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A Grey Wolf Optimizer Based Automatic Clustering Algorithm for Satellite Image Segmentation

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Abstract

Grey Wolf Optimizer has recently emerged as an efficient meta-heuristic optimization technique. It has good capability in exploitation for unimodal problems, superior exploration ability for multimodal problems, and also works fine for composite functions avoiding local minimas. This paper proposes an application of Grey Wolf Optimizer (GWO) algorithm for satellite image segmentation. The original GWO has been suitably modified to work as an automatic clustering algorithm. This algorithm has been applied on two satellite images. It is computationally efficient and its accuracy is superior in many cases in terms of Davies-Bouldin (DB) index, average inter-cluster distance and average intra-cluster distance.

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Keywords: Automatic Clustering; Satellite Image Segmentation; Grey Wolf Optimizer; Davies-Bouldin index

1. Introduction

Clustering is a process in which objects with similar properties are kept in one cluster. The properties of objects belongs to two different clusters vary. Thus it is the process of organizing similar objects together. The traditional methods of clustering, such as K-means and it's various modified algorithms need prior information about the number of clusters from user. The number of clusters is generally not be available for real life problems. So, the automatic clustering algorithms gained popularity [1], which determines the number of clusters automatically.

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Kettani et al. in [2] proposed an automatic clustering algorithm which involves restarting of a K-Means algorithm and predicts correct number of clusters with superior accuracy. Bandyopadhyay and Maulik [3] used genetic algorithm which automatically determines the number of clusters. Das et al.[4]improvised the differential evolution algorithm for automatic clustering. Chen and Ye described how particle swarm optimization can be used for automatic clustering [5]. Multi-objective-based particle swarm optimization (MOPSO) and the Multi-Objective Simulated Annealing (MOSA) were reported by Abubaker et al.[6] for automatic clustering. A Multi-objective Immunized Particle Swarm Optimization (MOIMPSO) is reported by Nanda and Panda [7] which combines the efficient features of artificial immune system and PSO. Recently Shukla and Nanda [8] proposed an automatic clustering algorithm based on Social Spider Optimization. A Symbiotic Organisms Search algorithm is used to solve multi-objective constrained optimization problems [20].

Image segmentation is defined as the process of segregating the pixels of an image into several clusters such that each cluster contains some significantly correlated portion of the image. To perform image segmentation, an $(m \times n \times p)$ image is converted into $(d \times p)$ matrix where $d = m \times n$. Conventionally for colored image cases $p = 3$ representing R, G and B components. Thus segmenting an image is equivalent to grouping this $(d \times p)$ matrix into clusters. Shi and Malik [9] initially treated image segmentation as graph partitioning problem. Maulik [10] applied genetic algorithm for medical image segmentation. Cuevas and Sossa [11] compared several evolutionary algorithms for image segmentation using multiple thresholds.

Satellite images analysis play a vital role in weather forecasting, regional planning and biodiversity conservation. The objective of segmenting a satellite image is to identify significant portions of the image, such as the urban areas, forests, crops, natural calamities (regions affected by flood, fire, smoke, land slide) for effective analysis. In these images at times it's difficult to segment smaller areas along with much larger areas. A cluster validity index based on symmetry, called Sym-index can effectively able to compute different sized clusters that are internally symmetrical [12]. A self-organizing map is introduced by Awad [13] which organizes the pixels based on grey levels of various bands into groups; then a thresholding technique is employed to segregate the satellite image into classifiable areas.

The paper is organized as follows. Section 2 consists of a brief review of original Grey Wolf Optimizer algorithm and the objective function used for clustering. Section 3 focuses on the proposed image segmentation using Modified Grey Wolf Optimizer (GWO) algorithm. Section 4 highlights the environment of simulation, parameters used in algorithms and the images used for segmentation. Section 5 has results for the simulations. Section 6 narrates the important conclusions.

2. Background

2.1. Original Grey Wolf Optimizer Algorithm

Grey Wolf Optimizer algorithm is introduced by Mirjaliliet al.[14] based on the natural behavior of grey wolves. In this algorithm the wolves are categorized into four types based on their behavior namely Alpha, Beta, Delta and Gamma. The Alpha is the group leader and represents the fittest solution. The Beta is second fittest solution, Delta is the third fittest solution, and the remaining wolves are referred to as omega. The steps involved in the original grey wolf optimizer algorithm have been summarized below:

1) Initialize the Search Agents.
2) Assign Alpha, Beta, and Gamma by fitness.
3) Encircle the prey

$$\vec{D} = |\vec{C} \,.\, \vec{X}_p(t) - \vec{X}(t)|$$

$$\vec{X}(t+1) = \vec{X}_p(t) - \vec{A}.\vec{D} \tag{1}$$

where t represents present iteration, $\vec{A}$ and $\vec{C}$ are coefficient vectors, $\vec{X}$ indicates the wolf's position vector