

IMAGE PROCESSING METHOD, TRAINING METHOD, DEVICES, APPARATUS AND COMPUTER-READABLE STORAGE MEDIUM

TECHNICAL FIELD

[0001] The present invention relates to the field of image processing technology, in particular to a method and a device for image processing, a method and a device for training, an apparatus and a computer-readable storage medium in terms of image processing.

BACKGROUND

[0002] With the rapid development of computer vision, outdoor vision systems are widely used. However, outdoor vision systems are prone to be affected by weather and other factors such as rain, making it of great practical significance to remove the impacts of raindrops, rain lines and other rain-related factors.

[0003] Existing image de-raining methods generally include the dictionary learning based method and the methods which are implemented by means of filtering using guided filter and other filters.

[0004] Based on the dictionary learning based method, rain line and edge background are in different structures and should be represented by different dictionaries to determine whether the edge is a rain line and therefore for the purpose of de-raining. However, in real life, rain line overlaps with some characteristics of background edge, in which case it is necessary to continuously introduce new features in the subsequent dictionary separation to increase the discrimination of the dictionary and further improve accuracy, which at the same time will increase the complexity of algorithm. However, neither traditional filters nor even the existing edge-preserving filters can achieve effective de-raining.

SUMMARY

[0005] In order to solve the problems in the prior art, at least one embodiment of the present invention provides a method and a device for image processing, a method and a device for training, an apparatus and a computer-readable storage medium in terms of image processing to cope with the problems mentioned in the Background section above.

[0006] First of all, the embodiments of the present invention provide an image processing method which involves: acquiring an image to be processed as an original rain-bearing image; generating by the first generator of a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image; and generating by the second generator of a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image.

[0007] In some embodiments, the rain in the original rain-bearing image includes raindrops or rain lines.

[0008] In some embodiments, the method further includes pre-training the first generator and the second generator, which pre-training includes: acquiring by the first discriminator of the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ; synthesizing the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image; acquiring by the second discriminator of the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; determining the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A , and updating parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0009] In some embodiments, the third adversarial loss value is equivalent to the weighted average of the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A .

[0010] In some embodiments, the pre-training the first generator and the second

generator further includes: comparing the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and updating parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0011] In some embodiments, the first discriminator is obtained as a raindrop-free discriminator, and the method further includes training the raindrop-free discriminator, which training specifically involves: taking the real non-raindrop-bearing image and the generated non-raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image or there is a corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image; obtaining discrimination error of the raindrop-free discriminator in discriminating the real non-raindrop-bearing image and the generated non-raindrop-bearing image; and, updating parameters of the raindrop-free discriminator through back propagation according to the discrimination error.

[0012] In some embodiments, the second discriminator is a raindrop discriminator, and the method further includes training the raindrop discriminator, which training specifically involves: taking the real raindrop-bearing image and the generated raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image or there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image; obtaining discrimination error of the raindrop discriminator in discriminating the real raindrop-bearing image and the generated raindrop-bearing image; and, updating parameters of the raindrop discriminator through back propagation according to the discrimination error.

[0013] In some embodiments, when there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image, the real raindrop-bearing image is the original rain-bearing image and the generated raindrop-bearing image is the synthesized rain-bearing image corresponding thereto.

[0014] Secondly, the embodiments of the present invention provide an image

processing device which comprises of: an acquisition module designed to acquire an image to be processed as an original rain-bearing image; a first generator designed to generate a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image; and, a second generator designed to generate a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image.

[0015] In some embodiments, the device further comprises of a first training module which is designed to pre-train the first generator and the second generator and comprises of: a first discriminator designed to acquire the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ; a synthesizer designed to synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image; a second discriminator designed to acquire the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; a first parameter adjustment module designed to determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A and to update parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0016] In some embodiments, the device further comprises of a second training module designed to pre-train the first generator and the second generator, which second training module includes: a comparator designed to compare the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and a second parameter adjustment module designed to update parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0017] In some embodiments, the first discriminator is a raindrop-free discriminator, and the device further comprises of a third training module designed to train the rain-free discriminator, which third training module includes: a first input unit taking the real non-raindrop-bearing image and the generated non-raindrop-bearing image as

input, under which circumstance there is no corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image or there is a corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image; a first error acquisition unit designed to obtain discrimination error in training of the raindrop-free discriminator in discriminating the real non-raindrop-bearing image and the generated non-raindrop-bearing image; and, a first parameter adjustment unit designed to update parameters of the raindrop-free discriminator through back propagation according to the discrimination error.

[0018] In some embodiments, the second discriminator is a raindrop discriminator, and the device further comprises of a fourth training module designed to train the raindrop discriminator. The fourth training module includes: a second input unit taking the real raindrop-bearing image and the generated raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image or there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image; a second error acquisition unit designed to obtain discrimination error in training of the raindrop discriminator in discriminating the real raindrop-bearing image and the generated raindrop-bearing image; and, a second parameter adjustment unit designed to update parameters of the raindrop discriminator through back propagation according to the discrimination error.

[0019] Thirdly, the embodiments of the present application also provide a training method which involves: acquiring an original rain-bearing image; generating by the first generator of a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image; generating by the second generator of a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image; acquiring by the first discriminator of the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B; synthesizing the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-

bearing image; acquiring by the second discriminator of the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; determining the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A , and updating parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0020] In some embodiments, the method further involves: comparing the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and updating parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0021] Fourthly, the embodiments of the present application also provide a training device which comprises of: an input layer designed to obtain an original rain-bearing image; a first generator designed to generate a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image; a second generator designed to generate a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image; a first discriminator designed to acquire the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ; a synthesizer designed to synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image; a second discriminator designed to acquire the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; and, a first parameter adjustment module designed to determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A and to update parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0022] In some embodiments, the device further comprises of a comparator and a second parameter adjustment module, which comparator is designed to compare the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle

consistency loss value, and which second parameter adjustment module is designed to update parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0023] Fifthly, the embodiments of the present application also provide a computer apparatus which comprises of at least one processor, a memory, a communication interface and a communication bus, which processor, memory and communication interface communicates with each other through the communication bus. And the computer apparatus further comprises of a memory coupled to the at least one processor, which memory stores executable instructions that make it possible to implement the method mentioned in the first aspect or the third aspect above when executed by the at least one processor.

[0024] Sixthly, the embodiments of the present application also provide a chip designed to implement the method mentioned in the first aspect above. Specifically, the chip comprises of a processor designed to call from the memory and run a computer program, indicating that any device installed with the chip can be used to implement the method mentioned in the first aspect or the third aspect above.

[0025] Seventhly, the embodiments of the present application also provide a computer-readable storage medium which stores a computer program. When the computer program is executed by the processor, the method mentioned in the first aspect or the third aspect above may be implemented.

[0026] Finally, the embodiments of the present application also provide a computer program product which includes a computer program instruction. The computer program instruction causes the computer to implement the method mentioned in the first aspect or the third aspect above.

[0027] In conclusion, the methods and devices for image processing described in the embodiments of the present invention obtain raindrop layer by means of the attention mechanism network and based on original rain-bearing image, and then obtain rain-free background image based on the pixel difference between the raindrop layer and the original rain-bearing image, which achieves image de-raining without using the corresponding rain-bearing and non-rain-bearing comparison chart as the training data

set, reducing the reliance on external information, lowering costs and improving the efficiency of image de-raining. In addition, the embodiments of the present application also improve the authenticity of generated images through pre-training.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] In order to give a clearer explanation on the technical solutions mentioned in the embodiments of the present invention, the drawings to be used in the embodiments or the description of the prior art are briefly introduced as below. Obviously, the drawings described below are only some embodiments of the present invention. Those of ordinary skill in the art also have an access to other drawings based on the following drawings without creative labor.

[0029] FIG. 1 is a flowchart of a specific embodiment of the image processing method proposed in the present invention;

[0030] FIG. 2 is a structural block diagram of a specific embodiment of the image processing device proposed in the present invention;

[0031] FIG. 3 is a flowchart of a specific embodiment of the training method proposed in the present invention;

[0032] FIG. 4 is a structural block diagram of a specific embodiment of the training device proposed in the present invention;

[0033] FIG. 5 is a basic structural block diagram of the computer apparatus described in this embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0034] A detailed description is made on the present application as follows with reference to the drawings and specific embodiments, making it possible to have a clearer understanding of the purpose, features and advantages of the present application. It should be understood that all the information described below with reference to the drawings and specific embodiments is merely exemplary, and should not be construed as limiting the scope of protection of the present application. Unless the context clearly indicates otherwise, terms referring to the singular form, such as “a” and “said”, should

include the plural. The terms such as “first” and “second” used in the present application may be used interchangeably to distinguish one or one type of component from another or another type of that, and are not intended to indicate the location or importance of the corresponding individual component.

[0035] Any reference herein to an “embodiment” means that specific features, structures, or characteristics described in connection with the embodiment may be included in at least one embodiment of the present application. The reference to the term in different places in the Specification does neither necessarily refer to the same embodiment, nor refer to any independent or alternative embodiment mutually exclusive of other embodiments. Those skilled in the art understand explicitly and implicitly that the embodiments described herein can be used combined with other embodiments.

[0036] The term “and/or” used herein merely describes three association relationships between associated objects. For instance, the phrase “A and/or B” may indicate three cases in which A exists alone, A and B exist simultaneously, and B exists alone. In addition, the character “/” used herein generally indicates an “or” relationship between the two associated objects placed before and after the character.

[0037] In order to enable those skilled in the art to have a better understanding of the solutions set out in the present application, a clear and complete description is made below in combination of the drawings attached on the technical solutions mentioned in the embodiments of the present application.

[0038] Rainwater, such as raindrops and rain lines, will hinder the visibility of background scene and reduce the image quality. Moreover, given that there are different impacts of rainwater and stains on image quality as rainwater is transparent and produces refraction and reflection, and that raindrops or rain lines with different shapes formed by rain have different impacts on image quality, it is much more difficult to remove raindrops or rain lines than removal of other factors affecting image quality such as stains. In summary, there are two major difficulties in rain removal: 1. The area blocked by raindrops is not fixed; 2. Most of the information of the background scene in the blocked area is completely lost.

[0039] The inventor found in research that all the existing image de-raining methods rely on supervision, and specifically need to be trained by comparing rain-bearing images and the corresponding non-rain-bearing images. Therefore, with respect to existing image de-raining methods, it is usually necessary to obtain many pairs of training samples, and in practice, it is difficult to collect each pair of training samples as a paired image data set consisting of rain-bearing images and non-rain-bearing images of the same scene, which further hinders the development of technology to a certain extent.

[0040] In the prior art, it is also feasible to produce such image sets by adding artificial rain layer by, for example, first obtaining an image, covering glass on the image and then sprinkling water spots on the glass to form a raindrop-bearing image. Alternatively, in the prior art, a waterdrop-bearing image can be also obtained by taking a picture without rain and then shooting the same scene by placing the waterdrop-bearing glass in front of the camera. Or, in the prior art, a rain-bearing image can be artificially synthesized by other means; but with regard to artificial synthesis of a rain-bearing image, the data set about the rain layer is not real and natural, and it is necessary to build paired image training databases and building a database meeting the requirements costs a lot. Given this, the inventor of the present application has proposed the embodiments of the present application through long-term research and development and experiments, in which embodiments no support of paired image collection database is required.

[0041] First of all, the present application provides an image processing method. FIG. 1 is a flowchart of a specific embodiment of the image processing method proposed in the present invention. As shown in FIG. 1, the image processing method of the present application includes:

[0042] Step 110: acquire an image to be processed as an original rain-bearing image. The acquired image can be a single image or a certain frame of image in video. The original rain-bearing image indicated here may be a real rain-bearing image, i.e. a non-synthetic rain-bearing image, such as a rain-bearing image taken in a natural scene or a certain frame of image in a rain-bearing video. The rain in the original rain-bearing

image includes raindrops or rain lines. It can be understood that raindrops will form visual rain lines when they drops quickly, or will form rain lines on the image based on the length of exposure time. Therefore, rain lines can be understood as a collection of raindrops with a small distance from each other.

[0043] Step 120: generate by the first generator of a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image. The first generator generates a raindrop layer based on the original rain-bearing image. A feature map may be formed using the self-attention mechanism, indicating, for example, that a raindrop layer may be obtained using the LSTM (Long-Short Term Memory) network or that several variants of the LSTM network (such as GRU (Gated Recurrent Unit)) or other network structures relying on self-attention mechanisms in the future may also be applied.

[0044] Step 130: generate by the second generator of a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image. Specifically, the original rain-bearing image and the pixels of the pure rain layer generated by the first generator are subtracted to generate a non-rain-bearing background layer and further to obtain a de-rained background image of the original rain-bearing image.

[0045] In the present application, a raindrop layer is first obtained using the attention mechanism network and according to the original rain-bearing image and then, a non-rain-bearing background image is obtained according to the pixel difference between the raindrop layer and the original rain-bearing image, in which case image de-raining can be realized without using the corresponding rain-bearing and non-rain-bearing comparison map as the training data set, reducing the dependence on external information, improving the efficiency of image de-raining and lowering de-raining costs.

[0046] In an embodiment of the present invention, the image de-raining method proposed in the present application further includes pre-training the first generator and the second generator, which pre-training further includes:

[0047] Acquiring by the first discriminator of the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss

value GAN_Loss_B. In this training method, a discriminator is added after the generator. For example, the first discriminator is connected following the second generator. The first discriminator can discriminate whether the non-rain-bearing background layer generated by the second generator is a real non-rain-bearing image, and the working principle based on which the first discriminator and the second generator interact with each other is similar to the GAN (Generative Adversarial Networks) in the prior art, indicating that the authenticity of the background image generated by the second generator can be improved by the first discriminator. Specifically, the first discriminator may be a non-raindrop discriminator through which an adversarial loss value (GAN_Loss_B) is obtained.

[0048] Synthesizing the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image. It is assumed that the physical model of the original real rain-bearing image I is Image (I), including background layer and rain layer. The synthesizer adds the pure rain layer generated by the first generator and the non-rain-bearing background layer generated by the second generator to obtain a synthesized raindrop-bearing image I_rec.

[0049] Acquiring by the second discriminator of the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A. The second discriminator may be a raindrop discriminator through which an adversarial loss value GAN_Loss_A is obtained.

[0050] Determining the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A, and updating parameters of the first generator and the second generator through back propagation according to the third adversarial loss value. Specifically, the third adversarial loss value is obtained based on the weighted average of the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A. For example, the final adversarial loss value is $GAN_Loss = (GAN_Loss_A + GAN_Loss_B) / 2$, which final adversarial loss value updates parameters of the second generator network and the first generator network, such as the LSTM network, through

back propagation.

[0051] In another embodiment, pre-training the first generator and the second generator further includes:

[0052] Comparing the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value, which specifically involves: obtaining the synthesized raindrop-bearing image I_{rec} by adding the raindrop layer generated by the first generator and the background layer generated by the second generator, and obtaining the cycle consistency loss value by comparing the synthesized raindrop-bearing image I_{rec} and the real raindrop-bearing image I that has been input.

[0053] Updating parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value, which cycle consistency loss value is used to ensure that the background of the generated non-raindrop-bearing image is consistent with that of the original raindrop-bearing image I .

[0054] The embodiments of the present application improve the authenticity of the generated pure rain layer and the synthesized rain-bearing image by training the first generator and the second generator.

[0055] Furthermore, in another embodiment, the method further includes pre-training the first discriminator, i.e. the raindrop-free discriminator, which pre-training involves:

[0056] Taking the real non-raindrop-bearing image and the generated non-raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image or there is a corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image. It can be understood that, in this embodiment, rain-bearing image and non-rain-bearing image with the corresponding relationship are not required in training the raindrop-free discriminator. Besides, the abovementioned pre-training of the first discriminator also involves Obtaining discrimination error of the raindrop-free discriminator in discriminating the real non-raindrop-bearing image and the generated non-raindrop-bearing image, and updating parameters of the raindrop-free discriminator through back propagation according to the discrimination error.

[0057] Furthermore, in another embodiment, the method further includes pre-training the second discriminator, i.e. the raindrop discriminator, which pre-training involves:

[0058] Taking the real raindrop-bearing image and the generated raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image or there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image. When there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image, the real raindrop-bearing image is the original rainy image and the generated raindrop-bearing image is the synthesized rainy image corresponding thereto.

[0059] Obtaining discrimination error of the raindrop discriminator in training in discriminating the real raindrop-bearing image and the generated raindrop-bearing image; and, updating parameters of the raindrop discriminator through back propagation according to the discrimination error.

[0060] In this embodiment, pre-training the two discriminators can further improve the authenticity of images generated by generators without corresponding image sets.

[0061] Secondly, the present invention provides an image processing device. FIG. 2 is a structural block diagram of a specific embodiment of the image processing device proposed in the present invention. As shown in FIG. 2, the image processing device provided in the present invention comprises of an acquisition module 201, a first generator 202 and a second generator 203.

[0062] The acquisition module 201 is used to acquire an image to be processed as an original rain-bearing image;

[0063] The first generator 202 is used to generate a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image.

[0064] The second generator 203 is used to generate a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image.

[0065] The specific modules included in the device are implemented with reference to the steps set out in FIG. 1 and can achieve the same beneficial effects. This embodiment

obtains raindrop layer based on original rain-bearing image, and then obtains rain-free background image based on the pixel difference between the raindrop layer and the original rain-bearing image, which achieves image de-raining without using the corresponding rain-bearing and non-rain-bearing comparison chart as the training data set, reducing the reliance on external information, lowering costs and improving the efficiency of image de-raining.

[0066] In another embodiment, the image processing device proposed in the present invention further comprises of a first training module designed to pre-train the first generator and the second generator. The first training module comprises of:

[0067] A first discriminator designed to acquire the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ; a synthesizer designed to synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image; a second discriminator designed to acquire the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; and, a first parameter adjustment module designed to determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A and to update parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0068] In another embodiment, the image processing device proposed in the present invention further comprises of a second training module designed to pre-train the first generator and the second generator. The second training module comprises of: a comparator designed to compare the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and, a second parameter adjustment module designed to update parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0069] The embodiments of the present application improve the authenticity of the generated pure rain layer and the synthesized rain-bearing image by training the first generator and the second generator.

[0070] In another embodiment, the first discriminator included in the image processing device proposed in the present application is a raindrop-free discriminator, and the device further comprises of a third training module designed to train the raindrop-free discriminator. The third training module includes:

[0071] A first input unit taking the real non-raindrop-bearing image and the generated non-raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image or there is a corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image; a first error acquisition unit designed to obtain discrimination error in training of the raindrop-free discriminator in discriminating the real non-raindrop-bearing image and the generated non-raindrop-bearing image; and, a first parameter adjustment unit designed to update parameters of the raindrop-free discriminator through back propagation according to the discrimination error.

[0072] In another embodiment, the second discriminator included in the image processing device proposed in the present application is a raindrop discriminator, and the device further comprises of a fourth training module designed to train the raindrop discriminator. The fourth training module includes:

[0073] A second input unit taking the real raindrop-bearing image and the generated raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image or there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image; a second error acquisition unit designed to obtain discrimination error in training of the raindrop discriminator in discriminating the real raindrop-bearing image and the generated raindrop-bearing image; and, a second parameter adjustment unit designed to update parameters of the raindrop discriminator through back propagation according to the discrimination error.

[0074] In this embodiment, pre-training the two discriminators can further improve the authenticity of images generated by generators without corresponding image sets.

[0075] Thirdly, the present application also provides a training method. FIG. 3 is a

flowchart of a specific embodiment of the training method proposed in the present invention. As shown in FIG. 3, the training method provided in the present application involves:

[0076] Step 310: acquire an original rain-bearing image;

[0077] Step 320: generate by the first generator of a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image;

[0078] Step 330: generate by the second generator of a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image;

[0079] Step 340: acquire by the first discriminator of the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ;

[0080] Step 350: synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image;

[0081] Step 360: acquire by the second discriminator of the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ;

[0082] Step 370: determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A , and update parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0083] Furthermore, the training method further involves: comparing the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and, updating parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0084] The above training method can help to further improve the authenticity and resolution of the de-rained background images generated by generators according to original rain-bearing images without corresponding image sets.

[0085] Fourthly, the present application also provides a training device. FIG. 4 is a structural block diagram of a specific embodiment of the training device proposed in

the present invention. As shown in FIG. 4, the training device provided in the present application comprises of an input layer 401, a first generator 402, a second generator 403, a first discriminator 404, a synthesizer 405, a second discriminator 406 and a parameter adjustment module.

[0086] The input layer 401 is designed to obtain an original rain-bearing image; the first generator 402 is designed to generate a pure rain layer according to the original rain-bearing image, which pure rain layer indicates the position of raindrops in the original rain-bearing image; the second generator 403 is designed to generate a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image; the first discriminator 404 is designed to acquire the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ; the synthesizer 405 is designed to synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image; the second discriminator 406 is designed to acquire the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; and, the first parameter adjustment module is designed to determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A and to update parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

[0087] In another embodiment, the training device further comprises of a comparator and a second parameter adjustment module, which comparator is designed to compare the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value, and which second parameter adjustment module is designed to update parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

[0088] The above training device, using training generators and discriminators, can help to further improve the authenticity and resolution of the de-rained background images generated by generators according to original rain-bearing images without corresponding image sets.

[0089] Fifthly, the embodiments of the present application also provide a computer apparatus which can be a neural network server. Please see FIG. 5 for details. FIG. 5 is a basic structural block diagram of the computer apparatus described in this embodiment.

[0090] The computer apparatus 5 comprises of a memory 51, a processor 52 and a communication interface 53 that are communicatively connected to each other through a system bus. It should be pointed out that only the computer apparatus 5 with the components 51-53 is shown in the figure; but it should be understood that not all components shown are required to be implemented and more or fewer components may be implemented instead. Those skilled in the art can understand that the computer apparatus 5 is a device that can automatically perform numerical calculation and/or information processing according to preset or stored instructions, whose hardware includes but is not limited to a microprocessor, an Application Specific Integrated Circuit (ASIC), a Field—Programmable Gate Array (FPGA), a Digital Signal Processor (DSP) and an embedded device.

[0091] The computer apparatus 5 may be a computing device such as a desktop computer, a notebook, a palmtop computer and a cloud server, and can interact with its users through a keyboard, a mouse, a remote control, a touchpad or a voice control device.

[0092] The memory 51 comprises of at least one type of readable storage medium and can store executable instruction controllers, microcontrollers, microprocessors or other data processing chips. The readable storage medium includes non-volatile or volatile memory, such as flash memory, hard disk, multimedia card, card-type memory (including SD or DX memory, etc.), random access memory (RAM), read-only memory (ROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), programmable read-only memory (PROM), magnetic memory, magnetic disk, optical disk, etc.. And the RAM includes static RAM and dynamic RAM. In some embodiments, the memory 51 may be an internal storage unit of the computer apparatus 5, such as hard disk or memory of the computer apparatus 5. In other embodiments, the memory 51 may also be an external

storage device of the computer apparatus 5, such as plug-in hard disk, Smart Media Card (SMC), Secure Digital (SD) card and Flash Card equipped on the computer apparatus 5. Of course, the memory 51 may also include both the internal storage unit and the external storage device of the computer apparatus 5. In this embodiment, the memory 51 is generally used to store the operating systems and various application software installed on the computer apparatus 5, such as program codes for performing image processing. In addition, the memory 51 can also be used to temporarily store various types of data that have been or will be output.

[0093] In the embodiments of the present application, the processor 52 may be a Central Processing Unit (CPU) or a Graphic Processing Unit (GPU), or may be another general-purpose processor, Digital Signal Processing (DSP), Application Specific Integrated Circuit (ASIC), Field-Programmable Gate Array (FPGA) or other programmable logic device, discrete gate or transistor logic device or discrete hardware component. And the aforementioned general-purpose processor may be a microprocessor or any conventional processor (such as single-chip microcomputer).

[0094] The processor 52 is generally used to control the overall operation of the computer apparatus 5. In this embodiment, the memory 51 is used to store program codes or instructions, which program codes include computer operation instructions. And the processor 52 is used to execute the program codes or instructions stored in the memory 51 or to process data, such as program codes for performing image processing.

[0095] The bus described herein may be an Industry Standard Architecture (ISA) bus, a Peripheral Component Interconnect (PCI) bus, or an Extended Industry Standard Architecture (EISA) bus. The bus system can be divided into address bus, data bus, control bus and so on. For ease of representation, only one thick line is used to represent bus in the figure, which does not mean that there is only one bus or one type of bus.

[0096] Sixthly, the embodiments of the present invention also provide a chip designed to implement the method mentioned in the first aspect above. Specifically, the chip comprises of a processor designed to call from the memory and run a computer program, indicating that any device installed with the chip can be used to implement the image processing method mentioned above.

[0097] Seventhly, the embodiments of the present invention also provide a computer-readable storage medium which may be a computer-readable signal medium or a computer-readable medium. The processor in computer reads the computer-readable program codes stored in the computer-readable medium, so that the processor can implement the functional actions involved in each step or any combination of steps of the image processing method as shown in the Flowchart 1, and also generates a device that implements the functional actions specified in each block or any combination of blocks shown in the block diagram.

[0098] The computer-readable medium comprises of (but is not limited to) electronic, magnetic, optical, electromagnetic or infrared memories or semiconductor systems, devices or units, or any appropriate combination of the foregoing. The memory is used to store program codes or instructions. The program codes include computer operation instructions. And the processor is used to execute the program codes or instructions stored in the memory.

[0099] For the definitions of the memory and the processor, reference may be made to the description of the foregoing embodiments concerning the computer apparatus and no details are explained here. The computer-readable storage medium stores a computer program which makes it possible to implement the method mentioned in any paragraph in the first aspects above when executed by processor.

[0100] Finally, the embodiments of the present invention also provide a computer program product which includes a computer program instruction. The computer program instruction causes the computer to implement the method mentioned in the first aspect above.

[0101] Those skilled in the art can understand that the exemplary units and algorithm steps described in the embodiments disclosed herein may be implemented by electronic hardware or a combination of software and electronic hardware. Whether those functions are implemented by hardware or software depends on the specific application of technical solutions and design constraints. Those skilled in the art may implement the described functions for specific different applications in different ways, which should not be considered beyond the scope of the present application.

[0102] In the embodiments of the present application, the disclosed system, device and method may also be implemented in other ways. For example, division of units is only a division of logical functions, and there may be other division methods in practice. For example, multiple units or components may be combined or may be integrated into another system, and besides, different units may be directly or indirectly coupled. In addition, the functional units in the embodiments of the present application may be integrated into one processing unit, or may exist physically and independently.

[0103] It should be understood that in the embodiments of the present application, the serial numbers of each process do not indicate the sequence in which those processes are executed, and the sequence in which those processes are executed should be determined by their respective functions and internal logics and should not constitute any limitation on the implementation of the embodiments of the present application.

[0104] If the functions aforesaid are implemented in the form of a software functional unit and are sold or used as independent products, they may be stored in a machine-readable storage medium. Therefore, the technical solutions mentioned in the present application may be embodied in the form of a software product, which software product may be stored in a machine-readable storage medium and may include several instructions to enable the electronic device to perform all or part of the technical solutions described in the embodiments of the present application. The aforesaid storage medium may include various media that can store program codes, such as ROM, RAM, removable disk, hard disk, magnetic disk or optical disk.

[0105] The above gives a detailed description of the implementation of the present application, but imposes no limitation on the protection scope of the present application. Those skilled in the art may make changes or replacements within the technical scope disclosed in the present application, provided that those changes or replacements shall fall within the protection scope of the present application.

Claims

WHAT IS CLAIMED IS:

1. An image processing method, comprising:
 acquiring an image to be processed as an original rain-bearing image;
 generating, by a first generator, a pure rain layer according to the original rain-bearing image; wherein, the pure rain layer indicates the position of raindrops in the original rain-bearing image; and
 generating, by a second generator, a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image.
2. The image processing method according to Claim 1, wherein the rain in the original rain-bearing image includes raindrops or rain lines.
3. The image processing method according to Claim 1, further comprising: pre-training the first generator and the second generator, wherein said pre-training the first generator and the second generator includes:
 acquiring by the first discriminator of the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ;
 synthesizing the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image;
 acquiring by the second discriminator of the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ;
 determining the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A , and updating parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.
4. The image processing method according to Claim 3, wherein the third adversarial loss value is equivalent to the weighted average of the first adversarial loss value

GAN_Loss_B and the second adversarial loss value GAN_Loss_A.

5. The image processing method according to Claim 3, wherein the pre-training the first generator and the second generator further includes:

comparing the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value;

updating parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

6. The image processing method according to Claims 3-5, wherein the first discriminator is a raindrop-free discriminator, and the method further comprises training the raindrop-free discriminator, and said training the raindrop-free discriminator comprises:

taking the real non-raindrop-bearing image and the generated non-raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image or there is a corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image;

obtaining discrimination error of the raindrop-free discriminator in discriminating the real non-raindrop-bearing image and the generated non-raindrop-bearing image;

updating parameters of the raindrop-free discriminator through back propagation according to the discrimination error.

7. The image processing method according to Claims 3-5, wherein the second discriminator is a raindrop discriminator, and the method further comprises training the raindrop discriminator, and said training the raindrop discriminator comprises:

taking the real raindrop-bearing image and the generated raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image or there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image;

obtaining discrimination error of the raindrop discriminator in discriminating the real raindrop-bearing image and the generated raindrop-bearing image;

updating parameters of the raindrop discriminator through back propagation according to the discrimination error.

8. The image processing method according to Claim 7, wherein when there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image, the real raindrop-bearing image is the original rain-bearing image and the generated raindrop-bearing image is the synthesized rain-bearing image corresponding thereto.

9. An image processing device, comprising:

an acquisition module designed to acquire an image to be processed as an original rain-bearing image;

a first generator designed to generate a pure rain layer according to the original rain-bearing image, wherein the pure rain layer indicates the position of raindrops in the original rain-bearing image; and

a second generator designed to generate a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image.

10. The image processing device according to Claim 9, further comprising a first training module which is designed to pre-train the first generator and the second generator and comprises:

a first discriminator designed to acquire the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ;

a synthesizer designed to synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image;

a second discriminator designed to acquire the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ; and

a first parameter adjustment module designed to determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A and to update parameters of the first generator and the second generator through back propagation according to the third adversarial loss

value.

11. The image processing device according to Claim 10, further comprising a second training module designed to pre-train the first generator and the second generator, and the second training module comprises:

a comparator designed to compare the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and

a second parameter adjustment module designed to update parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

12. The image processing device according to Claim 10 or Claim 11, wherein the first discriminator is a raindrop-free discriminator, and the device further comprises a third training module designed to train the rain-free discriminator, and the third training module comprises:

a first input unit taking the real non-raindrop-bearing image and the generated non-raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image or there is a corresponding relationship between the real non-raindrop-bearing image and the generated non-raindrop-bearing image;

a first error acquisition unit designed to obtain discrimination error in training of the raindrop-free discriminator in discriminating the real non-raindrop-bearing image and the generated non-raindrop-bearing image;

a first parameter adjustment unit designed to update parameters of the raindrop-free discriminator through back propagation according to the discrimination error.

13. The image processing device according to Claim 10 or Claim 11, wherein the second discriminator is a raindrop discriminator, and the device further comprises a fourth training module designed to train the raindrop discriminator, and the fourth training module comprises:

a second input unit taking the real raindrop-bearing image and the generated raindrop-bearing image as input, under which circumstance there is no corresponding relationship between the real raindrop-bearing image and the generated raindrop-

bearing image or there is a corresponding relationship between the real raindrop-bearing image and the generated raindrop-bearing image;

a second error acquisition unit designed to obtain discrimination error in training of the raindrop discriminator in discriminating the real raindrop-bearing image and the generated raindrop-bearing image; and

a second parameter adjustment unit designed to update parameters of the raindrop discriminator through back propagation according to the discrimination error.

14. A training method, comprising:

acquiring an original rain-bearing image;

generating, by the first generator, a pure rain layer according to the original rain-bearing image, wherein the pure rain layer indicates the position of raindrops in the original rain-bearing image;

generating, by the second generator, a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image;

acquiring, by the first discriminator, the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ;

synthesizing the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image;

acquiring, by the second discriminator, the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ;

determining the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A , and updating parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

15. The training method according to Claim 14, further comprising:

comparing the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and

updating parameters of the first generator and the second generator through back

propagation according to the cycle consistency loss value.

16. A training device, comprising:

an input layer designed to obtain an original rain-bearing image;

a first generator designed to generate a pure rain layer according to the original rain-bearing image, wherein the pure rain layer indicates the position of raindrops in the original rain-bearing image;

a second generator designed to generate a non-rain-bearing background layer according to the pure rain layer and the original rain-bearing image;

a first discriminator designed to acquire the non-rain-bearing background layer generated by the second generator to obtain the corresponding first adversarial loss value GAN_Loss_B ;

a synthesizer designed to synthesize the non-rain-bearing background layer generated by the second generator and the pure rain layer generated by the first generator to obtain a synthesized rain-bearing image;

a second discriminator designed to acquire the synthesized rain-bearing image to obtain the corresponding second adversarial loss value GAN_Loss_A ;

a first parameter adjustment module designed to determine the third adversarial loss value according to the first adversarial loss value GAN_Loss_B and the second adversarial loss value GAN_Loss_A and to update parameters of the first generator and the second generator through back propagation according to the third adversarial loss value.

17. The training device according to Claim 16, further comprising a comparator and a second parameter adjustment module, wherein,

the comparator is designed to compare the synthesized rain-bearing image and the original rain-bearing image to obtain a cycle consistency loss value; and

the second parameter adjustment module is designed to update parameters of the first generator and the second generator through back propagation according to the cycle consistency loss value.

18. A computer apparatus comprising at least one processor, a memory, a communication interface and a communication bus, wherein, the at least one processor,

memory and communication interface communicate with each other through the communication bus, the memory is coupled to the at least one processor and stores executable instructions, and the executable instructions are executed by the at least one processor to implement the method described in any one of Claims 1-8, Claim 14 or Claim 15.

19. A chip which is characterized in that it comprises of a processor designed to call from the memory and run a computer program, indicating that any device installed with the chip can be used to implement the method described in any one of Claims 1-8, Claim 14 or Claim 15.

20. A computer-readable storage medium which is characterized in that it stores a computer program that makes it possible to implement the steps involved in the method described in any one of Claims 1-8, Claim 14 or Claim 15 when the computer program is executed by the processor.