January 2014

REMOTE SENSING IMAGE CLASSIFICATION USING ARTIFICIAL BEE COLONY ALGORITHM

SRIDEEPA BANERJEE

Computer Engineering Department, Delhi Technological University, Delhi, India,
srideepa.banerjee@gmail.com

AKANKSHA BHARADWAJ

Computer Engineering Department, Delhi Technological University, Delhi, India,
akanksha.bharadwaj6@gmail.com

DAYA GUPTA

Computer Engineering Department, Delhi Technological University, Delhi, India, dgupta@dce.ac.in

V.K. PANCHAL

Computer Engineering Department, Delhi Technological University, Delhi, India, vkpans@gmail.com

Follow this and additional works at: <https://www.interscience.in/ijcsi>

Part of the [Computer Engineering Commons](#), [Information Security Commons](#), and the [Systems and Communications Commons](#)

Recommended Citation

BANERJEE, SRIDEEPA; BHARADWAJ, AKANKSHA; GUPTA, DAYA; and PANCHAL, V.K. (2014) "REMOTE SENSING IMAGE CLASSIFICATION USING ARTIFICIAL BEE COLONY ALGORITHM," *International Journal of Computer Science and Informatics*: Vol. 3 : Iss. 3 , Article 2.

DOI: 10.47893/IJCSI.2014.1137

Available at: <https://www.interscience.in/ijcsi/vol3/iss3/2>

This Article is brought to you for free and open access by the Interscience Journals at Interscience Research Network. It has been accepted for inclusion in International Journal of Computer Science and Informatics by an authorized editor of Interscience Research Network. For more information, please contact sritampatnaik@gmail.com.

REMOTE SENSING IMAGE CLASSIFICATION USING ARTIFICIAL BEE COLONY ALGORITHM

SRIDEEPA BANERJEE¹, AKANKSHA BHARADWAJ², DAYA GUPTA³ & V.K. PANCHAL⁴

^{1,2,3&4}Computer Engineering Department, Delhi Technological University, Delhi, India
Email:srideepa.banerjee@gmail.com, akanksha.bharadwaj6@gmail.com, dgupta@dce.ac.in, vkpans@gmail.com

Abstract: Remote Sensing has been globally used for knowledge elicitation of earth's surface and atmosphere. Land cover mapping, one of the widely used applications of remote sensing is a method for acquiring geo-spatial information from satellite data. We have attempted here to solve the land cover problem by image classification using one of the newest and most promising Swarm techniques of Artificial Bee Colony optimization (ABC). In this paper we propose an implementation of ABC for satellite image classification. ABC is used for optimal classification of images for mapping the land-usage efficiently. The results produced by ABC algorithm are compared with the results obtained by other techniques like BBO, MLC, MDC, Membrane computing and Fuzzy classifier to show the effectiveness of our proposed implementation.

Keywords: *Artificial Intelligence, Image Classification, Artificial Bee Colony (ABC), Swarm Intelligence*

1. INTRODUCTION

Remote sensing is the most important provider of the various data sources that are used in GIS. The satellite image is one of the main sources for capturing the geo-spatial information [1]. It has been globally used for knowledge elicitation of earth's surface and atmosphere. Image classification using artificial bee colony algorithm is proposed in this work. Classification is undoubtedly the most significant digital image processing step in remote sensing. Land cover mapping is an important application area of remote sensing discipline and Classification is the preferential step for producing thematic spatial information from satellite image data. For over the last two decades, Artificial Intelligence (AI) optimization algorithms (heuristic algorithms) such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Differential Evolution (DE) and Ant Colony Optimization (ACO) have been used widely for different optimization problems in many disciplines successfully. Swarm Intelligence is an innovative Artificial Intelligence technique that was born out of biological insights of the incredible abilities of social insects to solve their simple food/shelter related problems and is it now widely accepted as one of the most efficient optimization technique. As an AI optimization algorithm, Artificial Bee Colony (ABC) was recently proposed [3]. PSO is inspired from the social behaviours of bird and fish shoals, GA from natural evolutionary process, DE is a GA-based intuitional algorithm, ACO is motivated by the organized behaviour of ants[16], and ABC which is inspired from honey bees. These AI optimization algorithms are especially preferred when the classical deterministic methods are inadequate because of too many parameters and data sets are not homogenous.

These AI tools are effectively used in remote sensing, as well. [2]

ABC tries to model the intelligent social behaviour of honey bees in food foraging. Bees use several mechanisms like waggle dance to optimally locate nectar sources and to search new ones. This makes them a good candidate for developing new intelligent search algorithms.

As we have huge database, as provided by experts we need a technique which efficiently searches all possible cases. Thus we used the strength of ABC to most optimally classify the images into respective land-usage. In this paper we propose an implementation of ABC for satellite image classification. Classification plays a very important role in image processing and with the increase in images being acquired and archived, optimal classification tool for different application domains is needed. The objective here is to utilize the bee communication and food search method of information exchange and hence achieve maximum classification accuracy. Experimental results support our approach and we have compared our results with some more techniques like Minimum Distance Classifier (MDC), Maximum Likelihood Classifier (MLC), Biogeography Based Optimization (BBO), and Membrane Computing (MC) and Fuzzy classifier to show the performance of our proposed technique. Rest of the paper is organised as, section II describes the Artificial Bee Colony algorithm, in section III, our proposed ABC algorithm for classification explained, in section IV we have shown our experimental results and finally section V gives the conclusion.

2. ARTIFICIAL BEE COLONY

ABC was originally presented by Dervis Karaboga [3] under the inspiration of collective behaviour of honey bees with better performance in function optimization problem compared with GA, differential evolution (DE), and particle swarm optimization (PSO)[4].

2.1 Biological Inspiration

In the nature honey bees explore the locality of their hive in search of better nectar sources [5]. There are 3 types of bees depending on their work, employed bees, onlooker bees and the scout bees. The employed bees first leave the hive and search in particular direction for sources of pollen and nectar. After finding a suitable nectar source they bees go back to the hive and share their information to onlooker bees about the locations, quantity and quality of existing sources of pollen, nectar in the areas they have explored. Information exchange in the bees swarm is the most important occurrence in developing the collective knowledge. The area in the hive for this process is the dancing area. Bees exchange information about the food sources by a dancing ritual called a 'waggle dance' to promote their food locations and persuade the members of the colony to trail their lead. The onlooker bee after watching the dances chooses the most profitable source and follows one of the employed bees to the discovered source of food. Upon arrival to the food source, the foraging bee takes a load of nectar and returns to the hive relinquishing the nectar to a food storer bee. The options available for the bee now are [6]:

(1) Discard the nectar source location and become again an uncommitted follower; (2) continue the foraging at the discovered nectar source, without recruiting any other bee; (3) recruit other bees with the dance ritual prior to return to the food location. The bee decides for one of the possibilities using the mechanism based on the characteristics of the food source (quality, quantity, and distance from the hive).[6] The described process continues constantly, while the bees from a hive collect nectar and investigate new areas with possible food sources.

2.2 ABC Description

Social insect colonies can be considered as dynamical system gathering information from environment and adjusting its behaviour in accordance to it. [7]. There are three essential components of ABC optimization model of food source selection that leads to the emergence of collective intelligence of honey bee swarms: food sources, employed foragers and unemployed foragers.[8] There are two basic behaviours: recruitment to a food source and the abandonment of a food source[9].

1. *Food sources*: these are simulated by the a position of solution of optimization problem, the profitability of food source are expressed as fitness of the solution.
2. *Unemployed foragers*: these are of two types, scouts and onlookers. Their responsibility is exploring and exploiting food source.
3. *Employed foragers*: these search for and are equal to the number of food sources. The employed bees store the food source information and share with others according to a certain probability. The employed bee will become a scout when food source has been exhausted.

All the information about the currently rich food sources are available on the dance area and the onlooker watches numerous dances performed by the employed bees and chooses the profitable source. The onlooker bee decides the profit using the probability values of the food sources. The recruitment is thus proportional to the profitability of a food source. Basically, there are two important function supports the algorithm [8]:

$$P_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_n} \quad \text{-(a)}$$

$$V_{ij} = X_{ij} + \Phi_{ij} (X_{ij} - X_{kj}) \quad \text{-(b)}$$

Where P_i is the probability value associated with i th food source that calculated by the Eq. a. An onlooker bee selects a food source relying on P_i . In this equation, fit_i represents i th food source's nectar amounts, which is measured by employed bees and SN is the number of food source which is equal to the number of employed bees. Fitness is calculated using following equation:

$$fitness(i) = \begin{cases} 1/(1 + fnc_i), & fnc_i \geq 0 \\ 1 + abs(fnc_i), & fnc_i < 0 \end{cases}$$

fnc_i in the equation is the cost function of the quality of source. Greedy selection is applied to select the best source. In the real-world problems, X_{ij} and X_{kj} represent the different old food source positions. The difference between these two positions is the distance from one food source to the other one. D is the number of optimization parameters. Φ_{ij} is a random number between $[-1, 1]$ and controls the distance of a neighbour food source position around X_{ij} . [8]

2.3 Algorithm

1. Initialise food source positions

Repeat

2. Sending employed bees to food source positions
3. Calculating probability values used in probabilistic selection
4. Selection of food source positions by onlooker bees considering probability values
5. Onlooker bee following to that food source.
7. Abandoning sources with less probability and producing new food source in neighbourhood of old source.

Until Maximum cycle or desired error

3. CLASSIFICATION BASED ON ABC

3.1 Dataset used

Our objective is to use the proposed ABC algorithm as an efficient Land cover classifier for satellite image. We have taken a multi-spectral, multi resolution and multi-sensor image of size 472 * 546 of Alwar area in Rajasthan. The satellite image for 7 different bands is taken. These bands are Red, Green, Near Infra Red (NIR), Middle Infra Red (MIR), Radarsat-1 (RS1), Radarsat-2 (RS2), and Digital Elevation Model (DEM). The ground resolution of these images is 23.5m and is taken from LISS-III, sensor and is provided to us courtesy of DTRL (Remote sensing) Lab, DRDO, Delhi. The 7-Band Satellite Image of Alwar Area in Rajasthan is given in figure 1.

Fig 1. 7-Band Satellite Image of Alwar region, Rajasthan

3.2 Proposed Algorithm for Classification

Assumptions:

- Bees are represented by pixels of the image;
- Food sources are the land cover features- water, vegetation, urban, rocky and barren;
- Neighbourhood solutions are the neighbouring pixels of the already classified dataset provided by experts.
- Employed bees are simulated by pixels belonging to classified dataset which contain the pure values of the solution.
- Here the function values (nectar quality) are calculated using Euclidean distance, other distances like Bhattacharya and Manhattan can also be used.

Input: Multi-spectral satellite image

Output: Classified Image

Step 1: Initialization

- Initialize the population of solutions (food sources).
- Place the employed bees in the food sources.

Step 2: Quality assessment of food source:

- Evaluate the nectar quality of the source, here represented by the Euclidean distance between food source and particular bee.

Step 3: Greedy selection by Onlooker bees:

Repeat till all pixels classified

Repeat till all neighbourhood food sources exhaust

- Find function value (fnc_i) using Euclidean distance formula.
- Calculate the Fitness values using:

- Calculate the probability values P_i for each solution (food source)

- Find new food source in the neighbourhood of old source

Inside loop end –(Neighbourhood exhaust)

- Selection of food source by the onlooker for maximum P_i value.
- Onlooker following the employed bee to that source.
- Another bee is now made recruiter to food source.

End loop when all pixels classified

Display the output classified image.

3.3 Flowchart

Fig. 2- Flowchart of proposed algorithm

4. EXPERIMENTS AND RESULTS

4.1 Classification

We have taken a multi-spectral, multi resolution and multi-sensor image of Alwar area in Rajasthan. The dimensions of image are 472 * 546 pixels. Alwar region is a multi-terrain type image with mainly the following features: Water, Urban, Vegetation, Rocky, Barren. Our geosciences experts recognized all these features in Alwar region. Our objective is to use the proposed ABC based algorithm as an efficient Land cover classifier for satellite image and extract these features optimally. After applying the proposed algorithm to the Image, the classified image is obtained. we have different features with colors for distinguish ability. The blue, green, pink, red and black color represents water, vegetation, urban, rocky and barren region respectively. Figure 3 shows the satellite false color image and Figure 4 classified image of Alwar region after applying ABC.

Fig.3 Original image

Fig 4. Classified Image after applying ABC

4.2 Accuracy Assessment

A classification is not complete until its accuracy is assessed [11]. Practically it is not feasible to test every pixel of a classified image. A set of reference pixels is used. Reference pixels are points on the classified image for which actual features are known. The reference pixels are randomly selected. Accuracy assessment is an important step in the classification process. The goal is to quantitatively determine how effectively pixels were grouped into the correct feature classes in the area under investigation. Classification accuracy of our proposed algorithm is expressed using classification *error matrix*. Error matrices compare, on a category by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification.

For the validation process we have taken into consideration following number of pixels:

- 68 water pixels.
- 109 vegetation pixels.
- 139 urban pixels.
- 96 rocky pixels.
- 63 barren pixels.

Table1. Error Matrix when ABC is applied.

Feature	water	Veg	Urban	Rocky	Barren	Total
Water	68	0	0	0	0	68
Veg	0	109	1	0	0	110
Urban	0	0	112	0	4	116
Rocky	0	0	0	96	0	96
Barren	0	0	26	0	59	85
Total	68	109	139	96	63	475

The Kappa coefficient of the Alwar image can be calculated by applying following formula to the Error Matrix:

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

r = number of rows in the error matrix ($r=5$ in our case) x_{ii} = the number of observations in row i and column i (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 = total number of observations included in matrix. ($N=475$ in our case)

The Kappa (K) coefficient of the Alwar image is 0.917, which indicates that an observed classification is 91.7 percent better than one resulting from chance.

The producer's accuracy (PA) is obtained by dividing the number of correctly classified pixels in each category (on the major diagonal) by the number of training set pixels used for that category (the column total). It indicates how well the training pixels of a given cover type are classified.

Table 2. Producer's Accuracy of each feature

Feature	Water	Veg	Urban	Rocky	Barren
PA	100%	100%	80.57%	100%	93.65%

4.3 Comparison With other Techniques

To compare the results of our proposed artificial bee colony with some other implemented classification techniques, we have considered kappa coefficient as the parameter against which performance analysis is done.

Fig. 5- Comparison of kappa Coefficients

The techniques considered here are Minimum Distance Classifier (MDC), Maximum Likelihood Classifier (MLC), Biogeography Based Optimization (BBO), Membrane Computing (MC) and Fuzzy classifier with Kappa of 0.7364, 0.7525, 0.6715, 0.68812 and 0.9134 respectively [13,14]. However, ABC with $k = 0.917$ shows our classifier has good classification accuracy compared to other soft computing techniques. Figure 5 shows the graphical representation of this comparison.

5. CONCLUSION AND FUTURE SCOPE

A lot of research is being influenced by various biological entities and phenomena. It has led to the development of the swarm intelligent techniques which are population based meta-heuristics and they model social behaviour of some organisms. Artificial Bee Colony is a recent approach which tries to model

natural behaviour of real honey bees in food foraging. In this paper we have presented a ABC based algorithm as an efficient Land cover classifier for high resolution multi-spectral satellite image. Figure 4 shows the output classified image and it very well corresponds to the original image in fig. 3. The kappa coefficient of 0.917 also supports our algorithm's efficiency. From table 2 we can say that for the given dataset we have been able to classify water, vegetation, rocky areas perfectly. It can however be improved for urban region. Our computation technique overcomes the disadvantage of cluster classification techniques like BBO [15]. Here ABC works on the whole image taking each pixel and hence can identify the heterogeneous portions in image and can classify each portion perfectly. Heterogeneous regions are areas in image where a mixture of features is present and it becomes difficult to separate each of them. The results presented are preliminary and there is scope for improvement to develop this algorithm as efficient classifier. To improve the performance we can refine the neighbourhood concept and introduce some randomization. We also recommend for certain modification to the algorithm so that the Kappa coefficient can be improved further.

REFERENCES

1. Omkar S.N., Kumar Manoj, Muley Dipti, Urban Satellite Image Classification using Biologically Inspired Techniques in proceedings of IEEE, 2007.
2. Ümit Haluk Atasever, Coşkun Özkan, Filiz Sunar, 'The Use of Artificial Intelligence Optimization Algorithms in Unsupervised Classification', EARSel, 2011
3. Karaboga D, 2005. *An idea based on honey bee swarm for numerical optimization TR-06*, Erciyes University, En-
4. gining Faculty, Computer Engineering Department.
5. Yudong Zhang, LenanWu, 'Artificial Bee Colony for Two Dimensional Protein Folding', Advances in Electrical Engineering Systems, Vol. 1, No. 1, March 2012
6. Camazine, S. and Sneyd, J, 'A model of collective nectar source by honey bees: selforganization through simple rules. *Journal of Theoretical Biology* 149, 547-571, 1991.
7. D. Teodorovi'c, T. davidovi'c, M.Selmi'c, 'Bee Colony Optimization: The Applications Survey', ACM Transactions on Computational Logic, 2011.
8. Adil Baykasolu, Lale Özbakır and Pınar Tapkan 'Artificial Bee Colony Algorithm and Its Application to Generalized Assignment Problem', Swarm Intelligence: Focus on Ant and Particle Swarm Optimization, tech Education and Publishing, December 2007.
9. Mohd Afizi Mohd Shukran, Yuk Ying Chung, Wei-Chang Yeh, Noorhaniza Wahid, Ahmad Mujahid Ahmad Zaidi, 'Artificial Bee Colony based Data Mining Algorithms for Classification Tasks', Modern Applied Science, Vol. 5, No. 4; August 2011.
10. Karaboga, D., & Akay, B. B. (2005). *An artificial bee colony (abc) algorithm on training artificial neural network*, Erciyes

- University, Engineering Faculty, Computer Engineering Department.
- International Journal of computer Science and Information Security (IJCSIS), vol. 8, no. 2, 2010.
11. Karaboga, D., & Akay, B., A comparative study of Artificial Bee Colony algorithm', *Applied Mathematics and Computation* 214 (2009) 108–132
 12. Lillesand, T.M., Keifer, R.W., Chipman, J. W. (2004), "Remote Sensing and Interpretation", New York: John Wiley & Sons Ltd. pp.586-592.
 13. M. Dorigo and Thomas stutzle, 'Ant Colony Optimization', *IEEE Transactions on Evolutionary Computation*, Vol 6, Issue 4, pp-358-365, 2002.
 14. Lavika Goel, V.K Panchal, Daya Gupta, "Embedding Expert Knowledge to Hybrid Bio-Inspired Techniques- An Adaptive Strategy towards Focussed Land Cover Feature Extraction", *International Journal of computer Science and Information Security (IJCSIS)*, vol. 8, no. 2, 2010.
 15. Daya Gupta, Bidisha Das, V.K. Panchal, "A methodological study for the Extraction of Landscape Traits using Membrane Computing Technique", *Proceedings of International conference on genetic & evolutionary methods*, GEM '11.
 16. V.K.Panchal Parminder Singh Navdeep Kaur Harish Kundra, 'Biogeography based Satellite Image Classification', *IJCSIS*, Vol. 6 , No.2, 2009
 17. Dorigo M, Gambardella L M. "Ant colony system: a cooperative learning approach to the traveling salesman problem". *IEEE Transactions on Evolutionary Computation*, 1997.1(1).pp. 53-66.