

A DECODER TRAINING METHOD, A HIGH-RESOLUTION FACE IMAGE GENERATION METHOD, A DEVICE AND A COMPUTER DEVICE

TECHNICAL FIELD

[0001] The present invention relates to the field of image processing, in particular to a decoder training method, a high-resolution face image generation method, a device and a computer device.

BACKGROUND

[0002] As it is necessary to generate high-resolution face images in many scenarios with the development and application of artificial intelligence technology, there are existing methods in the prior art for generating high-resolution face images using random variables. Take the photo-like real face generation software developed by NVIDIA as an example. This software applies the Generative Adversarial Nets (GAN) and uses two neural networks to train each other, based on which the image generation network tries to generate synthetic images that are indistinguishable from real photos and the adversarial network tries to identify the differences. After several weeks of training in this way, the image generation network can generate face images that are indistinguishable from real ones.

[0003] However, the faces shown in the high-resolution face images generated by the prior art using random variables are random, which cannot meet the need in practical applications for generating high-resolution images of specified faces. In the prior art, there are two latest technologies to process blurry face image into clearer face image. One technology uses Image Super-Resolution method, and the other uses Conditioning Network and Prior Network. The Prior Network will make decisions in low-resolution images and high-resolution images and fill in high-resolution images according to probability priority. The prior art is to supplement new details that are not included in low-resolution images through filling in low-resolution images. So the

details added by the prior art in the process of transforming low-resolution images into high-resolution images are just a kind of "speculation".

SUMMARY

[0004] In order to solve the shortcomings existing in the prior art and the problems pointed out in the BACKGROUND section above and to generate images of specified faces, at least one embodiment of the present invention provides a decoder training method, a high-resolution face image generation method, a device and a computer device.

[0005] First of all, embodiments of the present invention provide a decoder training method which involves: acquiring a first face image which is a low-resolution face image with a resolution lower than a first preset value; decoding the first face image by the decoder to form a high-dimensional vector corresponding to the features of the first face image, which high-dimensional vector has a dimension higher than a second preset value; generating a second face image by the generator according to the high-dimensional vector, which second face image is a high-resolution face image with a resolution higher than a third preset value; determining the value of loss function according to the second face image and adjusting parameters of the decoder according to the value of loss function; and obtaining the well-trained decoder when the value of loss function meets a preset condition.

[0006] In some embodiments, the loss function is determined according to the distance between the features of the first face image and the features of the second face image.

[0007] In some embodiments, the distance between the features of the first face image and the features of the second face image is called L2 distance or cos distance; and the value of the loss function satisfies the preset condition that the value of the loss function is less than the preset value.

[0008] In some embodiments, the acquiring the first face image involves: acquiring a third face image whose resolution is higher than the resolution of the first face image; and down-sampling the third face image to obtain the first face image.

[0009] In some embodiments, the loss function is determined according to the distance between the features of the third face image and the features of the second face image.

[0010] In some embodiments, the distance between the features of the third face image and the features of the second face image is called L2 distance or cos distance; and the value of the loss function satisfies the preset condition that the value of the loss function is less than the preset value.

[0011] Secondly, embodiments of the present invention also provide a high-resolution face image generation method which involves: acquiring a low-resolution face image to be processed; inputting the low-resolution face image to be processed to a decoder trained as described in the first aspect, and outputting a high-dimensional vector corresponding to the features of the low-resolution face image to be processed by the decoder; and generating a high-resolution face image by the generator according to the high-dimensional vector output by the decoder.

[0012] Thirdly, embodiments of the present invention also provide a decoder training device, which is comprised of: an input layer designed to input a training image which is a first face image whose resolution is lower than a first preset value; a decoder designed to decode the training image and obtain a high-dimensional vector corresponding to the features of the training image, which high-dimensional vector has a dimension higher than a second preset value; an output layer designed to output the training result which is a high-dimensional vector corresponding to the features of the training image; a generator designed to receive the training result output by the output layer and form a second face image which is a high-resolution face image with a resolution higher than a third preset value;

[0013] A loss function value determination module designed to determine the value of loss function; and an adjustment module designed to adjust parameters of the decoder according to the value of the loss function and to obtain the trained decoder when the value of the loss function meets a preset condition.

[0014] In some embodiments, the loss function value determination module of the device determines the value of the loss function according to the distance between the

features of the first face image and the features of the second face image.

[0015] In some embodiments, the device further includes a third face image acquisition module designed to acquire a third face image whose resolution is higher than the resolution of the first face image; and a down-sampling module designed to down-sample the third face image to obtain the first face image.

[0016] In some embodiments, the loss function value determination module of the device determines the value of the loss function according to the distance between the features of the third face image and the features of the second face image.

[0017] In some embodiments, the device further includes a face recognition module designed to obtain the features of the first face image, the second face image or the third face image.

[0018] In some embodiments, the face recognition module of the device is a Light_CNN or a FaceNet.

[0019] Fourthly, embodiments of the present invention also provide a high-resolution face image generation device which is comprised of: a low-resolution face image acquisition module designed to acquire a low-resolution face image to be processed; a decoder which is a decoder trained by the training device described in the third aspect above; and a generator designed to generate a high-resolution face image according to the high-dimensional vector output by the decoder.

[0020] Fifthly, embodiments of the present invention also provide a computer device which is comprised of: at least one processor, a memory, a communication interface and a communication bus, which processor, memory and communication interface communicate with each other through the communication bus; a memory which is coupled to the at least one processor and stores executable instructions that make it possible to realize the method described in the first aspect or the second aspect above when executed by the at least one processor.

[0021] Sixthly, embodiments of the present invention also provide a chip designed to implement the method described in the first aspect above. Specifically, the chip includes a processor designed to call and run a computer program from the memory to further make it possible to implement the method described in the first aspect or the

second aspect above by the device on which the chip is installed.

[0022] Seventhly, embodiments of the present invention also provide a computer-readable storage medium which stores a computer program, making it possible to realize the method described in the first aspect or the second aspect above when the computer program is executed by a processor.

[0023] Finally, embodiments of the present invention also provide a computer program product which includes a computer program instruction, which computer program instruction makes it possible to have the method described in the first aspect or the second aspect above to be implemented by a computer.

[0024] The decoder training method and device described in the embodiments of the present invention enable the decoder to generate a high-dimensional face image close to the low-resolution face image after the high-dimensional vector output by the decoder according to the acquired low-resolution face image is input to the generator.

[0025] The decoder training method described in the embodiments of the present invention generates a high-dimensional vector corresponding to the features of the low-resolution face image after decoding the low-resolution face image by the decoder and a high-resolution face image generated according to the high-dimensional vector by the generator is used to determine the loss function to train the decoder, making the features of the generated face image are infinitely close to the low-resolution face image. The embodiments of the present application train the decoder through deep learning method, making it possible to obtain a high-resolution face image corresponding to the specified low-resolution face image after obtaining a high-dimensional vector through the decoding of the decoder and generating by the generator. The method and device for generating high-resolution face images described in the embodiments obtain a corresponding high-dimensional vector through decoding the low-resolution face image by the decoder trained by the training method of the present application and generate a high-resolution face image corresponding to the low-resolution face image directly according to the high-dimensional vector, avoiding the shortcoming of the prior art in the process of transforming a low-resolution image into a high-resolution image based on filling in

the low-resolution image and adding many new conjectural details. Through the method for generating high-resolution face images described in the present application, face images can be restored more realistically.

[0026] The embodiments in the present application adjust the loss function by using the second face image, making the final output second face image is close to the features of the first face image so that the decoder can be trained to output a high-dimensional vector that is more in line with requirements to input into the generator and finally generate a high-resolution face image associated with the low-resolution face image.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] In order to give a clearer explanation on the technical solutions described in the embodiments of the present invention, the drawings required for describing the embodiments of the present invention or the prior art are briefly introduced as below. Obviously, the drawings described below only involve some embodiments of the present invention. For those of ordinary skill in the art, other drawings can also be obtained based on the following drawings without paying any creative labor.

[0028] FIG. 1 is a flowchart of a specific embodiment describing the decoder training method of the present invention;

[0029] FIG. 2 is a flowchart of a specific embodiment describing the face image generation method of the present invention;

[0030] FIG. 3 is a structure diagram of a specific embodiment describing the decoder training device of the present invention;

[0031] FIG. 4 is a structure diagram of a specific embodiment describing the face image generation device of the present invention;

[0032] FIG. 5 is a basic structure diagram of the computer device described in the embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0033] A detailed description is made on the present application with reference to the accompanying drawings and specific embodiments, helping to have a clearer

understanding of the purpose, characteristics and advantages of the present application. It should be understood that the following description made with reference to the accompanying drawings and specific embodiments is for illustrative purposes only in all aspects, and should not be construed as limiting the scope of protection of the present application. Unless the context clearly indicates otherwise, the terms “a/an” and “said” indicating the singular should include the plural. As used in the present application, the terms “first” and “second” can be used interchangeably to distinguish one or one type of component from another or another type, and are not intended to indicate the location or importance of any individual component.

[0034] Any reference herein to “embodiment” means that specific features, structures or characteristics described with reference to any embodiment may be included in at least one embodiment of the present application. And the term “embodiment” referred in different places in the Specification does neither necessarily refer to the same embodiment nor serve as an independent or alternative embodiment that is mutually exclusive with other embodiments. Those skilled in the art understand explicitly and implicitly that the embodiments described herein can be used in combination with other embodiments.

[0035] 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.

[0036] 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.

[0037] First of all, embodiments of the present invention provide a decoder training method. FIG. 1 is a flowchart of a specific embodiment describing the decoder training method of the present invention, which method involves the following steps:

[0038] Step 110: acquire a first face image as a training image, which is a

low-resolution face image with a resolution less than a first preset value;

[0039] In this step, a face image with a lower resolution is acquired as a training image, for example, a face image with a resolution of 128×128 . The face image can be collected by an image collection device, for example, a face image collected by a camera. As under the circumstance where there is an uncontrollable environment, the collected face image may be not clear enough due to various reasons, the face image that is not clear enough may be used as the first face image described in the present application if it is necessary to obtain a high-resolution image of the face image that is not clear enough.

[0040] Step 120: decode the first face image by the decoder to form a high-dimensional vector corresponding to the features of the first face image, which high-dimensional vector has a dimension higher than a second preset value;

[0041] In this step, the decoder decodes the input low-resolution face image and obtains a high-dimensional vector corresponding to the features of the low-resolution face image, and the high-dimensional vector output by the decoder will be used as the input of the generator in the next step. For example, if the first face image has a resolution of 128×128 , the decoder decodes the face image and outputs a high-dimensional vector of 512×1 in this step. The specific second preset value of the high-dimensional vector mentioned here may be determined according to actual needs.

[0042] The input of the generator is a high-dimensional vector (one-dimensional), such as 512×1 (i.e., the output of the decoder), and the output is a high-resolution image (two-dimensional), such as 1024×1024 .

[0043] Step 130: generate a second face image by the generator according to the high-dimensional vector, which second face image is a high-resolution face image with a resolution higher than a third preset value;

[0044] In step 120, the high-dimensional vector, such as 512×1 , output by the decoder is used as the input of the generator. In this step, the generator generates a high-resolution second face image according to the high-dimensional vector, which second face image is clearer than the first face image and the third preset value of

whose specific resolution may be set specifically.

[0045] In this step, the generator may generate a high-resolution face image with a resolution of 1024×1024 according to the high-dimensional vector of 512×1 . In some embodiments, the face image generated by the generator may also be input to the adversarial network. No further description is made here since the present invention is not focused on the generation of confrontation mechanism.

[0046] Step 140: determine the value of loss function according to the second face image and adjust parameters of the decoder according to the value of loss function;

[0047] In the present application, the purpose of training the decoder is to generate a high-resolution face image corresponding to the input low-resolution face image. Therefore, decoder parameters may be adjusted according to the generated high-resolution face image by taking the similarity between the second face image and the target face image as the value of loss function.

[0048] The specific target face image may be the low-resolution first face image acquired in step 110, or other face image that is the same as or highly similar to the first face image.

[0049] Step 150: obtain the well-trained decoder when the value of loss function meets a preset condition.

[0050] It is believed that the value of loss function meets the preset condition and the trained decoder can be obtained when the generated second face image and the target face image share similarity to a preset degree. However, the training image will be further input to repeat the above training process if the value of loss function fails to meet the preset condition. Specifically, the preset condition to be met by the value of loss function is that the value of loss function is less than the preset value. And the loss function is determined according to the distance between the features of the generated face image and the features of the target face image.

[0051] In the embodiments of the present application, the loss function is adjusted using the second face image, as a result of which the second face image and the first face image that are finally output share similar features and the training decoder inputs a high-dimensional vector that is more aligned with the requirements so as to

input a high-resolution face image finally generated by the generator that is associated with the low-resolution face image.

[0052] Furthermore, the input low-resolution face image, i.e. the first face image, is used as the target image, and the value of loss function is determined according to the distance between the features of the first face image and the features of the second face image. Specifically, the distance between the features of the first face image and the features of the second face image is an L2 distance or a cos distance; and the value of the loss function satisfies the preset condition, i.e. the L2 distance or the cos distance, and is less than the preset value. Specifically, the first face image and the second face image may be input into the face recognizer respectively to obtain their respective feature values and calculate the distance between their respective features. It can be understood that the distance is less than the preset value, indicating that the similarity is higher than the preset value.

[0053] Furthermore, acquiring the first face image may include:

[0054] Acquiring a third face image whose resolution is higher than the resolution of the first face image; and down-sampling the third face image to obtain the first face image.

[0055] Specifically, the original high-resolution face image, i.e. the third face image, is used as the target image, in which case the loss function is determined according to the distance between the features of the third face image and the features of the second face image. The distance between the features of the third face image and the features of the second face image is an L2 distance or a cos distance; and the value of the loss function satisfies the preset condition that the L2 distance or the cos distance is less than the preset value.

[0056] A high-resolution face image is generated by the generator by means of acquiring a low-resolution face image by down-sampling the existing high-resolution face image and of using the decoder to process the low-resolution face image acquired by down-sampling the high-resolution face image. In this way, when calculating the loss, the loss can be determined and parameters of the decoder may be adjusted based on the similarity between the high-resolution face image generated by the generator

and the original high-resolution face image by comparing the two images. As the image involved in the comparison is an original high-resolution image, both the speed of training and the accuracy of training result can be further improved.

[0057] Secondly, embodiments of the present invention also provide a high-resolution face image generation method. FIG. 2 is a flowchart of a specific embodiment describing the high-resolution face image generation method of the present invention. The method involves the following steps:

[0058] Step 210: acquire a low-resolution face image to be processed;

[0059] For details of this step, please refer to step 110 in the embodiment shown in FIG. 1 to acquire a low-resolution face image, such as a 128*128 low-resolution face image.

[0060] Step 220: input the low-resolution face image to be processed to a decoder trained as described in the first aspect above, and obtain a high-dimensional vector corresponding to the features of the low-resolution face image to be processed that is output by the decoder;

[0061] In this step, a 128*128 low-resolution face image is input to the trained decoder for decoding, and a high-dimensional vector of 512*1 corresponding to the features of the low-resolution face is output by the decoder and is to be used as a subsequent input of the generator.

[0062] Step 230: generate a high-resolution face image by the generator according to the high-dimensional vector output by the decoder.

[0063] The high-dimensional vector of 512*1 output by the decoder is used by the generator as an input to generate a high-resolution face image with a resolution of 1024*1024.

[0064] In this embodiment, the trained decoder decodes the input low-resolution face image to obtain a high-dimensional vector corresponding to the features of the low-resolution face image and generates a high-resolution face image according to the high-dimensional vector, so that a high-resolution face image corresponding to the face image input can be formed. A corresponding high-dimensional vector is obtained through decoding the low-resolution face image by the decoder trained by the training

method of the present application and a high-resolution face image corresponding to the low-resolution face image is directly generated according to the high-dimensional vector, avoiding the shortcoming of the prior art in the process of transforming a low-resolution image into a high-resolution image based on filling in the low-resolution image and adding many new conjectural details. Through the method for generating high-resolution face images described in the present application, face images can be restored more realistically.

[0065] Thirdly, embodiments of the present invention also provide a decoder training device. FIG. 3 is a structure diagram of a specific embodiment describing the decoder training device of the present invention. The device is comprised of:

[0066] An input layer 301 designed to input a training image which is a first face image whose resolution is lower than a first preset value;

[0067] A decoder 302 designed to decode the training image and obtain a high-dimensional vector corresponding to the features of the training image, which high-dimensional vector has a dimension higher than a second preset value;

[0068] An output layer 303 designed to output the training result which is a high-dimensional vector corresponding to the features of the training image;

[0069] A generator 304 designed to receive the training result output by the output layer and form a second face image which is a high-resolution face image with a resolution higher than a third preset value;

[0070] A loss function value determination module 305 designed to determine the value of loss function;

[0071] An adjustment module 306 designed to adjust parameters of the decoder according to the value of the loss function and to obtain the trained decoder when the value of the loss function meets a preset condition.

[0072] In some embodiments, the value of the loss function is determined according to the distance between the features of the first face image and the features of the second face image.

[0073] In some embodiments, the training device further includes:

[0074] A third face image acquisition module designed to acquire a third face image

whose resolution is higher than the resolution of the first face image;

[0075] A down-sampling module designed to down-sample the third face image to obtain the first face image.

[0076] Specifically, the loss function value determination module determines the value of the loss function according to the distance between the features of the third face image and the features of the second face image.

[0077] In some embodiments, the device further includes a face recognition module which is designed to obtain the features of the first face image, the second face image or the third face image and which is a Light_CNN or a FaceNet.

[0078] In some embodiments, an antagonist can be placed following the generator. And given that the antagonist can be set based on the generation of confrontation in the prior art, no further description thereon is made in the present application.

[0079] In the embodiments of the present application, the loss function is determined and adjusted using the second face image, as a result of which the second face image and the first face image that are finally output share similar features and the training decoder inputs a high-dimensional vector that is more aligned with the requirements so as to input a high-resolution face image finally generated by the generator that is associated with the low-resolution face image. In the decoder training device, the modules included therein may be implemented with reference to the training method and specific steps shown in FIG. 1 to achieve the same technical effect.

[0080] Fourthly, embodiments of the present invention also provide a high-resolution face image generation device. FIG. 4 is a structure diagram of a specific embodiment describing the face image generation device of the present invention. The device is comprised of:

[0081] A low-resolution face image acquisition module 401 designed to acquire a low-resolution face image to be processed;

[0082] A decoder 402 which is a decoder trained by the training device described in the third aspect above;

[0083] A generator 403 designed to generate a high-resolution face image according to the high-dimensional vector output by the decoder.

[0084] The high-resolution face image generation device can be implemented with reference to the high-resolution face image generation method and specific steps shown in FIG. 2 to achieve the same technical effect.

[0085] Fifthly, embodiments of the present invention also provide a computer device which can be a neural network server. For details, please refer to FIG. 5 which is a basic structure diagram of the computer device described in the embodiment.

[0086] The computer device 5 is comprised of a memory 51, a processor 52 and a network interface 53 that communicate with each other via a system bus. It should be pointed out that only the computer device 5 having the components 51-53 is shown in this figure. But it should be understood that not all components shown are required to be implemented, and instead, more or fewer components may be implemented. Those skilled in the art can understand that the computer device 5 is a device that can automatically perform numerical calculation and/or information processing according to preset or stored instructions, which is comprised of hardware including but 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.

[0087] The computer device 5 may be a computing device such as a desktop computer, a notebook, a palmtop computer and a cloud server, and can interact with users through a keyboard, a mouse, a remote control, a touchpad or a voice control device.

[0088] The memory 51 is comprised of at least one type of readable storage medium, and can store an executable instruction controller, a microcontroller, a microprocessor or other data processing chip, including at least one type of readable storage medium. The readable storage medium includes non-volatile memory or volatile memory, such as flash memory, hard disk, multimedia card, card-type memory (e.g., SD or DX memory), 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.. The aforementioned RAM may include static RAM and dynamic RAM. In some embodiments, the memory 51 may be an

internal storage unit of the computer device 5, for example, a hard disk or a memory of the computer device 5. In other embodiments, the memory 51 may also be an external storage device of the computer device 5, for example, a plug-in hard disk, a Smart Memory Card (SMC), a Secure Digital (SD) card or a Flash Card on the computer device 5. Of course, the memory 51 may also include any internal storage unit and any external storage unit of the computer device 5. In this embodiment, the memory 51 is generally used to store the operating system and application software installed on the computer device 5, such as program codes for executing the face image generation method or the decoder training method described above. In addition, the memory 51 may also be used to temporarily store the data that has been or will be output.

[0089] 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, a Digital Signal Processing (DSP), an Application Specific Integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA) or other programmable logic device, discrete component gate or transistor logic device or discrete hardware component. And the general-purpose processor may be a microprocessor or any conventional processor, such as a single-chip microprocessor.

[0090] The processor 52 is generally used to control the overall operation of the computer device 5. In this embodiment, the memory 51 is used to store program codes or instructions, which program codes stored contain 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 the program codes executing the face image generation method or the decoder training method described above.

[0091] 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, and can be divided into address bus, data bus, control bus and so on. For ease of representation, only one thick line is used in the accompanying drawings to represent the buses involved, which does not indicate that there is only one or one type of bus.

[0092] Sixthly, embodiments of the present invention also provide a chip designed to implement the method described in the first aspect above. Specifically, the chip includes a processor designed to call and run a computer program from the memory to further make it possible to implement the face image generation method or the decoder training method above by the device on which the chip is installed.

[0093] Seventhly, 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 computer-readable program codes stored in the computer-readable medium can be read by the processor in computer, allowing the processor to perform the functional tasks set out in each step or any combination of steps as shown in the flowchart 1 and generate a device that perform the functional tasks set out in each block or any combination of blocks as shown in the diagram.

[0094] The computer-readable medium includes, but is not limited to, an electronic, magnetic, optical, electromagnetic or infrared memory, or a semiconductor system, device or unit, or any appropriate combination of the foregoing. The memory is used to store program codes or instructions, which program codes stored contain computer operation instructions. And the processor is used to execute the program codes or instructions stored in the memory.

[0095] For the definitions of the memory and the processor, reference may be made to the description of the foregoing embodiment of computer device, and no further details are explained herein. The computer-readable storage medium stores a computer program which makes it possible to implement the method described in any paragraph in the first aspect above when executed by a processor.

[0096] Finally, embodiments of the present invention also provide a computer program product containing a computer program instruction which makes it possible to implement the method described in in the first aspect above by computer.

[0097] Those skilled in the art can understand that the exemplary units and algorithms described in conjunction with the embodiments disclosed herein can be implemented by electronic hardware or a combination of software and electronic hardware. And whether those functions are implemented by hardware or software depends on the

specific application and design constraints of technical solutions. Those skilled in the art may use different ways to implement the described functions for each specific application, which implementation should not be deemed to go beyond the scope of the present application.

[0098] In the embodiments of the present application, the system, device and method described may be implemented in other ways. For example, unit division is only about the division of logical functions and there may be other divisions in actual implementation. As another example, multiple units or components may be combined or may be integrated into another system. In addition, different units may be directly or indirectly coupled. And the functional units in the embodiments of the present application may either be integrated into one processing unit or exist in the form of physical presence.

[0099] 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.

[0100] 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.

[0101] 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. A decoder training method comprising:

acquiring a first face image which is a low-resolution face image with a resolution lower than a first preset value;

decoding the first face image by a decoder to form a high-dimensional vector corresponding to features of the first face image, wherein the high-dimensional vector has a dimension higher than a second preset value;

generating a second face image by a generator according to the high-dimensional vector, wherein the second face image is a high-resolution face image with a resolution higher than a third preset value;

determining the value of loss function according to the second face image and adjusting parameters of the decoder according to the value of loss function; and

obtaining the well-trained decoder when the value of loss function meets a preset condition.

2. The method according to Claim 1, wherein the loss function is determined according to the distance between the features of the first face image and the features of the second face image.

3. The method according to Claim 2, wherein:

the distance between the features of the first face image and the features of the second face image is called L2 distance or cos distance;

and the value of the loss function satisfies the preset condition that the value of the loss function is less than the preset value.

4. The method according to Claim 1, wherein the acquiring the first face image involves:

acquiring a third face image whose resolution is higher than the resolution of the first face image;

down-sampling the third face image to obtain the first face image.

5. The method according to Claim 4, wherein the loss function is determined according to the distance between the features of the third face image and the features of the second face image.

6. The method according to Claim 5, wherein:

the distance between the features of the third face image and the features of the second face image is called L2 distance or cos distance;

the value of the loss function satisfies the preset condition that the value of the loss function is less than the preset value.

7. A high-resolution face image generation method, comprising:

acquiring a low-resolution face image to be processed;

inputting the low-resolution face image to be processed to a decoder trained as described in Claims 1-6, and obtaining a high-dimensional vector corresponding to the features of the low-resolution face image to be processed that is output by the decoder; and

generating a high-resolution face image by the generator according to the high-dimensional vector output by the decoder.

8. A decoder training device, comprising:

an input layer designed to input a training image which is a first face image whose resolution is lower than a first preset value;

a decoder designed to decode the training image and obtain a high-dimensional vector corresponding to the features of the training image, which high-dimensional vector has a dimension higher than a second preset value;

an output layer designed to output the training result which is a high-dimensional vector corresponding to the features of the training image;

a generator designed to receive the training result output by the output layer and form a second face image which is a high-resolution face image with a resolution higher than a third preset value;

a loss function value determination module designed to determine the value of loss function;

an adjustment module designed to adjust parameters of the decoder according to the

value of the loss function and to obtain the trained decoder when the value of the loss function meets a preset condition.

9. The device according to Claim 8, wherein the loss function value determination module determines the value of the loss function according to the distance between the features of the first face image and the features of the second face image.

10. The device according to Claim 8, further comprising:

a third face image acquisition module designed to acquire a third face image whose resolution is higher than the resolution of the first face image;

a down-sampling module designed to down-sample the third face image to obtain the first face image.

11. The device according to Claim 10, wherein the loss function value determination module of the device determines the value of the loss function according to the distance between the features of the third face image and the features of the second face image.

12. The device according to Claim 9 or Claim 11, further comprising a face recognition module;

wherein the face recognition module is designed to obtain the features of the first face image, the second face image or the third face image.

13. The device according to Claim 12, wherein the face recognition module of the device is a Light_CNN or a FaceNet.

14. A high-resolution face image generation device, comprising:

a low-resolution face image acquisition module designed to acquire a low-resolution face image to be processed;

a decoder which is a decoder trained by the training device described in Claims 8-13;

a generator designed to generate a high-resolution face image according to the high-dimensional vector output by the decoder.

15. A computer device, comprising: at least one processor, a memory, a communication interface and a communication bus, which processor, memory and communication interface communicate with each other through the communication bus; a memory which is coupled to the at least one processor and stores executable

instructions that make it possible to realize the method described in Claims 1-6 or Claim 7 when executed by the at least one processor.

16. A chip: a processor designed to call and run a computer program from the memory to further make it possible to implement the method described in Claims 1-6 or Claim 7 by the device on which the chip is installed.

17. A computer-readable storage medium which is characterized in that it stores a computer program which makes it possible to realize the method described in Claims 1-6 or Claim 7 when the computer program is executed by a processor.