

WHAT IS CLAIMED IS:

1. A method for fundus-image sample expansion, comprising:
 - obtaining a first fundus-image initial sample and a second fundus-image initial sample, wherein the first fundus-image initial sample is based on a first fundus-image data source, and the second fundus-image initial sample is based on a second fundus-image data source;
 - performing feature extraction on the first fundus-image initial sample to obtain first fundus-image initial feature data having a first data-source feature, and performing feature extraction on the second fundus-image initial sample to obtain second fundus-image initial feature data having a second data-source feature;
 - converting the first fundus-image initial feature data into second fundus-image expansion feature data having the second data-source feature, and converting the second fundus-image initial feature data into first fundus-image expansion feature data having the first data-source feature; and
 - performing image restoration on the first fundus-image expansion feature data to obtain a first fundus-image expansion sample corresponding to the first fundus-image data source, and performing image restoration on the second fundus-image expansion feature data to obtain a second fundus-image expansion sample corresponding to the second fundus-image data source.
2. The method for fundus-image sample expansion of claim 1, wherein obtaining the first fundus-image initial sample and the second fundus-image initial sample comprises:
 - collecting fundus images, and obtaining data source information of the fundus images;
 - for each of the fundus images, determining, according to the data source information, whether data source of the fundus image is the first fundus-image data source, the second fundus-image data source, or a fundus-image data source to-be-determined;
 - determining a fundus image whose data source is the first fundus-image data source as the first fundus-image initial sample, and determining a fundus image whose data source is the second fundus-image data source as the second fundus-image initial sample; and
 - inputting a fundus image whose data source is the fundus-image data source to-be-determined into a pre-trained fundus-image classification model, and determining, according to an output result of the fundus-image classification model, the fundus image as the first fundus-image initial sample, the second fundus-image initial sample, or a noise sample.

3. The method for fundus-image sample expansion of claim 2, wherein the first fundus-image data source is a fundus-image data set captured by using a near-infrared light as a light source, and the second fundus-image data source is a fundus-image data set captured by using a red-free light as a light source.

4. The method for fundus-image sample expansion of any of claims 1 to 3, wherein performing feature extraction on the first fundus-image initial sample to obtain the first fundus-image initial feature data having the first data-source feature, and performing feature extraction on the second fundus-image initial sample to obtain the second fundus-image initial feature data having the second data-source feature comprise:

determining a pre-trained first encoder and a pre-trained second encoder, wherein the first encoder is based on a convolutional neural network, and the second encoder is based on ~~a~~the convolutional neural network;

inputting the first fundus-image initial sample into the first encoder, and performing, with the first encoder, feature extraction on the first fundus-image initial sample to obtain the first fundus-image initial feature data having the first data-source feature; and

inputting the second fundus-image initial sample into the second encoder, and performing, with the second encoder, feature extraction on the second fundus-image initial sample to obtain the second fundus-image initial feature data having the second data-source feature.

5. The method for fundus-image sample expansion of claim 4, wherein converting the first fundus-image initial feature data into the second fundus-image expansion feature data having the second data-source feature, and converting the second fundus-image initial feature data into the first fundus-image expansion feature data having the first data-source feature comprise:

determining a pre-trained first transcoder and a pre-trained second transcoder, wherein the first transcoder is based on a residual network, and the second transcoder is based on ~~the~~a residual network;

inputting the first fundus-image initial feature data into the first transcoder, and converting, with the first transcoder, the first fundus-image initial feature data into the second fundus-image expansion feature data having the second data-source feature; and

inputting the second fundus-image initial feature data into the second transcoder, and converting, with the second transcoder, the second fundus-image initial feature data into the first fundus-image expansion feature data having the first data-source feature.

6. The method for fundus-image sample expansion of claim 5, wherein performing image restoration on the first fundus-image expansion feature data to obtain the first fundus-image expansion sample corresponding to the first fundus-image data source, and performing image restoration on the second fundus-image expansion feature data to obtain the second fundus-image expansion sample corresponding to the second fundus-image data source comprise:

determining a first decoder and a second decoder, wherein the first decoder is based on a deconvolutional neural network and corresponds to the second encoder, and the second decoder is based on ~~the~~ a deconvolutional neural network and corresponds to the first encoder;

inputting the first fundus-image expansion feature data into the first decoder, and performing, with the first decoder, image restoration on the first fundus-image expansion feature data to obtain the first fundus-image expansion sample corresponding to the first fundus-image data source; and

inputting the second fundus-image expansion feature data into the second decoder, and performing, with the second decoder, image restoration on the second fundus-image expansion feature data to obtain the second fundus-image expansion sample corresponding to the second fundus-image data source.

7. The method for fundus-image sample expansion of claim 6, wherein training the first encoder, the second encoder, the first transcoder, the second transcoder, the first decoder, and the second decoder comprising:

constructing a first discriminator and a second discriminator, wherein the first discriminator is configured to determine whether an input image is from the first fundus-image data source, and the second discriminator is configured to determine whether ~~an~~ the input image is from the second fundus-image data source;

forming a first generative adversarial network by sequentially connecting the first encoder, the first transcoder, the second decoder, and the second discriminator, and forming a second generative adversarial network by sequentially connecting the second encoder, the second

transcoder, the first decoder, and the first discriminator; and

training jointly, with a same loss function, the first generative adversarial network and the second generative adversarial network.

8. A device for fundus-image sample expansion, comprising:

an initial-sample obtaining module, configured to obtain a first fundus-image initial sample and a second fundus-image initial sample, wherein the first fundus-image initial sample is based on a first fundus-image data source, and the second fundus-image initial sample is based on a second fundus-image data source;

a feature-extraction module, configured to perform feature extraction on the first fundus-image initial sample to obtain first fundus-image initial feature data having a first data-source feature, and perform feature extraction on the second fundus-image initial sample to obtain second fundus-image initial feature data having a second data-source feature;

a feature-data conversion module, configured to convert the first fundus-image initial feature data into second fundus-image expansion feature data having the second data-source feature, and convert the second fundus-image initial feature data into first fundus-image expansion feature data having the first data-source feature;

an image-restoration module, configured to perform image restoration on the first fundus-image expansion feature data to obtain a first fundus-image expansion sample corresponding to the first fundus-image data source, and perform image restoration on the second fundus-image expansion feature data to obtain a second fundus-image expansion sample corresponding to the second fundus-image data source.

9. The device of claim 8, wherein the initial-sample obtaining module is configured to: collect fundus images, and obtain data source information of the fundus images;

for each of the fundus images, determine, according to the data source information, whether data source of the fundus image is the first fundus-image data source, the second fundus-image data source, or a fundus-image data source to-be-determined;

determine a fundus image whose data source is the first fundus-image data source as the first fundus-image initial sample, and determine a fundus image whose data source is the second fundus-image data source as the second fundus-image initial sample; and

input a fundus image whose data source is the fundus-image data source to-be-determined into a pre-trained fundus-image classification model, and determine, according to an output result of the fundus-image classification model, the fundus image as the first fundus-image initial sample, the second fundus-image initial sample, or a noise sample.

10. The device of claim 8, wherein the initial-sample obtaining module is configured to: determine that the first fundus-image data source is a fundus-image data set captured by using a near-infrared light as a light source, and determine that the second fundus-image data source is a fundus-image data set captured by using a red-free light as a light source.

11. The device of claim 8, wherein the feature-extraction module is configured to: determine a pre-trained first encoder and a pre-trained second encoder, wherein the first encoder is based on a convolutional neural network, and the second encoder is based on ~~a~~the convolutional neural network; input the first fundus-image initial sample into the first encoder, and perform, with the first encoder, feature extraction on the first fundus-image initial sample to obtain the first fundus-image initial feature data having the first data-source feature; and input the second fundus-image initial sample into the second encoder, and perform, with the second encoder, feature extraction on the second fundus-image initial sample to obtain the second fundus-image initial feature data having the second data-source feature.

12. The device of claim ~~8~~11, wherein the feature-data conversion module is configured to: determine a pre-trained first transcoder and a pre-trained second transcoder, wherein the first transcoder is based on a residual network, and the second transcoder is based on ~~the~~a residual network; input the first fundus-image initial feature data into the first transcoder, and convert, with the first transcoder, the first fundus-image initial feature data into the second fundus-image expansion feature data having the second data-source feature; and input the second fundus-image initial feature data into the second transcoder, and convert, with the second transcoder, the second fundus-image initial feature data into the first fundus-image expansion feature data having the first data-source feature.

13. The device of claim 812, wherein the image-restoration module is configured to:
determine a first decoder and a second decoder, wherein the first decoder is based on a deconvolutional neural network and corresponds to the second encoder, and the second decoder is based on ~~the~~a deconvolutional neural network and corresponds to the first encoder;

input the first fundus-image expansion feature data into the first decoder, and perform, with the first decoder, image restoration on the first fundus-image expansion feature data to obtain the first fundus-image expansion sample corresponding to the first fundus-image data source; and

input the second fundus-image expansion feature data into the second decoder, and perform, with the second decoder, image restoration on the second fundus-image expansion feature data to obtain the second fundus-image expansion sample corresponding to the second fundus-image data source.

14. The device of claim 813, wherein training the first encoder, the second encoder, the first transcoder, the second transcoder, the first decoder, and the second decoder comprising:

constructing a first discriminator and a second discriminator, wherein the first discriminator is configured to determine whether an input image is from the first fundus-image data source, and the second discriminator is configured to determine whether ~~an~~the input image is from the second fundus-image data source;

forming a first generative adversarial network by sequentially connecting the first encoder, the first transcoder, the second decoder, and the second discriminator, and forming a second generative adversarial network by sequentially connecting the second encoder, the second transcoder, the first decoder, and the first discriminator; and

training jointly, with a same loss function, the first generative adversarial network and the second generative adversarial network.

15. An electronic device, comprising:

a processor; and

a memory, configured to store fundus-image sample expansion programs of the processor which, when executed by the processor, cause the processor to:

obtain a first fundus-image initial sample and a second fundus-image initial sample, wherein the first fundus-image initial sample is based on a first fundus-image data source, and the second fundus-image initial sample is based on a second fundus-image data source;

perform feature extraction on the first fundus-image initial sample to obtain first fundus-image initial feature data having a first data-source feature, and perform feature extraction on the second fundus-image initial sample to obtain second fundus-image initial feature data having a second data-source feature;

convert the first fundus-image initial feature data into second fundus-image expansion feature data having the second data-source feature, and convert the second fundus-image initial feature data into first fundus-image expansion feature data having the first data-source feature; and

perform image restoration on the first fundus-image expansion feature data to obtain a first fundus-image expansion sample corresponding to the first fundus-image data source, and perform image restoration on the second fundus-image expansion feature data to obtain a second fundus-image expansion sample corresponding to the second fundus-image data source.

16. The electronic device of claim 15, wherein the processor configured to obtain the first fundus-image initial sample and the second fundus-image initial sample is configured to:

collect fundus images, and obtain data source information of the fundus images;

for each of the fundus images, determine, according to the data source information, whether data source of the fundus image is the first fundus-image data source, the second fundus-image data source, or a fundus-image data source to-be-determined;

determine a fundus image whose data source is the first fundus-image data source as the first fundus-image initial sample, and determine a fundus image whose data source is the second fundus-image data source as the second fundus-image initial sample; and

input a fundus image whose data source is the fundus-image data source to-be-determined into a pre-trained fundus-image classification model, and determine, according to an output result of the fundus-image classification model, the fundus image as the first fundus-image initial sample, the second fundus-image initial sample, or a noise sample.

17. The electronic device of claim 15, wherein the first fundus-image data source is a fundus-image data set captured by using a near-infrared light as a light source, and the second fundus-image data source is a fundus-image data set captured by using a red-free light as a light source.

18. The electronic device of claim 15, wherein the processor configured to perform feature extraction on the first fundus-image initial sample to obtain the first fundus-image initial feature data having the first data-source feature, and perform feature extraction on the second fundus-image initial sample to obtain the second fundus-image initial feature data having the second data-source feature is configured to:

determine a pre-trained first encoder and a pre-trained second encoder, wherein the first encoder is based on a convolutional neural network, and the second encoder is based on ~~a~~the convolutional neural network;

input the first fundus-image initial sample into the first encoder, and perform, with the first encoder, feature extraction on the first fundus-image initial sample to obtain the first fundus-image initial feature data having the first data-source feature; and

input the second fundus-image initial sample into the second encoder, and perform, with the second encoder, feature extraction on the second fundus-image initial sample to obtain the second fundus-image initial feature data having the second data-source feature.

19. The electronic device of claim ~~15~~18, wherein the processor configured to convert the first fundus-image initial feature data into the second fundus-image expansion feature data having the second data-source feature, and convert the second fundus-image initial feature data into the first fundus-image expansion feature data having the first data-source feature is configured to:

determine a pre-trained first transcoder and a pre-trained second transcoder, wherein the first transcoder is based on a residual network, and the second transcoder is based on ~~the~~a residual network;

input the first fundus-image initial feature data into the first transcoder, and convert, with the first transcoder, the first fundus-image initial feature data into the second fundus-image expansion feature data having the second data-source feature; and

input the second fundus-image initial feature data into the second transcoder, and convert,

with the second transcoder, the second fundus-image initial feature data into the first fundus-image expansion feature data having the first data-source feature.

20. The electronic device of claim ~~15~~19, wherein the processor configured to perform image restoration on the first fundus-image expansion feature data to obtain the first fundus-image expansion sample corresponding to the first fundus-image data source, and perform image restoration on the second fundus-image expansion feature data to obtain the second fundus-image expansion sample corresponding to the second fundus-image data source is configured to:

determine a first decoder and a second decoder, wherein the first decoder is based on a deconvolutional neural network and corresponds to the second encoder, and the second decoder is based on ~~the~~a deconvolutional neural network and corresponds to the first encoder;

input the first fundus-image expansion feature data into the first decoder, and perform, with the first decoder, image restoration on the first fundus-image expansion feature data to obtain the first fundus-image expansion sample corresponding to the first fundus-image data source; and

input the second fundus-image expansion feature data into the second decoder, and perform, with the second decoder, image restoration on the second fundus-image expansion feature data to obtain the second fundus-image expansion sample corresponding to the second fundus-image data source.

21. The electronic device of claim ~~15~~20, wherein training the first encoder, the second encoder, the first transcoder, the second transcoder, the first decoder, and the second decoder comprising:

constructing a first discriminator and a second discriminator, wherein the first discriminator is configured to determine whether an input image is from the first fundus-image data source, and the second discriminator is configured to determine whether ~~an~~the input image is from the second fundus-image data source;

forming a first generative adversarial network by sequentially connecting the first encoder, the first transcoder, the second decoder, and the second discriminator, and forming a second generative adversarial network by sequentially connecting the second encoder, the second transcoder, the first decoder, and the first discriminator; and

training jointly, with a same loss function, the first generative adversarial network and the second generative adversarial network.

22. A non-transitory computer readable storage medium, storing fundus-image sample expansion programs which, when executed by a processor, cause the processor to execute any of claims 1 to 7.