Chapter 3
Image Representation, Filtering, and Natural Computing in a Multivalued Quantum System

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ABSTRACT

Image processing on quantum platform is a hot topic for researchers now a day. Inspired from the idea of quantum physics, researchers are trying to shift their focus from classical image processing towards quantum image processing. Storing and representation of images in a binary and ternary quantum system is always one of the major issues in quantum image processing. This chapter mainly deals with several issues regarding various types of image representation and storage techniques in a binary as well as ternary quantum system. How image pixels can be organized and retrieved based on their positions and intensity values in 2-states and 3-states quantum systems is explained here in detail. Beside that it also deals with the topic that focuses on the clear filteration of images in quantum system to remove unwanted noises. This chapter also deals with those important applications (like Quantum image compression, Quantum edge detection, Quantum Histogram etc.) where quantum image processing associated with some of the natural computing techniques (like AI, ANN, ACO, etc.).

INTRODUCTION

These days computer science shows an explosive growth in activities intimately related to logic. There are various developments happened in classical logic but where the concept of 'Classical Logic' ends, there the concept of 'Quantum Logic' starts. It leads us to the door of future computing systems. This chapter mainly deals with some of the important issues of image processing in binary and ternary quantum systems. To store and represent the grayscale and RGB images in 2-states system are different from 3-states system and it is very challenging task. This chapter mainly deals with those challenges. Besides

these issues, this chapter also describes how quantum image processing performs a key role for the filteration of images in spatial as well as frequency domain to remove some unwanted noises. Quantum image processing is widely applicable to different areas of image processing. It actually enhances the benefits of image processing techniques after associating with quantum logic. It also improves the quality of several natural optimization algorithms through improving the slow convergence rate which is a common drawback of most optimization techniques. Quantum computing is a science which performs its operations based on the laws of quantum mechanics, which is the manner of particles at the sub-atomic level. The machine which follows the rules of quantum computing for its operations is called quantum computer.Quantum computation and quantum information is the learning of the information processing tasks that can be accomplished using the concept of quantum mechanical systems. Quantum computation and quantum information has trained us to think physically about computation, and it has been discovered that this approach helps us to identify many new and exciting capabilities for information processing and communication and computing (Michael A. Nielsen et al.,2010).Unlike classical part, the basic unit of information in quantum computing is called the qubit, which is also called quantum bit. Like a classical bit, a qubit can also be in one of two states. While a bit in a classical computer can be in the state 0 or in the state 1, a qubit can impose its superpositioned behaviour with it. A qubit can exist in the state |0> or the state |1>, but it can also exist in an intermediate normalized state which is called a superposition state. This is a state that is a linear combination of the states |0>and |1>.The superposition (|S>) of the above two qubits states can be articulated as,

$$| S >= x | 0 > +y | 1 > \tag{1}$$

where x and y belongs to a complex vector space and $|x|^2 + |y|^2 = 1$, which represents square of the length of the vectors, sometime called "Unit Vector". They are also called probability amplitudes.

$|x|^2$: Tells us the probability of finding |S>in state |0>
$|y|^2$: Tells us the probability of finding |S>in state |1>

So now we can define that qubit is unit vector in a two dimensional complex vector space (|> -Dirac's Ket notation) (Sreenivasachari & Ravikumar, 2013; McMahon, 2007).The special states |0> and |1> are known as computational basis states, and produces an orthonomal basis for this vector space. It cannot be examined a qubit to determine its quantum state, that is, the values of x and y. Instead, according to the quantum mechanics, it can be only acquired much more restricted information about the quantum state. When the measurement of a qubit can be either the result 0, with probability $|x|^2$, or the result 1, with probability $|y|^2$. Naturally, $|x|^2 + |y|^2 = 1$, since the probabilities must total to one. Geometrically, we can interpret that the qubit's state be normalized to length 1 as a much needed condition. Thus, in common a qubit's state is a unit vector in a two-dimensional complex vector space(Michael A. Nielsen et al., 2010).

When Quantum computing is associated with natural nerve computing, then besides continuity, approximation ability, and computation ability, it also provides parallelism and high effectiveness of quantum computation.Quantum computing is also combined with unsupervised learning (like K-means clustering) to obtain a significant accelerate compare to classical approach. The main objective of this chapter is to describe all these approaches in detail. The following Figure 1. shows how quantum computing is applicable in various domains of computer science.

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