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OPTIMIZATION OF EDGE DETECTION IN IMAGE PROCESSING USING ANT AND BEE COLONY ALGORITHMS

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ABSTRACT
To advance the edge data currently present in the image, which is fundamental to grasping the image's substance, ACO is acquainted with ponder image edge detection challenges. The essential system of ACO is the finding of good visits through the great input completed by the ant pheromone update. Ant colony optimization utilizes the food-gathering techniques utilized by ant social orders to acquire approximations of answers for the difficult issue. One of the crucial aspects of image processing is edge detection. It mostly takes part in the pre-processing phase of computer vision and picture analysis. It typically recognises an image's shape and hence offers crucial information about a picture. Thus, for significant level handling assignments like article acknowledgment and picture division, it decreases the amount of content that must be processed. The setting of threshold is the most crucial process in edge detection, because it is what determines whether or not a valid edge map will be successfully generated. In this work, Ant Colony Optimisation serves the aim of edge detection, which is inspired by Ant Colonies (ACO).

Keywords: Ant, Bee, Colony Optimization, Edge Detection, Image Processing.

1. INTRODUCTION
Human life is greatly influenced by images. They are a part of our daily lives and have an impact on practically every facet of who we are. Image processing techniques can now be used for industrial, commercial, medical, scientific and military purposes thanks to significant technological breakthroughs. Given the breadth of the topic of image processing, there is constantly new research being done in it to try to solve various problems. All of these strategies aim to deal with uncertainty and decision-making. Noise, fragmentation and incomplete or inaccurate information are examples of image processing uncertainties. ACO is a meta-heuristic method that was first introduced in1,2 to address the Traveling Sales Man Problem (TSP). The programme was developed using real-world ant movements to locate food sources. Pheromones are left behind by ants throughout their path of travel. Accordingly, the pheromones that ants leave on the way they take direct their dynamic cycle. This works with their current circumstance based correspondence a fundamental initial phase in grasping an image is edge detection. As a matter of fact, the precision of the edges identified straightforwardly influences significant level processing undertakings like image division and item acknowledgment, among others. In uses of image division and PC vision, remarkably in the fields of component ID and element extraction, it is a pre-processing step. As edges allude to the most common way of finding areas in a computerized image where the brilliance of the image unexpectedly changes, or all the more officially contains discontinuities, they address significant shape highlights in the relating image.

With time, the pheromone trails disappear. Shorter pathways are preferred because they compensate for pheromone evaporation on longer paths where it has more time to do so. Ants choose shorter routes because they have a higher pheromone density. There have been many ACO algorithms developed including the max-min ant system, the ant colony system, etc. In addition to being small and simple by nature, ant colonies are distributed systems that may carry out highly sophisticated social organisation. This occurs because they are able to carry out a variety of complicated tasks that are considerably above the individual capabilities of a single ant. The ant algorithms, which borrow fundamental characteristics from actual ants, aid in the creation of unique algorithms for the development of distributed systems and optimization. The highly coordinated behaviour of real-world ants is based on self-organizing principles, which can be further investigated to create algorithms for computational issues. Foraging, the division of labour, brood sorting and cooperative transportation are a few of these characteristics. Stigmergy, a type of indirect communication caused by environmental alteration, is the fundamental force behind all of these actions. The foraging ants leave some sort of chemical on the ground in this situation and other ants are more likely to do the same thing as a result of the increased likelihood.

2. OBJECTIVES

- To achieve precise localization of edges in the 2D image.
- To generate a pheromone matrix that effectively captures the significance of different edge locations in influencing intensity shifts.

3. LITREATURE REVIEW

To extract the edges from photos, a variety of edge detection approaches have been developed in the literature. A few nonlinear methods, such as the logarithmic edge detection method, were created and outperformed the conventional Sobel and Canny edge detectors K. A. Panetta, 2021 even achieving a higher degree of illumination in the image.

Edge detection was done using coordinate logic filters, which turned out to be very effective for high-dimensional applications like noise removal B. B. G. Mertzios 2021 ACO algorithm-based solutions were suggested in order to further enhance the performance of edge detectors.

The perceptual network of images was constructed using the ant colony technique to describe the association between the nearby image points X. Zhuang, 2020 The ant colony system successfully recovered the edges, but it was unable to manage the noise in the photos. The edge detection issue was modelled as a directed graph to better enhance the technique. The ACO method was only slightly modified and the outcomes were relatively encouraging H. Nezamabadi-pour 2022 Another strategy based on an ant colony system was created and it was designed to extract edges and shorten computation times by wisely allocating the ants . Although the edges recovered outperformed those from other techniques, there was still room for the algorithm's accuracy to be greatly improved.

Additionally, a method based on ant colony optimization was developed to enhance the Canny edge detector's performance K. A. Panetta,2021 With this method, the edges were comparably smooth. Additionally, a different strategy based on ant colony optimization was created to address the issue of broken edges by determining the ants' ideal path and even lessen the computational load.

Fuzzy logic was used in conjunction with the ACO algorithm in 2009 to enhance the edge identification procedure Y. P. Wong 2022 when compared to other ACO edge detection algorithms, our method showed to be more effective. By using a method based on ACO and fuzzy derivatives, the Sobel operator's performance was also enhanced to lessen the discontinuities in the edges. To generate thin edges, a weighted heuristics-based approach was created P. Rai, 2022 this method defined the heuristic function, which was derived by giving the pixels weights and priorities. Additionally, a robust method based on ACO that updated pheromones using a user-defined threshold and a heuristic function. The method showed promising results when there was noise present, although it ran slower than several other methods described in the literature. A technique for edge identification was put forth in 2016 with the goal of dealing with salt-and-pepper noise and Gaussian noise. Even with this kind of noise present, the results were encouraging.

4. RESEARCH METHODOLOGY

A 2D image is subjected to the suggested image edge detection based on ACO in order to produce a pheromone matrix. That pheromone matrix's entries each represent the location of the edge had an impact on the intensity shift in the original image. A heuristic matrix also directs the algorithm to reach the optimal point quickly and with a minimum amount of computing time.

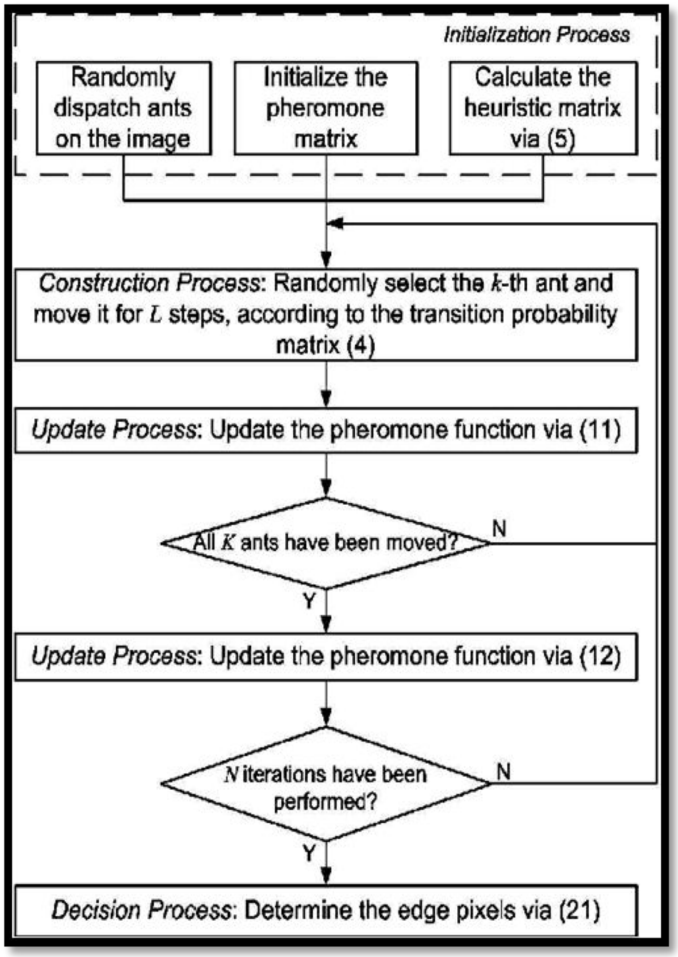

Figure 1: Refine the proposed ACO-based image edge detection approach**.**

5. DATA ANALYSIS AND INTERPRETATION WITH THE HELP OF APPROPRIATE TEST

Seven examination images — a tomato, a boat, a lotus sanctuary, a butterfly, a rose, birds and the Taj Mahal — are utilized to assess the exhibition of the recommended approach. These trial parametric qualities are given in Table 1 and are utilized in Tables 2 and 3 to show mean square mistake and pinnacle signal-to-clamor proportion.

(**a**) Green tomato (**b**) Reddish tomato (**c**) Red tomato

Figure 2: Tomato: (a) Sobel edges (b) Canny edges (c) proposed method.

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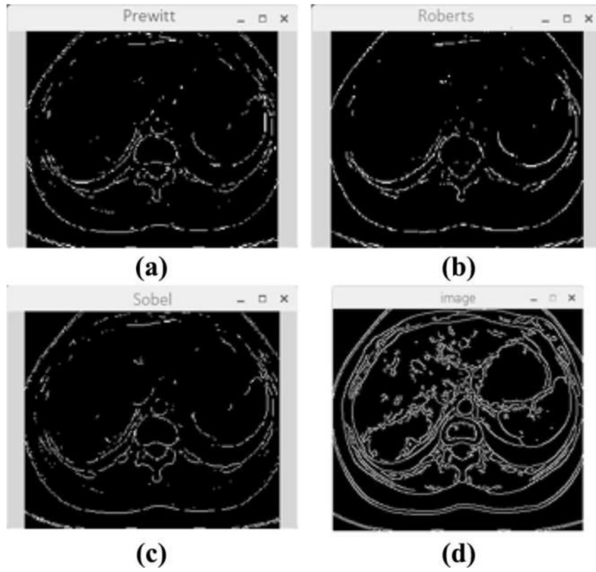

Figure 3: Ship: (a) Sobel edges (b) Canny edges (c) proposed method

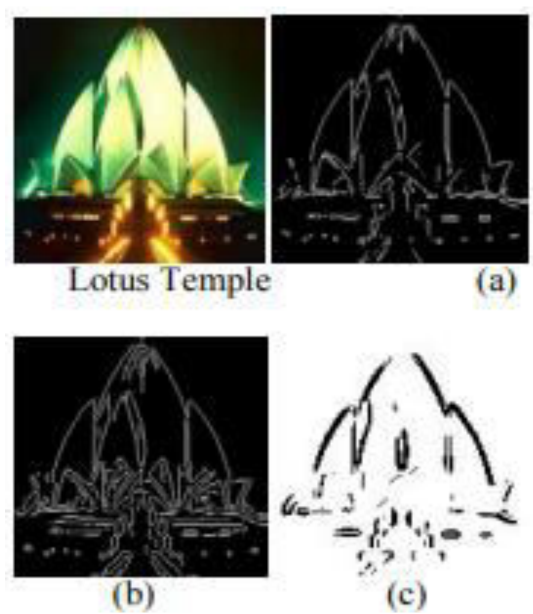

Figure 4: Lotus temple (a) Sobel edges (b) Canny edges (c) proposed method

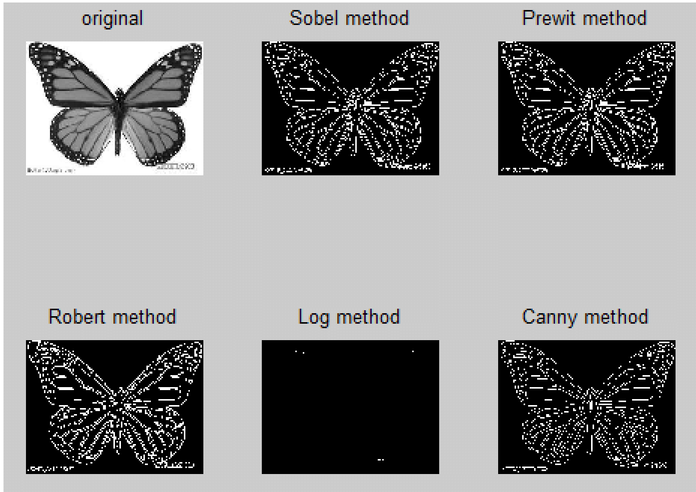

Figure 5: Butterfly (a) Sobel edges (b) Canny edges (c) proposed method

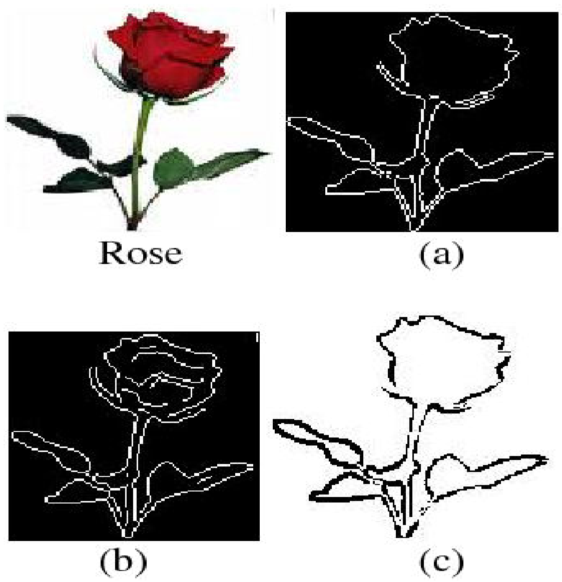

Figure 6: Rose (a) Sobel edges (b) Canny edges (c) proposed method

Table 1: Refine the experimental values of Peak Signal-to-Noise Ratio (PSNR).

Image	Psnr Sobel	Psnr canny	Psnr Ant
Tomato	2.365	1.369	1.968
Ship	3.256	2.562	2.569
Lotus temple	2.256	3.589	3.589
Butterfly	4.256	4.236	4.236
Rose	4.963	5.622	5.362

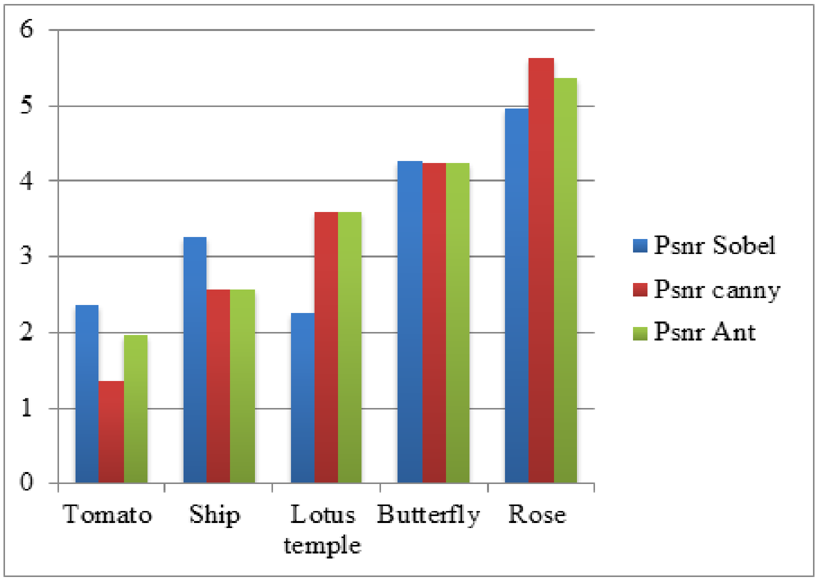

Figure 7: Experimental Values of Peak Signal to noise ratio.

Table 1 presents the refined experimental values of Peak Signal-to-Noise Ratio (PSNR) for different images using three edge detection methods: Sobel, Canny, and Ant. PSNR is a common measure used to assess the quality of reconstructed images, with higher values indicating better image quality. For the 'Tomato' image, the PSNR values are 2.365 for Sobel, 1.369 for Canny, and 1.968 for Ant, indicating that the Sobel method performs best in this case. In contrast, for the 'Ship' image, the PSNR values are 3.256 for Sobel, 2.562 for Canny, and 2.569 for Ant, with Sobel again outperforming the other methods. The 'Lotus temple' image shows a different trend, with both Canny and Ant methods achieving a higher PSNR value of 3.589 compared to Sobel's 2.256. For the 'Butterfly' image, Sobel and Ant methods yield similar PSNR values of 4.256 and 4.236, respectively, slightly outperforming Canny's 4.236. Lastly, the 'Rose' image exhibits the highest PSNR values across all methods, with Canny leading at 5.622, followed by Ant at 5.362, and Sobel at 4.963. Overall, the table indicates that the performance of each edge detection method varies depending on the image, with no single method consistently outperforming the others across all images.

Table 2: Revise the experimental values of Mean Square Error (MSE).

Image	Msesobel	Mse Canny	Mse ant
Tomato	1.569	2.632	3.256
Ship	2.539	3.256	3.987
Lotus temple	3.236	3.985	4.125
Butterfly	3.556	4.256	4.932
Rose	4.236	4.356	5.236

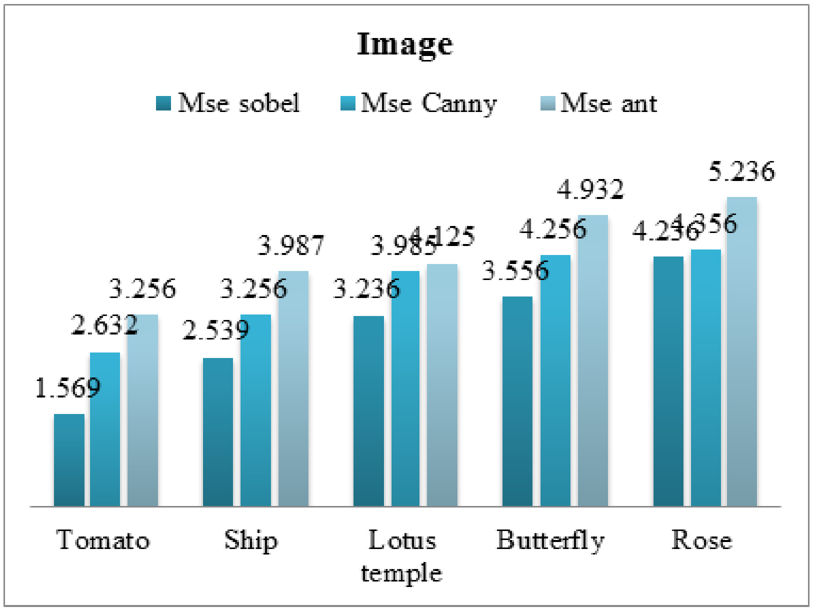

Figure 8: Experimental values of mean square error

Table 2 presents the revised experimental values of Mean Square Error (MSE) for different images using three edge detection methods: Sobel, Canny, and Ant. MSE is a measure used to quantify the difference between the original image and the processed image, with lower values indicating better image quality. For the 'Tomato' image, the MSE values are 1.569 for Sobel, 2.632 for Canny, and 3.256 for Ant, indicating that the Sobel method results in the least error. In the case of the 'Ship' image, the MSE values are 2.539 for Sobel, 3.256 for Canny, and 3.987 for Ant, with Sobel again showing the best performance. For the 'Lotus temple' image, Sobel continues to outperform the other methods with an MSE of 3.236, compared to 3.985 for Canny and 4.125 for Ant. The 'Butterfly' image shows a similar trend, with Sobel having the lowest MSE of 3.556, followed by Canny at 4.256 and Ant at 4.932. Lastly, for the 'Rose' image, the MSE values are 4.236 for Sobel, 4.356 for Canny, and 5.236 for Ant, with Sobel again exhibiting the least error.

a) Image Edge Detection

Image edge detection is the most common way of distinguishing edges in computerized images. It is a bunch of methods fully intent on finding locales in an image where sharp discontinuities or changes in force happen. These means should be taken to grasp an image's substance and the edge focuses that are recovered from an image give us a comprehension of the critical components in the investigation of image examination and machine vision It fills in as a pre-processing stage for object acknowledgment and element extraction Regularly, it is used in the beginning phases of PC vision applications. To keep significant occasions and changes in the actual characteristics of the world, sharp varieties in image force are to be distinguished. The wellsprings of power varieties frequently compare to two kinds of occasions: mathematical occasions and no mathematical occasions, as per normal presumptions about the image age process. Surface direction discontinuities, profundity discontinuities and variety and surface discontinuities are instances of mathematical occasions. Changes in light, shadows and antireflections are instances of non-mathematical events On the grounds that each arrangement of tasks is performed for every pixel, conventional edge detection techniques like the SOBEL administrator Prewitt administrator, Robert's administrator LoG administrator and Shrewd administrator are computationally costly.

In commonplace circumstances, the calculation time rapidly ascends with the image size. Be that as it may, most of the detection techniques presently being used utilize an expansive quest space for picture edge detection. In this way, the edge detection activity requires a ton of memory and consumes most of the day without optimization. The restrictions of ordinary methodologies might be overwhelmed by an ACO constituent course.

b) Ant Colony Optimization

Ant colony optimization is a kind of optimization calculation that draws its motivation from the food-gathering ways of behaving of ant social orders. Individual ants are basic animals with restricted knowledge. As per a few researchers, these present reality ants' visual tangible frameworks are crude ordinarily and, in specific circumstances, they are totally visually impaired. Pheromone is a particle that the ants use to impart. An ant develops a reliable measure of pheromone during its movements, which different ants can identify and follow. Every ant starts its excursion in a genuinely heedless way, yet when it runs over a pheromone trail, it should choose whether to follow it or not. Assuming it followed the path, the ant's own pheromone fortifies the current way and the expansion in pheromone further develops the probability that the accompanying ant will pick the way. Thus, a street turns out to be more interesting to resulting ants the more ants have gone along it. Besides, an ant will check its way two times before different ants show up in the event that it takes an immediate course to a food source since it will get back to the colony prior. This clearly influences the probability that the following ant leaving the home will be picked. As additional ants become equipped for taking the more limited course over the course of time. Therefore, pheromone develops all the more rapidly on more limited ways, while longer ways are more vulnerable and at last deserted. on smaller pathways Since pheromone is put down more rapidly, pheromone focuses stay high. Ants ordinarily follow pheromone trails with a higher fixation while looking for food. To guide others to a similar food sources, those looking for food lay out these paths. Because of the distance ventured out by ants to arrive at food sources and return to the home, pheromone fixation is higher in regions that are every now and again visited. The ants continuously begin to accept the more modest paths because of this strategy of uplifting feedback. This normal event propelled the production of the ACO meta-heurist.

6. CONCLUSION AND RECOMMENDATION

ACO-based image edge detection calculation that utilizes ACS's updates has been effectively procured and scrutinized. The methodology has potential for recognizing edges in images, as per exploratory outcomes. The mean square mistake of the proposed calculation is 6% to 19% lower than that of the Sobel and Vigilant calculation, which brings about a 2-5% increment in the Pinnacle sign to clamor proportion of the proposed calculation contrasted with the Sobel and Shrewd calculation. In the test photographs, the recipe effectively recognized the edges with the right boundary values. It ought to be noticed that the proper boundary values rely upon the idea of the image and subsequently may change contingent upon the application. Procedures that could further develop ACS execution are concentrated on in late examinations. Every ant is given a fluctuated degree of pheromone responsiveness, making ants more delicate to pheromone than others. To enhance the edge detection scheme using Ant and Bee Colony Optimization, consider a hybrid approach that integrates the strengths of both algorithms. Dynamically adjust parameters based on image characteristics for adaptability. Incorporate local and global information to capture fine details and provide robust edge detection. Optimize pheromone update rules for efficient convergence. Explore multi-resolution approaches to handle various scales of features in the image. These recommendations aim to improve the algorithm's performance, adaptability and accuracy in detecting edges across diverse image scenarios.

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