Hybrid Algorithm of Cuckoo Search and Firefly Algorithm for Natural Terrain Feature Extraction

Ravneet Kaur[1] Dr. Harish Kundra[2]
[1]Research Scholar [2]Professor & Head
[1,2]RIEIT, Railmajra, Punjab, India

Abstract— Natural Computing is the field of research that works with computational techniques that deal with natural inspiration. It attempts to understand the world around us in terms of information processing. Digital image classification techniques group pixels to represent land cover topographies. Land cover could possibly be agricultural, forested, urban, and other types of features. Mapping and classification of ordinary vegetation are foremost issues for biodiversity administration and preservation. Satellite data or remotely sensed data with very high spatial resolution are used for classification and study of vegetation, but generally satellite sensors are incomplete to several spectral bands, which is inadequate to classify and identify some natural vegetation formations. The objective is to show favouritism for natural vegetation and to classify the natural vegetation formations from the highly sensed data or satellite image. There are varieties of known satellite image classification techniques but in proposed work, Hybrid method with the combination of Firefly (FFA) and Cuckoo Search method to achieve the better classification rate is used. From simulation of proposed work, we have observed the value of kappa coefficient to be 0.96. After that, we have compared the obtained results with some previous existing methods like Fuzzy set, BBO, PSO, ABC, CS, hybrid Rough/BBO, hybrid Fuzzy/BBO, Hybrid FPAB/BBO, Hybrid ACO/SOFM, Hybrid ACO/BBO, Hybrid ABC/BBO and Hybrid of CS/ACO. We have implemented the hybrid algorithm with the combination of firefly and cuckoo search technique for satellite image classification of natural vegetation trained features for the betterment of results. The main benefit of hybrid method is to train the datasets of satellite image according to the globally best optimised feature. In the classification step, we can classify the image region according to their bands and detects the natural vegetation.

Key words: Natural Computing, Satellite imaginary, Firefly algorithm, Cuckoo search, Kappa Coefficient, Satellite Imaging, Classification

I. Introduction

Satellite imagery is abundant and plays a vital role in the provision geographical information. Satellite and remote sensing image provides quantitative and qualitative information, it reduce the complexity of on-site work and study time. Satellite remote sensing technology regularly collects data / images interval. The amount of data received in the data centre is huge as technology continues to grow. The number expands exponentially its speed, data volume. At an exponential rate, there is a strong need for effective mechanism to extract and interpret the value information from large-scale satellite imagery. Satellite images classification is a powerful technique for extracting information from a large number of satellite images. The satellite image classification process involves grouping the image pixel values and converted to meaningful categories. Some Satellite Image Classification methods and techniques are available. Satellite image classification method can be broadly divided into three categories: 1) Automatic 2) Manual and 3) Hybrids. All three methods have their own advantages and shortcomings.

A firefly is an insect that glows through a bioluminescent process. This gives each firefly a different or rather similar brightness, which is directly related to their attractiveness. The establishment of two fireflies can be based on their brightness to be attracted, which can be used to predict the distance between any two firefly's changes. This rhythmic flash, flashing speed and amount of time constitute a part of the signal system that brings together two fireflies. This flash rate is compiled in the form of an objective function to improve the solution of other algorithms. For this algorithm, some idealized rules are defined as follows:

1) A firefly is attracted to each other fireflies regardless of their sex; that attraction is purely based on the brightness of the firefly.
2) As the attraction or the brightness between the two fireflies increases, the corresponding distance between them decreases. In the case where there is no brighter firefly, movement occurs randomly;
3) How bright the firefly is determined by the objective function of the landscape.

In order to solve the optimization problem, we first define the objective function f (x); x = (x1, x2 ... xd). Then, the initial firefly group (candidate solution) xi (i = 1, 2... n) is generated. For each firefly xi, its brightness is associated with the encoded objective function f (xi) is calculated. For the maximization problem, the fly's brightness is only proportional to the value of the objective function. In addition, the brightness of each flight decreases with distance from its source. As the light is absorbed in the medium, the brightness changes depend on the degree of absorption. Two fireflies i and j in xi and xj, the distance r between them is the Cartesian distance. For different applications, the distance may take any suitable form an optimal solution. The firefly's attractiveness is the light intensity seen relative to its neighbouring fireflies. With each movement, the firefly's attractiveness decreases with distance from its source. Because, light is also absorbed in the medium, in the r = 0 when β_o as attractive, the brightness is updated as

$$\beta \ = \beta o \ e - r2$$

There are a large number of species (about two thousand species), and most plants produce short and harmonious flash lighting. The flash has three basic functions as follows:

1) The mating partner's attractiveness (communication).
2) Attractiveness of potential prey.
3) Provide a warning mechanism

Cuckoo is fascinating birds, not only because of the beautiful sounds they have, but also because of their positive regeneration strategy. Some species such as ani and Guira rhododendron lay their eggs in public nests, although, they may remove others' eggs to increase the probability of hatching their own eggs . A considerable number of species are parasitized by placing their eggs in the breeding parasites; other host birds (usually other species) are nested. There are three basic types of primary parasitism: intra-parasitic parasitism, cooperative breeding, and nest acquisition. Some host birds can clash directly with the invading rhododendron. If it is the host, the bird finds the eggs not their own, they will either throw these aliens or just give up their nest and build a new nest somewhere else. Some rhododendron species such as the New World parasite Tapera have been developed in this way. Female parasitic cuckoo tend to be very specialized. Imitating the colour and pattern of host eggs in several selected species .This reduces the probability of their eggs and thus, increases their reproducibility. In addition, the spawning time of some species is also amazing. The parasitic Rhododendron often chooses a nest where the host bird puts its own egg.

In general, cuckoo eggs hatched earlier than their host eggs. The first intuition action it will take is to expel the eggs once the first rhododendron is in the shadows. By pushing the eggs out of the nest blindly, eggs are deposited. The study also showed that cuckoo chicks could also imitate the call of host chicks to get more feeding opportunities. At the beginning, a given number of nests are 133 randomly chosen. Thereafter, only the best nest (with luckiest egg 134 or best solution) shall prevail for next generation, $x*$. Nests with 135 poorer solutions (x^{t+1}_j) are replaced with new eggs,or with solutions 136 from some available nest (x^{t+1}_i) using a Lévy flight, as 137 .The Equation is: $^{t+1}_{i=}x^t_i + \zeta\nu(x^t_i - x*)$

II. Related work

[1] Jing Dang, 2009, proposed Natural Computing as highly developed technology over the history decade. One important derivative of this development is the application of NC methods in finance. This paper gives an opening to a wide range of financial problems to which NC method have been gainfully applied. [2] Julie Main, 2001, introduced the concept and application of Case-based Reasoning systems. The first part briefly described about CBR and its usage. The subsequent section looks at the report and indexing of cases in CBR systems. [3] Janet L. Kolodner, 2008 proposed a case based analysis for old solutions to meet new demands; using old cases to give new state of affairs; using old cases for the analysis of new solutions.[4] D Casro et.al, presented basic fundamentals algorithms and various applications of natural computing.[5] Lila Kari, Grzegorz Rozenberg, reviewed many surfaces of Natural Computing such as cellular automata, neural network, genetic algorithm, swarm intelligence, membrane computing, intelligent water drop, firefly algorithm, bee colony optimization, biogeography based optimization, particle swarm optimization, cuckoo search. In [6] Harish Kundra explained the extension of the new organization algorithm based on the cellular automata that not only improves the classification accuracy in the dependency image by using the correlation technique, but also provides the hierarchical classification of the pixels classified into the level of association with each class and includes spatial edge detection method for classifying satellite images. In [7] Harish Kundra reviewed the higher efficiency and greater kappa coefficient value using PSO and CS as compare to swarm optimization algorithm and classified the diverse feature of remote sensing satellite image. [8] E. Emary explained that a feature selection system is based on FIFA optimization. Datasets typically include a large number of attributes, with irrelevant and redundant attributes. Redundant and unrelated attributes may reduce the accuracy of the classification because of the large search space. The primary goal of attribute reduction is used to select a subset of related attributes from a large number of available attributes to use all attributes to achieve comparable or better classification accuracy. This paper presents a system for feature selection that uses a modified version of the Fourier Transform algorithm (FFA) optimization. The improved FFA algorithm adaptively balances the development and utilization to quickly find the optimal solution. FFA is a new evolutionary computing technology, inspired by the light source of the light process. FFA can quickly search for feature space to obtain a subset of features that are minimized or nearly optimal, thereby minimizing a given stability functions. The fitting functions used include classification accuracy and feature reduction size. The proposed system was tested on eighteen datasets and proved to be superior to other search methods in the PSO and GA optimizer using different evaluation indices in this context.[9] Adwitya Sharma et.al proposed Classification techniques in which support vector machine (SVM) classification of data has made important contributions in the field of classification. However, researchers are sceptical of SVM performance due to over fitting, pair wise classification, and parameter normalization. For such regularization, known as a set of algorithms, the meta-heuristic algorithm has achieved the solution by iteratively updating the candidate solutions and finding the optimal solution to the problem by optimizing the objective function. In this paper, the parameters of the SVM are optimized by using the Firefly algorithm (FFA), which is superior to other Meta - heuristic algorithms for PSO and APSO. Experiments have been performed on various data sets collected from UCI repositories. [10] Hongjun Su concluded that an excitation algorithm (FA) for excitation band selection and optimization limit learning (ELM) for hyper spectral image classification. In this framework, the FA selects a subset of the original frequency bands to reduce the complexity of the ELM network. It is also suitable for optimizing the parameters in the ELM (i.e., the regularization coefficient C, the Gaussian kernel σ, and the hidden neuron number L). Due to very low complexity of the ELM, the classification accuracy can be used as an objective function of the FA during band selection and parameter optimization. In the experiment, two hyper spectral image datasets obtained by HYDICE and HYMAP are used, and the experimental results shows that the proposed method can provide better performance than particle swarm optimization and other related frequency band selection algorithms. [11] Iztok Fister Jr proposed the Cuckoo Search (CS) is an efficient, swarm intelligence based algorithm that has made significant progress since its launch in 2009. CS has many advantages because of its simplicity in solving highly nonlinear optimization problems in real-world engineering applications and effectiveness. This work has provided a timely review of all the most advanced developments over the last five years, including a discussion of the theoretical background and direction of future development of this powerful algorithm.

III. METHODOLOGY

A. Procedure for hybridization of Cuckoo Search and Firefly Algorithm

Sensed data or satellite image classification is a most difficult task and for the classification of sensed data or satellite image, the main part is feature extraction and feature optimisation because without appropriate feature set of sensed data or satellite image, accurate classification is not possible. So, in proposed work, hybrid technique is used to optimize the feature set with the combination of Cuckoo Search Optimisation and Firefly Algorithm. The Cuckoo Search and Firefly optimization algorithms are two most popular meta-heurisic search techniques that improve the classification rate as well as the efficiency of the proposed work by optimising the extracted feature set of sensed data or satellite image with the optimal solution from feature sets. The hybridisation of Cuckoo Search and Firefly Algorithm involves the following most appropriate steps for the classification of sensed data or satellite images with high accuracy:

- Step 1: Firstly, upload the sensed data or satellite image in workspace and we extract the feature set from the uploaded input data set of a sensed data, multi- spectral, and multi resolution and multi sensor image data/images of the datasets. A sensed data or satellite image is not a normal and simple dimension of image, there are several bands exists in a single image according to their feature set.
- Step 2: Initialised the population of n host nests in the implementation for the feature carrying purpose and initialised the cuckoo search and firefly algorithm.
- Step 3: Cuckoo Search and FFA is the iterative searching optimisation algorithm, so, we set the I_t iteration to optimisation purpose.
- Step 4: We find the best solution according to the all generated population from the feature set of input data set of a multi- spectral, multi resolution and multi sensor image data/images of the datasets according to the fitness function of cuckoo search algorithm.
- Step 5: Output of cuckoo search algorithm is passed to the firefly algorithm and after that, we got the more accurate feature set of a multi- spectral, multi resolution and multi sensor image data/images of the datasets according to the their bands which involve several bands.
- Step 6: At last, we find the best solution of both searching algorithm from the input dataset according to their bands of water pixels, vegetation pixels, urban pixels, rocky pixels and barren pixels
- Step 7: Store all data in different cell of optimised feature set according to the best solution for cuckoo search and firefly algorithm.

B. Classification of Sensed data or satellite image based on hybrid algorithm

The process of proposed methodology has been shown below with the original and test images for proposed work. In this section the classification of Sensed data or satellite image based on hybrid algorithm is given:

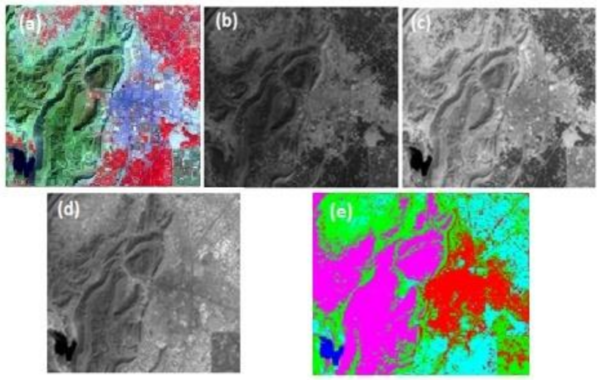

Fig. 1: (a) Original Satellite Image and (b) Red Channel (c) Green Channel (d) Blue Channel (e) Classified Image

Classification of sensed data or satellite image based on hybrid algorithm is given in above figure and there are different images like (a) the sensed data or original satellite image (b) Red channel of original uploaded satellite image (c) Green channel of original uploaded satellite image (d) Blue channel of original uploaded satellite image and (e) classified image with different colour segment and in classified image there total seven segments according to their bands.

C. Proposed algorithm

1) Assumptions

- Initialised Population
- Iterative loop = Total number of iteration
- First loop = Total number of rows (egg)
- Second loop = Total number of columns (egg)
- Inner most loop = Total number of dataset pixels (host nest)
- Classify = Dataset according to bands feature set

Input: Training feature dataset and sensed data or satellite image or multispectral satellite images
Output: Classified image according to the bands
Step 1: Load Original sensed data or Satellite Image (I) and extract the total number of rows and columns of satellite image pixels according to the bands of satellite image.

```
for i = all rows of original satellite image
      for j = all columns of original satellite image
 count = count+1
            band(count) = I(i,j)
            Save All_bands
      end
end
```

Step 2: Find the distance between cuckoo egg and the host nest using the given formula.
Calculate the Euclidean distance between the each pixel of cuckoo egg and the host nest (7 band pixels) using the formula and store their distance vectors.
for i = all rows of original satellite image
for j = all columns of original satellite image

$$d(p,q) = d(q,p) = \sqrt{(q_1-p_1)^2 + (q_2-p_2)^2 + \cdots + (q_n-p_n)^2} = \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}$$

Save Distance_Vectors
end
end

Where, n= 1 to 7 band pixel values, d is the distance between the egg and host, pi is the ith band pixel of cuckoo egg and qi is the ith band pixel of host.

Step 3: Find the most similar host nests for cuckoo egg.
for i = all bands

The most similar host is found by firefly Optimization algorithm. The similarity Criteria is solved is the best similarity mean of the difference between the pixels intensities calculated.

End

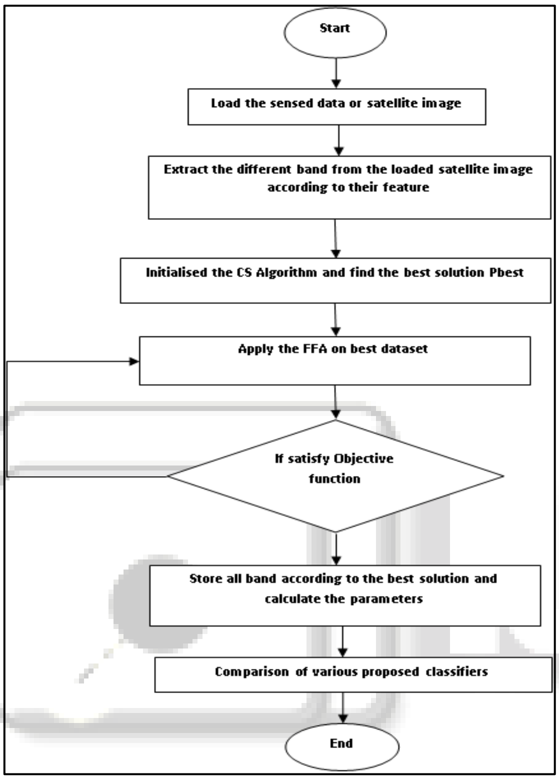

Fig. 2: Proposed Algorithm Flowchart

Initialized Firefly optimization

- Fireflies are unisex, so that one firefly will be attracted to other fireflies regardless of their sex.
- The attractiveness is proportional to the brightness, and they both decrease as their distance increases. Thus, for any two flashing fireflies, the less bright one will move towards the brighter one. If there is no brighter one than a particular firefly, it will move randomly.
- The brightness of a firefly is determined by the landscape of the objective function.

Step 4: Train data for optimised data according to bands
for i = all bands
Save Trained_Structure
end

Step 5: Finding best solution using the training structure for the classification of test satellite image

Step 6: After the classification mark and label the different bands based on the water, vegetation, and urban, rocky as well as barren according to the trained data.

Step 7: Calculate the performance parameters of the proposed simulation

Step 8: Get classified satellite image and error matrix in different color according to their feature sets.

Above algorithm describes the process of satellite image classification using hybridization of Cuckoo Search and Firefly Algorithm according to the existing bands in satellite image.

IV. RESULT AND DISCUSSIONS

In this section we describe the results of the proposed work for classification of sensed data or satellite image. For the evaluation of proposed work we calculate the Kappa coefficient using the hybridisation of algorithm in MATLAB work frame. The description of the Kappa coefficient is given below with the expression. The Kappa Coefficient can be defined as the discrete multivariate technique that is used to interpret the results of error matrix. The value of Kappa coefficient is always equal to or less than 1. If the value of Kappa coefficient is 1 then it implies perfect agreement and values less than 1 imply less than perfect agreement for the classification sensed data or satellite image. In exceptional situations, the value of Kappa coefficient can be negative. This is an indication that the two observers established less than would be expected just by probability. The Kappa statistic incorporates the both the off diagonal observations of the rows and columns and the diagonal observations to give a more robust statement of accuracy assessment than overall accuracy measures. The Kappa Coefficient can be calculated by applying the following formula to the error matrix:

$$\hat{K} = \frac{N_o \sum_{i=1}^{r} x_{ij} - \sum_{i=1}^{r}(x_{i+}..x_{+i})}{{N_o}^2 - \sum_{i=1}^{r}(x_{i+}..x_{+i})}$$

Where, r = no. of rows in the error matrix (r=5 in our case)
x_{ii} = the no. of observations in row i and column j (on the major diagonal)
x_{i+} = total of observations in row i (shown as marginal total to right of the matrix)
x_{+i}= total of observations in column i (shown as marginal total at bottom of the matrix)
N_o= total no. of observations included in matrix

A. *Simulation analysis of proposed work*

Here we describe the simulation analysis of proposed work on the basis of pixels sets. For validation process following number of pixels is taken into consideration in Cuckoo search and firefly algorithm:

Types	Pixels
Water Pixels	73
Vegetation Pixels	164
Urban Pixels	157
Rocky Pixels	101
Barren Pixels	70

Table 1:

Feature	Wat	Vegetat	Urb	Roc	Barr	Tot
Water	64	0	8	2	0	74
Vegetat	0	161	0	0	0	161
Urban	0	0	149	0	11	160
Rocky	0	0	0	99	2	101
Barren	0	0	5	2	60	67
Total	64	161	162	103	73	563

Table 1: Error Matrix Obtained After Implementing Proposed Work

Above table describe the error matrix of proposed work on the basis of hybridization of cuckoo search and firefly algorithm for the classification of sensed data and satellite image. Form the above table it is clear that the classification error is less than previous existing work based on the sensed data or satellite image classification and the comparison of the proposed work with previous works is given below in the form of graphical representation.

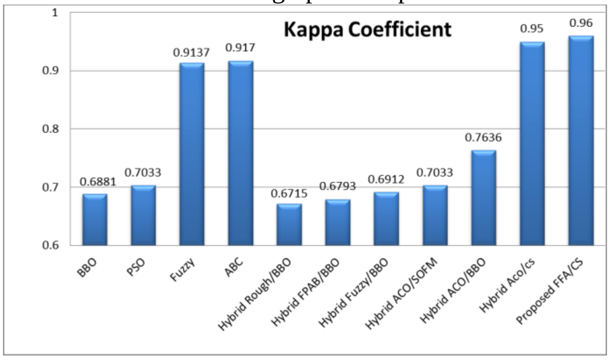

Fig. 3: Comparison of result obtained from various past works using kappa coefficient with proposed Work

Figure 3 shows the comparisons of the proposed work with various existing work on the basis of Kappa coefficients. The observed value of Kappa coefficient for proposed algorithm with hybridization of cuckoo search and firefly algorithm is 0.96, which shows that the observed classification of satellite image is better as compared to Kappa Coefficient of some other existing algorithms as shown in above figure. The Kappa coefficient of Fuzzy set (Banerjee et al., 2012), BBO (Panchal et al., 2009) (Goel L. et al., 2011), PSO (Panchal et al., 2009), ABC (Banerjee et al., 2012), CS (Bhardwaj et al., 2012), hybrid Rough/BBO (Goel S. et al., 2011), hybrid Fuzzy/BBO (Goel S. et al., 2011), Hybrid FPAB/BBO (Johal et al., 2010), Hybrid ACO/SOFM (Goel S. et al., 2011), Hybrid ACO/BBO (Goel S. et al., 2011) Hybrid ABC/BBO (Arora et al., 2012) and Hybrid of CS/ACO (Harish Kundra et.al, 2013) are 0.9137, 0.68812, 0.7033, 0.917, 0.9465, 0.6715, 0.6912, 0.6793, 0.7075, 0.7636 and 0.95respectively. Form the above observation we can find out the best conclusion of proposed sensed data or satellite image classification.

V. CONCLUSION

The main aim of the proposed work is the optimization of features by means of classification of the satellite image. Sensed image or satellite image is not like a simple image of simple plans; it has several plans according to the data categories. In proposed work, sensed or satellite image has used 7 bands and on the basis of these bands, we can extract the feature set. Hybridization of firefly algorithm and cuckoo search is taken place for the optimization purpose for improving the efficiency and classification rate of the simulated work. The best solution is being found out by the population generated of input of the feature set according to the data set considered. Later, the solution is achieved by the algorithms considered according to the bands measured. The value of Kappa coefficient came out to be 0.96. The natural vegetation is detected after the classification of the image region according to their bands.

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