International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

Improved Method of OCT Image Segmentation for the Detection and Classification of Retinopathy Diseases

Saya Nandini Devi M, Santhi S

Abstract: ***Image Segmentation is the process of dividing an image into regions or objects for the purpose of extracting useful information. It plays vital and dominant role in medical image analysis. OCT is a high speed and non-invasive method to determine three dimensional images of retina. This paper presents an improved method of automated OCT image segmentation in order to detect and classify Retinopathy diseases. Discrete wavelet transform (DWT) is a multiresolution approach and is widely used for OCT image segmentation. K-Means Cluster (KMC) approach is popular among researchers that offers better results for extracting the features for image segmentation. This work compares the segmentation process based on DWT with KMC and presents a better segmentation method comprising of K-Means Cluster with Genetic Algorithm Optimization (KMC-GAO) that identifies cluster centroid for obtaining the improved image segmentation performance of an OCT image. The performance metrics such as Structural Content (SC), Rand Index (RI), Variation of Information (VOI) and Global Consistency Error (GCE) are evaluated for all these segmentation techniques and it is observed that KMC-GAO segmentation offers better result than DWT method and KMC approach*****.**

Keywords : Discrete Wavelet Transform, K-Means Cluster, Genetic Algorithm, Image segmentation.

I. INTRODUCTION

Optical Coherence Tomography is a fast and multi milli meter non-invasive one cell resolution imaging procedure for biological tissues that is widely used as a standard tool in ophthalmology [1]. In principle it uses infrared light to provide 3D insight into live tissues at high resolution [2]. Due to its low cost, lack of irradiation and comfort of the patient it is quite popular as a diagnostic tool for identifying eye disorders [3]. Further it is a standard method for retina imaging and has demonstrated promising diagnostic results for retinal diseases. The retinal tract is visualized to identify and assess a variety of ocular diseases such as macular edema, age related macular degeneration and so on [4].

Manuscript published on November 30, 2019.
* Correspondence Author
Saya Nandini Devi M*, Research Scholar, Department of Electronics and Instrumentation Engineering, Annamalai University, Chidambaram-608002, India,
Santhi S, Department of Electronics and Instrumentation Engineering, Annamalai University, Chidambaram-608002, India.

Manual segmentation is a challenging task since it is time consuming and highly dependent on expertise when volumetric image data exists. Existing default automated segmentation methods available with OCT imaging systems are inconsistent. In addition to this the high reflectivity of some retinal layers produces poor image contrast and the presences of speckle noise also create challenges for automated segmentation. Hence it is necessary to determine a better automated segmentation approach for OCT image analysis for retinopathy diseases detection and classification. Morphological features of cysts, macular hole can be visualized based on shape and distribution in OCT images. For a reliable and efficient diagnosis of diseases such as macular edema, age related macular degeneration it is essential to have quantitative analysis of OCT images [5]. This requires careful observation of changes in layers of retina for which image segmentation is vital task. Further more for automated analysis of OCT images with more data sets for the detection and classification of retinopathy diseases, identifying a better image segmentation method is very much required.

Work has been steadily advancing in the last two decades with the automatic OCT image segmentation and as of now there is no single image segmentation technique that works for all segmentation tasks [6]. Frame by frame segmentation of Drusen from retinal SD-OCT image has been proposed [7]. A 3D graph theoretic segmentation technique has also been proposed for 3D macular OCT scans [8]. Adaptive kernel based segmentation approach for high resolution OCT scans also exists [9]. In automatic segmentation of FD-OCT has been demonstrated which employ diffusion filter and segmentation by constructing energy function based on gradient and smoothening constraints. In [10] graph based segmentation approach has also been proposed. Graph cut Segmentation method based on probability constraints was shown in [11]. A particular type of spectral graph theory based segmentation which was different from traditional graph approach was introduced in [12]. In [13] segmentation by sparsity based denoising, support vector machines, graph theory and dynamic programming was introduced. Even though considerable progress has been shown in the literature in recent years, still there is no current method with sufficient accuracy. This motivates for the development of a better image segmentation tool and this work thus emerged.

The rest of the paper is organized as below. The section II describes about the proposed methodology. Section III explains the metrics employed for performance analysis of the work. Section IV discusses about the results. At the end, Section V concludes the work carried out.

II. METHODOLOGY

The methodology of proposed image segmentation process is presented as shown in Fig 1. The edge detected output of OCT image is fed to different segmentation techniques such as Discrete Wavelet Transform (DWT), K-Means Cluster (KMC) and K-Means Cluster based segmentation with Genetic Algorithm Optimization (KMC-GAO). The performance analysis is carried out by using performance metrics such as Structural Content (SC), Rand Index (RI), Variation of Information (VOI) and Global Consistency Error (GCE).Based on these performance metrics analyses the better segmentation method for OCT image is determined.

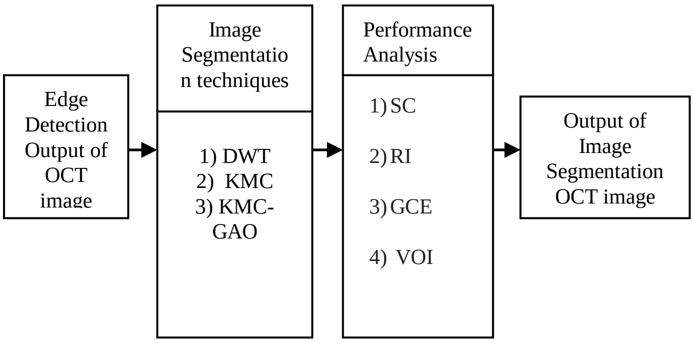


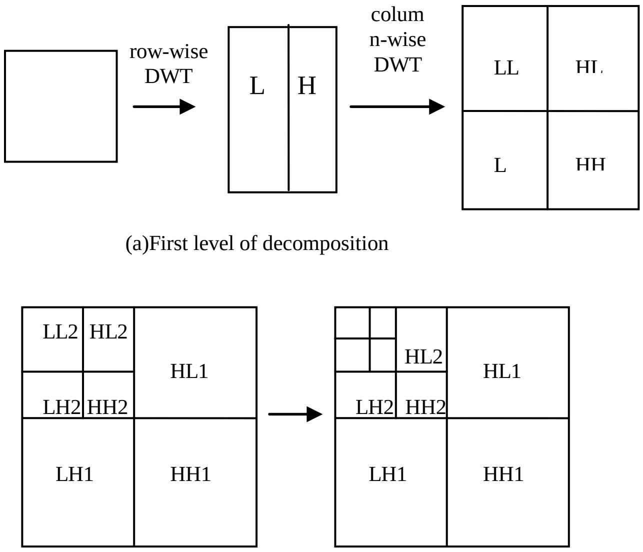
Fig. 1.Process flow of Image Segmentation

A. Existing Methods

Image segmentation is a method by which objects are separated into several quantities, which is why the pixels of an image can be accurately classified in a decision-oriented system. Thus, we can state that the aim of the segmentation of images is to simplify, change or transform an image's representation in a meaningful way so that further analyzes are made easier [14]. There are different manual techniques and approaches for image segmentation such as threshold based of Discrete Wavelet Transform (DWT) and centroid based of K-Means Cluster (KMC) technique. The principle behind the manual existing segmentation method of DWT and KMC are presented below.

Discrete Wavelet Transform (DWT)

Construction of feature image is essential for image segmentation. This requires clustering of the values of features of each pixel or block of pixels. The accuracy and efficiency of segmentation method depends on these features. For example, if a picture includes smooth regions, mean and variance can be segmented as features. Wavelet transformation is suitable for optimal characteristics and is therefore used in this work. The signal is decomposed by a wavelet in a time domain by passing the signal through high-pass and low-pass filters to create two copies, low-pass (L) and high-pass (H).Further downgrades may be rendered through a group of low-pass (LL) and high-pass (LH) filters [15]. Low-pass variant. Likewise, the high-level forms can also be broken down by moving the low-pass (HL) and high-pass (HH) filters through once again, as shown in fig2.



(a)First level of decomposition

(b)Second level of decomposition

(c)Third level of decomposition

Fig. 2.2D-DWT Level of Decomposition

This process can be further continued till a given signal gets decomposed to a pre-defined reference level. Thus the decomposition generates a group of signals specifying different frequency bands but in total represent a single signal. Then signals corresponding to different bands can be put together and plotted on a three dimensional graph.
Time, frequency and amplitude represents three axis on a three dimensional graph. The size is inversely recurrent in three-dimensional diagrams. The components for low frequencies are medium quantities, while broad maximum and high-frequency components reflect low and small peak sizes. The term "wavelet" applies to a small wave. Wavelet can be either continuous or isolated, so can be categorized as a transforming or transforming continuous wavelet. The discrete transforming wavelet is a computerized method to measure the simple transition of the wavelet of a signal. The DWT is the optimal solution for the cumulative estimation time.

Algorithm of Discrete Wavelet Transform

Wavelets transform is an effective tool for time-frequency analysis [16]. The input image is subjected to a two dimensional discrete wavelet transform (DWT). The image is decomposed into approximate, horizontal, vertical and detailed coefficient matrices. The estimated coefficients represent low frequency components whereas the components represent high frequency, both in the context and in the foreground with the accurate coefficients (horizontal, vertical or diagonal). A new comprehensive coefficients as well as an estimated new matrix extracted from the prior step are used to recreate the picture of the wavelet function. For recovery, the same wavelet method for decomposition is used. Essentially we have used the wavelet function of 1-level decomposition and reconstruct.

The re-constructed functional image has some negative coefficients, so that the built-in wavelet image can be extracted from its size. In conclusion, we extract the transition region from the feature image by applying the Otsu image threshold.

K-Means Cluster (KMC)

Clustering is a system in which items are grouped according to their attributes in classes [17]. Thus, a cluster is a group of objects "related" to each other, which are "unlike" objects of other clusters. Distance metrics play an important part in evaluating an individual data vector's inclusion rate to any group. There are numerous clustering methods that use various distance metrics. The membership degree is essential and depends on how far the data center and the information vector are from each other. K-Means Cluster visual description as shown in Fig.4.

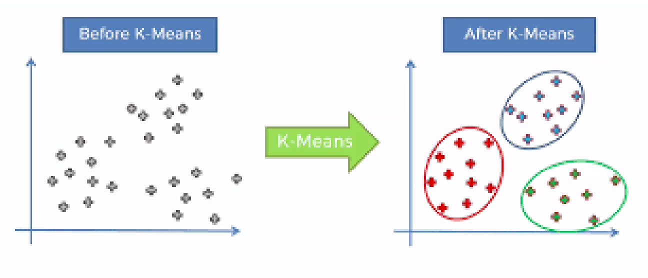


Fig. 3.Graphical representation of K-Means Cluster

The keyword (metadata) or its content (description) can be used for grouping an image. A keyword is a font that describes the keyword of an image that refers to its different characteristics in clustering by keyword. The like images are grouped into a cluster by assigning each characteristic value.

The material based on the content applies to shapes, textures or any other details from the image itself. The methods, strategies and algorithms used are based on statistics, pattern recognition, signal processing, etc. Based on the optimisation of a regional metric, clustering is a central method since the start of pattern recognition. K-means clustering is the most popular method used for model recognition.

Clustering K-means is a type of uncontrolled learning that is used when data without defined categories or groups are unlabelled. The purpose of this algorithm is to classify the classes in the information that the parameter *K*. The algorithm operates to allocate one of the K-groups to each data-point based on the characteristics.

The clustering helps to define and evaluate groups which have evolved organically, rather than identifying groups before looking at data. The K chosen explains how to determine the number of classes. A collection of characteristics that defines the resulting groups is the centre of each cluster. The weights of core features are analyzed so that the form of category that cluster describes can be qualitatively represented.

Algorithm of K-Means Cluster

The K-means distributed method utilizes iterative optimized tests. The number of clusters K and the data set are the algorithm outputs. The data set consists of a series of functions for each data point. Initial estimates for the K centroids begin with the algorithms, which can either be generated randomly or chosen randomly from the data set. The algorithm then iterates between two steps: data assignment step, centroid update step and choosing K.

B. Proposed Method

The Fig. 4 offers the structure of the system proposed; initially edge detection output OCT picture is relevant to the KMC and generates Genetic Algorithm optimization (GAO) centroid quality. The Genetic algorithm segmented OCT images as shown in Fig 5 depending on the centroid values.

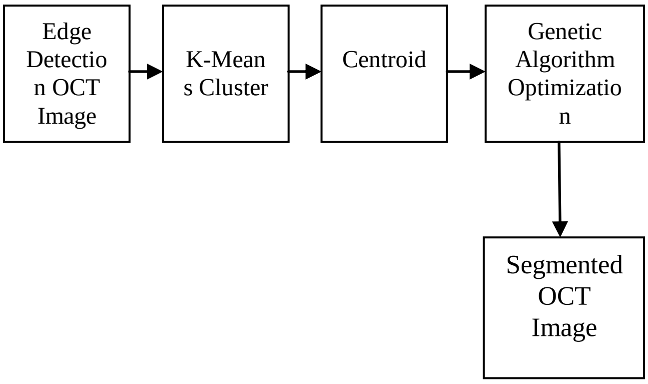


Fig. 4.Proposed method of KMC-GA

Genetic Algorithm (GA)

The workability of genetic algorithms (GAs) is based on Darwinian theory of survival of the fittest [18]. GA may contain a chromosome, a gene, set of population, fitness, fitness function, breeding, mutation and selection. A number of chromosome-represented solutions, known as population, begins with genetic algorithms. Solutions were drawn from a single population and used to form a new society, inspired by the prospect of better the new population than the old population. In addition, solutions are chosen to form new solutions, namely the offspring, according to their fitness. The cycle described above is replicated until certain conditions are met. The basic genetic algorithm GA is represented algorithmically as follows:

- Generate random chromosomes with respect to the present problem.
- Evaluate each chromosome fitness.
- Create new population until the iteration ends.
- Selection Process
- Crossover Process
- Mutation Process
- Place newer offspring over the new population.
- Use new generated population for further runs.
- If the end condition is satisfied, stop, and return the best solution.
- Otherwise, Go to step 2.

The genetic algorithms performance is largely influenced by crossover and mutation operators.

K-Means Cluster with Genetic Algorithm Optimization (KMC-GAO)

OCT is a fast and non-invasive medical imaging technique which helps in the investigation of each individual retinal layer structure.

For early detection of retinal diseases and the study of their progression, segmentation of the OCT images into the distinct layers of the retina plays a crucial role.
Nevertheless, the clinicians manual segmentation is extremely time consuming, time consuming and specialist in terms of level. There is therefore a tremendous need in order to develop a fast, reliable and simpler medical decision making automatic segmentation algorithm for retinal OCT images.

In this paper, the proposed algorithm involve the use of K-Means Cluster with Genetic Algorithm Optimization (KMC-GAO) to determine the optimal feature corresponding to each pixel or block of pixels.

The algorithm of KMC-GAO are mentioned below in step by step process,

Step 1:Initialize the parameters
Step 2:Assign the population chromosome
Step 3:Estimate the fitness function using K-means clustering process.
Step 4:The clustering process is performed with parallel wise distance estimation technique.
Step 5:Then selection process is done to perform the crossover and mutation.
Step 6:The elitism technique is compared with previous chromosome with current chromosome and produces the next chromosome.
Step 7:From Step 1 - Step 4, the best chromosome of cluster centroid value is generated.
Step 8:Using the cluster centroid value, the OCT images were segmented.

III. PERFORMANCES ANALYSIS

The performance metrics used for quantifying the performance of segmentation technique, which includes Structural Content (SC), Rand Index (RI), Variation of Information (VOI) and Global Consistency Error (GCE) are discussed below,

A. Structural Content (SC)

A higher value of SC (Structural Content) shows that image is of poor quality [19].

$$SC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} x(i,j)^2}{\sum_{i=1}^{M}\sum_{j=1}^{N} \hat{x}(i,j)^2} \quad (1)$$

B. Rand Index (RI)

Rand index counts the fraction of pairs of pixels whose labeling are consistent between the computed segmentation and the ground truth averaging across multiple ground truth segmentation. The RI between the test and ground-truth segmentations, M and N is the sum of number of couple of pixels which has same labels and those that have different labels are classified by the total number of couple of pixels [20]. The Rand Index is computed as

$$RI = (M, \{N_K\}) = \frac{1}{T}\sum_{i<j}\left[x_{ij}y_{ij} + (1 - x_{ij})(1 - y_{ij})\right] \quad (2)$$

where$x_{ij}$the event that pixel has same labels is, y_{ij} is the probability and T is the number of pairs in total. The issue is the normalization with an estimation of its expected value.

C. Global Consistency Error (GCE)

Global Consistency Error (GCE) forces all local refinements to be in the same direction. It measures the extent to which one segmentation can be viewed as a refinement of the other. Segmentations that are related in this manner are considered to be consistent, since they could represent the same natural image segmented at different scales [20].

$$GCE = \frac{1}{n} min\{\sum_i E(x1, x2, pi), \sum_i E(x2, x1, pi)\} \quad (3)$$

Where the two segmentations are $x1$ and $x2$ and produced the output value [0::1] where the zero indicates no error and pi assumed as the segments in $x1$ and $x2$ which have that pixel.

D. Variation Of Information (VOI)

The variation of information (VOI) is distance metric derived from the mutual information. Contrary to the mutual information it measures the amount of information (or entropy) which is not shared between two random variables [20]. The non-normalized version of VI is used with values 0 for absolute match to the ground truth and positive values for the opposite.

$$VI(x, y) = H(x) + H(y) - 2I(x, y) \quad (4)$$

Where, $H(x)$ and $H(y)$ are the entropies conjoined with 'x' and 'y'. $I(x, y)$ is the mutual information with connected variables.

Retrieval Number: D9146118419/2019©BEIESP
DOI:10.35940/ijrte.D9146.118419
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

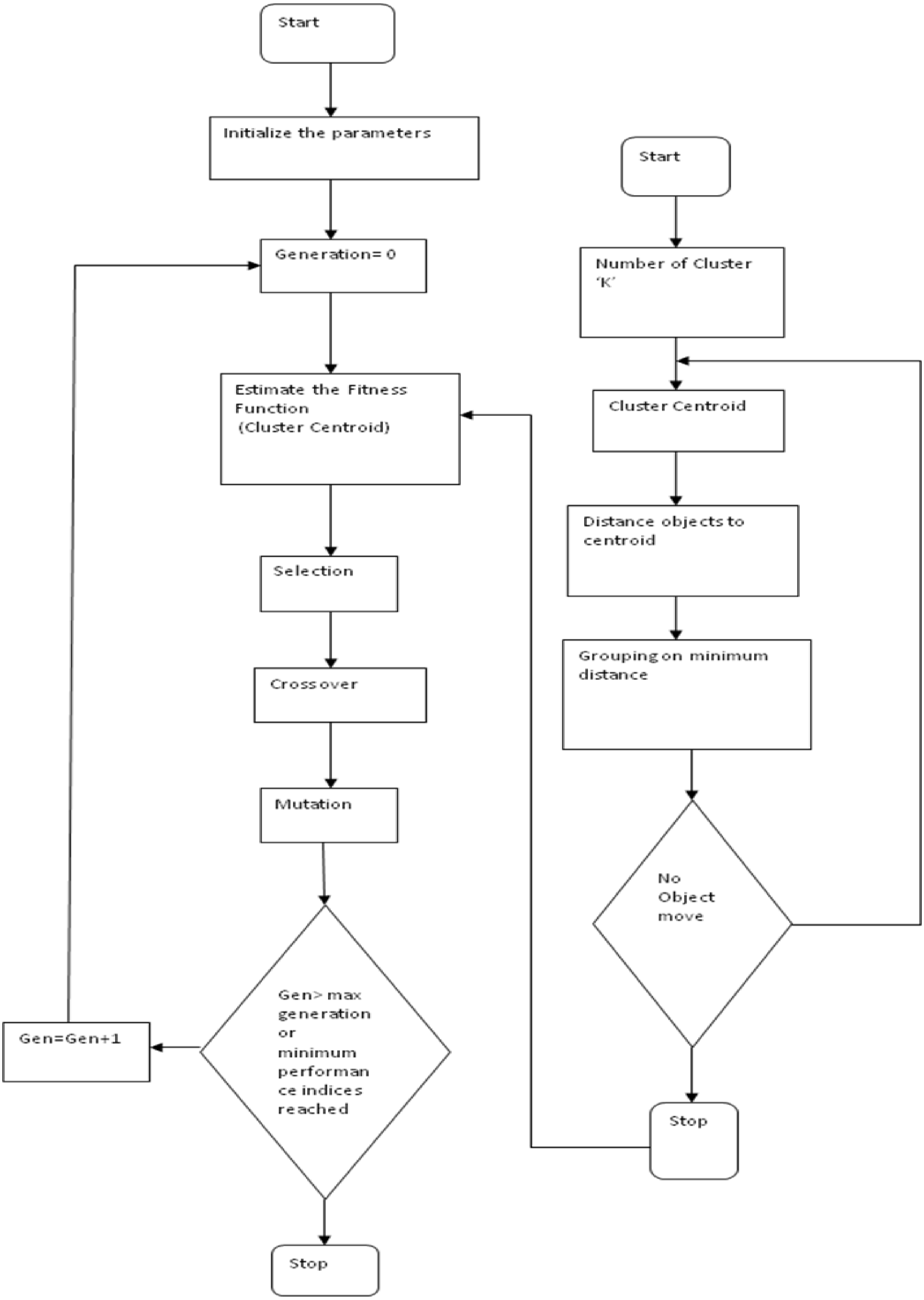


Fig. 5.Architecture of KMC-GAO

IV. RESULTS AND DISCUSSION

The proposed method is implemented in MATLAB (R2015a) that runs on Intel (R) core (TM)-i5 2600, 3.4 GHz CPU. This section validates in contrast with the current segmentation technologies the superior performance of the proposed KMC-GA system. The tests of the Fig segmentation software. 2 Display the OCT segmented image DWT output, and Fig.3 display KMC OCT segmented image. The Fig.4 demonstrates that the suggested approach is better segmented by OCT objects than by the other approaches and derived from regions the use of KMC-GAO algorithm. For the above-mentioned segmentation technologies and proposed methodology, many performance indicators such as SC, GCA, VOI and RI have been evaluated. Table 1 describes the measured performance metrics.

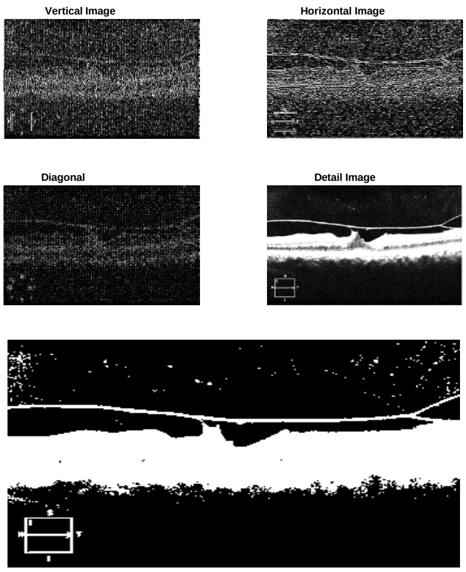


Fig. 6. 2DWT Segmentation Output of OCT

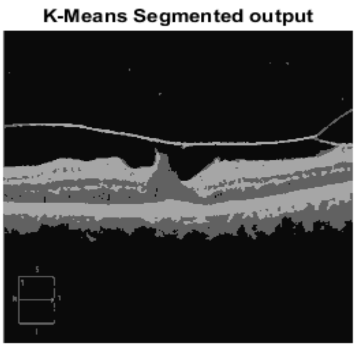


Fig. 7.K-Means cluster Segmentation Output of OCT

Fig. 8.KMC-GAO Segmentation Output of OCT

Table- I: Performance Analysis of Segmentation Technique

Image Segmentation Technique	Structural Content (SC)	Rand Index (RI)	Variation of Information (VOI)	Global Consistency Error (GCE)
Discrete Wavelet Transform	5.7875e+04	0.6215	0.2124	0.7034
K-Means Cluster Segmentation	5.4153e+04	0.8389	0.1863	0.6523
K-Means Cluster With Genetic Algorithm Optimization	**4.6172e+04**	**0.8764**	**0.1518**	**0.5491**

V. CONCLUSION

OCT images are widely used diagnostic tools for the detection of retinal disorders. Image segmentation is an essential task to classify the retinopathy diseases from an OCT image. In this paper, an improved method for OCT image segmentation technique is presented. The segmentation takes place with GA clustering in K-means. It is noted that KCA-GWO offers superior results from the analysis of different performance metrics than the current segmentation methodology such as DWT and KMC.

ACKNOWLEDGMENT

We would like to thank Dr.M.Ravishankar, Director of the Nethralayam , Senior Consultant of the Rajan Eye Care Hospital, Honorary Doctor of the Lions Club International, Founder of the Uyiralayam and Advisor of the Self Help Women's Association, Chennai for providing the Optical Coherence tomography Images.

REFERENCES

1. Wojtkowski, Maciej, et al. "In vivo human retinal imaging by Fourier domain optical coherence tomography." *Journal of biomedical optics* 7.3 (2002): 457-463.
2. Kajić, Vedran, et al. "Robust segmentation of intraretinal layers in the normal human fovea using a novel statistical model based on texture and shape analysis." *Optics express* 18.14 (2010): 14730-14744.
3. Lang, Andrew, et al. "Retinal layer segmentation of macular OCT images using boundary classification." *Biomedical optics express* 4.7 (2013): 1133-1152.
4. Shi, Fei, et al. "Automated 3-D retinal layer segmentation of macular optical coherence tomography images with serous pigment epithelial detachments." *IEEE transactions on medical imaging* 34.2 (2014): 441-452.

5. Lang, Andrew, et al. "Intensity inhomogeneity correction of macular OCT using N3 and retinal flatspace." *2016 IEEE 13th International Symposium on Biomedical Imaging (ISBI)*. IEEE, 2016.
6. Juang, Radford, et al. "Automatic segmentation of the left-ventricular cavity and atrium in 3D ultrasound using graph cuts and the radial symmetry transform." *2011 IEEE International Symposium on Biomedical Imaging: From Nano to Macro*. IEEE, 2011.
7. SinaFarsiu, et al. "Fast detection and sementation of drusen in retinal opticalcoherence tomography images". Ophthalmic Technologies XVIII. Vol. 6844, 2008.
8. Garvin MK, et al. "Automated 3-D intraretinal layer segmentation of macular spectral-domain optical coherence tomography images" .IEEE transactions on medical imaging, vol. 28, no. 9, september 2009.
9. Akshaya Mishra, et al. "Intra-retinal layer segmentation in optical coherence tomography images". Optics express, Vol. 17, No. 26, 2009.
10. IpekOguz, et al. "Graph-Based Retinal Fluid Segmentation from OCT Images".
11. Chen X, et al. "Three-dimensional segmentation of fluid-associated abnormalities in retinal OCT: probability constrained graph-search-graph-cut" .IEEE Trans Med Imaging. 2012, 1521-31.
12. Songhao Zhu, et al. "Graph theory based Image segmentation". IEEE,International Congress on Image and Signal Processing (CISP).
13. Raja Giryes, et al. "Sparsity-Based Poisson Denoising With Dictionary Learning". IEEE, VOl.23, No.12,2014.
14. Nameirakpam Dhanachandra, et al. "A survey on Image Segmentation Methods using Clustering Techniques". European Journal of Engineering Research and Science. Vol. 2, No. 1, January 2017
15. ShavetaThakral,et al."Image processing by using different types of Discrete wavelet transform".2018.
16. N.Valliammal, et al. "Leaf Image Segmentation Based On the Combination of Wavelet Transform and K Means Clustering".International Journal of Advanced Research in Artificial Intelligence, Vol. 1, No. 3, 2012'
17. SrinivasaRao, et al."Image Segmentation using Clustering Algorithms". International Journal of Computer Applications .Vol. 120 , No.14, June 2015.
18. Rahul Malhotra, et al. "Genetic Algorithms: Concepts, Design for Optimization of Process Controllers". Computer and Information Science Vol. 4, No. 2; March 2011.
19. Jaskiratkaur,et al." PERFORMANCE ANALYSIS OF CLUSTERING BASED IMAGE SEGMENTATION AND OPTIMIZATION METHODS". vol. 245–254, 2012.
20. Monika Xess, et al. "Analysis of Image Segmentation Methods Based on Performance Evaluation Parameters". International Journal of Computational Engineering Research,Vol, 04, No.3. 2014.