iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** V **Month of publication:** May 2016

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A Review on Various Exudate Segmentation Techniques in Fundus Images

Er. Kanika Bajaj[1], Er. Navjot Kaur[2]
[1]Computer Science Engineering Department, I.K Gujral Punjab Technical University

Abstract— Segmentation is a technique of dividing given image into numerous sectors. Its objective is to categorize image into various regions in such a way that every potential object in image get individual sector. Instinctive recognition of diabetic retinopathy wounds, like exudates can provide opportunity to identify certain diseases. Recently, several methods of fundus extraction techniques are proposed which can detect the exudates in fundus images in more promising manner. The related work has found that the issue of noise in fundus images is ignored in the majority of existing literature. Although Gabor filter bank has shown significant results over available techniques, but it is poor in its speed. Also it is not very effective for different type of noises at the same time. The overall objective of this paper is to review numerous image segmentation techniques for fundus image segmentation, and find suitable limitations in them.

Therefore to improve the accuracy of exudate extraction further a hybrid Gabor filter bank with trilateral based filtering technique is proposed in this dissertation. The hybrid Gabor filter bank with trilateral based filtering will use improved trilateral based filtering which enables us to detect exudates even in highly corrupted noisy images.

Keywords— Segmentation, Exudates, Retinal Vessel Segmentation, Fundus, Gabor Filter Bank

I. INTRODUCTION

A. Digital Image Processing

A digital image is a way to represent a 2-dimensional image in form of image pixels as a finite set of digital values. Values of pixels depict characteristics such as grey levels, heights, colours, opacities etc. Digital Image Processing is the process of manipulation of digital images using a digital computer. DIP deals with a computer-based processing of digital images. The input to the image processing system is a binary image which is processed using efficient algorithms, and output is in form of a processed image. Adobe Photoshop is a commonly used application for processing digital images.

Main aim of Digital image processing is–
Improvement of pictorial data for better understanding
Processing the digital images which can be used for transmission, storage and representation for autonomous machine perception.

B. Segmentation Process

Image segmentation process is a process of dividing a binary image into numerous sub-images which are a group of pixels which are similar based on certain homogeneity criterion for instance color, intensity and texture of the image, to find and discover objects and boundaries within an image. This is used to identify object of interest in the binary images. Main goal of Image processing is to retrieve required information from the image in such a way that it will not affect other features of the image. In Image Segmentation, a binary image is divided into numerous sub-images. Each of which represents certain kind of information in the form of color, intensity, or texture.

In a good segmentation technique:
Pixels which have similar grey scale value and form a connected region belong to the same category

Neighbouring pixels which have different grey scale values belong to different categories.

Segmentation approaches are depend on two properties of image-

1) Detecting Discontinuities: This segmentation approach aims to partition digital images when there is an abrupt change in the intensity value. It contains segmentation approaches such as edge detection.

Volume 4 Issue V, May 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

2) Detecting Similarities: This segmentation approach aims to partition a digital image into constituent sub-images based on some predefined similarity criterion. It contains segmentation approaches such as Thresholding, region growing, region splitting and merging.

Various Image Segmentation Techniques are-

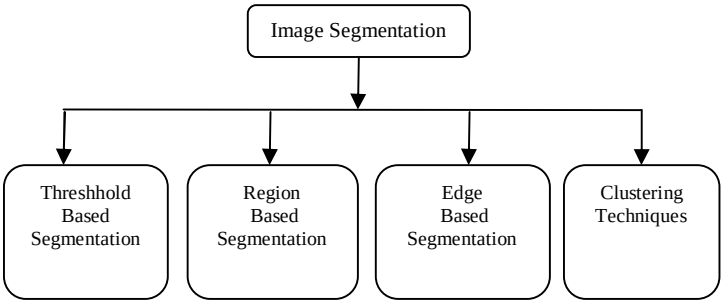


Fig. 1 Segmentation Techniques

C. Medical Image Segmentation

Image segmentation is the method of extracting required components from an image. Segmentation attempts to find an object of interest in the image. It involves dividing the image into 2 kinds of regions - either object or background to extract the desired information. Segmentation takes place naturally in the human visual system. Humans are specialists in identifying patterns, detecting shapes, lines and edges, and making decisions primarily based on the visual information. For segmentation, region based segmentation and edge based segmentation techniques are used. Segmentation plays a vital role in computer-based diagnosing of medical images. The target of image segmentation is to divide a picture in non-overlapping components on the basis of intensity and texture of the image. In segmentation technique, the primary step is denoising or image smoothing, to remove noise from the image like salt and pepper noise. In this various filters are used like vector median filter, high pass filter and low pass filter to remove noise from the image. Then, Thresholding is done, in which objects are extracted from the background based on the threshold values. Thresholding approach chooses a threshold T, to partition the image into sub-regions and differentiate objects of interest from the background. This technique is helpful in segmenting images having light objects against a dark background or vice versa. Next, appropriate Segmentation approach is used like region based, edge based or region splitting and merging. Clustering technique is employed for identification of affected area in any medical image. Clustering is a method of grouping data on the basis of their properties and characteristics. Every cluster member should have similar characteristics and properties. Steps in medical image segmentation are shown in figure below.

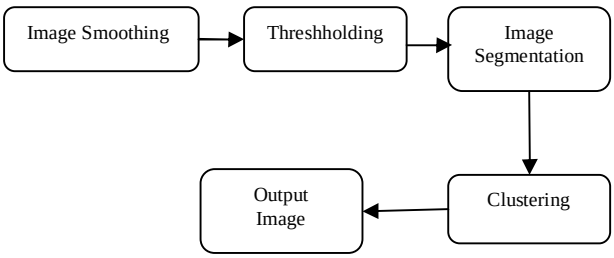


Fig. 2 Basic steps of medical image segmentation

Medical Images such as MRI (Magnetic Resonance Imaging), CT (Computed Tomography), PET (Positron Emission Tomography) etc. are a great source of information. The size, resolution and dimensions of medical images have grown with the time. The

Volume 4 Issue V, May 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

increase in the size and dimensions of the medical images has many technical challenges. There is need of techniques which can lead to automatic detection of diseases, tumors and lesions, and highlight their location in a group of images. The algorithms should be carefully designed and need thorough validation studies and so that algorithms neither signal false alarms, nor miss out fatal diseases and the results are usable in practice. Automated image segmentation techniques aim for automatic extraction of object characteristics from the image plays an important role in medical imaging.

D. Retinal Vessel Segmentation

Basically, Retina is a layer of tissue at the inner surface of the eye which converts incoming light to the neural signal which is further processed by the brain. It is useful in medicine to image the retina and develop algorithms for analyzing those images. The visual appearance of the retina in binary fundus images is a key indication of a wide range of eye diseases amongst individuals and could be diagnostic tool of a variety of problems concerning health and wellbeing of individuals. Many morphological properties of retinal arteries and veins (e.g. diameter, length, and branching angle) are of diagnostic significance and so are used in detecting and monitoring the disease progression, treating and evaluating some cardiovascular and ophthalmologic diseases (e.g. diabetes, hypertension, arteriosclerosis and neovascularization). Characteristics of retinal images like the displacement of arteries and vessels in the OD (optic disk) are useful in automatic detection of various problems related to eye like Glaucoma, diabetic retinopathy (DR), age-related macular degeneration (AMD) and vascular disorders etc. Pathologic changes within the structure of the vessel and arteries lead to the progression of many health problems like hypertension, diabetes, etc., alternative methods depend upon characteristics extracted from segmented retinal blood vessels to detect or grade the condition. The increasing significance of retinal vessel segmentation has driven the developing numerous retinal vessel segmentation strategies. Though a lot of progress has been made, the main points which affect the accuracy of the segmentation process are:

Differences in a numerous vessel and non-vessel objects, like the large variety of vessel diameters and the clear presence of certain pathological features in eye like hemorrhage, exudates and microaneurysms, etc.

Differences in local and global image appearance because of illumination which might result into certain image artifacts. For instance, reflection of light from the surface of a vessels and arteries and refraction of light within the vessels and arteries may result in the production of complex intensity profiles and singularities in the image.

Certain Morphological properties of arteries and vessels structures (e.g. the direction they cross and overlap) and the presence of highly noisy background in the fundus image will affect the precision of segmentation.

Accurate measurement and classification of blood vessels may be helpful information for clinical diagnosis. Abnormalities in diameter of retinal blood vessels and presence of unusual artefacts on retinal image are generally the first clinical finding in several retinal diseases, like diabetic retinopathy etc. Manually segmenting the blood vessels in the retina is a difficult task and needs great expertise. That's why automatic delineation and classification of retinal vessels and general analysis of retinal images is an opening move in the developing a computer-based system for detecting ophthalmic diseases.

Fig. 3 Example of Retinal Vessel Segmentation [1]

E. Vessel Segmentation Techniques

Retinal vessel segmentation techniques are important elements for analyzing blood vessels in the retina. Various techniques of vessel segmentation are:

1) Multiscale Feature Extraction And Region Growing: This technique deals with parallelizing the segmentation process with an aim to process large data sets of images in less time, having resolution varying from low to high. Parallelism is applied to the images by dividing an image into constituent sub images and every sub image can be processed simultaneously with other images within the available memory per processor to speed up the segmentation process. Region growing segmentation techniques work by starting from a seed point and combining the pixels depending on some prefixed criterion like similar intensity values and the pixels which lie spatially closer to the growing pixel. It is considered that the pixels having similar intensity values and nearby one another belong to the same object.

2) Hybrid Filtering: Hybrid filtering technique for segmenting retinal vessels is generally used as a preprocessing step in various areas like vessel segmentation/visualization, and pathology detection for extracting vessel structures in retinal fundus images. In this technique, a Hessian matrix is used and filter is used to combine eigen values of the matrix, the response of matched filters, and edge constraints on multiple scales. Orientation of the retinal vessels is provided by eigen vectors of the Hessian matrix and the edge constraints are used to suppress the response of spurious boundary edges. Hessian-based filters can be used to enhance vessels of various sizes and estimate their directions at the same time. However, Hessian-based filters are not able to distinguish step edges from vessels effectively whereas Matched filters can be used to distinguish step edges from vessels more effectively.

3) Ridge-Based Vessel Segmentation: Ridge based vessel segmentation technique is an automated segmentation process to segment retinal vessels in colour fundus images and for analysing retinal images with the help of a computer for e.g., in automated diagnosis of diabetic retinopathy. Ridge-based techniques consider a grey-scale image as 3D elevation map where intensity ridges determine the basic structure of the object. Once the intensity map is created, those ridge points are obtained which are local peaks in the direction of maximal surface gradient. To do so intensity map is traced starting from an arbitrary point along the steepest ascent direction. To create the primitives of vessels, ridge pixels are grouped that belong to the same ridge. This is a region growing algorithm which groups the ridge pixels by comparing already grouped pixels to the ungrouped pixels in the neighbourhood of that pixel. If there are no grouped pixels already available, we choose a new pixel randomly as seed from the remaining pixels.

4) Artificial Intelligence-Based Approaches: Retinal vessel segmentation algorithms based Artificial Intelligence uses expert knowledge from various sources to identify vessel structures and to segment the vessels from the fundus images. A knowledge source can be cine-angiography, digital subtraction angiography (DSA), magnetic resonance imaging (MRI), and magnetic resonance angiography (MRA). Few applications make use of a general blood vessel model as a source of knowledge while others use domain-dependent knowledge to know about the anatomical structure. Artificial Intelligence-based strategies are very accurate but have high computational complexity.

5) Neural Network-Based Approaches: It is a supervised technique for automatically segmenting vessels in fundus photographs. Neural Network based techniques are employed to identify the retinal diseases by extracting the retinal vasculature. Neural networks simulate the biological learning process and are extensively employed in pattern recognition. The Neural network consists of a number of elementary processors (nodes) each of which is assigned a weight. Each node in the neural network takes a number of inputs, performs operations on it and produces an output which is weighted sum of the inputs.

6) Gabor Filter: Dennis Gabor proposed the Gabor filtering technique which was later on used by Daugman to model the response of certain cells in the visual cortex of some mammals. Gabor filter is a linear filtering technique which is widely used for edge detection. Gabor filters have an advantage of having frequency and orientation representations identical to the human visual system, and so it is very helpful in segmenting retinal vessel structures. Gabor filters are basically bandpass filters which are mainly used in feature extraction and texture analysis for processing images. Gabor filters have uses in a large number of applications, like texture segmentation, target detection, fractal dimension management, document analysis, edge detection, retina identification, image coding and image representation.

II. LITERATURE SURVEY

Akram et al. [2013] [2] gave a methodology to accurately detect drusen in the fundus images. This method makes use of a filter which extracts all possible drusen regions from fundus images and also removes false pixels from the fundus image which may appear due to the resemblance of drusen with optic disc. This methodology represents each area using several characteristics and then classifies areas as drusen region and non-drusen region by applying support vector machine. STARE database is used to evaluate the performance of this proposed methodology using parameters for example sensitivity, specificity and accuracy.

Bhuiyan et al. [2013] [3] have discussed that the Age-related macular degeneration (AMD) is one of the main reasons for vision defect among the aged people and identification of persons with first stages of AMD is vital while considering the preventative strategies for late AMD. They proposed a technique for drusen detection from standard colour retinal images which enables quick, accurate and automated method to determine characteristics of drusen. The methodology achieved 100% accuracy to detect drusen region.

Esakkirajan et al. [2011] [4] presented a filter named Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF). This technique is superior to existing algorithms for removing noise. The MDBUTMF algorithm gives is more efficient in comparison to existing techniques even in the presence of very high noise. MDBUTMF is useful for eliminating salt and pepper noise from the images. It works by processing the corrupted images by firstly detecting the presence of impulse noise in the images. In this, every processing pixel is checked for impulse noise by checking if it's noisy or noisy free. The pixel is noise free if its value is between certain maximum and minimum grey level values and is not changed.

Fang et al. [2010] [5] gave a powerful technique for automatic segmentation of hard exudates from the retinal image. This technique is based on a course-to-fine strategy, in which firstly a coarse value is obtained in which some negative samples are allowed, then these negative samples are get rid of step by step. To obtain a coarse segmentation result, they also gave a multi-scale background subtraction technique. HEs are extracted by a SVM classifier by subtracting the optic disc region from the coarse value. The important points described in the paper are: (A) An efficient technique for segmentation of HE's (Hard Exudates); (B) A segmentation algorithm to mix multi-channel information; (C) Using the filter for segmenting the OD. The efficiency of the technique was tested using both lesion-based criterion and image-based criterion and it was concluded that the proposed technique is very efficient.

Kamboj et al. [2013] [6] explained that enhancing a corrupted image by removing noise is an important step in digital image processing for better perception. Various filters are used for removing various types of the noise from the images. Numerous noise models and filtering algorithms have been explained. A Filter can be classified as linear filter (whose outcome is a linear function of its input) and non-linear filter (whose outcome is a non-linear function of its input). Both of these filtering techniques have benefits as well as limitations. So a new type of filtering technique called Hybrid filters is defined. In the hybrid filters, two or more filtering techniques are used. Choice of which filter to use is based on the type of the noise and the extent of the noise present in the image and also on performance of the filtering scheme.

Krishnan et al. [2012] [7] used Attanassov intuitionist fuzzy histon (A-IFSH) based segmentation technique to propose an algorithm to extract the optic disc from digital retinal images. To find and locate the optic disc region from the fundus images, Optic disc pixel intensity and column wise neighbourhood operation are used in this paper. The strategy was tested on 100 images containing of 30 normal images, 39 images with glaucoma and 31 DR images. The experimental results yielded recall of 0.91, precision of 0.93 and F-score of 0.92. This technique is superior in comparison to the Otsu and Gradient vector flow (GVF) snake methods.

Nayak et al. [2009] [8] has discussed that the Glaucoma is an illness of the optic nerve which primarily affects the optical disc (OD) because of enlargement of the cup size of the eye. Digital image process techniques, like preprocessing, thresholding and morphological operations, are extensively used for the automated identification of optical disk and blood vessels. They extracted options like cup to disc (c/d) magnitude relation and also the magnitude relation of vessels area in inferior-superior facet to area of blood vessel within the nasal-temporal facet.

Odstrcilik et al. [2013] [9] improved the concept of matched filtering, and proposed an accurate method for segmenting retinal vessels from the fundus images. This proposed method aims to segment blood vessels which have different vessel from colour retinal images. The experiments prove that this technique to segment the blood vessels outperforms the performance of other blood vessel segmentation approaches by having an accuracy of 95%.

Pereira et al. [2015] [10] segmented exudates in the fundus images on the basis of the ant colony optimization technique. The efficiency of the method was evaluated with an online database and the experimental results proved that the proposed technique gives better performance in comparison to traditional Kirsch filter for exudates detection from the fundus images.

Roychowdhury et al. [2014] [11] presented a new three-step vessel segmentation technique using fundus images. Initially, high-pass filtering is used to extract a binary image by pre-processing the green plane of fundus images, and the other binary image is

Volume 4 Issue V, May 2016
ISSN: 2321-9653

extracted from the morphologically reconstructed enhanced image for the vessel regions. Then, the major vessels are extracted as the common areas in both the images. In the second step, Gaussian Mixture Model (GMM) categorizes the remaining pixels in the two binary images with the help of a couple of 8 features which are obtained predicated on pixel neighbourhood and first and second-order gradient images. In the third post-processing stage, the major portions of the blood vessels are combined with the classified vessel pixels. This is an efficient segmentation technique since its segmentation time is less and it has better accuracy in comparison to other supervised segmentation techniques. This technique has an accuracy of 95.3%, 95.2% and 95.15% in typically 11.7 seconds, 3.1 seconds and 6.7 seconds on three data sets CHASE DB1, DRIVE and STARE, respectively.

Rozlan et al. [2012] [12] developed a Graphical User Interface (GUI) which enhances the process of segmentation of blood vessels in retinal images, It can be helpful for the ophthalmologist to improve the morphological processes by analysing key characteristics in processed images for faster diagnosis. Qt creator software is used for GUI creation, Canny and other morphology based-operations are used for blood vessel segmentation. The system outputs an improved image which can be enhanced further using certain image enhancement techniques. This can help to detect diabetic retinopathy.

Santos et al. [2011] [13] proposed an efficient image processing method to segment drusen in the digital fundus images. The proposed algorithm aims at detecting AMD progression from a group of longitudinal images. This technique detects AMD progression in longitudinal data set with an area beneath the receiver operating characteristics curve of 0.99.

Shanmugavadivu et al. [2012] [14] gave a filtering technique for the purpose of restoration of the retinal images which have been corrupted with a fixed-value impulse noise. This technique is simpler as compared to other techniques, so the rate of restoration rate is faster. The technique is useful for the removal of noise from the images and is widely used for analysis of surface morphology.

Yin et al. [2012] [15] gave a method to segment the optic disc and optic cup from the colour fundus images. This strategy combines the 2 processes knowledge-based Circular Hough Transform and optimal channel selection to segment the OD (Optic Disk). The efficiency of this technique was evaluated on a dataset having 325 images. The experimental results give the average Dice coefficient for the disc and cup segmentation is 0.92 and 0.81 respectively, which is better as compared to the existing techniques. It gives a mean absolute CDR error of 0.10, which is significantly better than that in existing methods.

Zhang et al. [2015] [16] presented an algorithm for segmenting retinal vessel structures which makes use of a texton dictionary to categorise vessel pixels or non-vessel pixels. This algorithm also uses Keypoints which ios a small set of image features to derive the parameters for filtering. A Gabor filter bank presented in this paper has main aim of extracting keypoints from an image which represent significant information regarding vessel features with the help of SIFT algorithm. Keypoints are initially determined with the help of a validation set and after that seeds are derived from the keypoints to initialize a k-means clustering algorithm which is used to build a texton dictionary from another training set. To categorize vessel or non-vessel pixels, a 1-NN classifier is used.

TABLE I
COMPARITIVE ANALYSIS

Sr. No.	Year	Paper Title	Techniques	Benefits	Issues & Limitations
1.	2015	Retinal Vessel Segmentation using multi-scale textons derived from keypoints	Gabor filter Bank using keypoints	Uses a texton dictionary to classify vessel/non-vessel pixels.	Some false positive pixels are evident in segmentation results especially around Optic disk
2.	2013	Drusen Quantification for Early Identification of Age Related Macular Degeneration (AMD) Using Color Fundus Imaging	Combined techniques of local intensity distribution, adaptive intensity thresholding and edge information to find possible drusen area	This technique enables fast, accurate automated method to determine the characteristics of drusen. This method has 100% accuracy to detect the presence of any drusen. The segmentations produced mean sensitivity and specificity	This system needs to be validated in terms of producing the results by grading the same image with two individual graders.

				values of 74.94% and 81.17%, respectively.	
3.	2013	Automated drusen segmentation in fundus images for diagnosing age related macular degeneration	Based on three steps i.e. preprocessing, feature extraction and classification. It Uses filter bank to obtain drusen regions form fundus images and removes false pixels. It represents each region with a number of features and then applies support vector machine to categorize these regions as drusen and non-drusen.	The accuracy, sensitivity and specificity of the system were 0.97, 0.95 and 0.984 respectively. The proposed system achieved 100% accuracy at image level.	NA
4.	2011	Removal of High Density Salt and Pepper Noise Through Modified Decision Based Unsymmetric Trimmed Median Filter	This algorithm replaces the noisy pixel by trimmed median value when other pixel values, 0's and 255's are present in the selected window and when all the pixel values are 0's and 255's then the noise pixel is replaced by mean value of all the elements present in the selected window	This method yields improved output as compared to the Standard Median Filter (MF), Decision Based Algorithm (DBA), Modified Decision Based Algorithm (MDBA), and Progressive Switched Median Filter (PSMF) in terms of Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF). This method is efficient in removing salt and pepper noise in images at high noise densities.	NA
5.	2010	Automatic segmentation of hard exudates in fundus images based on boosted soft segmentation	It uses a coarse-to-fine strategy. A multi-scale background subtraction method obtains the coarse segmentation result. After subtracting the OD region from the coarse result, the HEs are obtained by a SVM classifier.	The experimental results show that this technique is very efficient and fast method to segment exudates.	This paper does not cover segmenting haemorrhage from retinal images, and identifying different stages of diabetic retinopathy in accordance with to the segmented lesions.
6.	2012	Application of intuitionist fuzzy histon segmentation for the automated detection of	2 step process: first the optic disc is located by combining a pixel intensity and CWNO	This technique gave precision-0.93, recall-0.91, F-score-0.92 and mean segmentation	NA

		optic disc in digital fundus images	procedure. Further, the OD is segmented using A-IFS (Attanassov intuitionistic fuzzy) Histon method.	accuracy of 93.4%. This method shows that fuzzy segmentation technique is superior to Otsu and Gradient vector flow (GVF) snake methods. This technique can help ophthalmologists to detect glaucoma, DR and other eye related diseases	
7.	2011	Statistical Characterization and Segmentation of Drusen in Fundus Images	This technique categorizes retinal structures with a statistical model of the colours in the retinal image to segment drusen to characterize the AMD progression in a data set of longitudinal images.	This technique detected progression in the longitudinal data set with an area under the receiver operating characteristics curve of 0.99	The technique creates false positives in normal images. However, a post-processing of the drusen candidates removes these false Positives when additional texture, shape, and spatial features are employed in the classification.
8.	2012	GUI System for Enhancing Blood Vessels Segmentation in Digital Fundus Images	Qt Creator software is used for GUI creation and Canny and other morphology-based methods are used for blood vessels segmentation	The GUI is helpful to users in performing blood vessel segmentation easily and in a user friendly manner in the retinal images. This system can be helpful to ophthalmologists to perform the appropriate morphological operations by analysing the processed images for quick diagnosis.	The system only detects the blood vessels in the fundus images and does not detect other features of DR (exudates, haemorrhages and microaneurysms). It does not classify whether the patient has eye diseases such as DR or not.

III.CONCLUSIONS

Recently, several methods of fundus extraction techniques are proposed which can detect the exudates in fundus images in more promising manner. The related work has found that the issue of noise in fundus images is ignored in the majority of existing literature. Although Gabor filter bank has shown significant results over available techniques, but it is poor in its speed. Also it is not very effective for multiple kinds of noises at a same time. This paper has reviewed numerous image segmentation techniques for fundus image segmentation, and finds suitable limitations in them. Therefore to improve the accuracy of exudate extraction further in near future a hybrid Gabor filter bank with trilateral based filtering technique will be proposed. The hybrid Gabor filter bank with trilateral based filtering will use improved trilateral based filtering which enables us to detect exudates even in highly corrupted noisy images.

REFERENCES

[1] Orlando, J. I. and M. B. Blaschko "Learning Fully-Connected CRFs for Blood Vessel Segmentation in Retinal Images" Medical Image Computing and Computer Assisted Intervention (MICCAI), 2014.

[2] Akram, M. Usman, Sundus Mujtaba, and Anam Tariq. "Automated drusen segmentation in fundus images for diagnosing age related macular degeneration." In Electronics, Computer and Computation (ICECCO), 2013 International Conference on, pp. 17-20. IEEE, 2013

[3] Bhuiyan A, Karmakar C, Xiao D, Ramamohanarao K, Kanagasingam Y. "Drusen quantification for early identification of age related macular degeneration (AMD) using color fundus imaging" 35rd Annual international conference of the IEEE, engineering in medicine and biology society (EMBC). Osaka, Japan: IEEE; 2013. pp. 7392–7395, 2013.

[4] Esakkirajan, S., T. Veerakumar, Adabala N. Subramanyam, and Prem CH Chand. "Removal of high density salt and pepper noise through modified decision based unsymmetric trimmed median filter." Signal Processing Letters, IEEE 18, no. 5 (2011): 287-290.

[5] Fang, Guoliang, Nan Yang, Huchuan Lu, and Kaisong Li. "Automatic segmentation of hard exudates in fundus images based on boosted soft segmentation." In Intelligent Control and Information Processing (ICICIP), 2010 International Conference on, pp. 633-638. IEEE, 2010.

[6] Kamboj, Priyanka, and P. Rani. "Image Enhancement Using Hybrid Filtering Technique." International Journal of Science and Research, IJSR 2, no. 6 (2013): 214-220.

[7] Muthu Rama Krishnan, M., U. Rajendra Acharya, Chua Kuang Chua, Lim Choo Min, Eddie Yin-Kwee Ng, Milind M. Mushrif, and Augustinus Laude. "Application of intuitionist fuzzy histon segmentation for the automated detection of optic disc in digital fundus images." In Biomedical and Health Informatics (BHI), 2012 IEEE-EMBS International Conference on, pp. 444-447. IEEE, 2012

[8] Nayak, Jagadish, Rajendra Acharya, P. Subbanna Bhat, Nakul Shetty, and Teik-Cheng Lim. "Automated diagnosis of glaucoma using digital fundus images." Journal of medical systems 33, no. 5 (2009): 337-346.

[9] Odstrcilik, Jan, Radim Kolar, Attila Budai, Joachim Hornegger, Jiri Jan, Jiri Gazarek, Tomas Kubena, Pavel Cernosek, Ondrej Svoboda, and Elli Angelopoulou. "Retinal vessel segmentation by improved matched filtering: evaluation on a new high-resolution fundus image database." Image Processing, IET 7, no. 4 (2013): 373-383.

[10] Pereira, Carla, Luís Gonçalves, and Manuel Ferreira. "Exudate segmentation in fundus images using an ant colony optimization approach." Information Sciences 296 (2015): 14-24.

[11] Roychowdhury, S., D. D. Koozekanani, and K. K. Parhi. "Blood Vessel Segmentation of Fundus 00Images by Major Vessel Extraction and Sub-Image Classification." (2014).

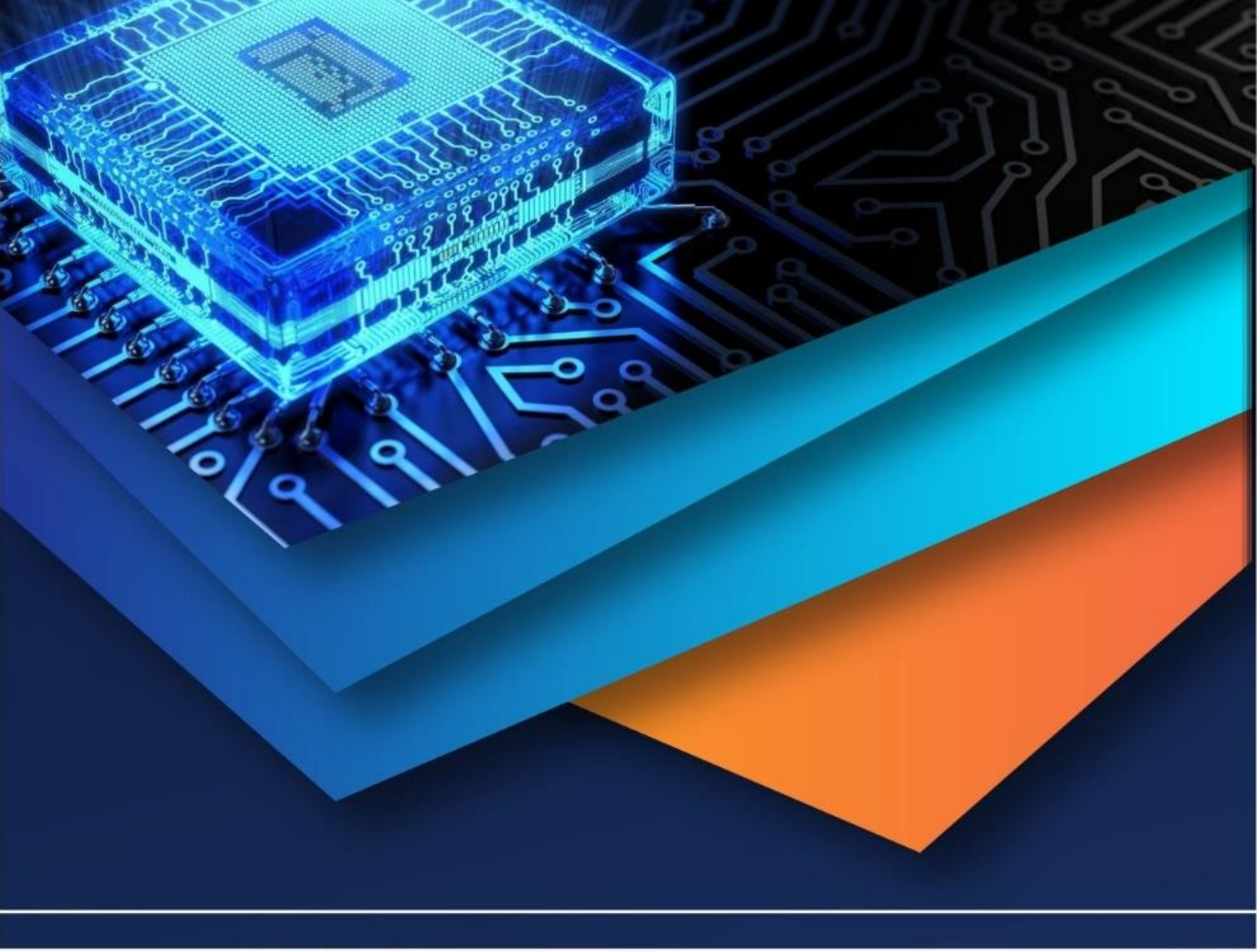
[12] Rozlan, Ahmad Zikri, N. S. Mohd Ali, and HadzliHashim. "GUI system for enhancing blood vessels segmentation in digital fundus images." In Control and System Graduate Research Colloquium (ICSGRC), 2012 IEEE, pp. 55-59. IEEE, 2012.

[13] Santos-Villalobos, Hector, Thomas Paul Karnowski, Deniz Aykac, Luca Giancardo, Yaquin Li, T. Nichols, K. W. Tobin, and Edward Chaum. "Statistical characterization and segmentation of drusen in fundus images." In Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE, pp. 6236-6241. IEEE, 2011.

[14] Shanmugavadivu, P., and P. S. Jeevaraj. "Laplace equation based Adaptive Median Filter for highly corrupted images." In Computer Communication and Informatics (ICCCI), 2012 International Conference on, pp. 1-5. IEEE, 2012.

[15] Yin, Fengshou, Jiang Liu, Damon Wing Kee Wong, Ngan Meng Tan, Carol Cheung, Mani Baskaran, Tin Aung, and Tien Yin Wong. "Automated segmentation of optic disc and optic cup in fundus images for glaucoma diagnosis." In Computer-based medical systems (CBMS), 2012 25th international symposium on, pp. 1-6. IEEE, 2012.

[16] Zhang, Lei, Mark Fisher, and Wenjia Wang. "Retinal vessel segmentation using multi-scale textons derived from keypoints." Computerized Medical Imaging and Graphics 45 (2015): 47-56.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY