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A REVIEW PAPER OF EDGE DETECTION USING ANT COLONY OPTIMIZATION TECHNIQUES

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Abstract— This paper examines ant colony optimization technique for edge detection. ACO is a technique to find out solutions for combinatorial optimization problem. The essential part of ACO algorithms is the combination of prior information about the structure of a solution with post information about the structure of previously obtained good solutions.

Keywords— Ant Colony Optimization, Edge Detection, Feature Extraction, Image Processing, Edge Models.

I. INTRODUCTION

Edge detection is a fundamental tool in image processing and computer vision in the areas of feature detection and feature extraction. The main aim of edge detection is to identifying points in a digital image at which the image brightness changes sharply or, more formally. Image edge detection deals with extracting edges in an image by identifying pixels where the intensity variation is high. It is a fundamental tool used in most image processing applications to obtain information from the frames as a precursor step to feature extraction and object segmentation. This process detects outlines of an object and boundaries between objects and the background in the image. The edge is the set of the pixel, whose surrounding gray is rapidly changing. The internal characteristics of the edge-dividing area are the same, while different areas have different characteristics. The edge is the basic characteristics of the image. There is a lot of information of the image in the edge. Edge detection is to extract the characteristics of discrete parts by the difference in the image characteristics of the object, and then to determine the image area according to the closed edge.

II. IMAGE PROCESSING

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image. Most image processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it [28].

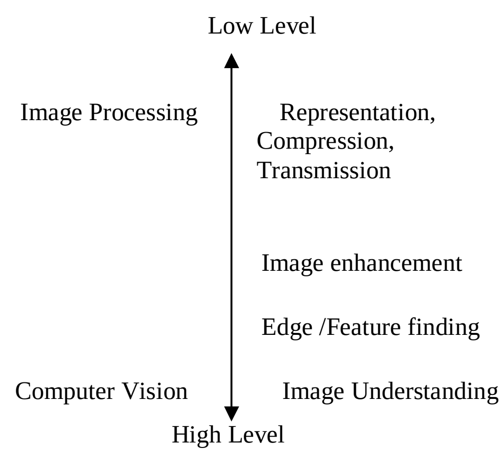

Figure 1 Image Processing

III. EDGE MODELS

The edges obtained from natural images are usually not at all ideal step edges. Instead they are normally affected by one or several of the following effects:

- Focal blur caused by a finite depth-of-field and finite point spread function.

- Penumbral blur caused by shadows created by light sources of non-zero radius.
- shading at a smooth object

A number of researchers have used a Gaussian smoothed step edge (an error function) as the simplest extension of the ideal step edge model for modeling the effects of edge blur in practical applications.[3][4] Thus, a one-dimensional image which has exactly

one edge placed at may be modeled as:

$$f(x) = (Ir - Il)/2(\mathrm{erf}\left(\frac{x}{\sqrt{2\sigma}}\right) +$$

At the left side of the edge, the intensity is

,

and right of the edge it is . The scale parameter σ is called the blur scale of the edge

IV. APPROACNHES TO EDGE DETECTION

There are many methods for edge detection, but most of them can be grouped into two categories, search-based and zero-crossing based. The search-based methods detect edges by first computing a measure of edge strength, usually a first-order derivative expression such as the gradient magnitude, and then searching for local directional maxima of the gradient magnitude using a computed estimate of the local orientation of the edge, usually the gradient direction. The zero-crossing based methods search for zero crossings in a second-order derivative expression computed from the image in order to find edges, usually the zero-crossings of the Laplacian or the zero-crossings of a non-linear differential expression. As a pre-processing step to edge detection, a smoothing stage, typically Gaussian smoothing, is almost always applied.

1) Edge detection based on gradient operator.

The edge is the place where image gray value is changing rapidly, so the method based on the derivation of the gradient operator is most widely used. The classical gradient operators are Sobel operator [1], Prewitt operator [2], Roberts operator, Laplacian operator.

2) Edge detection based on the optimum operator.

The gradient of the image edge is the maximum value, that is, the inflection point of the gray image is the edge. From the mathematical point of view, inflection point of the second derivative of the function is 0. Detecting this point, whose second derivative is 0 is a way of edge detection, for example, Marr-Hildreth operator[3], Canny operator[4,5].

3) Multiscale edge detection.

Wavelet transform is particularly suitable for signal mutation detection and edge detection. Rosenfeld [6] suggested a combined consideration on the edge detected by multiple dimensions operator; Marr advocated applying multiple scales of different operators, and put forward some combination rules.

4) Edge detection based on ant colony optimization:

(ACO) is a nature-inspired optimization algorithm [1], [2], motivated by the natural phenomenon that ants deposit pheromone on the ground in order to mark some favorable path

5) Some other methods.

The adaptive smooth filter method. The iterative computation of the smoothing filtering sharpens the signal edge. And then to detect the edge can get a high positioning accuracy. There are also methods based on integral transform and based on tensor.

V. ANT COLONY OPTIMIZATION

ANT colony optimization (ACO) is a nature-inspired optimization algorithm [1], [2], motivated by the natural phenomenon that ants deposit pheromone on the ground in order to mark some favorable path that should be followed by other members of the colony. This algorithm is used to solve many problems. ACO is introduced to tackle the image edge detection problem, where the aim is to extract the edge information presented in the image. Ant Colony Optimization is a paradigm for designing net heuristic algorithms for combinatorial optimization problems. ACO is a process whose aim is to identify points in an image where discontinuities or sharp changes in intensity occur.

Different steps of an ACO algorithm are the following:

- Problem graph representation
- Initializing ants distribution
- Node transition rule
- Pheromone updating rule

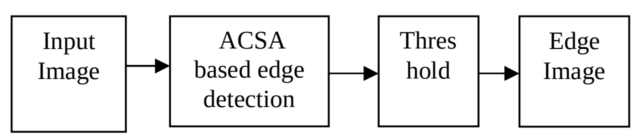

Figure 2 General steps for finding the edges of the given images

VI. PROBLEM DEFINITION

Image edge detection refers to the extraction of the edges in a digital image. It is a process whose aim is to identify points in an image where discontinuities or sharp changes in intensity occur. This process is crucial to understanding the content of an image and has its applications in image analysis and machine vision. It is usually applied in initial stages of computer vision applications. Edge detection is one of the fundamental problems in image analysis. The first ACO

algorithm proposed by Dorigo et al. Since then a number of ACO algorithms such as ant colony system, Max-Min ant system, ant colony algorithm for Solving continuous optimization problem, an improved ACO for solving the complex combinatorial optimization problem, has come in the fore. ACO has inspired from foraging behavior of some ant species. Ants deposit pheromone (a type of chemical) on the ground in order to communicate between the members of their community which also increases the probability that the other ants will follow the same path [39].
ACO is introduced to tackle the image edge detection problem, where the aim is to extract the edge information presented in the image, since it is crucial to understand the image's content [13].
The proposed approach starts from the initialization process, and then runs for N iterations to construct the pheromone matrix by iteratively performing both the construction process and the update process.
In the construction process four functions are taken (Flat, Quadratic, Sin, and wave) in computing the heuristic function. Finally, the decision process is performed to determine the edge. And then the comparison process is applied by varying the parameter values. In this we also define how edge detection is performed for a blurred image.

A. Initialization Process

Totally K ants are randomly assigned on an image I with a size of M1 × M2, each pixel of which can be viewed as a node. The initial value of each component of the pheromone matrix $\tau^{(0)}$ is set to be a constant $\tau_{(init)}$.

B. Construction Process

At the n-th construction-step, one ant is randomly selected from the above-mentioned total K ants, and this ant will consecutively move on the image for L movement-steps. This ant moves from the node (l,m) to its neighboring node (i, j) according to a transition probability that is defined as

$$P(i,j)n = \frac{(\tau i,j(n-1)}{\sum j \in \Omega i\ (\tau i,j(n-} \quad \ldots\ldots\ldots (1)$$

where $\tau_{i,j}^{(n-1)}$ is the pheromone information value of the arc linking the node i to the node j; Ω_i is the neighborhood nodes for the ant a_k given that it is on the node i; the constants α and β represent the influence of pheromone information and heuristic information, respectively; $\eta_{i,j}$ represents the heuristic information for going from node i to node j, which is fixed to be same for each construction-step.

There is a crucial issues in the construction process. The first issue is the determination of the heuristic information $\eta_{(i,j)}$ in (4). In this paper, it is proposed to be determined by the local statistics at the pixel position (i, j) as

$$\eta_{i,j} = 1/Z\ (V_c(I_{i,j})) \quad \ldots\ldots\ldots(2)$$

$I_{(i,j)}$ is the intensity value of the pixel at the position (i, j) of the image I, the function $V_c(I_{(Ii,j)})$ is a function of a local group of pixels c (called the *clique*), and its value depends on the variation of image's intensity values on the clique c (as shown in Figure 1). More specifically, for the pixel Ii,j under consideration, the function $V_c(I_{i,j})$ is

$$V_c(I_{i,j}) = f(|I_{i-2,j-1} - I_{i+2,j+1}| + |I_{i-2,j+1} - I_{i+2,j-1}| + |I_{i-1,j-2} - I_{i+1,j+2}| + |I_{i-1,j-1} - I_{i+1,j+1}| + |I_{i-1,j} - I_{i+1,j}| + |I_{i-1,j+1} - I_{i-1,j-1}| + |I_{i-1,j+2} - I_{i-1,j-2}| + |I_{i,j-1} - I_{i,j+1}|) \quad \ldots\ldots\ldots (3)$$

To determine the function f(·) in (3), the following four functions are considered in this paper;

$$f(x) = \lambda x, \qquad \text{for } x \geq 0,$$

$$f(x) = \lambda x^2, \qquad \text{for } x \geq 0,$$

$$f(x) = \begin{cases} \sin(\pi x/ 2\lambda) & 0 \leq x \leq \lambda; \\ 0 & \text{else.} \end{cases}$$

$$f(x) = \begin{cases} (\pi x \sin((\pi x/ \lambda))/ \lambda & 0 \leq x \leq \lambda; \\ 0 & \text{else} \end{cases} \quad \ldots\ldots\ldots\ldots\ldots(4)$$

The parameter λ in each of above functions adjusts the functions' respective shapes.

C. Update Process

The proposed approach performs two updates operations for updating the pheromone matrix.

• The first update is performed after the movement of each ant within each construction-step. Each component of the pheromone matrix is updated according to

$$\tau_{i,j}^{(n-1)} = \begin{cases} (1-\rho)\ .\ \tau_{i,j}^{(n-1)} + \rho.\ \Delta_{i,j}^{(k)} & \text{if (i, j) is visited by the current k-th ant;} \\ \tau_{i,j}^{(n-1)} & \text{otherwise} \end{cases} \quad \ldots\ldots\ldots(5)$$

Where ρ is the *evaporation rate*. $\Delta_{i,j}^{(k)}$ is determined by the heuristic matrix; that is, $\Delta_{i,j}^{(k)} = \eta_{i,j}$.

• The second update is carried out after the movement of all ants within each construction-step according to

$$\tau^{(n)} = (1-\psi).\ \tau^{(n-1)} + \psi.\tau^{(0)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

where ψ is the *pheromone decay coefficient*.

D. Decision Process

In this step, a binary decision is made at each pixel location to determine whether it is edge or not, by applying a threshold T on the final pheromone matrix $\tau^{(N)}$. In this paper, the above-mentioned T is proposed to be adaptively computed based on the method developed in [20].

E. Visualize Process

In this step, different values of the phi parameter are applied to the above algorithm. Smaller the value of the phi parameter more edges the algorithm detects in the image. As we go on decreasing the value of the phi parameter, output of the given image becomes clearer.

VII. CONCLUSION

This paper examined Ant Colony Optimization Algorithm for edge detection. Edge detection plays an important role in computer and image processing. The proposed approach yields superior subjective performance to that of the existing edge detection algorithm. The edge detection has better result if the image is noise free. It is difficult to find out edges in the noisy image because the proportion of noise is greater than data so that the corners of the image has got lost and no pixel for corner due to noise. Some time the edges detected as faulty when images are blurred.

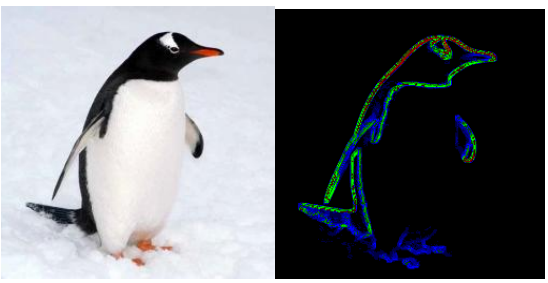

Figure 3: Edge detection of an image.

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