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An Optimal Top-Hat Mathematical Transform and Fuzzy Based Clustering for Eye Disease Diagnosis

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ABSTRACT

Background: Programmed analysis of Fundus images has turn out to be a concern for ophthalmologists and investigator in digital image processing. Certain research works on hemorrhage based Fundus detection has largely grouped the hemorrhages and microaneurysm into a particular cluster. Consequently, automatic detection for Fundus images is necessary, and among them the recognition of blood vessels is the most important. **Objective:** The information about blood vessels, such as length, width, tortuosity and branching pattern, not only offer information on pathological changes but also facilitate to grade diseases severity or mechanically diagnose the diseases. Conversely, manual detection of blood vessels is more complex due to the complexity involved in the Fundus images and with low contrast. As a consequence, consistent and automatic methods for extracting and calculate the vessel in Fundus images are needed. **Results:** In this paper, to provide exact position of vessel segment in the fundus image and improvement in performance rate with human graded orientation standard, a method called, Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) on digital fundus images is presented. To remove the background and enhance the brightness of diabetic based retinal blood vessels, a gray mathematical morphology model is designed through smoothening and toughening of retinal images. A Fuzzy based Feature Clustering is then performed to extract diabetic retinal blood vessels, tag on by a refinement procedure. The fuzzy based feature clustering extracts the pixel values of color features from the mean, standard deviation and the opening image from the Top-hat mathematical transform step, morphological features like area, convolution and feature ratio are extracted. **Conclusion:** Experimental work on digital fundus images using the TMTF-FC method performs research on the factors such as, feature extraction time, true positive rate and clustering efficiency.Result on public available database,DIARETDB1shows significant benefits of the proposed method.

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INTRODUCTION

With the fast and quicker advancement in computing technology and with the objective of improving the service through medical field, automatic diagnosis has received greater interest than ever before. Points of Interest for Automatic Retinal Lesion Detection (PI-ARTD) (Rocha *et al*., 2012) efficiently located the DR lesions present in the fundus images through visual dictionaries improving the quality of image being obtained and resolution. However, automatic detection of DR screening system was not introduced.

Ensemble-based Microaneurysm Detection (E-MD) (Antal and Hajdu, 2010) on the other hand provided means for automatic detection through ensemble based methodology resulting in the improvement of detecting microaneurysm. But, proper grading system for more DR specific lesions was not included. To address this issue, Uniform Robust Scale Invariant Feature Transform (URSIFT) (Ghassabi *et al*., 2013) was applied to retinal image with the objective of improving positional accuracy. But, automatic detection was not performed. In (Dizdaroğlu *et al*., 2014), Structure-based method was introduced for automatic detection of retinal images through vascular segmentation by means of zero level contour regularization.

Several hypotheses related to pathogenetic were identified in order to efficiently and significantly

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provide measures for cystic macular lesions in retinal dystrophies. Different factors and methods determining the blood retinal vessels were measured in (Salvatore *et al*., 2012). However, segmentation was not made in an efficient manner. In (Ramlugun *et al*., 2011), Contrast Limited Adaptive Histogram Equalization (CLAHE) was applied for reconstruction of the vessels in the image with the motive of improving the vessel extraction. But threshold factor, made the system to deteriorate in case of large vessels. M-Mediod based classifier (Akram *et al*., 2013) was applied to blood vessels through proliferative diabetic retinopathy using vascular pattern and optic disc and extensively differentiated normal and abnormal vessels. Blood vessel segmentation methodologies were applied in (Fraza *et al*., 2012) to improve the true positive rate and minimize the false positive rate through retinal vessel segmentation algorithms.

In this modern era, one of the great significance received in the health care system is medical image analysis where diabetes is considered to be one of the most common and dreadful diseases. Gaussian mixture model and support vector machine were introduced in (Akram *et al*., 2014) with the objective of improving the sensitivity and specificity in automatic detection of exudates. However, separation of blood vessels was not made in an efficient manner.

In (Gowthaman, 2014), Gabor filter bank was applied to the microaneurysms to improve the accuracy and laid measures for early detection of diabetic retinopathy. But, complexity and time increased with the increase in the exudates. With the motive of minimizing the execution time, gray level thresholding (Choukikar, 2014), was applied to retinal images for early detection of disease. Another method based on the extraction of optic cup was introduced in (Wyawahare and Patil, 2014) by modifying the calculated threshold value through binary threshold and entropy filtering.

In this paper, Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) on digital fundus images is designed to improve performance rate with human graded orientation standard. The contributions of TMTF-FC includes the following

- To reduce noise and enhance brightness of digital fundus images by converting green image channel to gray image channel by applying Background Normalization using Top-hat Mathematical Transform.
- To minimize the extraction time using Fuzzy based Feature Clustering algorithm through membership degree and efficient cluster center.
- To remove the background and enhance the brightness of diabetic based retinal blood vessels using gray mathematical morphology model through smoothening and toughening of retinal images.

The paper is structured in four sections; Section 2 describes the challenges associated with eye disease diagnosis, the materials used for analysis, and quantitative measures of performance of diabetic based retinal vessel. The top hat mathematical transform and fuzzy based clustering using digital fundus images and brief description of the method with architecture diagram is also given in Section 2. The experimental setup and the parameters used with state-of-the-art methods and the discussion is given in Section3 with the help of table and graph form. Finally the conclusion is illustrated in Section 4.

MATERIALS AND METHODS

Several research works and findings were conducted on retinal capillary to identify the rate and cause of disease. In (Salazar, 2011), lesions were observed at an intermittent manner to study the stage of diabetic retinopathy through optic coherence tomography. Another method called, automatic microaneurysm (Sopharak, 2011) was designed using morphological operators to study the severity of disease which also resulted in the improvement of sensitivity. However, grading in digital retinal images was not observed.

In (Tariq *et al*., 2013), Gaussian mixture model based classifier was applied to the digital retinal images for the effective detection of macula coordinates and exudates feature set. Though classification was improved, but automated medical system for grading was not addressed. A multi-layer threshold based technique was applied in (Usman and Shoab, 2013) to the blood vessels for early screening of diabetic retinopathy. Though high accuracy was achieved, early detection of diabetic retinopathy was not ensured. In (Akram *et al*., 2013), Gaussian Mixture Model (GMM), Support Vector Machine (SVM) and Multimodal Mediod based approach was applied to the retinal images for improving the accuracy and screening of DR.

Bayes classification model in addition to Gaussian function (Akram *et al*., 2012) was applied to retinal images for improving specificity and accuracy of Diabetic Retinopathy. Though accuracy was improved proper classification was not performed. Three stage classification model was applied in (Anam *et al*., 2013) with the objective of extracting candidate lesions resulting in the improvement of reliability of automatic detection of abnormalities. In (Patwari, 2013), image processing techniques were applied with the objective of improving accuracy of detecting microaneurysms.

Based on the above mentioned methods and mechanisms, in this paper, an efficient measure to improve the performance rate of retinal vessels extraction through Top-hat Mathematical Transform Fuzzy based Feature Clustering is presented and provided in the following subsections.

Top-hat Mathematical Transform Fuzzy based Feature Clustering:

Diabetic Retinopathy (DR) if not properly diagnosed at the initial stage, results in partial or complete loss of eye sight. Different stages and severity of DR disease can be measured in an extensive manner through retinal lesions.

The proposed method, Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) includes three steps, (1) Background Normalization using Top-hat Mathematical Transform, (2) Diabetic Retinal Blood Vessels Brightness Enhancement using gray mathematical morphology and (3) Feature Extraction using Fuzzy based Feature Clustering. Figure 1 shows the figurative representation of Top-hat Mathematical Transform Fuzzy based Feature Clustering.

The figure given below shows the construction and design of Top-hat Mathematical Transform Fuzzy based Feature Clustering which includes three step processes. The first step measures the area, convolution and feature ratio using top-hat mathematical transform in order to perform background normalization. With this, noise is reduced for the given digital fundus image. The second step applies an opening function to the original image and by applying gray mathematical morphology brightness enhancement is achieved through the reconstructed image. Finally, fuzzy based feature clustering algorithm is applied to the reconstructed image

By following the three steps mentioned above, TMTF-FC ensures exact position of vessel segment in the Fundus image with improved performance rate with human graded orientation standard. The detailed description of TMTF-FC is included in the forthcoming sections.

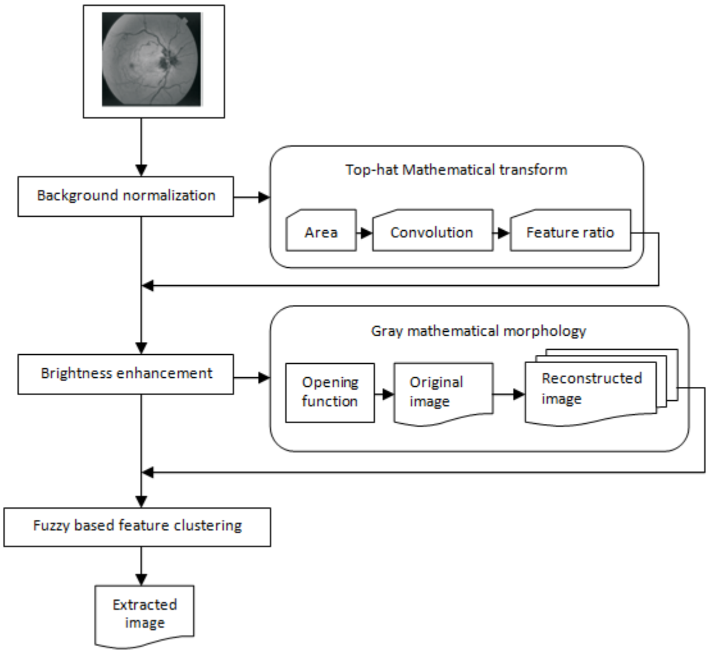

Fig. 1: Architecture diagram of Top-hat Mathematical Transform Fuzzy based Feature Clustering.

Background Normalization using Top-hat Mathematical Transform:

The first step in the design of Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) is the pre-processing of digital fundus images from the public available database, DIARETDB1. With unsatisfactory quality of images from public available database, pre-processing of digital fundus images is the foremost step in order to remove the background and enhance the brightness of diabetic based retinal blood vessels.

The proposed method localizes the blood vessels by converting green image channel to gray image channel as illustrated in figure 2. Due to high noise and low contrast images in the red and blue image channel, the method TMTF-FC uses the green image to enhance the brightness of digital fundus images and therefore to obtain best results . All the features of digital fundus images including, blood vessels, are not of clear visibility due to the hidden nature. Thus background normalization on digital fundus images is performed to improve the image quality. Background normalization in TMTF-FC is performed by applying Top-hat Mathematical Transform on digital fundus images.

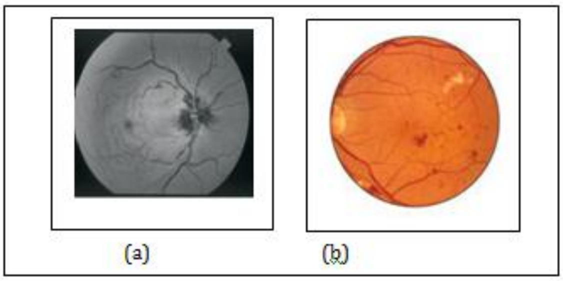

Fig. 2: (a) Original image from DIARETDB1 database (b) conversion of green image channel to gray image channel

To remove the background and enhance the brightness of diabetic based retinal blood vessels, a gray mathematical morphology model is designed through smoothening and toughening of retinal images. The key aspects in gray mathematical morphology model are to identify the structuring portions. The structuring portions are obtained by identifying the boundary pixels of the candidate. To obtain the roundness and boundary pixels of candidate object, each object's region (i.e., area), circumference (i.e., convolution) and structuring portions (i.e., feature ratio) are measured.

$$\text{Area}=\text{Diff}(\text{Boundary}) \quad (1)$$

$$\text{Convolution}=\text{Sum}\sqrt{(\text{Area}+2)} \quad (2)$$

$$\text{Feature ratio} = \frac{(4*\pi*\text{Area})}{\text{Convolution}^2} \quad (3)$$

From (1), (2) and (3), the object area, convolution and feature ratio are obtained in which a Top-hat Mathematical Transform is applied. In mathematical morphology, Top-hat Mathematical Transform is an operation that extensively extracts the small portions and features from given digital fundus images. The Top-hat Mathematical Transform in TMTF-FC method refers to the difference between the input digital fundus image and its opening by certain structuring portion.

Let 'Image_i' represents the original image where the structuring portions are applied with Top-hat Mathematical Transform that performs an opening function 'OP_i 'on the original image 'Image_i'. The opening function in Top-hat Mathematical Transform includes two operations, namely eroding the image (i.e.,Erode (Image_i)) and performing dilation (i.e., Dilate (Image_i)) on the eroded image.

$$\text{OF}=\text{Dilate}\ (\text{Erode}(\text{Image}_i)) \quad (4)$$

$$\text{OI}=\text{Max}\ \{\text{OF}_{IT}(\text{Image}_i)\} \text{ where IT}=1,2,..12 \quad (5)$$

$$\text{RI}=\text{OF}^{\text{Recon}}_{\text{Image}_i}(\text{OI}) \quad (6)$$

From (4), (5) and (6), the original image 'Image_i' is eroded and a dilation operation is applied to the eroded image which forms the opening function 'OF'. A maximum iteration '' of twelve is performed to the opening function 'OF' and stored as the opened image 'OI'. Figure 3 shows the original and smoothed image through reconstruction obtained by applying the Top-hat Mathematical Transform. The reconstructed image 'RI' is obtained by smoothing and toughening retinal images.

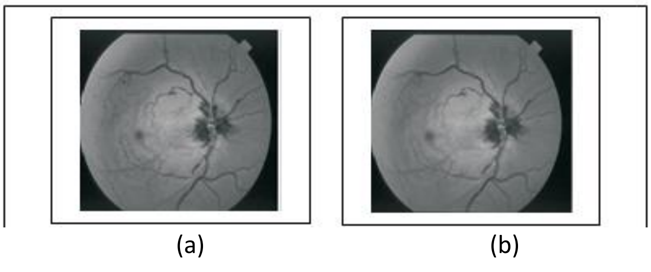

Fig. 3: (a) Original image (b) Top-hat Mathematical Transform Smoothed image.

The advantage of the application of Top-hat Mathematical Transform in TMTF-FC method in digital fundus images is that it extractsan image, containing those portions of an input digital fundus image that are smaller than the structuring portions and intensified than their background portions.

Diabetic Retinal Blood Vessels Brightness Enhancement:

In order to remove the background and enhance the brightness of diabetic based retinal blood vessels, gray mathematical morphology theories is applied to the reconstructed image. In gray mathematical morphology for the reconstructed image, top-hat mathematical transform is applied to the smoothed image at twelve iterations, and the mathematical values for the twelve iterations 'IT' are obtained using the threshold value given as below. The threshold value measures the difference between the Diabetic Retinal Blood Vessels and the original image.

$$\varphi\ (\text{Threshold})=(RI-\ OF_{IT}(\text{Image}_i)) \quad (7)$$

From (7), the threshold 'φ' is the difference between the opening function of the original image 'Image_i' and the reconstructed image 'RI'. Followed by this, the mathematical transform of opening by reconstruction and closing by reconstruction are applied to the reconstructed image by ensuring brightness enhancement to the image in an iterative manner. A set of features based on morphology (i.e., opening and closing) and intensity (i.e., iterations) are measured on each region-grown object so that by examination of the features the candidates are confidential as either a true or a spurious object.

Fuzzy based Feature Clustering:

Once the retinal vessels of the reconstructed image are enhanced, the final step in Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) is to extract the vessels using fuzzy based feature clustering algorithm. Fuzzy based Feature Clustering has the advantage of reducing the sum of square errors through repeated partitions in an iterative manner and therefore final extraction is achieved. The mathematical formulation to perform repeated partitions through iteration is given as below

$$VE_{Cluster}=(m_{ab})^{e}*Dist(O_b,CC_a) \quad (8)$$

From (8), the vessel extraction through cluster '$VE_{Cluster}$' is the product of membership degree of 'O_b' for cluster 'a' and 'e' representing the exponent for each membership degree with a distance between object 'O_b' and cluster center 'CC_a' respectively. The cluster center evaluated for the CC for twelve iterations is given as below

$$CC_a^{IT}=\frac{(m_{ab}^{IT})*O_b^{IT}}{m_{ab}^{IT}},\ \text{where IT}=1,2,..12 \quad (9)$$

The fuzzy based feature clustering extracts the pixel values of color features from the mean, standard deviation of the opening image from Top-hat mathematical transform step are extracted. The method TMTF-FC provides exact position of a vessel segment in the Fundus image with improved performance rate. The algorithmic description of Fuzzy based Feature Clustering (FFC) is given below:

Algorithm 1 - Fuzzy based Feature Clustering algorithm:

The above algorithm shows the step by step process of Fuzzy based Feature Clustering (FFC) algorithm. The FFC algorithm is divided in three steps. The first step does the process of converting the green image channel to gray image channel through background normalization by measuring area, convolution and feature ratio. The second step in the FFC algorithm is to measure the reconstructed image using erosion and dilation through Top-hat Mathematical Transform. Finally, the third step is the clustering of features using fuzzy technique by obtaining the feature cluster and cluster center. As a result, diabetic based blood vessel with human graded orientation standard is obtained with improved performance rate.

Input: Digital fundus Image
$\text{Image}_i = \{\text{Image}_1, \text{Image}_2,...\text{Image}_n\}$, exponent '*e*', threshold value 'φ'
Output: Obtains exact position of a vessel segment in the Fundus image
Step 1. Initialize partition vector $|M=m_{ab}|$ and threshold value
Step 2. For each Image_i
Step 3. Convert green image channel to gray image channel through background normalization
Step 3.1: Compute area using (1)
Step 3.2: Compute convolution using (2)
Step 3.3: Compute feature ratio using (3)
Step 4. Perform Top-hat Mathematical Transform
Step 4.1: Measure reconstructed image using dilation and erosion
Step 5. Fuzzy based Feature Clustering
Step 5.1: Measure fuzzification
Step 5.2: Obtain Feature Clustering from
Step 5.3: Compute cluster center using (9)
Step 6. End for

MATERIALS AND METHODS

In this section, the experimental set up used for evaluating the proposed method, Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) using DIARETDB1 database is provided. The DIARETDB1 database used for eye disease diagnosis is a public database for benchmarking diabetic retinopathy detection from digital fundus images. The experts who participated in the evaluation of images obtained in DIARETDB1 database considered that out of 89 colour fundus images, 84 images are of mild non-proliferative signs (Microaneurysms) of the diabetic retinopathy whereas 5 images were are considered as normal which do not contain any signs of the diabetic retinopathy. The digital fundus images from DIARETDB1 database were captured using the same 50 degree field-of-view digital fundus camera of different imaging settings and applied using MATLAB.

To measure the efficacy of the proposed method, TMTF-FC, two different diabetic detection methods were compared, namely Points of Interest for Automatic Retinal Lesion Detection (PI-ARTD)

(Rocha *et al.*, 2012) and Ensemble-based Microaneurysm Detection (E-MD) (Antal and Hajdu, 2010). The performance metrics used for evaluation are feature extraction time, true positive rate and clustering efficiency.

Results analysis of TMTF-FC:

In this work, we efficiently evaluated the proposed method to attain an effective eye disease diagnosis using DIARETDB1 database. The table given below table and graph describes the performance of the proposed TMTF-FC method for eye disease diagnosis and compared with the existing Points of Interest for Automatic Retinal Lesion Detection (PI-ARTD) (Rocha *et al.*, 2012) and Ensemble-based Microaneurysm Detection (E-MD) (Antal and Hajdu, 2010).

Measure of feature extraction time:

Feature extraction time using TMTF-FC refers to the time taken to extract the features present in different images of differing sizes. It is measured in terms of milliseconds (ms). The mathematical formulation for feature extraction time is given as below:

$$FET = Time\ (Image\ size) \quad (10)$$

From (10), the feature extraction time is highly dependent upon the size of image, because the extraction time is directly related to the size of the image.

Table 1: Tabulation for feature extraction time.

Image size (KB)	Feature extraction time (ms)		
	TMTF-FC	PI-ARTD	E-MD
230	11.70	14.13	18.8
315	18.35	23.45	27.49
380	21.45	25.85	31.35
430	29.21	32.33	35.98
410	39.85	45.86	51.32
505	41.35	49.32	54.13
585	45.44	51.32	59.35

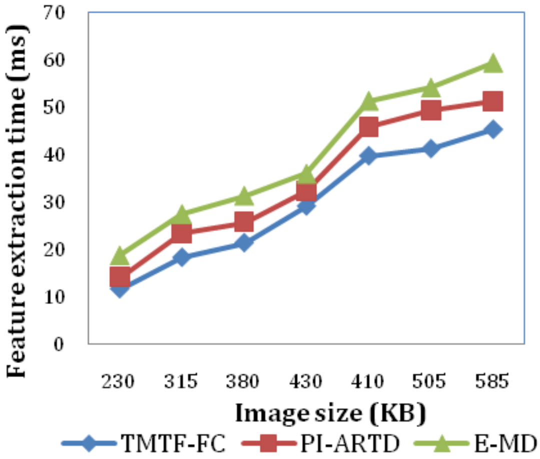

Fig. 4: Performance of feature extraction time with seven images.

In order to gain deeper insight on the influence of feature extraction time, in table 1, the size of images and feature extraction time required to obtain changeable components using DIARETDB1 database is recorded.

Figure 4 shows the feature extraction time using different Microaneurysm Detection methods as a function of different number of images with varying sizes in the range of 230 KB to 585 KB. Compared to the existing Points of Interest for Automatic Retinal Lesion Detection (PI-ARTD) (Rocha *et al.*, 2012) and Ensemble-based Microaneurysm Detection (E-MD) (Antal and Hajdu, 2010), the proposed Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) method consumes less time for feature extraction through clustering operations based on Fuzzy Feature.

This is because by applying Fuzzy based Feature Clustering for determining the vessel extraction and the parameters of the pixel values of color features through clustering operations, the feature extraction time decreases using TMTF-FC method by 12 – 20 % compared to PI-ARTD. In addition, with the application of membership degree with a distance between object cluster center's exact positions of a vessel segment in the Fundus image with improved performance rate are obtained, resulting in minimized extraction time by 23 – 60 % compared to E-MD respectively.

Measure of true positive rate:

True Positive Rate using TMTF-FC refers to the ratio to abnormal images correctly identified as abnormal to the summation of abnormal images correctly identified as abnormal and abnormal images incorrectly identified as normal. It is measured in terms of percentage (%). Higher the true positive rate, more efficient the method is said to be.

$$P_{True} = \frac{TP}{TP+FN} * 100 \quad (11)$$

Table 2: Tabulation for true positive rate.

No of images	True positive rate (%)		
	TMTF-FC	PI-ARTD	E-MD
5	81.35	62.23	41.55
10	74.38	60.32	40.25
15	71.55	58.14	39.35
20	68.14	57.35	38.15
25	72.22	63.45	45.83
30	74.35	69.25	51.35
35	65.21	63.15	50.25

Numerical results for true positive rate while observing abnormality and normality of digital fundus images are reported in table 2. The table reveals that with the increase in the number of images, the true positive rate is decreased though a slight variance was recorded at the fifth and sixth image with a size of 410 and 505 KB.

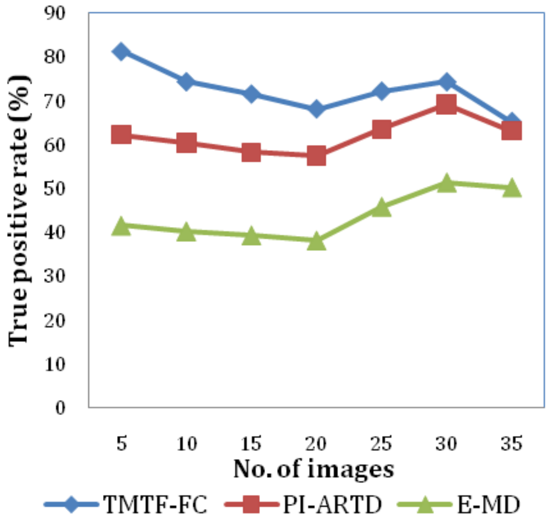

Fig. 5: Performance of true positive rate with respect to 35 images.

Figure 5 shows the true positive rate of the proposed method (TMTF-FC). To better understand, seven digital fundus images of different sizes that were extracted from DIARETDB1 database were used. For experimental purposes, image size in the range of 230 KB to 585 KB from DIARETDB1 database is used. Compared to the existing Points of Interest for Automatic Retinal Lesion Detection (PI-ARTD) (Rocha *et al*., 2012) and Ensemble-based Microaneurysm Detection (E-MD) (Antal and Hajdu, 2010), the true positive rate in the proposed TMTF-FC method is higher. This is because of the application of Background normalization that significantly obtain the roundness and boundary pixels of candidate object, each object's region, circumference and structuring portions.

With the obtained values relates with the gray mathematical morphology model that extensively extracts the small portions and features from given digital fundus images and therefore increases the true positive rate using TMTF-FC method. Furthermore, to have a significant impact of positive rate, the proposed TMTF-FC method, uses the Top-hat Mathematical Transform for effective eye diagnosis. This extensively improves the true positive rate using TMTF-FC method by 3 – 23 % compared to PI-ARTD and 22 – 48 % compared to E-MD respectively.

Measure of clustering efficiency:

Clustering efficiency in TMTF-FC is the measure of efficiency through which the extraction of vessels is performed in an efficient manner. Higher the clustering efficiency, more efficient the method is said as the extraction of vessels are more significant.

Table 3: Tabulation for clustering efficiency.

Methods	Clustering efficiency (%)
TMTF-FC	78.35
PI-ARTD	71.48
E-MD	68.77

Numerical results for clustering efficiency are recorded in table 3. In this case, the clustering efficiency obtained through TMTF-FC is comparatively higher than the two other methods namely, PI-ARTD(Rocha *et al.*, 2012) and E-MD(Antal and Hajdu, 2010) respectively.

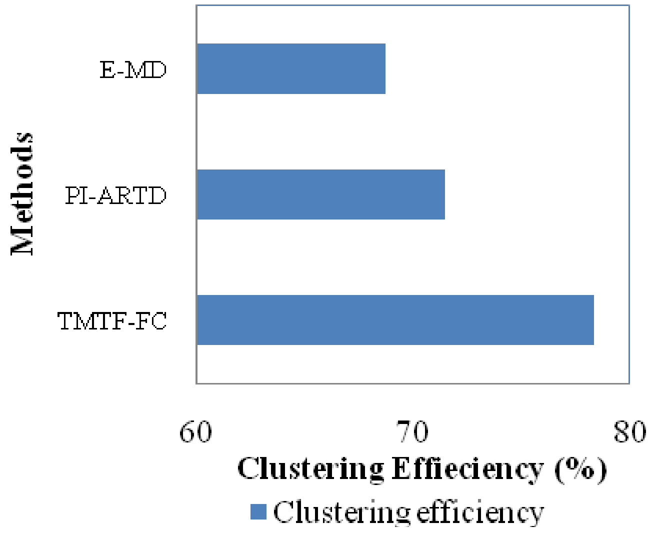

Fig. 6: Performance of clustering efficiency with respect to TMTF-FC, E-MD, PI-ARTD.

Lastly the clustering efficiency is measured via different number of images and sizes for implementation purpose. From the figure 6 it is illustrative that the proposed TMTF-FC method potentially yields better results than the existing E-MD (Antal and Hajdu, 2010) and PI-ARTD (Rocha *et al.*, 2012). The significant results achieved using the TMTF-FC method is because of the application of threshold value that measures the difference between the Diabetic Retinal Blood Vessels and the original image to obtain higher clustering efficiency during eye diagnosis using digital fundus image by 8.76 percent when compared to PI-ARTD. As a result, the clustering rate is improved to a coarser construction, because the Fuzzy based Feature Clustering (FFC) algorithm estimates the feature cluster and cluster center and thereby increasing the clustering efficiency by 3.709 percent when compared to E-MD(Antal and Hajdu, 2010).

Conclusion:

Effective eye disease diagnosis using fundus images is becoming more challenging due to the unrelenting advancement in the nature of disease that has become a challenging task for the medicine and health care community. In this work, Top-hat Mathematical Transform Fuzzy based Feature Clustering (TMTF-FC) on digital fundus images is designed with the objective of attaining an effective improvement in performance rate with human graded orientation standard. The resulting eye disease diagnosis problem has been formulated using Top-hat Mathematical Transform and solved through a novel Fuzzy based Feature Cluster algorithm. The initially selected images from DIARETDB1 database obtain changeable components using Diabetic Retinal Blood Vessels Brightness Enhancement using gray mathematical morphology. The proposed Fuzzy based Feature Cluster algorithm for efficient feature extraction by estimating membership degree and cluster center enhancing the clustering efficiency that provides exact position of a vessel segment in the Fundus image with improved performance. Finally, the difference between the Diabetic Retinal Blood Vessels and the original image is reduced by applying threshold value based on the top-hat mathematical transform. Experimental results demonstrate the high efficiency and robustness in terms of feature extraction time, clustering efficiency using the FFC algorithm on digital fundus image obtained through DIARETDB1 database.

Tables:

Figures:

2. Figure 2: (a) Original image from DIARETDB1 database (b) conversion of green image channel to gray image channel.
3. Figure 3: (a) Original image (b) Top-hat Mathematical Transform Smoothed image.
4. Figure 4: Performance of feature extraction time with seven images.
5. Figure 5: Performance of true positive rate with respect to 35 images.
6. Figure 6: Performance of clustering efficiency with respect to TMTF-FC, E-MD, PI-ARTD

REFERENCES

Anderson Rocha, Tiago Carvalho, F. Herbert Jelinek, Siome Goldenstein and Jacques Wainer, 2012. Points of Interest and Visual Dictionaries for Automatic Retinal Lesion Detection. IEEE Trans Biomed Eng., 59(8): 2244 – 2253.

Balint Antal and Andras Hajdu, 2012. An Ensemble-based System for Microaneurysm Detection and Diabetic Retinopathy Grading. IEEE Trans Biomed Eng., 59(6): 1720–1726.

Zeinab Ghassabi, Jamshid Shanbehzadeh, Amin Sedaghat and Emad Fatemizadeh, 2013. An efficient approach for robust multimodal retinal image registration based on UR-SIFT features and PIIFD descriptors. EURASIP J Image Video Process, (25): 1–15.

Bekir Dizdaroğlu, Esra Ataer - Cansizoglu, Jayashree Kalpathy - Cramer, Katie Keck, Michael F Chiangand Deniz Erdogmus, 2014. Structure-based level set method for automatic retinal vasculature segmentation. EURASIP J Image Video Process, (39): 1 - 15.

Serena Salvatore, MD, A. Gerald Fishman MD, A. Mohamed Genead MD, 2013. Treatment of cystic macular lesions in hereditary retinal Dystrophies. Surv Ophthalmol, 58(6): 560-584.

Girish Singh Ramlugun, Vivek Krishna Nagarajan, Chandan Chakraborty, 2011. Small retinal vessels extraction towards proliferative diabetic retinopathy screening. Expert Syst Appl, 39(1): 1141–1146.

Usman Akram, M., Shehzad Khalidb, Anam Tariqa, M. Younus Javeda, 2013. Detection of neovascularization in retinal images using multivariatem-Mediods based classifier. Comput Med Imaging Graph, 37(5-6): 346– 357.

Fraza, M.M., P. Remagninoa, A. Hoppe, B. Uyyanonvara, A.R. Rudnicka, C.G. Owen, S.A. Barmana, 2012. Blood vessel segmentation methodologies in retinal images – A survey. Comput Methods Programs Biomed, 108(1): 407–433.

Usman Akram, M., Anam Tariq, A. Shoab Khan, M. Younus Javed, 2014. Automated detection of exudates and maculafor grading of diabetic macular edema. Comput Methods Programs Biomed, 114(2): 141–152.

Gowthaman, R., 2014. Automatic Identification and Classification of Microaneurysms for Detection of Diabetic Retinopathy. International Journal of Research in Engineering and Technology, 03(2): 464–473.

Prashant Choukikar, Arun Kumar Patel, Ravi Shankar Mishra, 2014. Segmenting the Optic Disc in Retinal Images Using Bi-Histogram Equalization and Thresholding the Connected Regions. International Journal of Emerging Technology and Advanced Engineering, 4(6): 933–942.

Medha Wyawahare, V. and M. Dr. Pradeep Patil, 2014. Extraction of Optic Cup in Retinal Fundus images: A Compartitive Approach. International Journal of Signal Processing, Image Processing and Pattern Recognition, 7(2): 389–398.

Salazar, R., C.O. González-Castan, P. Rozas, J. Castro, 2011. Retinal capillary hemangioma and von Hippel-Lindaudisease:Diagnostic and therapeutic implications. Arch Soc Esp Oftalmol, 86(7): 218-221.

Akara Sopharak, Bunyarit Uyyanonvara, Sarah Barman and Tom Williamson, 2011. Automatic Microaneurysm Detection from Non-dilated Diabetic Retinopathy Retinal Images. Proceedings of the World Congress on Engineering, 2: 1583–1586.

Anam Tariq, M. Usman Akram, Arslan Shaukat, A. Shoab Khan, 2013. Automated Detection and Grading of Diabetic Maculopathy in Digital Retinal Images. J Digit Imaging, 26(4): 803–812.

Usman Akram, M., A. Shoab Khan, 2013. Multilayered thresholding - based blood vessel segmentation for screening of diabetic retinopathy. Eng Comput, 29(2): 165–173.

Usman Akram, M., Shehzad Khalid, A. Shoab Khan, 2013. Identification and classification of microaneurysms for early detection of diabetic retinopathy. Pattern Recognit, 46(1): 107–116.

Usman Akram, M., Anam Tariq, M. Almas Anjum and M. Younus Javed, 2012. Automated detection of exudates in colored retinal images for diagnosis of diabetic retinopathy. Appl Opt, 51(20): 4858–4866.

Anam Tariq, M. Usman Akram and M. Younus Javed, 2013. Computer Aided Diagnostic System for Grading of Diabetic Retinopathy. Computational Intelligence in Medical Imaging (CIMI), 1(1): 30–35.

Manjiri Patwari, B., R. Ramesh Manza, Neha Deshpande, 2013. Detection and Counting the Microaneurysms using Image Processing Techniques. International Journal of Applied Information Systems, 6 (5): 11–17.