# Cross-Country Path Finding using Hybrid approach of BBO and ACO

Harish Kundra
Assistant Professor
Rayat Institute of Engineering, & IT College, Punjab,India

Puja
M.Tech Student,
Rayat Institute of Engineering & IT
Railmajra, Punjab, India

Dr. V.K.Panchal
Scientist - G
DRDO
New Delhi , India

## ABSTRACT
Biogeography based optimization (BBO) and ant colony optimization (ACO) to develop global optimization path. In natural scenario, there are no prior paths and we don't have any prior information about any geographical area. The key factor to achieve a task in such area is Path planning; therefore this research direction is very useful in recent years. This hybrid approach describes autonomous navigation for outdoor vehicles which includes terrain mapping, obstacle detection and avoidance, and goal seeking in cross-country using Swarm Intelligence. These approaches combine the strengths of both Biogeography Based Optimization (BBO) for natural and obstacle detection from the satellite image and Ant Colony Optimization (ACO) algorithm for obstacle avoidance and shortest path to the goal. In this paper this hybrid approach is to explore the improved swarm computing algorithms for the satellite image obstacle extraction and path planning which is safer, shorter, smoother and quickly optimized.

Keywords: satellite image, Path planning, terrain mapping, obstacle detection and avoidance, and Swarm Intelligence.

## 1. Introduction
Path planning is a task to generate a safest path connecting the start and the destination in a known or unknown environment in terms of the shortest path and obstacle avoidance. Our task is to navigate in cross-country without any prior information and to reach the goal through a safe, smooth and shortest path. In this paper, we are presenting the use of Biogeography based Optimization (BBO) algorithm on satellite image for extraction of natural or human made objects called obstacles and Ant Colony Optimization (ACO) algorithm for path planning.

In cross-country, in-accessible natural and human-made objects extracted from satellite image and smooth path planning can be implemented for various kinds of purposes, e.g. military, transportation, robot navigation, etc. Automatic obstacle detection from satellite image and path planning is an emerging problem and no existing software is able to perform the task reliably. In this paper, combined approach of BBO and ACO algorithms has been implemented on satellite image to achieve the goal.

BBO and ACO algorithms come under the broad category of Swarm Intelligence which has been emerged from the behavior of social insects. Social insects are usually characterized by their self organization and with the minimum communication or the absence of it. Every social insect individually is self-autonomous. They can obtain information about environment and interact with the remote insects or environment indirectly, by stigmergy. All these features characterize Swarm Intelligence. We can find these features in nature such as ant colonies, bird flocking, animal herding, fish schooling etc. The two most widely used Swarm Intelligence algorithms are Ant Colony Optimization (ACO) and Biogeography based Optimization (BBO).

The paper is organized into five sections. Following the introduction, a section illustrates brief review of Swarm Intelligence algorithms. The third section describes the methodology and pseudo-code of implementation. The fourth section reports the result of the case-study implemented. The last section summarizes the important findings.

## 2. Conceptual Definition and Details
### 2.1 Satellite Image
Remote sensing affords us capability to literally see the invisible. It can be thought of as the eyes of many systems like GIS, providing repeated, synoptic visions of earth surfaces from an aerial or space vantage point [7]. Satellite remote sensing images are representation of earth surfaces as seen from space. Remote sensing with multi-spectral satellite imagery is based on the concept that different features/objects constituting the land cover reflect the electromagnetic radiations over a wide range of wavelength in its own characteristic way. The satellite image of red band is shown in figure 1 which is an input image.

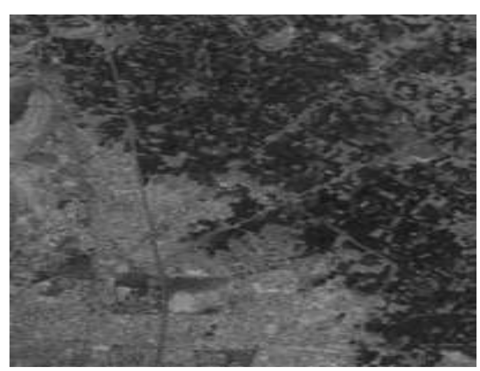


Figure1. Red band satellite image (input image)

### 2.2 Biogeography based Optimization

The science of biogeography can be traced to the work of nineteenth century naturalists such as Alfred Wallace (Wallace, 2005) and Charles Darwin (Darwin, 1995).Until the 1960s, biogeography was mainly descriptive and historical. In the early 1960s, Robert Macarthur and Edward Willson began working together on mathematical models of biogeography, their work culminating with classic 1987 publication 'The Theory of Island Biogeography' (Macarthur and Willson, 1967). Biogeography based optimization is a stochastic, population-based computer algorithm for problem solving [6]. It is a kind of swarm intelligence that is based on social-psychological principles and provides insights into social behavior, as well as contributing to engineering applications .Biogeography is nature's way of distributing species, and is analogous to general problem solutions. Suppose that we are presented with a problem and some candidate solutions. The problem can be in any area of life long as we have a quantifiable measure of the suitability of a given solution [4]. A good solution is analogous to an island with a high HSI, and a poor solution represents an island with a low HSI. High HSI solutions resist change more than low HSI solutions. By the same token, high HSI solutions tend to share their features with low HSI solutions. (This does not mean that the features disappear from the high HSI solution; the shared features remain in the high HSI solutions, while at the same time appearing as new features in the low HSI solutions. This is similar to representatives of a species migrating to a habitat, while other representatives remain in their original habitat). Poor solutions accept a lot of new features from good solutions. This addition of new features to low HSI solutions may raise the quality of those solutions. This new approach to problem solving is called biogeography-based optimization (BBO).

A problem is given, and some way to evaluate a proposed solution to it exists in the form of a HSI value. The islands are modeled by the HSI and SIVs conditions. So HSI values have the information to make a suitable change in its islands. The changes of the islands also depends upon the SIVs conditions.

### 2.3 Ant Colony Optimization

ACO was firstly proposed by M. Dorigo, 1992[8].It is a heuristic optimization method inspired by biological systems like ants, bees etc... It is a multi-agent approach for solving difficult combinatorial optimization problems. Although one ant is capable of building a solution, it is the behavior of an ensemble of ants that exhibits the shortest path behavior. The behavior is induced by indirect communication (pheromone paths) without central control.

Particularly important for the social life of some ant species is the trail pheromone, used for marking paths on the ground, for example, paths from food sources to the nest. By sensing pheromone trails foragers can follow the path to food discovered by other ants.

When an ant searches food, it leaves a specific fragrance called pheromone to record the route to food. The density of pheromone on the route is determined by the length of the route. When other ants bump into crossroad, they will choose the way with higher density of pheromone, and the way they choose will be left more pheromone. Pheromone mediated "following" behavior induces the emergence of shortest paths. Probability of choosing a branch of a path at a certain time depends on the total amount of pheromone on the branch. The choice is proportional to the number of ants that have used the branches. Hence, the ants find the shortest path from their nest to food source.

### 2.4. Description and Definitions

**Definition 1:** $island_i$ (i=1,2,3,4..) denotes islands in biogeography based optimization. n is the total number of islands.

**Definition 2:** collect the two pixel value for each islands.

**Definition 3:** calculate the HSI of two pixel value. for immigration and emigration.

**Definition 4:** calculate the HSI of whole image.i.e is the average of whole image.

**Definition 5:** check the SIVs condition. for each island in biogeography based optimization. If SIVs belongs to island 1 then his is high else check for the next islands.

**Definition 6:** $Ant_i$ (i=1,2,3…,n) denotes an ant in ant colony. n is the total number of ants. $\tau_{ij}$ denotes the pheromone between $g_i$ and $g_j$($g_i$ ,$g_j$ RS and $g_i \neq g_j$ )

**Definition 7:** Given $g_i$ is the current position of the ant and $g_j$ is the neighborhood of $g_i$ , or the intervisible area of the ants at $g_i$ . $d_{ij}$ is the distance between $g_i$ and $g_j$.

**Definition 8:** Suppose at time $t_i$ , $ant_k$ is at $g_i$ . The probability of this ant choosing $g_j$ as its next point is expressed as

$$\rho_{ij} = \frac{(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}{\sum(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}$$

Where α and β are the tuning parameters for balancing the effects of pheromone τ and heuristics η.

**Definition 9:** Pheromone is updated as:

$$\tau_{ij}(t+1)=(1-\rho)\tau_{ij}(t)+\sum_{k=1}^{m}\Delta\tau_{ij}$$

$$\Delta\tau_{ij} = \begin{cases} Q/L_{k,} & \text{ant}_k \text{ pass via side of passing} \\ 0 & \text{otherwise} \end{cases}$$

Where ρ is the evaporation coefficient and Q is the constant.

## 3. Methodology

Obstacle detection and path extraction of image procedure is to automatically categorize all pixels in image into roads, forest, barren land, water bodies and settlements. We extract the paths from image using BBO algorithm. To do this, appropriate HSI values have to be computed and then segmentation is performed. Now, obstacles have to be avoided and reach the goal through shortest path using ACO. In this phase, an algorithm for extraction of path and obstacle detection from satellite image is developed. This test image is presented various conditions under which the performance of our algorithm was evaluated.

### 3.1 Obstacles detection

The algorithm is based on total HSI value of whole image (average) using BBO. To obtain the desired results, the histograms of several of the scenes in the database containing Objects, were analyzed. From the analysis, we divided the histogram in islands. Region I take the two-two pixel value of initialize islands. and calculate the HIS value of every islands for immigration and immigration.

Region II calculates the HSI of whole image. Region III check the SIVs conditions if the SIVs belongs to the island first this means HSI is high and island firs having high HSI.Otherwise the SIVs does not belongs to island first this means low HSI.Every iteration check for every island. By this process high HSI island become more bright then low HSI.

### 3.2 Computing the HSI value using BBO

To evaluate the HSI values, we created number of islands which scan their respective regions assigned to them from the image. Every island having the HSI value by calculating the mean of two pixel value of every island. take the whole image HSI value by calculating the mean of global image. and also find check the SIVs conditions. Among these SIVs conditions select the most suitable candidate solution and communicate with each other.

### 3.3 Morphological Operations

Morphology is a technique of image processing based on shapes [5]. The value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image.

### 3.4 Path Planning Using ACO

After the above operations, many possible paths are extracted amidst the cross-country. Now ants are created and randomly initialized from the starting point. They randomly chose different ways of to reach the target. While moving to the target they deposit pheromone, after reaching to the target they retrace their respective paths. The path of the ant which reaches the starting point earliest is considered the shortest. Now the shortest path is obtained. While finding the way, the ants avoid obstacles coming in their way. On the whole, we have the safest and shortest path.

### 3.5 Simulation

The proposed algorithm is implemented with Matlab [9]. The algorithm is based on combined approach of BBO and ACO applied on satellite image. Firstly red band satellite image was taken and calculated HSI using BBO for paths extraction and obstacle detection. To obtain the HSI value, islands initialized in a specified area and also check the SIVs condition for every island.The high HSI islands was calculated. The paths extracted after applying BBO is shown in figure 2. Then obtained paths were refined using morphological operations to minimize the detection of shadows, trees and inconvenient areas. Figure 3 shows the refined image after morphological operations. Finally, ACO was implemented in which ants were initialized and they find the shortest path avoiding the obstacles from given source to destination.

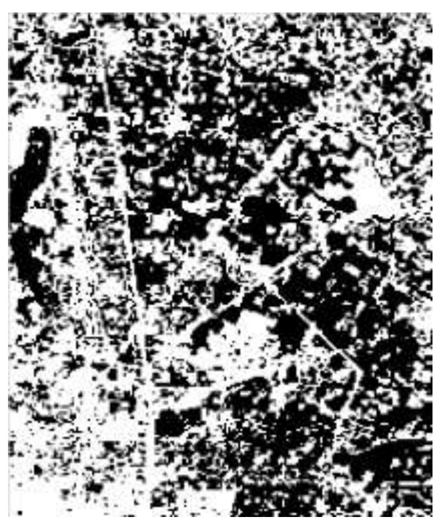
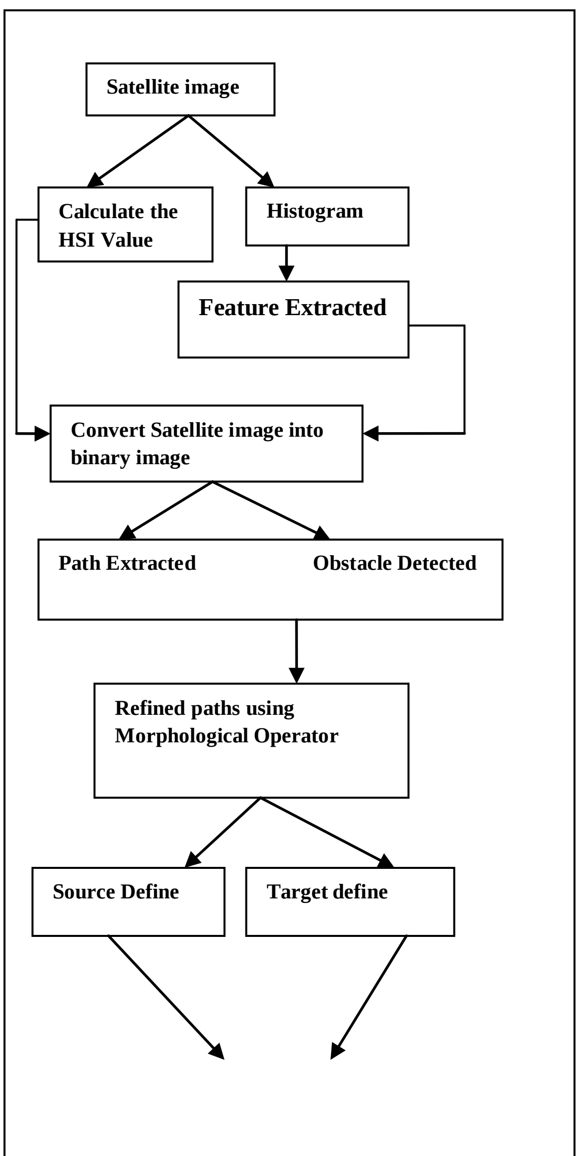


Figure2. Paths extracted after applying

Biogeography based optimization (BBO)

Figure3. Refined paths after morphological operations

The flowchart of the proposed algorithm is shown in figure 4. By following this algorithm we reached the target efficiently.



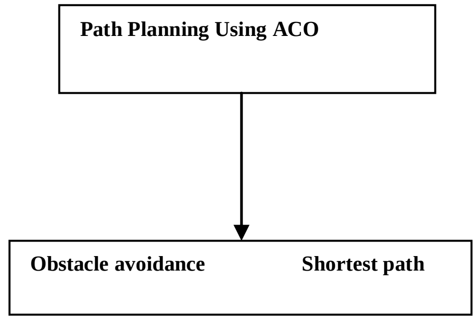




Figure4. Flowchart

The pseudo-code of the proposed algorithm is given in figure 5.

**Step 1:** Take the red band satellite image as input.

**Step 2:** Initialize islands like $I_1, I_2, I_3, I_4, \ldots$

**Step 3:** Collect the two pixels value for each island.

**Step 4:** For immigration and emigration calculate the HSI of two pixel value.

**Step 5:** calculate the HSI of whole image.

**Step 6:** check the SIVs conditions.

    For each island
        If SIVs belongs to $I_1$.
            Then HSI is high
            Else check for next.
        End
    end

**Step 7:** path extracted and obstacles detected

**Step 8:** refine paths using morphological operations

**Step 9:** for each ant

    Initialize the position
    Choose the next nearest node to the target
        If node is obstacle
            Then choose the other nearest node
        Else move and deposit pheromone
        End
    Calculate the distance and update pheromone
    End-for

**Step 10:** find shortest path

Figure5. Pseudo-code: Implementation of algorithm

## 4. Results

- Figure 6 shows the paths extracted and the shortest path from source to target from the satellite image using Swarm Intelligence.

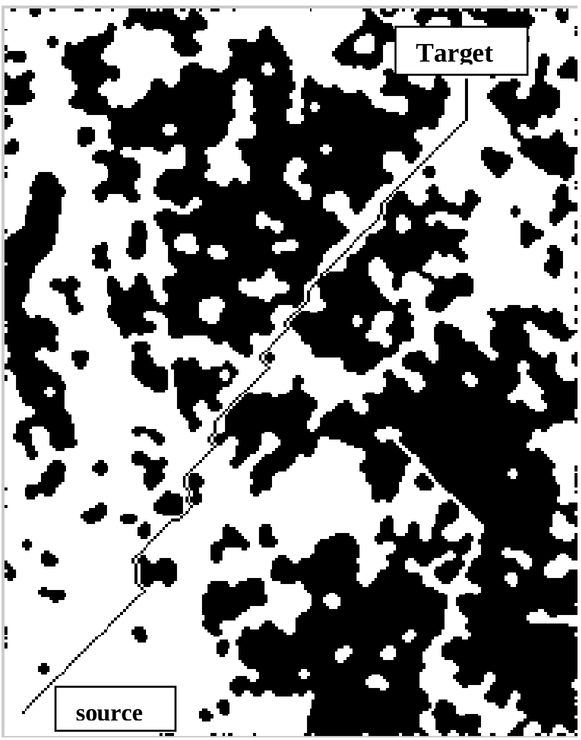



Figure6. Final safest and shortest path to target

## 5. Conclusion

Enlightened by Swarm Intelligence, BBO path extraction and ACO path planning algorithm is proposed in this paper. It's a bionic algorithm which simulates the process of insects foraging for food. To make a path more smooth morphological operations were implemented to minimize the effects of shadows, trees and inconvenient areas. It can quickly plan an optimized path even in a complex environment. The results prove that proposed approach effectively extracts the obstacles and finds the shortest and safest path. The simulation results show that it's a simple, quick and efficient algorithm. This proposed algorithm may further be used for enemy detection, autonomous navigation, GIS mapping etc.

## References

[1]. Al-Ani (2006), **"Feature Subset Selection using Ant Colony Optimization"**, International Journal of Computational Intelligence**,** vol. 2 no.1, pp. 53-58.

[2]. **Campbell**, J.B. (1987) **Introduction to Remote Sensing.** The Guilford Press, New York.

[3]. Drawin,C.(1995), **"The Origin of Species,"** Sixth Edition, Grameny Book, New York, pp.343-396.

[4]. Ergezer, M., Simon, D. and Du, D. (2009), **"Population Distributions in Biogeography- Based Optimization Algorithms with Elitism"**, In Proceedings of IEEE International Conference on System, Man and Cybernetics, San Antonio, U.S.A., pp.3-8.

[5]. H.Mayer, Automatic object extraction from aerial imagery a survey focusing on buildings CVIU, 74(2): 138-149, 1999.

[6] Macarthur, R. and Wilson, E. (1967), **"The Theory of Biogeography"**, First Edition, Princeton University Press, New Jersey, pp.19-67.

[7]. T.M. Lillesand and R.W. kiefer "**Remote Sensing & Image Interpretation**", 6th edition, Wiley, 2008.

[8]. Marco Dorigo and Thomas Stutzle "**Ant Colony Optimization**", The MIT Press Cambridge, Massachusetts, London, England, 2004.

[9]. MATLAB (7.0), Mathworks, http://www.mathworks.com