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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: $c_{\mu}(x,y) = \Omega[2\pi f_0 (r - r_0)]$

Where $r = \sqrt{(x-x_0)^2 + (y-y_0)^2}$. Ω is a fluctuating function like a wavelet function. Filters are defined in the Fourier domain; 2D filters G_k are constructed by the 1D filters F_k as:

$$F_k(\omega) = \cos(\omega \pm \omega_k), |\omega \pm \omega_k| \le \pi/(N-1); F_k(\omega) = 0, oth.$$

Where N is the number of filters and $\omega_k = \pi(k-1)/(N-1)$.

By considering a phase delay, G_k filters are defined as:

$$G_k(\omega_1, \omega_2) = e^{i|\omega| r_0} \cdot F_k(|\omega|)$$

Given filters G_k , the formulation of a circlet in the Fourier domain will be as: $\hat{c}_{\mu}(\omega) = e^{i<\omega, x_c>} \cdot G_k(\omega)$, where $x_c = (x_0, y_0)$ is central position and r_0 is radius of the circlet.

Reducing the noise

Enhancing the RGB image

Converting to L*a*b color space

Applying FCT on L* band

Analyzing CT coefficients to find OD

Fig. 1. General steps of the proposed algorithm.

OD Detection using FCT

Fig. 1 shows general block diagram of the method. First, original image (Fig. 2(a)) is filtered using a median filter with 3×3 window size and then is enhanced using Contrast Limited Adaptive Histogram Equalization (CLAHE) algorithm [2] (Fig. 2(b)). Next, since RGB components are highly correlated, the enhanced image is converted to L*a*b color space. Finally, FCT with parameters $N = 4$ and $r_0 = \{30, 32, \cdots, 40\}$ is applied on the L* band (Fig. 2(c)).

Fig. 2. (a) A sample of RI, (b) enhanced image, and (c) the L* band of (b).

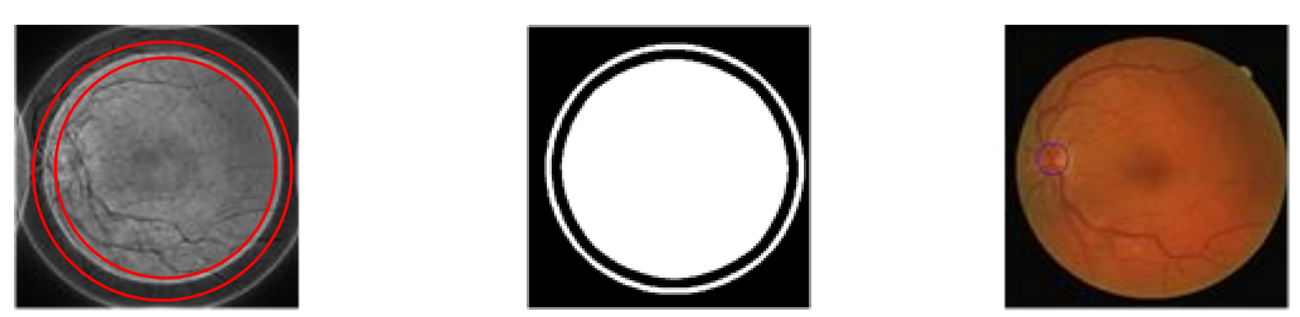

Fig. 3. (a) the absolute FCT coefficients of Fig. 1.(a) correspond to radius $r_0 = 32$ and frequency $k = 2$ (b) searching area correspond to Fig. 2(a), and (c) detected OD by FCT.

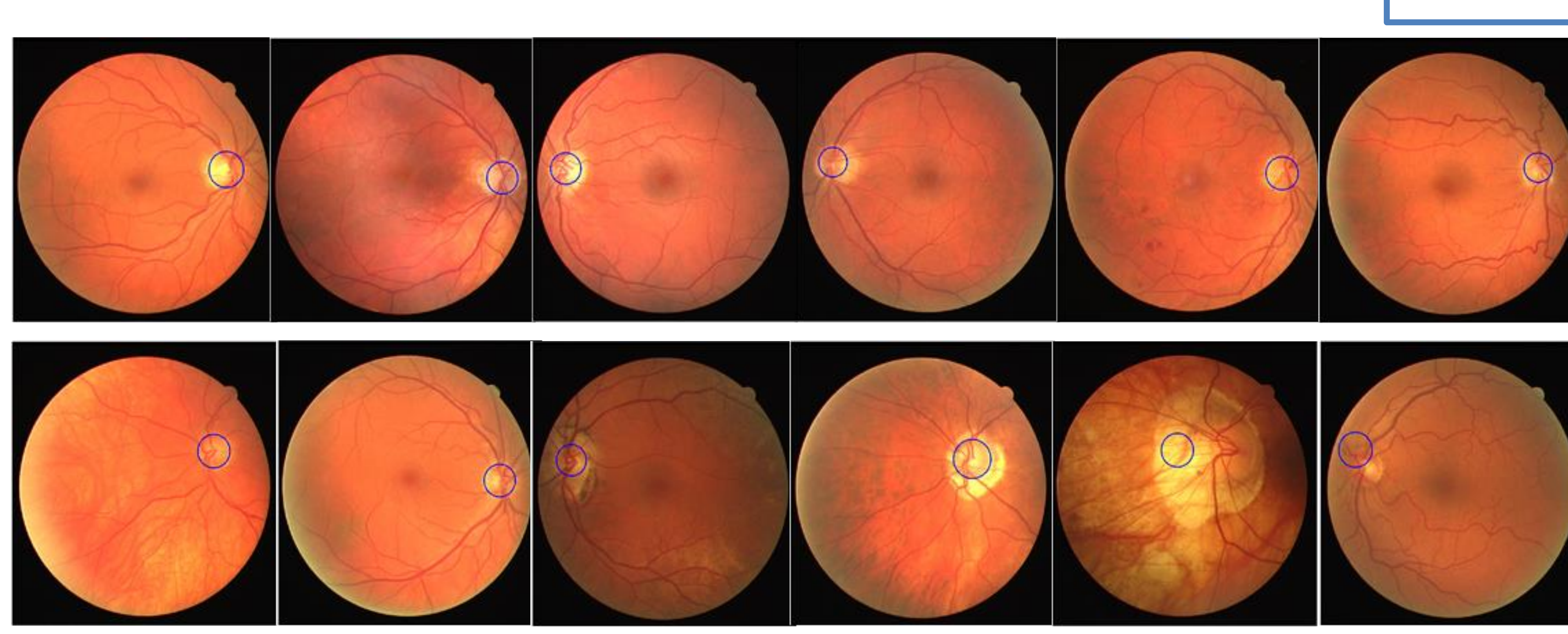

Fig. 4. The result of our algorithm for some samples of the dataset. Top row and four RIs in bottom left depict the images with exact location of OD and two RIs in bottom right exhibit the images with close location.

Analysis of FCT Coefficients

OD corresponds to the maximum coefficient of FCT. This is a challenge to find desired coefficient (Fig. 3(a)) as ROI (yellow border in Fig. 2(a)) follows a circular pattern that produces high undesired coefficients and form a ring shape in FCT coefficients (surrounded by two red circles in Fig. 3(b)) 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 = ~ (Mask-IV + ~ Mask-I)

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

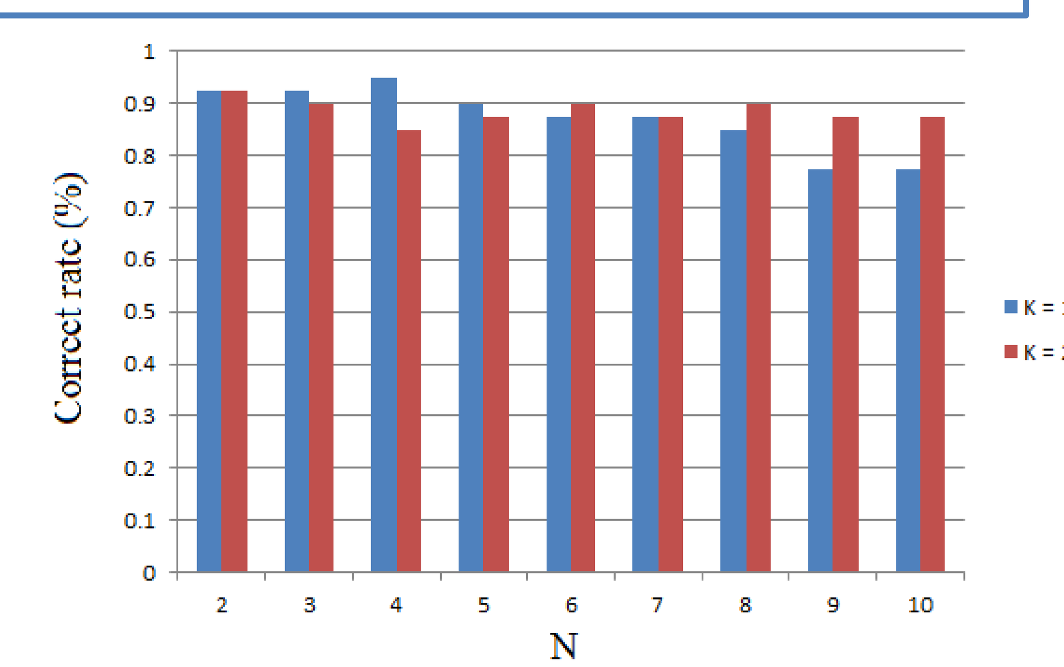

Fig. 5. The correct rate (%) for the changes of N between 2 and 10 and for frequencies k=1 and k=2.

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 Esmaeili et al [7] and Youssif 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's 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 on our experiments, maximum correct rate for k>2 was 10% because in higher 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.

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

Method	Correct rate
Esmaeili et al [7]	100.0 %
Youssif et al [8]	100.0 %
Our method	**95.00 %**
Park et al [4]	90.25 %
Sekhar et al [5]	90.00 %
Zhu et al [6]	90.00 %

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