does not eliminate Einstein's characteristic randomness. Physicists cannot accept the classical deterministic view. They argue that quantum mechanics, which describes the physical world, is not a perfect world and should be controlled more theoretically. As the debate escalated, Einstein and others came up with the concept of quantum entanglement, thereby testing the fundamentals of quantum mechanics. Despite the overwhelming evidence to date that the Copenhagen School has triumphed, the debate around this scientific question seems to have come to an end because of the deep pursuit of these two

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streams of science and their pursuit of understanding of science, leading to the subsequent birth of quantum information.

As the result of the development of quantum mechanics, quantum computing as become a new way to solve problems. Basically, quantum computation is to use the principle of quantum mechanics to do the calculation in a brand-new and more efficient way. For a quantum computer, it is made of many quantum processors and each of them is a two-state quantum system. By using the principle of quantum superposition, we could manage to make the calculation of certain function more quickly.

The principle of quantum computing

Turing's model can be perceived as the basis of computer. It also provides a proposition which can make almost every situation fit. The computer we are using today is made based on it. It is widely used in the CAD modelling, the curve fitting, the temperature control, to name but a few. For a normal computer, we enter an value and the computer would follow the arithmetic to give you a value. The range of quantum computer is not beyond the range of normal computer. It just makes the process faster. For a quantum computer, first set for calculating function is $f(x)$, according to the preparation of quantum computers function input value$\{x_i\}$ to initial state vector $|f < 0 >\}$, according to the quantum algorithm to design it is operating procedures, control quantum computer state vector rotation in the Hilbert space, operation at the end of the final vector is $|f < t >\}$, the state vector real son quantity measurement, finally to obtain the output value of the outcome.

If we need to conduct quantum computing effectively, there are four requirements we need to follow.

1. The qubits must be coherent for enough time.

2. It has a complete universal unitary operation capability

3. It has the ability to prepare the initial state

4. It must have the ability to do quantum measurement so as to get the final result.

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The logic quantum gate

Logic quantum gate is the basis of quantum computer. The commonly used simple gate is single qubit gate. The simplest is the X,Y and Z gate. Together they are called Pauli gate. Each of them can be expressed in matrix form.

$$X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} = |0\rangle\langle 1| + |1\rangle\langle 0|$$

$$Y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix} = -i|0\rangle\langle 1| + i|1\rangle\langle 0|$$

$$Z = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} = |0\rangle\langle 0| - |1\rangle\langle 1|$$

As z gate seem to be not effective when $|0\rangle\ or\ |1\rangle$ is used. Actually, they are eigenstates of this gate. Base on this we can get two vectors and people named them

$$|+\rangle\ and\ |-\rangle$$

$$|+\rangle\ and\ = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle) and\ |-\rangle = \frac{1}{\sqrt{2}}(|0\rangle - |1\rangle)$$

Then there is one very popular gate Hadamard gate. This gate is known as a fundamental gate and the matrix form is known as $H = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$

It is used in the famous schrodinger's equation with vector in Hilbert space.

$$i\hbar\frac{d}{dt}|\varphi\rangle = \hat{H}|\varphi\rangle$$

In this form, it shows how space and time corresponding with each other.

There is also $R_\phi = \begin{bmatrix} 1 & 0 \\ 0 & e^{i\phi} \end{bmatrix}$, there are also many more gates, but with nearly the same principle. By combining them, we could do some meaningful calculation.

Quantum computation requires all kinds of coherent control, and the evolution of quantum entanglement and quantum entanglement is sensitive to drying and various

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experimental error elimination stages. To solve this problem, people began to consider using quantum coding methods to prevent or correct this phenomenon. The direction of effort caused by coherence elimination errors in computation further leads to the emergence of fault-tolerant quantum computation. However, the fault-tolerant quantum computing scheme is often too complex, requiring multiple operations to achieve the expected operation, so it often needs to consume a large number of resources and operations to achieve a group of evolution, which puts forward a high requirement for quantum mechanics. The experiment. How to reduce the complexity of fault-tolerant quantum computation? A very clever approach is to shift the difficulty: that is, we can consider shifting the difficulty of coherent control over the evolution of the entangled state during the calculation to the pre-entangled state or other aspects. A paper in Nature shows that a universal quantum computer can be achieved using only specific entangled resources, single-bit operations, Bell basic measurements and classical communications. Similarly, other quantum logic gates, such as Toffoli gates, can be constructed. The key of the scheme is to prepare specific entangled states, so the difficulty of realizing quantum logic gates turns to prepare specific entangled states. However, due to the preparation of a specific entangled state, the difficulty of the experiment is greatly reduced

Conclusion

So far, people have made more and more in-depth research on quantum computing, and made constant progress in theory and experiment. However, while in principle there is no difficulty in achieving this goal, there is still a long way to go before quantum computing on a large scale can actually be achieved. At present, the main task facing scientists is to improve the ability of coherent manipulation in quantum systems through scalability. On the other hand, the ambitious goals of quantum computing will lead to the expansion of human tentacles into more microscopic worlds. A byproduct of quantum computer research may be the development of technology based on microscopic quantum regulation, which may be the seed of a new technological revolution.

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