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Significance of Genetic Algorithms in Image Segmentation

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Abstract

Genetic Algorithms have been commonly getting used for solving mutually constrained and unconstrained optimization problems based on a natural selection process that imitates biological evolution. The algorithm repeatedly modifies a population of individual solutions until we get satisfactory results. The same procedures we would like to implement on large set of images and try to segment the images based on constraints and doing so we can improve the quality of image which can lead to proper image analysis.

Keywords: *Genetic Algorithms, Image, Segmentation, biological and analysis*

1. Introduction

Digital images are important means of passing on information. Extracting the information from images and understanding such information can be an important characteristic of Machine learning. Trying to mimic the humans by making robots is the example for this. Image segmentation is one of the initial steps in direction of understanding images and then finds the different objects in them. Especially these days, we have been using robots for medical applications frequently and vastly. These robots get required input using artificial neural networks.

Artificial neural networks (ANNs) are a family of models inspired by biological neural network especially in brain and are used to estimate or approximate functions that can depend on a large number of inputs which are generally unknown. Artificial neural networks are generally accessible as systems of interconnected "neurons" which exchange messages between each other. The connections have numeric weights that can be tuned based on experience, making neural nets adaptive to inputs and capable of learning.

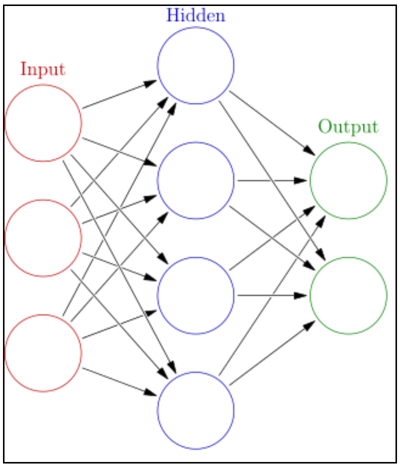

Figure 1. Artificial Neuarl Network

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2. Genetic Algorithm

Genetic algorithms (GAs) are new paradigm for search operation based on principles of natural selection which were introduced by John Holland in 1970s. These properties are based on inheritance in Object oriented Languages where child class derives properties from parent class based on some access constraints. GAs is basically the natural selection process where it accepts some inputs and calculates output while making multiple solutions. In this paper, we briefly discuss about out implementation of hybrid k-means algorithm and results are compared with available k-means and fuzzy c-means algorithms.

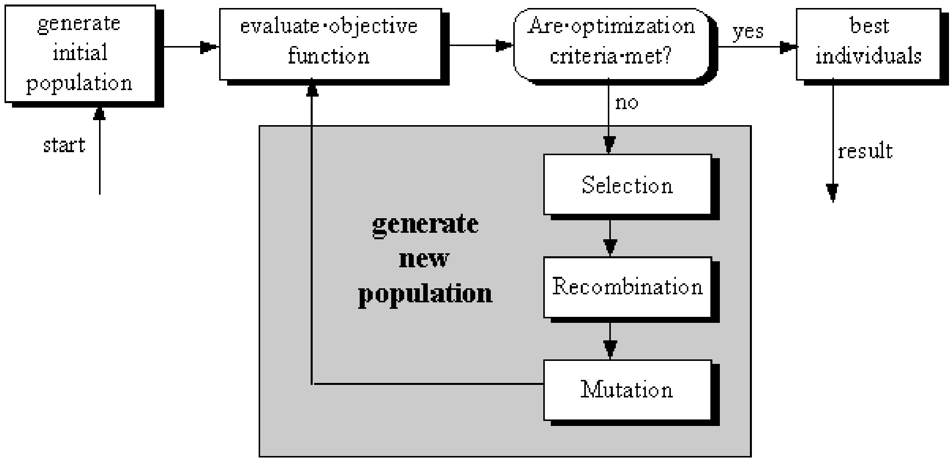


Figure 2. Overview on Genetic Algorithm Process

Genetic Algorithms (GAs) are search algorithms which are based on the evolutionary thoughts of natural selection and genetics. They represent an intelligent utilization of a random search which can be used to solve optimization problems. Although randomized, they exploit historical information to direct the search into the region of better performance within the search space. The basic techniques of the GAs are designed to simulate processes in natural systems necessary for evolution. Especially those follow the principles of "survival of the fittest". Since in nature, competition among individuals for insufficient resources results in the fittest individuals dominating over the weaker ones. In that domination, whoever wins they will be surviving.

Genetic algorithms are inspired by Darwin's theory about evolution. Algorithm is started with a set of solutions (represented by chromosomes) called population. Solutions from one population are taken and used to form a new population. This is motivated by a hope that the new population will be better than the old one. Solutions which are selected to form new solutions (offspring) are selected according to their fitness *i.e.* the more suitable they are the more chances they have to reproduce.

2.1. Parameters of GA

Genetic Algorithms have mainly 3 parameters. *i.e.* Crossover probability, Mutation probability and Population size.

Crossover Probability says how often will be crossover performed. If there is no crossover, offspring is exact copy of parents. If there is a crossover, offspring is made from parts of parents' chromosome. If crossover probability is 100%, then all offspring is made by crossover. If it is 0%, whole new generation is made from exact copies of chromosomes from old population.

Mutation probability says how often will be parts of chromosome mutated. If there is no mutation, offspring is taken after crossover without any change. If mutation is performed, part of chromosome is changed. If mutation probability is 100%, whole chromosome is changed, if it is 0%, nothing is changed.

Population size says how many chromosomes are there in a population of one generation. If there are very small chromosomes, GA has few possibilities to perform crossover and only a small part of search space is explored. On the other hand, if there are too many chromosomes, GA slows down.

2.2 GA Process

The Performance of GA mainly depends on Cross over and Mutation operations.

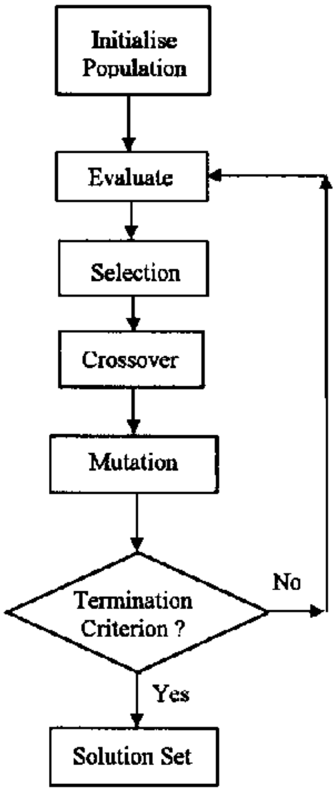


Figure 3. Process of Genetic Algorithm

A typical GA mainly requires Initial population and Fitness function. Based on this fitness function, we will decide to whether evaluate or not further. The performance is influenced mainly by Crossover and Mutation operators. GA mainly takes chromosomes as input which can be represented as binary string in computer for processing.

2.2.1. Encoding of Chromosome: The chromosome should be in some way contain information about solution which it represents. The most used way of encoding is a binary string. The chromosome may be looking like this.

Chromosome 1:	1101111000011110
Chromosome 2:	1101100100110110

Each chromosome has one binary string. Each bit in this string can represent some characteristic of the solution.

2.2.2. Cross Over: Crossover selects genes from parent chromosomes and creates new children. The simplest way to do this is to choose randomly some crossover points and everything before this point can be copied from the first parent and then everything after a crossover point can be copied from the second parent. Specific crossover made for a specific problem can improve performance of the genetic algorithm.

Chromosome 1	11011 | 00100110110
Chromosome 2	11011 | 11000011110
Offspring 1	11011 | 11000011110
Offspring 2	11011 | 00100110110

2.2.3. Mutation: After a crossover is performed, mutation takes place. This is to avoid falling all solutions in population into a local optimum of solved problem. Mutation changes randomly the new offspring. For binary encoding we can switch a few randomly chosen bits from 1 to 0 or from 0 to 1. The mutation depends on the encoding as well as the crossover.

Original offspring 1	1101111000011110
Original offspring 2	1101100100110110
Mutated offspring 1	1100111000011110
Mutated offspring 2	1101101100110110

3. Image Segmentation

Image Segmentation divides the image into meaningful regions based on similar attributes which is nothing but pixel categorization. Image segmentation methods are generally based on one of two fundamental properties of the intensity values of image pixels: similarity and discontinuity. In the first type, the concept is to partition the image into several different regions such that the image pixels belonging to a region are similar according to a set of predefined criteria's. Whereas in the second type, the concept of partition the image on the basis of abrupt changes in the intensity values is used. Edge detection technique is an example of this category which is similar to the boundary extraction. Based on the discontinuity or similarity criteria, many segmentation methods have been introduced which can be broadly classified into six categories:

(1) Edge Detection
(2) Histogram based method
(3) Neural Network based segmentation methods
(4) Physical Model based approach

(5) Region based methods (Region splitting, Region growing & merging)
(6) Clustering (Fuzzy C-means clustering and K-Means clustering).

In this paper, we will focus on Neural Network based image segmentation which relies on processing small regions of an image using a neural network or a set of different artificial neural networks. After this, the decision-making method marks the regions of an image on the basis of the category recognized by the artificial neural network.

In this paper we

Step 1: Initialization

Step 2: Distance Calculation

Step 3: Object Clustering

Step 4: Centroid Calculation

Step 5: Apply Genetic Algorithm

Step 5.1: Initialization

Step 5.2: Fitness Function

Step 5.3: Selection of chromosomes

Step 5.4: Crossover

Step 5.5: Mutation

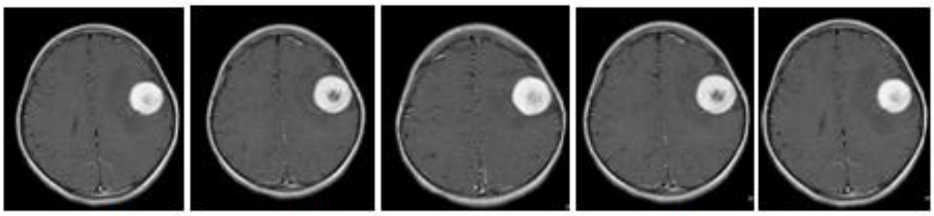
Step 5.6: Updation

Step 5.7: Termination criteria

Step 6: Image Segmentation

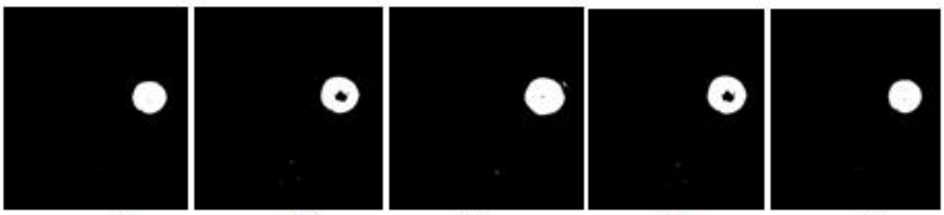
4. Results and Discussion

The results obtained for our proposed technique is also compared with results of the existing method in order to find the effectiveness of the proposed method.



(a) (b) (c) (d) (e)

Figure 4: Input MRI Images



(a) (b) (c) (d) (e)

Figure 5: Segmented Output using Hybrid K-Means

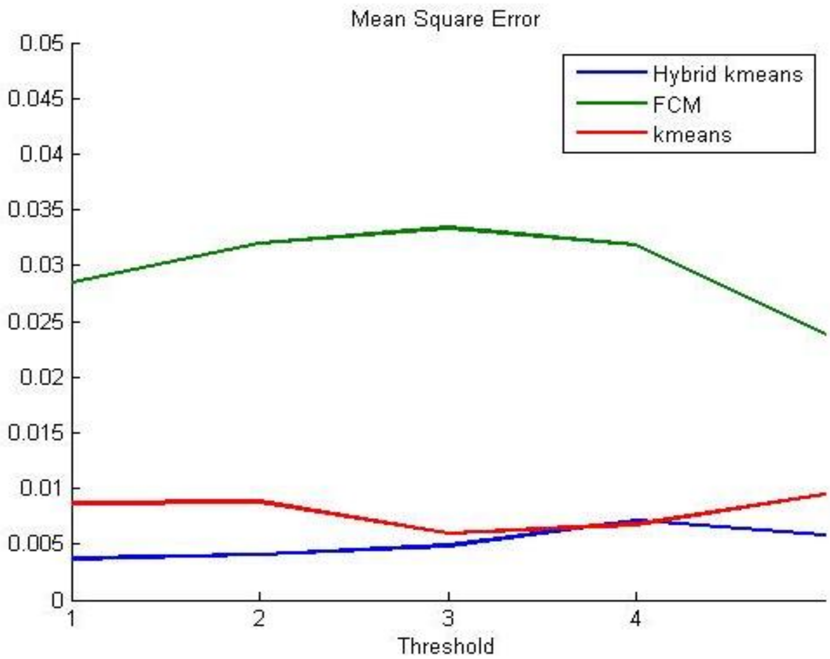


Figure 6. Comparison of MSE for proposed Hybrid K-means and Existing FCM and K-means

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