FAST CIRCLET BASED FRAMEWORK FOR OPTIC DISK DETECTION

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Introduction
Optic Disc (OD) detection in Retinal Images (RI) of fundus is crucial to automate a screening system for diabetic retinopathy. Most researches for automatic localization of OD benefit the regions of vessels. We present a fast and novel method based on Fast Circlet Transform (FCT) to detect OD in digital retinal fundus images that doesn’t need the location of the vessels.

Fast Circlet Transform
FCT, a tool to detect circular objects, decomposes an image into circles called “circlets” described by a central position, radius and central frequency content [1]. The circlet function can be written as:

\[ c_{kG}(x, y) = \omega_2 \left( 2\pi f \omega_1 \left( r - r_0 \right) \right) \]

where \( \omega_2 = \sqrt{r^2 - x^2 - y^2} \). \( G \) is a fluctuating function like a wavelet function. Filters are defined in the Fourier domain: 2D filters \( G_z \) are constructed by the 1D filters \( F_z \) as:

\[ F_z(a) = \cos(\omega a \omega_1) \omega_2 \angle (a \omega_1) \omega_1 \in \mathbb{R} \]

By considering a phase delay, \( G_z \) filters are defined as:

\[ G_z \omega_2 \angle (\omega a \omega_1) = e^{j\omega a \omega_1} F_z \omega_2 \angle (\omega a \omega_1) \]

Given filters \( G_z \), the formulation of a circlet in the Fourier domain will be as:

\[ c_{kG}(x, y) = e^{j\omega a \omega_1} G_z \omega_2 \angle (\omega a \omega_1) \]

where \( \omega_2 = \sqrt{r^2 - x^2 - y^2} \) is central position and \( r_0 \) is radius of the circlet.

OD Detection using FCT
Fig. 1 shows general block diagram of the method. First, original image (Fig. 2a) is filtered using a median filter with 3x3 window size and then is enhanced using Contrast Limited Adaptive Histogram Equalization (CLAHE) algorithm [2] (Fig. 2b). Next, since RGB components are highly correlated, the enhanced image is converted to L*a*b color space. Finally, FCT with parameters \( N = 3 \) and \( r_0 = \{30, 32, \ldots, 40\} \) is applied on the L* band (Fig. 2c).

Analysis of FCT Coefficients
OD corresponds to the maximum coefficient of FCT. This is a challenge to find desired coefficient (Fig. 3a) as ROI (yellow border in Fig. 2a) follows a circular pattern that produces high undesired coefficients and form a ring shape in FCT coefficients (surrounded by two red circles in Fig. 3b) for all radii and all frequencies. This problem is solved by obtaining the mask of the ROI as the following steps:

Mask: Apply Otsu thresholding to the L* band follow by the Hole filling operator

Mask-I: Apply opening operator to Mask

Mask-II: Apply erosion operator to Mask-I

Mask-III: Subtract Mask-II from Mask-I

Mask-IV: Obtain the edge of Mask-III using Sobel method, then, apply dilation operator on the edge.

Finally Searching Area (SA) is obtained by:

\[ SA = + \text{(Mask IV)} \approx \text{Mask I} \]

Where + and − denotes OR and NOT logical operator. The SA corresponds to Fig. 3a is depicted in Fig. 3b. When the corresponding SA’s are applied to the coefficients for all radii and all frequencies, the maximum coefficient within SA’s is found which determines the location and radius of the optic disk. Fig. 3c illustrates the detected OD using FCT.

Table I. Comparison of results of OD localization with previous works on Drive dataset.

<table>
<thead>
<tr>
<th>Method</th>
<th>Correct rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esmaili et al [7]</td>
<td>100.0 %</td>
</tr>
<tr>
<td>Yousif et al [8]</td>
<td>100.0 %</td>
</tr>
<tr>
<td>Our method</td>
<td>95.00 %</td>
</tr>
<tr>
<td>Park et al [4]</td>
<td>90.25 %</td>
</tr>
<tr>
<td>Sekhkar et al [5]</td>
<td>90.00 %</td>
</tr>
<tr>
<td>Zhu et al [6]</td>
<td>90.00 %</td>
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Results and Discussion
Our proposed algorithm is tested on DRIVE publicly available dataset [3] contains 40 retinal images. The performance of the method is evaluated by an expert and the results are compared with previous works in Table I. Proposed method outperforms previous works that didn’t utilize the information of vessels [4-6]. It must be noted that our method doesn’t exploit the info of vessels’ structure for the localization of the OD while the methods proposed by Esmaili et al [7] and Yousif et al [8] that achieved 100% correct rate, took the advantageous of vessels’ shape. The performance of the proposed method could be improved by using vessels’ structure info.

Fig. 4 shows the result of our algorithm for some samples of the dataset. The proposed algorithm produces a well localization of OD without requiring the location of the vessels. The produced circle could be used as an initial contour for deformable models to segment the OD with more accuracy. In addition, the effect of variations of the number of filters, N, and frequencies, k in the performance is shown in Fig 5. It is seen that correct rate for different value of N for k=1 and k=2 is above 77.5% and 85%, respectively. In our experiments, maximum correct rate for k=2 was 100% because in high frequencies the effect of noise increases; in addition, curved vessels generate high coefficients in higher frequencies lead to missing the OD and decreasing correct rate. The maximum correct rate in our experiment was 95% for N=4 and k=1.

References

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