Chapter XIV
Immune Programming Applications in Image Segmentation

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ABSTRACT

In fact, image segmentation can be regarded as a constrained optimization problem, and a series of optimization strategies can be used to complete the task of image segmentation. Traditional evolutionary algorithm represented by Genetic Algorithm is an efficient approach for image segmentation, but in the practical application, there are many problems such as the slow convergence speed of evolutionary algorithm and premature convergence, which have greatly constrained the application. The goal of introducing immunity into the existing intelligent algorithms is to utilize some characteristics and knowledge in the pending problems for restraining the degenerative phenomena during evolution so as to improve the algorithmic efficiency. Theoretical analysis and experimental results show that immune programming outperforms the existing optimization algorithms in global convergence speed and is conducive to alleviating the degeneration phenomenon. Theoretical analysis and experimental results show that immune programming has better global optimization and outperforms the existing optimization algorithms in alleviating the degeneration phenomenon. It is a feasible and effective method of image segmentation.

INTRODUCTION

Based on the research of the characteristics mechanism of Artificial Immune System (AIS), the feasibility of applying Immune Programming (IP) into the digital image processing is further discussed. The IP mechanism is successfully used into image segmentation, and the image threshold segmentation algorithm based on the maximum information entropy theory and the image segmentation algorithm based on the expense function minimization are proposed in this paper. At the same time give out definite algorithm design and operation steps. We also do simulation experiment both on image threshold segmentation based on the maximum entropy
theory and image segmentation based on cost function minimization, and compare them with classical genetic algorithm, analysis and summarize the segmentation result and experiment data.

The structure of the chapter is organized as follows: Backgrounds and Previous Research Work provides a detailed review and a background of the existing methods of image segmentation, as well as the main challenges for these methods and the advantages of IP. The Main Thrust of the Chapter consists of two parts: firstly, the image threshold segmentation based on the maximum entropy theory is introduced, and the advantages and disadvantages of this method are demonstrated by several groups experiment; in the second part, the image segmentation based on cost function minimization is introduced, and simulation experiment results is given. Concluding Remarks concludes the whole chapter with the special emphasis on: The IP mechanism is successfully introduced into image segmentation, and the image threshold segmentation algorithm based on the maximum information entropy theory and the image segmentation algorithm based on the expense function minimization are proposed in this paper. This method is fit for not only the images with double-peak-shaped histogram, but also those of complicated-shaped histogram. finally, the future directions are addressed in Future Research Directions. The terms and definitions, as well as an additional reading list, can be found at the end of the chapter.

BACKGROUND AND PREVIOUS RESEARCH WORK

Image segmentation is a technical process which can divide an image into regions with certain and special characteristics and extract the objectives interested from them. Classic image segmentation is to construct a differential operator that is sensitive to pixel gray-level’s step changing, such as Laplace operator, Roberts gradient operator, Sobel gradient operator, etc.

The speed of edge detection based on operators is high, but the results obtained are always intermittent and incomplete information. And this kind of methods is sensitive to noises, so the influence of edge feature from noises is great. For the image with significant double peak and comparative deep valley-bottom histogram, the acceptable segmentation can be got with traditional evolutionary algorithm quickly. Contrarily for the image without such features, in the complex cases such as the target and background are multi or close gray levels, or the gray histogram is multi-peak or single peak but no main valley-bottom, traditional evolutionary algorithm is easy to get into the local optimum, and can not get acceptable segmentation.

Immune Programming (IP) combining immune mechanism and evolution mechanism, is a novel idea of utilizing Artificial Immune System (AIS) into engineering application. As a global optimization algorithm with strong robustness, immune programming absorbs the advantage of genetic algorithm——parallel searching. It can construct immune operator by utilizing local characteristic information. By vaccinating and immune selecting, it can intervene the parallel global searching with certain intensity, and effectively restrain the degenerative phenomena in the existing evolution algorithms. The constructed algorithm shows wonderful global convergence capability, and keeps certain individual diversity under the guiding of the affinity, which helps to avoid premature convergence and greatly improve the algorithm global performance. The more complex the problems to be settled , the more superior that IP will show. However, complexity and great computation is two characteristics that image segmentation originally have, which can make the advantages of IP be fully used in image segmentation. Hence, more accurate segmentation results can be got by IP than other evolutionary algorithms.

Based on the research of the characteristics mechanism of AIS, the feasibility of applying IP into the digital image processing is further discussed in this paper. The IP mechanism is successfully used into image segmentation, and the image threshold segmentation algorithm based on the maximum information entropy theory and the image segmentation algorithm based on the expense function minimization are proposed in this paper. This algorithm is fit for not only the images with double-peak-shaped histogram, but also those of complicated-shaped histogram. Theoretical analysis and experimental results show that immune programming has better global optimization and outperforms the existing optimization algorithms in alleviating the degeneration phenomenon. It is a feasible and effective method of image segmentation.
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