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QUANTUM CIRCUIT BY ONE STEP METHOD AND SIMILARITY WITH NEURAL NETWORK

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ABSTRACT

We implement the Deutsch problems and Berstein Varizani method and others, by one step method- The one step method means built unitary transformation by which, we can compute the linear coefficient to solve the quantum computer problems with logic gates obtained by linear coefficients in superposition methods. We remark a string analogy between neural network and quantum computers

KEYWORDS: *Quantum Circuit, Neural Network, Self-Organizing Map, Modern Quantum Mechanics*

Article History

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INTRODUCTION

In this paper we show the one step method can improve the quantum circuit. The important reduction of the complexity by one step method allow the representation by superposition as in the neural network of the Boolean functions without any recursion method and with the computation of the superposition linear coefficients by one step computation. The reduction of the computation complexity is dramatically improved in a way to represent by quantum computer any complex computation by simple superposition. A strong analogy with neural network and quantum computer is put in evidence.

QUBITS QUANTUM CIRCUIT AND ONE STEP METHOD

Given the quantum circuit in one qubit

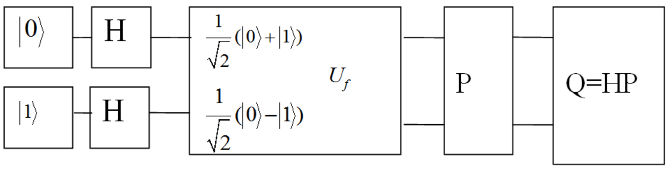

Figure 1: Quantum Computer Unitary Transformation with One Qubit $|0\rangle$ or $|1\rangle$

$$H\left|0\right\rangle = \frac{1}{\sqrt{2}}(\left|0\right\rangle + \left|1\right\rangle)$$
$$H\left|1\right\rangle = \frac{1}{\sqrt{2}}(\left|0\right\rangle - \left|1\right\rangle)$$
$$for$$
$$U_f\left|x\right\rangle\left|y\right\rangle = \left|x\right\rangle\left|y \oplus f(x)\right\rangle$$
$$P = U_f(\frac{1}{\sqrt{2}}(\left|0\right\rangle + \left|1\right\rangle)\frac{1}{\sqrt{2}}(\left|0\right\rangle - \left|1\right\rangle)) =$$
$$= \frac{1}{2}U_f((\left|0\right\rangle\left|0\right\rangle - \left|0\right\rangle\left|1\right\rangle + \left|1\right\rangle\left|0\right\rangle - \left|1\right\rangle\left|1\right\rangle) = \frac{1}{2}(\left|0\right\rangle\left|0 \oplus f(0)\right\rangle - \left|0\right\rangle\left|0 \oplus f(1)\right\rangle + \left|1\right\rangle\left|1 \oplus f(0)\right\rangle - \left|1\right\rangle\left|1 \oplus f(1)\right\rangle)$$

Now with

$$A = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, AA^T = \begin{bmatrix} 0 \\ 1 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix}^T = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$
$$H = \frac{1}{\sqrt{2}}(-1)^{\begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} = \frac{1}{\sqrt{2}}(-1)^{rs}$$

And for

$$H\left|0\right\rangle = \frac{1}{\sqrt{2}}\sum_{z=0}^{1}(-1)^{0z}\left|z\right\rangle = \frac{1}{\sqrt{2}}((-1)^{0*0}\left|0\right\rangle + (-1)^{0*1}\left|1\right\rangle) = \frac{1}{\sqrt{2}}((-1)^0\left|0\right\rangle + (-1)^0\left|1\right\rangle) = \frac{1}{\sqrt{2}}(\left|0\right\rangle + \left|1\right\rangle)$$
$$H\left|1\right\rangle = \frac{1}{\sqrt{2}}\sum_{z=0}^{1}(-1)^{1z}\left|z\right\rangle = \frac{1}{\sqrt{2}}((-1)^{1*0}\left|0\right\rangle + (-1)^{1*1}\left|1\right\rangle) = \frac{1}{\sqrt{2}}((-1)^0\left|0\right\rangle + (-1)^1\left|1\right\rangle) = \frac{1}{\sqrt{2}}(\left|0\right\rangle - \left|1\right\rangle)$$
$$or$$
$$H\left|\lambda\right\rangle = \frac{1}{\sqrt{2}}\sum_{z=0}^{1}(-1)^{\lambda z}\left|z\right\rangle, with\ \lambda = 0,1$$

We have

$$H\begin{bmatrix} \left|0\right\rangle \\ \left|1\right\rangle \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}\begin{bmatrix} \left|0\right\rangle \\ \left|1\right\rangle \end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix} \left|0\right\rangle + \left|1\right\rangle \\ \left|0\right\rangle - \left|1\right\rangle \end{bmatrix} = \begin{bmatrix} H\left|0\right\rangle \\ H\left|1\right\rangle \end{bmatrix}$$

With the H operator, we have

$$Q = HP = \frac{1}{2} H|0\rangle|0 \oplus f(0)\rangle - H|0\rangle|0 \oplus f(1)\rangle + H|1\rangle|1 \oplus f(0)\rangle - H|1\rangle|1 \oplus f(1)\rangle =$$

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

$$\frac{1}{2\sqrt{2}}[|0\rangle|0 \oplus f(0)\rangle - |0\rangle|0 \oplus f(1)\rangle + |0\rangle|1 \oplus f(0)\rangle - |0\rangle|1 \oplus f(1)\rangle +$$

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

$$\frac{|0\rangle}{2\sqrt{2}}[|0 \oplus f(0)\rangle - |0 \oplus f(1)\rangle + |1 \oplus f(0)\rangle - |1 \oplus f(1)\rangle +$$

$$\frac{|1\rangle}{2\sqrt{2}}[|0 \oplus f(0)\rangle - |0 \oplus f(1)\rangle - |1 \oplus f(0)\rangle + |1 \oplus f(1)\rangle$$

That can write in this way

$$\alpha = \frac{1}{2\sqrt{2}}[|0 \oplus f(0)\rangle - |0 \oplus f(1)\rangle + |1 \oplus f(0)\rangle - |1 \oplus f(1)\rangle]$$

$$\beta = \frac{1}{2\sqrt{2}}[|0 \oplus f(0)\rangle - |0 \oplus f(1)\rangle - |1 \oplus f(0)\rangle + |1 \oplus f(1)\rangle]$$

Or

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

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

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

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

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

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

And

$$Q = \alpha|0\rangle + \beta|1\rangle$$

Now if $f(0) = f(1) = 0$ we have

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

$$\beta = \frac{1}{\sqrt{2}}(|f(0)\rangle - |f(1)\rangle) = 0$$

Now if $f(0) = f(1) = 1$ we have

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

$$\beta = \frac{1}{\sqrt{2}}(|f(0)\rangle - |f(1)\rangle) = 0$$

Now if $f(0) = 0, f(1) = 1$ we have

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

$$\beta = \frac{1}{\sqrt{2}}(|f(0)\rangle - |f(1)\rangle) = \frac{1}{\sqrt{2}}(|0\rangle - |1\rangle)$$

Now if $f(0) = 1, f(1) = 0$ we have

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

$$\beta = \frac{1}{\sqrt{2}}(|f(0)\rangle - |f(1)\rangle) = \frac{1}{\sqrt{2}}(|1\rangle - |0\rangle)$$

ONE STEP METHOD IN QUANTUM COMPUTER FOR ONE QUBIT

Given

$$\begin{bmatrix} & y & x \\ C_1 & 0 & 0 \\ C_2 & 1 & 0 \\ C_3 & 0 & 1 \\ C_4 & 1 & 1 \end{bmatrix}$$

Where we have all the possible situations for the free variables y and x

$$\begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{bmatrix}^T = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 2 \end{bmatrix}$$

For $\omega = -1$ we have the expression

$$H=(-1)^{rs}=(-1)^{\begin{bmatrix}0&0&0&0\\0&1&0&1\\0&0&1&1\\0&1&1&2\end{bmatrix}}=\begin{bmatrix}1&1&1&1\\1&-1&1&-1\\1&1&-1&-1\\1&-1&-1&1\end{bmatrix}=\begin{bmatrix}1&1\\1&-1\end{bmatrix}\otimes\begin{bmatrix}1&1\\1&-1\end{bmatrix}=H\otimes H$$

The Hadamard transformation is the discrete Fourier transformation for the unitary roots

$$x^2=1$$

With the unitary matrix and the four dimensional vector

$$\begin{bmatrix}f(0)\\1-f(0)\\f(1)\\1-f(1)\end{bmatrix}=\begin{bmatrix}0\oplus f(0)\\1\oplus f(0)\\0\oplus f(1)\\1\oplus f(1)\end{bmatrix}$$

We have

$$\begin{bmatrix}1&1&1&1\\1&-1&1&-1\\1&1&-1&-1\\1&-1&-1&1\end{bmatrix}\begin{bmatrix}f(0)\\1-f(0)\\f(1)\\1-f(1)\end{bmatrix}\frac{1}{2}=\begin{bmatrix}1\\0\\f(0)+f(1)-1\\f(0)-f(1)\end{bmatrix}$$

For

$$A^T=\begin{bmatrix}1&-1&1&-1\\1&-1&-1&1\end{bmatrix},A=\begin{bmatrix}1&1\\-1&-1\\1&-1\\-1&1\end{bmatrix}$$

We remark that for

$$1=\begin{bmatrix}1\\-1\end{bmatrix},0=\begin{bmatrix}-1\\1\end{bmatrix},A=\begin{bmatrix}1&1\\1&0\end{bmatrix}=\begin{bmatrix}1&x\end{bmatrix}=\begin{bmatrix}1&1\\-1&-1\\1&-1\\-1&1\end{bmatrix}$$

We have

$$A\alpha = y$$

$$\begin{bmatrix} 1 & 1 \\ -1 & -1 \\ 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} = \begin{bmatrix} f(0) \\ 1-f(0) \\ f(1) \\ 1-f(1) \end{bmatrix}$$

And

$$A^T A\alpha = A^T y, \alpha = (A^T A)^{-1} A^T y$$

For

$$y = \begin{bmatrix} f(0) \\ 1-f(0) \\ f(1) \\ 1-f(1) \end{bmatrix}$$

We have

$$A^T A = 4\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

So

$$\alpha = \frac{1}{4}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \begin{bmatrix} f(0) \\ 1-f(0) \\ f(1) \\ 1-f(1) \end{bmatrix} = \frac{1}{2}\begin{bmatrix} f(0)+f(1)-1 \\ f(0)-f(1) \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$$

And

$$V = (f(0)+f(1)-1)|0\rangle + (f(0)-f(1))|1\rangle = \alpha_1|0\rangle + \alpha_2|1\rangle = \alpha_1 \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} + \alpha_2 \begin{bmatrix} 1 \\ -1 \\ -1 \\ 1 \end{bmatrix}$$

Values of the linear coefficients α

$$\begin{bmatrix} f(0) \\ f(1) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, \begin{bmatrix} f(0)+f(1)-1 \\ f(0)-f(1) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$$

$$\begin{bmatrix} f(0) \\ f(1) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} f(0)+f(1)-1 \\ f(0)-f(1) \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$$

$$\begin{bmatrix} f(0) \\ f(1) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \begin{bmatrix} f(0)+f(1)-1 \\ f(0)-f(1) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$$

$$\begin{bmatrix} f(0) \\ f(1) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, \begin{bmatrix} f(0)+f(1)-1 \\ f(0)-f(1) \end{bmatrix} = \begin{bmatrix} 0 \\ -1 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}$$

One step method diagram and similar with the neural network

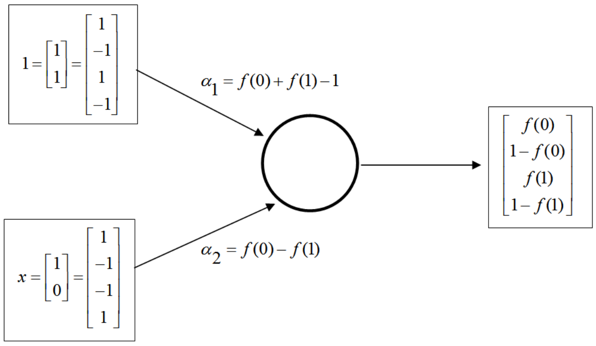

Figure 2: Diagram for One Step Method in Quantum Computer (Neural Network Similarity)

TWO QUBITS QUANTUM CIRCUIT

For the quantum circuit

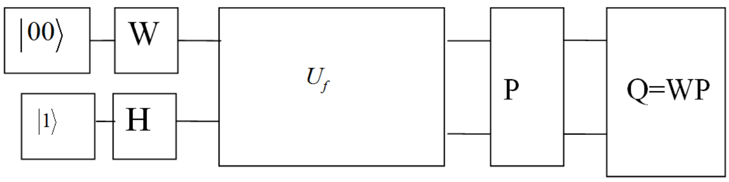

Figure 2: Quantum Computer Unitary Transformation with Two Qubits $|00\rangle$

We have

$$W = H \otimes H = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & 0 \end{bmatrix} \begin{bmatrix} |00\rangle \\ |10\rangle \\ |01\rangle \\ |11\rangle \end{bmatrix} = \begin{bmatrix} |00\rangle+|10\rangle+|01\rangle+|11\rangle \\ |00\rangle+|10\rangle-|01\rangle-|11\rangle \\ |00\rangle-|10\rangle+|01\rangle-|11\rangle \\ |00\rangle-|10\rangle-|01\rangle+|11\rangle \end{bmatrix}$$

$$W|00\rangle = |00\rangle+|10\rangle+|01\rangle+|11\rangle$$

$$H|1\rangle = |0\rangle-|1\rangle$$

$$for$$

$$|x\rangle|y\rangle = |00\rangle|1\rangle$$

$$P = W|00\rangle H|1\rangle = (\frac{1}{2\sqrt{2}}|00\rangle+|10\rangle+|01\rangle+|11\rangle)(|0\rangle-|1\rangle))$$

$$\frac{1}{2\sqrt{2}}U_f(|00\rangle|0\rangle+|10\rangle|0\rangle+|01\rangle|0\rangle+|11\rangle|0\rangle)-(|00\rangle|1\rangle+|10\rangle|1\rangle+|01\rangle|1\rangle+|11\rangle|1\rangle)$$

$$=\frac{1}{2\sqrt{2}}|00\rangle|0\oplus f(0,0)\rangle+|10\rangle|0\oplus f(1,0)\rangle+|01\rangle|0\oplus f(0,1)\rangle+|11\rangle|0\oplus f(1,1)\rangle)-(|00\rangle|1\oplus f(0,0)\rangle+$$
$$+|10\rangle|1\oplus f(1,0)\rangle+|01\rangle|1\oplus f(0,1)\rangle+|11\rangle|1\oplus f(1,1)\rangle)$$

And

$$\frac{1}{2\sqrt{2}}W|00\rangle|0\oplus f(0,0)\rangle+W|10\rangle|0\oplus f(1,0)\rangle+W|01\rangle|0\oplus f(0,1)\rangle+W|11\rangle|0\oplus f(1,1)\rangle)-(W|00\rangle|1\oplus f(0,0)\rangle+$$
$$+W|10\rangle|1\oplus f(1,0)\rangle+W|01\rangle|1\oplus f(0,1)\rangle+W|11\rangle|1\oplus f(1,1)\rangle)$$

Is

$$\frac{1}{2\sqrt{2}}(|00\rangle+|10\rangle+|01\rangle+|11\rangle)|0\oplus f(0,0)\rangle+(|00\rangle+|10\rangle-|01\rangle-|11\rangle)|0\oplus f(1,0)\rangle$$
$$+(|00\rangle-|10\rangle+|01\rangle-|11\rangle)|0\oplus f(0,1)\rangle+(|00\rangle-|10\rangle-|01\rangle+|11\rangle|0\oplus f(1,1)\rangle)$$
$$-(|00\rangle+|10\rangle+|01\rangle+|11\rangle)|1\oplus f(0,0)\rangle-(|00\rangle+|10\rangle-|01\rangle-|11\rangle)|1\oplus f(1,0)\rangle+$$
$$-(|00\rangle-|10\rangle+|01\rangle-|11\rangle)|1\oplus f(0,1)\rangle-(|00\rangle-|10\rangle-|01\rangle+|11\rangle)|1\oplus f(1,1)\rangle)$$

So we have

$$S=\frac{1}{2\sqrt{2}}|00\rangle[|0\oplus f(0,0)\rangle+|0\oplus f(1,0)\rangle+|0\oplus f(0,1)\rangle+|0\oplus f(1,1)\rangle)-|1\oplus f(0,0)\rangle+$$
$$-|1\oplus f(1,0)\rangle-|1\oplus f(0,1)\rangle-|1\oplus f(1,1)\rangle]+$$
$$|10\rangle[|0\oplus f(0,0)\rangle+|0\oplus f(1,0)\rangle-|0\oplus f(0,1)\rangle-|0\oplus f(1,1)\rangle)$$
$$-|1\oplus f(0,0)\rangle-|1\oplus f(1,0)\rangle+|1\oplus f(0,1)\rangle+|1\oplus f(1,1)\rangle]+$$
$$|01\rangle[|0\oplus f(0,0)\rangle-|0\oplus f(1,0)\rangle+|0\oplus f(0,1)\rangle-|0\oplus f(1,1)\rangle)$$
$$-|1\oplus f(0,0)\rangle|1\oplus f(1,0)\rangle+$$
$$-|1\oplus f(0,1)\rangle+|1\oplus f(1,1)\rangle)+$$
$$|11\rangle[|0\oplus f(0,0)\rangle-|0\oplus f(1,0)\rangle-|0\oplus f(0,1)\rangle+|0\oplus f(1,1)\rangle)$$
$$-|1\oplus f(0,0)\rangle+|1\oplus f(1,0)\rangle+|1\oplus f(0,1)\rangle-|1\oplus f(1,1)\rangle)$$

For

$$\begin{bmatrix} 0\oplus f(0,0) \\ 1\oplus f(0,0) \\ 0\oplus f(1,0) \\ 1\oplus f(1,0) \\ 0\oplus f(0,1) \\ 1\oplus f(0,1) \\ 0\oplus f(1,1) \\ 1\oplus f(1,1) \end{bmatrix} = \begin{bmatrix} f(0,0) \\ 1-f(0,0) \\ f(1,0) \\ 1-f(1,0) \\ f(0,1) \\ 1-f(0,1) \\ f(1,1) \\ 1-f(1,1) \end{bmatrix}$$

where

$$x\oplus y=1$$
$$for$$
$$x\neq y$$

We have

$$S=\frac{1}{2\sqrt{2}}[(-4+2(f(0,0)+f(1,0)+f(0,1)+f(1,1)|00\rangle+2(f(0,0)-f(1,0)-f(0,1)+f(1,1)|10\rangle$$
$$2(-f(0,0)+f(1,0)+f(0,1)-f(1,1)|01\rangle+2(-f(0,0)-f(1,0)+f(0,1)+f(1,1)|11\rangle]$$

Given the vector

$$S = \frac{1}{2\sqrt{2}}[\alpha_1|00\rangle + \alpha_2|10\rangle + \alpha_3|01\rangle + \alpha_4|11\rangle]$$

We have the vector

$$\begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} = \begin{bmatrix} (-4+2(f(0,0)+f(1,0)+f(0,1)+f(1,1) \\ 2(f(0,0)-f(1,0)-f(0,1)+f(1,1) \\ 2(-f(0,0)+f(1,0)+f(0,1)-f(1,1) \\ 2(-f(0,0)-f(1,0)+f(0,1)+f(1,1) \end{bmatrix}$$

Now for

$$\begin{bmatrix} 0\oplus f(0,0) \\ 1\oplus f(0,0) \\ 0\oplus f(1,0) \\ 1\oplus f(1,0) \\ 0\oplus f(0,1) \\ 1\oplus f(0,1) \\ 0\oplus f(1,1) \\ 1\oplus f(1,1) \end{bmatrix} = \begin{bmatrix} f(0,0) \\ 1-f(0,0) \\ f(1,0) \\ 1-f(1,0) \\ f(0,1) \\ 1-f(0,1) \\ f(1,1) \\ 1-f(1,1) \end{bmatrix}$$

ONE STEP METHOD FOR TWO QUBIT IN QUANTUM COMPUTER

With

$$\begin{bmatrix} value & y & x_1 & x_2 \\ C_1 & 0 & 0 & 0 \\ C_2 & 1 & 0 & 0 \\ C_3 & 0 & 1 & 0 \\ C_4 & 1 & 1 & 0 \\ C_5 & 0 & 0 & 1 \\ C_6 & 1 & 0 & 1 \\ C_7 & 0 & 1 & 1 \\ C_8 & 1 & 1 & 1 \end{bmatrix}$$

And

$$\begin{pmatrix} 0&0&0\\1&0&0\\0&1&0\\1&1&0\\0&0&1\\1&0&1\\0&1&1\\1&1&1 \end{pmatrix} \cdot \begin{pmatrix} 0&0&0\\1&0&0\\0&1&0\\1&1&0\\0&0&1\\1&0&1\\0&1&1\\1&1&1 \end{pmatrix}^T = \begin{pmatrix} 0&0&0&0&0&0&0&0\\0&1&0&1&0&1&0&1\\0&0&1&1&0&0&1&1\\0&1&1&2&0&1&1&2\\0&0&0&0&1&1&1&1\\0&1&0&1&1&2&1&2\\0&0&1&1&1&1&2&2\\0&1&1&2&1&2&2&3 \end{pmatrix},$$

And

$$(-1)^{\begin{pmatrix} 0&0&0&0&0&0&0&0\\0&1&0&1&0&1&0&1\\0&0&1&1&0&0&1&1\\0&1&1&2&0&1&1&2\\0&0&0&0&1&1&1&1\\0&1&0&1&1&2&1&2\\0&0&1&1&1&1&2&2\\0&1&1&2&1&2&2&3 \end{pmatrix}}$$

Can write in this way

$$W = (-1)^{\begin{bmatrix} 0&0&0&0&0&0&0&0\\0&1&0&1&0&1&0&1\\0&0&1&1&0&0&1&1\\0&1&1&2&0&1&1&2\\0&0&0&0&1&1&1&1\\0&1&0&1&1&2&1&2\\0&0&1&1&1&1&2&2\\0&1&1&2&1&2&2&3 \end{bmatrix}} = \begin{bmatrix} (-1)^0&(-1)^0&(-1)^0&(-1)^0&(-1)^0&(-1)^0&(-1)^0&(-1)^0\\ (-1)^0&(-1)^1&(-1)^0&(-1)^1&(-1)^0&(-1)^1&(-1)^0&(-1)^1\\ (-1)^0&(-1)^0&(-1)^1&(-1)^1&(-1)^0&(-1)^0&(-1)^1&(-1)^1\\ (-1)^0&(-1)^1&(-1)^1&(-1)^2&(-1)^0&(-1)^1&(-1)^1&(-1)^2\\ (-1)^0&(-1)^0&(-1)^0&(-1)^0&(-1)^1&(-1)^1&(-1)^1&(-1)^1\\ (-1)^0&(-1)^1&(-1)^0&(-1)^1&(-1)^1&(-1)^2&(-1)^1&(-1)^2\\ (-1)^0&(-1)^0&(-1)^1&(-1)^1&(-1)^1&(-1)^1&(-1)^2&(-1)^2\\ (-1)^0&(-1)^1&(-1)^1&(-1)^2&(-1)^1&(-1)^2&(-1)^2&(-1)^3 \end{bmatrix}$$

So we have

$$W = \begin{bmatrix} 1&1&1&1&1&1&1&1\\ 1&-1&1&-1&1&-1&1&-1\\ 1&1&-1&-1&1&1&-1&-1\\ 1&-1&-1&1&1&-1&-1&1\\ 1&1&1&1&-1&-1&-1&-1\\ 1&-1&1&-1&-1&1&-1&1\\ 1&1&-1&-1&-1&-1&1&1\\ 1&-1&-1&1&-1&1&1&-1 \end{bmatrix} = H \otimes H \otimes H$$

and

$$W=(H\otimes H\otimes H)\left|y\oplus f(x_1.x_2)\right\rangle=\begin{bmatrix}1&1&1&1&1&1&1&1\\1&-1&1&-1&1&-1&1&-1\\1&1&-1&-1&1&1&-1&-1\\1&-1&-1&1&1&-1&-1&1\\1&1&1&1&-1&-1&-1&-1\\1&-1&1&-1&-1&1&-1&1\\1&1&-1&-1&-1&-1&1&1\\1&-1&-1&1&-1&1&1&-1\end{bmatrix}\begin{bmatrix}f(0,0)\\1-f(0,0)\\f(1,0)\\1-f(1,0)\\f(0,1)\\1-f(0,1)\\f(1,1)\\1-f(1,1)\end{bmatrix}=$$

$$\begin{bmatrix}4\\2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\0\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\0\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\0\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}$$

That can write in this way

$$\begin{bmatrix}1&-1&1&-1&1&-1&1&-1\\1&-1&-1&1&1&-1&-1&1\\1&-1&1&-1&-1&1&-1&1\\1&-1&-1&1&-1&1&1&-1\end{bmatrix}\begin{bmatrix}f(0,0)\\1-f(0,0)\\f(1,0)\\1-f(1,0)\\f(0,1)\\1-f(0,1)\\f(1,1)\\1-f(1,1)\end{bmatrix}=\begin{bmatrix}2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}=\begin{bmatrix}\alpha_1\\\alpha_2\\\alpha_3\\\alpha_4\end{bmatrix}$$

Or in a more simple way

$$A\alpha=y$$

is

$$\begin{bmatrix}1&1&1&1\\-1&-1&-1&-1\\1&-1&1&-1\\-1&1&-1&1\\1&1&-1&-1\\-1&-1&1&1\\1&-1&-1&1\\-1&1&1&-1\end{bmatrix}\begin{bmatrix}\alpha_1\\\alpha_2\\\alpha_3\\\alpha_4\end{bmatrix}=\begin{bmatrix}f(0,0)\\1-f(0,0)\\f(1,0)\\1-f(1,0)\\f(0,1)\\1-f(0,1)\\f(1,1)\\1-f(1,1)\end{bmatrix}$$

By the commutative diagram we have

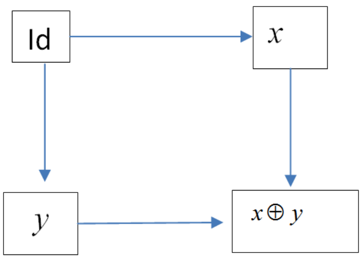

Figure 3: commutative Graph for Two Qubits in One Step Method

So, we have

$$\alpha_1|00\rangle+\alpha_2|10\rangle+\alpha_3|01\rangle+\alpha_4|11\rangle=\alpha_1\begin{bmatrix}1\\-1\\1\\-1\\1\\-1\\1\\-1\end{bmatrix}+\alpha_2\begin{bmatrix}1\\-1\\-1\\1\\1\\-1\\-1\\1\end{bmatrix}+\alpha_3\begin{bmatrix}1\\-1\\1\\-1\\-1\\1\\-1\\1\end{bmatrix}+\alpha_4\begin{bmatrix}1\\-1\\-1\\1\\-1\\1\\1\\-1\end{bmatrix}$$

For the different functions we have

$$For\begin{bmatrix}f(0,0)\\f(1,0)\\f(0,1)\\f(1,1)\end{bmatrix}=\begin{bmatrix}1\\1\\1\\1\end{bmatrix}we\text{ have}\begin{bmatrix}2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}=\begin{bmatrix}4\\0\\0\\0\end{bmatrix}$$

$$For\begin{bmatrix}f(0,0)\\f(1,0)\\f(0,1)\\f(1,1)\end{bmatrix}=\begin{bmatrix}0\\0\\0\\0\end{bmatrix}we\text{ have}\begin{bmatrix}2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}=\begin{bmatrix}-4\\0\\0\\0\end{bmatrix}$$

$$For\begin{bmatrix}f(0,0)\\f(1,0)\\f(0,1)\\f(1,1)\end{bmatrix}=\begin{bmatrix}0\\1\\0\\1\end{bmatrix}we\text{ have}\begin{bmatrix}2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}=\begin{bmatrix}0\\-4\\0\\0\end{bmatrix}$$

$$For\begin{bmatrix}f(0,0)\\f(1,0)\\f(0,1)\\f(1,1)\end{bmatrix}=\begin{bmatrix}0\\0\\1\\1\end{bmatrix}we\text{ have}\begin{bmatrix}2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}=\begin{bmatrix}0\\0\\-4\\0\end{bmatrix}$$

$$For\begin{bmatrix}f(0,0)\\f(1,0)\\f(0,1)\\f(1,1)\end{bmatrix}=\begin{bmatrix}0\\1\\1\\0\end{bmatrix}we\text{ have}\begin{bmatrix}2f(0,0)+2f(1,0)+2f(0,1)+2f(1,1)-4\\2f(0,0)-2f(1,0)+2f(0,1)-2f(1,1)\\2f(0,0)+2f(1,0)-2f(0,1)-2f(1,1)\\2f(0,0)-2f(1,0)-2f(0,1)+2f(1,1)\end{bmatrix}=\begin{bmatrix}0\\0\\0\\-4\end{bmatrix}$$

We remark that for

$$1=\begin{bmatrix}1\\-1\end{bmatrix}, 0=\begin{bmatrix}-1\\1\end{bmatrix}, A=\begin{bmatrix}1&1&1&1\\1&0&1&0\\1&1&0&0\\1&0&0&1\end{bmatrix}=\begin{bmatrix}Id & x & y & x\oplus y\end{bmatrix}=\begin{bmatrix}1&1&1&1\\-1&-1&-1&-1\\1&-1&1&-1\\-1&1&-1&1\\1&1&-1&-1\\-1&-1&1&1\\1&-1&-1&1\\-1&1&1&-1\end{bmatrix}$$

Superposition and quantum computation (similarity with neural network)

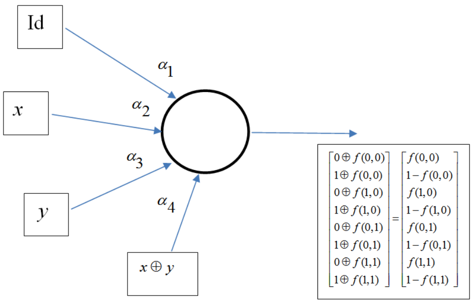

Figure 4: Superposition Graph for Two Qubits in One Step Method (Similarity with Neural Network)

CLASSICAL LOGIC FOR TWO QUBITSBY ONE STEP METHOD IN QUANTUM COMPUTER

The gate AND in Toffoli is

$$|s,x,y\rangle \Rightarrow |s\oplus f(x,y)\rangle$$
$$for$$
$$f(x,y)=x\wedge y$$

We have

$$\begin{bmatrix}0\oplus f(0,0)\\1\oplus f(0,0)\\0\oplus f(1,0)\\1\oplus f(1,0)\\0\oplus f(0,1)\\1\oplus f(0,1)\\0\oplus f(1,1)\\1\oplus f(1,1)\end{bmatrix}=\begin{bmatrix}0\\1\\0\\1\\0\\1\\1\\0\end{bmatrix}=\begin{bmatrix}1&0&0&0&0&0&0&0\\0&1&0&0&0&0&0&0\\0&0&1&0&0&0&0&0\\0&0&0&1&0&0&0&0\\0&0&0&0&1&0&0&0\\0&0&0&0&0&1&0&0\\0&0&0&0&0&0&0&1\\0&0&0&0&0&0&1&0\end{bmatrix}\begin{bmatrix}0\\1\\0\\1\\0\\1\\0\\1\end{bmatrix}$$

And

$$\begin{bmatrix} 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \\ 0 \\ 1 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} -2 \\ -2 \\ -2 \\ 2 \end{bmatrix}$$

So, we have the superposition of the basic functions

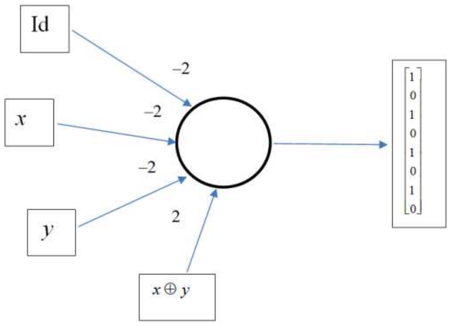

Figure 5: AND Operation in Quantum Computer by One Step Method and Similarity with Neural Network

In a explicit form we have

$$-2|00\rangle - 2|10\rangle - 2|01\rangle + 2|11\rangle = -2\begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} - 2\begin{bmatrix} 1 \\ -1 \\ -1 \\ 1 \\ 1 \\ -1 \\ -1 \\ 1 \end{bmatrix} - 2\begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ -1 \\ 1 \\ -1 \\ 1 \end{bmatrix} + 2\begin{bmatrix} 1 \\ -1 \\ -1 \\ 1 \\ -1 \\ 1 \\ 1 \\ -1 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \\ 0 \\ 1 \\ 1 \\ 0 \end{bmatrix}$$

Boolean functions in quantum computer and superposition weights

$$\begin{bmatrix} f(x,y) & \alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 \\ 1 & 4 & 0 & 0 & 0 \\ x & 0 & -4 & 0 & 0 \\ y & 0 & 0 & -4 & 0 \\ x \oplus y & 0 & 0 & 0 & -4 \\ x \wedge y & -2 & -2 & -2 & 2 \\ x \vee y & 2 & -2 & -2 & -2 \\ x \to y & 2 & 2 & -2 & 2 \\ y \to x & 2 & -2 & 2 & 2 \end{bmatrix}, \begin{bmatrix} \neg f(x,y) & \alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 \\ 0 & -4 & 0 & 0 & 0 \\ \neg x & 0 & 4 & 0 & 0 \\ \neg y & 0 & 0 & 4 & 0 \\ x \equiv y & 0 & 0 & 0 & 4 \\ \neg(x \wedge y) & 2 & 2 & 2 & -2 \\ \neg(x \vee y) & -2 & 2 & 2 & 2 \\ \neg(x \to y) & -2 & -2 & 2 & -2 \\ \neg(y \to x) & -2 & 2 & -2 & -2 \end{bmatrix}$$

We remark that the logic negation $\neg$ in one step quantum computer is given by the transformation

$$\begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix},$$

The transformation between AND and OR that are one dual to the other or $x \wedge y = \neg(\neg x \vee \neg y)$ is obtained by the transformation

$$\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix}$$

And the transformation between $\neg(x \wedge y) \Rightarrow x \rightarrow y$ or $\neg x \vee \neg y \Rightarrow \neg x \vee y$ is

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix}$$

In conclusion with 4 functions we can generate all the 16 Boolean functions and with three transformations we can move from one function to all the others. With one step method in quantum computer we can found a new structure inside the 16 Boolean functions.

THREE QUBITS BY ONE STEP METHOD IN QUANTUM COMPUTER

For three qubits we have the oracle structure

$$\begin{bmatrix} & 1 & x & y & z & x\oplus y & x\oplus z & y\oplus z & x\oplus y\oplus z \\ C_1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ C_2 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ C_3 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ C_4 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ C_5 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \\ C_6 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ C_7 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ C_8 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

For $1 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}, 0 = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$

We have the transformation by which we can compute the coefficients of the superposition for the expression

$$s \oplus f(x, y, z)$$

Where x, y and z assume the values 1 or zero. With 8 basis functions we can compute by superposition all the

$2^8 = 256$ Boolean functions. The oracle can be represented by the diagram

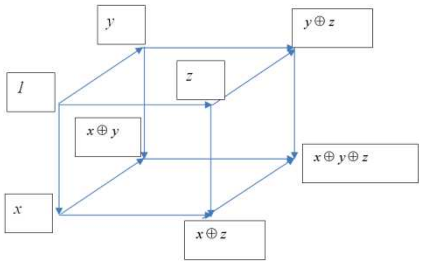

Figure 6: Oracle in Three Qubits for One Step Method

FOURIER TRANSFORMATION AND UNITARY TRANSFORMATION

Given the equation

$$x^2 = 1$$
$$x = 1, x = -1$$

For the generator $w = -1$ we have the cycle group composition low

$$\begin{bmatrix} & w & w^2 \\ w & w^2 & w \\ w^2 & w & w^2 \end{bmatrix}$$

Now we know that the eigenvalue of the unitary matrix are roots of the unity. In our case we have $x^2 = 1$ which roots are 1 and -1. The generator of the cycle group of the roots is $\omega = -1$. So we have the discrete Fourier matrix

$$F = \begin{bmatrix} (\omega^0)^0 & (\omega^0)^1 \\ (\omega^1)^0 & (\omega^1)^1 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

And the discrete Fourier transform of the vector p_k into a vector P^i

$$P^i = \sum_{k=0}^{n-1} p_k \omega^{ik}$$

With the inverse discrete Fourier transform where we use the vector of Morphogenetic sources P^i as coefficients to rebuilt the original field given by the vector p_k.

$$p_k = \sum_{i=0}^{n-1} P^i \omega_{ik}, \omega_{ik} = \omega^{-ik}$$

Where $\omega = e^{i\frac{2\pi}{2}} = -1$. So

$$F = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

For more complex Fourier transformation we have

$$F = \begin{bmatrix} (\omega^0)^0 & (\omega^0)^1 & (\omega^0)^2 & (\omega^0)^3 \\ (\omega^1)^0 & (\omega^1)^1 & (\omega^1)^2 & (\omega^1)^3 \\ (\omega^2)^0 & (\omega^2)^1 & (\omega^2)^2 & (\omega^2)^3 \\ (\omega^3)^0 & (\omega^3)^1 & (\omega^3)^2 & (\omega^3)^3 \end{bmatrix}$$

For

Where $\omega = e^{i\frac{2\pi}{4}} = i$ we have

$$F = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & i & -1 & -i \\ 1 & -1 & 1 & -1 \\ 1 & -i & -1 & i \end{bmatrix}$$

The Fourier discrete transformation is

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & i & -1 & -i \\ 1 & -1 & 1 & -1 \\ 1 & -i & -1 & i \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -i \\ -1 \\ i \end{bmatrix}$$

For XOR we have

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & i & -1 & -i \\ 1 & -1 & 1 & -1 \\ 1 & -i & -1 & i \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 2 \\ i-1 \\ 0 \\ -(i+1) \end{bmatrix}$$

In conclusion we can simulate by the discrete Fourier Transformation and wave fields the one step quantum circuit and generate a new form of the classical logic.

CONCLUSIONS

In this paper I show the possibility to represent Deutch quantum circuit by a one step unitary transformation.

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