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A HYBRID ACPSO BASED EDGE DETECTION METHOD FOR GRAY LEVEL IMAGES

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Abstract— Edge information the most major image edge and it incorporates the helpful information for image recognition. It has provided valuable and important for people to recognize the target and interpret the image. This paper is combine two methods together and performs image edge detection. This method conducts ant colony optimization (ACO) and particle swarm optimization (PSO) on the image and transforms its sub-optimal solution to the distribution of initial pheromone. It performs ACO and shows the edge information of the image. An image edge detection method based on Hybrid Ant Colony and Particle Swarm Optimization (ACPSO) is proposed in this paper to handle the following defects: the traditional image edge detection methods are not good at image edge detection, they are trapped into local optimum easily, they can lose balance between two mechanisms: random and positive feedback easily and they are too slow in convergence speed. Edge detection method plays an important role in image processing. It consists in detecting edges or contours in images which allows extracting information from them. A method requests to develop that can identify edges clearly in a noisy image. The ACPSO method is applied to find image edge detection. The proposed ACPSO method presents better edges then traditional method.
Index Terms— Edge Detection, ACO, PSO, ACPSO, Positive Feedback, Pheromone

INTRODUCTION

Edge detection is an important foundation for the research of such fields as image fusion, image segmentation, shape extraction, image matching and image tracking [1]. In reality, a great number of incomplete or fuzzy image data are usually contained in the image, the image edges in particular .edge information usually partially hidden or distorted for various factors [2]. As the most basic image feature, edge information contains the useful information that can be used for image recognition and provides a valuable and significant feature parameter for people to describe or recognize targets and interpret the image [3].

Swarm intelligence method is a significant branch of artificial intelligence biological bionics, including genetic method with genetic mechanism, ant colony optimization which simulates the foraging behaviors of ants and the particle swarm optimization drawn from the predation of birds [4]. Ant colony optimization (ACO) has such strengths as positive feedback, distributive and robustness and it can be applied in many fields while on the other hand, image has significant meaning in real life and edge is key factor of image, so exploration has been made on the image edge detection method of ACO [5]. Then, the procedures of edge detection and analysis have conducted specific, leave pheromone on the edge pixel points and construct pheromone matrix, it is proven by the final experiment that the edge information obtained with algorithm is complete.

One of the basic issues in image processing and computer vision is identifying the sudden changes of brightness in a defined as the boundary between the objects and the background or the boundary between overlapping objects. There are many methods for extracting and detecting the edge [6]. Most edge detector programs determine the color or the intensity values of the edge pixels. In images without noise, edges are recognized by the gray level changing at a specific pixel.

PSO is a population-based evolutionary method for problem solving based on social-psychological principles [7]. In the PSO is used as a method to optimize the parameters of gradient operator. The edge detection method based on PSO is use of this strong point [8]. Hence it could provide a great potential to detect the edge where many pixel positions essential to be found [9]. The PSO method have a good performance of detecting simple and regular edges but also in detecting complex edges on noisy images with complex textures.

This approach will be observed and compared with the common operators Sobel and canny edge detectors on three image sets of varying difficulty. This paper contents five parts. The section II provides some literature review. The proposed new edge detection based on ACPSO is introduced in the section III. In section IV have some experiment and results and finally section V gives the conclusion.

II. LITERATURE REVIEW

Ant Colony Optimization (ACO) is inspired by the behavior of real ant colonies to approximate the solutions of optimization problems [15]. It is introduced to tackle the image edge detection problem based on the distribution of ants on an image. To standard edge detectors is less sensitive to Gaussian noise and gives details and thinner edges when compared to earlier ant-based approach [16]. A pheromone matrix that represents the edge presented at each pixel position of the image, according to the movements of ants on the image. When compare edge detector with other ant-based approaches to standard edge detectors is less sensitive to Gaussian noise.

An edge detection technique that is based on ACO is establishing pheromone matrix that represents the edge information at each pixel based on the routes formed by the ants dispatched on the image [17]. The success of the technique in extracting edges from a digital image and an ant will move from a given node to another. This value is influenced by the heuristic information and the pheromone information. The feasibility of the approach in identifying edges in an image with suitable parameter values, the algorithm able to identify edges in the canonical test images. The performances of ACS have been explored and ants are assigned different pheromone sensitivity levels, which makes some ants more sensitive to pheromone than the others. The ACS method for edge detection could be extended and possibly be improved by making use of such technique [20]. The image edge detection issues where the purpose is to evolve the edge information in the picture, since it is critical to understand the image content. The discovery of good tours is the positive feedback done through the pheromone update by the ants. ACO is introduced to confront the image edge detection problem, it is critical to understand the image content where the intention is to evolve the edge information presented in the image.

Image edge detection is a technique of segmenting an image into regions of discontinuity thereby marking sharp changes in intensity [21]. A modified ACO method to detect the edges in an image by updating the pheromone matrix twice and using weighted heuristics. The method can be deliberated as an improvement to the original ant system can handle broken edges in an image. Certain changes to the original approach render accuracy in detecting the edges and the quality of edges detected is low. Edge detection is usually used as a preprocessing operation in many machine vision industrial applications. A convenient and robust method for edge detection based on ACO which employs a new heuristic function, adopts a user defined threshold in pheromone update process and provides a group of suitable parameter values. The presence of noise outperforms ACO based edge detection techniques and four conventional edge detectors. Many edge detection methods have been proposed in the last decades. Unfortunately blur edges while removing noises in the image [24].

Handwriting recognition has been a major topic of research but the recognition of handwritten characters using deep learning has been a hot topic of research in the past five years [25]. This system provides reducing the hectic task of manually going through the handwritten documents in places such as banks and post offices. The particle swarm optimization to minimize the fitness function and observed that the method has worked quite well in detecting the edges and the edges detected are an improvement over the first derivative based edge detectors. PSO is an easy to apply optimization technique that does not require much complex calculations and it works for a population of particles and as a result provides more effective results. A large area of the image by considering a large population size and improves the localization accuracy. The main disadvantage of Sobel operator is it is not giving complete view of all edges [22].

The fuzzy heuristic edge detector that is fused into a PSO has proven to be successful as an edge detection operator [8]. The FPSO edge detection technique proves to be sensitive to detect the IC or weaker edges and the OC or strong edges thus making it a promising method for the measurements of the cortical. To test the accuracy by comparing the measurements obtained from this method and ground truth values. The cognitive component quantifies the individual past performances or resembles individual memory of the position that was best for the particle. This component suggest that the particles will be drawn back to their own best positions, resembling the tendency of individuals to return their past most satisfied situations or places.

Edge detection is a fundamental tool for the basic study of human brain particularly in the areas of feature detection and feature extraction [9]. The original MRI image is subjected to image segmentation which is done using Particle Swarm optimization combining Fuzzy C-Means Clustering method. This technique yields edge detected image of the human brain as compared to other edge detection methods. A heuristic approach based on biologically stimulated Particle Swarm Optimization (PSO) is suggested to be used at multiresolution level to increase the quality of detected edges. In the pre-processing stage, one level of Discrete Wavelet Transform (DWT) or Dual-Tree Complex Wavelet Transform (DT-CWT) is applied to the input image to create new subbands images [11]. SO was applied on the decomposed subband images in order to gain more connected edges. Some of these aforementioned challenges lead edge detectors to problems such as detection of broken edges, false edge detection and artifacts which distort the original information in the image.

Applying an edge detector to an image, in the ideal case, may obtain a set of connected curves which indicate the boundaries of objects [13]. The use of the PSO algorithm on the pixel in the image except whose gradient is nonzero and these pixels which are around the curve have found rather than on the all pixels in the image. The task is tried to shorten the time of the algorithm and detect edge in the image with more complexity. The existing edge detection algorithms like Canny and Sobel are lack in edge preservation factor. These algorithms are not good for noisy images. The general basic step obtained is to convert the image into grey scale i.e. black and white image and then applying steps of the algorithm. Now-a-days we need more specific images so that the treatment over various diseases and problems could be cured as soon as possible.

III. METHODOLOGY

Hybrid Method Ant Colony and Particle Swarm Optimization (ACPSO)

Due to the equal probability of selecting noise and edge points, traditional ACO is not anti-noise. In order to suppress the noise, median filter is adopt in preprocessing, which eliminate the random noise effectively. After each update, the particle swarm obtains a set of better parameters, which is sent to ACO for edge detection. Then fitness value is calculated to present the quality of the detected edge. Particles move to better directions founded on the value, and update the location of next generation. New location parameters are used by ACO for detection, until reaches the iteration time. Then output the parameters of optimal location and the edge image. To improve efficiency and reduce iterations, this study only updates local pheromone for detection. The proposed image edge detection of ACPSO methods includes following steps:

Ant Colony Optimization (ACO)

Ant Colony Optimization (ACO) method Proposed by Dorigo which is metaheuristic inspired by foraging behavior of real ants which means of a colony of artificial ants which cooperate and communicate indirectly. It has been successfully applied to problems such as vehicle routing, scheduling, image processing and bioinformatics graphs. To achieve this, ant moves on vertexes of a weighted and connected graph, applying a state transition rule. Ants are social insects which are studied by researchers from different areas. One behavior studied is the search food. While walking from food source to their nest and vice-versa, real ants deposit a chemical substance called pheromone on the ground.

Step 1: Initialization Process

In initialization process for an image I of size M x N is taken as input which work as a solution space for the artificial ants. The K numbers of ants are arbitrarily moved over the entire image such that the every pixel of the image is observed as a node. The constant is assigned to each which is the initial value of every component of the pheromone matrix τ^((0)) as a constant τ_init

Step 2: Construction Process

During the nth step of construction, one ant being randomly selected from K total ants and this ant move over the image for L steps. This ant will move from the (l, m) node to (i, j) node which is its neighboring pixel, is specified by the transition probability given by the equation (1).

$$P_{(l,m)(i,j)}^{(n)} = \frac{(\tau_{i,j}^{(n-1)})^{\alpha}(\eta_{i,j})^{\beta}}{\sum_{(i,j)\varepsilon\Omega_{(l,m)}}(\tau_{i,j}^{(n-1)})^{\alpha}(\eta_{i,j})^{\beta}} \quad ...(1)$$

Here represents the pheromone value at node (i, j), Ω (l, m) is the neighbourhood of nodes of the node (l, m), heuristic information at node is represented by (i, j). The constants α and β shows the influence of the pheromone matrix and heuristic matrix respectively.

Step 3: Update Process

This process performs two operations to update the pheromone matrix. The first update is performed after the construction process step. Update each component of the pheromone matrix according to the following expression:

$$\tau_{i,j}^{(n-1)} = \begin{cases} (1-\rho).\tau_{i,j}^{(n-1)} + \rho.\Delta_{i,j}^{(k)}, & if\ the\ k-th\ ant\ gp\ through\ (i,j) \\ \tau_{i,j}^{(n-1)}, & otherwise \end{cases} \quad ...(2)$$

Among them, $\Delta_{i,j}^{(k)}$ is decided by heuristic matrix, which means $\Delta_{i,j}^{(k)} = \eta_{i,j}$. The second update operation needs to satisfy:

$$\tau^{(n)} = (1-\psi).\tau^{(n-1)} + \psi.\tau^{(0)} \quad ...(3)$$

Step 4: Decision process

The solution is based on the values in the final pheromone matrix. This is done to be able to classify each pixel as either an edge or a non-edge. Though, when it comes to analysing the work carried out by the ant collective in image edge detection, a result showing various degrees in intensity values is just as good as a black and white declaration. Hence, in an ant's image edge detection, the solution is a direct result of the values in the final pheromone matrix. In this step, a binary decision is made at each pixel location to determine whether it is edge or not. The decision is made by applying a threshold τ on the final pheromone matrix. Here the threshold value τ chosen to be adaptively computed.

C. Particle Swarm Optimization (PSO)

Every single particle i in a populace has the following possessions: a recent location in an inquest zone, a recent speed, vi, and a local best location in inquest zone, yi. The local best location reacts to the location in inquest zone, where the objective function f provided the least calculated error for the particle i. the location that produced the least error throughout all the yi is known as the global best location and is represented by y'. The local and global best locations are updated using (4) and (5), respectively. It is supposed that the swarm consists of s particles, thus i ∈ {1,...,s}

$$y_i(t+1) = \begin{cases} y_i(t) & if\ f(x_i(t+1)) \le f(y_i(t+1)) \\ x_i(t+1) & if\ f(x_i(t+1)) > f(y_i(t+1)) \end{cases} \quad ...(4)$$

$$y'(\mathrm{t}) \in \{(y_0(t), y_1(t), \dots, y_s(t)\},$$
$$f\big(y(t)\big) = \min\{f(y_0(t)), f(y_1(t)), \dots, f(y_s(t))\} \quad ...(5)$$

Throughout every loop, every particle in the group is updated utilizing (6) and (7). The randomly generated, $r1$ and $r2$ would be used to influence the nature of the procedure. For all measurement, $j \in \{1, \dots, n\}$, let xi,j , yi,j and vi,j be the recent location, recent local best location and speed of the jth dimension of ith particle. The inertia weight w is utilized to control the convergence behavior of the PSO and the constants $c1$ and $c2$ control how far a particle will move in a single loop The speed update step is:

$$v_{i,j}(t+1) = \mathrm{w}v_{i,j}(t) + c_1 r_{1,j}(t) - x_{i,j}(t)\big[y_{i,j}(t) - x_{i,j}(t)\big] + c_2 r_{2,j}(t) - x_{i,j}(t)\big[y'_j(t) - x_{i,j}(t)\big] \quad ...(6)$$

The next of the particle x_i (t+1) is decided by adding the new speed v_i(t+1) to the particles recent position x_i(t),

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad ...(7)$$

Each measurement value of speed vector vi is arranged to the range [− , $vmax$] to in order to decrease the probability of the particle leaves the inquest zone. The value of $vmax$is typically selected to be k ×, with 0.1 ≤ k ≤ 1.0 [11], where $xmax$ represents the field of the inquest zone. Notice that the value of xi is not limited to the range [−, $vmax$]; it is just restricting the greatest displacement which a particle is capable of achieve throughout a single loop. Normally, execution of the PSO modifies the value of w throughout the training run, and linearly decreasing it from 1 to near 0 over the run. The acceleration coefficients, $c1$ and $c2$ control the maximum distance a particle will cover in one loop.

D. Algorithm (ACPSO)

```
Step 1:  Read the image
Step 2:  Perform preprocessing on image using Median filter
Step 3:  Initialization of particle swarm matrix:
         Set ranges of particle swarm parameters; randomly select a group of particles
Step 4:  Calculate the value of edge quality evaluation function in PSO, i.e. Adpf:
              For k = 1 to particle SwarmSize
                   Image edge detection
              For m = 1 to ant StepNum
              For n = 1 to AntNum
                   Calculate the transition probability with formula (2), the ant moves to the next position
              End For
                   Update the pheromone matrix with formula (3)
              End For
                   Threshold segmentation, edge extraction; calculate Adpf value of parameters
              End For
Step 5:  PSO iteration:
         For i = 1 to the iterations LoopCount:
             Update the particle velocity and position with formula (6) (7);
             Calculate edge quality of new particle group
         End For
```

IV. EXPERIMENTAL RESULTS

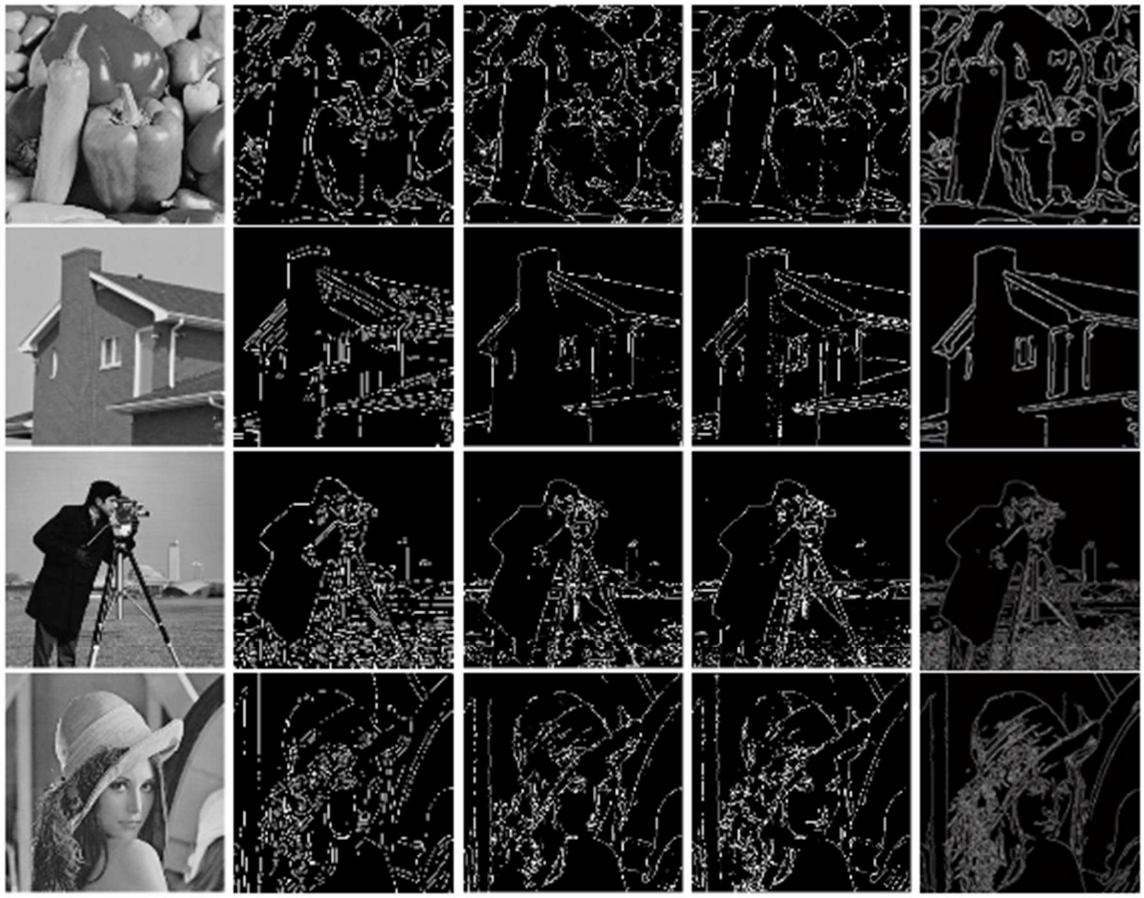
It can be seen from the experiment that the proposed ACPSO method can extract excellent image edges with clear contours and continuous edges. In the edge detection with traditional method, noises and false edges occurs easily and edges are sub-divided. Besides, this method can effectively filter the background information of the image and preserve the target information only. It extracts single line and there exist no double edges, therefore, it is clear that the edge detection method of ACPSO is a very effective method. In Fig. 1. Shows test results of standard images using different edge detection methods. The proposed method ants can find more edge points and reduce the search time under the same motions, through collaboration strategy, the ants can be obtained and the search efficiency has been improved. Therefore, this method can better solve the inflexible search step length of ants. The purpose of this paper was to find the edge of the image in noisy image. However, a majority of edge detector to remove noise effects precisely.

Mean Squared Error

The Mean Squared Error (MSE) incorporates degradation function and statistical characteristics of noise in the edge detected image. It measures the average squared difference between the estimator and the parameter. The higher MSE indicates a greater difference between the original and processed image.

$$\text{MSE} = \frac{\sum_{M,N}[I_1(m,\ n) - I_2(m,\ n)]^2}{M,\ N} \qquad ...(8)$$

Where I1 is original image and I2 is edge detected image, m and are height and width of the image. The MSE should be higher to ensure it found more edge points on the image and also it capable of detect weak edge points.



(a) (b) (c) (d) (e)

Fig. 1. Test Results of Standard Images Edge Detection (a) Original Image (b) Canny Operator (c) Log (d) FCMACO (e) ACPSO

Peak Signal to Noise Ratio

Peak Signal to Noise Ratio (PSNR) is ration between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR is usually expressed in terms of the decibel. PSNR is a rough estimation to human perception of reconstruction quality. In edge detection PSNR should lower to achieve proper results. The PSNR is calculated based on the MSE by,

$$PSNR = 10log_{10}\left(\frac{R^2}{MSE}\right) \quad ...(9)$$

R is the maximal variation in the input image data. If it has an 8 bit unsigned integer data type, R is 255.

Special Parameter of Edge Quality Evaluation

The edge quality is taken as the parameters optimization standard of the fitness function in PSO and it is represented by the edge quality evaluation function. More edge points detected, the better the edge quality of edge detection. In this method improved of the connected component and the edge points are combined to obtain rich edge information. The improved edge quality evaluation function that is the fitness function is calculated as,

$$Fitness\ function = \frac{N_{8\ connected}}{N_{4\ connected} \cdot N_{edg\ \ point}} \quad ...(10)$$

If the value of the evaluation function is lesser, which means the eight connected components become smaller, while four connected components and edge points are comparatively more, keep sufficient edge points information. Simulation experimentations display that this method is feasible and reliable with the visual observation. In order to demonstrate the effect of edge evaluation function, different standard images were detected by four operator techniques. The comparison of detect effects by method of and the proposed evaluation function is shown in TABLE I and TABLE II. As mentioned above, the smaller the value of edge evaluation function, the better the effect of image edge detection.

TABLE I. COMPARISON OF DIFFERENT METHODS

Images/ Methods	Canny		Log		FCMACO		ACPSO	
	MSE	*PSNR*	*MSE*	*PSNR*	*MSE*	*PSNR*	*MSE*	*PSNR*
Peppers	0.283	53.562	0.282	53.688	0.293	53.442	0.276	52.952
House	0.286	53.567	0.281	53.644	0.292	53.411	0.272	52.807
Cameraman	0.284	53.588	0.278	53.690	0.291	53.492	0.263	52.921
Lena	0.283	53.605	0.276	53.708	0.297	53.508	0.258	52.843

TABLE II. COMPARISON OF DIFFERENT METHODS

Images/Methods	Canny	Log	FCMACO	ACPSO
Peppers	0.302	0.199	0.196	0.174
House	0.332	0.388	0.138	0.116
Cameraman	0.335	0.235	0.228	0.185
Lena	0.241	0.162	0.102	0.100

V. CONCLUSION

Image edge detection directly affects the processing of the entire image, so, the research on image edge detection is of great importance. Both ant colony optimization and particle swarm optimizations are swarm intelligence methods and with their positive feedback, distributive and robustness, they have been widely applied in many fields while image edge is a key factor of image. So in this paper research has been made on the image edge detection method based on ant colony optimization and particle swarm optimization. The combination of the global search ability of particle swarm optimization and the fast convergence of ant colony optimization can improve the convergence time of the hybrid method and prevent local convergence. The experiment has demonstrated that this method has many excellent features and better edge detection accuracy.

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