A Novel Method for Edge Detection of a Color Image with ACO algorithm in Swarm Intelligence

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Abstract—Edge detection is the most important task in image processing. It detects the presence and location of edges from an image having sharp changes in brightness or color intensity of an image. There are various techniques present for edge detection but the newer technique, Ant Colony Optimization is introduced here. Primarily ACO is used to detect edges of ray scale image but here an attempt is made to detect edges of color image. Using ACO feature extraction and edge pattern detection of a color image can be done. To avoid problem of over segmentation of an image which is observed in case of traditional algorithm due to static threshold value selection, the dynamic threshold value is generated with the help of an adaptive threshold histogram method.

Keywords—Adaptive threshold, Ant Colony Optimization, Edge detection, pattern detection, over segmentation.

I. INTRODUCTION

A new technique called Swarm intelligence is used mainly for problem solving. The swarm intelligence is inspired with the social behavior of some insects and animals such as bird flocks, fish schools and wildebeest herds etc. Ant colonies are so good at finding the shortest path from one location to another, that an algorithm was developed based on their behavior called as Ant Colony Optimization. Ant colony optimization (ACO) is inspired by their division of labor and foraging behavior of some ant species. The individuals are often inefficient to perform the labor they might perform, but in group they might consistently work as fighters, scouts, nurses, undertakers, foragers, or cleaners with a defined line of work in a factory [1]. A chemical substance known as the pheromone is deposited by these ants on the ground to mark some promising path that should be followed by other members of the colony. The chemical trail i.e. pheromone has a falling action over time due to the evaporation of trail and the quantity left by ants depends on the number of ants using this trail. There is an indirect communication between the ants by way of chemical pheromone trails that enables them to find shorter paths between their nest and food sources. This real ant colonies characteristic is used in ACO algorithms to solve, discrete optimization problems [2]-[4].

ACO is primarily used for detection of edges in a grayscale images. The templates are used to study self organization process, where a template can be defined as a pattern used to construct another pattern [5]-[6]. The ACO uses distributed nature of swarm intelligence methods that allow us to utilize such nature inspired approaches to increase efficiency in the self organizing process and to improve performance of problem solving.

Image segmentation is an important feature of image processing where image is divided into different regions [7]. To achieve this different edge detection methods have been introduced. In this paper ACO is presented to be used for detecting edges in color image as edge detection in color image is an important feature. The limitations occur due to static threshold value generation in case of ACO for grayscale image feature extractions are eliminated as the threshold value is generated dynamically. By giving the facility of dynamically adjusting threshold parameters to...
individual swarm agents in response to the changing environment, increases the self-organization capability of Swarm by increasing adaptability. Because of this the Swarm allows to successfully self-organize into patterns representing the image feature structure over a wider range of image characteristics (such as ambient lighting, entropy, noise) [8].

II. LITERATURE REVIEW

The previous work on image edge detection performed by various researchers is given below. Raman Maini & Dr. Himanshu Aggarwal proposed a variety of image edge detection techniques of Gradient and Laplacian based edge detection and their comparison. Gradient-based algorithms such as Sobel and Prewitt filter have a major drawback as they are very sensitive to noise. To overcome this, an adaptive edge detection algorithm is used to provide a robust solution which is adaptable to the varying noise levels of these images to help distinguish valid image contents from visual artifacts introduced by noise.

Bonabeau, B., Dorigo, M., & Theraulaz, G. propose that every single insect in a social insect colony seems to have its own plan, and so far an insect colony looks so organized. No supervisor is needed for the seamless integration of all individual activities. It is to use a positive feedback mechanism, based on an analogy with the trail-laying trail following behavior of some species of ants and some other social insects, to reinforce those portions of good solutions [9].

Rob J. Mullen, Dorothy N. Monekosso, Paolo Remagnino, propose that so far only image edge gradient is considered as the heuristic information that is used to guide the ant agents. Shweta Agarwal performed Edge detection in Blurred images using Ant Colony Optimization Technique.

Edge detection in gray-level images is a well-established area, but edge detection in color images has not received the same attention. The primary difference between color images and gray-level images is that, in a color image, a color vector (which generally having three components Red, Green and Blue) is assigned to a pixel, while a scalar gray-level is assigned to a pixel of a gray-level image [10] - [12].

III. ACO FOR GRAY IMAGE FEATURE EXTRACTION

This algorithm is based on the workings of original AS (Dorigo & Gambardella, 1997), with an updated, application specific pheromone update rule and heuristic information. The algorithm uses artificial ants as a simple computational agent. It is initialized with N ants that occupy ‘random’ pixels within the image; here the image pixels are equivalent to states in the search environment. The aim of the ants is to locate and plot the boundaries within the image. To achieve this heuristic information is introduced. With each move to a new pixel every ant deposits an amount of pheromone, where the amount deposited may be a function of, e.g. change in image gradient, and pheromone evaporation occurs at a fixed rate per iteration. The transition rule is then a function of heuristic information and pheromone map [13].

3.1. Initialization Process

Every image I size is represented by M x N. Fig. 1 shows a two dimensional graph representation of an Image. The ‘K’ specifies number of artificial ants. These ‘K’ ants are taken as input and randomly distributed over the entire image such that every pixel is considered as a node [10].

3.2. Construction Process

At each time step t, one ant among N ants is randomly selected which moves a distance of 1 pixel to one of the eight surrounding pixels. The movement of ant is shown in Fig. 1.
In the above equation ‘τ’ represents the pheromone value at node (i, j), Ω (l, m) is the neighbouring node of node (l, m). The heuristic information at node (i, j) is represented by η_{i,j}. The influence of the pheromone matrix and heuristic matrix is shown by the constants α and β respectively.

3.3. Update Process
In this process the pheromone matrix is updated after the two update operations. The first update takes place after movement of each ant in each construction step. Each building block of pheromone matrix is modified as given in equation (2) and the second update is performed after movement of entire ants in all construction-step as given in equation (3).

\[ \text{Eq. (2)} \]
\[ \text{Eq. (3)} \]

In this ψ is the pheromone decay coefficient. The search for subsequent ants is broadened by local update which reduced the pheromone level on the traversed edges. [14].

3.4. Decision Process
In this step, the solution is established from the values present in final pheromone matrix. By applying the threshold value τ on final pheromone matrix the decision is made.

3.5. Visualization Process
Here, different values of the Si (ψ) parameter are applied to the above algorithm. If the value of the phi parameter is smaller the algorithm detects more edges in the image. By decreasing the value of the phi parameter, output of the given image becomes clearer [15].

IV. PROPOSED METHODOLOGY

The proposed color image edge detection based on ACO is applied on a 2D image for generation of a pheromone matrix. Each entry of pheromone matrix represents intensity change in original image. The adaptive threshold value is generated at every time which is used in Decision Process by ants.
frequencies are calculated and average mean value is generated. Then finally the result is fused [16]. These values depend on the input color image.

V. EXPERIMENTAL RESULTS

Experiments are conducted to evaluate the performance of the proposed approach on the basis of peak signal to noise ratio shown in Table 1 using some experiment images, three Quercus Family Leaf images, Lena and Flight are shown in Figure 3-7.

*Figure 3. Leaf1: (a) Sobel Edges, (b) Prewitt Edges, (c) Canny Edges, (d) Proposed Method*

*Figure 4. Leaf2: (a) Sobel Edges, (b) Prewitt Edges, (c) Canny Edges, (d) Proposed Method*

*Figure 5. Leaf3: (a) Sobel Edges, (b) Prewitt Edges, (c) Canny Edges, (d) Proposed Method*

*Figure 6. Lena: (a) Sobel Edges, (b) Prewitt Edges, (c) Canny Edges, (d) Proposed Method*

*Figure 7. Flight: (a) Sobel Edges, (b) Prewitt Edges, (c) Canny Edges, (d) Proposed Method*

*Figure 8. Comparison based on PSNR Values*
Fig 8 shows comparison of ACO with other techniques based on PSNR values of Leaf and non leaf images

**Table 1: The PSNR Values**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Image</th>
<th>PSNR Sobel</th>
<th>PSNR Prewitt</th>
<th>PSNR Canny</th>
<th>PSNR Proposed System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Leaf1</td>
<td>6.81</td>
<td>5.89</td>
<td>1.68</td>
<td>7.83</td>
</tr>
<tr>
<td>2.</td>
<td>Leaf2</td>
<td>8.68</td>
<td>7.68</td>
<td>0.93</td>
<td>9.15</td>
</tr>
<tr>
<td>3.</td>
<td>Leaf4</td>
<td>8.86</td>
<td>7.78</td>
<td>0.98</td>
<td>9.52</td>
</tr>
<tr>
<td>4.</td>
<td>Lena</td>
<td>4.68</td>
<td>4.45</td>
<td>3.56</td>
<td>5.22</td>
</tr>
<tr>
<td>5.</td>
<td>Flight</td>
<td>5.51</td>
<td>5.40</td>
<td>5.65</td>
<td>5.72</td>
</tr>
</tbody>
</table>

**CONCLUSION**

The self-organizing properties of an ant algorithm have been investigated in this paper. The original Ant System algorithm is modified, especially for image feature extraction of a color image. In traditional ACO, it uses a static threshold value which may result into oversegmentation of an image. To avoid this, proposed algorithm uses adaptive threshold histogram method to improve the dynamic nature of threshold value. Which eliminates the problem of over segmentation occurs due to selection of static threshold. From the experimental results the peak signal to noise ratio (PSNR) is increased by 2 to 5% for leaf and non leaf images. By dynamically selecting optimal threshold value different images are successfully tested for boundary detection.

In future, this algorithm can be extended for simultaneously detecting multiple features from the color image. To achieve this multiple swarms may be used where one is detecting boundaries of an image whereas other is used to detect inner portion. These two swarms will be independent from each other and will generate two separate pheromone maps. Finally, these two maps will be combined to generate final result.

**REFERENCES**


