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New quantum inspired meta-heuristic techniques for multi-level colour image thresholding

Sandip Dey[a,*], Siddhartha Bhattacharyya[b,*], Ujjwal Maulik[c]

[a] Department of Information Technology, Camellia Institute of Technology, Madhyamgram, Kolkata 700129, India
[b] Department of Information Technology, RCC Institute of Information Technology, Beliaghata, Kolkata 700015, India
[c] Department of Computer Science & Engineering, Jadavpur University, Kolkata 700032, India

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ABSTRACT

The efficient meta-heuristic techniques, called ant colony optimization, differential evolution and particle swarm optimization, inspired by the fundamental features of quantum systems, are presented in this paper. The proposed techniques are Quantum Inspired Ant Colony Optimization, Quantum Inspired Differential Evolution and Quantum Inspired Particle Swarm Optimization for Multi-level Colour Image Thresholding. These techniques find optimal threshold values at different levels of thresholding for colour images. A minimum cross entropy based thresholding method, called Li's method is employed as an objective (fitness) function for this purpose. The efficiency of the proposed techniques is exhibited computationally and visually on ten real life true colour images. Experiments with the composite DE (CoDE) method, the backtracking search optimization algorithm (BSA), the classical ant colony optimization (ACO), the classical differential evolution (DE) and the classical particle swarm optimization (PSO), have also been conducted subsequently along with the proposed techniques. Experimental results are described in terms of the best threshold value, fitness measure and the computational time (in seconds) for each technique at various levels. Thereafter, the accuracy and stability of the proposed techniques are established by computing the mean and standard deviation of fitness values for each technique. Moreover, the quality of thresholding for each technique is determined by computing the peak signal-to-noise ratio (PSNR) values at different levels. Afterwards, the statistical superiority of the proposed techniques is proved by incorporating Friedman test (statistical test) among different techniques. Finally, convergence curves for different techniques are presented for all test images to show the visual representation of results, which proves that the proposed Quantum Inspired Ant Colony Optimization technique outperforms all the other techniques.

1. Introduction

Till date, segmentation has turned out to be one of the most admired techniques in digital image processing. Assuming an image as a region, it can be effectively used to divide the given region into a number of homogeneous and disjoint subregions. There must have at least one attribute in common in each subregion, which may include texture, colour or any other feature. So far, image segmentation technique has been successfully applied in various domains of applications. Some of them may include face detection [1], image retrieval [2] and object recognition [3] to name a few. Thus far, plentiful segmentation techniques are available in the literature. A detailed review of different segmentation methods has been presented in [3]. As we know that a colour pixel is a mixture of three different colour components, some additional computational complexities may arise for colour image segmentation.

From the last few decades, thresholding has been used as an image segmentation tool which is usually exploited to extract an object from its background image. The success behind the ongoing popularity of image thresholding is assumed to be its intrinsic simplicity, exactitude and robustness. The simplest form

* Corresponding authors.
E-mail addresses: dsandip_vc@yahoo.com (S. Dey), dr.siddhartha.bhattacharyya@gmail.com (S. Bhattacharyya), umaulik@cse.jdvu.ac.in (U. Maulik).

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