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Enhancement of Digital X-Ray Image by Combining the Genetic Optimization and Watershed Transformation Technique

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Abstract* — X-ray image is an important tool in clinical medical diagnosis because of its large amount of information, but the phenomenon of noise, artifact, edge fog and non-uniform signal is liable to happen. So X-ray image segmentation which divides the image into several non-overlaps, meaningful and connatural segment, defected area automatic identification and automatic diagnosis. Watershed transformation based on mathematical morphology is a method of region segmentation. It can locate accurately and get continuous and closed object boundary. But over-segmentation often happens when watershed transformation is used directly, and a preprocessing of image before watershed transformation can restrain this phenomenon effectively. The size and shape of structure element which is necessary for morphology operation affect the result of image process directly, and its selection is depended on the experience of the researcher. This article proposes a method of combination of watershed transformation and genetic optimization to realize the accurate segmentation of X-ray image.

***Index Terms*—Genetic Optimization, Image Enhancement, Watershed Transformation, X-ray Images**

I. INTRODUCTION

Image segmentation is an important process and its results are used in many image processing applications. However, despite its importance, there doesn't to seem to be any general method of image segmentation that works well on all images. Image segmentation involves a lot of uncertainty, often with many parameters that need tube tuned to provide optimal results. For example, the Phoenix image segmentation method has 14 adjustable parameters. This large number of parameters creates a very large search space. Color images have even more information than grey-scale images, and this information can be used to create higher quality segmentation. It does, however, increase the complexity of the problem. A way of handling the large search space is to use a directed each method, such as genetic algorithms. Genetic algorithms have many qualities that make them well suited to the problem of image segmentation, such as the ability to forego a local optimum to reach a global optimum and the ability to efficiently find an optimal solution from within a large search space. Genetic algorithms could allow an image segmentation process that usually requires manual input to become unsupervised. Genetic algorithms have been used to successfully color segment images. Due to their flexibility, it seems feasible to be able to use them to come up with a general segmentation method.

II. IMAGE SEGMENTATION

Image segmentation is an important process and its results are used in many image processing applications. However, there is no general way to successfully segment all images. Images have more information than grey-scale images, and this information can be used to create higher quality segmentation. It does, however, increase the complexity of the problem. A way of handling this complexity is to use a directed search method, such as genetic algorithms. Genetic algorithms, which mimic the process of evolution, have many qualities that make them well suited to the problem of image segmentation, such as the ability to forego a local optimum to reach a global optimum and the ability to efficiently find an optimal solution from within a large search space. The main uses of genetic algorithms in image segmentation are for the modification of parameters in existing segmentation algorithms and pixel-level segmentation. Various algorithms that successfully apply genetic algorithms to image segmentation have been developed. Though these results are promising, none of them solve this open problem. Image segmentation is the process of dividing an image into homogeneous regions. This is equivalent to finding the boundaries between the regions. Segmentation is the first step for many higher level image processing and computer vision operations, including shape recognition, medical imaging, locating objects in satellite images, face detection and road sign recognition. Image segmentation is an old and important problem, and there are numerous image segmentation methods. Most of these methods were developed to be used on a

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certain class of images and therefore aren't general image segmentation methods divide the image segmentation algorithms into three major categories:
1. Edge Based
2. Region Based
3. Clustering Based

1. Edge Based Techniques

Edge detection involves the detection of boundaries between different regions of the image. These boundaries correspond to discontinuities between pixels of the chosen feature (e.g. color, texture, intensity).

2. Region Based Techniques

Region splitting is an image segmentation method whereby pixels are classified into regions. Each region corresponds to a range of feature values, with thresholds being the delimiters. The choice of these thresholds is very important, as it greatly affects the quality of the segmentation. This method tends to excessively split regions, resulting in over segmentation. Region growing joins neighboring pixels with similar characteristics to form larger regions. This continues until the termination conditions are met. Most of the region growing algorithms focus on local information, making it difficult to get good global results. This method tends to excessively add to regions, resulting in under segmentation region merging recursively merges similar regions. It is similar to region growing, except that two whole regions are combined, rather than one region combining with individual pixels. Region splitting and merging tries to overcome the weaknesses of region growing and region splitting by combining the two techniques. Initially the image is divided into arbitrary regions. Region splitting and region merging occur until the termination conditions are met. The Phoenix image segmentation algorithm is a region splitting method for segmentation that has been widely used and tested on color images. It uses histogram analysis, thresholding and connected component analysis to partially segment the image. Each region then has the same process applied to it recursively, until termination conditions are met and the image is fully segmented. The algorithm uses 17 parameters, 14 of which are adjustable. This isn't discussed here as it is used to match particular objects and so isn't relevant to general image segmentation

3. Clustering Based Techniques

Clustering separates the image into various classes without any prior knowledge. This method is based on the assumption that objects within each class should have a high degree of similarity, while those in different classes should be dissimilar. It is considered an unsupervised image segmentation technique.

III. GENETIC ALGORITHM

Genetic algorithms are an optimization technique that can be used in image segmentation. It mimics natural selection, allowing an algorithm to adapt. Solutions are represented by a population of individual chromosomes, usually represented as binary strings. A chromosome is made up of genes, each of which can represent a particular characteristic. Each individual in the population is evaluated and given a fitness score based on how well they solve the particular problem. The higher the individual's fitness score, the greater their probability of breeding. Breeding creates the next generation through crossover and mutation. Crossover combines the chromosome of two individuals, creating a new individual which is unlike either of the parents. Mutation, which occurs only a small percent of the time, randomly alters a new individual's chromosome. Since the more optimal individuals have a greater chance of breeding, the population tends to evolve and reach an optimal solution. Genetic algorithms have been used to solve a wide variety of problems, including numerical and combinatorial optimization, circuit design and cellular automata rule design. In image processing, genetic algorithms have successfully been used for feature extraction, object recognition, knowledge based segmentation and image classification. Image segmentation is easily and naturally formulated as on optimization problem. It can either be seen as finding the optimal segmentation amongst all candidate segmentations, or as finding the optimal parameters for an existing image segmentation algorithm. In both cases, this creates an extremely large search space, indicating the use of genetic algorithms. Genetic algorithms are advantageous in that they are able to forego local optima in an attempt to reach the global optimum. This makes them far less likely to get caught in a local optimum than deterministic optimization techniques, such as local hill-climbing and gradient descent. Though more computationally expensive than these methods, genetic algorithms are less computationally expensive than exhaustive searches and other adaptive techniques, such as simulated annealing, which is theoretically guaranteed to find a global optimum. While, genetic algorithms cannot guarantee finding a global optimum, they usually give a good approximation. This makes genetic algorithms a good compromise between accuracy and computational intensity. Many image segmentation problems have large search spaces but need only an approximate global optimum. In this case, genetic algorithms using a directed search have proven useful. A disadvantage of genetic

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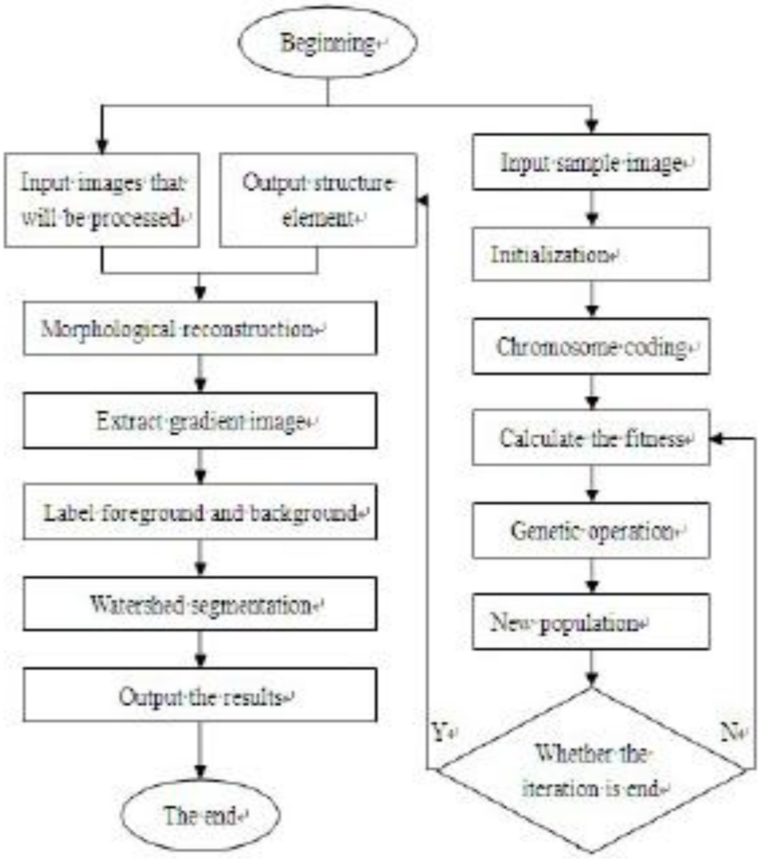
algorithms is that they can take a long time to converge. Though this is the case, they are still much more efficient than performing an exhaustive search. Many images, particularly natural scenes, are complex and noisy. A characteristic of genetic algorithms is their effectiveness and robustness in dealing with uncertainty, insufficient information and noise. Combined with the fact that no matter how it is posed, the image segmentation problem involves a very large search space, making genetic algorithms well suited to the problem. One of the major challenges for designing genetic algorithms is defining a fitness function. The only information available to the population of chromosomes is the result of the fitness function evaluated every generation. This makes an appropriately defined fitness function essential for successful genetic algorithms. In the context of image segmentation, the fitness function should evaluate the resulting segmentation. There is, however, no generally accepted unsupervised method of evaluating image segmentation.

IV. PROPOSED ALGORITHM

The Genetic Algorithm Module is a simple module, with much of the functionality being provided by the GA Lib library. Its basic behavior and interaction with the Region Merging Module is shown in Figure. The genetic algorithm is represented by a GA Simple GA object, provided by GA Lib. This class is used for genetic algorithms with non-overlapping populations, and inherits from the general GA Genetic Algorithm class.



.Genetic algorithm is a global optimization approach, and it simulates the natural selection and evolution mechanism. It maps the search space as genetic- space, every population corresponds to a group of solution. Every individual in the population is distributed corresponding fitness value based on the evaluation criterion (fitness function). Make selecting, intersecting and mutating operations according to the fitness value of every individual, by eliminating the low fitness value and keeping the high ones to obtain a new population. It iterates the process to get a population with more optimizing solution. Learning samples are needed first in the process of genetic algorithm optimizing the structure element, that is to choose a image which is similar to the image waiting for treating, and use the chosen image to exercise to get the structure element and segment the image waiting for treating with the obtained structure element. The concrete process of algorithm is following:

1. Generate initial population. Set the scale of the initial population and time of iterating, in this article the number of population is 30 and the time of iterating is 100.

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2. Chromosome coding. The structure element in this article is 5×5， and its shape is generated randomly by chromosome coding, that is a binary character string of length 25, and 1 means structure element point while 0 means not.
3. Calculate the fitness value of individual. Fitness function is the standard to judge the quality of an individual. The higher the fitness value is, the higher possibility that this individual inherited to next generation will be.
4. Genetic operation. The selection, crossover and mutation of individuals are according to the fitness of individuals.
    - Selection. The roulette wheel selection is used in this paper. It combined with the elitist strategy (the individual with the highest fitness will go to the next generation without selection, crossover and mutation) to ensure the optimal solution will not disappear in the iteration.
    - Crossover. Single-point crossover is used in this paper.0.7 is the probability of crossover.
    - Mutation. 0.02 is the probability of mutation.
5. Generating new population. There are some new individual after the genetic operation. These new individuals are inserted into the population that generates a new population. Then turn to step 3 until the end of iteration.
6. Output result. Calculating the fitness value of individual to find out the largest one when the end of iteration. The best structure element corresponds to the individual with the largest fitness.

V. APPLICATION

According to the features of X-ray images, this project uses the watershed transformation based on morphological reconstruction for X-ray image segmentation. For the problem in processing that the choice of structure element in morphology operation depends on the researcher's experience and experiments, this paper introduces genetic algorithms for automatic selection of structure element. Because of the particularity of image processing, genetic algorithms need a training sample. The optimal structure element will get form the sample image processing, then it is used to the image which waited for processing. The simulation results show that the selection of structure element using genetic algorithms is feasible, and it gets meaningful results when the structure element used in watershed segmentation based on morphological reconstruction.

VI. CONCLUSION

According to the features of X-ray images, this article uses the watershed transformation based on morphological reconstruction for X-ray image segmentation. This paper introduces genetic algorithms for automatic selection of structure element. Because of the particularity of image processing, genetic algorithms need a training sample. The optimal structure element will get form the sample image processing, then it is used to the image which waited for processing. The simulation results show that the selection of structure element using genetic algorithms is feasible, and it gets meaningful results when the structure element used in watershed segmentation based on morphological reconstruction.

VII. FUTURE SCOPE

Improvements on the system could include using different merging criteria (instead of the fusion factor) or using a different color space. As mentioned the fitness function is very important to a genetic algorithm. Various fitness functions were suggested, though only one was experimented with. These fitness functions, as well as others could be experimented with. A fitness function is just a function, so there is the possibility that genetic programming1 could be used to evolve a fitness function. Manually segmented images could be used as ground truths and a discrepancy measure could be used as a fitness function. If this training set of images is a good representation of the type of images that one wishes to segment, this could be successful. The evolved fitness function could be used in a program, such as the one implemented in this paper to provide unsupervised image segmentation. The main challenge of doing this would be to provide suitable terminal and function sets.

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