Advanced Edge Detection using Ant Colony Optimization

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Abstract
Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Image Edge detection reduces the amount of data and filters out useless information from image, while preserving the important structural properties in an image. Since edge detection is using in image processing for object detection. Ant Colony Optimization (ACO) is used to detect edges in digital images. The techniques generate a pheromone matrix , it represents the edge information at each pixel position on the routes formed by ants dispatched on the image. The edge map of image is obtained using thresholding process . The end points obtained from threshoding process are calculated and the ants are placed at these end points.All the movement of the ants is decided by the local variation of the pixel intensity values. By using an thresholding technique the edges from the final pheromone matrix are extracted. The results are analyze using Shanon's Entropy function and SNR Values .

Key Words – **Edge** Detection Methods, Edge Detection using Ant Colony Optimization, Ant Colony Optimization, Edge Detector, Pheromone matrix.

I. Introduction

Edge detection is the process of identifying and locating sharp discontinuities in an image[1]. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a image. Classical methods of edge detection involve convolving the image with an operator ,which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are large number of edge detection operators available, each designed to sensitive to certain types of edges. Operators can be optimized to look for the horizontal, vertical, or diagonal edge. Edge detection is very difficult in noisy images, since both the noise and edges contain high- frequency content. Attempt to reduce the noise result in blurr edges. Operators used on noisy images are larger in scope, so they can average enoughdata to discount localized noisy pixels. This results is in less accurate localization of detected edges. Not all the edges involve a step change in intensity. The operator needs to be choosen to be responsive to such gradual change in those cases. So, there are problem of false edge detection, missing true edges, high computational time, localization, and problems due to noise .

Problem Statement

Edge detection is a fundamental step in image processing, image pattern recognition, image analysis, and computer vision techniques. The main problem definition or statement can be stated as how can we improve the performance of Edge Detection process in image processing? And also that how can we use the Ant Colony optimization with thresholding and thinning for improve the performance of edge detection.and how to improve edge detection process in noisy image.

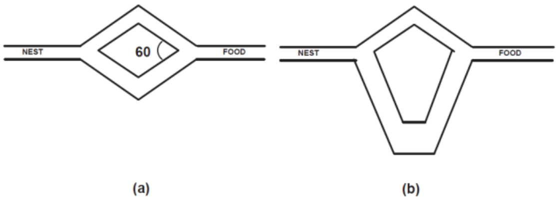
Objective

In this research, we would investigate how to improve edge detection when more noise in image For this purpose, thresolding and thinning process included with the ant clolny optimization. It is a difficult task as when noise is in large quantity . Higher the value of entropy will be the higher information content. However, a very large value of entropy shows larger noise content or double edges. In this research we proposed new method for edge detection for only images.It can be applicable for edge detection in video streaming.

II. Literature Review

Ant Colony Optimization Method[2]

Edge detection refers to the process of extracting edges from the image where there are sudden changes or discontinuities.These extracted edge points from an image provides an insight into the important details in the field of image analysis and machine vision .It acts as a preprocessing step for feature extraction and object recognition . Various techniques are reported in the literature like Sobel , Prewitt, Roberts , Log and Canny detection techniques. However, most of the existing detection techniques use a huge search space for the image edge detection. Therefore, without optimization the edge detection task is memory and time consuming.
What is happening in this experiment is that the several cases of ant colony optimization have been tested here:



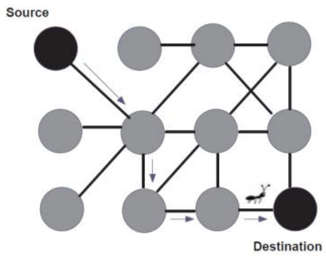
First case is with the cases where ants are made to walk over two branches of equal length. Here it is observed that in the initial phase, both paths are having same number of ants and after that one path gets more number of ants than theother.The reason behind this phenomenon is that ants at the very outset selectboth paths equally. But after some time due to random nature one path gets morepreference than the other.As ants are leaving pheromone trails behind, so thepath selected by the more number of ants gets more amount of pheromone which further reinforces the selection of that path.This nature of natural phenomenon is in another terms can be described as auto-catalytic or feedback process [2]. This is also explaining the stigmergy i.e., the indirect mode of communication happened due to the modifications in the environment.Second experiment leads to the possibility that the one path is double the longer than the other path [2]. At the very start, selection is equal for both paths but after some time what is happening is that ants are selecting the path shorter amongthe two.

The main reason behind is that ants choosing the shorter path are coming back from to their nest from food sources quickly. What is affecting their decision is that the shorter path is containing more amount of pheromone, so lead to the selection of that path more due to the auto-catalytic process, as described earlier.

The effect of randomness is greatly reduced here and stigmergy, auto-catalysis, and differential path length are coming into action. Despite the fact that the shorter path is present, still some ants choose the longer path due to the path exploration [2]. A third case is also studied where a shorter path is added after a long time , and what happened here is that the ants are still attached with longer path due to the auto-catalytic nature and slow evaporation of pheromone trails.

Nature of Artificial Ants

With the help of the double bridge experiment, it is quite known that ants have a builtin optimization capability: i.e., they are able to select the shortest path between two points in their environment depending upon the probabilistically rules based on the local information. This concept is researched further and tried to be implemented on the case of the artificial ants.These artificial ants are further used for the purpose of getting shorter paths on the connected graph. But the problem that arises in this case is that the ants while building the solution may generate loops. Removal of the forward pheromone update is the solution to this problem, but this will lead to the disturbance of the system. Even the double bridge experiment will cease to work.So, the properties of the artificial ants are prepared in such a way that they are able to solve minimum cost path problem on generic graphs. Those are that they are given some amount of limited memory in which are able to remember the paths traversed and also the cost of the links associated with it[3].



With the help of memory, they are able to build solutions for the minimum cost path problems. These behaviours are [1] (1) Without forward pheromone updating, probabilistic construction of solutions which is biased by pheromone trails; (2) backward path of deterministic nature with loop elimination and with pheromone updating; and (3) evaluation of the generated solutions quality and use that for the determination of the quantity of pheromone to deposit [2]. Also it is observed that by taking into account the pheromone evaporation, the performance of the ants are greatly improved. The first algorithm we are going to discuss is Simple ACO(S-ACO). It acts a instructive way to explain the basic steps hidden behind the concept of ACO algorithms [2].

$$p_{i,j}^{(n)} = \frac{\left(\tau_{i,j}^{(n-1)}\right)^{\alpha} (\eta_{i,j})^{\beta}}{\sum_{j\in\Omega_i}\left(\tau_{i,j}^{(n-1)}\right)^{\alpha} (\eta_{i,j})^{\beta}}, if\ j \in \Omega_i$$

where $\left(\tau_{i,j}^{(n-1)}\right)$ is pheromone information in the previous loop while moving from node i to node j; Ω_i is the neighborhood nodes for the recent ant given that it is in the node i; the constants α and β influences the pheromone information and heuristic information, respectively.

The local pheromone update [3] is performed as followed by the equation:

$$\tau_{ij} = (1-\varphi).\tau_{ij} + \varphi.\tau_0$$

where $\varphi \in (0,1]$ is the pheromone decay coefficient and τ_0 is the pheromone initial values.

The offline pheromone update [3] is performed by the equation as follows:

$$\tau_{i,j}^{(n-1)} = \begin{cases} (1-\rho).\,\tau_{i,j}^{(n-1)} + \rho.\Delta_{i,j}^{(k)}, & if\,(i,j)\,belongs\,to \\ & the\,best\,tour; \\ \tau_{i,j}^{(n-1)} & else \end{cases}$$

III. Proposed Work

Proposed Algorithm Flowchart

The Flow Chart of the proposed system:

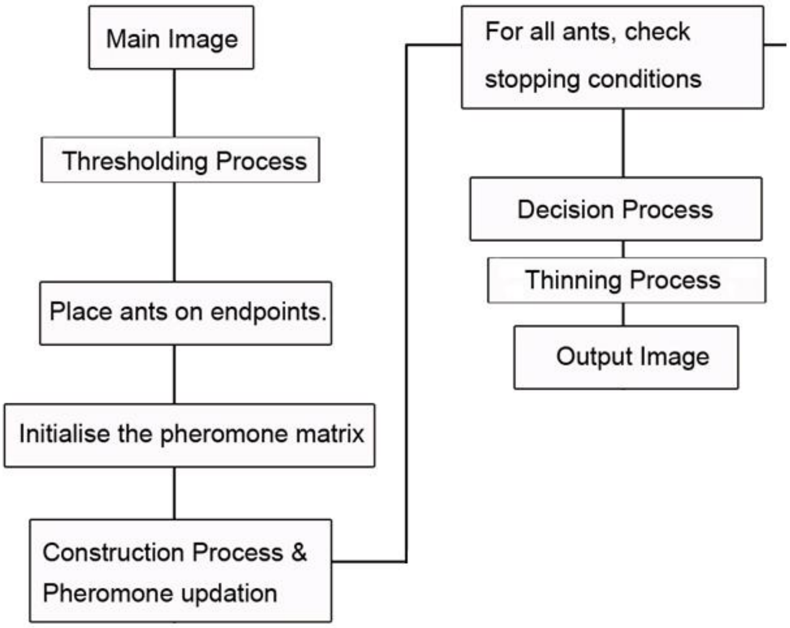


Fig. 4 Flow Chart of Proposed Algorithm

Explanation of whole process

1. **Thresholding Process :** In image processing,the thresholding is used for to split an image into smaller segments,junks, using at least one color or grayscale value for define their boundary.

2. **Placing Ants at End Points :** The end points obtained using threshoding are calculated and the ants are placed at these points.
3. **Updation of Pheromones :** It is the way the pheromone matrix is updating.
4. **Decision Process :** Check whether all ants have moved atleast one step, if yes, than perform the global pheromone update . Check whether the ant can move to the next position by applying the stopping rules

5. **Thinning Process :** Thinning is a morphological operation that is used for remove selected foreground pixels from binary images**.**

IV. Conclusion

In this research , various techniques and concepts of Edge Detection are studied. Among these I have found that Ant colony optimozation concepts are more effective and efficient to perform edge detection. The ants in this proposed study move on the edge pixels undetected by the thresholding process. This process reduces the redundant edge pixels in more connected edges. For the qualitative analysis of this proposed method over the edge detectors, the results are analyzed by Shannon's Entropy function.The thresholding is used for edge detection and ACO is used for edge improvement .The ACS method for edge detection could be extended and possibly be improved by making use of such techniques.

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