A Review of Computer Vision Using Ant Colony Optimization

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Abstract—Reliable feature recognition is necessary in broad fields of computer vision and image processing. Edges often act as primary artifacts of visual data. Edge detection is to mark sharp changes of the intensity or brightness of digital images. Canny edge detection and ant colony optimization detection are two essential edge detection approaches. The former is susceptible to noises presented on source images. The information loss occurs when Gaussian smoothing is used to improve connectivity of Canny edge detection. Edges can be also detected via other approaches. To avoid edge suppression and feature deformity, ACO has been proposed for edge and contour detection against false detection, by which more intrinsic information will be extracted. The evolutionary computation oriented ACO scheme is a promising approach for feature capturing without the necessity of smoothing filters. It is among the most effective approaches for edge detection. However, it may give rise to broken pieces of numerous true edges occasionally. To further improve accuracy, contour tracking schemes are needed to achieve stable feature recognition. Some intelligent schemes are too complex to handle in real time, so a simple adaptive contour tracking scheme has been proposed which is combined with enhanced ACO schemes. This technology integration will result in the sufficient true edge representation together with well connected linkage, which can be easily extended to contour detection of binary, grayscale and true color images. Using quantitative metrics, an objective study is made to evaluate performance outcomes based on integration of the ACO schemes and adaptive contour tracking.

Keywords—Feature Recognition; Ant Colony Optimization (ACO); Adaptive Contour Tracking; Qualitative Analysis.

I. INTRODUCTION

THIS paper is a review paper which provides an idea to combine the features of image processing and artificial intelligence together. Many methods have been introduced through which we can extract the relevant information which is needed. In this proposed work, the ACO technique is used for improving the image quality and extracting relevant information.

A. Ant Colony Optimization

Ant colony optimization (ACO) [1] is a technique that optimizes problems through guided search of the solution space [2]. The ACO metaheuristic was originally designed to solve the Traveling Salesman problem [3], but has since been extended to a wide range of applications. The ACO algorithm is inspired from the natural trail following behavior of ants. As an ant travels through paths, it drops pheromone, which then influences the selection of paths by the other ants. The deposits work like a positive feedback by reinforcing good choices. The first ACO algorithm was the Ant System [3]. Since then, other implementations of the algorithm have been developed. The ACO metaheuristic involves solution construction on a graph. Many ants travel through the solution space adding solution components to partial solutions until they reach a complete solution. The selection of the components depends on the pheromone content of the paths and a heuristic evaluation [2]. At each step of construction, ant $k$ selects the next node using a probabilistic action selection rule, which dictates the probability with which ant $k$ will choose to go from current node $i$ to next node $j$:

$$p_{ij}^k = \frac{[\tau_{ij}]^\alpha [\eta_{ij}]^\beta}{\sum_{l \in N^k_i} [\tau_{il}]^\alpha [\eta_{il}]^\beta}$$

if $j \in N^k_i$ (1)

where $\tau_{ij}^k$ is the pheromone content of the arc from node $i$ to node $j$, $N^k_i$ is the neighborhood nodes for ant $k$ given that it is on node $i$. The neighborhood only includes nodes that have not been visited by ant $k$. If all feasible nodes have been visited, then all neighbors of the current node become available for visit. The constants $\alpha$ and $\beta$ represent the influence of pheromone content and heuristic respectively. Experimental results recommend setting $\alpha = 1$ and $\beta$ from 2 to 5 [2]. Finally, $\eta_{ij}$ is the heuristic information for going from node $i$ to node $j$. The heuristic information is a measure of the cost of extending the current partial solution. Once a solution is built, it is evaluated and pheromone is deposited relative to the quality of the solution. The ants deposit pheromone on the arcs they visited as follows:

$$\tau_{ij}^{new} = \tau_{ij}^{current} + \sum_{k=1}^m \Delta\tau_{ij}^k$$ (2)

where $\Delta\tau_{ij}^k$ is the amount of pheromone ant $k$ will add to the arc going from node $i$ to node $j$, and $m$ is the total number of ants. The amount of pheromone added is defined by:
\Delta T_{ij}^k = \begin{cases} \frac{1}{C^k} \\ 0 \end{cases}

(3)

$C^k$ is the total cost of the path solution. All arcs in the same path will have the same cost value. Pheromone evaporation is also applied to all arcs following this relation:

$$\tau_{ij} = (1 - p) \tau_{ij} \quad 0 < p \leq 1 \quad (4)$$

Different steps of an ACO algorithm are the following:

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

![Fig 1 General steps for finding the edges of the given image](image)

**B. Computer Vision**

Computer vision is a field that includes methods for acquiring, processing, analyzing, and understanding images and, in general, high-dimensional data from the real world in order to produce numerical or symbolic information, e.g., in the forms of decisions.[4][5][6] A theme in the development of this field has been to duplicate the abilities of human vision by electronically perceiving and understanding an image.[7] This image understanding can be seen as the disentangling of symbolic information from image data using models constructed with the aid of geometry, physics, statistics, and learning theory.[8] Computer vision has also been described as the enterprise of automating and integrating a wide range of processes and representations for vision perception.[9]

Applications range from tasks such as industrial machine vision systems which, say, inspect bottles speeding by on a production line, to research into artificial intelligence and computers or robots that can comprehend the world around them. The computer vision and machine vision fields have significant overlap. Computer vision covers the core technology of automated image analysis which is used in many fields. Machine vision usually refers to a process of combining automated image analysis with other methods and technologies to provide automated inspection and robot guidance in industrial applications.

As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner.

As a technological discipline, computer vision seeks to apply its theories and models to the construction of computer vision systems. Examples of applications of computer vision include systems for:

- Controlling processes, e.g., an industrial robot;
- Navigation, e.g., by an autonomous vehicle or mobile robot;
- Detecting events, e.g., for visual surveillance or people counting;
- Organizing information, e.g., for indexing databases of images and image sequences;
- Modeling objects or environments, e.g., medical image analysis or topographical modeling;
- Interaction, e.g., as the input to a device for computer-human interaction, and
- Automatic inspection, e.g., in manufacturing applications.

Sub-domains of computer vision include scene reconstruction, event detection, video tracking, object recognition, learning, indexing, motion estimation, and image restoration.

In most practical computer vision applications, the computers are pre-programmed to solve a particular task, but methods based on learning are now becoming increasingly common.

![Fig 2 Relation between computer vision and various other fields.](image)

**II. DETECTING IMAGE EDGES USING ACO**

**A. Image Edge Detection**

Image edge detection refers to the extraction of the edges in a digital image. It is a series of actions whose aim is to identify points in an image where discontinuities or sharp changes in intensity occur. This series of action is crucial to understand the content of an image [10,11] and these extracted edge points from an image provides an insight into the important details in the field of image analysis and machine vision [12]. It acts as a pre-processing step for feature extraction and object recognition [13]. It is normally applied in initial stages of computer vision applications. The purpose of detecting sharp changes in image intensity is to capture significant events and hangs in the physical properties of the world. Under general assumptions about the image formation process, the causes of intensity changes usually correspond to two types of events one is Geometric events and other is Non-geometric events.
Geometric events consist of discontinuities in surface orientation, discontinuities in depth, discontinuities in color and texture. Non-geometric events consist of changing illumination, shadows and inter-reflections [10,11]. Conventional approaches to edge detection like SOBEL operator [14], Prewitt operator [15], Robert’s operator [16], LoG operator [17] and CANNY operator [18] detection techniques are computationally expensive because each set of operations is conducted for each pixel. In normal courses, the computation time quickly increases with the size of the image. However, most of the existing detection techniques use a huge search space for the image edge detection [19]. Therefore, without optimization the edge detection task is memory and time consuming. An ACO constituent course has the potential of overcoming the limitations of conventional methods. Several ACO-based approaches to the edge detection problem have been proposed [20, 21]. AS is the first ACO algorithm. Since its development, a number of extensions have emerged. One of the successful ones is ACS.

B. ACO Based Image Edge Detection

In this proposed method, number of ants move on a 2-D image, stepping from one pixel to another to construct a pheromone matrix, which determine the edge information for each pixel location in the image to extract the edges of the image. The movement of the ants is directed by the local variation of the image’s intensity values [22]. Image Edge detection [21, 23] process has the following steps: first is the initialization process. After this pheromone matrix is constructed by the ACO when it further runs for N no. of iterations. Iterative process consists of construction process and update process. The last is decision process by which edge is determined.

III. LITERATURE SURVEY

The Previous work on image edge detection performed by various researchers is given below.

1. Raman Maini & Dr. Himanshu Aggarwal proposed a comparison of various image edge detection techniques of Gradient and Laplacian based edge detection. Gradient-based algorithms such as Prewitt filter have a major drawback of being very sensitive to noise. The kernel size and coefficients are fixed and cannot be adapted to a given image. Therefore, an adaptive edge detection algorithm is necessary to provide a robust solution that is adaptable to the varying noise levels of these images to help distinguish valid image contents from visual artifacts introduced by noise.

2. Marco Dorigo, Gianni Di Caro and Luca M. Gambardella proposed ant algorithms for discrete optimization which introduces the ant colony optimization (ACO) meta-heuristic and the basic biological findings on real ants and their artificial counter parts while in the other part a number of applications to combinatorial optimization and routing in communications networks are described.

3. Shweta Agarwal performed Edge detection in Blurred images using Ant Colony Optimization Technique. Edge detection in blurred digital images and prioritized them using different color values according to their strength and importance. Here algorithm does not consider image deblurring hence eliminating any chances of data loss and a blur image will produce multiple edges in an area of concern is few among these edges will be non-prominent and less useful.

4. Anna Veronica Baerina, Carlos Oppus proposed edge detection using ant colony optimization in which they established a pheromone matrix that represents the edge information at each pixel based on the routes formed by the ants dispatched on the image.

Here results are based on at different values of parameter controlling the degree of exploration of the ants. Increase in the parameter value results in smoother edges. The value should be between, but not equal to, 0 and 1 because it causes some significant features to be missed. Therefore, higher values of parameter controlling the degree of exploration of the ants are suitable for images that contain less amount details while lower values are suitable for those that contain more details.

IV. CONCLUSION

An algorithm will be framed which will contain the features of computer vision and ACO. Image features are extracted using ACO technique. Noise removal will also be there. The feasibility of the algorithms will be based on the PSNR ratio.

REFERENCES