# Chapter 24
# Chaotic Map Model-Based Interference Employed in Quantum-Inspired Genetic Algorithm to Determine the Optimum Gray Level Image Thresholding

**Sandip Dey**
*Camellia Institute of Technology, India*

**Siddhartha Bhattacharyya**
*RCC Institute of Information Technology, India*

**Ujjwal Maulik**
*Jadavpur University, India*

## ABSTRACT

*In this chapter, a Quantum-Inspired Genetic Algorithm (QIGA) is presented. The QIGA adopted the inherent principles of quantum computing and has been applied on three gray level test images to determine their optimal threshold values. Quantum random interference based on chaotic map models and later quantum crossover, quantum mutation, and quantum shift operation have been applied in the proposed QIGA. The basic features of quantum computing like qubit, superposition of states, coherence and decoherence, etc. help to espouse parallelism and time discreteness in QIGA. Finally, the optimum threshold value has been derived through the quantum measurement phase. In the proposed QIGA, the selected evaluation metrics are Wu's algorithm, Renyi's algorithm, Yen's algorithm, Johannsen's algorithm, Silva's algorithm, and finally, linear index of fuzziness, and the selected gray level images are Baboon, Peppers, and Corridor. The conventional Genetic Algorithm (GA) and Quantum Evolutionary Algorithm (QEA) proposed by Han et al. have been run on the same set of images and evaluation metrics with the same parameters as QIGA. Finally, the performance analysis has been made between the proposed QIGA with the conventional GA and later with QEA proposed by Han et al., which reveals its time efficacy compared to GA along with the drawbacks in QEA.*

DOI: 10.4018/978-1-4666-7456-1.ch024

## 1. INTRODUCTION

All the animals are in inherent race aiming to control over environmental resources. The evolution can be determined by the competent. The rule of nature advocates that the better participants in all respect would be able to survive and scatter their own genetic material among the others. Artificial intelligence, a branch of computer science, embraces the evolutionary computations that mostly involve the optimization problems which are poles apart from each other. Basically Evolutionary Algorithms (EAs) can be considered as very good examples of stochastic search and optimization methods that always tag on the rules of natural biological evolution (Han, 2002). Since the last decade, researchers throughout the world are working on EAs that includes the optimization problems serving various objectives (Kim, 2006). Unlike the traditional optimization methods, the applications of EAs are vast and provide very successful results especially for solving complex optimization problems. EAs can deal with a number of participants in chorus which proves its parallelism capability. It has a very quick response for adapting different problems that in turn make a very good result (Han, 2002).

There are numerous evolutionary computation methods to develop various optimization techniques. Some of them are Genetic Algorithm (GA) developed by Fraser (Fraser, 1957), Bremermann (Bremermann, 1962) and Holland (Holland, 1975), evolution strategies (ES) developed by Rechenberg (Rechenberg, 1973), Schwefel (Schwefel, 1995) and evolutionary programming (EP) developed by Fogel (Fogel, 1966). These methods have the strengths of their own and also suffer from various weaknesses. The most non ignorable problem crops up to fit in are that; these methods take lot of times especially for the convergence for optimization of complex problems (Han, 2002).

EAs work on the principle of survival for the fittest. A selection is made at each generation based on the objective functions (or fitness functions). After the completion of each generation some strong vectors would be able to survive and some will not. The upshot of each iteration results better solution by the evolution mechanism, incorporated by the evolutionary algorithm (Han, 2002).

Image segmentation plays a very important role in image processing. This is mainly used in pattern recognition. Segmentation is the process which partitions a whole image into number of homogenous subsets called regions where each region possesses a different well-defined property. If an image $\boldsymbol{I}$ is partitioned into a number of non-empty regions, $R_1$, $R_2$, …, $R_n$ then the following properties must hold (Pal, 1993).

$$\bigcup_{j=1}^{n} R_j = I \tag{1}$$

$$R_j \cap R_k = \phi \ \forall \ j \neq k \tag{2}$$

Segmentation is the earliest and most widely used method for image thresholding. The purpose of using thresholding is to distinguish an image into objects (foreground $\boldsymbol{O}$) and its background ($\boldsymbol{B}$) (Sahoo, 1997). In practice, there exist various algorithms that may be used to determine the threshold values of images. Let $I=[I_{pq}]_{m\times n}$ be a given image where each $(p, q)$ consists of any gray value $L$ with the following properties (Jawahar, 1997):

$$I_{pq} \in \{0,1,2,\ldots,L\text{-}1\} \tag{3}$$

$$O=\{I_{pq} \mid I_{pq}>T\} \tag{4}$$

$$O=\{I_{pq} \mid I_{pq}\leq T\} \tag{5}$$

where, $T$ represents the selected threshold value.

Quantum Computing (QC) is a method that has been envisaged from the principles of quantum physics. It is one of the most demanding topics of research in this twenty-first century. The Schrödinger equation (SE) is the sole resource from where the dynamic processes of QC can be