An Analytical Survey on the Satellite based Natural Terrain Feature Identification Techniques

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Abstract— Due to advancement in technology, human has made it possible to capture the data from satellites. Satellite data has various application in the field of scientific research and development. In this research wok, satellite data is used for the classification of natural terrain features. The main focus of this paper is to present a comparative review on the existing approaches of terrain feature identification for the area of Alwar region, India. Natural terrain features are the features available on a particular terrain. This area has the availability of land cover features like vegetation, water, barren, urbanization and hilly area. Considered techniques are based on swarm intelligence based adapted approaches. Swarm intelligence techniques are also one of the popular inventions of scientist that provide optimized solutions by their global information sharing social species. So, overall terrain feature identification is performed based on the image classification process. Also a comparative review on the existing techniques is presented with the explanation of image classification process. We are considering kappa coefficient parameter for comparison of existing techniques.

Keywords— Natural Terrain Features, Optimization, Swarm Intelligence, Remote Sensing, Satellite Image

I. INTRODUCTION

Swarm Intelligence is an artificial concept inspired from the collaborative multi agent social species that work intellectually to design intelligent system and optimized algorithm [1]. From the ancient years, natural social species fascinated the individual and researchers for the seamless intelligence work solutions. These social species can be small ants, termites, wasp, bee, flying birds, school of fishes and other animal groups also [2]. These species work in collaborative behavior. Even each individual agent have their own agenda but the work seems to be in a well organized manner and their coordinated behavior can achieve complex goals. In swarm intelligence, we analyze the behavior of social species, model their behavior and use the modeled form to develop an artificial swarm concept. All the agents of a particular colony species interact with each other directly or indirectly and solve the problem in a robust and optimized manner. The global cooperation of these social species to work collaboratively is due to strategy of self organization. Based on the variety of social species of insects and animals, there exists a number of Swarm Intelligence techniques. Some of the popular swarm intelligence techniques are listed Bat Algorithm, Cuckoo Search, Ant Colony Optimization, Firefly Algorithm, Intelligent Water Drops Algorithm, Biogeography Based Optimization, Particle Swarm Optimization and Artificial Bee Colony Optimization [3].

In this paper, we are doing the comparative review on the existing swarm intelligence based natural terrain feature extraction methods. Alwar region based satellite data is used for the image classification. The multi-spectral images of Alwar region are taken using Canadian satellite and an Indian satellite named LISS-III.

The organization for the rest sections of paper is given: Section II presents the basic of image classification, Section III briefs about the Literature survey of the existing techniques with comparative results. Section IV concludes the paper.

II. IMAGE CLASSIFICATION

Image Classification can be defined as the process to classify the entire pixels of an image into different possible feature classes as per their attribute values. This classification process changes the overall structure of the image as per feature class values. This classified image can be further used for various real life problems. There is the existence of a variety of methods and approaches for the categorization of image pixels into different clusters. To generate the different terrain visualization, spectral patterns based approach is mostly used pattern recognition method [4] [5]. There exist two types of image classification Supervised and Unsupervised classification [6] [7].

- Defining the Classification/feature classes.
- Selection of features.
- Sampling of training data.
- Estimation of Universal Statistics.
- Classification based on various classifiers.

- Verification of Results.

Figure 1: Basic Process of Satellite Image Classification

In Image Classification process, we emphasize to use spectral pattern recognition methods as compare to spatial pattern recognition procedures that are the directly obtained satellite data. In spectral pattern recognition, supervised and unsupervised approaches are mainly taken into account. These are discussed as below:

(a) Supervised Classification

In Supervised Classification, training dataset is considered to classify a particular area with required feature classes. The selection of these training samples depends upon the analyst's knowledge about the geographical place & different terrain features. In simple words we can say that supervised classification is the method in which analyst is 'supervising' the classification process. Thus, in this supervised classification technique, firstly information classes are identifying which are further used to represent the spectral classes [8]. This can be explained in the steps given below:

- **TRAINING STAGE** – This is the initial stage of supervised classifications process in which analyst

understands the training areas & their features and develop a numerical description of the spectral bands and land cover terrain features.

- **CLASSIFICATION STAGE** – After understanding the training dataset, analyst can classify the terrain features. In this step, analysts have to find the perfect match for each pixel in which it can be placed. If no similar pixels match found in the training set then that is labelled as unclassified pixels. In this way, different classification feature classes are formed.

- **OUTPUT STAGE** – The final step of supervised image classification process is to generate the output. As an output spectral data which is further used at a number of real life situations.

(b) Unsupervised Classification

Unlike Supervised Classification, Unsupervised Classification does not use the training dataset for classification process. Here some algorithms are involved to check the unknown pixels and categorize them into a set of feature classes. In unsupervised classification, no predefined samples are involved for terrain feature classification. [8].

- The basic idea behind involved to classify the pixels is that values of pixel in the same feature class should be close comparable whereas the pixel values of different classes should be different.

- In unsupervised Classification, the classes obtained are spectral classes because the initial features are not known to analyst due to involvement of training dataset. So, these feature classes are natural grouping of image values.

- The classified data is compared with the same referred data by the analyst to identify the spectral classes.

- During feature class assignment, each pixel is compared to all the classes to find the closest best match.

- This value assignment process of each pixel can also be represented in the form of a black & white or colour map.

- This map form is then compared with the actual real world view by the analyst to determine the accuracy level. For this, the analyst should have the knowledge about the actual scenic view from the past experience.

III. LITERATURE SURVEY

Here, the existing work for the natural terrain feature identification is discussed with the respective technique. The considered concepts are discussed and compared based on the accuracy assessment based kappa coefficient parameter as shown in table I. The integrated hybrid concept of ACO/BBO is used. Individual BBO algorithm for image classification shows some clustering errors. So, this hybrid approach shows better results as compare to BBO and also resolved the drawbacks for BBO approach in image classification. Here authors have compared used hybrid concept with other possible existing techniques like Hybrid Rough Set /BBO and Hybrid ACO/SOFM [9] the Cuckoo Search method for the satellite image classification process to identify the land cover features is presented in [10]. Cuckoo bird has specialized clever behavior to store his egg in the nest of other species. Alwar region dataset is considered for land cover identification. In this proposed algorithm, image pixels are assigned as the cuckoo bird and feature land cover attribute as the host nest to store the cuckoo egg. Authors have used evaluation parameter of kappa coefficient to check of performance of cuckoo search algorithm. In [11] author have presented the integrated ACO and CS based algorithm for the classification of land field area. The obtained results using hybrid approach were efficient enough as compare to other approaches. In [12] author have used intelligent water drops algorithm for natural terrain feature identification, intelligent water drops are considered as the image pixels and soil particles are obstacles that can interrupt the accurate feature extraction process. The presented approach shows efficient results as compare to some traditional and swarm based concepts. Further the concept of cuckoo search in [13] with particle swarm optimization to identify the terrain attributes is used. In the previous work, authors have evaluated kappa coefficient value as 0.9422 which was a good achievement. But here they further enhanced the kappa coefficient value to 0.9633. The algorithm also gives improved results as compare to the individual concepts of CS and PSO. Singla have presented the work on hybrid Artificial Bee Colony and Cuckoo Search based optimization for natural terrain feature classification [14]. Authors have used the alwar dataset and evaluate the parameters of kappa coefficient, overall accuracy, producer's accuracy and user accuracy. The proposed algorithm shows efficient results as compare to other methods with a kappa coefficient value of 0.979.Also the CS and BBO for the satellite image classification is used in [15]. The output results shows better accuracy and kappa coefficient value of 0.965 which is far better as compare to other exiting swarm intelligence techniques for image classification.

TABLE I

COMPARATIVE ANALYSIS OF NATURAL TERRAIN FEATURE IDENTIFICATION TECHNIQUES

Reference Number	Technique Used	Key Features	Kappa Coefficient
9	Hybrid ACO/BBO	Land Cover feature Extraction	0.7636
10	Cuckoo Search (CS)	Terrain feature	0.9465
11	Hybrid CS/ACO	Natural Terrain feature	0.9422
12	IWD	Natural Terrain Feature extraction	0.8723
13	Hybrid CS/PSO	Terrain feature	0.9633
14	Hybrid CS/ABC	Terrain feature extraction	0.979
15	Hybrid CS/BBO	Land cover/Terrain feature classification	0.965

CS-Cuckoo Search, ACO-Ant Colony Optimization , PSO-Particle Swarm Optimization, BBO-Biogeography based optimization, ABC- Artificial Bee Colony Optimization.

The analytical comparison is made on the basis of kappa coefficient as the accuracy assessment parameter. The considered algorithms are compared based on the kappa coefficient value as shown in figure 2.

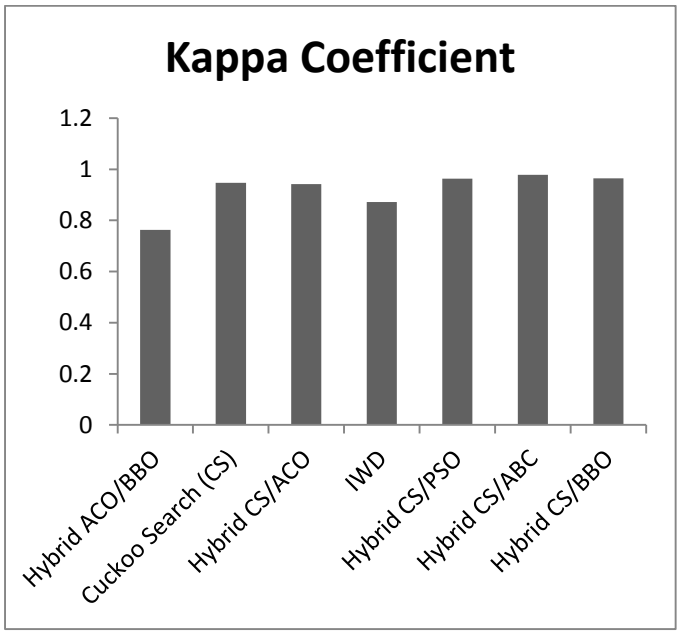

Figure 2: Comparison Analysis of considered techniques based on Kappa Coefficient

IV. CONCLUSION

Natural Terrain feature identification is an important application using the satellite data. In this paper, an analytical comparative review is presented for terrain identification using image classification process. We have considered kappa coefficient as a evaluation parameter to check the evaluation of exiting methods. The considered concept for classification are Cuckoo search, Intelligent water droplet model, Hybrid ACO/BBO approach, Hybrid CS/ACO approach, Hybrid CS/PSO, Hybrid CS/ABC and Hybrid CS/BBO approach. From these techniques hybrid CS/ABC shows efficient results as compare to other methods.

Further, integration of some other swarm concepts can be made with other computational approaches like rough set theory, fuzzy logic, neural network, honey bee foraging, biogeography based optimization, firefly algorithm etc.

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