JOURNAL OF MECHANICS OF CONTINUA AND MATHEMATICAL SCIENCES
www.journalimcms.org

ISSN (Online) : 2454 -7190 Vol.-15, No.-7, July (2020) pp 117-125 ISSN (Print) 0973-8975

MEDICAL IMAGE SEGMENTATION

Shubhajoy Das[1], Debashis Das[2]

[1]Research Scholar, Department of Computer Science and Engineering
Techno India University, Kolkata, West Bengal, India

[2]Associate Professor, Department of Computer Science and Engineering
Techno India University, Kolkata, West Bengal, India

[1]shubhajoydas@rocketmail.com

Corresponding Author: Shubhajoy Das

https://doi.org/10.26782/jmcms.2020.07.00009

Abstract

The main purpose of segmentation is to partition an image based on features into different regions. Unsupervised classification algorithms K means, K-nearest neighbor, neural networks can be used to perform efficient image segmentation. Image segmentation is an important step to perform classification of images. Segmentation algorithms such as watershed segmentation, support vector machines can be used to find the region of interest. A genetic algorithm based image segmentation algorithm, ant colony optimization algorithm is proposed and we compare it with k-means segmentation. We apply some segmentation algorithms in industry standard datasets and view the results of our segmentation algorithms.

Segmentation is a basic task in image processing and can be applied in large number of domains. We emphasize on how a segmentation algorithm can be developed to segment out tum ours from medical magnetic resonance images. We have used the open CV python package for our image processing tasks.

Keywords : Magnetic Resonance Imaging, Medical Image processing, support vector machine, unsupervised classification, Image segmentation, Ant Colony Optimization, Genetic Algorithms, K-means algorithm

I. Introduction

A typical image contains a lot of information, most of which is not required. We need a *region of interest* from the image to interpret useful information from the image. Various features can be used such as pixel features, texture feature, shape features. A very simple algorithm to perform segmentation is thresh holding represented by

$$B(r, c) = \begin{cases} 1 \text{ if } p(r, c) \leq t \\ 0 \text{ if } p(r, c) > t \end{cases}$$

We can compute the optimum threshold by assuming a Gaussian distribution of the two regions of the image and computing the mean and standard deviations of the image. The image will be classified as background, region of interest and boundary

$$F(x) = \frac{1}{\sqrt{2\pi\sigma 2}} e - \frac{(x-\mu)2}{2\sigma 2}$$

Region growing methods, Region merging methods previously used by researchers suffer from the defect that they are computationally inefficient. In Region growing methods seed regions are provided and they are grown by the algorithm.

Pixel based feature use a window of size nxn to compute pixel features. One methodology that can be used is classify neighbouring pixels based on a threshold value and shifts the window. We could normalize the pixel values in a specific window to gain better results. An efficient algorithm for image segmentation would be to calculate the standard deviation of the pixel values of the window and assign the values to the coordinates. We can then use k means algorithm to segment the image.

Shape based features such as centroid

$$\text{Centroid (gx, gy)} = \begin{cases} g_x = \frac{1}{N}\sum_{i=1}^{N} x\, i \\ g_y = \frac{1}{N}\sum_{i=1}^{N} y\, i \end{cases}$$

Eccentricity

Eccentricity: E = L/W [L: length of bounding box W: width of bounding box]

Can be applied to the region of interest to classify areas in medical images. An efficient algorithm for segmentation is to select an arbitrary region of nxn window and find the shape features centroid, Eccentricity and use a support vector machine to classify the image.

II. Literature Review

K. Sakthivel, R. Nallusamy, C. Kavitha [III] in there paper on image segmentation propose an algorithm based on identifying features from pixels and edges of an image and using the support vector machine and fuzzy k-means algorithm to train the support vector machine. The difference between k-means and Fuzzy C-means algorithm is that the cluster centres follow concepts from fuzzy logic and a large number of iterations are carried out to train the support vector machine.

Edge detection is an approach to image segmentation based on abrupt changes in intensity of an image. We can detect changes in image intensity.

The magnitude of the vector

$$v(f) = \text{grad}(f) = [gx, gy] = [f'(x), f'(y)]$$

The direction of the gradient vector is given by the angle which is measured with respect to x axis

$$\mathbf{\Theta} = \operatorname{atan}\left(\frac{\mathbf{G}_y}{\mathbf{G}_x}\right)$$

Graph based segmentation algorithms measure have the graph weights as the dissimilarity between the pixels. A spanning tree of the graph is found to segment the images.A weight is assigned to each edge by using an 8- connected neighbour,4-connected neighbour and using metrics such as contrast, covariance etc.

Zoltan Kato[a] Ting-Chuen Pong[b1] [I] Markov random field image segmentation model for color textured images.They use a colour image and gabor filter. The parameters of the markov model are estimated using Expectation Maximization algorithm. A segmented area has the joint probability distribution of the clique as the energy function

K means algorithm is an unsupervised classification algorithm which clusters the image based on similarity which can be measured by Euclidean distance, Manhattan distance .We initially select the total number of clusters and the cluster center and continue our iteration to find the best fit. The convergence of the K-means algorithm depends o how the cluster centers are selected. There are variants of the k means algorithm which estimate the cluster centers initially. The k means algorithm can be implemented for segmentation of images. K-means++ can be used to estimate the initial cluster centres. This makes the algorithm converge faster.

Watershed segmentation is an image segmentation algorithm which differentiates the image into valleys and ridges .The watershed algorithm provides a district line between the boundary's of the image and so has provided very accurate results in medical image segmentation. The watershed segmentation algorithm assigns every point in the pixel to a boundary or valley. The discontinuity between the intensity of the pixels can be corrected using morphological operators before applying the watershed segmentation.

Texture based features can be used for image segmentation such as gray level co-occurrence matrix. Gray level co-occurrence matrix is a statistical method of examining image texture that considers the spatial relationship between pixels. After computing the gray level co-occurrence matrix features are extracted from the gray level co-occurrence matrix such as entropy, energy, correlation, local homogeneity.

Gray level co-occurrence matrix is computed using this formula

$$P(i, j|\Delta x|\Delta y) = \sum_{i=0}^{i=n}\sum_{j=0}^{j=n}\{1, \text{ if } I(x, y) = i \text{ and } I(x+\Delta x, y+\Delta y) = j;\ 0, \text{ otherwise}\}$$

After computing the Grey Level co-occurrence matrix various values are calculated such as entropy, correlation

$$\text{Entropy} = -\sum_{i=0}^{i=n}\sum^{j=n} c(i,j) \times \log(c(i,j))$$

Correlation=$-\sum_{i=0}^{i=n}\sum_{j=0}^{j=n}=\{ixj\}xGLCM(i,j)-\{\mu x \text{ x } \mu y\}/(\sigma x \text{ x } \sigma y)$

The Gray level co-occurrence matrix can be modified for rotational invariance by finding the Gray level co-occurrence matrix at different angles and finding the average values.

A Fourier transform of an image is the representation of an image from spatial domain to a frequency domain. After computing the Fourier transform of an image we can train the algorithm on a bench mark to identify region of interests from images from the peak amplitude and Average amplitude of the waves as features of the algorithm.

III. Working of Ant Colony Optimization and Genetic Algorithm

Genetic algorithms work on the principle of how biological genes evolve by following Darwin's theory of evolution. The theory suggests that the fit individuals in a generation evolve to produce a new chromosome from two or more chromosome pairs. The different individuals mate to produce new chromosome pairs. The various operations in the genetic algorithm operation are crossover and mutation. The mutation operation depends upon a set probability and one or more genes are mutated with a different value. There are different types of crossover such as 1-point crossover ,2-point crossover, single-point crossover

Ant colony optimization algorithms work on the behavior of ants. A large number of ants move from a destination to source foraging for food and the ants leave out pheromone trails. The other ants follow the pheromone trails, based on the intensity of the pheromones in the various paths. The pheromones evaporate as time passes and new paths are found. The ants also follow there sensory intuition to make the judgment to the path. Ant Colony optimization algorithms have shown very good results in comparison to genetic algorithms in a large number of problems. The reason would be how the two solutions converge based on there criteria/assumptions.

ACO mimic the behavior of ants and the accuracy has shown to be quite good. There have been proposals where a Ant Colony Optimization combined with Genetic Algorithm has shown better results.

IV. Genetic Algorithm Approach for Image Segmentation

Genetic Algorithms use the theory of evolution to estimate the best chromo some, they use a fitness function to estimate the next generation. The various operators are applied such as crossover, mutation and the fitness of the next generation is estimated.

Step 1

We work on a window size of nxn. Normalize the intensity values of the image. Apply median filter on the image to remove noise.

Convert the image to grayscale

Measure the standard deviation of the intensity values of the image in the specified window. Store the standard deviation of each window.

Step 2

Every pixel in the nxn window is assigned a same region. In the first iteration of the algorithm we check the fitness function and proceed to keep the chromosomes which are most favorable.

Fitness function used is =xij-σ window/(distance between all pixels)

We minimize the fitness function. We assign a value to the window. We try this for all neighboring windows.

Step 3

We then combine the windows using crossover operator and check the fitness function and we keep the most favorable chromosomes.

We then calculate the fitness function.

Step 4

The iteration is repeated large number of times and the best offspring is the result of our segmentation Algorithm.
We can also use gray level co-occurrence matrix as the fitness function or entropy of the window.

Genetic algorithm operators

Crossover

Two chromosomes are selected from the current population and a point where the crossover has to be taken is chosen and they are combined

Mutation

An array of points is selected at random from the chromosome and that point is mutated with a different value with a specified probability.

V. Ant Colony Optimization based Image Segmentation Algorithms.

Ant colony optimization are a class of meta heuristic algorithms which reduce np complete problems to finding paths through a graph based on a pheromone trail left by a movement of a colony of ants. The performance of Ant Colony optimization algorithms rely heavily on the parameters chosen initially.

Pheromone update functions used in ACO algorithm for image segmentation is:-

$$\tau i\, j \leftarrow (1-\rho)\cdot \tau i\, j + \sum \Delta\tau ij^{k}$$

Where ρ is the evaporation rate, m is the number of ants and Δij^{k} is the quantity of pheromone laid by the ant in cell (i, j) of the image

$\Delta\tau ij^{k}$={I(i, j)*Lk where I(i, j) is the average intensity of the surrounding pixels top, bottom, left, right, diagonals

0 otherwise, if the ant does not visit the edge

Lk is the amount of pheromone left by the ant k

Step1

We assign a m number of ants to start at vertices (0, 0) and move arbitrarily based on the probability

$P_{i,j}^{k}=\{\tau_{ij}^{\alpha}.\eta^{\beta}/ \sum\tau_{ij}^{\alpha}.\eta^{\beta}$ where the denominator includes the value of the net pheromone of all the vertices visited by the ant

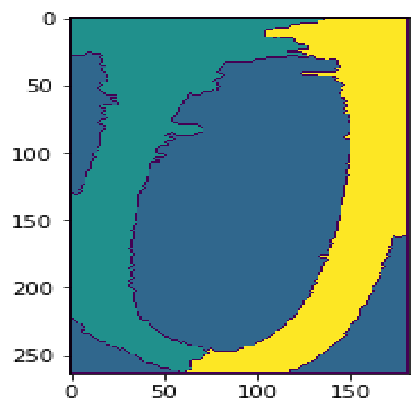
The parameters **α** and **β**

Give the relative importance of the heuristic function versus the heuristic η_{ij}

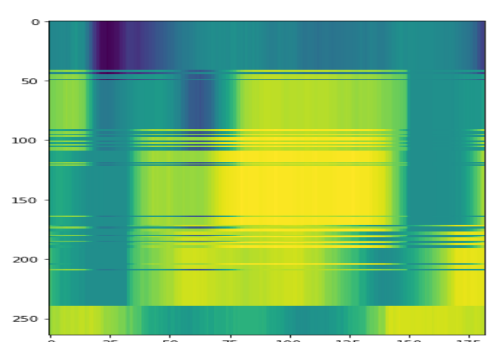
The Ant Colony Optimization algorithm can be run for different parameters of the algorithm.

VI. Result and Discussions

A K means based segmentation algorithm has been implemented in python and the results were compared with the watershed segmentation algorithm. The resultant images after the segmentation process are given below which uses digit dataset. K means algorithm segmentation with 5 cluster centres. The accuracy of the K means algorithm can be improved if we use thresh holding. The Genetic algorithm can take the output of the watershed segmentation algorithm and use that algorithm for an improved segmentation of the image.

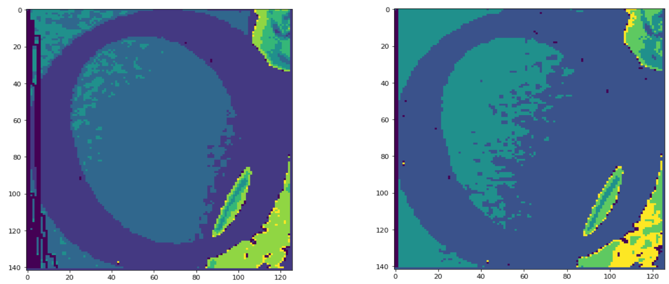


Watershed Segmentation

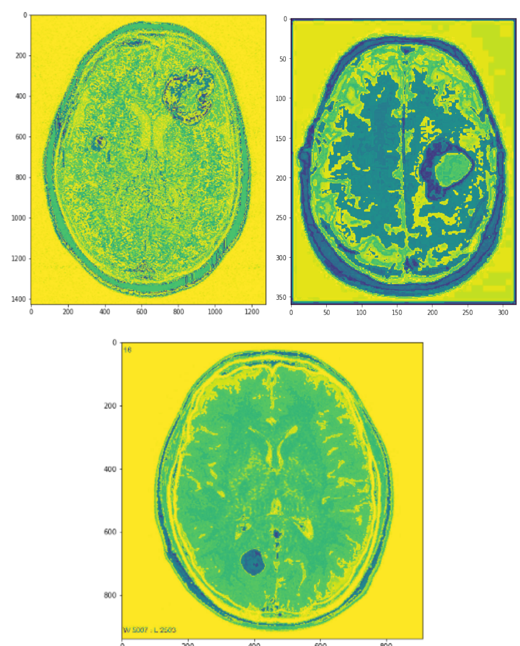


K-Means Segmentation

Ant colony optimization segmented image with 10000 ants



The two images are for different values of L=0.08,0.05 for ant colony optimization. Medical image segmentation is not accurate due to the presence of noise so a very vague representation is estimated, we can still distinguish the boundary's of the tumor and the grey matter, white matter, cerebrospinal fluid in the segmented image. The Region of interest is extracted by using the bitwise And operator with the original image which gives us the tumors location. The bit wise or is applied on the image. The denser regions with a distinct boundary is the tumor in the image segmented



V. Performance Metrics of Segmentation Algorithms

Performance metrics for segmentation algorithms used are Precision, Recall, F1-score, Jaccard distance, Dice coefficient.

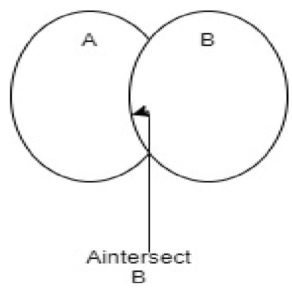
Precision=True Positive/(True Positive+False Positive)

Recall=True Negative/(True Negative+False Negative)

F1-score=2*precision*recall/(precision+recall)

Dice coefficient =2*overlap/Total area of the two images

Dice coefficient=2*(A∩B)/(A+B)



VI. Conclusions and Future Work

The ant colony optimization algorithm has provided very good segmentation results. We can improve the performance of the algorithm by using different parameters for Alpha and Beta in our algorithm.

The region of interest can be separated out by using background subtraction based on a threshold value. Classification algorithms can be applied to the image to identify the image. We can also calculate the standard deviation, mean as feature vectors of the image. And perform classification using classifiers to check if tumour is present.

Grey level co-occurrence matrix can be estimated to find the texture features and classify the tumour as malignant or benign. Genetic algorithm based image segmentation techniques have not shown good results in image segmentation tasks. The genetic algorithm based image segmentation methods have shown results better then thresh holding. A method to optimize the genetic algorithm based segmentation is to use a pre segmented image as an input to the genetic algorithm based segmentation algorithm.

A very robust method to segment the final image would be to apply watershed segmentation after applying ant colony optimization to find the tumour from the brain magnetic resonance imaging images.

References

I A Markov random field image segmentation model for color textured images Zoltan Kato a,*, Ting-Chuen Pong b,1

II Bradski, G., 2000. The Open CV Library. Dr. Dobb Journal of Software Tools.

III Colour Image Segmentation Using SVM Pixel Classification Image K. Sakthivel, R. Nallusamy, C. Kavitha TW World Academy of Science, Engineering and Technology International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol:8, No:10, 2014

IV Dorigo, Marco & Birattari, Mauro & Stützle, Thomas. (2006). Ant Colony Optimization. Computational Intelligence Magazine, IEEE. 1. pp 28-39. 10.1109/MCI.2006.329691.

V Digital Image Processing and Analysis by Bhabatosh Chanda and Dwijesh Dutta Majumder PDF Online. ISBN 9788120343252 from PHI Learning.

VI Gonzalez, Rafael C., and Richard E. Woods. Digital Image Processing. Upper Saddle River, N.J.: Prentice Hall, 2002.pp700-809

VII M. Haseyama, M. Kumagai and H. Kitajima, "A genetic algorithm based image segmentation for image analysis," 1999 IEEE International Conference on Acoustics, Speech, and Signal Processing. Proceedings. ICASSP99 (Cat. No.99CH36258), Phoenix, AZ, USA, 1999,

VIII Scikit-learn: Machine Learning in Python, Pedregosa et al., JMLR 12, pp. 2825-2830, 2011