

## An Analysis the Image Edge Detection by Using Ant Colony Optimization

Mrs. Tejashree Shinde<sup>1</sup>, Dr. Manish Shrivastava<sup>2</sup>,

Research Scholar, Department of CSE, VGU Jaipur<sup>1</sup>

HOD, Department of CSE, VGU Jaipur<sup>2</sup>

**Abstract-** Edge detection is the technique of discovering & identifying abrupt discontinuities in an image. The boundaries of objects in a scene are marked by discontinuities, which are sharp variations in pixel intensity. This procedure, which has applications in both image analysis & machine vision, is essential for comprehending a picture's information. In the early stages of computer vision applications, it is typically used. Edge detection is the foundation for many image analysis & machine vision applications and seeks to pinpoint the borders of objects in an image. The pheromone matrix is created by applying the picture edge detection algorithms that were employed in this work to 2D images. We will employ the MATLAB language and tool, as well as the ACO, Canny, Sobel, and Prewitt research approaches, in this study.

**KEYWORDS-** Edge Detection, Ant Colony Optimization, Canny, Sobel, & Prewitt

### I. INTRODUCTION

Image edge detection is the process of identifying edges in digital images. It is a method whose objective is to locate areas in a picture where sharp discontinuities or variations in intensity take place. This procedure, which has applications in both image analysis & machine vision, is essential for comprehending a picture's information. In the early stages of computer vision applications, it is typically used. Edge detection is the foundation for many image analysis & machine vision applications and seeks to pinpoint the borders of objects in an image. Due to the fact that each set of processes is performed for each pixel, traditional edge detection methods are computationally expensive. Using traditional methods, the computation time quickly rises as the image size does as well. The limitations of conventional approaches may be overcome by an ACO-based strategy. Additionally, it is easily parallelizable, making the approach suitable for distributed systems.

ACO is a naturally inspired optimization method that is inspired by behavior of ant species [M. Dorigo et al. 2004], [P. Xiao, J. Li et al. 2010]. To indicate routes between a food source and their colony for other ants in the colony to follow, ants leave pheromone trails on

the ground. Pheromone traces disappear over time. The longer it takes an ant to get from one side of the trail to the other, the longer the pheromones have to dissipate. Shorter, more advantageous pathways are marched over more quickly & given more pheromone evaporation compensation. Because pheromone is put down more quickly on shorter pathways, pheromone densities stay high. The ants eventually choose the shorter paths because to this positive feedback mechanism. The ACO metaheuristic was created as a result of this natural event. The first ACO algorithm, ant system (AS), was proposed by Dorigo et al. [2004] [Jing Tian, et al. 2008]. Extensions to AS have been created since then. Many optimization issues have been solved with ACO. An ACO-based technique for image edge detection is presented in this paper.

### II. LITERATURE REVIEW

Saman M. Almufti et al. (2022) An intelligent swarm algorithm called ACO uses the behaviour of ants to improve solutions to challenging optimization issues. TSP, WSN, Benchmark Problem, & several image processing applications have all been solved using ant-based techniques throughout the years. Canny & Sobel edge detectors are two examples of

techniques utilized in the image processing domains to find edges in digital images. For the purpose of improving the quality of the edge detector, this study presented a hybridized ACO technique. The suggested method initializes both the information at each pixel routed by ants on the input image and its attribute matrix. The suggested algorithm's experimental findings are displayed together with comparisons to those of the basic ACO edge detector & Canny original built-in edge detection method in MATLAB. The MSE & PNSR are computed both before and after applying Gaussian noise, and all three techniques are evaluated on various images.

Cristina Ticala et al. (2022) One of the techniques that is most frequently used to solve complex issues is ACO. Particularly when processing complex images is involved, image processing is a challenging undertaking. In this study, we quantify the distance between pixels from two photographs using a fuzzy Euclidean metric. This is the first assessment of fuzzy index & fuzzy euclidean metrics in the context of ACO picture edge detection. When comparing similarities between the fuzzy images that are taken into consideration, especially medical images, the Canny edge detection is regarded as the ground truth. Using preexisting data sets & well non-fuzzy similarity measures like Jaccard's index, Dice's coefficient, and the Pratt's Figure of Merit, experiments were carried out and successful comparisons were made.

Atul Srivastava et al. (2022) Edge detection involves gathering the contour of edges & locating discontinuities in pixel intensity. In computer vision, edge detection in digital images is a key phenomenon. In the early phases of the creation of edge detection algorithms, common approaches like Sobel Canny were developed. These techniques are quick yet noise-sensitive. Due to their adaptability, soft computing methods including ACO, FLS, GA, PSO, & GA have a wide range of applications in picture edge identification. Popular ACO edge detection algorithms are discussed & compared in this research. The

selection of constants, pheromone evaporation rate, number of iterations, etc., affect the quality of edges detected by the ACO-based edge detection technique.

S. Baltierra et al (2022) Multiplicative noise is aggressive and can be seen in Synthetic Aperture Radar, ultrasound, & ultrasonic imaging. Canny & Sobel edge detectors need filtering methods & preprocessing to process images with multiplicative noise. Bio-inspired algorithms can estimate solutions, making them a feasible option for multiplying noisy images. This article suggests the ACO method for edges recognition in multiplicative noise pictures. Modifying the ACO algorithm detects contours. Trials show that the strategy described for photos with multiplicative noise works even at high noise levels.

Vishnu Sharma et al. (2022) ACO a branch of soft computing, is the subject of this study. ACO uses a computational intelligence-based approach to solve a combinatorial optimization problem. Due to the method's simplicity & effectiveness, routing, scheduling, sub-set, task, & classification problems have all been addressed using it. In this paper, we investigate the image processing implications of ACO. In this work, we address the usage of ACO in many aspects of image processing as well as how it manages uncertain information & image-based decision-making. The various tasks that were examined & handled include edge detection, feature selection, edge linking, compression, & segmentation.

### III. METHODOLOGY

The study of methodology, or the ways in which research is conducted, is known as "methodology." It involves thinking critically on the established practices and rules within a certain field of study. It typically includes things like the paradigm, the theoretical model, and the phases. Research refers to the process of investigating and learning about something new. In other terms, research is the practice of conducting in-depth, methodical studies. The individual conducting this scientific inquiry can be called a researcher, and it has been said that

need is the mother of all inventions. In this research, the pheromone matrix was generated using image edge detection algorithms applied to 2D pictures. The proposed image edge detection method employs ACO techniques (Perumal 2018). Each pixel's intensity in the original image is represented by the pheromone matrix, which is modified by the edge's position. In order for ants to traverse a 2-D image in which one pixel "steps out" to another pixel, the proposed method aids in the construction of a pheromone matrix. The edge information of each pixel in the image will be handled by pheromone matrices for the research. The image's border can be retrieved with the use of a pheromone matrix (Jama & Baykan 2020). To track the ants' motions, we'll use the intensity values of the images and how they fluctuate locally. The implementation work will utilize a grayscale image. It is a data matrix  $I$  where the values represent intensities across a certain range, and hence it is an intensity image. Each pixel in a grayscale image is represented by a single element in a single matrix. The initialization phase of ACO optimization involves the use of input photos to train a colony of artificial ants on, which will then be used to find optimal solutions. For the pheromone matrix's formation, ACO methods will use a running total of iterations (Pravin et al. 2019). The Iterative method will incorporate both the building and updating phases. The deciding step is the last one when the edge matters. The methods of ACO, Canny, Sobel, & prewitt will be utilized in this study, along with the language & tool of MATLAB.

#### IV. IMPORTANCE OF PROPOSED RESEARCH INVESTIGATION

The suggested study is crucial for elucidating the ACO technique (Dinh and Tu 2021). Image compression, edge recognition, structural damage monitoring, & image segmentation are just a few of the many computation issues that come from working with images, making this research crucial. This research is crucial for comprehending why ACO is useful in the field of image processing (Sharma and Mir 2019). The

study's technique is designed to help pinpoint the best approach to fixing image processing problems.

The significance of the work lies in its ability to shed light on the difficulties inherent to image processing optimization & ways in which ACO might be used to overcome them. Both the business and academic worlds rely heavily on solutions to optimization challenges (Tang et al 2021). These algorithms were conceptualized after seeing ant colonies. Image processing has crucial applications in human life. The medical, defense, business, and manufacturing sectors will all benefit from developments in image processing (Jino Ramson et al. 2019).

In soft computing, image processing & analysis play crucial roles, hence this research is crucial. The most common types of uncertainty in image processing are fragmentation noises & imprecise information, making this study crucial for elucidating the function of ACO in resolving the traveling salesman problem (Li and MR 2019).

#### Sobel operator

It's a first-derivative gradient operator that can spot horizontal and vertical edges in a picture, as well as those with a very large gradient magnitude. An intensity image is computed using a discrete differentiation operation. A mask is used in both the vertical & horizontal dimensions.

This is the sobel operator's horizontal mask:

-1	-2	-1
0	0	0
1	2	1

And vertical mask of sobel operator is as follows:

-1	0	1
-2	0	2
-1	0	1

From the above masks, it can be understood that it gives more information at the edges

rather than at the center as we have taken that 0 at the center in mask.

Prewitt operator edge extraction

Prewitt operator [Rafael C Gonzalez 2009] adopts the following procedure to obtain the edge image from the given input image.

1. For each pixel of an image  $f(i, j)$  obtain row gradient by convoluting a mask of  $3 \times 3$  as shown below.

1	1	1
0	0	0
-1	-1	-1

$$Gr(f(i, j)) = (f(i-1, j-1) + f(i-1, j) + f(i-1, j+1)) - (f(i+1, j-1) - f(i+1, j) - f(i+1, j+1))$$

2. For each pixel of an image  $f(i, j)$  obtain column gradient by convoluting a mask of  $3 \times 3$  as shown below

1	0	-1
1	0	-1
1	0	-1

$$Gc(f(i, j)) = (f(i-1, j-1) + f(i, j-1) + f(i+1, j-1)) + (-f(i-1, j+1) - f(i, j+1) - f(i+1, j+1))$$

3. Obtain the final gradient FG of image pixel  $f(i, j)$  is given by magnitude of gradient  $FG(f(i, j)) = \text{Abs}(Gr(f(i, j))) + \text{Abs}(Gc(f(i, j)))$
4. If  $FG(f(i, j)) > T$ , then place that pixel in the edge image where  $T$  is a threshold of an image.
5. Finally display the edge image after completing the above process for all the pixels of an image.

### Canny

It is one of Gaussian based edge detector it extracts the edges in an image. It detects a extensive range of edges in an image. It will apply Gaussian filter to image and remove noise and smoothen the image, then it find the gradient of an image for that it apply non

maximal suppression later it will identify edges by applying hysteresis. The hysteresis threshold is having factors for identification i.e., by having low threshold value or high threshold value, or by using width of gaussain which determines noisiness of an image. In our paper we use different edge detection methods and apply these methods in examples of some real time application using GUI (Graphical User Interface) and calculated using different parameters like MSE, PSNR, & SNR

### MSE

Mean Square Error is used to measure errors in digital image. It is one of the metric for image quality estimator. Always MSE should be low, so that it is better to prefer low error images.

### PSNR

Peak Signal to Noise Ratio is ratio between signal to noise and it is measured logarithmic decibels. Always PSNR is high means noise is less so always we prefer to have high PSNR value. It is used to measure the quality of image & SNR is ratio between powers of a signal to noise. SNR should be high or efficient result.

## V. RESULTS AND ANALYSIS

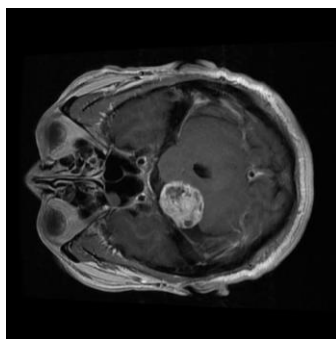
To implement this work used Ant colony optimization algorithms with a combination of "Sobel" edge detection filter and perform comparative analysis with Prewitt and Sobel filter. In order to create an image edge map that is sufficiently connected, this method of edge detection, which makes use of the ACO algorithm, is utilized. In the beginning, the edge map of the picture is obtained by employing a variety of standard edge detectors from the MATLAB toolbox as well as adaptive thresholding. Calculations are made based on the end points obtained with such detectors. After that, the ants are positioned in these specific locations. The local fluctuation in the intensity values of the pixels acts as a compass to direct the movement of the ants. While sending an ant to the next likely edge pixel, it takes into account the probability of just-not-yet-discovered neighboring pixels. This

guarantees that no details are overlooked. The two rules for stopping are put into place to stop the ants from moving through the pixel that has previously been identified.

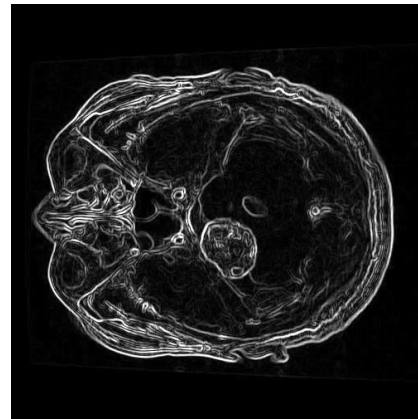
Results of proposed work with comparative analysis of ACO (Sobel, Canny), Prewitt, and Sobel.

Table 1: Results of Brain Tumor Image

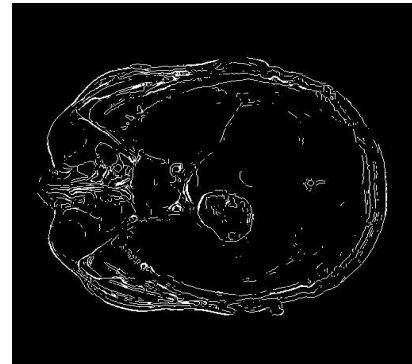
Algori thm	PS NR	SN R	MS E	R MS E	SS I M
Sobel	26. 74 9	10. 89 9	137 .45 9	11. 72 4	0. 8 0 1
Prewi tt	21. 96 7	3.7 42	413 .38 0	20. 33 1	0. 6 5 6
Propo sed ACO+ Sobel	22. 20 2	1.2 85	391 .56 3	19. 78 7	0. 7 8 7
Propo sed ACO+ Cann y	23. 12 2	6.2 66	316 .79 9	17. 79 8	0. 7 0 4



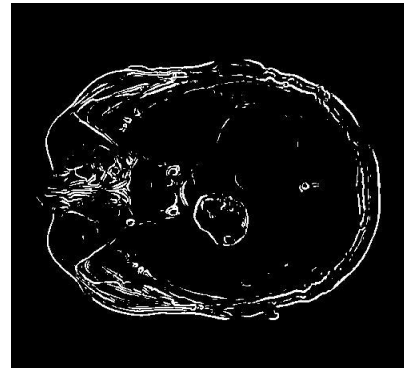
(a) Original Brain



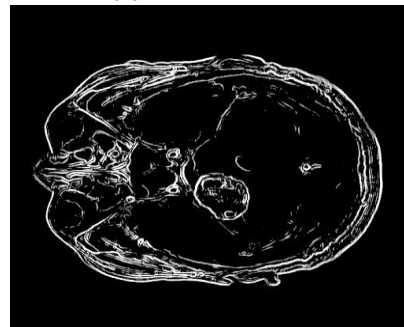
(b) Filter Brain



(c) ACO\_Brain



(d) Prewitt Brain

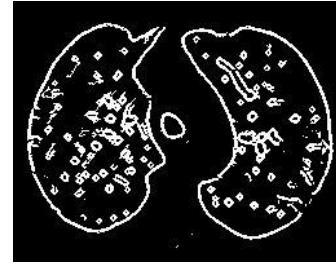


(e) Sobel Brain

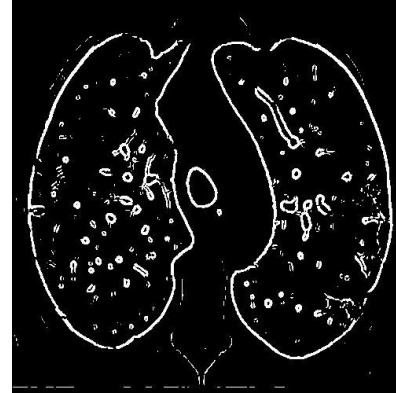
Figure 1 Comparison of ant-based edge detection algorithms. (a) Original image of Brain tumor (b) Filter image (c) ACO Brain (d) Perwitt brain and (e) Sobel brain

Table 2: Results of Lungs Covid Image

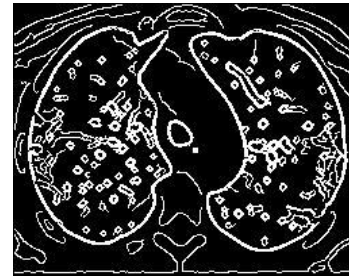
Algori thm	PS NR	S N R	MSE	RM SE	SS IM
Sobel	17. 91 3	7. 50 9	1051 .338	32. 42 4	0. 67 3
Prewit t	20. 06 7	3. 94 5	640. 154	25. 30 1	0. 53 3
Propo sed ACO+ Sobel	15. 90 1	3. 76 3	1670 .850	40. 87 6	0. 54 7
Propo sed ACO+ Canny	18. 05 8	7. 14 6	1016 .687	31. 88 5	0. 76 6



(c) ACO\_Sobel\_Lungs



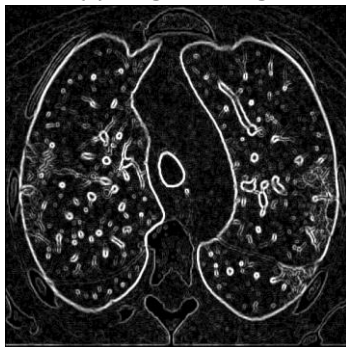
(d) ACO\_Canny\_Lungs



(e) Prewitt Lungs



(a) Original Lungs



(b) Filter Lungs



(f) Sobel Lungs

Figure 2 Comparison of ant-based edge detection algorithms. (a) Original image of lungs (b) Filter image (c) ACO sobel lungs (d)

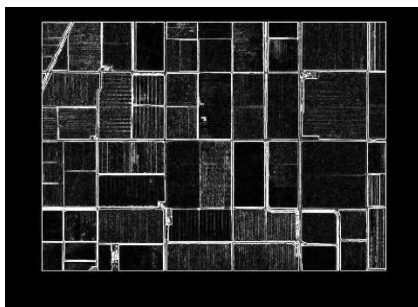
ACO canny lungs (e) Prewitt Lungs & (f) Sobel brain

Table 3: Results of Farm Image

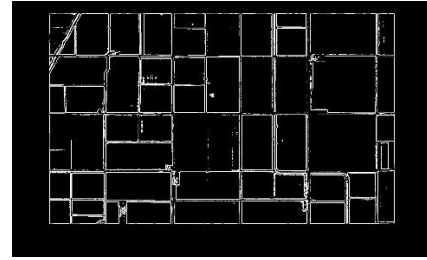
Algorithm	PSNR	SNR	MSE	RMS	SSIM
Sobel	25.772	10.797	172.6	13.118	0.910
Prewitt	22.186	5.986	392.998	19.824	0.825
Proposed ACO+Sobel	23.195	5.487	311.551	17.650	0.835
Proposed ACO+Canny	23.185	8.874	312.241	17.670	0.819



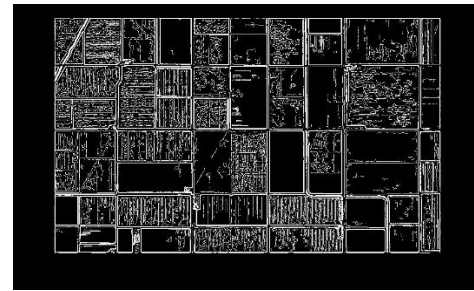
(a) Original Image farm



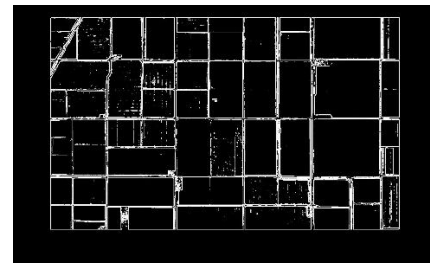
(b) Filter Image farm



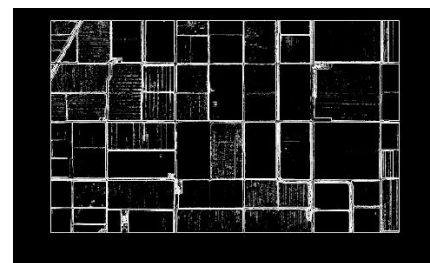
(b) ACO\_Farm\_Sobel



(d) ACO\_Farm\_Canny



(e) Prewitt Farm



(f) Sobel Farm

Figure 3 Comparison of ant-based edge detection algorithms. (a) Original image of farm (b) Filter image farm (c) ACO farm sobel (d) ACO farm canny (e) Prewitt Lungs & (f) Sobel brain.

## VI. CONCLUSION

In our proposed work we have taken three different digital images like brain tumor images, lungs covid images, an farm images using edge

detector operators like Sobel, Prewitt, ACO canny & ACO sobel these are different operators have been implemented on these digital images and among all of these from the above output waveforms or pictures from Table 4.1 to Table 4.2, the difference in the output result can be observed. The SSIM has low MSE and high PSNR, RMSE and SNR is observed.

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