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The procedure for isolation of neoplasms on the retina of the eye

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Abstract. In operation, a computer diagnostic procedure on the human retina neoplasms. The use of this technique in medical institutions in the operation of the ophthalmic practitioner allows early detection of the disease, at periodic inspection of a pictorial pattern of disease progression. The test procedure is performed on a set of real human retinal photographs taken from international STARE database with known diagnoses. Given the numerous experiments which show the possibility of using this technique, developed on the basis of the diagnostic system in a doctor 's office-ophthalmic.

1. Introduction

Currently, diabetic retinopathy is the leading cause of blindness in developed countries of the world population. Statistics show that in the world like disease affects more than 93 million people [1, 2]. This complication is retinopathy of diabetes disease associated with improper blood vessels of the eye fundus. In diabetic retinopathy, retinal vessels become more brittle, permeable, which can lead to hemorrhages.

Firstly, the retinopathy is dangerous in that in the course of the disease may develop acute vascular occlusion of the retina and optic nerve, requiring immediate treatment. The early signs of diabetic retinopathy is characterized by two ways: microaneurysm and hemorrhage. Microaneurysm sometimes leads to narrowing and occlusion of retinal blood vessels, as well as the weakening of the walls of blood vessels. The hemorrhage is the accumulation of blood outflow from blood vessels in the eye cavity or surrounding tissue.

In accordance with the international classification of diabetic retinopathy microaneurysm levels generally present at early stages of the disease, and hemorrhage are manifested in later stages. Early detection, as well as periodic screening of eyeground potentially assists in reducing disease progression and prevent further vision loss.

In practice, the detection of diabetic retinopathy is a time consuming manual process that requires skilled physician ophthalmic. The physician diagnoses using ophthalmoscopy ophthalmologist 's presence, which is a diagnostic examination of the fundus by the fundus or ophthalmoscope lens. Despite the effectiveness of the manual approach to evaluation of this method is the most labor-intensive, further possible errors due to the influence of the human factor.



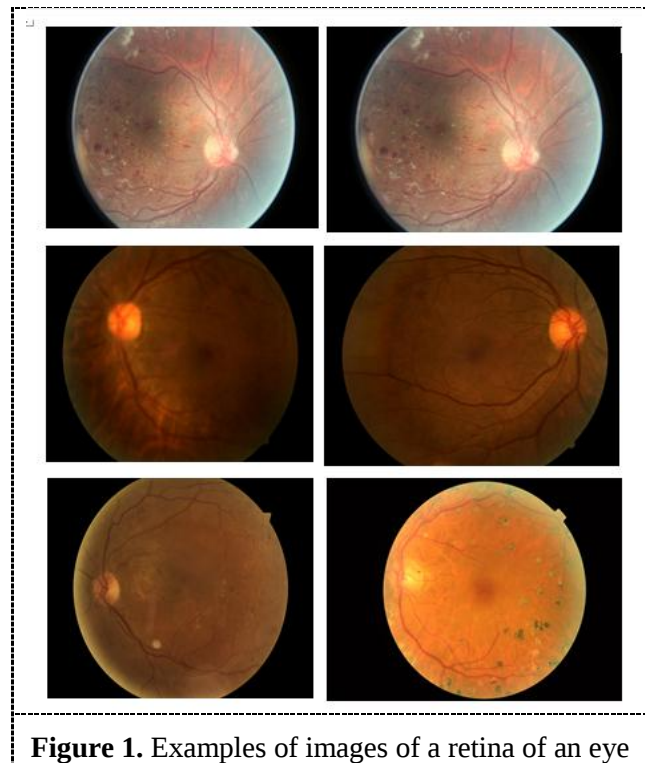


Figure 1. Examples of images of a retina of an eye

The analysis above shows the relevance of neoplastic development computer diagnostic procedures on the retina of the eye on the basis of the images obtained with the simple ophthalmoscope. In addition, it should be noted that the implementation of the methods and systems, constructed based on these measures allow for the driver, is considerably cheaper than the purchase of expensive special digital complexes, and it can be used not only in the large eye centers, but also in all hospitals.

2. The procedure for isolation of neoplasms on the retina of the eye

This approach involves a sequence of steps that convert the original color image of the retina to a form convenient for analysis of informative regions, namely blood vessels and neoplasms.

The procedure consists of the following steps:

1. Mean shift Segmentation method is an iterative process, which consists of the following steps: Each pixel of the input image is considered in the space environment:

$$(x, y) = \begin{cases} X - sp \leq x \leq X + sp \\ Y - sp \leq y \leq Y + sp \\ (R, G, B) - (r, g, b) \leq sr \end{cases}, \quad (1)$$

where sp – a spatial radius, sr – color radius, (X, Y) – surrounding pixels, (R, G, B) and (r, g, b) – pixel color (X, Y) and (x, y) respectively.

For this surrounding mean spatial value and mean value of color of pixel is calculated. These values become surrounding centers on the following iteration.

Iterative process of bypass of the image continues to the required level. As a result of completion of iterative process color of pixels of the input image will accept final value.

2. Conversion of the source image to gray-scale

For convenience of the subsequent processing the image is transferred to a format with 256 gradation of color, gray without indexing [3, 4].

The algorithm of the translation consists in:

- to sequential changeover of brightness of each point of the image of a retina of an eye on a equation:

$$x(i, j) = 0.3r + 0.59g + 0.11b, \quad (2)$$

where r, g, b – values of red, green and blue flowers in each processed point.

- copying of the received value on three channels, that is:

$$r = g = b = x(i, j) \quad (3)$$

3. Filtering image

It is executed by means of the algorithm of median filtering described in [5].

4. Contrast increase

In view of the fact that on the image of a retina of an eye there are many dark sections and details on them become almost indiscernible the algorithm of increase of contrast of the image by alignment of the histogram is applied. This algorithm consists of the following steps:

- creation of the histogram of brightness of $H[i]$ initial eight bit single-channel images $f(x, y)$;
- rating of the histogram in the range $[0, 1]$ by division of each value of the histogram of $H[i]$ into total quantity of pixels N images $f(x, y)$ and creation of the integral histogram:

$$H'[j] = \frac{\sum_{0 \leq i \leq j} H[i]}{N} \quad (4)$$

- computation of new value of brightness of pixel according to the received histogram:

$$f'(x, y) = H'(f(x, y)) \quad (5)$$

5. Improving of boundaries between a background and blood vessels

This algorithm consists of the following stages:

- the retina mask by means of threshold conversion is calculated:

$$f''(x, y) = \begin{cases} 0, & \text{if } f(x, y) > 40 \\ 255, & \text{otherwise} \end{cases} \quad (6)$$

- the received image is subtracted from rounded $f'(x, y)$:

$$f'''(x, y) = f''(x, y) - f'(x, y) \quad (7)$$

6. Binarization

It is executed by means of Otsu's algorithm described in [6].

7. Separation of circuits

This stage is necessary for separation of walls of blood vessels of a retina of an eye.

As algorithm the morphological gradient was selected. He finds a circuit of objects which extent exceeds the kernel size (the structuring element). By experiments the size of a kernel was selected equal 3×3 , the form – a rectangle.

The morphological gradient represents a difference between stretching and an erosion:

$$\text{gradient}(f'''(x, y)) = \text{dilate}(f'''(x, y)) - \text{erode}(f'''(x, y)) \quad (8)$$

8. Marking of spots

Algorithm of marking of spots following:

- 1) are viewed sequentially all selected on the previous step of a circuit;
- 2) for each found circuit such parameters as are calculated:

$$\text{perimetr} = \sum_{i=1}^N \sum_{j=1}^M x_{i,j}, \quad (9)$$

where N, M – quantity of points of a circuit of a spot across and down

$$square = \sum_{i=1}^N \sum_{j=1}^M x_{i,j}, \quad (10)$$

where N, M – quantity of points in a spot across and down

$$compact = square / perimeter^2 \quad (11)$$

$$area = H * W \quad (12)$$

The decision on circuit belonging to a spot is made on the basis of the following conditions:

$$spot = \begin{cases} square / area < 5 \\ 0.087 \leq compact \leq 0.05 \\ n \geq 10 \end{cases} \quad (13)$$

where $spot$ – a spot, n – quantity of points in a circuit.

3. Examination of the isolation techniques of neoplasms on the retina of the eye

The offered technique including the considered algorithms was realized and was checked on 100 images of a retina of an eye. Images were taken from basis of STARE. For the analysis the images of sick patients were selected. The part of images of these objects and results of their preliminary processing are given in table 1 and in fig. 2.

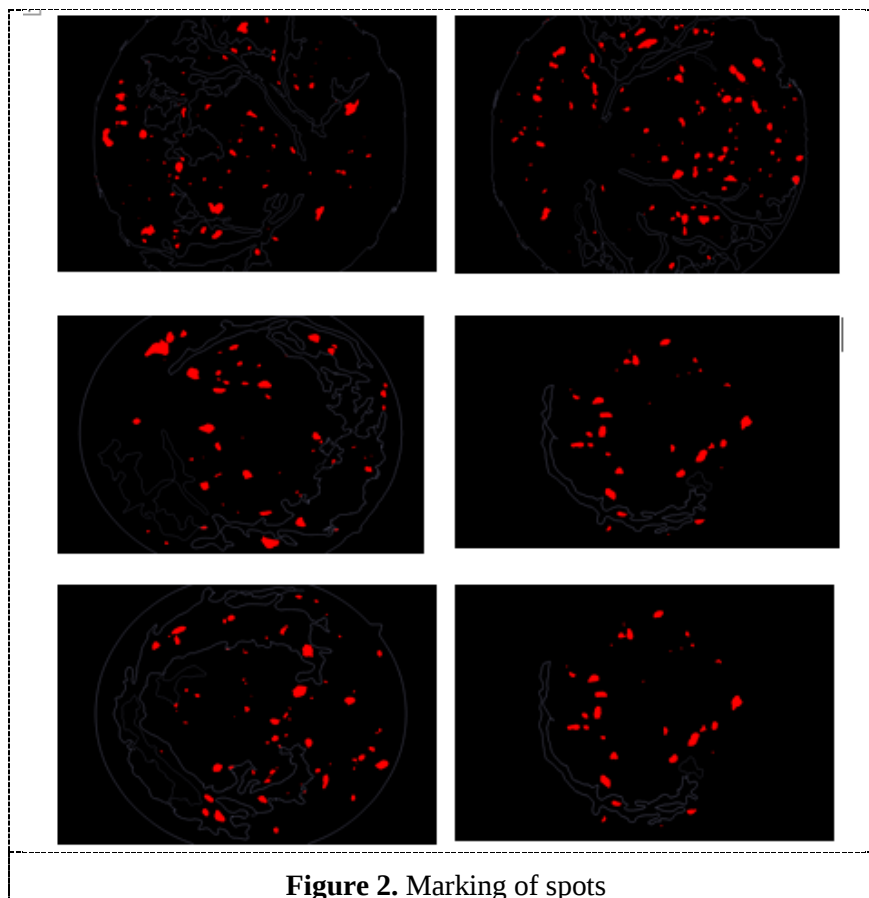
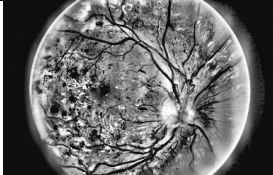
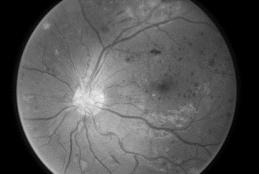
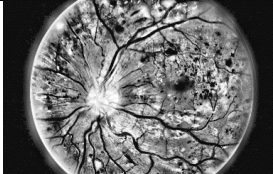
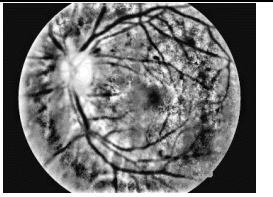
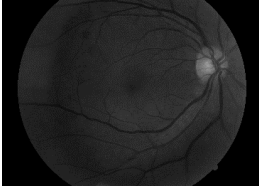
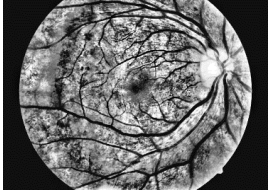
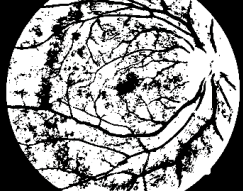
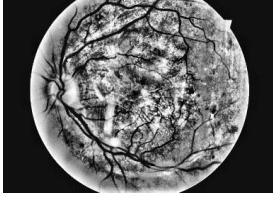


Figure 2. Marking of spots

Table 1. Sequential processing retinal images

Segmentation, the conversion into halftone filtering	The contrast enhancement, improvement of the boundaries between the background and blood vessels	Binarization	Contours
			
			
			
			
			

The received results demonstrate that the described approach provides rather high accuracy of marking of tanks and spots. However it is necessary to mark also some shortcomings of this approach. So, faint tanks can be lost as a result of binarization. Besides, in certain cases some spots can be marked as tanks. The specified defects can be eliminated by means of development of the algorithm allowing to select tanks on faint sections of the image.

4. Conclusion

The technique of preliminary image processing of a retina of an eye is offered. This technique includes algorithms: segmentations, conversions of the color image in gray-scale, filterings, increases of contrast, improving of boundary between a background and blood vessels, binarizations, and also markings of spots on an eye retina.

The advantage of this technique is accuracy when marking spots. Further development of an analysis algorithm of the selected spots, an assessment of their sizes, quantities is planned. The algorithm will allow to make decisions on existence or not at the patient of a diabetic retinopathy, and also to evaluate its level.

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