Chapter 12
Optimum Gray Level Image Thresholding using a Quantum Inspired Genetic Algorithm

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ABSTRACT

In this article, a genetic algorithm inspired by quantum computing is presented. The novel algorithm referred to as quantum inspired genetic algorithm (QIGA) is applied to determine optimal threshold of two gray level images. Different random chaotic map models exhibit the inherent interference operation in collaboration with qubit and superposition of states. The random interference is followed by three different quantum operators viz., quantum crossover, quantum mutation and quantum shifting produce population diversity. Finally, the intermediate states pass through the quantum measurement for optimization of image thresholding. In the proposed algorithm three evaluation metrics such as Brinks's, Kapur's and Pun's algorithms have been applied to two gray level images viz., Lena and Barbara. These algorithms have been applied in conventional GA and Han et al.'s QEA. A comparative study has been made between the proposed QIGA, Han et al.'s algorithm and conventional GA that indicates encouraging avenues of the proposed QIGA.

INTRODUCTION

The concept of quantum computing (QC) has been originated from the discipline of quantum physics. In the upcoming twenty-second century, QC may be visualized as one of the most challenging research areas for the scholars of computer science and engineering (Mcmohan, 2008; Gonzalez, 2002). The inher-

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ent dynamism of QC has been derived from the Schrödinger equation (SE) (Talbi, 2006). QC has some physical phenomena in its own like superposition, interference, coherence & decoherence, entanglement etc., which facilitate the parallelism capability. The features of QC can be embedded into the classical algorithms via a proper coupling to construct quantum inspired algorithms. The new quantum version of classical algorithms may possess exponentially speed up as compared with the pure classical algorithms (Dey, 2011). So the reflection of the research activities have been turned into designing quantum versions of the conventional algorithms such that these would fit on the quantum computer when invented (Dey, 2011). According to Richard Feynman, the efficacy of classical computers is very low when the quantum mechanical activities are concerned. His observation postulates that the effect of quantum mechanics would compensate the said problem fully (Talbi, 2004). The parallelism potential makes QC to be superior to its counterpart in the context of time complexity (Talbi, 2006; Reiffel, 2000). The application of QC conceited its existence when applied into some complex optimization problems that need larger solution space (Han, 2002). Grover's database search algorithm (Grover, 1998) and Shor's quantum factoring algorithm (Shor, 1997) are two popular quantum inspired algorithm that have been already discovered.

There are some renowned soft computing approaches used in this direction so far. Heuristic search and various optimization techniques or image analysis using intensity distribution are appropriate examples in this regards (Ren, 2009; Filho, 2008; Nakiba, 2010; Bazi, 2007). Thresholding plays a very important role in image segmentation, which acquiesce a binary image. The basic purpose of image thresholding is to separate object with its background (Pal, 1993). Threshold converts a given gray scale or color image into its corresponding binary image based on a predefined threshold intensity value. The pixel intensity values greater than the threshold value are grouped into one category, called foreground (*F*). The remaining pixels are fallen into other category, called background (*B*) or vice-versa (Sahoo, 1997; Jawahar, 1997). The pixels belonging to set (*F*) are set to 1 (white), while the remaining pixels in the other set are set to 0 (black) (Pal, 1988; Dey, 2011).

Let $I = \left[I_{pq}\right]_{a\times b}$ be the gray scale image of the dimension $a\times b$ where, $\left(p,q\right)$ signifies a pixel coordinate of the test image and T is said to be the predefined threshold value satisfying the following properties [6]

$$F = \left\{I_{pq} \middle| I_{pq} > T\right\} \tag{1}$$

$$B = \left\{I_{pq} \middle| I_{pq} \le T\right\} \tag{2}$$

Here, $I_{pq} \in \left[0, L\right]$ where, L represents the maximum threshold value of the image. It has been observed that some severe complications may arise for determining the optimum threshold due to some unwanted phenomena. A few typical examples of such complications may include poor contrast, abrupt illumination changes, immobile and correlated noise, no apposite objective measures etc. (Sezgin, 2004 ; Dey, 2011). Image thresholding are widely used in image processing (Sezan, 1990), video change detection (Su, 2006), Magnetic Resonance Image (MRI) (Atkins, 1998), Optical Character Recognition (OCR) (Sezgin, 2004), infrared gait recognition (Xue, 2010) to name a few.