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REPRESENTATION OF DISEASED RETINAL IMAGES USING QUANTUM FOURIER TRANSFORM

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Abstract

Quantum mechanical systems promise a secure computational model and cryptographic techniques. There are many proposals for representing the quantum information (Audio, Image and Video). This work also representing the quantum images of diseased retinal images by using quantum Fourier transform equation, which uses to store the image information using Bra-Ket notations. This rumination enjoys the tenor that sharing of confidential image is alternate with true randomness rather than classical pseudo randomness. Finally Quantum form of diseased retinal images will be illustrated by using the quantum computational properties.

Key Words: *Quantum Computation, Retinal Images, Quantum Fourier Transform*

1. Introduction

In modern cryptography and secure communication environment, secret sharing of data plays a primary role and its protection has been more important over the last decades. The open nature of these channels makes the data transfer over them unguarded to various attacks and hence the multimedia content security has become an essential requirement. Many approaches had been expanded in content protection for different scopes of cryptography. Quantum computations also enticed a great deal of attention since they allow realizing secure data transmission, which can store, process and transfer the information by using the unique properties of quantum theories including the superposition and entanglement [16, 17].

In the field of quantum information processing, the representations of quantum images are proposed in many ways by researchers. This work is also to illustrate the quantum images but by using Quantum Fourier Transform (QFT) [2] in classical computer which renders the greatest advancement in implementing the complex vectors of quantum image processing algorithm by using quantum computation techniques.

1.1. Requirements

In the absence of the physical quantum hardware, to implement the illustration of quantum image is experimented in classical computer and the quantum key distribution is also proceeded to realize the secure key distribution. The simulation based experiments are done for the database of five different corneal disease images for our research purpose. Quantum illustration of these images with corresponding equations are simulated in the classical computer with Intel (R) core (TM) i3-2330M CPU@ 2.20 GHZ, 64 bit Operating system, 3GB RAM equipped with the MATLAB R2017a environment and Quantum Information Toolkit [19] which provides the Bra-Ket notations and quantum communication tools for quantum image processing, analysis, visualization, manipulation of state vectors and algorithm development.

2. Proposed Method

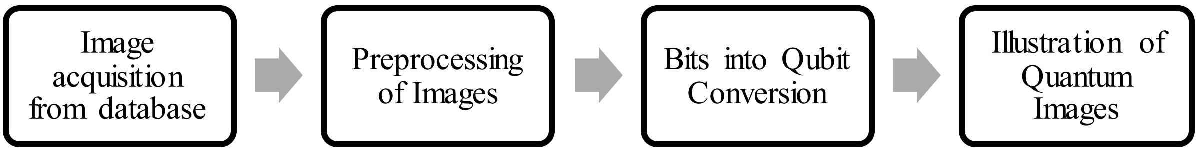


Figure-1: Block Diagram

2.1 Image acquisition and Preprocessing

In this work the corneal disease images are taken as the input images for our research purpose, which are collected from eye hospitals. Those diseases are Age-related Macular Degeneration (AMD), Pathologic Myopia (PM), Choroidal Neo Vascularization (CNV), Retinal Vein Occlusion (RVO) and Diabetic Macular Edema (DME). And the images are in the form of .jpeg files. The preprocessing steps for noise free images are necessary for further quantum illustration process. First, the images are converted into RGB to gray scale image. And another one of the important steps of preprocessing is digital filtering, because of images are mixed with noise naturally so it distracts the original image signal. For digital filtration of image, the Butterworth filter is used which is quickly round-off the cutoff frequency without ripples when compare to others like box, disk, gaussian and median filters [15]. Finally the preprocessed image signal is noiseless and higher resolution for the input of quantum image processing.

2.2 Representation of Quantum Images using Quantum Fourier Transform

Step 1: The values of original images (colors and its corresponding positions) are basically in the form of decimal values, is assigned. Formally, the state of a qubit is a unit vector in the 2-dimensional complex vector space. The vector $\binom{\alpha}{\beta}$ can be written as $\alpha|0\rangle + \beta|1\rangle$ where, $|0\rangle=\binom{1}{0}$ and $|1\rangle=\binom{0}{1}$. $|\varphi i\rangle$ a ket, Dirac notation for vectors. So, the input values are converted into the vector form to represent as the state vector. By using the quantum information toolkit, the decimal to state vector conversion for m, N values, where m is decimal representation and N is the number of qubits (2^n values).

Step 2: An n-qubit system [1,7] can exist in any superposition of the 2^n basis states. $\alpha_0|00000\rangle + \alpha_1|00001\rangle + \cdot\cdot\cdot + \alpha_{2n-1}|11111\rangle$ with $\sum_{i=0}^{2n-1} |\alpha_i|^2=1$. So, the vector form of the input image is converted into the structure form of quantum Ket function denoted as I.

Table-1: Representation of Images as Qubits

Decimal Value, m	No. of Qubits, N= 2^n	State Vectors	Denoted as ket function
0	1	1 0	1|0>
1	1	0 1	1|1>
1	2	0 1 0 0	1|01>

3	2	0 0 0 1	1|11>
2	3	0 0 1 0 0 0 0 0	1|010>
5	3	0 0 0 0 0 1 0 0	1|101>

Step 3:

The image is derived in the form of quantum vectors [5, 6], which follows

$$|I\rangle = \frac{1}{\sqrt{2^n}} \sum_{s=0}^{N-1} |A_s\rangle \otimes |s\rangle \quad (1)$$

Where $N=2^n$ denotes the number of Qubits

$|I\rangle$ – Illustration of Input Image, $|A_s\rangle$ – Color value in s^{th} sample point

$|s\rangle$ – Position of sample points (s=0, 1… N-1), $\otimes$ - Kronecker Product

The Quantum Fourier transform (QFT) implements the analog of the classical Fourier transform, which is defined in exactly the same way, although the notation differs slightly. Thus the QFT [25] can be expressed as

$$|j\rangle \rightarrow \frac{1}{\sqrt{2^n}} \sum_{k=0}^{2^n-1} x_j \, e^{2\Pi ijk/2^n} \, |k\rangle \quad (2)$$

The Quantum Fourier transform can be viewed as unitary matrix, acting on quantum state vectors, where the unitary matrix QFT is given by

$$\mathrm{QFT} = \frac{1}{\sqrt{N}}\begin{bmatrix} a & a^2 & a^3 & \dots & a^{(n-1)} \\ a^2 & a^4 & \omega^6 & \dots & a^{2(n-1)} \\ \vdots & \vdots & \vdots & & \vdots \\ \vdots & \vdots & \vdots & & \vdots \\ a^{(N-1)} & a^{2(N-1)} & a^{3(N-1)} & \dots & a^{(n-1)(n-1)} \end{bmatrix} \quad (3)$$

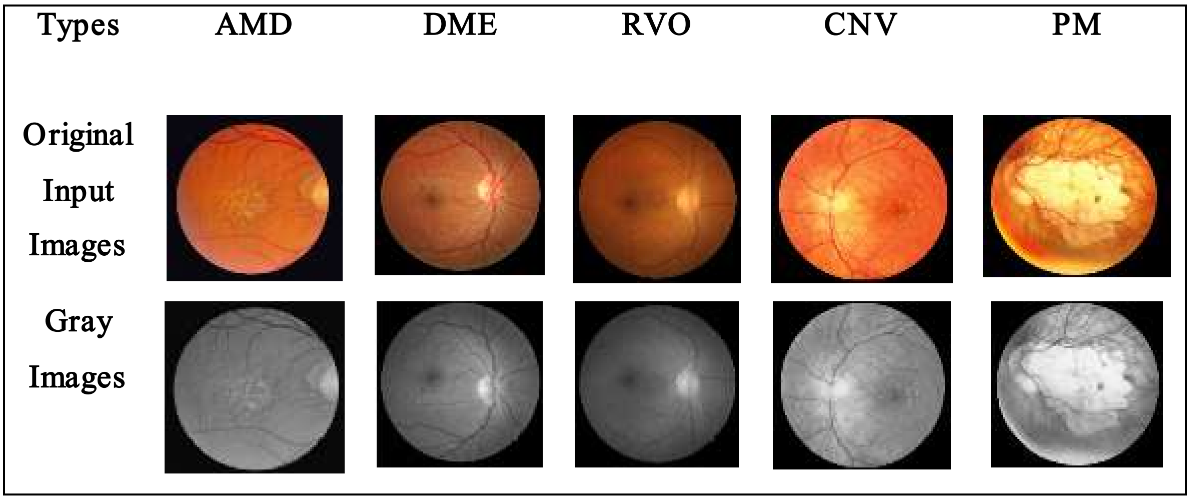
Step 4: Finally, execute the Quantum Fourier Transform equation on the n-qubit system values of image to get its QFT form, which are complex value.

$$QFT(|I\rangle) = QFT\left(\frac{1}{\sqrt{2^n}}\sum_{s=0}^{N-1}|A_s\rangle \otimes |s\rangle\right) \quad (4)$$

$QFT(|I\rangle)$, which gives the representation of quantum images and it will be proceeded into the quantum key distribution process.

3. Results and Performance Analysis

In this work, the simulation based experiments are done for the database of five different corneal diseases (AMD, DME, RVO, CNV and PM). Because of these noisy image signals, the preprocessing steps are followed to get the noiseless and higher order signals. Figure-2 shows the preprocessed image signals.



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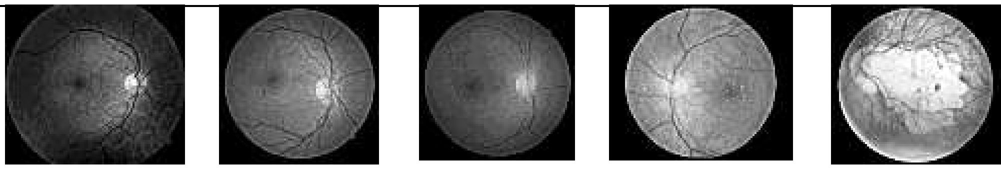
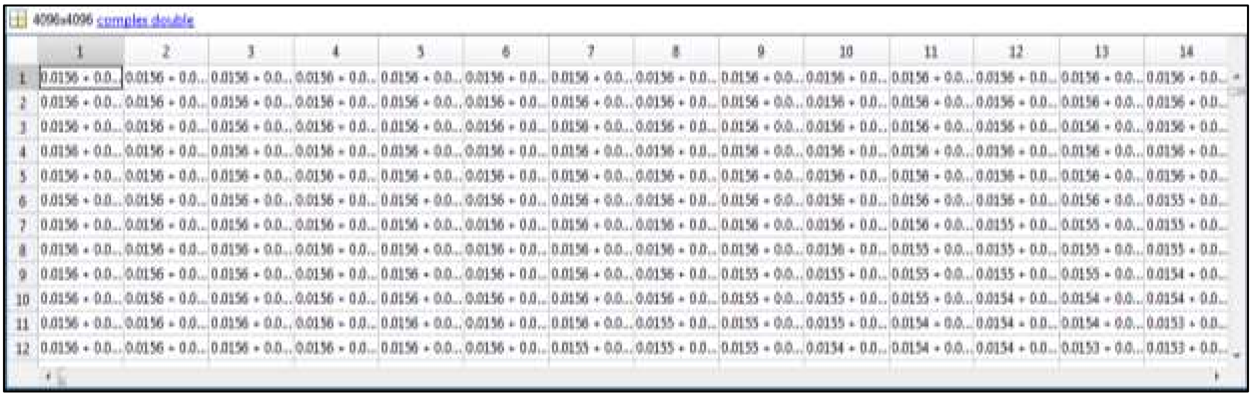
Filtered Images	

Figure-2: Preprocessed Images for Corneal Diseases

In simulation, it can be viewed as a transform from 2^n numbers (in classical) into a range of size 2^n (in quantum), containing the frequency components from the domain. For this experiment, n=12 (i.e. $N=2^{12}$) size of complex structure is shown in Figure 3.

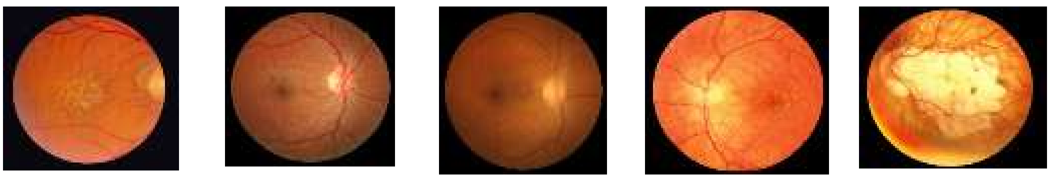


4096x4096 complex double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...
2	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...
3	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...
4	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...
5	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...
6	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0155 + 0.0...
7	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...
8	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...
9	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0154 + 0.0...
10	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0154 + 0.0...	0.0154 - 0.0...	0.0154 + 0.0...
11	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0155 + 0.0...	0.0154 - 0.0...	0.0154 + 0.0...	0.0154 - 0.0...	0.0153 + 0.0...
12	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 - 0.0...	0.0156 + 0.0...	0.0156 + 0.0...	0.0155 + 0.0...	0.0155 + 0.0...	0.0155 - 0.0...	0.0154 + 0.0...	0.0154 - 0.0...	0.0154 + 0.0...	0.0153 - 0.0...	0.0153 + 0.0...

Figure-3: Qunatum Fourier Transform for 2^n values (n=12)

The execution of the Quantum Fourier Transform equation on the n-qubit system values of original image to get its QFT form, which are complex value. The classical and quantum illustrations of images are follows in Figure 4.

Image Type	AMD	DME	RVO	CNV	PM
Classical Images					

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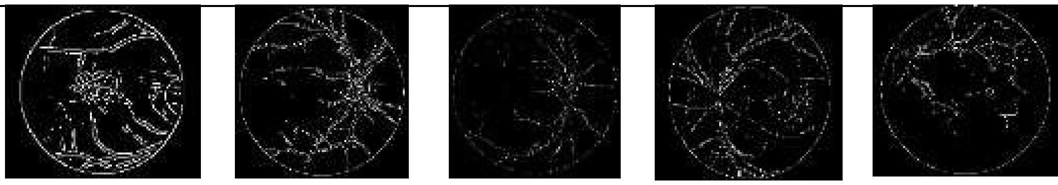
Quantum Images	

Figure-4: Classical vs Quantum illustrations of Images

4. Conclusion

Finally, the illustration of quantum image is proposed by using Quantum computation to store the image sample values as n-qubit system. The proposed method allows to represent quantum image, which can be useful for future quantum telecommunications. Simulation results show that the images stored as the qubit systems, which can be reliably recognized and recovered on realistic quantum computers. The proposed method should be strengthening to provide the best results for quantum image processing. Finally from the results, the quantum images are illustrated by using Quantum Fourier Transform.

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