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Social spiders optimization and flower pollination algorithm for multilevel image thresholding: A performance study

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ABSTRACT

In this paper, we investigate the ability of two new nature-inspired metaheuristics namely the flower pollination (FP) and the social spiders optimization (SSO) algorithms to solve the image segmentation problem via multilevel thresholding. The FP algorithm is inspired from the biological process of flower pollination. It relies on two basic mechanisms to generate new solutions. The first one is the global pollination modeled in terms of a Levy distribution while the second one is the local pollination that is based on random selection of local solutions. For its part, the SSO algorithm mimics different natural cooperative behaviors of a spider colony. It considers male and female search agents subject to different evolutionary operators. In the two proposed algorithms, candidate solutions are firstly generated using the image histogram. Then, they are evolved according to the dynamics of their corresponding operators. During the optimization process, solutions are evaluated using the between-class variance or Kapur's method. The performance of each of the two proposed approaches has been assessed using a variety of benchmark images and compared against two other nature inspired algorithms from the literature namely PSO and BAT algorithms. Results have been analyzed both qualitatively and quantitatively based on the fitness values of obtained best solutions and two popular performance measures namely PSNR and SSIM indices as well. Experimental results have shown that both SSO and FP algorithms outperform PSO and BAT algorithms while exhibiting equal performance for small numbers of thresholds. For large numbers of thresholds, it was observed that the performance of FP algorithm decreases as it is often trapped in local minima. In contrary, the SSO algorithm provides a good balance between exploration and exploitation and has shown to be the most efficient and the most stable for all images even with the increase of the threshold number. These promising results suggest that the SSO algorithm can be effectively considered as an attractive alternative for the multilevel image thresholding problem.

1. Introduction

Image segmentation is an important task for meaningful analysis and interpretation of acquired image in many fields. Many segmentation techniques have been proposed in the literature. Among all the existing techniques, thresholding method is one of the most popular due to its simplicity, robustness and accuracy (Pal & Pal, 1993; Sahoo, Soltani, & Wong, 1988).

Image thresholding is a process by which the whole image is segmented into one or several regions on the basis of one or more threshold values (Sahoo et al., 1988). Bi-level thresholding refers to the process of dividing an input image into two classes, such as the background and the object of interest. An extension to more than two classes leads naturally to multilevel thresholding where more than two distinct objects or regions need to be depicted. In bi-level thresholding, image pixels with gray values greater than a certain value or threshold are classified as object pixels while the others are classified as background pixels. In multilevel thresholding, image pixels belonging to the same class have gray levels within a specific range defined by several thresholds (Maitra & Chatterjee, 2008). A great interest is devoted to multilevel thresholding within the community of researchers because of the intrinsic nature of real world images where it is required to identify several objects and for which bi-level thresholding fails to produce satisfactory results.

The thresholds can be obtained with a local or a global process (Sezgin & Sankur, 2004). In local thresholding, a different threshold is assigned to each part of the image. In global thresholding, a

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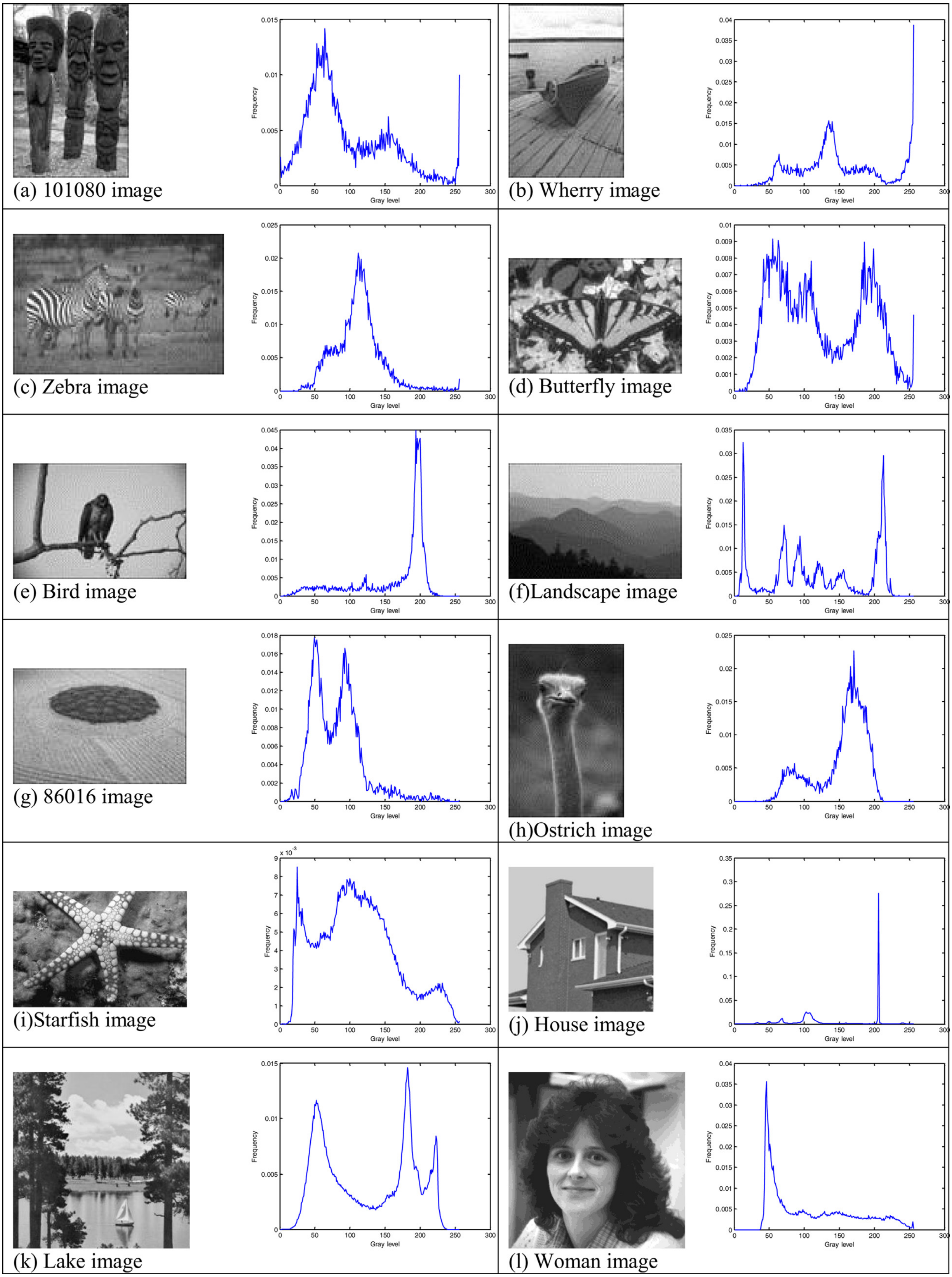

Fig. 1. Real images used in the paper with their histograms.