A Review: Image Segmentation Using Genetic Algorithm

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Abstract— Image segmentation is an important and difficult task of image processing and the consequent tasks including object detection, feature extraction, object recognition and categorization depend on the quality of segmentation process. In this paper we suggest Genetic Algorithm to solve the problem of image segmentation. The problem was treated as optimization problems based GA. GAs is used to segment an image by using an optimization function without any threshold values. GAs based image segmentation can provide more accurate results than traditional segmentation methods. The genetic procedure provided a faster convergence to the optimal solution. This is because the sampling strategy allows exploring the solution space by a strategy that is not biased. The preliminary results indicate that GA-based methods perform better than the traditional methods in terms of quality. Also, by developing hybrid algorithms such as GAs and Artificial Neural Networks (ANNs) we can reduce the processing time and increase the visual quality of the final segmentation underscoring the advantages of hybrid algorithms.

Keywords— Image segmentation, Fuzzy C means, Competitive neural network, Genetic algorithms, Possibilistic Fuzzy C Means, Mutation, Crossover, Randomness

1 INTRODUCTION

The Image segmentation refers to the process of partitioning an image into multiple segments based on selected image features (sets of pixels). The goal of image segmentation is to simplify the image and also change its representation to make them easy to understand and more meaningful. The purpose of image segmentation is to locate objects and boundaries in images, which results in a set of regions that communally cover the entire image. Every pixel in a region is similar in some characteristics such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics [1]. Image segmentation is a vital field in image analysis, coding, and understanding .It has wide diversity of applications ranging from car assembly, airport security, object recognition, face recognition, image processing, medical imaging, image and video retrieval, through to criminal investigative analysis.

1. Requirements for Image Segmentation [2].
Good image segmentation meets certain requirements:
   a) Every pixel in the image belongs to a region.
   b) A region is connected: any two pixels in a particular region can be connected by a line that doesn't leave the region.
   c) Each region is homogeneous with respect to a chosen characteristic. The characteristic could be syntactic (for example, color, intensity or texture) or based on semantic interpretation.
   d) Adjacent regions can't be merged into a single homogeneous region.
   e) No regions overlap.

1. Methods of Image Segmentation
Image segmentation is important problem and there available numerous image segmentation methods. Most of these methods were developed to be used on a certain class of images and therefore aren't general image segmentation methods [3].

Image Segmentation is divided into three major categories:
- Edge Based
- Region Based
- Clustering Based

1. Edge Based Techniques
Edge detection includes the detection of boundaries between different regions of the image. Due to these boundaries discontinuities occurs between the pixels of the chosen feature such as color, texture and intensity.

2. Region Based Techniques
Region splitting is an image segmentation method in which pixels are classified into regions. Each region has a range of feature values, with thresholds being delimiters. It is very important to choose these thresholds, as it greatly affects the quality of the segmentation. This tends to excessively split regions, resulting in over segmentation.

3. Clustering Based Techniques
Clustering separates the image into various classes without any prior information. In this the data which belong to same class should be as similar as possible and the data which belongs to different class should be as different as possible

2 COMPUTING

The computing is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application.

3 HARD COMPUTING

Hard computing or conventional computing requires a precisely declared analytical model and a lot of computation time.

4 SOFT COMPUTING

Soft Computing (SC) is a promising field that consists of corresponding elements of fuzzy logic, neural computing, evolutionary computation, machine learning and probabilistic reasoning. Soft computing differs from conventional hard computing- it is tolerant of imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness and low solution cost, thus have found wide applications. As soft computing techniques resemble human brain, the results are fast and accurate [4].
The principal constituents, i.e., tools, techniques, of Soft Computing (SC) are – Fuzzy Logic (FL), Neural Networks (NN), Support Vector Machines (SVM), Evolutionary Computation (EC), and – Machine Learning (ML) and Probabilistic Reasoning (PR)

5 DIFFERENT SOFT COMPUTING TECHNIQUES USED FOR IMAGE SEGMENTATION

1. Fuzzy Clustering
Clustering is used for dividing data points into homogeneous classes or clusters so that items in the same cluster are as similar as possible and items in different classes are as dissimilar as possible. Some parameters that can be used as similarity measures include distance, connectivity and intensity. In non-fuzzy or hard clustering, data is divided into crisp clusters, where each data point belongs to exactly one cluster. In fuzzy clustering, the data points can belong to more than one cluster, and associated with each of the points are membership grades which indicate the degree to which the data points belong to the different clusters. The main idea behind fuzzy clustering is that an object can belong to more than one class and does so to varying degrees called memberships. The membership created by fuzzy clustering algorithm has several advantages [5].
The partition should have two properties: Homogeneity inside clusters (the data which belong to one cluster should be as similar as possible) and Heterogeneity between the clusters (the data which belong to different clusters should be as different as possible).

2. Possibilistic Fuzzy C Means
Possibilistic approach is used to clustering the membership function or the degree of typicality of a point in a fuzzy set (or cluster) is assumed to be absolute depend on the membership values of the same point in other clusters contained in the problem domain [6]. By contrast, many clustering approaches impose a probabilistic constraint, according to which the sum of the membership values of a point in all the clusters must be equal to one. PCM algorithm avoids the assumption of the probabilistic constraint. The PCM is based on the relaxation of the probabilistic constraint in order to interpret in possibilistic sense the membership function or degree of typicality [7].

3. Artificial Neural Network
An Artificial Neural Network (ANN) is an information processing method that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the narrative structure of the information processing system. It consist of a large number of highly interconnected processing elements (also called neurons) working in union to solve specific problems. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process [8].
Neural networks learn by example. They cannot be programmed to perform a specific task. The examples must be selected carefully otherwise useful time is wasted or even worse the network might be functioning incorrectly. The disadvantage is that because the network finds out how to solve the problem by itself, its operation can be unpredictable.

3.1 Supervised method
Supervised method requires expert human input for segmentation. This means that human experts are carefully selecting training data which is then used to segment the images. Supervised techniques are based on human or operator knowledge to select training images and manually.

segment them into n regions. Each region assigns a label and the proposed architecture is trained using the selected images as training images. Then the method is able to segment similar images. Labels are assigned to the regions according to the knowledge stored in the neural network architecture used.

3.2 Unsupervised methods
Unsupervised methods are semi or fully automatic. User Intervention might be necessary at some point in the process to improve the performance of the method, but the results should be more or less human independent. An unsupervised method automatically partitions the images without operator intervention. The method is segmenting the image into k sub regions and then automatically assigns labels to those regions [9].

4. Competitive Neural Networks
Competitive Networks learn to classify input vectors according to how they are grouped in the input space. They differ from another network in that neighboring neurons learn to recognize neighboring sections of the input space. Thus, competitive layers learn both the distributions and topology of the input vectors which they are trained on. A neural network in which a group of neurons compete for the right to become active is called competitive neural network. When more than one neuron is about to get fired, the activation of the node with the largest net input is set equal to 1 and the activation of all other nodes are set equal to 0 [10].

5. Genetic Algorithms
A genetic or evolutionary algorithm applies the principles of evolution found in nature to the problem of finding an optimal solution to a Solver problem. In a "genetic algorithm," the problem is encoded in a series of bit strings that are manipulated by the algorithm; in an "evolutionary algorithm," the

decision variables and problem functions are used directly. Most commercial Solver products are based on evolutionary algorithms.

An evolutionary algorithm for optimization is different from "classical" optimization methods in several ways [11]:

Random Versus Deterministic Operation
Population Versus Single Best Solution
Creating New Solutions Through Mutation
Combining Solutions Through Crossover
Selecting Solutions Via "Survival of the Fittest"

A simple GA working can be described as given in fig1.

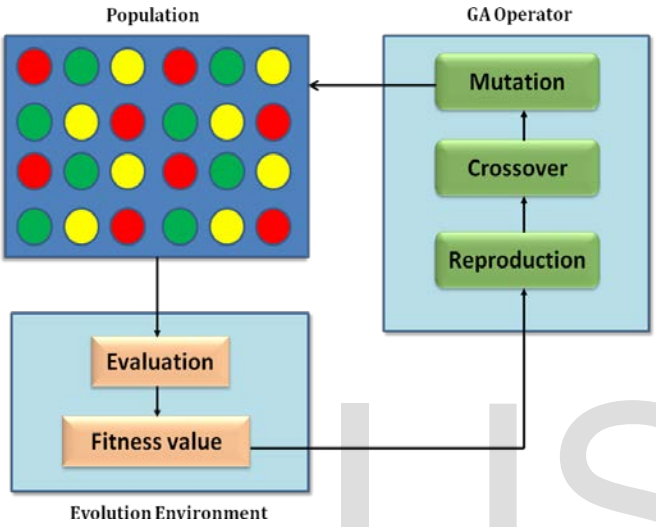

Figure 1: Genetic Algorithm process

Randomness

First, it relies in part on random sampling. This makes it a nondeterministic method,

This may yield somewhat different solutions on different runs -- even if you haven't changed your model. In contrast, the linear, nonlinear and integer Solvers also included in the Premium Solver are deterministic methods -- they always yield the same solution if you start with the same values in the decision variable cells.

Population

Second, where most classical optimization methods maintain a single best solution found so far, an evolutionary algorithm maintains a population of candidate solutions. Only one (or a few, with equivalent objectives) of these is "best," but the other members of the population are "sample points" in other regions of the search space, where a better solution may later be found.

The use of a population of solutions helps the evolutionary algorithm avoid becoming "trapped" at a local optimum, when an even better optimum may be found outside the vicinity of the current solution.

Mutation

Third -- inspired by the role of mutation of an organism's DNA in natural evolution – an evolutionary algorithm periodically makes random changes or mutations in one or more members of the current population, yielding a new candidate solution. (This may be better or worse than existing population members)

There are many possible ways to perform a "mutation," and the Evolutionary Solver actually employs three different mutation strategies. The result of a mutation may be an infeasible solution, and the Evolutionary Solver attempts to "repair" such a solution to make it feasible; this is sometimes, but not always, successful.

The various mutation operators are:

a. Flipping.
b. Interchanging.
c. Reversing.

Crossover

Fourth -- inspired by the role of sexual reproduction in the evolution of living things – an evolutionary algorithm attempts to combine elements of existing solutions in order to create a new solution, with some of the features of each "parent." The elements of existing solutions are combined in a "crossover" operation, inspired by the crossover of DNA strands that occurs in reproduction of Biological organisms.

As with mutation, there are many possible ways to perform a crossover operation -- some much better than others -- and the Evolutionary Solver actually employs multiple variations of two different crossover strategies.

The various crossover techniques are:

a. Single point crossover.
b. Two point crossover.
c. Multi-point/N-point crossover.
d. Uniform crossover.
e. Three point crossover.

Crossover probability is a parameter to describe how often crossover will be performed. If there is no crossover, offspring's are exact copies of their parents. If there is crossover, the offspring's are made from parts of both parent's chromosome. If crossover probability is 100%, then all offspring's are made by crossover. If it is 0%, whole new generation is made from exact copies of chromosome from all population. Crossover is made in the hope that new chromosome will contain good parts of old chromosomes and therefore the new chromosome will be better [12].

Selection

Fifth -- inspired by the role of natural selection in evolution -- an evolutionary algorithm performs a selection process in which the "most fit" members of the population survive, and the "least fit" members are eliminated. In a constrained optimization problem, the notion of "fitness" depends partly on whether a solution is feasible (i.e. whether it satisfies all of the constraints), and partly on its objective function value. The selection process is the step that guides the evolutionary algorithm towards ever-better solutions.

Common selection methods are:

a. Roulette wheel selection.

b. Rank selection.
c. Tournament selection.
d. Random selection.
e. Boltzmann selection.
f. Stochastic Universal sampling

From above 5 method of image segmentation, using competitive neural network is better approach as compared to fuzzy clustering methods. The genetic algorithms in image segmentation also considered to be alternate approach. Genetic algorithms are used to reduce the complexity of the problem. Genetic algorithms in image segmentation are used for the modification of the parameters in existing segmentation algorithms and are viewed as function optimizers. GAs is tools on probabilistic and casualty, not necessarily they will have the same type of evolution when applied to the same problem. ANN and fuzzy logic techniques required more information regarding system and more mathematics as compare to GAs [13].

So, On the basis of comparative study of all the soft computing technique the most accurate method to segment an image is genetic algorithms, because it can handle the complex color images, which is very useful at the present time as most image are colorful .

4 Conclusions

The image segmentation using various algorithms such as fuzzy, competitive neural network and genetic algorithms have been discussed in comparison to the traditional techniques. By comparing fuzzy and competitive neural network, image segmentation using competitive neural network is better approach as compared to fuzzy clustering methods. The genetic algorithms in image segmentation also considered to be alternate approach. Genetic algorithms are used to reduce the complexity of the problem. Genetic algorithms in image segmentation are used for the modification of the parameters in existing segmentation algorithms and are viewed as function optimizers. This paper also suggest hybrid algorithms such as GAs and Artificial Neural Networks (ANNs) in order to reduce the processing time and increase the visual quality of the final segmentation underscoring the advantages of hybrid algorithms.

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