Graphic Characterization of Terrain Using Information Computational Methods

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Abstract:
As is well known, automated pattern recognition and satellite data analysis include a broad spectrum of pattern recognition. Image classification is a crucial remote sensing technology that facilitates the automatic understanding of massive amounts of data. Numerous researchers have put a great deal of effort into this field, and their results are impressive. In order to distinguish between diverse terrain classes, such as water, urban, rocky, vegetation, and barren, we are examining a variety of nature-inspired strategies in this article. the many methods we are using to do this, including the hybrid algorithms of Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC) and Biogeography Based Optimization (BBO), Firefly and Firefly Algorithm, and Hybrid Cuckoo Search & Firefly Algorithm. These methods with a strong natural influence are crucial for applications involving distant sensing. These methods have shown good results showing increased efficiency and larger values of the Kappa coefficient, making them highly helpful for classifying aspects of the terrain. This research examines many methods of classifying satellite photos that draw inspiration from nature.

Keywords: Firefly Based Optimization, Natural Computing, Satellite Image, Remote Sensing, Particle Swarm Optimization, Kappa Coefficient, Image Classification, Cuckoo Search, Artificial bee Colony (ABC) Algorithms.

Introduction:

The study of the geographic distribution of living organisms is known as biogeography. The study of biogeography has its roots in the research of nineteenth-century naturalists like Charles Darwin and Alfred Wallace. Information may be gathered via the science and art of remote sensing without requiring physical contact, location, or the phenomena under study. Applications for remote sensing photographs include reconnaissance, the creation of military and civilian map products, the evaluation of environmental damage, zoning regulations, land use, land assessment, urban planning, electronic monitoring, and agricultural assessment. The categorization of remote sensing photographs is a crucial technique for identifying variations in natural phenomena.

1.1. Natural Computing

Natural computing refers to computational processes observed in nature and computations designed by humans inspired by nature. Analyzing complex natural phenomena in terms of computational processes enhances our understanding of the nature and nature of computation. Nature as a source of inspiration is essential to advancing technology and solving complex computational problems, a new term has been developed to cover it. Calculation methods influenced by nature are called “Natural Computing “. Natural Computing refers to computational processes that occur in nature and artificially created computations inspired by nature.

Therefore, Natural Computing can be defined as a computational process that uses nature inspired design methods as computational agents. Here, Artificial Machines are understood as machine created using human intelligence and having the same role as natural machines. It is divided into four main sections to help people better understand the and ideas behind natural computing. It is based on the use of technology, disease prevention technology, the world’s research technology and human brain modelling technology.

The goal of swarm intelligence (SI), a branch of artificial intelligence (AI), is to create intelligent multi-agent systems by modelling their behavior after that of social animals like flocks of birds or schools of fish, as well as of social insects like ants, termites, bees, and wasps. Examples of swarm intelligence-based algorithms include the Bat Algorithm, Biogeography Based Optimization [1], Ant Colony Optimization (ABO), Cuckoo Search (CS), Particle Swarm Optimization (PSO) [2], Artificial Bee Colony (ABC) Optimization, Firefly Algorithm, and more. Swarm intelligence [3] research aims to improve a number of soft computing and naturally inspired approaches.

The concept of remote sensing is used to collect data from satellites to obtain scenic views. Remote sensing is the process of collecting, processing and analysing geographic data and related satellite images without the need for real location. Planners worked on different computational methods and developed their algorithms to classify the landscape. Image data is classified using a hybrid algorithm based on swarm intelligence. A place full of character and prestige, Alwar is located in Rajasthan, India. The area has the following classes: Barren, Rocky, Vegetation, Urban, and Water. Indian satellite LISS-III and Canadian satellite LISS III were used to take various pictures of the Alwar region.

1.2 Image Classification

The main component of the approach taken to address the land cover mapping issue is image classification. As a result, the classification of satellite images has emerged as an important area of image processing study. The right set of picture features is required for every form of classification.

2. Proposed Method

A comparative study between the hybrid CS and FIREFLY algorithm [4] , the hybrid PSO and FIREFLY algorithm [5] , Classification using FIREFLY algorithm [6], and the fusion of BBO and ARTIFICIAL BEE COLONY optimization [2] have all been examined in this study. Table 1-4 shows the error matrix of the respective algorithms. The number of pixels successfully classified by algorithm is indicated by the error matrix's interpretation along columns. For instance, in Table 1 the suggested algorithm properly categorized 116 of the total 139 Urban pixels in the third column as Urban, whereas 1 were incorrectly labelled as Vegetation and 26 as barren. There are no incorrectly identified water, vegetation & Rocky pixels.

2.1 Dataset

For our dataset we have considered some locations that have good land cover characteristics, such as vegetation, water, urban areas, barren areas, and rocky areas. The image is 548*474 pixels in size. The proposed image is subjected to the suggested algorithms, and a categorised image with various classifications is produced. In addition to the RGB (RED, GREEN, AND BLUE) band, green band, MIR (MIDDLE INFRA-RED), RS1 (RADAR SET1), RS2 (RADAR SET2), NIR (NEAR INFRA-RED) and DEM bands, there are other bands to be taken into consideration (DIGITAL ELEVATION MODEL). Figure 1 shows the different bands of the satellite picture used as input:

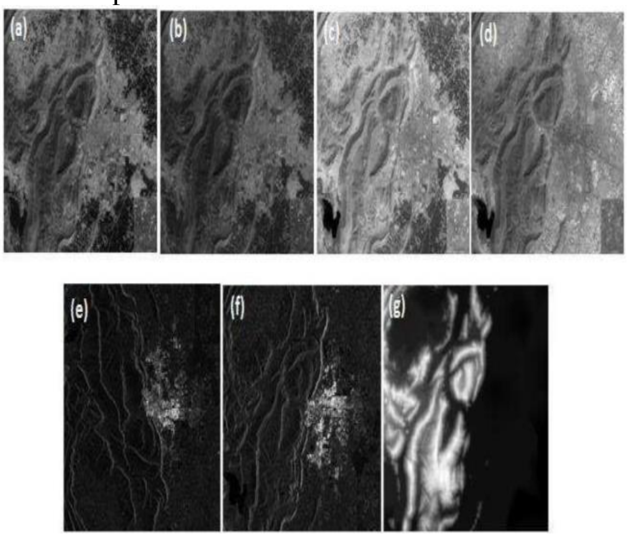


Figure 1: Alwar Region’s Band Satellite Image

2.2 Kappa Coefficient

A discrete multivariate technique used to evaluate the finding of the error matrix is known as the Kappa coefficient. Compared to overall accuracy metrics [9] [10] [11], the Kappa statistic provides a more useful evaluation of statement accuracy by including and observing both off-diagonal rows and columns and off-diagonal observations.

For the image of Alwar after formula is applied to the below error matrix, it will get the Kappa coefficient:

$$\hat{k} = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_{i+} \cdot\cdot x_{+i})}{N^2 - \sum_{i=1}^{r} (x_{i+} \cdot\cdot x_{+i})}$$

r = total no. of rows in the error matrix
xii = the no of observations in ith row and ith column (which is on the major diagonal)
xi+ = total of observations in row i
x + *i* = total no. of observations in column i
N = total no. of observations included in matrix.

2.3 Overall accuracy

Validation tests are performed during image classification to determine the effectiveness of our plan. This fact report aims to evaluate the effectiveness of assigning pixels in the observation area to appropriate classes. The widely used error matrix in remote sensing [12] [13]is used to assess the categorization accuracy. The relationship between the identified reference data and the associated automated classification results are compared using error matrices, category by category. For a categorized image, it is not reasonable to test every pixel. A set of arbitrarily chosen reference pixels is used to perform the experiment. Referenced pixels are areas of the categorized image where their true properties can be identified. The overall total accuracy is calculated as ratio of accurate observations to all classifications.

This metric of accuracy can be determined as follows:

O = Total number of valid classifications (sum of all values along the major diagonal) divided by the Total no. of classifications.

Table 1. Error Matrix after applying Biogeography based Optimization and Artificial Bee colony optimization Algorithm.

Classes	Water	Vegetation	Urban	Rocky	Barren	Total
Rocky	0	0	0	**96**	0	96
Urban	0	0	**112**	0	**4**	116
Vegetation	0	**109**	**1**	0	0	110
Barren	0	0	**26**	0	**59**	85
Water	**68**	0	0	0	0	68
Total	**68**	**109**	**139**	**96**	**63**	475

Table 2. Error Matrix after applying Cuckoo Search and Firefly Algorithm.

Classes	Water	Vegetation	Urban	Rocky	Barren	Total
Rocky	0	0	0	**99**	**2**	101
Barren	0	0	**5**	**2**	**60**	67
Urban	0	0	**149**	0	**11**	160
Water	**64**	0	**8**	**2**	0	74
Vegetation	0	**161**	0	0	0	161
Total	**64**	**161**	**162**	**103**	**73**	563

Table 3. Error Matrix after applying Image Classification using Firefly Algorithm.

Classes	Rocky	Water	Barren	Urban	Vegetation	Total

Vegetation	2	1	0	17	121	141
Water	7	54	4	0	4	69
Urban	3	0	1	110	0	114
Barren	0	0	93	0	0	93
Rocky	80	0	4	0	0	84
Total	92	55	102	117	125	501

Table 4. Error Matrix after applying Image Classification using Particle Swarm Optimization & Firefly Algorithm.

Classes	Water	Vegetation	Urban	Rocky	Barren	Total
Barren	0	0	1	0	57	58
Rocky	0	0	0	101	0	101
Urban	1	0	158	0	10	169
Water	73	0	0	0	0	73
Vegetation	0	161	1	0	0	162
Total	74	161	160	101	67	563

Figure 01: Using Biogeography based Optimization and Artificial Bee colony optimization Algorithm, the original Alwar image (on the left) and the classified image (on the right) are compared.

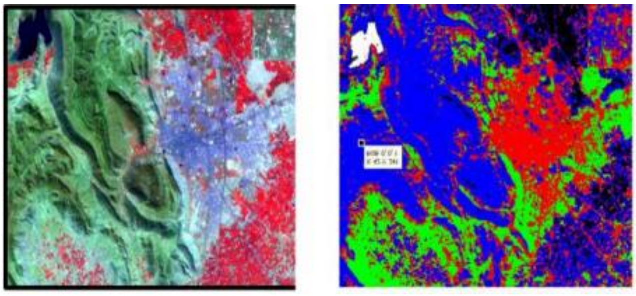


Figure 02: Using Cuckoo Search and Firefly Algorithm, the original Alwar image (on the left) and the classified image (on the right) are compared.

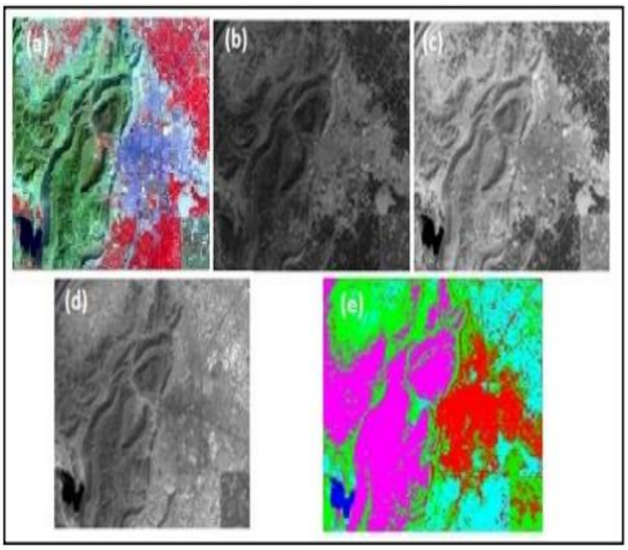


Figure 03: Using Classification of Firefly Algorithm, the original Alwar image (on the left) and the classified image (on the right) are compared.

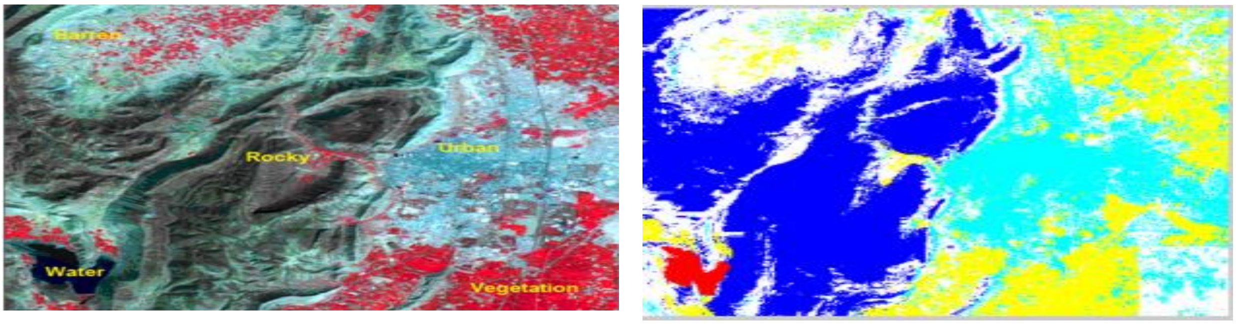


Figure 04: Using Particle Swarm Optimization & Firefly Algorithm, the original Alwar image (on the left) and the classified image (on the right) are compared.

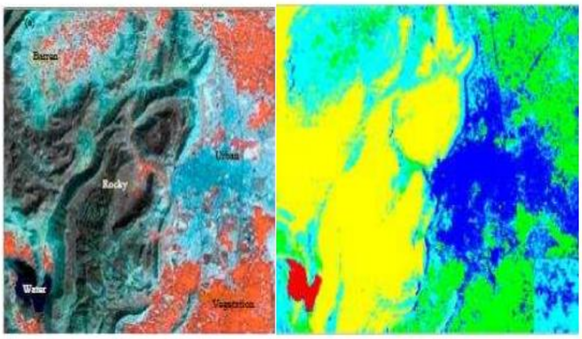
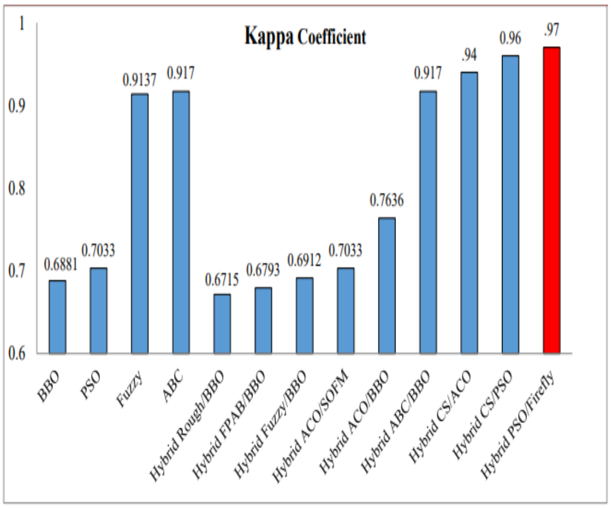


Figure 5: Kappa coefficient comparison of various Algorithms



3. Result Analysis

In this paper, we have done a comparative study of four algorithms which are hybrid CS and Firefly, hybrid PSO and Firefly, image classification using Firefly algorithm and BBO/ABC algorithm, their kappa coefficient is 0.96, 0.97,0.894 ,0.917 or Figure 2-6 shows the algorithms applied to the Alwar 7-band image and their respective classified image obtained. Black, green, yellow, red and blue represent barren, vegetation, rocky, urban and water. Figure 5 shows a comparison between the kappa coefficient of the algorithms. Figure 1 to 5 shows a comparison between the overall accuracy of these algorithms. From the comparative study, it is clear that the hybrid PSO and Firefly algorithm have the highest kappa coefficient, i.e. 0.97, while the hybrid CS and Firefly have the highest overall accuracy of 0.96.

4. Conclusion and Future Scope

This paper investigated the variables to compare the results of the investigation of several nature-inspired methodologies, including hybrid CS and Firefly, hybrid BBO and ABC, hybrid PSO and Firefly, and image classification using the Firefly Algorithm, biogeography-based categorization, and hybrid PSO and Firefly algorithms. The Kappa coefficient (KHAT) was used as a measure of acquired knowledge. In addition, it provides us with a method to assess knowledge content using multiple supervised paradigms and mixed categorizations. The overall accuracy is calculated to compare the efficiency of the algorithms. Future research goals include designing changes to the algorithm that would further increase the Kappa coefficient as well as increase the overall accuracy.

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