**I J C T A**, 8(5), 2015, pp. 2265-2273


# Automatic Detection of Microaneurysm using Local Rotating Cross Sectional Profile Analysis

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***Abstract:*** Diabetes is a metabolic disease which damage blood vessel. Damage in retinal blood vessel of the human eye due to effect of diabetes is termed as Diabetic Retinopathy (DR). This abnormality in the blood vessel will cause a leakage of blood from the vessel and forms a red dot. This is named as Microaneurysm. Microaneurysm in the retina causes a swelling of retinal tissue which in turn causes clouding in vision. Microaneurysm is the first symptom of Diabetic Retinopathy. Detection of microaneurysm is mainly used for the early diagnosis and treatment of DR in order to prevent the vision loss. The proposed method is used to detect microaneurysms in colour fundus images using local rotating cross-section profile analysis. Based on the profile parameters such as peak value, height and width, microaneurysms are identified. The method is successfully applied to the publically available MESSIDOR database fundus images and the results related with the detection of microaneurysms are obtained with high accuracy.

***Keywords:*** Fundus image, Rotating Cross Sectional Profile Analysis

## 1. INTRODUCTION

Diabetic retinopathy is one of the complications of diabetic mellitus. Diabetes mellitus is a condition in which the level of blood sugar will be elevated because the body is unable to use and store sugar. This unused high sugar content will damage blood vessels in the body over time and can affect a variety of body organs such as the heart, eyes and kidneys. Diabetes affects the eyes by causing damage to the blood vessels in the retina. Breakdown of retinal blood vessels may result in leakage of fluid in the center of retina (macular edeme) or abnormal blood vessels that grow on the surface of the retina (neovascularization) that can bleed and scar. This can lead to loss of vision.

There are two major types of diabetic retinopathy: non-proliferative retinopathy and proliferative retinopathy. Non-proliferative diabetic retinopathy is the earlier stage of diabetic retinopathy. In this stage there will be a visible damage in the small retinal blood vessels which leaks fluid and small amount of blood. These blood vessels will develop balloon-like swelling called microaneurysms.

Proliferative diabetic retinopathy is characterized by severe retinal blood vessel damage and reduced oxygenization of the retina that the retina reacts by growing abnormal blood vessels (neovascularization). These abnormal blood vessels are fragile and can bleed and pull on the retina as they grow. Proliferative diabetic retinopathy can also lead to traction of retinal detachments.

Diagnosis of DR is performed by evaluating retinal (fundus) images. Manual grading of these images to determine the severity of DR is rather slow and resource demanding [1]. The presence of microaneurysms (MAs) on the retina appears as small, round shaped, red dots. In this paper, we automated the detection of retinal

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MA. The recognition of MAs is essential for the process of DR grading, since it forms the basis of deciding whether an image of a patient's eye should be considered healthy or not. MAs have a clinically established maximal diameter, usually considered to be less than the diameter of the major optic veins. Thin blood vessels crossing may result in small circular spots that are locally similar to MAs, both in size and shape.

## 2. PROPOSED METHODOLOGY

The main objective is to detect microaneurysm (MA). The main input of the proposed method is the inverted green channel of a fundus image, because the MAs, hemorrhages, and the vasculature will appear as bright structures, i.e., local intensity maximum regions. The schematic workflow of the proposed method is shown in the Fig.1.

### 2.1. Preprocessing

The main aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some of the image features important for further processing. The reliability of an optical inspection can be significantly increased by image pre-processing. Several filter operations which intensify or reduce certain image details enable an easier or faster evaluation[2].

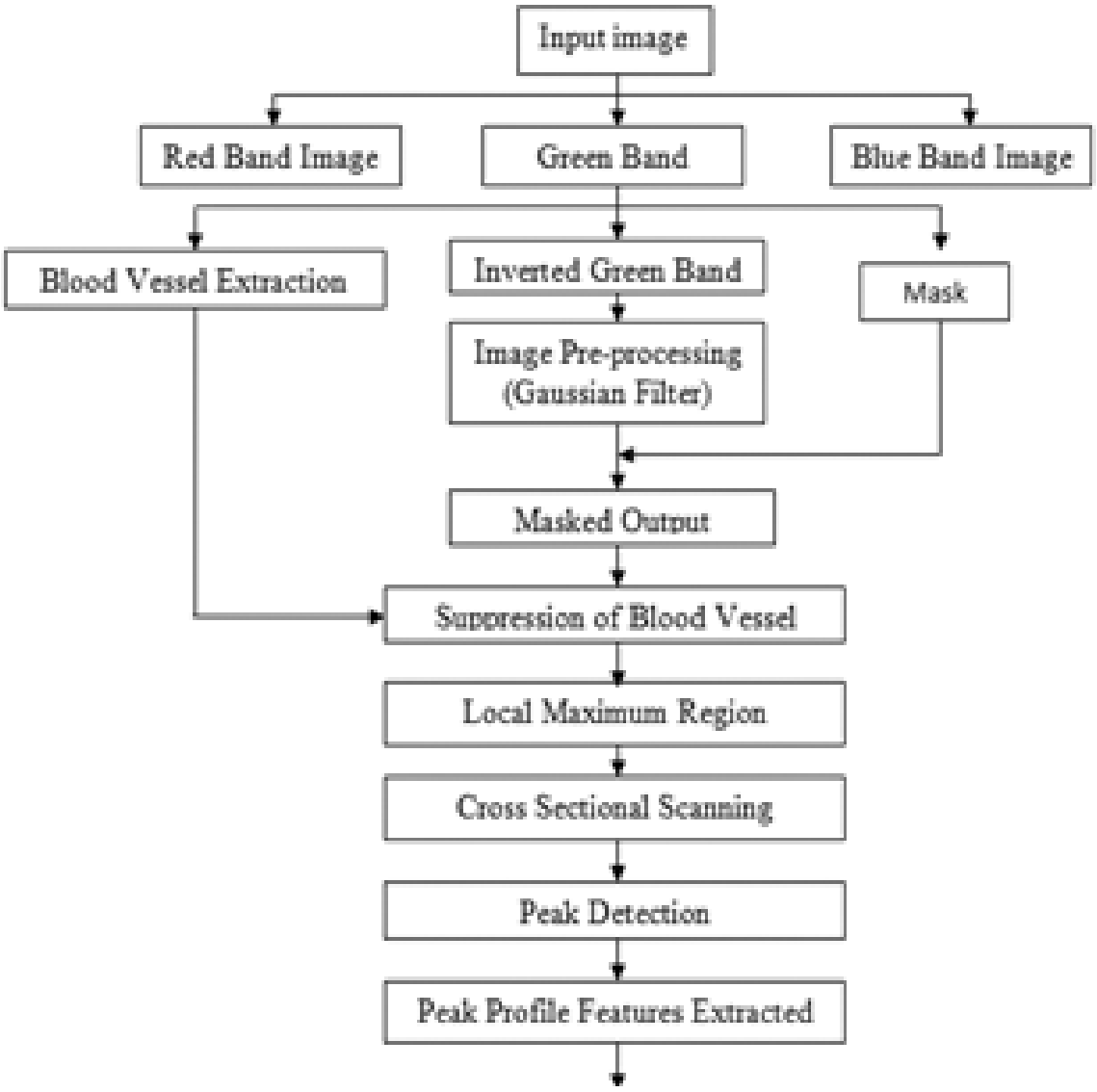



**Figure 1: The Proposed Methodology**

The fundus image is given as an input image. The input image is an RGB image. It can be separated into Red Band (RB), Green Band (GB) and Blue Band (BB) images. Figure 2 shows the input RGB fundus image with its three colour bands (RB, GB and BB). The colour band images contain different information about the anatomical and pathological structures of the retinal image. From the input RGB image, green band of the fundus image is extracted alone. This is done because MA appears with highest contrast in the green plane of the colour image.

Then the green band is inverted so that the microaneurysms will have the highest intensity value. This inverted green band is used for further processing. Figure 3 (a) shows the green band of the input image and figure 3(b) shows the inverted green band image.

Image smoothing is done with a Gaussian mask in order to reduce the effect of noise. Many retinal fundus images are available in a lossy compressed format, which result in the distortion of small structures such as microaneurysms. Convolution with a Gaussian mask with a variance of 1.0 is applied. This amount of smoothing suppressed noise sufficiently while preserving true microaneurysms. Figure 4 shows the inverted GB image after applying Gaussian filter.

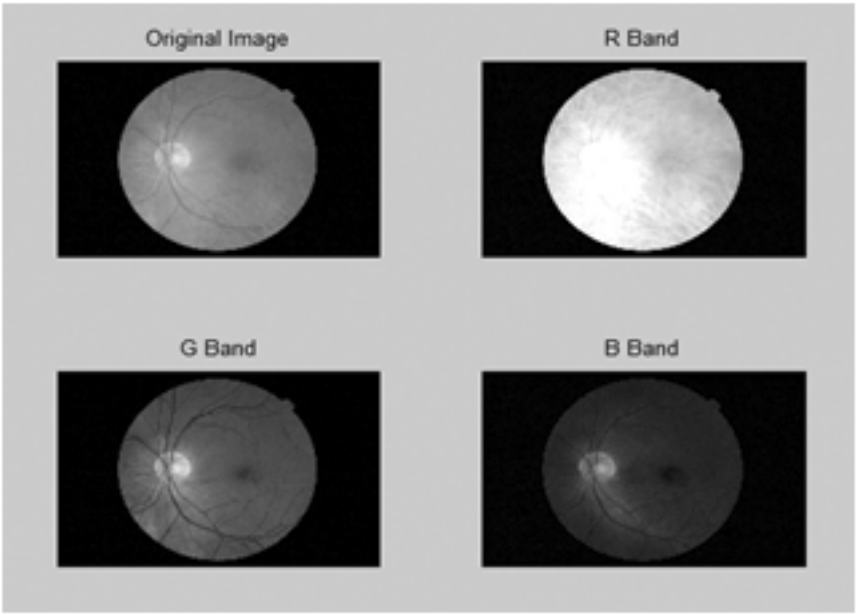



**Figure 2: Input image and its three band images (RB, GB and BB)**
**(courtesy: http://www.adcis.net/en/Download-Third-Party/Messidor.html)**

**(a)** **(b)**

**Figure 3: (a) Green Band image (b) Inverted Green Band image**

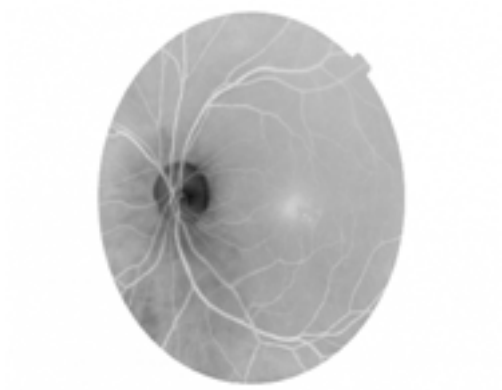


**Figure 4: Image after smoothing**

## 2.2. Thresholding

In order to limit the boundaries and to remove the unwanted information beyond the specified boundary, the background mask is generated by the application of threshold to the green band of the image. In the mask generation process, gray scale is converted into binary image. All the pixels with gray level above 40 in the green band image are converted into 1 and others are converted into 0. Figure 5 (a) is the GB of the input image and figure5 (b) is the mask generated from the GB image.Image with more data results in a longer execution time. So the images are rescaled such that the input images have spatial resolution with diameter of their ROI equal to 540 pixels, since this was the smallest ROI diameter in the publicly available fundus image sets [4].

## 2.3. Local Maximum Region Extraction

Microaneurysms are local intensity maximum structures on the pre-processed retinal image, usually with a Gaussian like intensity distribution. It means that every MA region contains at least one regional maximum

**(a)** **(b)**

**Figure 5: (a) Green Band image (b) Mask**

**(a)** **(b)**

**Figure 6: (a) Inverted Image (b Extracted Local Maximum Region**

also. A local maximum region (LMR), of a gray scale (intensity) image is a connected component of pixels with a given constant intensity value, such that its neighboring pixel in the region has a strictly lower intensity [5]. Therefore, it is sufficient only to consider the LMRs of the pre-processed image as possible MA candidate regions. Pixels of the image are processed sequentially, and compared to their 8-neighbor pixels. If all neighbors have a lower intensity, then the pixel itself is a LMR. If there is a neighboring pixel with high intensity, then the current pixel may not be a maximum. A pixel is considered to be a possible maximum if all its neighboring pixels have lower or the same intensity, in which case pixels with the same intensity are stored in a queue, and are tested in the same way. If eventually the queue is emptied so that all the pixels it contained proved to be a possible maxima, then the corresponding connected component is a LMR [6]. Figure 6 (a) shows the inverted GB image and figure 6 (b) shows the local maximum region extracted from the inverted image.

Pixels of a LMR are considered individually as a possible candidate, and the pixel with the maximum final score will represent the region. This procedure is referred to as a nonmaximum suppression. The usage of image smoothing, as discussed in the previous section, gains important at this point, since the local intensity variations may be high on a raw retinal image, resulting in many local maxima.

## 2.4. Cross Sectional Scanning

Vessel segments in the retinal image have points with local maxima in at least one direction. On the other hand, Microaneurysms are circular objects and have local maxima from all directions. The intensity value along the discrete line segments of different orientations are scanned, whose central pixel will be the candidate pixel. The length of the line segment is taken as 21pixels which gives better results. Each pixel is scanned with a slope of $15^0$ up to $180^0$, having 12 cross sectional scans totally [7]. For microaneurysms spot, the entire cross sectional profiles will definitely be a Gaussian like peak from all the directions which is used to differentiate from other non circular spots.

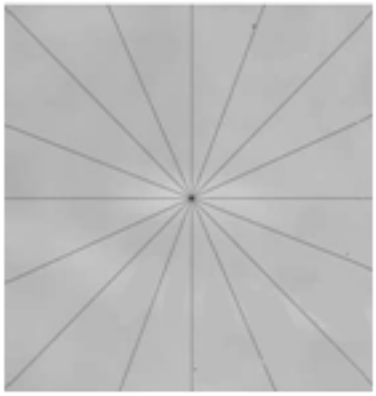
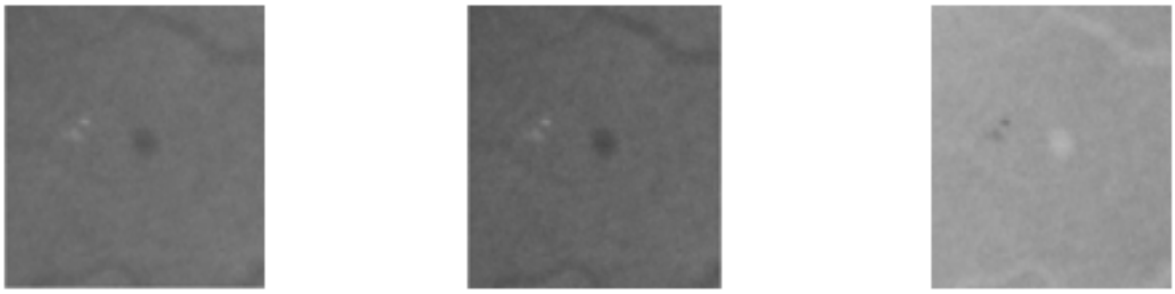


**Figure 7: Cross Section at different angles**



**(a)** **(b)** **(c)**

**Figure 8: MA spot in (a) colour image (b) GB image and (c) Inverted GB image**

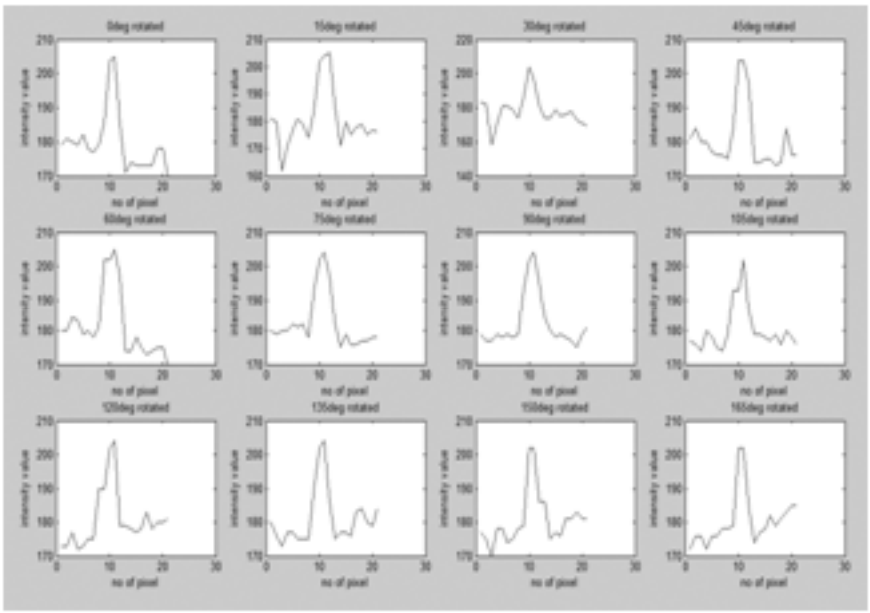
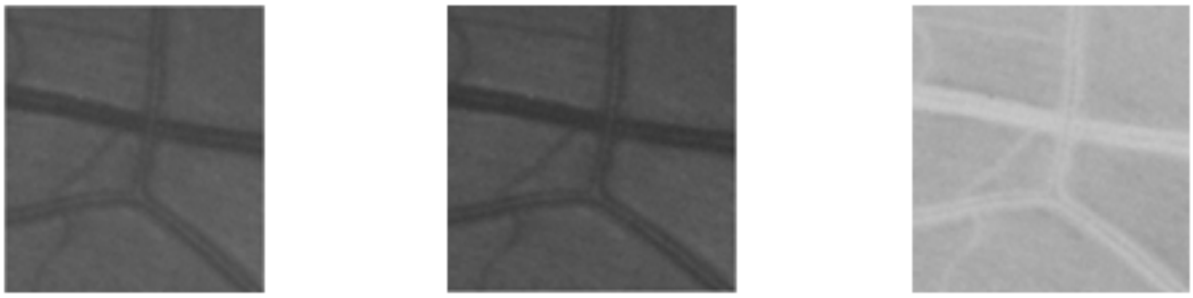



**Figure 9: Different Cross Sectional Profiles for MA spot**



**(a)** **(b)** **(c)**

**Figure 10: Blood vessel spot in (a) colour image (b) GB image and (c) Inverted GB image**

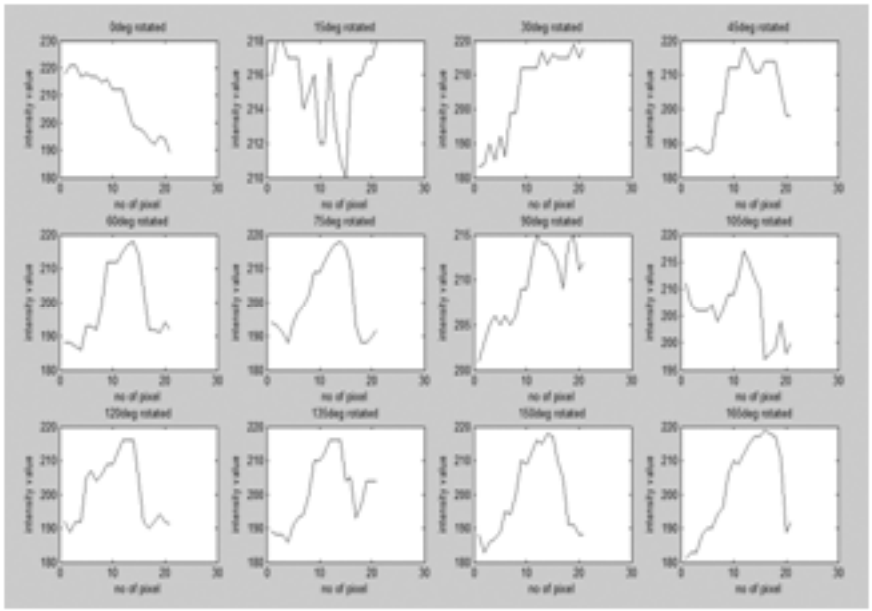



**Figure 11: Different Cross Sectional Profiles for Blood Vessel spot**

### 2.5. Peak Detection

On the obtained cross-section profiles we perform a peak detection step [10][11]. Our aim is to decide whether a peak is present at the centre of the profile, i.e., at the location of the candidate point for a specific direction. If there is more peaks at the centre of the profile, then the candidate is a possible MA.

### 2.6. Profile Width

The width of the profile is calculated at different points. For MA candidate, the profile is narrow and the width will be small. Other than MA candidate, the profile will not be narrow and the width will be high. The profile width is calculated at 98% and 95% of the total peak profile. The difference between the two widths is calculated which will be very small for a MA candidate and for other candidate it will be high. By calculating the width difference, we can differentiate MA candidate with other candidates.

### 2.7. Blood Vessel Extraction

Some of the small blood vessels will also have peaks in different directions[8]. In order to differentiate blood vessel with MA, blood vessel is extracted and suppressed by assigning an average gray level to it. In inverted GB image, both MA and blood vessel will have higher intensity value. Matched filter technique is used for extracting the blood vessels from the retinal image and a new gray level is applied to it [12].

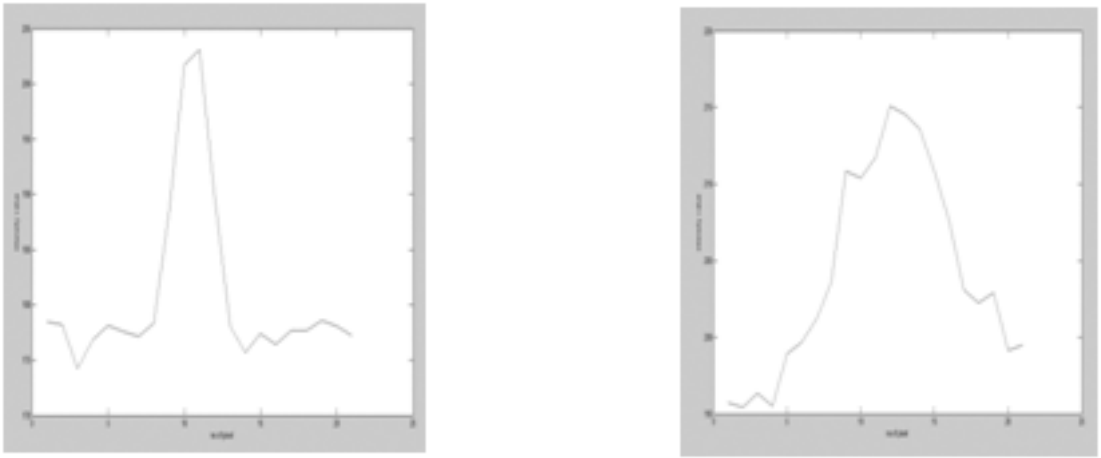


**Figure 12: Average of the cross sectional profiles of (a) MA spot and (b) Blood Vessel Spot**

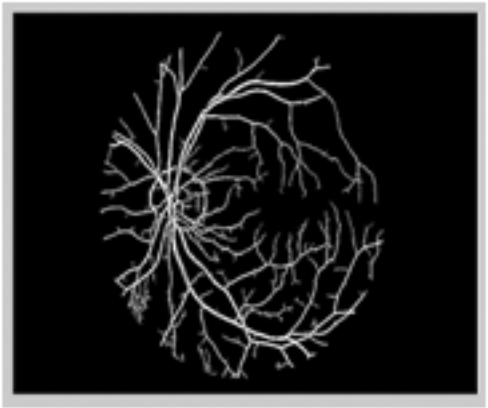
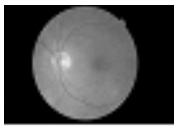
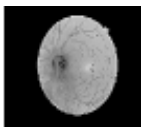
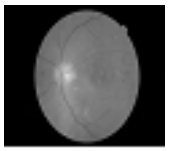
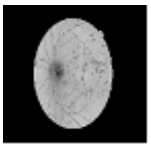
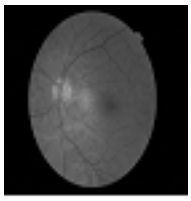
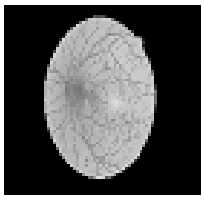
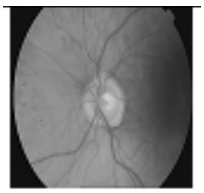
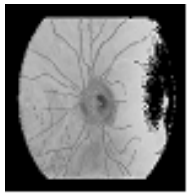
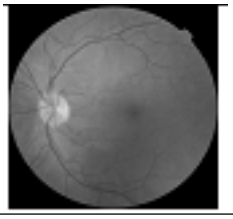
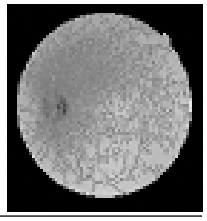


**Figure 13: Extracted Blood Vessel**

## 3. RESULTS AND DISCUSSION

The detection of Microaneurysms (MA) is done by means of cross sectional profile analysis. 21 pixels distance is selected and a profile with intensity value is generated. Again, with 11$^{th}$ pixel as the center one, the image is rotated for a 15 degree and the profile is generated. Likewise different profiles are obtained for the same pixel distance at different angles. For a single local maxima pixel, we obtain 12 profiles at different angles. The profile peak values greater than 190 are noted. For a microaneurysm spot more than 9 profiles should have peak value greater than 180.The profile width is calculated at 98% and 95% from the peak. The peak width distance should be less than or equal to 4 pixels. The differences between the two profile widths are calculated which should be less than or equal to two pixels. This shows that the profile is narrow. More than 8 profiles should be narrow. If the profile obtained has the above mentioned values, then the local maxima pixel is a microaneurysm spot. The detected microaneurysm spot was plotted with a plus symbol in red color. Sometimes the small blood vessels will also have same profile like microaneurysm. To avoid false spots, blood vessel is extracted and suppressed. By doing this false spots will be eliminated. The images are obtained from the publically available MESSIDOR and Retinopathy Online Challenge (ROC) databases.

**Table 1**
**Results For Detected Microaneurysm**

| *S. No* | *Image ID* | *Input Image* | *Detected MA spots* |
|---|---|---|---|
| 1 | MESSIDOR 20051020_43906 |  |  |
| 2 | MESSIDOR 20051020_45068 |  |  |
| 3 | MESSIDOR 20051021_51625 |  |  |
| 4 | ROC Image29_training |  |  |
| 5 | ROC Image_5_training |  |  |

## 4. CONCLUSION

The detection of microaneurysms (MA) is the main objective of this work. The images were obtained from the well known MESSIDOR and Retinopathy Online Challenge (ROC) databases. The proposed method detects MAs on retinal images, based on the principle of analyzing directional cross-section profiles centered on the candidate pixels of the pre-processed image. The number of pixels to be processed is significantly reduced by only considering the local maxima of the pre-processed image. We apply peak detection on each profile, and calculate a set of values that describe the height, width and shape of the central peak. The statistical measures of these values as the orientation of the cross-section changes constitute the feature set used in a classification step to eliminate false candidates. The detected microaneurysm spot is shown with a plus symbol on the inverted green band of the image.

The future scope of the project is to detect haemorrhages with cross sectional profile analysis method.

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