

# A Nuclei Segmentation Method Based on Whale Optimization Algorithm Fuzzy Clustering in Histopathological Images

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**Abstract**—A nuclei segmentation in the histopathological images is a challenging problem, specifically in the images stained with the hematoxylin and eosin dye. To alleviate this, a new whale optimization algorithm based fuzzy clustering method has been presented in this work for nuclei segmentation in the histopathological images. In the proposed method, the whale optimization algorithm is applied to find the best fuzzy clusters based on the objective function defined as compactness. The evaluation of the introduced method is conducted on the publicly available histopathological image dataset, namely H&E stained ER+ breast cancer images. The experimental results evince that the proposed approach acquires comparatively better accuracy of segmentation than the standard clustering based image segmentation methods in terms of both the qualitative and quantitative measurements. Therefore, it can be stated that the introduced method is an efficacious nuclei segmentation method for histopathological images.

**Index Terms**—Histopathological images, Nuclei segmentation, Nature-inspired algorithm, Whale optimization algorithm.

## I. INTRODUCTION

Segmentation in an image is the process of finding the different regions according to the various features like pixel intensity value, texture of region, and color value. The segmentation tries to represent the region of interests with minimal description. It is an important phase in the analysis of real-time applications like object detection and recognition, optical character recognition, and aerial image analysis [1]. Generally, segmentation groups the similar set of pixels that exhibit same characteristics. Usually, the intensity of the pixels is considered to perform the image segmentation [2]. However, this feature lacks in producing quality segmentation, especially when the morphological complexities in images are increased [3] such as segmenting the nuclei in the histopathological images [4].

The segmentation of the nuclei is the main functional unit in the automated analysis of the histopathological images and it's accuracy defines the system efficiency [5]–[7]. However, a reliable nuclei segmentation method is a challenging problem, specifically in the hematoxylin and eosin (H&E) stained images [5]. Some of the factors that hardens the nuclei segmentation process are complex nuclei shapes, nuclei

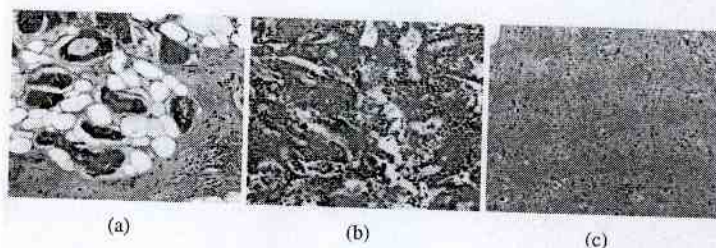


Fig. 1. Representative histology images, scanned at 40x magnification level [27].

overlapping, artifacts while capturing histopathological images and inhomogeneity in staining [5], [8], [9]. To demonstrate the complexity involved, Fig. 1 shows some typical histopathology images. Literature consists of large number of methods for nuclei segmentation based on clustering approach [3], [10]–[16] where the preferred method for clustering is k-means. Generally, such methods use k-means to cluster the considered features into multiple features which are further post-processed to achieve the desired results. However, on the cluttered images, k-means fails to generate quality clusters due to overlapping boundaries [17]. For such images, fuzzy clustering is successful [18]. However, fuzzy clustering also suffers from a number of demerits such as it is biased towards initialization, suffers from premature convergence, and may result local optimal solutions [19]–[21]. In such scenarios, nature-inspired algorithms have performed better in literature [22]–[26].

Nature-inspired algorithms are the mathematical models that perform optimization according to the nature behavior [28]. These algorithms have been widely used in many engineering problems, especially clustering in domains such as computer vision, data mining, and big data [29]–[32]. Some of the popular nature-inspired algorithms include WOA (whale optimization algorithm) [33], GA (genetic algorithm) [34], DE (differential evolution) [35], and PSO (particle swarm optimization) [36]. Whale optimization algorithm is recently proposed nature-inspired algorithm which is based on the hunting behavior of the humpback whales [33]. Mirjalili et al. [33]

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