Optimizing Robinson Operator with Ant Colony Optimization As a Digital Image Edge Detection Method

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Abstract. Edge detection serves to identify the boundaries of an object against a background of mutual overlap. One of the classic methods for edge detection is the Robinson operator. Operator Robinson produces a thin, not assertive and grey line edge. To overcome these deficiencies, the proposed improvements to edge detection method with the approach graph with Ant Colony Optimization algorithm. The repairs may be performed are thicken the edge and connect the edges cut off. Edge detection research aims to do optimization of operator Robinson with Ant Colony Optimization then compare the output and generated the inferred extent of Ant Colony Optimization can improve result of edge detection that has not been optimized and improve the accuracy of the results of Robinson edge detection. The parameters used in performance measurement of edge detection are morphology of the resulting edge line, MSE and PSNR. The result showed that Robinson and Ant Colony Optimization method produces images with a more assertive and thick edge. Ant Colony Optimization method is able to be used as a method for optimizing operator Robinson by improving the image result of Robinson detection average 16.77% than classic Robinson result.

Keywords : Edge Detection, Robinson Operator, Ant Colony Optimization

1. Introduction

The edge line of image is a fundamental component in image processing, particularly in the areas of detection and feature extraction. Edge detection of an image is the process which generates the edge line of objects in image that aims to improve the appearance of the boundary lines of an area or object. Up to this point has been known some classic edge detection methods, one of them is the Robinson operator. However, for some conditions, classic edge detection method still has weaknesses, namely the possibility of error detection of edge or a broken edge detection.

Based on the morphology of the edge line result, Robinson operator produces the thin, not assertive and grey edge line[4]. To overcome these deficiencies, the proposed improvements to edge detection method with the approach graph with Ant Colony Optimization algorithm[1]. Through this approach, graph was expected to yield a not optimal edge detection can be improved. The repairs may be performed are thicken the edge and connect the edges cut off. Ant Colony Optimization (ACO) is a heuristic method that mimics the behavior of ants in order to solve the problem of discrete optimization[2]. ACO also be used to detect the edge of image, that to extract edge information from images. The proposed approach to harnessing the movement number of ants on the image based on the local variations in the value of the intensity of image. This information is used to build a matrix of pheromones, which provides information the edges of image.

ACO method are able to be used as a method for fixing a Canny edge detection method with fix image edge detection of Canny results average 12.05% of the results of detection of Canny. Canny methods and ACO are able to detect the edges of image with accuracy up to 82.7%[5]. This research discusses to do optimizing Robinson operator use Ant Colony Optimization then compare the output that is generated for the inferred the extent of Ant Colony Optimization can improve the results of edge detection that has not been optimized and improve the accuracy of the result of Robinson edge detection.
2. Robinson Operator
Robinson is the operator Compass that the type of operators who are looking for the edge by using eight wind direction, i.e. East, South East, South, South West, West, Northwest, North and North East. Robinson operators introduced by Robinson in 1977. This operator is identical to the 3 x 3 matrix or form window size 3 x 3 pixels, with r1 to r8 with calculated use mask as shown in Figure 1[3].

![Figure 1. Mask of operator Robinson](image)

2.1. Algorithm of Robinson operator edge detection
In detecting the edge of digital imagery, the Robinson operator had the following stages:
1. Read the value of the pixels of RGB image converted into grayscale image
2. Doing convolution between every pixel in the image to the eight mask of Robinson operator that already determined as in Figure 1.
3. In image, not all pixels can do convolution, that rows and columns which is located on the edge of the image have a neighbor is not complete. In this case, create additional rows and columns at edge is filled with a value of 0 so that the process convolution can be implemented.
4. In convolution, there are two possibilities if found, solved in the following manner, namely: a. If the value result of convolution is negative, the value is made 0. b. If the value result of convolution is bigger than maximum grayscale degree (>255), the value is converted to the maximum grayscale degree.
5. Take the maximum value from eight convolution result.
6. Output image is the result of the convolution value.

3. Ant Colony Optimization
The ACO may be used to detect the image edge, that to extract edge information from images. The proposed approach to harnessing the movement number of ants on the image based on the local variations in the value of the image intensity. This information is used to build a matrix of pheromones, which provides information the image edge. On the ACO, artificial ants behave like intelligent agent made by memory and the ability to see. Edge detection approach based ACO aims to utilize a number of ants moving on a 2-D image to build a matrix of pheromones, that every entry that represents the information on each location pixel image. In addition, the movement of the Ant driven by a local variation of the value of the intensity of the image[6].

4. Simulation Results and Discussion
The proposed method was tested on four different images of 100 x 100 pixels resolution. The values of $\alpha$ and $\beta$ were varied: $\alpha = \{1, 2, 0.1\}; \beta = \{0.1, 0.7, 1\}$. 
Table 1. Result of Image 1

| Image 1 | Robinson | Robinson + ACO |
|---------|----------|----------------|
|         | $\alpha = 1$, $\beta = 0.1$ | $\alpha = 2$, $\beta = 0.7$ | $\alpha = 0.1$, $\beta = 1$ |
| MSE     | 129.89   | 96.25          | 94.86          | 96.03          |
| PSNR    | 27.03    | 28.33          | 28.39          | 28.34          |

Table 2. Result Of Image 2

| Image 2 | Robinson | Robinson + ACO |
|---------|----------|----------------|
|         | $\alpha = 1$, $\beta = 0.1$ | $\alpha = 2$, $\beta = 0.7$ | $\alpha = 0.1$, $\beta = 1$ |
| MSE     | 134.65   | 96.98          | 95.29          | 100.35         |
| PSNR    | 26.87    | 28.3           | 28.37          | 28.15          |

Table 3. Result of image 3

| Image 3 | Robinson | Robinson + ACO |
|---------|----------|----------------|
|         | $\alpha = 1$, $\beta = 0.1$ | $\alpha = 2$, $\beta = 0.7$ | $\alpha = 0.1$, $\beta = 1$ |
| MSE     | 154.47   | 100.60         | 99.14          | 101.91         |
| PSNR    | 26.28    | 28.14          | 28.20          | 28.08          |

Table 4. Result of image 4

| Image 4 | Robinson | Robinson + ACO |
|---------|----------|----------------|
|         | $\alpha = 1$, $\beta = 0.1$ | $\alpha = 2$, $\beta = 0.7$ | $\alpha = 0.1$, $\beta = 1$ |
Figure 2. Comparison chart value MSE of Robinson and Robinson + ACO

From the graph in Figure 2 can be drawn the conclusion that the MSE value of the Robinson edge detection is higher than Robinson + ACO (132.85-> 98.0125). The higher MSE value, then the view of image result will be even worse. This proves that Robinson + ACO better than Robinson.

Figure 3. Comparison chart value PSNR of Robinson and Robinson + ACO

From the graph in Figure 3 can be drawn the conclusion that the PSNR value of the Robinson edge detection is lower than Robinson + ACO (26.96-> 28.25). The higher PSNR value, than the view of image result is better. This proves that Robinson + ACO better than Robinson.

5. Conclusions

The results of optimizing Robinson operator use Ant Colony Optimization produces images with a more assertive and thick edge. Ant Colony is able to be used as a method for optimizing Robinson operator by correcting the image of Robinson detection average 16.77% than the results of Robinson detection. Robinson and ACO methods are able to detect the image edge with accuracy up to 79.90%. On the method of Ant Colony, if seen from the parameters of testing that the best results if seen from the morphology of the resulting edge line, MSE and PSNR, yield the best edge detection at the time $\alpha = 2, \beta = 0.7$.

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