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Satellite Image Classification using Ant Colony Optimization and Neural Network

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ABSTRACT

From the last three decades, remote sensing has come up with great applications in the field of science and technology. The concept of remote sensing is the observation of earth using data acquired instruments satellites and aircrafts from the outer space. Remote sensing helps to monitor the environment states, natural resources availability and terrain features. The unique capabilities of remote sensing concept regarding earth observations are that it helps to monitor, forecast, understand and manage the available resources of earth. Here, remote sensing data used for the observations of land cover terrain features with the help of image classification process. It helps to obtain the geo spatial from satellite data that can be used in several applications of computing, research, space intelligence, defense etc. In this research work, we are using this image classification for the identification of land cover terrain features from the satellite data of Alwar region, India. Concept of ant colony optimization and neural network has been used for the classification. Ant colony is swarm intelligence based global optimization concept. The output from the ACO is used for the further optimization with neural network approach. Results are evaluated in terms of Overall accuracy and kappa coefficient. Results obtained using proposed integrated approach are efficient to declare the validate classification of image.

Keywords: Image Classification, Satellite Image, Neural Network, Swarm Intelligence, Ant Colony Optimization

I. INTRODUCTION

Image Classification is the process to classify the entire pixels of an image into different possible feature classes as per their attribute values [1]. 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 [2]. There exist two types of image classification Supervised and Unsupervised classification.

In Supervised Classification [3], 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. Unlike Supervised Classification, Unsupervised Classification [4] 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

Remote Sensing is the method to get information about any far object without any kind of contact with that object [5]. Remote sensing involves the steps to sense the object, record their emitted energy, process that energy and finally analysing that for the information of object [6]. Generally, remote sensing concept is considered to sense the objects of earth surface using satellites. We can also say that in our day-to-day life, we are performing the process of remote sensing at each and every moment. From human five senses, some of the senses require direct contact with the sensing organs to get the information of any object. The Remote Sensing process is usually described in the form of an image that can represents the observed scene during the process.

In this research work, dataset of Alwar region is used for the satellite image classification. Seven bands spectral images multi-featured Alwar region have been captured using Canadian satellite and an Indian satellite. There are five classes of region like urban, water, rocky, vegetation and barren. Concepts of ACO and BPNN are used for the classification. Initially, ACO is applied then output from ACO is considered as input to BPNN. Overall concept improves the classification results in terms of overall accuracy and kappa coefficient.

Rest of the sections are structured in the following manner. Section 2 describes the basic concept of ACO and BPNN. Section 3 presents proposed concept. Section 4 presents a discussion on evaluated results. Section 5 concludes the paper.

II. BASIC CONCEPTS

This section presents the basics of used concepts of back propagation neural network and ant colony optimization.

A. Back Propagation Neural Network

Neural Network [7] comprises of an input, output and one or more hidden layers. The connection between these layers is like, each node from input layer is connected to a node from hidden layers and every node from hidden layers is connected to a node in output layer. A basic model for neural network is shown in figure 1. To every connection a weight is associated to it. Input layer consists of the raw information that is fed into the network. This part of network never changes its values. Every single input to the network is duplicated and sent down to the nodes in hidden layer. Hidden Layer accepts data from the input layer. It uses input values and modifies them using some weight value, this new value is then sent to the output layer but here also some modification by some weight is done from connection between hidden and output layer. Output layer processes the information received from the hidden layer and produces an output. This output is then processed by activation function.

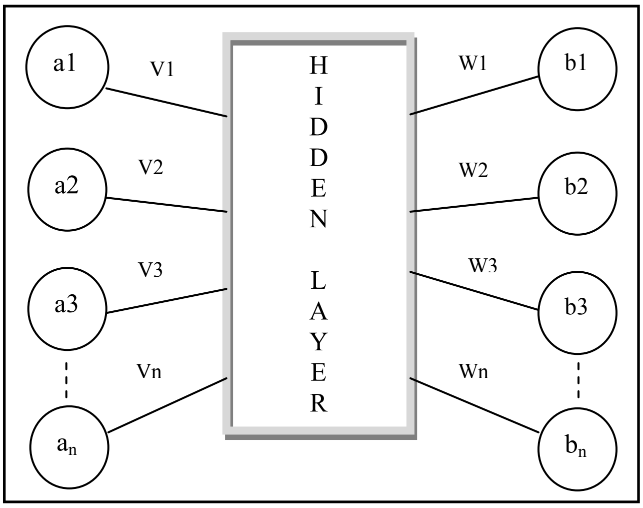

Figure 1. Basic Model of Neural Network

Here, $a_1, a_2, a_3, \ldots, a_n$ are the inputs, H_L is Hidden layer, $b_1, b_2, b_3, \ldots, b_n$ are the outputs to the given inputs.

(1) Activation Function: The actual output is evaluated by activation function. As shown in the figure 1, SUM is collection of the output nodes from hidden layer that have been multiplied by connection weights, added to get single number and put through activation function. Activation function gets mentioned together with learning rate, momentum and pruning [7].

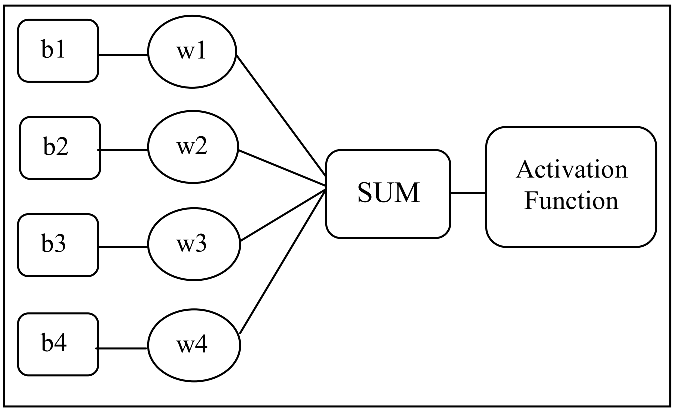

Figure 2. Activation Function

One of the most popular Neural Network algorithms is Back-Propagation Algorithm. Back-propagation is the most widely used algorithm for supervised learning with multi-layered feed-forward networks [8].

B. Ant Colony Optimization

Ant Colony Optimization is an artificial intelligence based concept introduced by Marco Dorigo for the optimization of the NP hard problems [9]. In ACO, a number of artificial ants build up the solutions to an optimization problem and exchange information on their quality via a communication scheme [10]. Ant Colony Optimization is the based on the optimization behavior of social species ants that work in local and global experience sharing behavior. In ACO, ants use a substance name pheromone to share their experience with the path of other ants.

Ant colonies [11], or more accurately social insect societies, are distributed systems that, in spite of behaving individually, present a highly structured social organization. As a result of this organization, ant colonies can perform complex tasks. The ''ant colony algorithm'' is derived from the observation of real ants and their behavior. The main idea is that the self-organizing principles, which allow the highly coordinated behavior of real ants, can be exploited to coordinate populations of artificial agents that collaborate to solve computational problems.

The approach, [12] behind ACO can be summarized as an iterative process in which a population of simple agent's recursively construct candidate solutions; this construction process is guided by heuristic information over the given problem. ACO has been applied to a various range of hard combinatorial problems. Here, problems are defined in terms of components and states, which are basically the sequences of components. Ant Colony Optimization incrementally generates solution paths for the given component and it adds new components to a state. Memory contains all the transitions between pairs of solution components and also the degree of desirability is associated to each transition depending on the quality of the solutions in which it occurred so far. While a new solution is generated, a component 'c' is included in a state, with a probability that is proportional to the desirability of the transition between the last component included in the state, and c itself [13]. Pseudo code for basic working of ant colony optimization technique is given as:-

```
Set initial_state;
Initialize pheromone trail and heuristic value;
  do
    {
       MOVE_neighbour states;
       BUILD_feasible solution;
       COMPUTE_heuristic value
       EVALUATE_solution;
       UPDATE_pheromone;
    }
  while (current state solution == destination state solution) // Termination condition.
```

Initial state is Starting state, ant moves towards its Destination.
Pheromone trail is a chemical substance produced and released into the environment by an ant in order to trace the path.
Heuristic Information represents the candidate solution.

III. PROPOSED CONCEPT

In this section, the proposed integrated approach of ACO and BPNN is applied. It is the proposed concept to recognize the available terrain classes in reference dataset of Alwar region for experimentation. Here, entre data is categorized in two phases as mentioned: Verification and Validation. For verification phase, 70% of total data is used and output results are evaluated in terms of classified Alwar image by using the proposed algorithm. Rest 30% data is used for validation phase where accuracy assessment matrices are used to validate the classification results. This validation phase results are discussed in next section. The steps of proposed algorithm of verification phase for terrain attitude identification is discussed here.
Input- Stacked Alwar image and 7-band data values & images
Output- Classified Alwar image

Algorithm

Step 1: Consider the input image to be classified by making the assumption of ants as the pixels of the image. The overall objective of ACO is to find the global solution. The target food source (solution) is assumed as the feature classes.

Step 2: Satellite data images with training data is used for experimentation and evaluate the distance between the consecutive pixels from initial image length to end of image.

Step 3: Evaluate the best solution for each pixel (ant) to store in their feature class (global best solution).

3.1. To find the quality solution for ants, apply the algorithm of Ant Colony Optimization.

Ant Colony Optimization

- Here our optimization problem is to find the mean of similarity difference of pixel intensities, given as by Equation
  $f(x) = mean(sqrt((x-y)^2));$
- Each ant starts searching through n-dimensional search space & keep the following information to find the shortest path:

  $\tau_{ij}(t)$ – Revised pheromone concentration linked with l_{ij}at iteration t
  $\tau_{ij}(t-1)$– Pheromone Concentration at previous iteration (t–1)
  $\Delta\tau_{ij}(t)$ – Change in Pheromone concentration
- Objective function is used to evaluate each ant. Thus, pheromone concentration for each possible path is calculated as follows by Equation
  $$\tau_{ij}(t) = \rho\tau_{ij}(t-1) + \Delta\tau_{ij}(t); \quad t = 1,2,3,\ldots\ldots,T$$

where, T is the number of iterations, ρ is the pheromone evaporation rate (0–1) and $\Delta\tau_{ij}(t)$ is the change in pheromone concentration.

The change in pheromone concentration can be calculated as by Equation:

$$\Delta\tau ij(t) \sum_{k=0}^{m} \begin{cases} R/fitness_k & \text{if option } l_{ij} \text{ is chosen by ant } k \\ 0 & \text{otherwise} \end{cases}$$

where, R is the constant well known as pheromone reward factor; and $fitness_k$ is objective function value that is calculated for ant k

3.2. Store the best solutions and discard the worst by evaluating values based on lesser distance value.

Step 4: Apply back propagation neural network approach to optimize the previous obtained results.

12.1: Consider the input layer, and number of hidden layes depending upon the node values.

12.2: Create intial vector matrix to store the iteration values and find the position of the hidden layer.

12.3: If the hidden layer will be present at the first position, then feature of pixel will be defined with the next present layer. By comparing the values of these pairs, then feature class will be defined as independent class.

12.4: If the hidden layer will not be present at the first position, then feature of pixel will be defined with the current layer and probable equilalent node path value, then feature class will be defined as dependent class.

12.5: If the hidden layer will be present at the last position, then feature of pixel will be defined with the previous present layer. These feature class may be dependent or independent class.

Step 5: To calculate the overall best solution, Pearson Correlation between the brighter firefly calculated by the algorithm and fireflies is evaluated.

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

More the value of correlation, lesser the distance between the brighter & lesser brighter firefly and overall the solution will be more efficient.

Step 6: Assign the best solution class to the pixel under experimentation as per the Pearson Correlation value.

Step 7: Repeat the steps III to VI until all the pixels classified.

IV. RESULTS & DISCUSSION

In this research work, dataset of Alwar region Rajasthan is used. The input image for the experimentation with dimensions 472×546 pixels is shown in figure 3. The feature classes of this area are Barren, Rocky, Vegetation, Urban and Water. The multi-spectral images of Alwar region are taken using Canadian satellite and an Indian satellite named LISS-III.

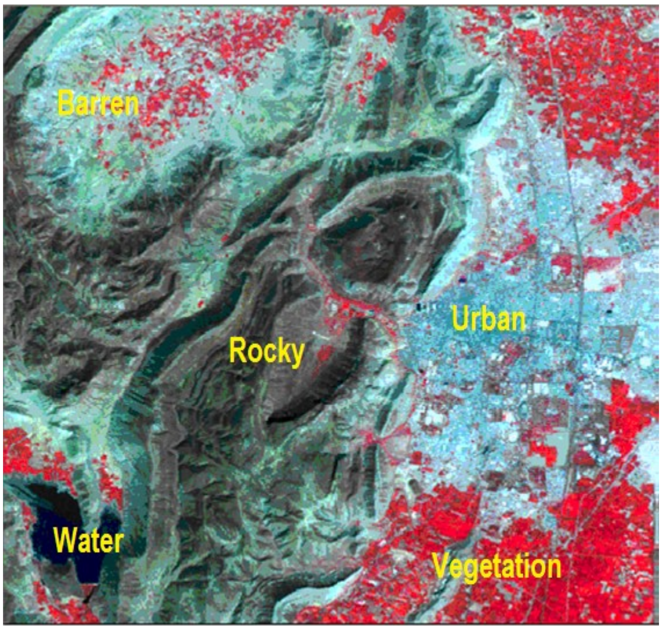

Figure 3. Input Image of Alwar region

After the classification process as discussed in section 3, classified image is obtained using proposed integrated approach of ACO and BPNN. The obtained classified image is shown in figure 4.

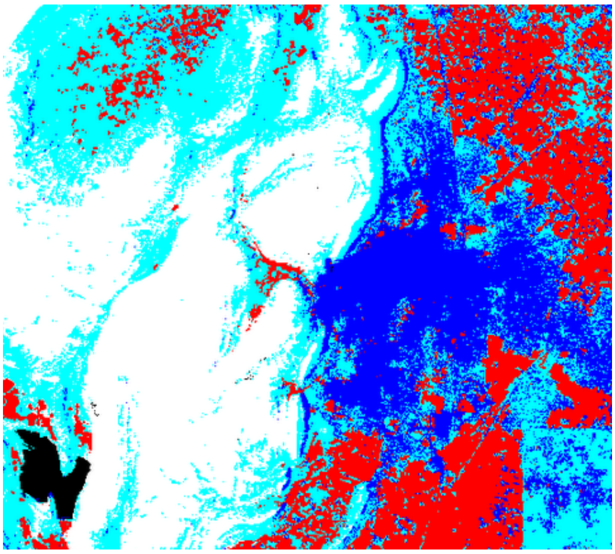

Figure 4. Classified Image

Further, results are evaluated in terms of kappa coefficient and overall accuracy.

Overall accuracy is the summation of correctly classified pixels available in diagonal elements divided by the overall samples considered for evaluation. The evaluated values of overall accuracy along with comparison to Artificial Bee Colony Optimization [14] are shown in figure 5.

Kappa coefficient is a statistical parameter used to evaluate the results from correlation matrix. It also ensures the betterment of classification results with correlation matrix instead of any random evaluation. Unlike overall accuracy, kappa coefficient considers the commission and omission errors. It is also an efficient evaluation approach in case of any alike matrices but significantly unalike. It can be evaluated as formulation given in equation.

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

The evaluated results along with comparison to Artificial Bee Colony Optimization are shown in figure 5. In addition, the evaluated values for both the overall accuracy and kappa coefficient are presented in table I.

TABLE I
EVALUATED RESULTS AND COMPARISON

Method	Overall Accuracy	Kappa Coefficient
Proposed Approach	95.78 %	0.931
Artificial Bee Colony	93.47 %	0.917

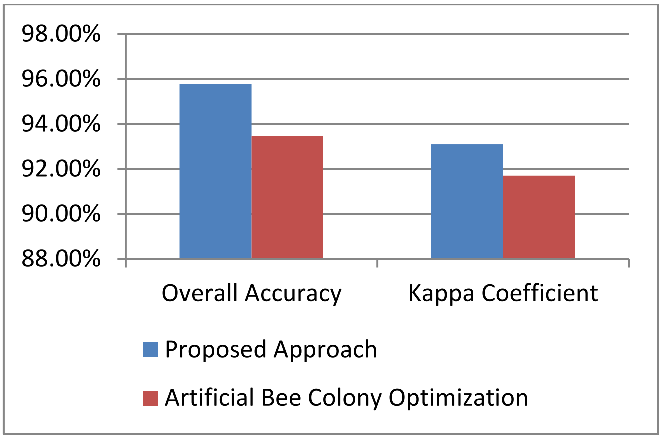

Figure 5. Comparison Results

V. Conclusion

As discussed, remote sensing based satellite image classification is performed based on the integrated approach of ACO and BPNN. In this approach, initially, ACO is used. Then, evaluated results from ACO are further considered as input to BPNN. This approach has overall improved the results. Dataset of Alwar region is used having five classes of water, urban, vegetation, barren and rocky region. The overall results are presented in terms of overall accuracy and kappa coefficient. From evaluated results, it is observed that Kappa coefficient & overall accuracy of proposed approach is better as compare to Artificial Bee Colony Optimization technique. So, It can be said that integrated approach of ACO & BPNN gives the high values as compare to Artificial Bee Colony Optimization technique.

VI. REFERENCES

[1] Lu, Dengsheng, and Qihao Weng. "A survey of image classification methods and techniques for improving classification performance." *International journal of Remote sensing* 28, no. 5 (2007): 823-870.

[2] Haralick, Robert M., and Karthikeyan Shanmugam. "Textural features for image classification." *IEEE Transactions on systems, man, and cybernetics* 6 (1973): 610-621.

[3] Gorte, Ben. "Supervised image classification." In *Spatial statistics for remote sensing*, pp. 153-163. Springer, Dordrecht, 1999.

[4] Omran, Mahamed GH, Andries Petrus Engelbrecht, and Ayed Salman. "Differential evolution methods for unsupervised image classification." In *Evolutionary Computation, 2005. The 2005 IEEE Congress on*, vol. 2, pp. 966-973. IEEE, 2005.

[5] Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. *Remote sensing and image interpretation*. John Wiley & Sons, 2014.

[6] Jensen, John R., and Kalmesh Lulla. "Introductory digital image processing: a remote sensing perspective." (1987): 65-65.
[7] Cilimkovic, Mirza. "Neural networks and back propagation algorithm." *Institute of Technology Blanchardstown, Blanchardstown Road North Dublin* 15 (2015).
[8] Riedmiller, Martin, and Heinrich Braun. "A direct adaptive method for faster backpropagation learning: The RPROP algorithm." In *Neural Networks, 1993., IEEE International Conference on*, pp. 586-591. IEEE, 1993.
[9] Dorigo, Marco, Vittorio Maniezzo, and Alberto Colorni. "Ant system: optimization by a colony of cooperating agents." *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics)* 26, no. 1 (1996): 29-41.
[10] Dorigo, Marco, and Mauro Birattari. "Ant colony optimization." In *Encyclopedia of machine learning*, pp. 36-39. Springer, Boston, MA, 2011.
[11] Birattari, Marco Dorigo Mauro, Christian Blum Luca M. Gambardella, and Francesco Mondada Thomas Stützle. "Ant Colony Optimization and Swarm Intelligence." *Lecture Notes in Computer ScienceSpringer, Berlin, pp 3748Maniezzo V, Sttzle T, Vo S (eds) Matheuristicshybridizing metaheuristics and mathematical programming, Annals of information systems* 10.
[12] Dorigo, Marco, and Christian Blum. "Ant colony optimization theory: A survey." *Theoretical computer science* 344, no. 2-3 (2005): 243-278.
[13] Mahanti, P. K., and Soumya Banerjee. "Automated testing in software engineering: using ant colony and self-regulated swarms." In *Proceedings of the 17th IASTED international conference on Modelling and simulation (MS'06)*, pp. 443-448. 2006.
[14] Banerjee, Srideepa, Akanksha Bharadwaj, Daya Gupta, and V. K. Panchal. "Remote sensing image classification using Artificial Bee Colony algorithm." *International Journal of Computer Science and Informatics* 2, no. 3 (2012): 67-72.