

CLAIMS

1. An image restoration method, comprising:

performing region division on an acquired image to obtain at least one sub-image; and

inputting each of the at least one sub-image to a multi-path neural network, and restoring each sub-image by using a restoration network determined for the sub-image to obtain and output a restored image of each sub-image, thereby obtaining a restored image of the acquired image.

2. The method of claim 1, wherein inputting each of the at least one sub-image to the multi-path neural network, and restoring each sub-image by using the restoration network determined for the sub-image to obtain and output the restored image of each sub-image comprises:

encoding each sub-image to obtain features of the sub-image;

inputting the features of each sub-image to sub-networks of the multi-path neural network, selecting a restoration network for each sub-image by using path selection networks in the sub-networks, and processing, according to the restoration network of each sub-image, the sub-image to obtain and output processed features of the sub-image; and

decoding the processed features of each sub-image to obtain the restored image of the sub-image.

3. The method of claim 2, wherein inputting the features of each sub-image to the sub-networks of the multi-path neural network, selecting the restoration network for each sub-image by using the path selection networks in the sub-networks, and processing, according to the restoration network of each sub-image, the sub-image to obtain and output the processed features of the sub-image comprises:

when a number of the sub-networks is N and the N sub-networks are

sequentially connected,

inputting an i -th level of features of each sub-image to an i -th sub-network, and selecting an i -th restoration network for each sub-image from M restoration networks in the i -th sub-network by using an i -th path selection network in the i -th sub-network;

processing, according to the i -th restoration network, the i -th level of features of each sub-image to obtain and output an $(i+1)$ -th level of features of the sub-image;

updating the i to $i+1$, and returning to the inputting the i -th level of features of each sub-image to the i -th sub-network, and selecting the i -th restoration network for each sub-image from the M restoration networks in the i -th sub-network by using the i -th path selection network in the i -th sub-network;

until an N -th level of features of each sub-image are obtained and output, determining the N -th level of features of each sub-image as the processed features of the sub-image,

wherein when $i=1$, the i -th level of features of each sub-image are the features of the sub-image, and

wherein the N is a positive integer not less than 1, M is a positive integer not less than 2, and i is a positive integer, i is greater than or equal to 1 and i is less than or equal to N .

4. The method of claim 1, wherein when a number of obtained restored images of sub-images is greater than or equal to a preset number, the method further comprises:

acquiring restored images of the preset number of sub-images, and acquiring reference images corresponding to the restored images of the preset number of sub-images;

training, based on the restored images of the preset number of sub-images and the corresponding reference images, networks except for the path selection networks in the multi-path neural network by an optimizer according to a preset loss function between the restored images of the preset number of sub-images and the corresponding reference images, and updating parameters of the networks except for

the path selection networks in the multi-path neutral network; and

training, based on the restored images of the preset number of sub-images and the corresponding reference images, the path selection networks by the optimizer using a reinforcement learning algorithm according to a preset reward function, and updating parameters of the path selection networks.

5. The method of claim 4, wherein after acquiring the restored images of the preset number of sub-images and acquiring the reference images corresponding to the restored images of the preset number of sub-images, and before training the networks except for the path selection networks in the multi-path neutral network by the optimizer according to the loss function between the obtained restored images of the preset number of sub-images and the corresponding reference images, and updating the parameters of the networks except for the path selection networks in the multi-path neutral network, the method further comprises:

training, based on the restored images of the preset number of sub-images and the corresponding reference images, the networks except for the path selection networks in the multi-path neutral network by the optimizer according to the loss function between the restored images of the preset number of sub-images and the corresponding reference images, and updating parameters in the multi-path neutral network.

6. The method of claim 4, wherein the reward function is formulated as follows:

$$r_i = \begin{cases} -p(1-1_{\{1\}}(a_i)), & 1 \leq i \leq N \\ -p(1-1_{\{1\}}(a_i)) + d, & i = N \end{cases}$$

where the r_i is a reward function for an i-th level of sub-networks, P is a preset penalty, $1_{\{1\}}(a_i)$ is an indicator function, and d is a coefficient of difficulty; and

when $a_i=1$, a value of the indicator function is 1, and when $a_i \neq 1$, the value

of the indicator function is 0.

7. The method of claim 6, wherein the coefficient of difficulty d is formulated as follows:

$$d = \begin{cases} L_d / L_0, & 0 \leq L_d \leq L_0 \\ 1, & L_d \geq L_0 \end{cases}$$

where the L_d is the preset loss function between the restored images of the preset sub-images and the corresponding reference images, and L_0 is a threshold.

8. An image restoration apparatus, comprising:

a division module configured to perform region division on an acquired image to obtain at least one sub-image; and

a restoration module, configured to input each of the at least one sub-image to a multi-path neural network, and restore each sub-image by using a restoration network determined for the sub-image to obtain and output a restored image of each sub-image, thereby obtaining a restored image of the acquired image.

9. The apparatus of claim 8, wherein the restoration module comprises:

an encoding sub-module, configured to encode each sub-image to obtain features of the sub-image;

a restoration sub-module, configured to input the features of each sub-image to sub-networks of the multi-path neural network, select a restoration network for each sub-image by using path selection networks in the sub-networks, and process, according to the restoration network of each sub-image, the sub-image to obtain and output processed features of the sub-image; and

a decoding sub-module, configured to decode the processed features of each sub-image to obtain the restored image of the sub-image.

10. The apparatus of claim 9, wherein the restoration sub-module is further configured

to:

when the number of sub-networks is N and the N sub-networks are sequentially connected,

input an i -th level of features of each sub-image to an i -th sub-network, and select an i -th restoration network for each sub-image from M restoration networks in the i -th sub-network by using an i -th path selection network in the i -th sub-network;

process, according to the i -th restoration network, the i -th level of features of each sub-image to obtain and output an $(i+1)$ -th level of features of each sub-image;

update the i to $i+1$, and return to the inputting the i -th level of features of each sub-image to the i -th sub-network, and selecting the i -th restoration network for each sub-image from the M restoration networks in the i -th sub-network by using the i -th path selection network in the i -th sub-network; and

until an N -th level of features of each sub-image are obtained and output, determine the N -th level of features of each sub-image as the processed features of the sub-image,

wherein when $i=1$, the i -th level of features of each sub-image being the features of the sub-image, and

wherein the N is a positive integer not less than 1, M is a positive integer not less than 2, and i is a positive integer, i is greater than or equal to 1 and i is less than or equal to N .

11. The apparatus of claim 8, wherein when a number of obtained restored images of sub-images is greater than or equal to a preset number, the apparatus further comprises:

an acquisition module, configured to acquire restored images of the preset number of sub-images, and acquire reference images corresponding to the restored images of the preset number of sub-images; and

a first training module, configured to:

train, based on the restored images of the preset number of sub-images and the corresponding reference images, networks except for the path selection networks in

the multi-path neutral network by an optimizer according to a preset loss function between the restored images of the preset number of sub-images and the corresponding reference images, and update parameters of the networks except for the path selection networks in the multi-path neutral network; and

train, based on the restored images of the preset number of sub-images and the corresponding reference images, the path selection networks by the optimizer by use of a reinforcement learning algorithm according to a preset reward function, and update parameters of the path selection networks.

12. The apparatus of claim 11, further comprising:

a second training module, configured to:

after the restored images of the preset number of sub-images are acquired and the reference images corresponding to the restored images of the preset number of sub-images are acquired, and before the networks except for the path selection networks in the multi-path neutral network are trained by the optimizer according to the loss function between the obtained restored images of the preset number of sub-images and the corresponding reference images, and the parameters of the networks except for the path selection networks in the multi-path neutral network are updated,

train, based on the restored images of the preset number of sub-images and the corresponding reference images, the networks except for the path selection networks in the multi-path neutral network by the optimizer according to the loss function between the restored images of the preset number of sub-images and the corresponding reference images, and update the parameters except for the path selection networks in the multi-path neutral network.

13. The apparatus of claim 11, wherein the reward function is formulated as follows:

$$r_i = \begin{cases} -p(1 - 1_{\{1\}}(a_i)), & 1 \leq i \leq N \\ -p(1 - 1_{\{1\}}(a_i)) + d, & i = N \end{cases}$$

where the r_i is a reward function for an i-th level of sub-networks, P is a preset penalty, $1_{\{1\}}(a_i)$ is an indicator function, and d is a coefficient of difficulty; and

when $a_i=1$, a value of the indicator function is 1, and when $a_i \neq 1$, the value of the indicator function is 0.

14. The apparatus of claim 13, wherein the coefficient of difficulty d is formulated as follows:

$$d = \begin{cases} L_d/L_0, & 0 \leq L_d \leq L_0 \\ 1, & L_d \geq L_0 \end{cases}$$

where the L_d is the preset loss function between the restored images of the preset sub-images and the corresponding reference images, and L_0 is a threshold.

15. An electronic device, comprising a processor, a memory and a communication bus, wherein

the communication bus is configured to implement connection and communication between the processor and the memory; and

the processor is configured to execute an image restoration program stored in the memory to implement the image restoration method of any one of claims 1 to 7.

16. A computer readable storage medium, having stored therein one or more programs, wherein the one or more programs are capable of being executed by one or more processors to implement the image restoration method of any one of claims 1 to 7.

17. A computer program, when being executed by a computer, causes the computer to implement the image restoration method of any one of claims 1 to 7.