Proceedings of the 2009 IEEE International Conference on Systems, Man, and Cybernetics
San Antonio, TX, USA - October 2009

Image Classification and Processing using Modified Parallel-ACTIT

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***Abstract*—Image processing and recognition technologies are required to solve various problems. We have already proposed the system which automatically constructs image processing with Genetic Programming (GP), Automatic Construction of Tree-structural Image Transformation (ACTIT). However, it is necessary that training image sets are properly classified in advance if they have various characteristics. In this paper, we propose Modified Parallel-ACTIT which automatically classifies training image sets into several subpopulations. And it optimizes tree-structural image transformation for each training image sets in each subpopulations. We show experimentally that Modified Parallel-ACTIT is more effective in comparison with ordinary ACTIT.**

***Index Terms*—Image Processing, Evolutionary Computation, Parallel Processing**

I. Introduction

For realization of machine intelligence, image processing and recognition technologies are getting more and more important. However, it is difficult to construct image processing in each problems. Therefore, general-purpose method which constructs image processing without depending on problems becomes necessary.

On the other hand, the Evolutionary Computation[1][2][3] researches are applied to image processing popularly[4]. Evolutionary Computation is an optimizing algorithm inspired by evolutional processes of living things. The authors have already proposed the system which automatically constructs an image-processing filter, Automatic Construction of Tree-structural Image Transformation (ACTIT)[5]. In this system, ACTIT approximates a required image processing by combining tree-structurally several image-processing filters prepared in advance with Genetic Programming (GP)[3], a kind of Evolutionary Computation. We have ever shown that ACTIT is the effective method for many problems.

However, it is difficult that ACTIT constructs an effective image processing which is applied to all images in case there are many and various images. Therefore, it is necessary that training image sets are properly classified in advance if they have various characteristics. In this paper, we propose Modified Parallel-ACTIT which automatically classifies training image sets and constructs effective image processing for each images. We describe the experimental results of comparison of ordinary ACTIT and Modified Parallel-ACTIT.

This paper is composed of the followings. Section 2 explains the related works, ACTIT, and parallel processing in Evolutionary Computation. Section 3 describes Modified Parallel-ACTIT, which is the proposed system in this paper. Section 4 experimentally shows that the proposed system is effective. Finally, section 5 describes conclusions and future works.

II. Related Works

A. ACTIT

Automatic Construction of Tree-structural Image Transformation (ACTIT)[5] is one of the researches of image processing using Genetic Programming (GP)[3]. In this system, ACTIT automatically constructs a tree-structural image transformation by combining several image-processing filters prepared in advance with GP by referring to training image sets. The individual in GP is a tree-structural image transformation. A tree-structural image transformation is composed of terminal nodes which mean input images and non-terminal nodes which mean several kinds of image-processing filters and a root which means an output image.

Fig. 1 shows the processing flow of ACTIT system. We prepare training image sets including several original images, their target images and weight images which indicate the important degree of pixel. We set parameters which GP uses to optimize tree structure, and give training image sets to ACTIT. Then ACTIT optimizes tree-structural image transformation with GP. As a result, we can get an optimized tree-structural image transformation which has the maximum fitness.

The tree-structural image transformation applies a certain processing to images which have the same characteristics. If the constructed tree-structural image transformation is appropriate, we can expect the similar effects to the images having the same characteristics as the learned ones. We have ever shown that ACTIT is an effective method for many problems, for instance, 2D image processing for detections of defects, 3D medical image processing[6] and so on.

B. Parallel Processing in Evolutionary Computation

Many researches proved the performance of GA (Genetic Algorithm) and GP in parallel[7][8]. The followings show the main parallel model in GA and GP.

1) Island Model: In Island model, the population in GA and GP is divided into parts of population (Island). Each part of population is assigned to multiple processors. And

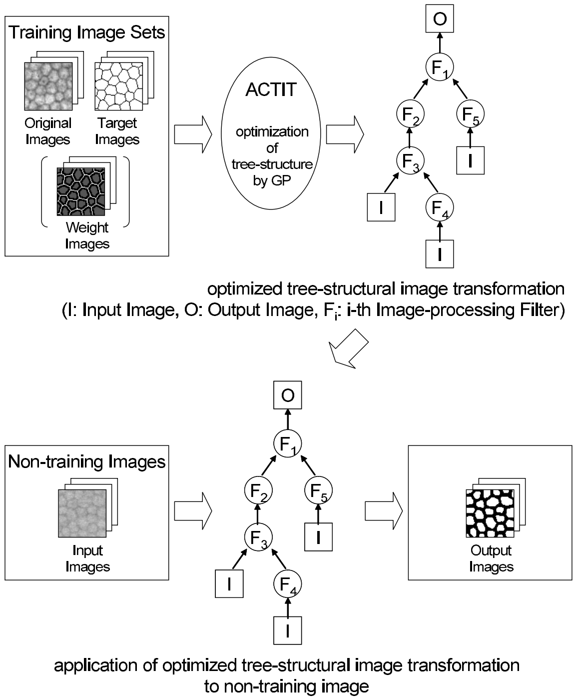

Fig. 1. The processing flow of ACTIT system.

each part of population is applied to normal genetic operator in parallel. Besides, exchanging individuals between parts of population (Migration) is performed. In Island model, each part of population independently evaluates. Therefore we expect that they keep variousness of the whole population. Fig. 2 shows Island model.

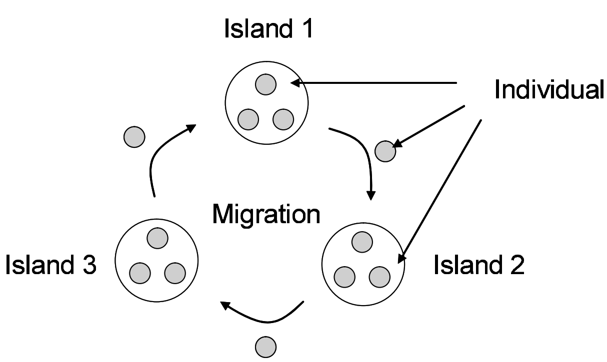

Fig. 2. Island model.

2) Master-slave Model: In Master-slave model, fitness of individuals in GA and GP are calculated fast in parallel. Master-slave model is generally composed of one control node (Master) and multiple calculation nodes (Slaves). In Master-slave model, one control node performs genetic operators composed of selection, crossover and mutation. And multiple calculation nodes share calculating fitness of individuals which costs computing time. Fig. 3 shows Master-slave model.

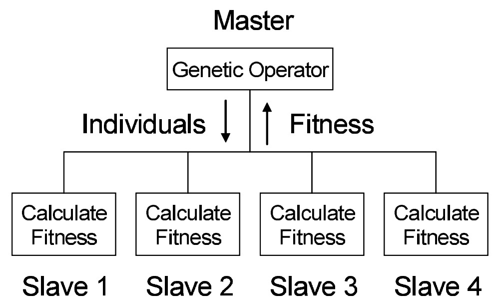

Fig. 3. Master-slave model.

III. Modified Parallel-ACTIT

A. Construction of Image Classification and Processing

ACTIT system is the effective method for many problems. However, it is difficult that we obtain an effective image processing which is applied to many and various training image sets. Therefore, it is necessary that training image sets are properly classified in advance if they have various characteristics. But a manual classification of many and various images is very hard for human. So we propose Modified Parallel-ACTIT which automatically classifies training image sets into several subpopulations and constructs tree-structural image transformation for each training image sets in each subpopulations.

Fig. 4 shows the processing flow of the proposed system. In the proposed system, the population in GA and GP is divided into parts of population like Island model. Each part of population is applied to normal genetic operator in parallel. And each part of population has different training image sets in each generation.

$Best\_island[i]$ is defined as the part of population which has the best individual for training image set $i (0 \leq i < training\_num)$. $Best\_fitness[i]$ is defined as the fitness of the best individual for training image set i. The best individual is the most effective tree-structural image transformation which is applied to training image sets in each generation. A control node calculates $best\_island[i]$ and $best\_fitness[i]$ for all training image sets at a uniform generation. The following shows how to calculate fitness of the individual in island $n (0 \leq n < island\_num)$. In case island n equals $best\_island[i]$, the fitness is difference of a target image and an output of image processing like ordinary ACTIT. In case island does not equal $best\_island[i]$, the fitness is the maximum of ordinary fitness and $best\_fitness[i]$.

Each part of population does not care unfavorite training image sets. Therefore each part of population constructs a favorite and different image processing each other. Finally, training image set i is classified into $best\_island[i]$ in final generation.

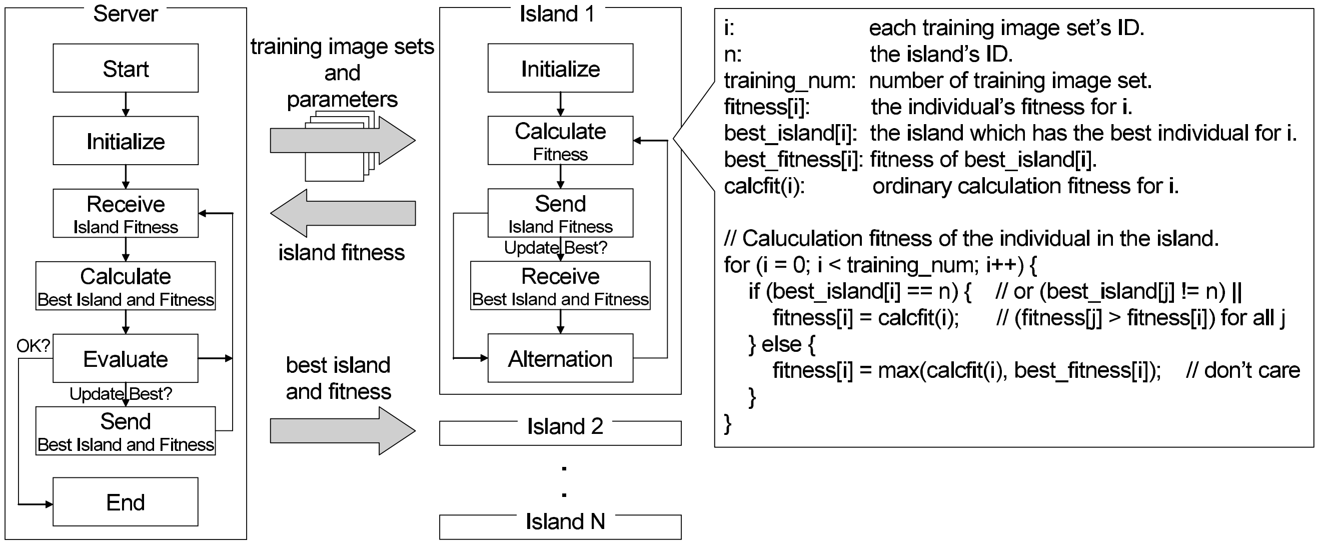

Fig. 4. The processing flow of proposed system.

B. Application to Non-training Images

It is necessary to applies optimized tree-structural image transformations to non-training images that we select an image transformation which is applied to non-training images. Therefore, the proposed system constructs a classifier by learning from image features which training image sets have. And an effective image transformation is selected basing upon classification result in case of applying a classifier to non-training images. We employ Support Vector Machine (SVM)[9] as a classifier.

Fig. 5 shows application of optimized tree-structural image transformations to non-training images. First, we input training image sets to the proposed system. Then we obtain classification results of training image sets and optimized tree-structural image transformations. Next, the proposed system calculates image features of training image sets and constructs a classifier by learning from image features. Image features are average, maximum, minimum value in the whole image and so on. Image features of non-training images are also calculated and input to a classifier. An effective image transformation is selected basing upon classification result are applied to non-training images. And we obtain output of image processing.

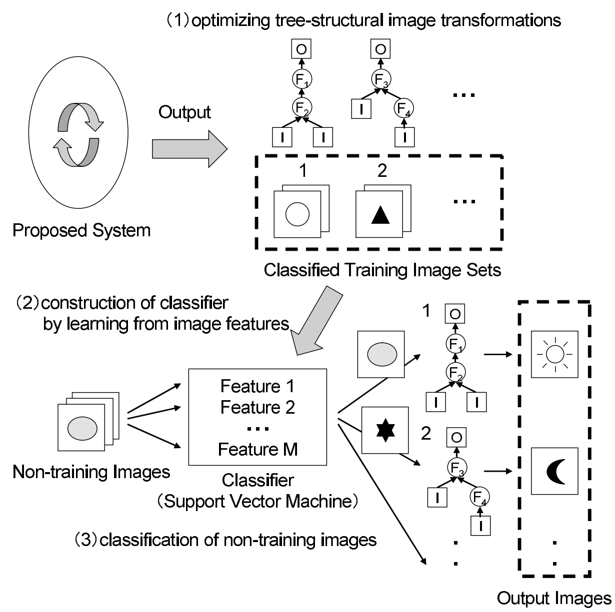

Fig. 5. Application of optimized tree-structural image transformations to non-training images.

IV. Experiments

A. Experimental Setting

We compared the performance of the proposed system with ordinary ACTIT. We employed six coins segmentation images and six concrete cracks detection images as training image sets. Fig. 6 and Fig. 7 show training image sets. These images have various characteristics, object color, background, lightness, and a border between textures. The total number of islands (classes) is three. GP parameters are employed general values.

B. Experimental Results

Fig. 8 and Fig. 9 show identifications of classification results (shown above images), output images, and the fitness of image processing. Identifications of classification results and output images are the best ones of five trials. The fitness of image processing are average value of five trials.

First, we refer to classification results of training image sets. Coins segmentation images are classified into three classes,

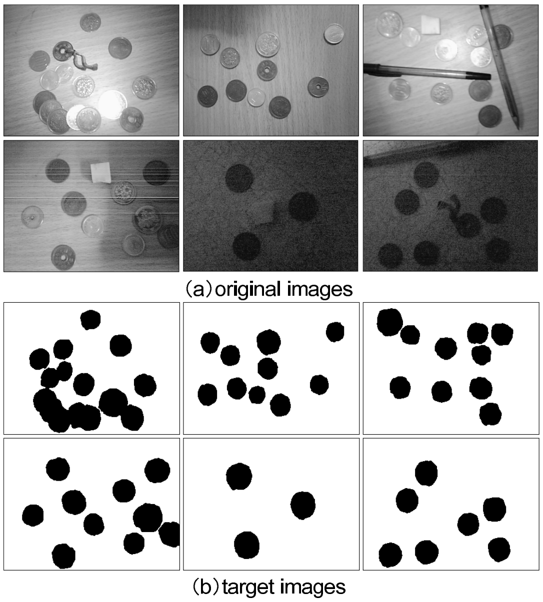

Fig. 6. Coins segmentation images.

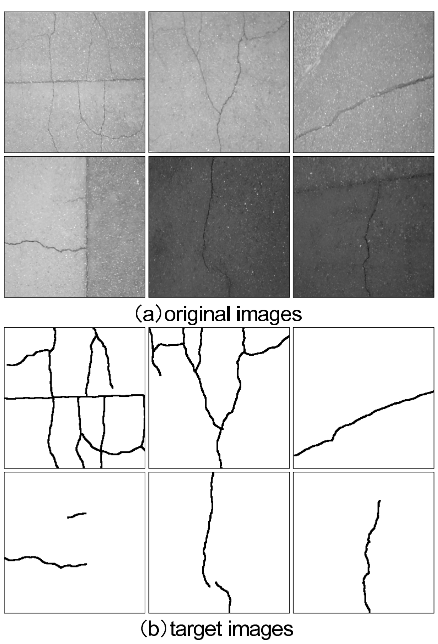

Fig. 7. Concrete cracks detection images.

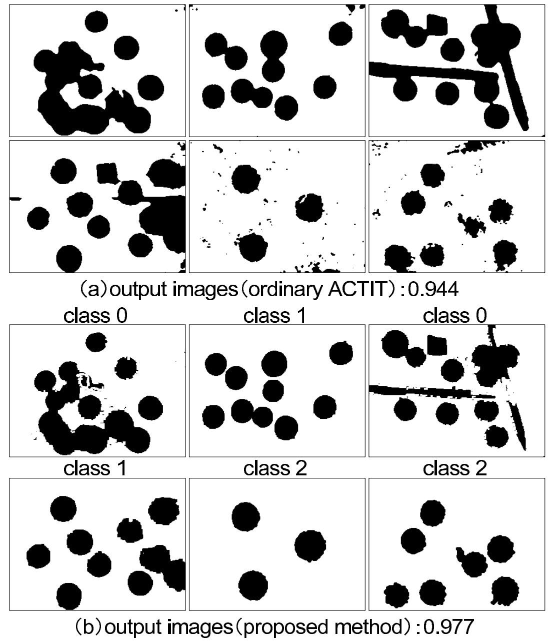

Fig. 8. Experimental results of comparison of ordinary ACTIT and the proposed method in case of coins segmentation images.

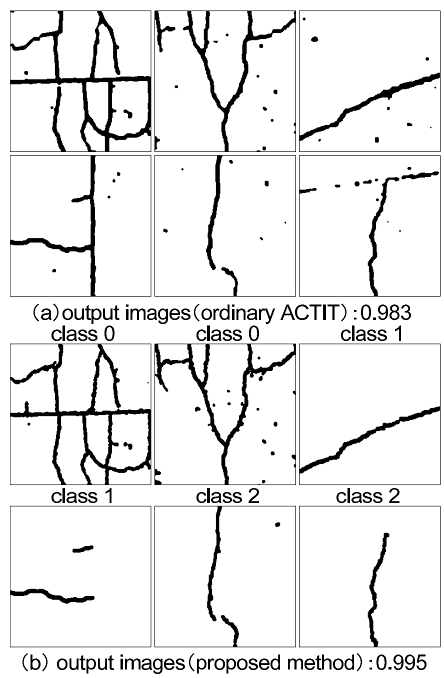

Fig. 9. Experimental results of comparison of ordinary ACTIT and the proposed method in case of concrete cracks detection images.

which have simple, reflection of light, and darkness features. Concrete cracks detection images are also classified into three classes, which have many cracks, a border between textures, and darkness features. These classification results are similar to human's ones. We experimentally showed that the proposed method effectively classified training image sets.

Next, we refer to the quality of output images. In case of coins segmentation images, coins are skillfully extracted in both ordinary ACTIT and the proposed method. However, in ordinary ACTIT, there are many noises on images and coins expand and connect to neighbor coins. On the other hand, in the proposed method, there are a few noises on images and coins do not transform. In case of concrete cracks detection images, cracks are successfully detected in both ordinary ACTIT and the proposed method. However, in ordinary ACTIT, a border between textures is detected as a crack by mistake. On the other hand, in the proposed method, a border between textures is not detected as a crack. Since training image sets are properly classified, the proposed system constructs effective image processing for images which have the same characteristics.

Lastly, we refer to the experimental results of application of optimized tree-structural image transformations to non-training images. Fig. 10 and Fig. 11 show identifications of classification results and output images.

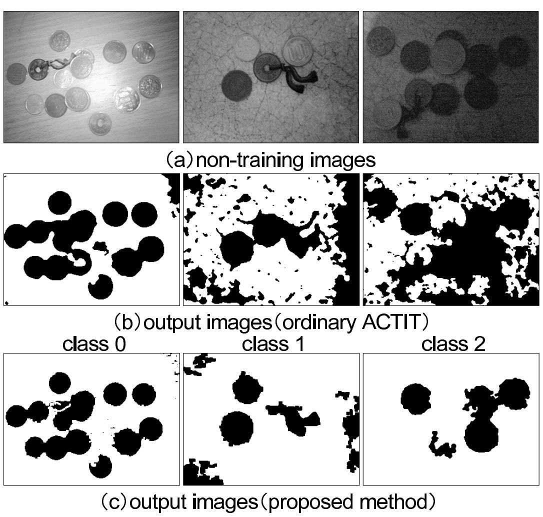

Fig. 10. Experimental results of application of optimized tree-structural image transformations to non-training images in case of coins segmentation images.

Experimental results show that non-training images are classified into the proper classes. In case of coins segmentation images, there are miss extraction and noises in both ordinary ACTIT and the proposed method. However, the quality of output images of the proposed method was better than that of ordinary ACTIT. These experimental results show that the proposed method is also effective for non-training images.

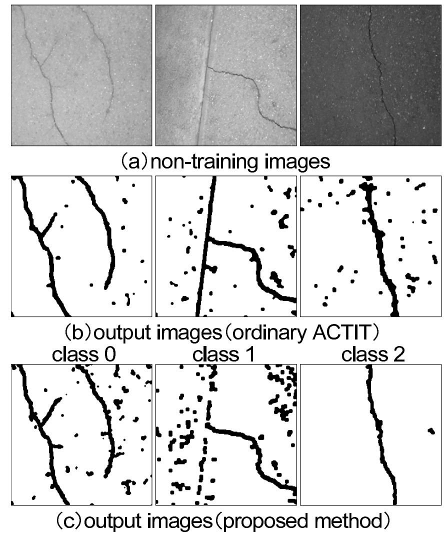

Fig. 11. Experimental results of application of optimized tree-structural image transformations to non-training images in case of concrete cracks detection images.

V. Conclusion

We proposed Modified Parallel-ACTIT which automatically classifies training image sets and constructs effective image processing for each images. The proposed method effectively classified training image sets. The quality of output images of the proposed method was better than that of ordinary ACTIT. We experimentally showed that the proposed method was effective for both training image sets and non-training images.

In future works, it is necessary that we apply the proposed system to many real images. We plan to employ Graphics Processing Unit (GPU)[10] to the proposed system for the purpose of reducing processing time. We propose parallel model which are more effective for image classification. And we aim to construct a fast evolutionary image processing system for many and various images.

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