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A REVIEW: An Improved ACO Based Algorithm for Image Edge Detection

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ABSTRACT:
ACO i.e. Ant Colony Optimization is an evolutionary optimization approach adopted from the behaviour of ant species. This insect pursues a very unique, highly efficient and optimized approach for foraging. These species leave a chemical mark known as pheromone behind as they forage for food in any arbitrary environment. ACO is a very good candidate as an algorithm operator in order to enhance the overall performance of the approach and then this integrated for edge detection, object recognition and feature matching applications. In this paper, ACO is integrated with some basic logical approach is utilized in tackling edge detection problems. The proposed approach is able to provide continuous and clear object boundaries at the same time it is also able to suppress the noisy surroundings. Simulations results are included in order to evident the superior performance of the proposed approach.

KEYWORDS: Ant Colony Optimization, Logical Operators

1. INTRODUCTION:

Swarm Edge detection is an important preprocessing step in many computer vision applications [1-3]. It is obvious that computer here refers to machine of any type which has the capability of learning. The examples of computer vision applications include feature matching, shape recognition, objet recognition, 3D construction, object deformation detection and identification. In theory, edges are nothing but a set of pixels in the image where sharp intensity changes are present and they correspond to contours of objects of interest in the image. Edge detection process takes input a grayscale intensity image and provides a black and white image indicating the edges of objects in the image. Many edge detection techniques has been proposed in past one or two decades. A lot of them are based on digital differential methods [4]. These include Sobel, Roberts, Laplacian operators etc. The above categories of methods are prone to noise. In an attempt to supress the noise, Marr et al. [5] and Canny [6] added a preprocessing step in which the image of interest is firstly treated with a Gaussian smoother and then used for edge detection. This preprocessing step adds blurring to the image and henceforth to edges. As a consequence, locating accuracy of the edges detected decreases. One has to make a tradeoff between the two properties [7]. The tradeoff is shown in the figure below and the location accuracy sacrifice is marked by red circles

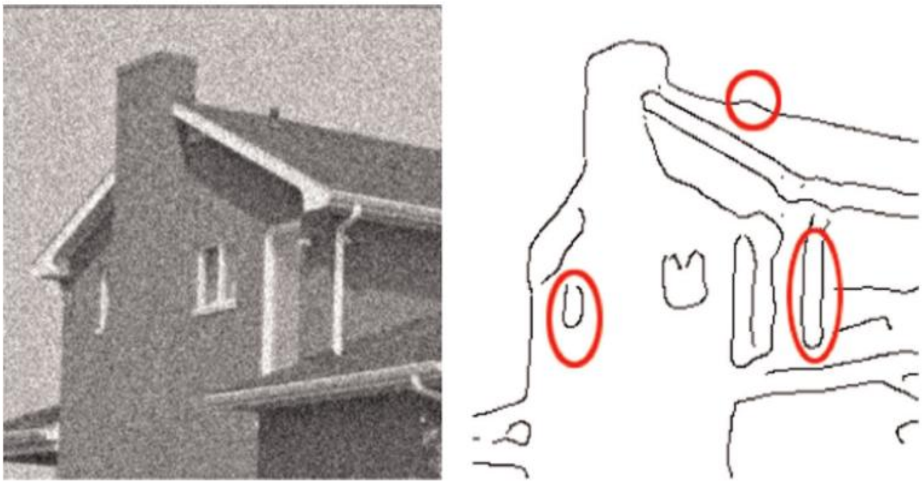


Figure 1 Noisy house image (left) and Canny edge image (right)

To overcome this dilemma, edge detection could be formulated as an optimization problem. There are numerous optimization problem solving problems available in the literature. A few are genetic algorithms, ant colony algorithms, bacterial foraging algorithm. Of these Ant Colony Optimization (ACO) [8], is a relatively new approach and has been used for edge detection [9-15] and broken edge compensation [16, 17]. The proposed approach is able to provide continuous and clear object boundaries at the same time it is also able to suppress the noisy surroundings. ACO as a swarm intelligence approach has been adopted to directly detect image edges by Zhuang [9, 10] since 2004. He used ACS to build the perceptual depth of images for extracting edges. But his both the two methods are capable of detecting simple edges. Later, Nezamabadi-Pour et al. [11] used the AS and applied directed graph to detect edges. They formulated relationship between

2. ANT COLONY OPTIMIZATION FOR EDGE DETECTION:

The general approach towards automatic facial expressions detection system (micro-expressions as well) consists of three steps: (1) face acquisition, (2) facial data extraction and representation, and (3) facial expression recognition. Face acquisition (1) includes an automatic detection and tracking of the face in the input video. Extraction of the face direction could be added to this step.

An ant is a simple computational agent in the ant colony optimization algorithm. It iteratively constructs a solution for the problem at hand. The intermediate solutions are referred to as solution states. At each iteration of the algorithm, each ant moves from a state **x** to a state **y**, corresponding to a more complete intermediate solution. Thus, each ant **k** computes a set $\mathbf{A_x(k)}$ of feasible expansions to its current state in each iteration, and moves to one of these in probability. For ant **k**, the probability $\mathbf{p^k_{xy}}$ of moving from state **x** to state **y** depends on the combination of two values, viz., the attractiveness $\boldsymbol{\eta_{xy}}$ of the move, as computed by some heuristic indicating the a priori desirability of that move and the trail level $\boldsymbol{\Gamma_{xy}}$ of the move, indicating how proficient it has been in the past to make that particular move.

The trail level represents a posteriori indication of the desirability of that move. Trails are updated usually when all ants have completed their solution, increasing or decreasing the level of trails corresponding to moves that were part of "good" or "bad" solutions, respectively.

In general, the $_{\mathbf{kth}}$ ant moves from state **x** to state **y** with probability

$$p_{xy}^k = \frac{(\tau_{xy}^{\alpha})(\eta_{xy}^{\beta})}{\sum_{z\in \mathrm{allowed}_x}(\tau_{xz}^{\alpha})(\eta_{xz}^{\beta})}$$

where

$\boldsymbol{\Gamma_{xy}}$ is the amount of pheromone deposited for transition from state x to y, $0 \le \alpha$ is a parameter to control the influence of $\boldsymbol{\Gamma_{xy}}$, $\boldsymbol{\eta_{xy}}$ is the desirability of state transition **xy** (a priori knowledge, typically $\mathbf{1/d_{xy}}$ where d is the distance) and $\beta \ge 1$ is a parameter to control the influence of $\boldsymbol{\eta_{xy}}$. $\boldsymbol{\Gamma_{xy}}$ and $\boldsymbol{\eta_{xy}}$ represent the attractiveness and trail level for the other possible state transitions.

3. METHODOLOGY:

In facial data extraction and representation for expression analysis, two main approaches exist: geometric feature-based methods and appearance-based methods.

In the first section problem statement and objective is define and in the second section proposed methodology is explained and discussed in details with the help of self-explanatory steps and flow charts. In this section, data used in the study, hardware/software used and detailed methodology Followed in this study is discussed.

PROBLEM DEFINITION:

After an extensive and exhaustive literature survey it was clear that no matter what set of parameters we choose, we cannot obtain an edge image which clearly reflects the object of interest and at the same time suppresses the surroundings which is necessary for better object recognition. Hence an improved approach is required to counter this dilemma.

OBJECTIVE:

Once the problem statement is set, the objective becomes clear. The objective of this study is to combine the various edge images obtained by different ACO parameter settings logically so that image surround suppression performance can be enhanced and at the same time object edges can be obtained clearly so that object recognition becomes easy.

Other minor objectives are to

1. Obtain a set of ACO parameters, which can provide different level of edge images.
2. Perform logical operations which to check that the images are not same.

DATA USED:

The images used in this study are mostly the standard images used in image processing world. These include “Lena”, “House”, and “Cameraman” images. We have also included one image which is outside the set of standard images. This is an image of a vehicle from the back displaying its licence plate. The images used in this study are shown below.

Figure 2 Images upon which the developed methodology is tested

HARDWARE/SOFTWARE SPECIFICATIONS:

Hardware: Lenovo 'Ideapad' with Core Intel i5 with 2 GB NVIDIA Graphics Card and 4 GB internal RAM

Software: Microsoft Windows 8.1 professional with Matlab 2013 installed.

APPROACH:

STEP 1: CHOICE OF TECHNIQUE FROM VARIOUS ACO ALGORITHMS:

After doing an extensive literature survey, it was found that there are many variants of the basic ant colony optimization techniques available. So the choice of technique to be used in this study was important. Hence after reviewing all variants of ACO, it was clear that AntMiner+ was the best for our purpose of edge detection.

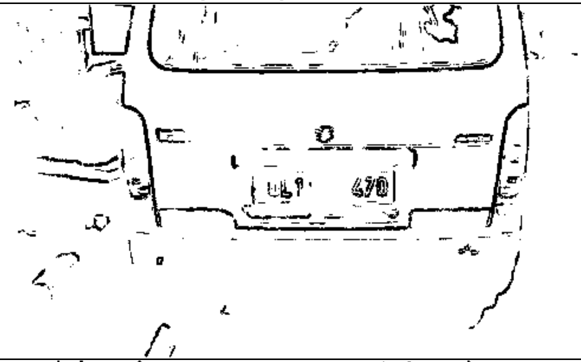
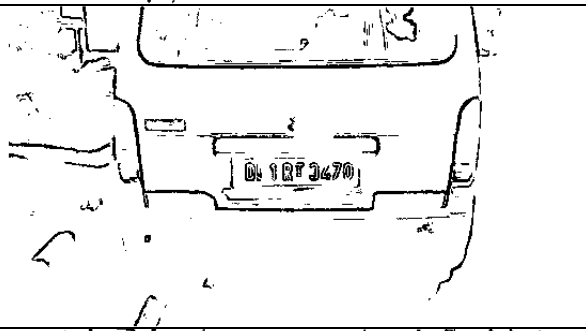
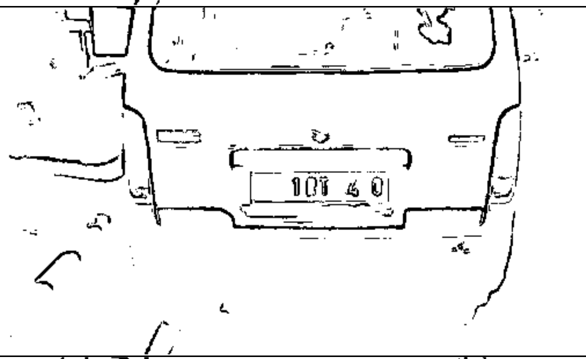
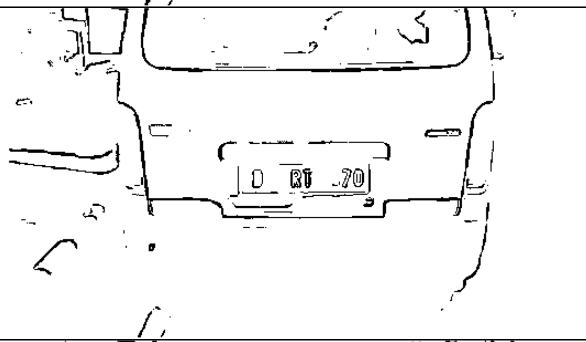
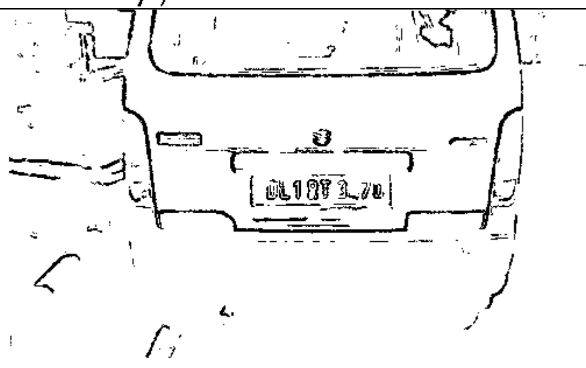
STEP 2: IMPLEMENTING ACO ON MATLAB:

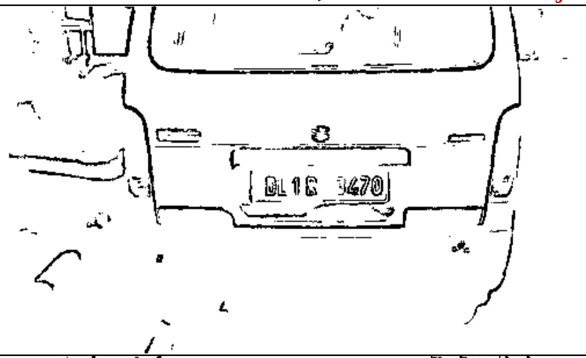
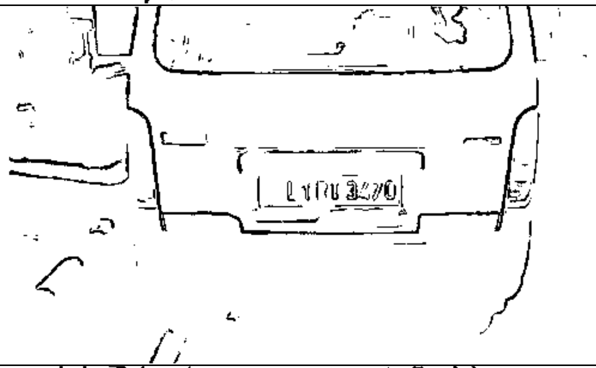
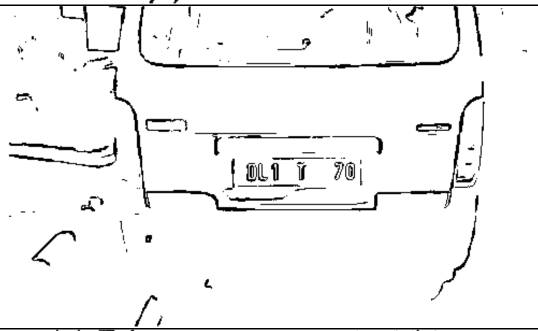
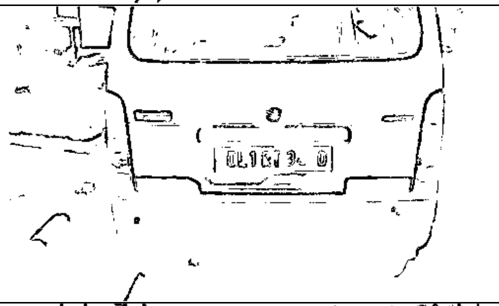
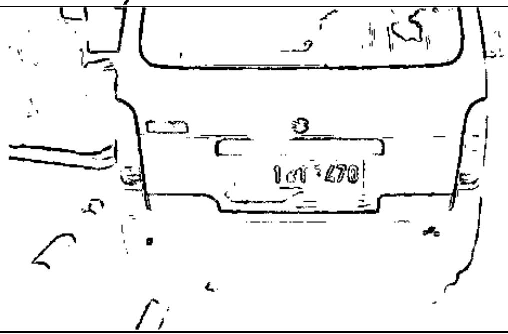
As ACO is a popular optimization technique so it has to be already implemented on environments like Matlab. But are not available freeware so writing the ACO algorithm on Matlab became a requirement. Hence in this step ACO was implemented on Matlab. The filename "ACO_main" is the main source code file. The code have been provided at the end of the report under the section "Appendix".

STEP 3: INITIALIZING THE PARAMETERS:

Now as the basic algorithm has been developed, it can be used for our purpose of edge detection. But the algorithm requires some parameters to be initialized first. These parameters are "Weight factor for pheromone information" i.e. α, "Weight factor for heuristic information" i.e. β and some more. Now the question arises, what values should be provided that can give best results? This question has been answered by many authors but only one set of values of such parameters is not enough. Therefore in this study, we chose 10 combinations of the parameter values. These 10 combinations were chosen from a set of 144 combinations from a different experiment. It was found that these 10 combinations are providing most of the edge information from the image. Therefore these 10 combinations are kept as standard set for all images. The results of these combinations can be seen in the next chapter. For sake of understanding, one set is shown here.

Table 1 Table showing various ACO Parameter values applied on the car image and corresponding results

S No	Parameter values	Corresponding Image
1.	**Alpha = 1** **Beta = .1** **Rho = .1** **Phi = .01**	
2.	**Alpha = 2** **Beta = .1** **Rho = .1** **Phi = .01**	
3.	**Alpha = 5** **Beta = .1** **Rho = .1** **Phi = .01**	
4.	**Alpha = 10** **Beta = .1** **Rho = .1** **Phi = .01**	
5.	**Alpha = 1** **Beta = .0.5** **Rho = 0.1** **Phi = 0.01**	

6.	**Alpha = 2** **Beta = .0.5** **Rho = 0.1** **Phi = 0.01**	
7.	**Alpha = 5** **Beta = .0.5** **Rho = 0.1** **Phi = 0.01**	
8.	**Alpha = 10** **Beta = .0.5** **Rho = 0.1** **Phi = 0.01**	
9.	**Alpha = 1** **Beta = .1** **Rho = 0.1** **Phi = 0.01**	
10.	**Alpha = 2** **Beta = .1** **Rho = 0.1** **Phi = 0.01**	

As we can observe from the above table that ACO with different parameters is giving different edge information. Hence one set of parameters is not enough for good edge detection.

STEP 4: LOGICALLY COMBINING THE EDGE IMAGES:

After obtaining the different edge images, we have to combine them in such a manner so that maximum edge information is extracted. To confirm that all the edge images do not contain the information, first we performed an "AND" operation on the 10 images. The result obtained doesn't contain all the edge information. Hence it is verified that we require multiple images for good edge detection results.

C = A * B; C is 1 only if A and B both are one

The multiple images need to be combined in such a manner so that maximum information can be extracted. It was observed that performing a logical "OR" on the images will give us the desired image.

C = A + B; C is one when either A or B is one

For sake of understanding, one such result is shown below. It is clearly observable that a huge amount of information addition is done by performing the above operation. The license plate number is clear and complete which was not in any of the images obtained in the previous step.

Figure 3 Images after performing logical AND operation on various parameter edge images a) Cameraman b) House c) Lena and d) CAR image

The above results reveal that the entire image used for performing logical operations do not contain similar information. This is evident from the above test. If all the images would have contained the same information then the logically AND output image should have contained all the information which it is not containing. Hence it is proved that all the input images have different edge information so it is required to combine the results from all these image so as to obtain enhanced results in context to object recognition and feature matching applications.

Figure 4 Figure showing the logically ORed images of a) Cameraman b) House c) Lena and d) CAR image

COMPARISONS TO PREVIOUSLY PUBLISHED RESULTS:

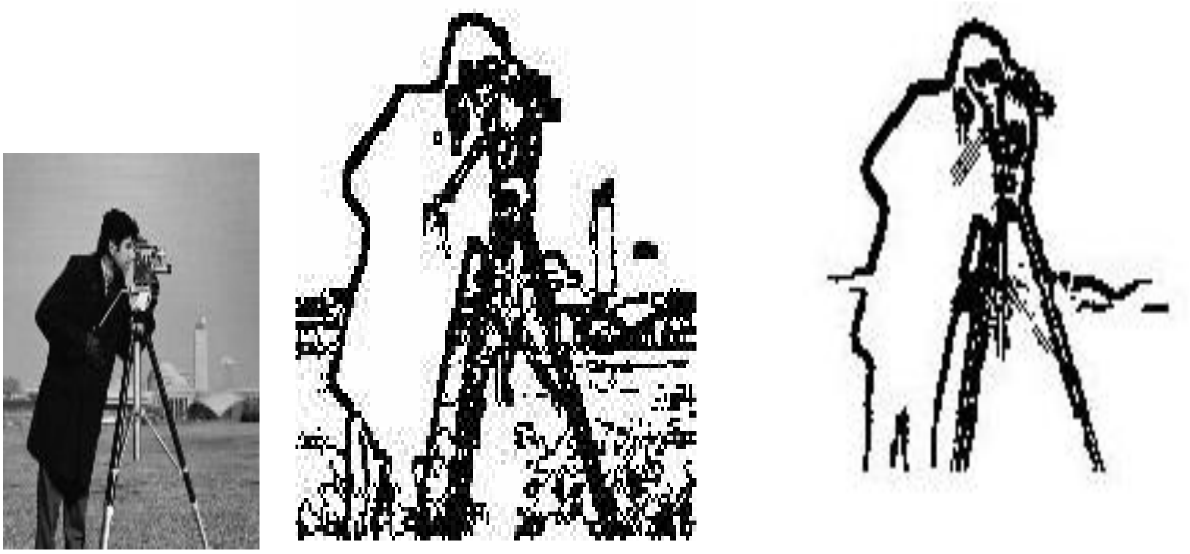


Figure 5 Extracted edge information of the image Cameraman a) Original image. b) Nezamabadi-Pour et al.'s method [18]; (c) the proposed ACO-based image edge detection. A good suppression is achieved surround

In the figure 5 we compare our result to Nezamabadi Pour et al's method. In figure a the original Image of cameraman is given, In figure b the Nezamabadi Pour et al's final result and in figure c the proposed ACO based image edge detection result is given. And after the comparison we conclude that the proposed result gives clear Images.

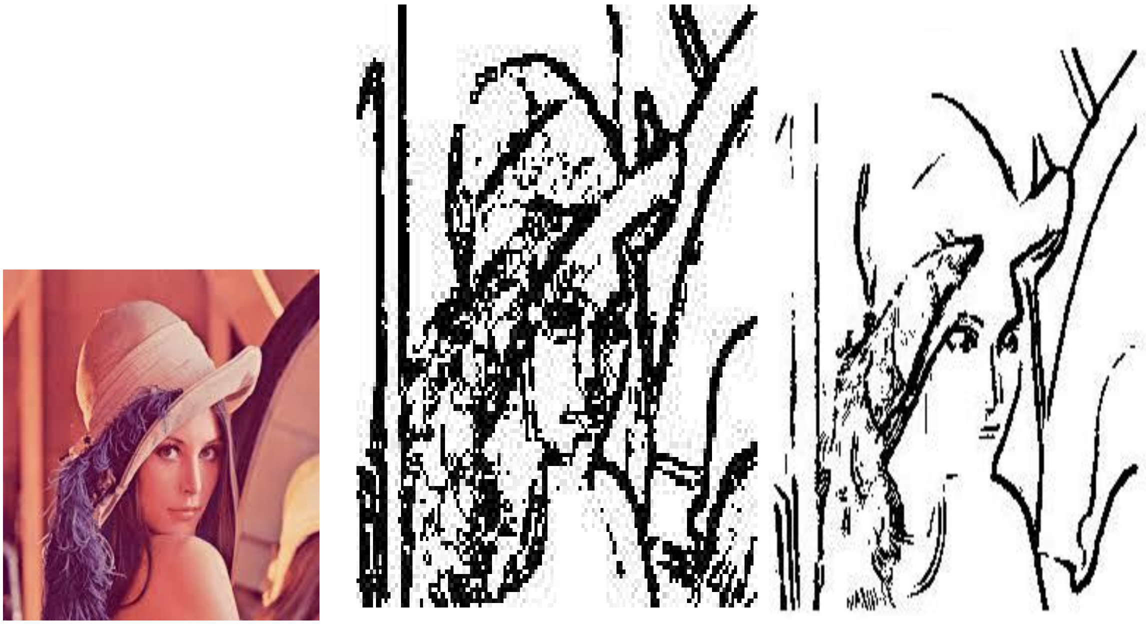


Figure 6 Various extracted edge information of the image Lena a) Original image. b) Nezamabadi-Pour et al.'s method (c) the proposed ACO-based image edge detection. Good surround suppression is achieved by the proposed approach

In the figure 6 we compare the our result to Nezamabadi Pour et al's method. In figure a the original Image of Leena is given, In figure b the Nezamabadi Pour et al's final result and in figure c the proposed ACO based image edge detection result is given. And after the comparison we conclude that the proposed result gives clear Images.

CONCLUSION:

Edge detection plays a vital role in image processing applications, which is important part in computer vision. In this thesis an integrated ACO and logic theory approach is implemented which shows tremendous improvement in the obtained results. In this study, we collected the information from various ACO operations under different parameter conditions and the combined them logically so that maximum information can be extracted. The experiment was successful and the obtained results outmatch the results obtained in previous studies

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