A Review of Genetic Algorithm application for Image Segmentation

Raj Kumar Mohanta
Department of IT
NM Institute of Engineering & Technology,
Bhubaneswar, Odisha
rajkumar_19it@yahoo.co.in

Binapani Sethi
MTech (ECE)
Konark Institute of Science & Technology,
Bhubaneswar, Odisha
binapani_sethi@yahoo.co.in

Abstract

Image segmentation is an important technique of Image Processing. It is a difficult task of image processing and the subsequent tasks including object detection, feature extraction, object recognition and classification depend on the quality of segmentation process. However there is no general way to successfully segment all images. The image segmentation problem can be characterized by several factors which make the parameter selection problem difficult. The segmentation problem is formulated as an optimization problem and Genetic Algorithm efficiently locate the global maximum in a search space and solves the problem of parameter selection in image segmentation. The aim of this paper is to review Genetic Algorithm applications for image segmentation.

Keywords: Image Segmentation, Genetic Algorithm, Artificial Neural Network, Image Processing.

1. Introduction

Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels [1]. This partitioning can be done by region extraction or by edge detection. After partition different objects of an image has same texture or color. The result of image segmentation consists of a set of regions whose union forms the entire image. However it is hard to find a general way to successfully segment all images. Even the process of choosing the right segmentation method is also very difficult process. Methods developed for one type of image might not be applied to different images.

Segmentation techniques can be classified into three categories:

- Classical algorithms mostly based on mathematical or statistical methods
- Artificial Intelligence techniques
- Optimization techniques

The classical algorithms include characteristic histogram thresholding, edge/boundary detection, region extraction or region growing, relaxation, semantic and syntactic approaches. Segmentation methods are applied from the artificial intelligence that uses Artificial Neural Networks approaches. Optimization techniques which involves Genetic Algorithm (GA). The main use of genetic algorithm in image segmentation is the modification of parameters in existing segmentation algorithms and pixel-level segmentation [2]. GA has the ability to determine optimal number of regions of a segmentation result or to choose some features such as the size of the analysis window or some heuristic thresholds.

2. Image Segmentation

Image Segmentation denotes a process by which input image is partitioned into non-overlapping regions [3]. Each region is homogeneous and connected. The region is homogeneous if all region pixels satisfy homogeneity conditions defined per one or more pixels attributes such as intensity, color, texture etc. The region is connected if a connected path between any two pixels within the region exist [4]. In this process the digital image can be segmented with uniform and homogeneous characteristics. The goal of image segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. It is the first step towards computer vision and image processing operation which includes face detection, medical imaging, locating objects in...
satellite images etc. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

2.1 Requirements for Image Segmentation

Good image segmentation meets certain requirements: [5] [6] [7] [8]

- Every pixel in the image belongs to a region.
- A region is connected: any two pixels in a particular region can be connected by a line that doesn’t leave the region.
- 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.
- Adjacent regions can’t be merged into a single homogeneous region.
- No regions overlap.

2.2 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 [6].

Bhanu and Lee [7] divide the image segmentation algorithms into three major categories:

1. Edge Based
2. Region Based
3. 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.

2.3 Applications of Image Segmentation

Image Segmentation has many applications which are:

- Face recognition
- Fingerprint recognition
- Medical imaging such as:
  - Locate tumors and other pathologies
  - Measure tissue volumes
  - Computer-guided surgery
  - Diagnosis
  - Treatment planning
  - Study of anatomical structure
- Locate objects in satellite images (roads, forests, etc.)
- Iris recognition
- Traffic control systems
- Brake light detection
- Machine vision
- Agricultural imaging – crop disease detection etc.

3. Related Works

There are many algorithms for image segmentation. But due to different constraint it is difficult to find the optimal solution. In [9], it classifies the belonging of the pixels and then use region growing to get the object. Linking the area information and color histogram for building video databases based on objects was proposed in [10]. In [11] a genetic algorithm based segmentation process to change the image characteristics caused by variable environmental condition was proposed. In [12] a two step approach to image segmentation is reported. The authors in [13] proposed a graph-based method.

4. Genetic Algorithm

Genetic Algorithm (GA) is an optimization method that utilizes Darwinian criterion of population evolution for solving optimization problems based on natural selection. The process of natural selection is used to raise the effectiveness of group of possible solutions to meet an environment optimum [14]. GA is based on the principle of “Survival of the fittest”. Holland proposed GA in the early seventies [15] as computer programs that mimic the natural evolutionary process. De Jong extended the GA to functional optimization [16] and a detailed mathematical model of a GA was presented by Goldberg in [17]. The GA has robustness that allows its structural functionality to be applied to many
different search problems [17, 18]. Genetic algorithm belongs to the larger class of Evolutionary Algorithm (EA). Other algorithms in the same class include Evolutionary Strategies (ES), Evolutionary Programming (EP) and Genetic Programming (GP). A more striking difference between genetic algorithms and most of the traditional optimization methods is that GA uses a population of points at one time in contrast to the single point approach by traditional optimization methods.

A typical genetic algorithm requires:

1. A genetic representation of the solution domain.
2. A fitness function to evaluate the solution domain.

Once these functions are defined GA proceeds to initialize a population of solution randomly, then it is improved by repeated application of GA operators like selection, crossover and mutation.

4.1 Search Space

The space for all possible feasible solutions is called search space. Each solution can be marked by its value of the fitness of the problem. Looking for the solution means looking for extrema (either maximum or minimum) in search space. The search space can be known by the time of solving a problem and we generate other points as the process of finding the solution continues. (Shown in fig. 1)

4.2 Genetic Algorithm Methodology

In a Genetic Algorithm, a population of strings called chromosomes which encode candidate solutions to an optimization problem evolves toward better solutions. The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (crossover and mutation) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

4.3 Genetic Algorithm procedure

Genetic Algorithm consists of the following steps:

**Step1:** Choose the initial population of individuals

**Step2:** Evaluate the fitness of each individual in that population

**Step3:** Repeat on this generation until termination (time limit, sufficient fitness achieved etc.):

- Select the best-fit individuals for reproduction.
- Breed new individuals through crossover and mutation operations to give birth to offspring
- Evaluate the individual fitness of new individuals
- Replace least-fit population with new individuals

4.4 Image segmentation using Genetic Algorithm

For Image Segmentation Farmer and Shugars [19] divide the genetic algorithms used for image segmentation into two major classes:

1. **Parameter selection**, where genetic algorithms are used to modify the parameters of an existing image segmentation method to improve its output.

2. **Pixel-level segmentation**, where genetic algorithms are used to perform region labeling.

Most image segmentation methods have many parameters that need to be optimized, and therefore the first method is used more often [11].

5. Conclusion

Genetic Algorithm has many advantages in obtaining the optimized solution. It was proved to be the most powerful optimization technique in a large space. Genetic algorithm allows to perform robust
search for finding the global optimum. The result of the optimization depends on the chromosome encoding scheme and involvement of genetic operators as well as on the fitness function. However the quality of image segmentation can be improved by selecting the parameters in an optimized way.

References