

METHOD AND DEVICE FOR EVALUATING QUALITY OF FUNDUS IMAGE AND STORAGE MEDIUM

The present application claims priority to the Chinese Patent Application No. 201910046569.4, filed with the National Intellectual Property Administration, PRC on January 18, 2019, and entitled "METHOD AND DEVICE FOR EVALUATING QUALITY OF FUNDUS IMAGE AND STORAGE MEDIUM", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present application relates to the technical field of image detection, and in particular, to a method and device for evaluating quality of a fundus image and a storage medium.

BACKGROUND

As the number of patients with diabetes, hypertension, glaucoma, etc. increases and the fundus screening is performed, the number of fundus images acquired increases dramatically. This brings great work pressure to ophthalmic medical treatment. Clear fundus images are the prerequisite for automatic screening of fundus diseases, so it is necessary to evaluate the quality of fundus images. The current quality evaluation methods include: a reference-oriented method based on an edge and brightness, a no-reference-oriented method based on a length of a visible vessel in a macular area and a multi-scale filter bank response, and a comprehensive quality evaluation method based on an elliptical local vessel density algorithm and taking full account of multiple characteristics such as image color, brightness, contrast and ambiguity.

The inventor has found that the foregoing quality evaluation methods are all based on DR application scenarios to evaluate the quality of fundus images. The quality problems encountered in fundus images are mainly as follows: The macular area is blackened, overexposure, image blur and camera lens stains occur, an optic disc is taken as the center or there is no optic disc, etc. AMD screening based on fundus images requires the macular area to be clearly visible, but the existing quality evaluation methods cannot be well applied to clinical application scenarios of AMD

screening, and cannot meet the requirements on the real-time performance of the clinical application scenarios of AMD screening.

SUMMARY

The present application provides a method and device for evaluating quality of a fundus image and a storage medium, which can solve the problems that the applicability and real-time performance of the quality evaluation methods in the prior art cannot meet clinical application scenarios of AMD screening.

In a first aspect, the present application provides a method for evaluating quality of a fundus image. The method includes:

acquiring a fundus image set to be processed;

constructing a classification model according to a deep learning method and the fundus image set;

acquiring a fundus image of a clinical patient collected in real time;

after determining that the fundus image is qualified according to the classification model, cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network;

positioning an optic disc area and a macular area in the fundus image according to the target detection network; and

sending prompt information when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

Optionally, after the acquiring a fundus image set to be processed and before the constructing a classification model according to a deep learning method and the fundus image set, the method further includes:

performing data cleaning on the fundus image set, and resizing the cleaned src images to the same size as dst images.

Optionally, the constructing a classification model according to a deep learning method and the fundus image set includes:

selecting a neural network as a classification model;

setting the size of an image input to the neural network;

preprocessing the fundus image set to obtain a training set and a test set;

training the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, selecting an optimal model parameter, and taking a model corresponding to the optimal model parameter as the classification model.

Optionally, before the cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network, the method further includes:

filtering out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

Optionally, the positioning an optic disc area and a macular area in the fundus image according to the target detection network includes:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

Optionally, after the acquiring a fundus image of a clinical patient collected in real time and before the determining that the fundus image is qualified according to the classification model, the method further includes:

setting at least two detection areas, and designing an offset range for the macular area and the optic disc area; where the at least two detection areas include detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

Optionally, the target detection network is a yolo network.

In a second aspect, the present application provides a device for evaluating quality of a fundus image, which has a function of implementing the method for evaluating quality of a fundus image provided in the first aspect. The function can be implemented by hardware, or by hardware executing corresponding software. The hardware or software includes one or more modules corresponding to the foregoing function, and the module may be software and/or hardware.

In a possible design, the device includes:

an input/output module, configured to acquire a fundus image set to be processed;

a processing module, configured to construct a classification model according to a deep learning method and the fundus image set; acquire a fundus image of a clinical patient collected in real time through the input/output module; and after determining that the fundus image is qualified according to the classification model, cut a black edge of the fundus image according to the classification model, and input the image into a target detection network; and

a detection module, configured to position an optic disc area and a macular area in the fundus image according to the target detection network; and

send prompt information through the input/output module when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

Optionally, after the input/output module acquires a fundus image set to be processed, before constructing a classification model according to a deep learning method and the fundus image set, the processing module is further configured to:

perform data cleaning on the fundus image set.

Optionally, the processing module is specifically configured to:

select a neural network as a classification model;

set the size of an image input to the neural network;

preprocess the fundus image set to obtain a training set and a test set;

train the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

Optionally, before cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network through the input/output module, the processing module is further configured to:

filter out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

Optionally, the detection module is specifically configured to:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

Optionally, after the input/output module acquires a fundus image of a clinical patient collected in real time, before determining that the fundus image is qualified according to the classification model, the processing module is further configured to:

set at least two detection areas, and design an offset range for the macular area and the optic disc area; where the at least two detection areas include detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

Optionally, the target detection network is a yolo network.

In a further aspect of the present application, a device for evaluating quality of a fundus image is provided. The device includes at least one connected processor, a memory and an input/output unit, where the memory is configured to store program code, and the processor is configured to call the program code in the memory to perform the following operations of:

acquiring a fundus image set to be processed through the input/output module;

constructing a classification model according to a deep learning method and the fundus image set; acquiring a fundus image of a clinical patient collected in real time through the input/output module; and after determining that the fundus image is qualified according to the classification model, cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network;

positioning an optic disc area and a macular area in the fundus image according to the target detection network; and

sending prompt information through the input/output unit when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

Optionally, after the input/output unit acquires a fundus image set to be processed, before constructing a classification model according to a deep learning method and the fundus image set, the processor is further configured to perform the following operation of:

performing data cleaning on the fundus image set.

Optionally, the processor specifically performs the following operations of:

selecting a neural network as a classification model;

setting the size of an image input to the neural network;

preprocessing the fundus image set to obtain a training set and a test set;

training the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

Optionally, before cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network through the input/output module, the processor is further configured to perform the following operations of:

filter out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

Optionally, the processor is configured to perform the following operations of:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

Optionally, after the input/output unit acquires a fundus image of a clinical patient collected in real time, before determining that the fundus image is qualified according to the classification model, the processor is further configured to perform the following operations of:

setting at least two detection areas, and designing an offset range for the macular area and the optic disc area; where the at least two detection areas include detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

In a further aspect of the present application, a non-volatile computer storage medium is provided, including instructions that, when running on a computer, cause the computer to perform the methods provided in each aspect above.

Compared with the prior art, the method according to the solution of the present application includes: constructing a classification model according to a deep learning method and a fundus image set; acquiring a fundus image of a clinical patient collected in real time; after determining that the fundus image is qualified according to the classification model, cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network; positioning an optic disc area and a macular area in the fundus image according to the target detection network; and sending prompt information when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image. Through this solution, the acquisition quality of the fundus image can be fed back in real time, and the stability of fundus image quality can be ensured.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic flowchart of a method for evaluating quality of a fundus image according to an embodiment of the present application;

FIG. 2 is a schematic diagram of a fundus image qualified according to an embodiment of the present application;

FIG. 3 is a schematic diagram of a fundus image with quality abnormalities according to an embodiment of the present application;

FIG. 4 is a schematic diagram of a fundus image with the quality to be evaluated according to an embodiment of the present application;

FIG. 5 is a schematic diagram of a fundus image detected based on a classification model according to an embodiment of the present application;

FIG. 6 is a schematic diagram of a test flow based on the constructed classification model and

a target detection network according to an embodiment of the present application;

FIG. 7 is a graph of test results according to an embodiment of the present application;

FIG. 8 is a schematic structural diagram of a device for evaluating quality of a fundus image according to an embodiment of the present application; and

FIG. 9 is a schematic structural diagram of a device for evaluating quality of a fundus image according to an embodiment of the present application.

The implementation, functional features and advantages of the present application will be further described in combination with embodiments with reference to the accompanying drawings.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will be described in detail. Examples of the embodiments are shown in the accompanying drawings, in which the same or similar reference numerals refer to the same or similar elements or elements having the same or similar functions throughout. The embodiments described below by referring to the accompanying drawings are examples and are merely intended to explain the present invention, and cannot be interpreted as limiting the present invention.

It can be understood by those skilled in the art that the singular forms "a", "an", "the" and "this" used herein may also include plural forms unless expressly stated. It should be further understood that the word "including" used in the specification of the present invention means the presence of described features, integers, steps and operations, but does not exclude the presence or addition of one or more other features, integers, steps and operations.

It can be understood by those skilled in the art that unless otherwise defined, all terms (including technical terms and scientific terms) used herein have the same meanings as those generally understood by those of ordinary skill in the art to which the present invention belongs. It should also be understood that terms such as those defined in a general dictionary should be understood to have meanings consistent with those in the context of the prior art, and will not be interpreted in idealized or overly formal meanings unless specifically defined as here.

Those skilled in the art should understand that the concepts of "application", "application

program", "application software" and similar expressions referred to in the present invention are the same concepts common to those skilled in the art, and refer to computer software organically constructed by a series of computer instructions and related data resources and suitable for electronic operation. Unless otherwise specified, this naming itself is not limited by the kind and level of a programming language, or an operating system or platform on which it runs. Naturally, such concepts are not limited by any form of terminals.

The present application provides a method and device for evaluating quality of a fundus image and a storage medium, which are used for clinical medical detection.

In order to solve the foregoing technical problems, the present application mainly provides the following technical solutions:

A model for fundus image quality classification is constructed based on deep learning and 8000 clinical fundus images. Fundus images having image quality problems caused by environmental factors are filtered out by the classification model, and then fundus images having abnormal angle problems such as no optic disc caused by a shooting angle are filtered out by macular area positioning and optic disc positioning. Based on the above two points, the quality of the photographed fundus images is controlled. When the images with poor quality are photographed, a control system can remind clinical operators to re-collect images. This ensures the stability of fundus image quality and improves the accuracy of subsequent diagnosis. This algorithm has good sensitivity and specificity, and can improve the efficiency and specificity of fundus imaging.

Deep learning refers to a method of replicating this dense neural network. By processing multiple data streams at a time, a computer can significantly reduce the time required to process data. An artificial neural network is generated by applying this technology to deep learning. The artificial neural network is composed of input nodes, output nodes and a node layer.

The input nodes are configured to receive data.

The output nodes are configured to output result data.

The node layer is configured to convert the data input from the input nodes into the content

usable by the output nodes. The node layer refers to a plurality of hidden nodes between the input nodes and the output nodes. The node layer can also be a hidden layer. When data advances through these hidden nodes, the neural network uses logic to decide to transfer the data to the next hidden node.

Referring to FIG. 1, a method for evaluating quality of a fundus image according to the present application is described below, and the method includes the following steps.

Step 101. Acquire a fundus image set to be processed.

The fundus image set includes a plurality of clinically acquired fundus images. The fundus image includes features of a macular area, an optic disc (OD), retinal vessels, fovea and other major structures. The macula is an avascular gray circular area on the temporal side of an optic disc in the fundus image. The fundus image set can be divided into a test set and a training set.

For example, the fundus image set comes from a diabetic retinopathy detection competition, from which about 4,000 normal images and about 4,000 images with quality abnormalities are selected. The quality abnormalities include the following: image blur occurs, there is no optic disc in an image, an optic disc is in the middle of an image, a macular area is blackened, overexposure occurs and serious lesions occur.

In some embodiments, in order to construct a classification model, after the fundus image set to be processed is acquired, the collected fundus image set can also be subjected to data cleaning, and the cleaned src images are resized to the same size as dst images. Src images refer to source images and the dst images refer to destination images.

Step 102. Construct a classification model according to a deep learning method and the fundus image set.

In some embodiments, the constructing a classification model according to a deep learning method and the fundus image set includes:

selecting a neural network as a classification model;

setting the size of an image input to the neural network (e.g., setting the size of an image input

to this neural network to be $256*256$);

preprocessing the fundus image set to obtain a training set and a test set;

training the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

In some embodiments, before the classification model is constructed, it is also possible to filter out defective fundus images caused by environmental factors in the fundus image set, and filter out fundus images with abnormal angle problems such as no optic disc caused by a shooting angle, so as to improve the accuracy and precision of constructing the classification model, facilitate the clinical real-time evaluation of quality of the collected images, and improve the accuracy and efficiency of quality evaluation.

Step 103. Acquire a fundus image of a clinical patient collected in real time.

The fundus image is an image shot clinically in real time, and there can be one or two or more fundus images.

Step 104. After determining that the fundus image is qualified according to the classification model, cut a black edge of the fundus image according to the classification model, and input the image into a target detection network.

The target detection network is to divide the input image into $S*S$ grids. If coordinates of the center position of a certain detection object fall into a certain grid, this grid is responsible for detecting this detection object. The target detection network may be a yolo network, and the version of the target detection network is not limited in the present application.

In some embodiments, the acquired fundus images may be defective due to environmental factors, and have abnormal angle problems such as no optic angle caused by a shooting angle. Therefore, before the cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network, the method further includes:

filtering out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning. For example, when defective images caused by environmental factors are filtered out, these over-exposed and over-dark images can be filtered out by the image quality classification model.

Step 105. Position an optic disc area and a macular area in the fundus image according to the target detection network.

In some embodiments, the positioning an optic disc area and a macular area in the fundus image according to the target detection network includes the following steps.

(1) Convert the fundus image into a grayscale image, filter retinal vessels in the fundus image, project the fundus image from a spatial domain to a directional domain based on a linear operator, and adjust parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area.

(2) Because there is no blood vessel in the macular area, adopt a mode of positioning the macular area of a retinal fundus image; when the fundus image is preprocessed, segment the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends. Curve fitting is performed on the calibrated vessel ends by adopting the least square method to obtain the macular area.

The multi-scale method means estimating three-dimensional information through a two-dimensional image. This is an inverse process. The multi-scale method can also be called single image depth estimation based on a multi-scale deep network.

In the present application, when the least square method is used for curve fitting, according to the given m vessel ends, this curve is not required to pass through these vessel ends accurately, but an approximate curve $y = \varphi(x)$ of a curve $y = f(x)$.

Step 106. Send prompt information when it is determined that an abnormal image with quality defects exists in the processed fundus image.

The prompt information is used for reminding a clinical operation user to re-acquire an image from an acquisition part corresponding to the abnormal image.

For ease of understanding, schematic diagrams of a fundus image with quality abnormalities and a fundus image with normal quality are given below to facilitate comparative analysis or learning. FIG. 2 is a schematic diagram of a fundus image qualified, and FIG. 3 is a schematic diagram of a fundus image with quality abnormalities. After it is detected that the fundus image shown in FIG. 3 is abnormal in quality, a display interface of a detection instrument immediately prompts that the currently acquired fundus image is abnormal in quality and an image needs to be re-acquired.

Compared with the prior art, the method according to the embodiment of the present application includes: constructing a classification model according to a deep learning method and the fundus image set; acquiring a fundus image of a clinical patient collected in real time; after determining that the fundus image is qualified according to the classification model, cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network; positioning an optic disc area and a macular area in the fundus image according to the target detection network; and sending prompt information when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image. Through this solution, the acquisition quality of the fundus image can be fed back in real time, and the stability of fundus image quality can be ensured. This solution can also provide a preliminary data filtering function for fundus AMD screening and improve the accuracy of AMD screening.

Optionally, in some embodiments of the present application, after the acquiring a fundus image of a clinical patient collected in real time and before the determining that the fundus image is qualified according to the classification model, the method further includes:

setting at least two detection areas, and designing an offset range for the macular area and the optic disc area; where the at least two detection areas include detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

For ease of understanding, the process of positioning a macular area and an optic disc area in the present application will be illustrated with specific application scenarios. FIG. 4 shows a fundus image with the quality to be evaluated; and FIG. 5 shows a fundus image detected based on a classification model. When the target detection network detects FIG. 4, if two positioning frames (also called detection frames) of the area shown in FIG. 5 appear simultaneously, it is determined that the fundus image shown in FIG. 4 is qualified. The two detection frames are a macular detection frame and an optic disc detection frame respectively. After the qualified fundus image is detected based on this method, the shapes and colors of the macula and the optic disc and blood vessels can be clearly presented in the fundus image. Therefore, the present application can provide a high-quality fundus image for clinical determining of a lesion state of human eyes, which is beneficial to clinical analysis.

Optionally, in some embodiments of the present application, because the fundus image may include abnormal states of macula, glaucoma, cataract and other lesions, it is necessary to acquire clear and visible images. Before step 105, an image with angle abnormalities such as no optic disc caused by a shooting angle can be filtered out through macular area positioning and optic disc positioning.

The macular area positioning refers to positioning the macular area from the fundus image. For example, the macular area can be positioned from the fundus image by image processing according to the grayscale characteristics of the macular area, or the macular area image can be determined according to the relative positions of the fovea, the optic disc and blood vessels.

In some embodiments, the macular area can be positioned by positioning a macular area of a retinal fundus image. According to the feature that there is no blood vessel in the macular area, the retinal vessels are segmented by a multi-scale method based on the preprocessing of the fundus image, and then the vessel ends are calibrated. The macular area is obtained by curve fitting of calibrated points by using the least square method.

Optic disc positioning includes image preprocessing, bilateral smoothing filtering, pattern recognition and classification. The image preprocessing can be performed by adopting Lab brightness projection to transform the fundus image into a grayscale image. The bilateral smoothing filtering is used to filter retinal vessels in the fundus image. The pattern recognition and classification can project an original image from a spatial domain to a directional domain based on a linear operator, and adjust the parameter according to the relative sizes of the optic disc and the image to obtain the optic disc area.

For ease of understanding, the method for evaluating quality of a fundus image according to the present application will be illustrated with specific application scenarios. Taking the clinical test based on the classification model as an example, the fundus image set collected during the clinical test is divided into a training set and a test set.

The training set includes 3490 qualified fundus images and 4220 fundus images with quality abnormalities.

The test set includes 460 qualified fundus images and 424 fundus images with quality abnormalities.

FIG. 6 is a schematic diagram of a test flow based on the constructed classification model and a target detection network. In FIG. 6, the fundus image set is collected, fundus images are resized, and classification is constructed according to a deep learning method and the fundus image set. If the fundus image is qualified, the macular area and the optic disc area are automatically positioned based on the target detection network. If the macular area and the optic disc area are positioned, the test result is given, and it is prompted that there is no need to re-photograph an image. If one or none of the macula area and the optic disc area is positioned, re-photographing is prompted according to the test result. If the fundus image has quality abnormalities, re-photographing is prompted according to the test results, and the process ends.

Based on the test flow shown in FIG. 6, the test results are as follows:

False positive fpr(1-specificity): 0.07

True positive tpr(sensitivity): 0.99

The graph of the test results is shown in FIG. 7.

The technical features mentioned in the foregoing embodiments are also applicable to the embodiments corresponding to FIGs. 8 and 9 in the present application, and the following similarities are not repeated subsequently.

The method for evaluating quality of a fundus image according to the present application has been described above, and a device for evaluating quality of a fundus image is described below.

FIG. 8 is a schematic structural diagram of a device 80 for evaluating quality of a fundus image. The device can be applied to clinical medical detection. The device 80 according to the embodiment of the present application can implement the steps of the method for evaluating quality of a fundus image executed in the embodiment corresponding to FIG. 1. Functions of the device 80 can be implemented by hardware, or by hardware executing corresponding software. The hardware or software includes one or more modules corresponding to the foregoing function, and the module may be software and/or hardware. The device 80 may include an input/output module 801, a processing module 802 and a detection module 803. For function implementation of the processing module 802 and the input/output module 801, refer to the operations performed in the embodiment corresponding to FIG. 1, and this is not described in detail here. The processing module can be configured to control the transceiving operation of the the input/output module 801.

In some embodiments, the input/output module 801 can be configured to acquire a fundus image set to be processed;

the processing module 802 can be configured to construct a classification model according to a deep learning method and the fundus image set; acquire a fundus image of a clinical patient collected in real time through the input/output module 801; and after determining that the fundus image is qualified according to the classification model, cut a black edge of the fundus image according to the classification model, and input the image into a target detection network; and

the detection module 803 is configured to position an optic disc area and a macular area in the fundus image according to the target detection network; and

send prompt information through the input/output module 801 when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

In the embodiment of the present application, the processing module 802 constructs a classification model according to a deep learning method and the fundus image set; the input/output module 801 acquires a fundus image of a clinical patient collected in real time; after it is determined that the fundus image is qualified according to the classification model, a black edge of the fundus image is cut according to the classification model, and the image is input into a target detection network through the input/output module 801; an optic disc area and a macular area in the fundus image are positioned according to the target detection network; and the input/output module 801 sends prompt information when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image. Through this solution, the acquisition quality of the fundus image can be fed back in real time, and the stability of fundus image quality can be ensured. This solution can also provide a preliminary data filtering function for fundus AMD screening and improve the accuracy of AMD screening.

Optionally, after the input/output module 801 acquires a fundus image set to be processed, before constructing a classification model according to a deep learning method and the fundus image set, the processing module is further configured to:

perform data cleaning on the fundus image set.

Optionally, the processing module 802 is specifically configured to:

select a neural network as a classification model;

set the size of an image input to the neural network;

preprocess the fundus image set to obtain a training set and a test set;

train the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

Optionally, before cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network through the input/output module, the processing module 802 is further configured to:

filter out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

Optionally, the detection module 803 is specifically configured to:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

Optionally, after the input/output module 801 acquires a fundus image of a clinical patient collected in real time, before determining that the fundus image is qualified according to the classification model, the processing module 802 is further configured to:

set at least two detection areas, and design an offset range for the macular area and the optic disc area; where the at least two detection areas include detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and

determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

The device for evaluating quality of a fundus image according to the embodiment of the present application is described above in terms of modular functional entities respectively. A device for evaluating quality of a fundus image is described below in terms of hardware. As shown in FIG. 9, the device includes a processor, a memory, an input/output unit and a computer program that is stored in the memory and can run on the processor. For example, the computer program can be a program corresponding to the method for evaluating quality of a fundus image in the embodiment corresponding to FIG. 1. For example, when the device for evaluating quality of a fundus image implements the function of the device 80 for evaluating quality of a fundus image as shown in FIG. 8, the processor implements, when executing the computer program, each step of the method for evaluating quality of a fundus image executed by the device 80 for evaluating quality of a fundus image in the embodiment corresponding to FIG. 8; or the processor implements, when executing the computer program, functions of each module of the device 80 for evaluating quality of a fundus image in the embodiment corresponding to FIG. 8. For another example, the computer program may be a program corresponding to the method for evaluating quality of a fundus image in the embodiment corresponding to FIG. 1.

The processor may be a central processing unit (CPU), or may be another general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or another programmable logic device, a discrete gate or a transistor logic device, a discrete hardware component, or the like. The general-purpose processor may be a microprocessor, or the processor may be any conventional processor or the like. The processor is a control center of the computer device and connects various parts of the whole computer device by various interfaces and lines.

The memory can be configured to store the computer program and/or modules, and the processor implements various functions of the computer device by running or executing the computer program and/or modules stored in the memory and calling data stored in the memory. The memory may mainly include a program storage area and a data storage area, where the program

storage area can store an operating system, an application program required by at least one function (such as a sound playing function and an image playing function), etc. The data storage area can store data (such as audio data and video data) created according to the use of a mobile phone, etc. In addition, the memory may include a high-speed random access memory, and may also include a non-volatile memory, such as a hard disk, a memory, a plug-in hard disk, a smart media card (SMC), a secure digital (SD) card, a flash card, at least one disk storage device, a flash memory device, or another volatile solid-state storage device.

A transceiver can also be replaced by a receiver and a transmitter, which can be the same or different physical entities. When the receiver and the transmitter are the same physical entity, they can be collectively referred to as a transceiver. The memory can be integrated in the processor or provided separately from the processor. The transceiver can be an input/output unit.

Through the description of the foregoing embodiments, those skilled in the art can clearly understand that the methods of the foregoing embodiments can be implemented by means of software plus a necessary universal hardware platform, or certainly, can be implemented through hardware, but in many cases, the former is a better embodiment. Based on such an understanding, the technical solution of the present application which is essential or a part contributing to the prior art may be embodied in the form of a software product. The computer software product is stored in a storage medium (such as a ROM/RAM), including a plurality of instructions for causing a terminal (which may be a mobile phone, a computer, a server, or a network device) to perform the methods described in the embodiments of the present application.

The embodiments of the present application have been described above with reference to the accompanying drawings, but the present application is not limited to the foregoing specific embodiments. The foregoing specific embodiments are only illustrative and not restrictive. Under the inspiration of the present application, those of ordinary skill in the art can make many forms without departing from the purpose of the present application and the protection scope defined by the claims. Any equivalent structure or equivalent flow transformation made by using the content of the specification of the present application and accompanying drawings, directly or indirectly applied to other related technical fields, shall fall within the protection scope of the present

application.

CLAIMS

1. A method for evaluating quality of a fundus image, comprising:

acquiring a fundus image set to be processed;

constructing a classification model according to a deep learning method and the fundus image set;

acquiring a fundus image of a clinical patient collected in real time;

after determining that the fundus image is qualified according to the classification model, cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network;

positioning an optic disc area and a macular area in the fundus image according to the target detection network; and

sending prompt information when it is determined that an abnormal image with quality defects exists in the processed fundus image, wherein the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

2. The method according to claim 1, wherein after the acquiring a fundus image set to be processed and before the constructing a classification model according to a deep learning method and the fundus image set, the method further comprises:

performing data cleaning on the fundus image set.

3. The method according to claim 2, wherein the constructing a classification model according to a deep learning method and the fundus image set comprises:

selecting a neural network as a classification model;

setting the size of an image input to the neural network;

preprocessing the fundus image set to obtain a training set and a test set;

training the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

4. The method according to claim 3, wherein before the cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network, the method further comprises:

filter out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

5. The method according to claim 4, wherein the positioning an optic disc area and a macular area in the fundus image according to the target detection network comprises:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

6. The method according to claim 4 or 5, wherein after the acquiring a fundus image of a clinical patient collected in real time and before the determining that the fundus image is qualified according to the classification model, the method further comprises:

setting at least two detection areas, and designing an offset range for the macular area and the optic disc area; wherein the at least two detection areas comprise detection frames for detecting a

macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

7. The method according to claim 4, wherein the target detection network is a yolo network.

8. A device for evaluating quality of a fundus image, comprising:

an input/output module, configured to acquire a fundus image set to be processed;

a processing module, configured to construct a classification model according to a deep learning method and the fundus image set; acquire a fundus image of a clinical patient collected in real time through the input/output module; and after determining that the fundus image is qualified according to the classification model, cut a black edge of the fundus image according to the classification model, and input the image into a target detection network; and

a detection module, configured to position an optic disc area and a macular area in the fundus image according to the target detection network; and

send prompt information through the input/output module when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

9. The device according to claim 8, wherein after the input/output module acquires a fundus image set to be processed, before constructing a classification model according to a deep learning method and the fundus image set, the processing module is further configured to:

perform data cleaning on the fundus image set.

10. The device according to claim 9, wherein the processing module is specifically configured to:

select a neural network as a classification model;

set the size of an image input to the neural network;

preprocess the fundus image set to obtain a training set and a test set;

train the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

11. The device according to claim 10, wherein before cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network through the input/output module, the processing module is further configured to:

filter out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

12. The device according to claim 11, wherein the detection module is specifically configured to:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

13. The device according to claim 11 or 12, wherein after the input/output module acquires a fundus image of a clinical patient collected in real time, before determining that the fundus image is qualified according to the classification model, the processing module is further configured to:

set at least two detection areas, and design an offset range for the macular area and the optic disc area; wherein the at least two detection areas comprise detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

14. A device for evaluating quality of a fundus image, comprising:

at least one processor, a memory and an input/output unit;

wherein the memory is configured to store program code, and the processor is configured to call the program code stored in the memory to perform the following operations of:

acquiring a fundus image set to be processed through the input/output module;

constructing a classification model according to a deep learning method and the fundus image set; acquiring a fundus image of a clinical patient collected in real time through the input/output module; and after determining that the fundus image is qualified according to the classification model, cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network;

positioning an optic disc area and a macular area in the fundus image according to the target detection network; and

sending prompt information through the input/output unit when it is determined that an abnormal image with quality defects exists in the processed fundus image, where the prompt information is used for reminding a user to re-acquire an image from an acquisition part corresponding to the abnormal image.

15. The device according to claim 14, wherein after the input/output unit acquires a fundus image set to be processed, before constructing a classification model according to a deep learning method and the fundus image set, the processor is further configured to perform the following operation of:

performing data cleaning on the fundus image set.

16. The device according to claim 15, wherein the processor specifically performs the following operations of:

selecting a neural network as a classification model;

setting the size of an image input to the neural network;

preprocessing the fundus image set to obtain a training set and a test set;

training the neural network by using the training set; and

after the trained neural network meets preset sensitivity and specificity on the test set, select an optimal model parameter, and take a model corresponding to the optimal model parameter as the classification model.

17. The device according to claim 16, wherein before cutting a black edge of the fundus image according to the classification model, and inputting the image into a target detection network through the input/output module, the processor is further configured to perform the following operations of:

filter out, through an image quality classification model, a fundus image with an exposure greater than a preset exposure and a grayscale value greater than a preset grayscale value in the fundus image set; and

filtering out a fundus image without an optic disc in the fundus image set through macular area positioning and optic disc positioning.

18. The device according to claim 17, wherein the processor is configured to perform the following operations of:

converting the fundus image into a grayscale image, filtering retinal vessels in the fundus image, projecting the fundus image from a spatial domain to a directional domain based on a linear operator, and adjusting parameters according to the relative sizes of an optic disc and the fundus image to obtain the optic disc area; and

when preprocessing the fundus image, segmenting the retinal vessels in the fundus image in a multi-scale method to calibrate a plurality of vessel ends; and performing curve fitting on the calibrated vessel ends by adopting the least square method to obtain the macular area.

19. The device according to claim 17 or 18, wherein after the input/output unit acquires a fundus image of a clinical patient collected in real time, before determining that the fundus image is qualified according to the classification model, the processor is further configured to perform the following operations of:

setting at least two detection areas, and designing an offset range for the macular area and the optic disc area; where the at least two detection areas comprise detection frames for detecting a macular area and an optic disc area; and

evaluating the quality of the fundus image according to the classification model, and determining that the fundus image is qualified if a macular detection frame and an optic disc detection frame simultaneously appear on the fundus image.

20. A non-volatile computer storage medium, comprising instructions that, when running on a computer, cause the computer to perform the method according to any one of claims 1 to 7.