METHOD AND APPARATUS FOR VISUALIZING CHANGE IN MYOPIC FUNDUS, STORAGE MEDIUM, AND ELECTRONIC DEVICE

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to the field of image processing technologies, and in particular, to a method and apparatus for visualizing change in a myopic fundus, a storage medium, and an electronic device.

BACKGROUND

[0002] As a typical fundus change in eye tissues of myopic patients, a fundus tessellated is commonly seen in myopic patients, causing damage to retina of the myopic patients. If a interventional therapy is not given timely, the fundus tessellated may eventually develop into a fundus pathological change or trigger macula degeneration, seriously affecting vision of the patient.

[0003] Currently, the fundus tessellated is mainly evaluated based on subjective experience through a fundus image. However, severity of the fundus tessellated may not be accurately reflected, and the fundus tessellated may not be easily observed. Therefore, in a case where a doctor lacks relevant medical knowledge, the severity of the fundus tessellated may not be diagnosed accurately. As the evaluation of the severity of the fundus tessellated depends on a relevant knowledge level of the doctor, accuracy of the evaluation of the fundus tessellated is limited. Thus, it is difficult for people to learn about change and development of the myopic fundus, so that some patients may miss optimal time for interventional therapy, causing irreversible damage and even blindness to the vision of the patient.

SUMMARY

[0004] In view of this, the present disclosure provides a method and apparatus for visualizing change in a myopic fundus, a storage medium, and electronic device, so as to assist a doctor in gaining a detailed understanding of changes and development in the myopic fundus, which is conducive to improving understanding of people in the fundus tessellated and changes in the myopic fundus. Furthermore, a better and more comprehensive understanding of the myopia status and progression may be achieved, facilitating comprehensive and accurate prevention and control of myopia and establishment of a corresponding accurate prevention and control system.

[0005] In a first aspect, an embodiment of the present disclosure provides a method for visualizing change in a myopic fundus, including: determining, based on a fundus image to be processed, an image of fundus characterization region, where the image of fundus characterization region includes a tessellation characteristic region; and determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed, where the first visualized image is configured to characterize distribution of a tessellation, and the determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed includes: determining, based on the image of fundus characterization region, a digital image corresponding to the fundus image to be processed, where the digital image represents the distribution of the tessellation in a digital form; and determining, based on the digital image, the first visualized image corresponding to the fundus image to be processed through a mapping processing.

[0006] According to the first aspect, in some implementations of the first aspect, the determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed includes: determining a plurality of window regions in the image of fundus characterization region by using a preset window, where each of the plurality of window regions includes at least one pixel; determining a tessellation characteristic of each of the plurality of window regions; determining, based on the tessellation characteristic of the window region, a tessellation index by using an area of the window region or characteristic data of a region of interest in the image of fundus characterization region; and determining, based on the tessellation index, the digital image corresponding to the fundus image to be processed.

[0007] According to the first aspect, in some implementations of the first aspect, the tessellation index includes at least one of fundus tessellated density, tessellation proportion, and a tessellated morphology parameter.

[0008] According to the first aspect, in some implementations of the first aspect, the characteristic data of the region of interest in the image of fundus characterization region includes at least one of a diameter of the region of interest, an area of the region of interest, and boundary data of the region of interest.

[0009] According to the first aspect, in some implementations of the first aspect, the determining a tessellation characteristic of each of the plurality of window includes: performing, for each of the plurality of window regions, when the window region includes a pixel located at an edge of the region of interest and an area of the window region outside the region of interest is greater than a preset threshold, an edge processing on the region of interest, where the edge

processing includes performing a mirror processing on the pixel located at the edge of the region of interest by taking the edge of the region of interest as a reference to obtain a mirrored edge region; and determining, based on a window region including at least part of the mirrored edge region, the tessellation characteristic of the window region.

[0010] According to the first aspect, in some implementations of the first aspect, the determining the tessellation characteristic of each of the plurality of window regions includes: performing, for each of the plurality of window regions, when the window region includes a pixel located at an edge of the region of interest, an enlargement processing on the edge of the region of interest to determine an enlarged edge region; and determining, based on a window region including at least part of the enlarged edge region, the tessellation characteristic of the window region.

[0011] According to the first aspect, in some implementations of the first aspect, the first visualized image includes a two-dimensional first visualized image or a three-dimensional first visualized image, and the determining, based on the digital image, the first visualized image corresponding to the fundus image to be processed includes: mapping the digital image to a two-dimensional color space, and determining the two-dimensional first visualized image; or mapping the digital image to a three-dimensional space, and determining the three-dimensional first visualized image; or mapping the digital image to a two-dimensional color space, mapping the two-dimensional color space to a three-dimensional space, and determining the three-dimensional first visualized image.

[0012] According to the first aspect, in some implementations of the first aspect, the image of fundus characterization region further includes an atrophy region; and after the determining, based on a fundus image to be processed, an image of fundus characterization region, the method further includes: determining, based on the image of fundus characterization region, the atrophy region in the image of fundus characterization region; and determining, based on the first visualized image and the atrophy region, a second visualized image corresponding to the fundus image to be processed.

[0013] According to the first aspect, in some implementations of the first aspect, the image of fundus characterization region further includes an atrophy region; and after the determining, based on a fundus image to be processed, an image of fundus characterization region, the method further includes: determining, based on the image of fundus characterization region, the atrophy region in the image of fundus characterization region; and determining, based on the first visualized image, the atrophy region, and the tessellation characteristic region, a second visualized image corresponding to the fundus image to be processed.

[0014] According to the first aspect, in some implementations of the first aspect, the image of fundus characterization region further includes at least one of a peripapillary atrophy region, a macula region, and a papilla region.

[0015] According to the first aspect, in some implementations of the first aspect, after the determining, based on a fundus image to be processed, an image of fundus characterization region, the method further includes: determining, based on the image of fundus characterization region, the peripapillary atrophy region in the image of fundus characterization region; determining, based on at least one of the peripapillary atrophy region, the macula region, and the papilla region, a marked region of the image of fundus characterization region, where the marked region is configured to characterize a region prompting a user to focus on; and determining, based on the first visualized image and the marked region, a third visualized image corresponding to the fundus image to be processed.

[0016] According to the first aspect, in some implementations of the first aspect, the determining, based on at least one of the peripapillary atrophy region, the macula region, and the papilla region, a marked region of the image of fundus characterization region includes: when the marked region of the image of fundus characterization region is determined based on the peripapillary atrophy region, determining the marked region by marking with a wrap angle extension line, where the wrap angle extension line is obtained by extending two sides of a wrap angle to obtain the wrap angle extension line.

[0017] According to the first aspect, in some implementations of the first aspect, the determining, based on at least one of the peripapillary atrophy region, the macula region, and the papilla region, a marked region of the image of fundus characterization region includes: when the marked region of the image of fundus characterization region is determined based on the macula region, determining the marked region by marking the macula region in the image of fundus characterization region.

[0018] According to the first aspect, in some implementations of the first aspect, the determining, based on at least one of the peripapillary atrophy region, the macula region, and the papilla region, a marked region of the image of fundus characterization region includes: when the marked region of the image of fundus characterization region is determined based on the papilla region, determining the marked region by marking the papilla region in the image of fundus characterization region.

[0019] In a second aspect, an embodiment of the present disclosure provides an apparatus for visualizing change in a myopic fundus, including: a determining module, configured to determine, based on a fundus image to be processed, an image of fundus characterization region,

where the image of fundus characterization region includes a tessellation characteristic region; and a visualization module, configured to determine, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed, where the first visualized image is configured to characterize distribution of tessellation; where the visualization module is further configured to: determine, based on the image of fundus characterization region, a digital image corresponding to the fundus image to be processed, where the digital image represents the distribution of the tessellation in a digital form; and determine, based on the digital image, the first visualized image corresponding to the fundus image to be processed through a mapping processing.

[0020] In a third aspect, an embodiment of the present disclosure provides an electronic device, including: a processor; and a memory configured to store executable instructions of the processor, where the processor is configured to implement the method mentioned in the first aspect.

[0021] In a forth aspect, an embodiment of the present disclosure provides a computer-readable storage medium, where a computer program is stored in the storage medium for executing the method mentioned in the first aspect.

[0022] In the embodiment of the present disclosure, the first visualized image corresponding to the fundus image to be processed is determined through the image of fundus characterization region including the tessellation characteristic region. The first visualized image is configured to characterize distribution of the tessellation. As the first visualized image visually reflects the distribution of the fundus tessellated, a doctor may determine severity of the fundus tessellated based on the first visualized image. Therefore, the method for visualizing change in the myopic fundus provided by the embodiment of the present disclosure may assist a doctor in gaining a detailed understanding of changes and development in the myopic fundus, which is conducive to improving understanding of people in the tessellation and changes in the myopic fundus. Furthermore, a better and more comprehensive understanding of the myopia status and progression may be achieved, facilitating comprehensive and accurate prevention and control of myopia and establishment of a corresponding accurate prevention and control system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Through a more detailed description of embodiments of the present disclosure with reference to the accompanying drawings, the above and other purposes, features and advantages of the present disclosure will become more obvious. The accompanying drawings are provided for further understanding of the present disclosure, and constitute a part of the specification. The

accompanying drawings and the embodiments of the present disclosure are used to explain the present disclosure and do not constitute a limitation to the present disclosure.

[0024] FIG. 1 is a schematic diagram of an application scenario according to an embodiment of the present disclosure.

[0025] FIG. 2 is a flowchart of a method for visualizing change in a myopic fundus according to an embodiment of the present disclosure.

[0026] FIG. 3 is a flowchart of determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed according to an embodiment of the present disclosure.

[0027] FIG. 4 is a flowchart of determining, based on the image of fundus characterization region, a digital image corresponding to the fundus image to be processed according to an embodiment of the present disclosure.

[0028] FIG. 5 is a flowchart of determining a tessellation characteristic of each of the plurality of window regions according to an embodiment of the present disclosure.

[0029] FIG. 6 is a flowchart of another method for visualizing change in a myopic fundus according to an embodiment of the present disclosure.

[0030] FIG. 7 is a flowchart of still another method for visualizing change in a myopic fundus according to an embodiment of the present disclosure.

[0031] FIG. 8 is a schematic structural diagram of an apparatus for visualizing change in a myopic fundus according to an embodiment of the present disclosure.

[0032] FIG. 9 is a schematic structural diagram of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0033] The technical solutions in the embodiments of the present disclosure will be clearly and completely described below with reference to the accompanying drawings in the embodiments of the present disclosure. Apparently, the described embodiments are only a part of the embodiments of the present disclosure, but not all of the embodiments.

[0034] A fundus tessellated is commonly seen in myopic patients and is a typical fundus change in eye tissues of myopic patients. Damage caused by the fundus tessellated is mainly a retinal damage. The retinal damage may be represented in various forms, such as peripheral retinal degeneration, a retinal hole, relatively close to retinoschisis center, and neovascularization. If a interventional therapy is not given timely, the fundus tessellated may eventually develop into

pathological myopia, leading to retinal detachment or triggering macula degeneration, seriously affecting vision of the patient.

[0035] Currently, evaluation of the fundus tessellated is mainly based on subjective experience of experts, which is neither objective nor precise. Meanwhile, researchers or individuals lacking relevant medical knowledge are unable to determine severity of the fundus tessellated accurately based on fundus images or examination reports. As the evaluation of severity of the fundus tessellated depends on a relevant knowledge level of the doctor, understanding of the fundus tessellated is limited, which is not conducive to understanding the changes and progression of myopic fundus. Thus, it is difficult for facilitating comprehensive and accurate prevention and control of myopia and establishing a corresponding accurate prevention and control system, so that some patients in some underdeveloped medical areas may miss optimal time for interventional therapy, causing irreversible damage to the vision of the patient.

[0036] Therefore, a method for visualizing change in a myopic fundus is urgently needed, so as to assist the doctor in gaining a detailed understanding of changes and development in the myopic fundus, thereby improving understanding of people in the tessellation and myopic fundus change. Furthermore, a better and more comprehensive understanding of the myopia status and progression may be achieved, facilitating comprehensive and accurate prevention and control of myopia and establishment of a corresponding accurate prevention and control system.

[0037] An application scenario of an embodiment of the present disclosure is briefly described below with reference to FIG. 1.

[0038] FIG. 1 is a schematic diagram of an application scenario according to an embodiment of the present disclosure. As shown in FIG. 1, the scenario is a scenario of image processing. Specifically, the scenario of the image processing includes a server 110 and a user terminal 120 in communication connection with the server 110. The server 110 is configured to execute the method mentioned in the embodiments of the present disclosure.

[0039] Exemplarily, in an actual application process, a user sends an instruction for processing an image through the user terminal 120. After receiving the instruction, the server 110 performs a visualization processing on a fundus image to be processed to determine a first visualized image corresponding to the fundus image to be processed. The first visualized image is configured to characterize distribution of tessellation. Specifically, a specific process of visualization processing of the fundus image to be processed is as follows: determining, based on a fundus image to be processed, an image of fundus characterization region, where the image of fundus characterization region includes a tessellation characteristic region; and determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus

image to be processed, where the first visualized image is configured to characterize the distribution of the tessellation.

[0040] Exemplarily, the fundus image to be processed mentioned above includes, but is not limited to, all image data stored by a medical institution for a same patient or different patients during treatment, relevant fundus image data of one or more patients input by the user, and fundus image data of one or more patients photographed according to a requirement during treatment. The fundus image to be processed may be a 45° fundus image, a 60° fundus image, a wide-angle fundus image, a fundus image with other field angles, or even a fundus image of other modalities. The fundus image may be photographed with a papilla as a center, with a macula center as the center, and may also be images in other eye positions. Exemplarily, the server 110 may directly receive the fundus image to be processed, or may acquire the fundus image to be processed from a data storage device.

[0041] Exemplarily, the user terminal 120 mentioned above includes, but is not limited to, a computer terminal such as a desktop computer and a notebook computer, as well as a mobile terminal such as a tablet computer and a mobile phone.

[0042] FIG. 2 is a flowchart of a method for visualizing change in a myopic fundus according to an embodiment of the present disclosure. As shown in FIG. 2, the method for visualizing change in the myopic fundus provided by the embodiment of the present disclosure includes the following steps.

[0043] Step S210: determining, based on a fundus image to be processed, an image of fundus characterization region.

[0044] The image of fundus characterization region includes a tessellation characteristic region.

[0045] Exemplarily, based on the fundus image to be processed, the image of fundus characterization region is determined according to tessellation characteristic data. A tessellation characteristic region is included in the image of fundus characterization region, and corresponds to the tessellation characteristic data in the fundus image to be processed.

[0046] Exemplarily, a fundus characteristic of the fundus image to be processed is segmented and extracted, for example, the tessellation is segmented and extracted, so as to determine the tessellation characteristic data according to a segmentation result.

[0047] In some embodiments, an initial fundus image to be processed is acquired, and the initial fundus image to be processed is preprocessed to determine the fundus image to be processed. The preprocessing of the initial fundus image to be processed includes, but is not limited to, performing extraction of a region of interest (ROI) on the initial fundus image to be processed, and performing an image enhancement processing on the initial fundus image to be

processed to determine the fundus image to be processed. For example, the image enhancement processing on the initial fundus image to be processed may include process of sharpening, filtering, smoothing, and the like. Alternatively, after the extraction of a region of interest is performed on the initial fundus image to be processed, the image enhancement processing is performed on an extracted ROI region to determine the fundus image to be processed. The embodiments of the present disclosure do not further limit the method of preprocessing the initial fundus image to be processed.

[0048] Step S220: determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed.

[0049] The first visualized image is configured to characterize distribution of tessellation.

[0050] Exemplarily, based on the image of fundus characterization region, the first visualized image corresponding to the fundus image to be processed is determined according to tessellation characteristic parameters such as fundus tessellated density data (that is, a ratio of a unit tessellated area within a calculation range to an area of the calculation range), tessellation proportion data (that is, a ratio of an area of the tessellation within a calculation range to an area of the tessellation in the fundus image to be processed), a tessellated fractal dimension, and tessellated morphology data in the tessellation characteristic data. The first visualized image is capable of visually representing the distribution of the tessellation. The first visualized image may be a two-dimensional heat map, and may also be a three-dimensional contour map. Therefore, the distribution of the tessellation may be observed visually by the doctor according to the first visualized image, so as to determine the severity of a fundus tessellated based on the distribution of the tessellation.

[0051] In some embodiments, a specific execution method of Step S220 is shown in FIG. 3, and details are not described herein again.

[0052] According to the method for visualizing change in the myopic fundus according to the embodiment of the present disclosure, the first visualized image corresponding to the fundus image to be processed is determined based on the image of fundus characterization region including the tessellation characteristic region. As the distribution of a fundus tessellated may be reflected visually in the first visualized image, severity of the fundus tessellated may be determined by a doctor based on the first visualized image. Therefore, the method for visualizing change in the myopic fundus according to the embodiment of the present disclosure may assist the doctor in diagnosis of the fundus tessellated, and achieve a purpose of popularization of fundus tessellated diagnosis. In addition, in the embodiment of the present disclosure, by preprocessing an initial fundus image to be processed, the fundus image to be processed is

determined, which can help to improve accuracy of a subsequent processing and robustness of the method, so that distribution of real tessellation in the first visualized image may be more accurate, thereby improving accuracy of evaluation of the severity of the fundus tessellated based on the first visualized image by the doctor. Thus, the doctor is better assisted in understanding changes of the fundus of a myopic patient, progression of the fundus change, thereby facilitating myopia follow-up, prevention and control.

[0053] FIG. 3 is a flowchart of determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed according to an embodiment of the present disclosure. As shown in FIG. 3, the determining, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed according to the embodiment of the present disclosure (that is, Step S220 in the embodiment shown in FIG. 2) specifically includes the following steps.

[0054] Step S310: determining, based on the image of fundus characterization region, a digital image corresponding to the fundus image to be processed.

[0055] The digital image represents the distribution of the tessellation in a digital form.

[0056] Exemplarily, a calculation range is selected based on the image of fundus characterization region; and a digital image corresponding to the fundus image to be processed is determined based on an area of the tessellation in the calculation range, fundus tessellated density or tessellation proportion. For example, a figure shown in the digital image corresponds to the fundus tessellated density, so that different figures represent different distribution conditions of the tessellation. It should be understood that the figure shown in the digital image may alternatively correspond to other tessellated characteristic parameters such as the tessellation proportion, a tessellated fractal dimension, and tessellated morphology data, so as to represent the distribution of the tessellation. The fundus tessellated density is only one of indices used for visualization, and other indices may alternatively be used for visualization.

[0057] In some embodiments, a specific implementation of Step S310 is shown in FIG. 4, and details are not described herein again.

[0058] Step S320: determining, based on the digital image, the first visualized image corresponding to the fundus image to be processed.

[0059] Exemplarily, based on the digital image, the first visualized image corresponding to the fundus image to be processed is determined through a mapping processing. Alternatively, based on the digital image, the first visualized image corresponding to the fundus image to be processed is determined through a visualization tool processing. It should be understood that, according to a requirement, the first visualized image may be presented in a two-dimensional or

three-dimensional form. Correspondingly, the digital image can be processed through the mapping processing or the visualization tool to obtain a two-dimensional image or a three-dimensional image.

[0060] Exemplarily, the figure shown in the digital image is represented as a grayscale value, and is mapped to a color space, so as to obtain a two-dimensional first visualized image.

[0061] According to the embodiment of the present disclosure, the first visualized image corresponding to the fundus image to be processed is determined by using a digital image, and the digital image represents the distribution of the tessellation in a digital form. The first visualized image result obtained based on the digital image is more accurate. In addition, according to the embodiment of the present disclosure, a representation form of the first visualized image may be further selected according to different requirements, so that the first visualized image may adapt to requirements of different scenarios, and increase usage range of the first visualized image. Therefore, in different scenarios, the embodiments of the present disclosure may achieve a purpose of assisting a doctor in diagnosing the fundus tessellated, thereby further promoting popularity of fundus tessellated diagnosis.

[0062] FIG. 4 is a flowchart of determining, based on the image of fundus characterization region, a digital image corresponding to the fundus image to be processed according to an embodiment of the present disclosure. As shown in FIG. 4, the determining, based on the image of fundus characterization region, the digital image corresponding to the fundus image to be processed provided by an embodiment of the present disclosure (that is, Step S310 in the embodiment shown in FIG. 3) specifically includes the following steps.

[0063] Step S410: determining a plurality of window regions in the image of fundus characterization region by using a preset window.

[0064] The window region includes at least one pixel.

[0065] Exemplarily, according to a clinical requirement, the preset window is set to meet different viewing ranges. That is, a calculation range is determined. A shape and size of the preset window may be set according to the clinical requirement. For example, the preset window may be a square of 3 mm × 3 mm, or a circle with a radius of 5 mm, or a polygon of another size determined according to the requirement. When the size of the preset window is set based on a papilla diameter, for example, when the size of the window ranges from 1PD to 2PD, processing effect is better.

[0066] Exemplarily, the preset window is utilized to slide to select window regions at different positions of the image of fundus characterization region, and a plurality of window regions in the image of fundus characterization region are determined. Alternatively, by using the preset

window, a plurality of regions of the size of the preset window are selected in the image of fundus characterization region according to the size of the preset window and a requirement, and the plurality of window regions in the image of fundus characterization region are determined.

[0067] Step S420: determining a tessellation characteristic of each of the plurality of window regions.

[0068] Exemplarily, as for each of the plurality of window regions, the tessellation characteristic of the window region is determined based on the tessellation in each of the plurality of window regions

[0069] Step S430: determining, based on the tessellation characteristic of the window region, a tessellation index by using an area of the window region or characteristic data of a region of interest in the image of fundus characterization region.

[0070] Exemplarily, the tessellation index includes at least one of fundus tessellated density, tessellation proportion, and tessellated morphology parameter. The characteristic data of the region of interest in the image of fundus characterization region includes at least one of a diameter of the region of interest, an area of the region of interest, and boundary data of the region of interest. Exemplarily, based on the tessellation characteristic of the window region, an area of the tessellation in each window region is calculated to determine an area of tessellation in the window region. Based on the tessellated area in the window region, the fundus tessellated density or the tessellation proportion, that is, the tessellation index, is determined by using the area of the window region or an area of the region of interest in the image of fundus characterization region. Alternatively, the tessellation index is determined based on at least one of the diameter of the region of interest in the image of fundus characterization region and the boundary data of the region of interest. The tessellated morphology parameter refers to a parameter determined based on morphology of the tessellation in the image. The morphology of the tessellation in the image includes at least one of a shape, curvature, area, density, width, fractal dimension, compactness, intersection degree, and bifurcation degree of tessellation. In some embodiments, the tessellated morphology parameter is proportional to the shape, the curvature, the area, the density, the width, the fractal dimension, the compactness, the intersection degree, and the bifurcation degree. That is to say, the higher the shape, the curvature, the area, the density, the width, the fractal dimension, the compactness, the intersection degree, or the bifurcation degree of tessellation is, the greater the tessellated morphology parameter will be. The compactness of the tessellation is determined based on a length of a contour line of a region and an actual area within the region. Those skilled in the art can flexibly adjust a reference characteristic of the tessellated morphology parameter according to practical

application. The tessellation index in the fundus image may be calculated and quantified to mapping with eye biological parameters, such as an eye axis and a refractive index. In addition, the tessellation index may reflect a change in eye structure, such as a change in choroid and retina, so that a reference basis for subsequent clinical diagnosis, surgery, optometrist matching, and the like is provided.

[0071] Step S440: determining, based on the tessellation index, the digital image corresponding to the fundus image to be processed.

[0072] Exemplarily, the digital image corresponding to the fundus image to be processed is determined based on the fundus tessellated density or the tessellation proportion. A figure shown in the digital image represents the fundus tessellated density or the tessellation proportion at a corresponding position of the fundus image to be processed.

[0073] According to the embodiment of the present disclosure, the digital image corresponding to the fundus image to be processed is determined through the tessellation index, so that the fundus tessellated density or the tessellation proportion in the fundus image to be processed may be represented by figures, thereby representing the distribution of the tessellation. According to the embodiment of the present disclosure, the distribution of the tessellation is represented through the digital image, so that the distribution of the tessellation may be more clear, and accuracy of the first visualized image is further improved.

[0074] Exemplarily, the tessellation index and the digital image corresponding to the fundus image to be processed may further be used for image classification, that is, characterizing whether the fundus image is a fundus tessellated. Optionally, a tessellation index threshold may also be set. When the tessellation index is less than the tessellation index threshold, it is represented that the fundus image is not a fundus tessellated. When the tessellation index is greater than the tessellation index threshold, the fundus image is determined to be a fundus tessellated, and severity of the fundus tessellated may be determined based on a range where the tessellation index ranges between. Exemplarily, the severity of the fundus tessellated includes mild, moderate and severe.

[0075] Exemplarily, when the tessellation index is the fundus tessellated density, the tessellation index threshold may range from 0 to 20%, and specifically may be 2%, 5%, 7.3%, 8%, 8.5%, 9%, and the like. That is, when the fundus tessellated density is greater than the tessellation index threshold, the fundus image to be processed is determined to be a fundus tessellated. When the fundus tessellated density is less than the tessellation index threshold, the current fundus image is determined not to be a fundus tessellated. Similarly, those skilled in the art may flexibly adjust the tessellation index threshold based on an actual situation, so that the

tessellation index threshold is adapted to the tessellation proportion, the tessellated morphology parameter, and the like.

[0076] FIG. 5 is a flowchart of determining a tessellation characteristic of each of the plurality of window regions according to an embodiment of the present disclosure.

[0077] According to the embodiment of the present disclosure, the tessellation characteristic of the window region includes an area of tessellation of the window region. As shown in FIG. 5, the determining a tessellation characteristic of each of the plurality of window regions (that is, Step S420 in the embodiment shown in FIG. 4) specifically includes the following steps.

[0078] Step S510: determining, for each of the plurality of window regions, whether the window region includes a pixel located at an edge of the region of interest, and an area of the window region outside the region of interest is greater than a preset threshold.

[0079] Exemplarily, since the plurality of window regions are determined based on the fundus image, the plurality of windows include at least one window region. For each of the plurality of window regions, at least one window region including the pixel located at the edge of the region of interest is determined.

[0080] Exemplarily, if the window region includes the pixel located at the edge of the region of interest, Step S520 and/or Step S540 is executed. One of Step S520 and Step S540 may be selected to be executed or both of them may be executed simultaneously based on a requirement. If the window region does not include the pixel located at the edge of the region of interest, the pixel in the window region will not be processed. It should be understood that when the window region does not include the pixel located at the edge of the region of interest, the tessellation characteristic of the window region may be directly determined by calculation. For example, by calculating an area of the tessellation in the window region, the tessellation characteristic of the window region is determined.

[0081] Step S520: performing a mirror processing on the pixel located at the edge of the region of interest by taking the edge of the region of interest as a reference to obtain a mirrored edge region.

[0082] Exemplarily, since the fundus image to be processed is a circular region, when a value is assigned to the fundus tessellated density or the tessellation proportion in the edge region, an error is easy to occur. Therefore, the edge region of the region of interest need to be optimized.

[0083] Exemplarily, the mirror processing is performed on the pixel located at the edge of the region of interest by taking the edge of the region of interest as a reference, that is, the pixel located at the edge of the region of interest is mirrored along the edge of the region of interest to obtain the mirrored edge region.

[0084] Step S530: determining, based on a window region including at least part of the mirrored edge region, an area of tessellation of the window region.

[0085] Exemplarily, based on the window region including at least part of the mirrored edge region, a more accurate value of the area of tessellation of the window region is calculated and obtained.

[0086] Step S540: performing an enlargement processing on the edge of the region of interest to determine an enlarged edge region.

[0087] Exemplarily, by performing the enlargement processing on the edge of the region of interest, it may be avoided that a value of the fundus tessellated density or the tessellation proportion of the edge region is too small, thereby reducing a deviation.

[0088] Step S550: determining, based on a window region including at least part of the enlarged edge region, an area of tessellation of the window region.

[0089] Exemplarily, based on the window region including at least part of the enlarged edge region, a more accurate value of the area of tessellation of the window region is calculated and obtained.

[0090] According to the embodiment of the present disclosure, the window region including the pixel located at the edge of the region of interest may be optimized, so that it may be avoided that the value of the fundus tessellated density or the tessellation proportion of the edge region is too small, thereby reducing a deviation. Therefore, according to the embodiment of the present disclosure, a more accurate tessellation characteristic of the window region may be obtained, thereby improving accuracy of subsequent processing, improving accuracy of the visualized image, and providing a basis for assisting a doctor in diagnosing severity of the fundus tessellated and severity of a myopic fundus change.

[0091] In some embodiments, the first visualized image includes a two-dimensional first visualized image or a three-dimensional first visualized image. The two-dimensional first visualized image includes a heat map. The three-dimensional first visualized image includes a contour map. The determining, based on the digital image, the first visualized image corresponding to the fundus image to be processed includes: mapping the digital image to a two-dimensional color space, and determining the two-dimensional first visualized image; or mapping the digital image to a three-dimensional space, and determining the three-dimensional first visualized image; or mapping the digital image to a two-dimensional color space, then mapping the two-dimensional color space to a three-dimensional space, and determining the three-dimensional first visualized image.

[0092] Exemplarily, the digital image is mapped to the two-dimensional color space through a color mapping algorithm (for example, a Jet color mapping algorithm) to determine the two-dimensional first visualized image (for example, a heat map). Alternatively, the digital image is processed through a mapping tool and mapped to the two-dimensional color space to determine the two-dimensional first visualized image. A figure shown in the digital image is used as a grayscale value and mapped to the two-dimensional color space to determine the two-dimensional visualized image.

[0093] Exemplarily, the digital image is mapped to the three-dimensional space to determine a three-dimensional first visualized image (for example, a contour map).

[0094] FIG. 6 is a flowchart of another method for visualizing change in a myopic fundus according to an embodiment of the present disclosure. The embodiment shown in FIG. 6 is an extension based on the embodiment shown in FIG. 2. A difference between the embodiment shown in FIG. 6 and the embodiment shown in FIG. 2 will be described in the following, and similarities are not repeated here.

[0095] In another embodiment of the present disclosure, the image of fundus characterization region may further include an atrophy region. As shown in FIG. 6, another method for visualizing change in the myopic fundus provided in another embodiment of the present disclosure further includes following steps after the determining, based on a fundus image to be processed, an image of fundus characterization region (that is, Step S210 in the embodiment shown in FIG. 2).

[0096] Step S610: determining, based on the image of fundus characterization region, an atrophy region in the image of fundus characterization region.

[0097] Exemplarily, according to a principle of fundus lesion, tessellation usually appears first. As a disease progresses, after severity of the tessellation develops into a certain degree, the tessellation gradually disappears, and an atrophy starts to replace the tessellation. That is, after the atrophy appears, the atrophy will cover the tessellation. Severity of the atrophy is higher than severity of the tessellation.

[0098] Exemplarily, based on the image of fundus characterization region, characteristic segmentation extraction is performed to determine the atrophy region in the image of fundus characterization region. After Step S610 is completed, Step S620 and/or Step S630 is selected to be executed. That is, one of Step S620 and Step S630 may be executed selectively or both of them may be simultaneously executed based on a requirement.

[0099] Step S620: determining, based on the first visualized image and the atrophy region, a second visualized image corresponding to the fundus image to be processed.

[0100] Exemplarily, based on the atrophy region in the image of fundus characterization region, the digital image corresponding to the fundus image to be processed is determined. A figure shown in the digital image in a region corresponding to the atrophy represents a distribution of the atrophy. A color different from a color of tessellation is configured to represent the atrophy region, and the atrophy region is superimposed on the first visualized image to determine the second visualized image. The second visualized image is configured to characterize distribution of the tessellation and the atrophy.

[0101] In some embodiments, based on the atrophy region in the image of fundus characterization region, the digital image corresponding to the fundus image to be processed is determined to generate a second visualized image only including the atrophy region. The second visualized image may be directly generated based on the atrophy region. The second visualized image is configured to characterize the distribution of the atrophy.

[0102] Step S630: determining, based on the first visualized image, the atrophy region, and the tessellation characteristic region, a second visualized image.

[0103] Exemplarily, based on the digital image corresponding to the atrophy region and the tessellation characteristic region, a two-dimensional image including the atrophy region and the tessellation characteristic region is generated through a mapping processing. The two-dimensional image and the first visualized image are superimposed to generate the second visualized image. The second visualized image is configured to characterize the distribution of the tessellation and/or the atrophy.

[0104] Due to the principle of the fundus lesion, the tessellation appears first. After severity of the tessellation develops into a certain degree, the atrophy may cover the tessellation, and the tessellation region in the fundus image to be processed becomes less, but the severity is increased. In order to reduce an error of a result of an image processing, the embodiment of the present disclosure generates the second visualized image through a combination of the first visualized image and the atrophy. The second visualized image can characterize the distribution of the tessellation and the atrophy. Therefore, the tessellation and the atrophy may be diagnosed by a doctor through the second visualized image, thereby further promoting the diagnosis and popularization of the fundus tessellated and the atrophy.

[0105] FIG. 7 is a flowchart of still another method for visualizing change in a myopic fundus according to an embodiment of the present disclosure. The embodiment shown in FIG. 7 is an extension based on the embodiment shown in FIG. 2. A difference between the embodiment shown in FIG. 7 and the embodiment shown in FIG. 2 will be described in the following, and similarities are not repeated here.

[0106] In the embodiments of the present disclosure, the image of fundus characterization region further includes at least one of an peripapillary atrophy region, a macula region, and a papilla region. As shown in FIG. 7, another method for visualizing change in the myopic fundus provided by another embodiment of the present disclosure further includes the following steps after the determining, based on a fundus image to be processed, an image of fundus characterization region (that is, Step 210 in the embodiment shown in FIG. 2).

[0107] Step S710: determining, based on the image of fundus characterization region, a peripapillary atrophy region in the image of fundus characterization region.

[0108] Exemplarily, based on the papilla in the image of fundus characterization region, a peripapillary atrophy is extracted to determine the peripapillary atrophy region in the image of fundus characterization region. Specifically, the papilla region is fitted into a circle, and a wrap angle range of the peripapillary atrophy relative to the papilla is calculated. The wrap angle refers to an angle formed by lines connecting the two endpoints of the peripapillary atrophy and a center of the circle fitted for the papilla region.

[0109] Step S720: determining, based on at least one of the peripapillary atrophy region, the macula region, and the papilla region, a marked region of the image of fundus characterization region.

[0110] The marked region is configured to characterize a region prompting a user to focus on.

[0111] Exemplarily, when the marked region of the image of fundus characterization region is determined based on the peripapillary atrophy region, the marked region is obtained by marking with a wrap angle extension line. The wrap angle extension line is obtained by extending two sides of a wrap angle to obtain the wrap angle extension line.

[0112] Exemplarily, when the marked region of the image of fundus characterization region is determined based on the macula region, the macula region in the image of fundus characterization region is marked to obtain the marked region.

[0113] Exemplarily, when the marked region of the image of fundus characterization region is determined based on the papilla region, the papilla region in the image of fundus characterization region is marked to obtain the marked region. It should be understood that when the marked region is determined based on any two or three combinations of the peripapillary atrophy region, the macula region and the papilla region, mark lines of different regions have different colors, so as to distinguish different marked regions, and a doctor may pay attention to different key regions according to different marked regions.

[0114] Step S730: determining, based on the first visualized image and the marked region, a third visualized image corresponding to the fundus image to be processed.

[0115] Exemplarily, the marked region is superimposed on the first visualized image to determine the third visualization image corresponding to the fundus image to be processed. The third visualized image includes the distribution of tessellation of the marked region.

[0116] In some embodiments, after the second visualized image is generated based on the first visualized image and the atrophy region, the marked region of the image of fundus characterization region is determined based on at least one of the peripapillary atrophy region, the macula region, and the papilla region. An obtained marked region is superimposed on the second visualized image to determine the third visualized image corresponding to the fundus image to be processed. The third visualized image includes the distribution of the tessellation and /or the atrophy of the marked region.

[0117] According to the embodiment of the present disclosure, a user may be prompted to focus on a disease condition within the marked region. A degree of disease in the marked region has a greater impact on a patient compared to other regions. Therefore, the user may be reminded to pay more attention on the marked region in, thereby reducing probability of misdiagnosis. Meanwhile, a reference may be provided for early intervention, facilitating comprehensive and accurate prevention and control of myopia and establishment of a corresponding accurate prevention and control system.

[0118] FIG. 8 is a schematic structural diagram of an apparatus for visualizing change in a myopic fundus according to an embodiment of the present disclosure. As shown in FIG. 8, an apparatus 800 for visualizing change in a myopic fundus provided by the embodiment of the present disclosure includes a determining module 801, and a visualization module 802. Specifically, the determining module 801 is configured to determine, based on a fundus image to be processed, an image of fundus characterization region, where the image of fundus characterization region includes a tessellation characteristic region. The visualization module 802 is configured to determine, based on the image of fundus characterization region, a first visualized image corresponding to the fundus image to be processed, where the first visualized image is configured to characterize distribution of tessellation.

[0119] In some embodiments, the visualization module 802 is further configured to determine, based on the image of fundus characterization region, a digital image corresponding to the fundus image to be processed, where the digital image represents the distribution of the tessellation in a digital form; and determine, based on the digital image, the first visualized image corresponding to the fundus image to be processed.

[0120] In some embodiments, the visualization module 802 is further configured to determine a plurality of window regions in the image of fundus characterization region by using a preset

window, where each of the plurality of window regions comprises at least one pixel; determine a tessellation characteristic of each of the plurality of window regions; determine, based on the tessellation characteristic of each of the plurality of window regions, a tessellation index by using an area of the window region or characteristic data of a region of interest in the image of fundus characterization region; and determine, based on the tessellation index, the digital image corresponding to the fundus image to be processed.

[0121] In some embodiments, the tessellation characteristic of the window region includes an area of tessellation of the window region. The visualization module 802 is further configured to perform, for each of the plurality of window regions, when the window region comprises a pixel located at an edge of the region of interest and an area of the window region outside the region of interest is greater than a preset threshold, an edge processing on the region of interest, where the edge processing comprises performing a mirror processing on the pixel located at the edge of the region of interest by taking the edge of the region of interest as a reference to obtain a mirrored edge region; and determine, based on a window region comprising at least part of the mirrored edge region, the tessellation characteristic of the window region; or perform, for each of the plurality of window regions, when the window region comprises a pixel located at an edge of the region of interest, an enlargement processing on the edge of the region of interest to determine an enlarged edge region; and determine, based on a window region including at least part of the enlarged edge region, the tessellation characteristic of the window region. Specifically, the preset threshold may range from 0 to 50% of an area of the window region. And specifically, the preset threshold may be 10% of the area of the window region, 20% of the area of the window region, or 5% of the area of the window area, and the like.

[0122] In some embodiments, the first visualized image includes a two-dimensional first visualized image or a three-dimensional first visualized image. The visualization module 802 may be further configured to map the digital image to a two-dimensional color space, and determine the two-dimensional first visualized image; or map the digital image to a three-dimensional space, and determine the three-dimensional first visualized image; or map the digital image to a two-dimensional color space, then map the two-dimensional color space to a three-dimensional space, and determine the three-dimensional first visualized image.

[0123] In some embodiments, the image of fundus characterization region may further include an atrophy region. The visualization module 802 is further configured to, after an image of fundus characterization region is determined based on a fundus image to be processed, determine the atrophy region in the image of fundus characterization region based on the image of fundus characterization region; and determine, based on the first visualized image and the atrophy

region, a second visualized image corresponding to the fundus image to be processed; or determine, based on the first visualized image, the atrophy region, and the tessellation characteristic region, the second visualized image.

[0124] In some embodiments, the image of fundus characterization region further includes at least one of an peripapillary atrophy region, a macula region, and a papilla region. The visualization module 802 is further configured to, after an image of fundus characterization region is determined based on a fundus image to be processed, determine, based on the image of fundus characterization region, the peripapillary atrophy region in the image of fundus characterization region; determine, based on at least one of the peripapillary atrophy region, the macula region, and the papilla region, a marked region of the image of fundus characterization region, where the marked region is configured to characterize a region prompting a user to focus on; and determine, based on the first visualized image and the marked region, a third visualized image corresponding to the fundus image to be processed.

[0125] FIG. 9 is a schematic structural diagram of an electronic device according to an embodiment of the present disclosure. The electronic device 900 (the electronic device 900 may be specifically a computer device) includes a memory 901, a processor 902, a communication interface 903, and a bus 904. Communication among the memory 901, the processor 902, and the communication interface 903 are realized through the bus 904.

[0126] The memory 901 may be a read-only memory (ROM), a static storage device, a dynamic storage device, or a random access memory (RAM). A program may be stored in the memory 901. When the program stored in the memory 901 is executed by the processor 902, the processor 902 and the communication interface 903 are configured to perform each step in the method for visualizing change in the myopic fundus provided by embodiments of the present disclosure.

[0127] The processor 902 may be a general-purpose central processing unit (CPU), a microprocessor, an application specific integrated circuit (ASIC), a graphics processing unit (GPU), or one or more integrated circuits, and is configured to execute a related program to implement functions required to be performed by each unit of the device for visualizing change in the myopic fundus of the embodiments of the present disclosure.

[0128] The processor 902 may also be an integrated circuit chip, and is capable of processing a signal. In an implementation process, each step of the method for visualizing change in the myopic fundus of the present disclosure may be completed through an integrated logic circuit of hardware or an instruction in a form of software in the processor 902. The processor 902 may alternatively be a general-purpose processor, a digital signal processor (DSP), a application

specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic devices, a discrete gate or transistor logic device, or a discrete hardware component. The disclosed methods, steps, and logical diagrams in the embodiments of the present disclosure can be implemented or executed by the processor 902. The general-purpose processor may be a microprocessor, or the processor may be any conventional processor or the like. The steps of the methods disclosed with reference to the embodiments of the present disclosure may be directly reflected in a completion of the hardware decoding processor execution, or a completion of a combination of hardware and software modules in the decoding processor execution. The software module may be located in a mature storage medium in the art, such as a random access memory, a flash memory, a read-only memory, a programmable read-only memory, an electrically erasable programmable memory, or a register… The storage medium is located in the memory 901, and the processor 902 reads information in the memory 901, and completes, in combination with hardware of the processor 902, a function required to be executed by a unit included in the device for visualizing change in the myopic fundus, or perform the method for visualizing change in the myopic fundus of the embodiments of the present disclosure.

[0129] The communication interface 903 may be, for example, but is not limited to, a transceiver apparatus such as a transceiver, to implement communication between the electronic device 900 and another device or a communications network. For example, the fundus image to be processed may be acquired through the communication interface 903.

[0130] The bus 904 may include a path for transmitting information between various components (for example, the memory 901, the processor 902, and the communication interface 903) of the electronic device 900.

[0131] It should be noted that although the electronic device 900 shown in FIG. 9 only shows a memory, a processor, and a communication interface, in a specific implementation process, a person skilled in the art should understand that the electronic device 900 further includes other devices necessary to implement normal operation. Meanwhile, according to specific needs, a person skilled in the art should understand that the electronic device 900 may further include a hardware device that implements other additional functions. In addition, a person skilled in the art should understand that the electronic device 900 may alternatively include only the device necessary for implementing the embodiments of the present disclosure, and does not necessarily include all the components shown in FIG. 9.

[0132] Those skilled in the art may be aware that, in combination with the examples described in the embodiments disclosed in this specification, units and algorithm steps may be

implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of a technical solution. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of the present disclosure.

[0133] It may be clearly understood by a person skilled in the art that, for the purpose of convenient and brief description, a detailed working process of the foregoing system, device, and unit may refer to a corresponding process in the foregoing method embodiments, and details are not described herein again.

[0134] In the several embodiments provided in the present disclosure, it should be understood that the disclosed system, device, and method may be implemented in other manners. For example, the apparatus embodiments described above are merely illustrative, for example, division of units is merely a logical function division, and there may be other division manners in actual implementation. For example, a plurality of units or components may be combined or may be integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual coupling or direct coupling or communication connection may be indirect coupling or communication connection through some interfaces, devices, or units, and may be in electrical, mechanical, or other forms.

[0135] The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, that is, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected according to actual needs to achieve the objectives of the solutions of the embodiments.

[0136] In addition, functional units in the embodiments of the present disclosure may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units may be integrated into one unit.

[0137] The embodiments of the present disclosure may alternatively be a computer readable storage medium, on which computer program instructions are stored. When executed by a processor, the computer program instructions cause the processor to perform the steps in the method according to various embodiments of the present disclosure described in the specification. When the functions are implemented in the form of a software functional unit and sold or used as an independent product, the functions may be stored in a computer-readable storage medium. Based on such understanding, the technical solution of the present disclosure essentially or a part of the technical solution that contributes to the prior art ,or part of the

technical solution may be embodied in the form of a software product. The computer software product is stored in a storage medium, and includes several instructions for causing a computer device (which may be a personal computer, a server, or a network device) to perform all or part of the steps of the methods described in the embodiments of the present disclosure. The foregoing storage medium includes: any medium that may store program code, such as a USB flash drive, a removable hard disk, a read-only memory, a random access memory, a magnetic disk, or an optical disk… The computer-readable storage medium may adopt any combination of one or more readable media. The readable medium may be a readable signal medium or a readable storage medium. The readable storage medium may include, but is not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or any combination of the foregoing.

[0138] The above are only specific embodiments of the present disclosure, but the scope of protection of the present disclosure is not limited thereto, and any changes or substitutions may be easily conceived of by those skilled in the art within the technical scope disclosed in the present disclosure, which should be covered within the protection scope of the present disclosure. Therefore, the protection scope of the present disclosure shall be subject to the protection scope of the claims.