

Resolving Mixed Pixels by Hybridization of Biogeography Based Optimization and Ant Colony Optimization

Suruchi Sinha, Abhishek Bhola, V.K.Panchal, Siddhant Singhal and Ajith Abraham

Abstract - Recent advances in remote sensing techniques made research possible in those areas where human hands are inaccessible. Digital Imagery brings the virtual image of a desired location, which requires some pre-processing to bring the view to an optimal level. Accuracy level in image classification is assumed on the categorization of the pixel into one of the several land cover classes. When the recognition of pixel accounts for two different classes at the same time, the resulting pixel is categorized as a mixed pixel. This paper proposes a novel approach by clustering the dataset of mixed pixel and thereafter implementing fusion of Ant Colony Optimization (ACO) and Biogeography Based Optimization (BBO) thereby resolving the problem of mixed pixels.

Keywords: Mixed Pixels, Clustering, BBO, ACO, Multi spectral dataset.

I. INTRODUCTION

Remote sensing is a technique of acquiring information about a specific object or phenomenon, without making physical contact with the object under investigation. Light reflected from an object is encountered with a "remote" screen and is captured by the sensors. This is the concept of remote sensing. The simplest example would be, when we engage into viewing the monitor of our computer we actively engage in remote sensing where, eyes are the sensors [1]. By satellite, aircraft, spacecraft, buoy, ship and helicopter images, data is created to analyze and compare things like vegetation rates, erosion, pollution, weather, forestry and land use [2]. With the increasing use of digital imagery in many fields of science, like

remote sensing, there is a need for accurate image analysis and classification. By image classification we mean, converting spectral data into a finite set of classes, which represent the surface types as seen in imagery. The intent of the classification process is to categorize digital image into one of several land cover classes. The purpose of image classification is to identify and portray, at a unique grey level, the features occurring in an image in terms of the object or the type of land these features actually represent. Image classification is perhaps the most important part of digital image analysis [3].

Usually, multispectral data is used to perform the classification and indeed the spectral patterns present within the data for each pixel is used as the numerical basis which are referred as digital numbers (DN) ranging from 0-225 [4]. Multispectral image is composed of images taken at different wavelength for same target area elaborating the chief features present there. For example, in the field of agriculture, a remotely sensed multi spectral image acquired by sensors, an onboard satellite is used for analysis of agricultural variation such as chlorophyll content [5]. Therefore, accuracy at granular level is foremost concern here.

The smallest piece of information in a digitized multispectral image is pixel. In multi spectral image, a pixel which detects signal from various components such as forest, vegetation, urban, rocky, water are called mixed pixel and on the other hand a pixel derived from only one component is called pure pixel [5]. There are chances of occurrence of mixed pixels in a high resolution image as well. For example, MRI, i.e., Magnetic Resonance Imaging, used for disease diagnosis, the sensors detect signals from blood vessel, a fat bone and so on [6].

Hence, it is observed in remote sensing, that a pure spatial resolution cannot perfectly improve the classification analysis. The authors design a model for determining the correct class for a mixed pixel in a multi spectral imagery. The simulation results show the applicability of the method on the complete set of mixed pixels, which can be resolved using swarm intelligence techniques. With suitable accuracy assessment in the procedures, this technique can provide a remarkable, rapid means of producing quality land cover data on continuous basis.

This paper is organized as follows. Section 2 summarizes the problem definition. Section 3 discusses

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the problem resolution and. Section 4 introduces the executing algorithms. Section 5 is the experimentation performed on dataset. Finally some conclusions and future works are presented towards the end.

II. RELATED CONCEPTS AND ARCHITECTURES

The data set of an expert for mixed pixels of different classes is taken into account. The approach of these techniques is threefold.

A. Fuzzy Clustered Mean Algorithm

Using FCM, we can retrieve clusters of pixels, similar in nature. Clustering function is performed in order to cluster the pixels, sharing the same characteristics as one. FCM is used in partitioning an image into number of clusters. In Fuzzy-C Means clustering, each point has a weight associated with a particular cluster. Pick cluster centers, assign each pixel in the image to the clusters that minimize the distance between the pixel and the cluster centre. Re-compute the cluster centers by averaging the entire pixel in cluster [8].

B. Biogeography Based Optimization

Nature of biological species, to migrate to a place, which suits their interest more, is commonly seen. This behavioral activity of theirs, has deduced an optimization technique called the Biogeography Based Optimization. Geographical areas that are well suited as residences for biological species are said to have a high habitat suitability index (HSI) [9]. Majorly, the conditions that are the deciding factor for the HSI value includes, rainfall, diversity of vegetation and diversity of topographic features, land area and temperature. Habitats with a high HSI tend to have a large number of species, while those with a low HSI have a small number of species [10].

C. Ant Colony Optimization

Ants are the social insects that work in groups to find food. The Ant Colony Optimization algorithm studies the behavior of ants and makes use of their self organizing principles with highly coordinated behavior that helps in solving complex problems [11]. Ants travel from their nests in search of food, and return to their nests in minimum possible time, by travelling the minimum distance. The ants, while on their route, leave a chemical substance called pheromone [12]. This chemical has a property of evaporating. Most of the ants are blind, but they follow each other with the help of pheromone trail. The shortest route to be found by ants was given by the Double Bridge experiment.

Deneubourg et al. performed this experiment with Argentine ant species *I. humilis* [13]. Here two different cases were setup. In the first case, two paths of equal length were made from the nest to food source. Initially, ants chose a random path and then later, any one path was the more chosen one with more pheromone deposit on that path. The double bridge experiment led the path towards the development of Artificial Ants, which used the foraging behavior of the natural ants. Later several experiments were carried out by changing different parameters in the double bridge experiment [14].

III. PROBLEM DEFINITION

The basic building block of this study is the concept of mixed pixels (See Figure 1). A fundamental assumption that is commonly made in remote sensing is that each pixel in the image represents the area on the Earth's surface that is contained in a single class. This is often not the case; with mixed pixels containing the presence of more than one class [7]. Origin of mixed pixels may be attributed to the following:

- Mixed caused by the presence of small, sub-pixel targets within the area it represents.
- Mixing as a result of the pixel straddling the boundary of discrete classes.
- Mixing problem due to the contribution of a target (black spot) outside the area represented by a pure but influenced by its point spread function. The PSF i.e. Point Spread Function can be thought of as an extended blob in an image that represents an unresolved object[7].

Also, the pixel appears to belong to one of the pure pixels set for a land cover such as land, water, vegetation etc., where a pure pixel set refers to the set of pixels which have been clearly identified as the pixels representing any of the land covers with no ambiguity. Thus, mixed pixels result from the fact that individual areas consisting of several different features or classes may be below the resolution capability of sensor. Recognition of pixel representing specific class becomes difficult when the pixel accounts for two different classes at the same time. The spectral signatures of a pixel show similar characteristics in different classes.

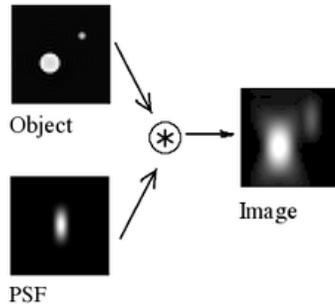


FIGURE 1. Object is pure pixel and image is the resulting mixed pixel [7].

IV. PROBLEM SOLUTION

The FCM algorithm discussed above in Section II brings each pixel to a cluster, which based upon certain characteristic or property, such as color intensity, texture. In our discussion we take each mixed pixel as a natural agent and the classes are assumed to be the different habitats. The behavior of a particular pixel in different classes is considered. Previous research work demonstrates that mixed pixel showing different features can be classified using BBO itself [7]. The methodology followed was calculating the difference in the value of the Highest Suitability Index, i.e., HSI [9] of pure data set of a class and the changed HSI when a new pixel is added to pure data set of same class (see Section II). But when we have a higher number of mixed pixels it will be troublesome to calculate the HSI difference for each pixel by the previously stated solution. The complexity function increases, thus reducing the accuracy level. To reduce that, we hybridized the concept of ACO with BBO. When a single pixel from the cluster of mixed pixels shows its belongingness to a class, then the other mixed pixels will follow it as well, imitating the behavior of the natural agent ants. To verify the hypothesis, the method is demonstrated further and is also applied to a real dataset, for which the ground data are available. This paper presents a novel method for mixed pixel classification using swarm intelligence techniques.

V. ALGORITHM DESCRIPTION

Input: Dataset of pure and mixed pixels of land features.

```
/* These are the two lists that contain the pixels that
are purely classified and those which depict the
features of more than one land class, respectively */
Output: Classified clusters of mixed pixels.
/* Each pixel from the mixed pixel list is assigned to
one of the pure pixels list. */
```

1. Begin

2. Initially choose a set of mixed pixels viz water-vegetation, urban-rocky, urban-vegetation.

3. Read the data set of pure pixels, i.e, mixed_pixel_data.

```
/* If we choose water-vegetation mixed pixel data set
then we need to consider set the of pixels representing
water and vegetation*/
```

4. cluster_n.xls= fcm(mixed_pixel_data, n)

```
/* This step is to perform the clustering of similar type
of pixels & n is the number of clusters formed */
```

```
/* Clustering here is done on the basis of the seven
band information for each pixel in the multispectral
image and
```

```
the number of clusters can be decided depending upon
the size of data */
```

5. for i = 1 to n do /* these steps are to be repeated for each cluster formed */

a) pheromone_1=0 and pheromone_2=0

```
/* These are the counters that will keep record of the
pheromone deposited on the two different paths. the
path with more pheromone will be chosen at the end,
as per the concept of ACO */
```

b) m= no. of pixels in cluster[i]

c) for j =1 to 1/5th of m do

```
/* Apply concept of BBO on each pixel. As in BBO
the birds migrate to each of the habitat to see the best
suitability, similarly, the mixed pixel is added to both
the classes, to determine its better suitability*/
```

```
/* We choose 1/5th of the overall pixels to test the few
initial pixels only and determine the greater pheromone
deposit on the two paths*/
```

i) original_HSI_1= mean (standard deviation of each band DN values (refer section II) of pure pixel data set of class_1 of which a mixed pixel corresponds)

ii) original_HSI_2= mean (standard deviation of each band DN values (refer section II) of pure pixel data set of class_2 of which a mixed pixel corresponds)

iii) Add pixel[j] from mixed pixel to tables of both the pure pixels. /*Emigration*/ [10]

iv) Calculate New_HSI_1 and New_HSI_2 as we calculated $original_HSI_1$ and $original_HSI_2$.
v) $Deviation_1 = Original_HSI_1 - New_HSI_1$;
 $Deviation_2 = Original_HSI_2 - New_HSI_2$
vi) if($Deviation_1 < Deviation_2$)
classify Pixel[j] as Class_1 /*Immigration*/
and
pheromone_1 ++;
/*pheromone update*/
else
classify Pixel[j] as Class_2 /*Immigration*/ [10]
and
pheromone_2 ++;
/*pheromone update*/
d) If ($pheromone_1 > pheromone_2$), then
classify remaining pixels of the cluster as Class_1
/*Choosing the path with more pheromone*/
else
classify remaining pixels of the cluster as Class_2
/*Choosing the path with more pheromone*/

6. All mixed pixels classified.

VI. EXPERIMENTAL RESULTS

To testify the effectiveness of the proposed method for mixed pixel classification, an experiment is performed on the simulated dataset of ALWAR, Rajasthan India region. The area is selected because it contains a good variety of land use features, like urban, water body, rocky vegetation and open areas. The mixed pixels and pure pixels training set of water and vegetation is taken as input. The target is to resolve all the mixed pixels according to our proposed algorithm. Calculating HSI (calculated as mean of standard deviation of each band data values of pure pixel data set of class_1 of which a mixed pixel correspond) of the input data is the foremost step of the experiment [11].

$Original_HSI_1$, i.e. of pure water = 4.4698.
 $Original_HSI_2$, i.e. of pure vegetation = 10.95475.

FCM algorithm as discussed in II, is applied on mixed data set. It provides us with 10 clustered sheets (10 is taken randomly, according to the size of the mixed data) where each sheet holds the mixed pixels of similar property in it. Considering particular cluster data sheet, data value of first pixel in the sheet is added to the pure data set. Again HSI calculation is done. The value of the observed difference between the HSI pure and HSI mixed derives a conclusion about the category of the mixed pixel. Lower the value of difference,

higher the chances of the pixel belonging to that class [11]. Following is the table showing the output data we got after observing clustered data sheet no. 5 and 10.

No.	Pixel No.	Deviation 1 (Pure Water)	Deviation 2 (Pure Veg)	Decision
Clustered sheet 5				
1	12 th	1.3219	0.38284	Veg
2	19 th	1.2699	0.37774	Veg
3	25 th	0.9929	0.37110	Veg
4	139 th	1.2891	0.15981	Veg
5	189 th	1.1159	0.37038	Veg
Clustered sheet 10				
1	27 th	0.051716	0.61598	Water
2	39 th	0.153004	0.55989	Water
3	109 th	0.092693	0.60041	Water
4	142 th	0.011261	0.75639	Water
5	198 th	0.187305	0.57853	Water

TABLE 1. PIXEL DEVIATION VALUES AND DECISION MADE.

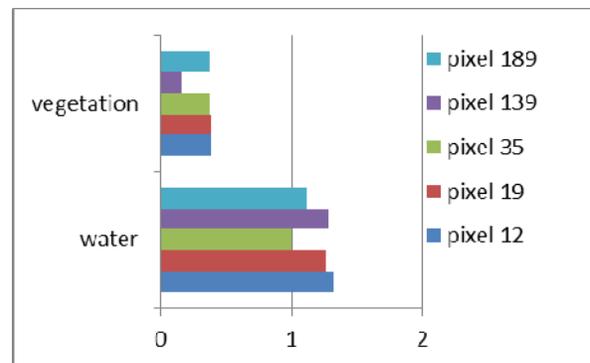


FIGURE 2. CLUSTERED SHEET 5 DATA

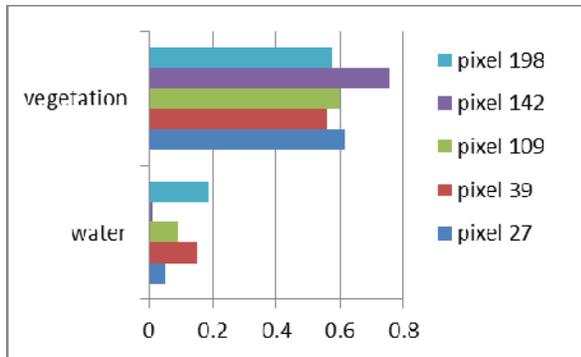


FIGURE 3. CLUSTERED SHEET 10 DATA

Table 1 depicts the deviation value of each pixel in their respective sheets on the basis of which decision is made. We take the mixed pixel as the real ants [15]. The two classes are the two different paths for them. Ant following the smallest path, i.e., the class having smaller HSI pure – HSI mixed value, has the maximum pheromone deposition. (Refer Section V). The remaining ants would thus follow a path with higher pheromone deposition. Hence, if a part of the mixed pixels of a clustered sheet belongs to the same class, then rest of the pixels would also belong to the same class. Calculation of deviation of all the pixels would not be required. We consider the clustered sheet numbered 5 and 10. Figure 2 discusses sheet 5 and Figure 3 discusses sheet 10. Result shows sheet 5 contains all vegetation pixels (deviation 1 is greater than deviation 2) and sheet 10 contains all water pixels (the deviation 1 is smaller than deviation 2).

In this way the whole cluster can be resolved by noticing 1/5th (according to algorithm) of the pixels. Same way this algorithm can be applied on all the 10 sheets. Thus the target of resolving mixed data set has been achieved. After resolving the mixed data set of water-vegetation of ALWAR area, the resolved pixels are added to their respective pure data set according to the decisions. The two classes, i.e., vegetation and water of multi spectral grey scaled image can now be accurately classified. Hence, we show in Figure 4, the classified image obtained after applying the algorithm. The green color is taken as the default color to show vegetation in green and blue for water. In this way, whole mixed data set can be rectified.

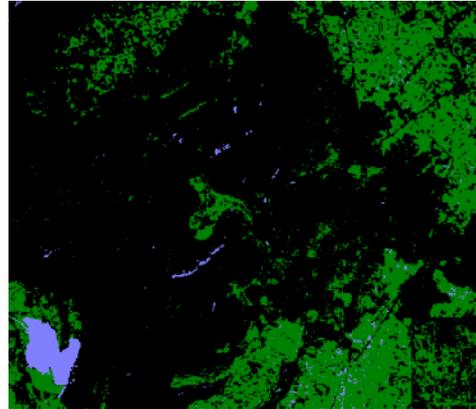


FIGURE 4. MULTI SPECTRAL IMAGE OF ALWAR SHOWING WATER IN BLUE AND VEGETATION IN GREEN WHERE BLUE AND GREEN ARE TAKEN AS DEFAULT COLOR.

VII. CONCLUSIONS AND FUTURE WORK

The result of the experiment shows that the mixed pixels can be resolved by the proposed algorithm. When the number of mixed pixels is greater, this technique reduces the effort, as well as complexity of calculating the HSI for each mixed pixel.

Mixed pixel has been the problem area in satellite imaging for long. So there is a demand for such techniques which can provide high accuracy when classifying the real data. Our hypothesis of hybridization of BBO and ACO can resolve greater number of mixed pixels in a given data set. Thus our proposed method to resolve a set of particular mixed pixels is extremely helpful in providing great accuracy in image processing at atomic level.

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REFERENCES

- [1] http://rst.gsfc.nasa.gov/Intro/Part2_1.html.
13 November 2011, 22:00 (IST).
- [2] Maurice S. Klein Gebbinck, Th.E. Schouten, Theo E. Schouten, "Accurate area estimation by data driven decomposition of mixed pixels" Technical Report CSI-R9622, Remote sensing and image classification, Computer Science Institute, University of Nijmegen, 1996.
- [3] Kosaka, N. Uto, K. Kosugi, Y., "ICA-aided mixed-pixel analysis of hyperspectral data in agricultural land" IEEE Geoscience and Remote Sensing Letters, vol 2, pp. 220-224, 2005.
- [4] Pi-Fuei Hsieh; Lee, L.C.; Nai-Yu Chen, "Effect of spatial resolution on classification errors of pure and mixed pixels in remote sensing" IEEE Geoscience and Remote Sensing Letters, vol 39, pp. 2657-2663.
- [5] P. Bostdogianni, Maria Petrou and Josef Kittler, "Mixed pixel classification in Remote sensing" , Image and Signal Processing for Remote Sensing, Proc. SPIE Vol. 2315, p. 494-505, 1994.
- [6] Mitsuhiro Tomosada and Hiroe Tsubaki, "Novel Mixture Model For Mixed Pixel Classification of Multispectral Image Data". International Journal of Mathematical Model and Methods in Applied Measures. Issue 1, Vol 5, 2011.
- [7] V.K.Panchal and Nitish Gupta. "Swarm Intelligence For Mixed Pixel Resolution", IEEE Geo Sciences and Remote Sensing Symposium (IGRASS), pp-2801-2804, 2011.
- [8] N.R. Pal and J.C. Bezdek , Dept. of Computer. Sci., Univ. of West Florida, "Validity for the fuzzy c-means model." IEEE Transaction Of Fuzzy System, Vol 3, pp-370-379, Aug 1995.
- [9] Dan Simon, "Biogeography Based Optimization" IEEE Transaction on Evolution Computation, Vol 12., No. 6, Dec 2008.
- [10] V.K..Panchal, D. Bhugra, S Goel, V.Singhania " Study on the behaviour of BBO over natural terrain features". IEEE Electronics Computer Technology(ICET) 3rd International Conference , Vol 4, pp 28-32, 2011.
- [11] V.K. Panchal and Poonam Singh; "Review on Ant Miners." World Congress on Nature And Biologically Inspired Computing, Vol 2 pp-1641-1644, 2009.
- [12] Marco Dorigo and Thomas Stutzle, "Ant Colony Optimization" IEEE Transaction on Evolutionary Computation, Vol 6, Issue 4, pp -358-365, 2002.
- [13] Valeri Rozin and Michael Margaliot, "The Fuzzy Ant." The computational intelligence magazine, IEEE, vol 2, Issue 4, pp-18 -28.
- [14] M. Dorigo and G.D Cao, Ant Algorithms for Discrete Optimization, Artificial Life 5 pp 137-172 1999.