Description

Iris Recognition Method and Apparatus, Colored Contact Lens Detection Method and Apparatus, and Readable Storage Medium and Detection Device

Cross-Reference to Related Application

The disclosure claims the priority to Chinese Patent Application No. 202111372916.6, filed with the Chinese Patent Office on November 19, 2021 and entitled “Colored Contact Lens Detection Method and Apparatus, Iris Recognition Method and Apparatus, and Readable Storage Medium and Device”, which is incorporated in its entirety herein by reference.

Technical Field

The disclosure relates to the field of iris recognition, and in particular to iris recognition method and apparatus, colored contact lens detection method and apparatus, and readable storage medium and detection device.

Background

As shown in Fig. 1, a portion between an outer iris circle and an inner iris circle is the iris, which is a ring-like structure positioned between a pupil and a sclera. Owing to the blockage by eyelids and eyelashes, part of iris information is lost. The iris has a diameter of 12 mm or so and a thickness of 0.5 mm or so. Interlaced fine features in a filament or streak shape indicate the uniqueness of the iris. These textured features are typically used for iris recognition.

The iris recognition primarily includes iris image acquisition, iris image quality evaluation, iris image preprocessing, iris image normalization, iris image feature extraction, iris feature comparison, etc.

The iris recognition is actually to recognize an iris region from an eye. However, in practical application, users (especially female users) often wear colored contact lenses, which brings some problems to iris recognition and affects the accuracy of iris recognition accordingly. The colored contact lenses can generally include transparent colored contact lenses (similar to contact lenses, having basically no impact on iris recognition), light colored contact lenses, and dark colored contact lenses. Specifically, the dark colored contact lens and the light colored contact lens are shown in Figs. 2 and 3 below.

Two methods for detecting colored contact lenses are primarily available in the prior art:

1) One method is to determine a grayscale on the basis of a feature that a colored contact lens region is darker, which primarily includes: a grayscale value of pixels is determined directly, and then, the colored contact lens region is determined according to a set threshold.

The method can recognize some dark colored contact lenses, but can hardly recognize the light colored contact lenses.

2) The other method is based on deep learning, which primarily includes: training sample data that are divided into colored contact lens samples and non-colored contact lens samples are collected; and then, deep training is performed according to a deep network model constructed, so as to recognize whether colored contact lenses are worn.

Deep learning is highly dependent on training samples, especially types of colored contact lenses. But it is actually impossible to collect all types of colored contact lenses. In consequence, the deep network model trained cannot classify the colored contact lenses accurately.

Summary

In order to solve the technical problems that the above methods for detecting colored contact lenses cannot recognize the colored contact lenses and are dependent on training samples, the disclosure provides iris recognition method and apparatus, colored contact lens detection method and apparatus, and readable storage medium and detection device. Accordingly, a dark colored contact lens and a light colored contact lens may be accurately recognized without depending on image samples and with robustness.

The disclosure provides the technical solutions as follows:

In a first aspect, the disclosure provides a colored contact lens detection method. The method includes:

an eye image is acquired;

an average pixel value of the eye image is calculated, grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image are stretched to a range [0,1], and grayscale values of pixels having grayscale values greater than the average pixel value are set to 0, so as to obtain a first image matrix;

a gradient transformation is performed on the eye image, and a grayscale value of each pixel in an image obtained through the gradient transformation is normalized to a range [0,1], so as to obtain

the pupil is preliminarily located from the initial eye image through an edge detection operator and edge gradient binarization detection, so as to preliminarily determine the pupil position, the pupil radius, the upper eyelid boundary, and the lower eyelid boundary.

In an example, the middle region is an image obtained by cutting off 1/3 of the binarized image in a vertical direction downwards from an upper edge, cutting off 1/3 of the binarized image in the vertical direction upwards from a lower edge, cutting off 1/3 of the binarized image in a horizontal direction rightwards from a left boundary, and cutting off 1/3 of the binarized image in the horizontal direction leftwards from a right boundary.

In a second aspect, the disclosure provides a colored contact lens detection apparatus. The apparatus includes: an image acquisition module, a first image matrix calculation module, a second image matrix calculation module, a binarized image calculation module, and a colored contact lens determination module.

The image acquisition module is configured to acquire an eye image.

The first image matrix calculation module is configured to calculate an average pixel value of the eye image, stretch grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image to a range [0,1], and set grayscale values of pixels having grayscale values greater than the average pixel value to 0, so as to obtain a first image matrix.

The second image matrix calculation module is configured to perform a gradient transformation on the eye image, and normalize a grayscale value of each pixel in an image obtained through the gradient transformation to a range [0,1], so as to obtain a second image matrix.

The binarized image calculation module is configured to perform a matrix addition operation on the first image matrix and the second image matrix, and binarize each pixel in an image obtained through the matrix addition operation according to a set binarization threshold, so as to obtain a binarized image.

The colored contact lens determination module is configured to count a proportion of pixels having grayscale values of 1 in a portion, outside a pupil region, of the binarized image, determine a binarized image having a proportion greater than a set colored contact lens threshold as indicating that no colored contact lens is worn, and determine a binarized image having a proportion smaller than or equal to the set colored contact lens threshold as indicating that the colored contact lens is worn.

In an example, the image acquisition module includes:

When the eye image is collected, under the impact of light supplement, etc., the spot is likely to be generated in the pupil. In the disclosure, the spot is filled through spot detection and the biquadratic interpolation. An effect image after the spot is filled is shown in Fig. 7.

S200: an average pixel value of the eye image is calculated, grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image are stretched to a range [0,1], and grayscale values of pixels having grayscale values greater than the average pixel value are set to 0, so as to obtain a first image matrix.

A specific embodiment of the step is as follows: grayscale values of all pixels in the eye image are summed and averaged, so as to calculate the average pixel value. Grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image are stretched to a range [0,1], and grayscale values of pixels having grayscale values greater than the average pixel value are set to 0, so as to obtain a first image matrix Img1. In the disclosure, the grayscale value means the pixel value.

S300: a gradient transformation is performed on the eye image, and a grayscale value of each pixel in an image obtained through the gradient transformation is normalized to a range [0,1], so as to obtain a second image matrix.

In the step, the gradient transformation is performed on the eye image through an edge detection Canny operator. Then, the grayscale value of each pixel in the image obtained through the gradient transformation is normalized to the range [0,1], so as to obtain a second image matrix Img2.

S400: a matrix addition operation is performed on the first image matrix and the second image matrix, and each pixel in an image obtained through the matrix addition operation is binarized according to a set binarization threshold, so as to obtain a binarized image.

In the step, the first image matrix Img1 and the second image matrix Img2 are added, so as to obtain a result matrix Image= Img1+Img2. Then, the result matrix is compared with the binarization threshold. For example, the binarization threshold is set to 0.6. Then, the pixel is binarized. The binarization threshold value of 0.6 is merely illustrative and is not intended to limit the disclosure. A specific binarization method is as follows:

$$\mathrm{Image}(x, y) = \begin{cases} 0 & \mathrm{Image}(x, y) < 0.6 \\ 1 & \mathrm{Im\,age}(x, y) \geq 0.6 \end{cases}$$

The binarized image is illustratively shown in Fig. 8.

S500: a proportion of pixels having grayscale values of 1 in a portion, outside a pupil region,

In some examples of the disclosure, in order to eliminate the impact of an upper eyelid, a lower eyelid, and eyelash noise, the step that a proportion of pixels having grayscale values of 1 in a portion, outside a pupil region, of the binarized image is counted specifically includes S051-S503.

S501: a middle region is selected from the binarized image, and a total number N_T of pixels in the middle region is counted.

Illustratively, the middle region is an image obtained by cutting off 1/3 of the binarized image in a vertical direction downwards from an upper edge, cutting off 1/3 of the binarized image in the vertical direction upwards from a lower edge, cutting off 1/3 of the binarized image in a horizontal direction rightwards from a left boundary, and cutting off 1/3 of the binarized image in the horizontal direction leftwards from a right boundary. The middle region is a rectangular portion in Fig. 9. 1/3 of the binarized image in a direction is merely illustrative and is not intended to limit the disclosure.

S502: a number N_1 of pixels having grayscale values of 1 in a portion, outside the pupil region, of the middle region is counted.

A region composed of the pixels having grayscale values of 1 in the portion, outside the pupil region, of the middle region denotes the colored contact lens region within the middle region.

S503: the proportion is calculated according to a formula N_1/N_T.

The step is to calculate a proportion of the colored contact lens region to the middle region. The proportion is used as the proportion of the pixels having grayscale values of 1 in the portion, outside the pupil region, of the binarized image. Accordingly, the impact of the upper eyelid, the lower eyelid, the eyelash noise, etc. is eliminated.

A colored contact lens detection apparatus 10 for detecting a colored contact lens is provided in an example of the disclosure. As shown in Fig. 10, the apparatus includes: an image acquisition module 100, a first image matrix calculation module 200, a second image matrix calculation module 300, a binarized image calculation module 400, and a colored contact lens determination module 500.

The image acquisition module 100 is configured to acquire an eye image.

The first image matrix calculation module 200 is configured to calculate an average pixel value of the eye image, stretch grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image to a range [0,1], and set grayscale values of pixels having grayscale values greater than the average pixel value to 0, so as to obtain a first image matrix.

Claims

1. A colored contact lens detection method, comprising:

acquiring an eye image;

calculating an average pixel value of the eye image, stretching grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image to a range [0,1], and setting grayscale values of pixels having grayscale values greater than the average pixel value to 0, so as to obtain a first image matrix;

performing a gradient transformation on the eye image, and normalizing a grayscale value of each pixel in an image obtained through the gradient transformation to a range [0,1], so as to obtain a second image matrix;

performing a matrix addition operation on the first image matrix and the second image matrix, and binarizing each pixel in an image obtained through the matrix addition operation according to a set binarization threshold, so as to obtain a binarized image; and

counting a proportion of pixels having grayscale values of 1 in a portion, outside a pupil region, of the binarized image, determining a binarized image having a proportion greater than a set colored contact lens threshold as indicating that no colored contact lens is worn, and determining a binarized image having a proportion smaller than or equal to the set colored contact lens threshold as indicating that the colored contact lens is worn.

2. The colored contact lens detection method according to claim 1, wherein the acquiring an eye image comprises:

preliminarily locating a pupil from an initial eye image, so as to obtain a pupil position, a pupil radius, an upper eyelid boundary, and a low eyelid boundary;

intercepting the initial eye image by selecting a vertex of the upper eyelid boundary, a bottom point of the lower eyelid boundary, and two intersections between the upper eyelid boundary and the lower eyelid boundary as interception boundaries individually, so as to obtain an eye region image; and

detecting a spot from the eye region image, and filling, for the eye region image from which the spot is detected, the spot detected from the eye region image through biquadratic interpolation.

3. The colored contact lens detection method according to claim 1 or 2, wherein the counting a proportion of pixels having grayscale values of 1 in a portion, outside a pupil region, of the binarized

image comprises:

selecting a middle region from the binarized image, and counting a total number N_T of pixels in the middle region;

counting a number N_1 of pixels having grayscale values of 1 in a portion, outside the pupil region, of the middle region; and

calculating the proportion according to a formula N_1/N_T.

4. The colored contact lens detection method according to claim 1, wherein the binarization threshold is 0.6.

5. The colored contact lens detection method according to claim 1, wherein the colored contact lens threshold is 0.8.

6. The colored contact lens detection method according to claim 2, wherein the preliminarily locating a pupil from an initial eye image, so as to obtain a pupil position, a pupil radius, an upper eyelid boundary, and a low eyelid boundary comprises:

preliminarily locating the pupil from the initial eye image through an edge detection operator and edge gradient binarization detection, so as to preliminarily determine the pupil position, the pupil radius, the upper eyelid boundary, and the lower eyelid boundary.

7. The colored contact lens detection method according to claim 3, wherein the middle region is an image obtained by cutting off 1/3 of the binarized image in a vertical direction downwards from an upper edge, cutting off 1/3 of the binarized image in the vertical direction upwards from a lower edge, cutting off 1/3 of the binarized image in a horizontal direction rightwards from a left boundary, and cutting off 1/3 of the binarized image in the horizontal direction leftwards from a right boundary.

8. A colored contact lens detection apparatus, comprising:

an image acquisition module configured to acquire an eye image;

a first image matrix calculation module configured to calculate an average pixel value of the eye image, stretch grayscale values of pixels having grayscale values smaller than or equal to the average pixel value in the eye image to a range [0,1], and set grayscale values of pixels having grayscale values greater than the average pixel value to 0, so as to obtain a first image matrix;

a second image matrix calculation module configured to perform a gradient transformation on the eye image, and normalize a grayscale value of each pixel in an image obtained through the gradient transformation to a range [0,1], so as to obtain a second image matrix;

a binarized image calculation module configured to perform a matrix addition operation on the first image matrix and the second image matrix, and binarize each pixel in an image obtained through the matrix addition operation according to a set binarization threshold, so as to obtain a binarized image; and

a colored contact lens determination module configured to count a proportion of pixels having grayscale values of 1 in a portion, outside a pupil region, of the binarized image, determine a binarized image having a proportion greater than a set colored contact lens threshold as indicating that no colored contact lens is worn, and determine a binarized image having a proportion smaller than or equal to the set colored contact lens threshold as indicating that the colored contact lens is worn.

9. The colored contact lens detection apparatus according to claim 8, wherein the image acquisition module comprises:

a preliminary pupil location unit configured to preliminarily locate a pupil from an initial eye image, so as to obtain a pupil position, a pupil radius, an upper eyelid boundary, and a low eyelid boundary;

an image interception unit configured to intercept the initial eye image by selecting a vertex of the upper eyelid boundary, a bottom point of the lower eyelid boundary, and two intersections between the upper eyelid boundary and the lower eyelid boundary as interception boundaries individually, so as to obtain an eye region image; and

a spot filling unit configured to detect a spot from the eye region image, and fill, for the eye region image from which the spot is detected, the spot detected from the eye region image through biquadratic interpolation.

10. The colored contact lens detection apparatus according to claim 8 or 9, wherein the colored contact lens determination module comprises:

a middle region selection unit configured to select a middle region from the binarized image, and count a total number N_T of pixels in the middle region;

a pixel counting unit configured to count a number N_1 of pixels having grayscale values of 1 in a portion, outside the pupil region, of the middle region; and

a proportion calculation unit configured to calculate the proportion according to a formula N_1/N_T.

11. A computer-readable storage medium, storing a computer program executable by a processor, wherein the computer program implements steps of the colored contact lens detection

method according to any one of claims 1-7 when executed by the processor.

12. A detection device, comprising at least one processor and a memory storing a computer program, wherein the processor implements steps of the colored contact lens detection method according to any one of claims 1-7 when executing the computer program.

13. An iris recognition method, comprising:

detecting a colored contact lens through the colored contact lens detection method according to any one of claims 1-7;

detecting the iris from an eye image, so as to obtain an iris region; and

counting a proportion of pixels having grayscale values of 1 in the iris region of a binarized image, and recognizing the iris from the eye image for a binarized image having a proportion smaller than a set recognition threshold.

14. The iris recognition method according to claim 13, wherein the recognizing the iris from the eye image comprises:

processing a region of the pixels having grayscale values of 1 in the binarized image as a noise region.

15. An iris recognition apparatus, comprising:

the colored contact lens detection apparatus according to any one of claims 8-10;

an iris detection module configured to detect the iris from an eye image, so as to obtain an iris region; and

a recognition and determination module configured to count a proportion of pixels having grayscale values of 1 in the iris region of a binarized image, and recognize the iris from the eye image for a binarized image having a proportion smaller than a set recognition threshold.