IMAGE PROCESSING METHOD, SYSTEM, DEVICE, STORAGE MEDIUM, AND PROGRAM PRODUCT

The present disclosure claims priority to Chinese Patent Application No. 202410381709.4, filed with the China National Intellectual Property Administration on March 29, 2024, entitled "IMAGE PROCESSING METHOD, SYSTEM, DEVICE, STORAGE MEDIUM, AND PROGRAM PRODUCT", the entire content of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to the field of image processing technologies and, in particular, to an image processing method, a system, a device, a storage medium, and a program product.

BACKGROUND

A processor may perform super-resolution processing on an image to improve the image quality and definition of the image. For example, the processor may be a graphics processing unit (graphics processing unit, GPU), and the super-resolution processing may be artificial intelligence (artificial intelligence, AI) super-resolution processing.

Currently, the process of performing super-resolution processing on an image by a processor involves a large number of neural network computations. Each time a neural network computation is completed, a computation result needs to be stored in a memory chip of the processor, and before the next neural network computation, the computation result of the previous neural network computation needs to be read from the memory chip of the processor. For example, the memory chip of the processor may be a high bandwidth memory (high bandwidth memory, HBM). In the above process, a large number of read and write operations result in significant read and write overhead, thereby leading to low image processing efficiency.

SUMMARY

Various aspects of the present disclosure provide an image processing method, a system, a device, a storage medium, and a program product to improve image processing efficiency.

In a first aspect, an embodiment of the present disclosure provides an image processing method, including:

determining initial super-resolution image data of an initial image, where the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction;

performing transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and

generating target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, where the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

In a second aspect, an embodiment of the present disclosure provides an image processing method applied to an image processor, where the method includes:

determining initial super-resolution image data of an initial image, where the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction, and the initial image is an image to be subjected to artificial intelligence super-resolution;

performing transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and

generating target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, where the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

In a third aspect, an embodiment of the present disclosure provides an image processing apparatus, where the image processing apparatus includes a determination module, a transformation module, and a generation module, where

the determination module is configured to determine initial super-resolution image data of an initial image, where the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction;

the transformation module is configured to perform transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and

the generation module is configured to generate target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, where the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

In a fourth aspect, an embodiment of the present disclosure provides an image processing apparatus applied to an image processor, where the apparatus includes a determination module, a transformation module, and a generation module, where

the determination module is configured to determine initial super-resolution image data of an initial image, where the intermediate image data is image data obtained after performing super-resolution processing on the initial image in a channel direction, and the initial image is an image to be subjected to artificial intelligence super-resolution;

the transformation module is configured to perform transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and

the generation module is configured to generate target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, where the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

In a fifth aspect, an embodiment of the present disclosure provides an image processing system, where the image processing system includes an image processor and a memory chip, where

the image processor is configured to execute the method of any one of the first aspect to determine image data of a super-resolution image corresponding to an initial image, and store the image data of the super-resolution image into the memory chip.

In a sixth aspect, an embodiment of the present disclosure provides an image processing system, where the image processing system includes an image processor and a memory chip, where

the image processor is configured to execute the method of any one of the second aspect to determine image data of a super-resolution image corresponding to an initial image, and store the image data of the super-resolution image into the memory chip.

In a seventh aspect, an embodiment of the present disclosure provides an image processing device, including: a memory and a processor,

where the memory stores computer-executable instructions; and

the processor executes the computer-executable instructions stored in the memory, to cause the image processing device to perform the method of any one of the first aspect.

In an eighth aspect, an embodiment of the present disclosure provides an image processing device, including: a memory and a processor,

where the memory stores computer-executable instructions; and

the processor executes the computer-executable instructions stored in the memory, to cause the image processing device to perform the method of any one of the second aspect.

In a ninth aspect, an embodiment of the present disclosure provides a computer-readable storage medium, where computer-executable instructions are stored in the computer-readable storage medium, and when the computer-executable instructions are executed by a processor, the method of any one of the first aspect is implemented.

In a tenth aspect, an embodiment of the present disclosure provides a computer-readable storage medium, where computer-executable instructions are stored in the computer-readable storage medium, and when the computer-executable instructions are executed by a processor, the method of any one of the second aspect is implemented.

In an eleventh aspect, an embodiment of the present disclosure provides a computer program product including a computer program, where when the computer program is executed by a processor, the method of any one of the first aspect is implemented.

In a twelfth aspect, an embodiment of the present disclosure provides a computer program product including a computer program, where when the computer program is executed by a processor, the method of any one of the second aspect is implemented.

Embodiments of the present disclosure provide an image processing method, a system, a device, a storage medium, and a program product. Through the above method, initial super-resolution image data of an initial image may be determined; transformation processing may be performed on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and target image data may be generated according to the target pixel coordinates of the respective pixels in the initial super-resolution image

data. Through the above method, during the process of performing super-resolution processing on the initial image, pixel shuffle is not required, avoiding a large number of storage and read operations, thereby reducing read and write overhead, and improving image processing efficiency.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings described herein are used to provide a further understanding of the present disclosure and constitute a part of the present disclosure. The illustrative embodiments of the present disclosure and the description thereof are used to explain the present disclosure and do not constitute an improper limitation of the present disclosure. In the drawings:

FIG. 1 is a schematic diagram of a tensor according to an exemplary embodiment of the present disclosure;

FIG. 2 is a schematic flow diagram of a convolution operation and a pixel shuffle operation according to an exemplary embodiment of the present disclosure;

FIG. 3 is a schematic diagram of pixel shuffle according to an exemplary embodiment of the present disclosure;

FIG. 4 is a schematic flow diagram of an image processing method according to an exemplary embodiment of the present disclosure;

FIG. 5 is a schematic flow diagram of another image processing method according to an exemplary embodiment of the present disclosure;

FIG. 6 is a schematic diagram of image processing according to an exemplary embodiment of the present disclosure;

FIG. 7 is a schematic structural diagram of an image processing apparatus according to an exemplary embodiment of the present disclosure;

FIG. 8 is a schematic structural diagram of another image processing apparatus according to an exemplary embodiment of the present disclosure;

FIG. 9 is a schematic structural diagram of an image processing device according to an exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

It should be noted that the user information (including but not limited to user device information, user personal information, and the like) and data (including but not limited to

data used for analysis, stored data, displayed data, and the like) involved in the present disclosure are all information and data authorized by the user or fully authorized by all parties, and the collection, use, and processing of the relevant data need to comply with relevant laws, regulations, and standards, and corresponding operation entries are provided for the user to choose to authorize or refuse.

To make the objectives, technical solutions, and advantages of the present disclosure clearer, the technical solutions of the present disclosure are clearly and completely described below with reference to specific embodiments of the present disclosure and the corresponding drawings. Obviously, the described embodiments are merely some embodiments of the present disclosure, rather than all embodiments. Based on the embodiments of the present disclosure, all other embodiments obtained by those of ordinary skill in the art without creative effort fall within the protection scope of the present disclosure.

For ease of understanding, the technical terms involved in the embodiments of the present disclosure are first described.

1) Storage format of image data

There are generally two storage formats for image data: one is a channel-first storage format (NCHW), and the other is a channel-last storage format (NHWC), where:

N may indicate the number of images in a batch;

H may indicate the number of pixels in a vertical direction of the image;

W may indicate the number of pixels in a horizontal direction of the image;

C may indicate the number of channels of the image.

For an image, the image data may be stored as a three-dimensional tensor through the above two storage formats.

2) Spatial coordinates and linear offsets of elements in the tensor

The spatial coordinate of an element may indicate a coordinate position of the element in a tensor space.

The linear offset of an element may indicate an ordinal position of the element in the tensor. In a storage space of the tensor, the elements of the tensor may be linearly stored in ascending order of their linear offsets.

The linear offset of an element may be determined based on the spatial coordinate of the element and a stride array of the tensor to which the element belongs.

The stride array may include a stride of the tensor in each dimension. For a stride in any dimension, the stride may indicate the number of elements required to skip in the storage

space of the tensor along that dimension to obtain the next element. The stride array may be determined based on a shape of the tensor.

Exemplarily, assuming that the shape of a tensor is [H, W, C], the spatial coordinate of an element in the tensor in the H dimension is x, the coordinate of the element in the tensor in the W dimension is y, and the coordinate of the element in the tensor in the C dimension is z, then:

the stride array of the tensor may be: (W*C, C, 1);

the linear offset of the element may be: x* W*C + y*C + z*1.

Below, a three-dimensional tensor with a shape of [H, W, C], where H=2, W=2, and C=4, is used as an example, and the spatial coordinates and linear offsets of elements in the tensor are described with reference to FIG. 1.

FIG. 1 is a schematic diagram of a tensor according to an exemplary embodiment of the present disclosure. Referring to FIG. 1, the shape of a tensor A is [2, 2, 4], then the stride array of the tensor A may be (8, 4, 1). The tensor A may include 4 channels, and each channel may include a 2*2 matrix. Channel 0 may include elements a0, b0, c0, and d0; channel 1 may include elements a1, b1, c1, and d1; channel 2 may include elements a2, b2, c2, and d2; and channel 3 may include elements a3, b3, c3, and d3.

The spatial coordinates of the elements in the tensor A may be shown in Table 1:

Table 1

Elements	Spatial coordinates
Element a0	(0, 0, 0)
Element b0	(0, 1, 0)
Element c0	(1, 0, 0)
Element d0	(1, 1, 0)
Element a1	(0, 0, 1)
Element b1	(0, 1, 1)
Element c1	(1, 0, 1)
Element d1	(1, 1, 1)
Element a2	(0, 0, 2)
Element b2	(0, 1, 2)

Element c2	(1, 0, 2)
Element d2	(1, 1, 2)
Element a3	(0, 0, 3)
Element b3	(0, 1, 3)
Element c3	(1, 0, 3)
Element d3	(1, 1, 3)

Based on the stride array of the tensor A and the spatial coordinates of the elements, it may be determined that the linear offsets of the elements in the tensor A may be shown in Table 2:

Table 2

Elements	Linear offsets
Element a0	0
Element b0	4
Element c0	8
Element d0	12
Element a1	1
Element b1	5
Element c1	9
Element d1	13
Element a2	2
Element b2	6
Element c2	10
Element d2	14
Element a3	3
Element b3	7
Element c3	11
Element d3	15

As shown in FIG. 1, in ascending order of linear offsets, elements a0, a1, a2, ... d1 and d2 may be stored sequentially in the storage space of tensor A.

3) AI super-resolution

AI super-resolution technology is capable of increasing the number of vertical pixels and the number of horizontal pixels of an image to improve the definition of the image. Currently, AI super-resolution processing may be performed on an image by a processor. When the processor performs AI super-resolution processing on an image, a channel-last storage format is generally adopted, and the shape of a three-dimensional tensor corresponding to image data may be represented as [H, W, C].

During the AI super-resolution processing on an image by the processor, a large number of convolution operations (convolution) exist, and a pixel shuffle operation (pixel shuffle) is further performed after the convolution operations.

Below, with reference to FIG. 2, taking the shape of a three-dimensional tensor being [H, W, C] as an example, the process of performing a convolution operation and a pixel shuffle operation on a three-dimensional tensor by a processor is described.

FIG. 2 is a schematic flowchart of a convolution operation and a pixel shuffle operation provided by an exemplary embodiment of the present disclosure. In FIG. 2, rectangular boxes may represent neural network operators, elliptical boxes may represent storage spaces, and the dashed box may represent the pixel shuffle process.

Referring to FIG. 2, first, a processor may perform a convolution operation on a three-dimensional tensor with a shape of [H, W, C] through a convolution operator to obtain a three-dimensional tensor with a shape of [H, W, 4C], and stores the three-dimensional tensor with the shape of [H, W, 4C] into a storage space. Next, the processor may read, through reshape operator 1, the three-dimensional tensor stored by the convolution operator from the storage space, perform reshape processing on the read three-dimensional tensor to obtain a five-dimensional tensor with a shape of [H, W, 2, 2, C], and store the five-dimensional tensor with the shape of [H, W, 2, 2, C] into the storage space; next, the processor may read, through a transpose operator, the five-dimensional tensor stored by reshape operator 1 from the storage space, perform transpose processing on the read five-dimensional tensor to obtain a five-dimensional tensor with a shape of [2, H, 2, W, C], and store the five-dimensional tensor with the shape of [2, H, 2, W, C] into the storage space; next, the processor may read, through reshape operator 2, the five-dimensional tensor stored by the transpose operator from the storage space, perform reshape processing on the read five-dimensional tensor to obtain a three-dimensional tensor with a shape of [2H, 2W, C], and store the three-dimensional tensor with the shape of [2H, 2W, C] into the storage space.

As can be seen from FIG. 2, the processor first expands, through the convolution operation, the number of channels of an initial three-dimensional tensor (a three-dimensional

tensor with a shape of [H, W, C]) to 4 times the original number to obtain an intermediate three-dimensional tensor (a three-dimensional tensor with a shape of [H, W, 4C]). Then, through the pixel shuffle operation, the intermediate three-dimensional tensor is converted into a three-dimensional tensor with a shape of [2H, 2W, C], thereby completing super-resolution of the initial three-dimensional tensor in both the vertical and horizontal directions.

However, in the process of the above convolution operation and pixel shuffle operation, a large number of storage and reading operations exist. In a specific implementation process, the processor needs to write data to a memory chip of the processor and read data from the memory chip of the processor multiple times. Data read and write operations occupy a relatively large amount of time in the image processing process, resulting in relatively low image processing efficiency.

The inventors found that the process of performing pixel shuffle on a three-dimensional tensor by a processor is essentially a process of performing arrangement transformation on elements of the three-dimensional tensor. The elements in the three-dimensional tensor do not change, and only the arrangement order of the elements changes.

Below, with reference to FIG. 3, the process of pixel shuffle is described.

FIG. 3 is a schematic diagram of pixel shuffle provided by an exemplary embodiment of the present disclosure. Assuming H=1, W=1, and C=1, the shape of the three-dimensional tensor before pixel shuffle may be [1, 1, 4], and the shape of the three-dimensional tensor after pixel shuffle may be [2, 2, 1].

The left side of FIG. 3 may be a schematic diagram of the three-dimensional tensor before pixel shuffle, where each cube may represent one element in the three-dimensional tensor. The number of vertical elements of the three-dimensional tensor before pixel shuffle may be 1, the number of horizontal elements may be 1, and the number of channels may be 4.

The right side of FIG. 3 may be a schematic diagram of the three-dimensional tensor after pixel shuffle, where each cube may represent one element in the three-dimensional tensor. The number of vertical elements of the three-dimensional tensor after pixel shuffle may be 2, the number of horizontal elements may be 2, and the number of channels may be 1.

As can be seen from FIG. 3, before and after pixel shuffle, the elements in the three-dimensional tensor do not change, and only the arrangement order of the elements changes. It should be understood that the change in the arrangement order of the elements causes the spatial coordinates of the elements to change, which in turn causes the linear offsets of the elements to change.

In view of this, embodiments of the present disclosure propose the following concept: super-resolution image data (i.e., target image data) may be determined based on an image size of a super-resolution image (i.e., the image size of an image obtained through pixel shuffle in the related art), and pixel coordinates of respective pixels in image data before pixel shuffle (i.e., initial super-resolution image data). The above method can avoid performing pixel shuffle processing on an image, thereby avoiding a large number of storage and reading operations, reducing read and write overhead, and improving image processing efficiency.

Below, the technical solutions of the present disclosure are described in detail through specific embodiments. It should be noted that the following embodiments may exist independently or be combined with each other, and the same or similar content is not repeatedly described in different embodiments.

FIG. 4 is a schematic flowchart of an image processing method provided by an exemplary embodiment of the present disclosure. Referring to FIG. 4, the method may include:

S401, determine initial super-resolution image data of an initial image.

An executing entity of the embodiments of the present disclosure may be an image processing device, or a processing chip provided in the image processing device. For example, the processing chip may be a GPU. For ease of understanding, the image processing device serving as the executing entity is taken as an example in the following description.

The initial image may be an image to be subjected to super-resolution processing.

The initial super-resolution image data may be image data obtained after performing super-resolution processing on the initial image in a channel direction. The number of channels of an image corresponding to the initial super-resolution image data is greater than the number of channels of the initial image.

In this embodiment, an initial super-resolution image size corresponding to the initial super-resolution image data may be preset, and super-resolution processing may be performed on the initial image in the channel direction according to the initial super-resolution image size to obtain the initial super-resolution image data. That is, the number of channels of the initial image may be expanded according to the initial super-resolution image size to obtain the initial super-resolution image data.

For example, assuming that an image size of the initial image is [H, W, C] and the initial super-resolution image size is [H, W, 4C], the number of channels of the initial image may be expanded to 4 times the original number to obtain the initial super-resolution image data.

S402, perform transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data.

The target image size may be an image size of a super-resolution image corresponding to the initial image. In this embodiment, the target image size may be set according to image processing requirements. For example, assuming that the image size of the initial image is [H, W, C] and it is required to expand, through super-resolution processing, the number of vertical pixels of the initial image to 2 times the original number of the vertical pixels and expand the number of horizontal pixels of the initial image to 2 times the original number of the horizontal pixels, the target image size may be determined to be [2H, 2W, C].

The pixel coordinates of the respective pixels in the initial super-resolution image data may be spatial coordinates of the respective pixels in a tensor corresponding to the initial super-resolution image data.

For example, assuming that the initial super-resolution image size is [H, W, 4C], a three-dimensional tensor with a size of [H, W, 4C] may be used to represent the initial super-resolution image data. For any pixel in the initial super-resolution image data, the pixel coordinate of the pixel may be the spatial coordinate of the pixel in the above three-dimensional tensor.

The target pixel coordinates may be the spatial coordinates of the respective pixels in a three-dimensional tensor corresponding to the super-resolution image of the initial image.

In this embodiment, relative to the image size of the initial image, the number of vertical elements and the number of horizontal elements of the initial super-resolution image size remain unchanged, and the number of channels is increased. For example, the image size of the initial image may be [H, W, C], and the initial super-resolution image size may be [H, W, 4C]. Relative to the image size of the initial image, the number of vertical elements of the target image size is increased, the number of horizontal elements is increased, and the number of channels remains unchanged. For example, the image size of the initial image may be [H, W, C], and the target image size may be [2H, 2W, C]. The inventors have found that the pixels included in the image data corresponding to the target image size are the same as the pixels included in the initial super-resolution image data, and only the arrangement order of the respective pixels in the image data corresponding to the target image size differs from the arrangement order of the respective pixels in the initial super-resolution image data. If the initial super-resolution image size and the target image size are determined, a transformation relationship between the spatial coordinates corresponding to the initial super-resolution

image size and the spatial coordinates corresponding to the target image size may be determined according to the initial super-resolution image size and the target image size.

In this embodiment, the initial super-resolution image size and the target image size may be set based on image processing requirements, the coordinate transformation relationship may be determined according to the initial super-resolution image size and the target image size, and transformation processing may be performed on the pixel coordinates of the respective pixels in the initial super-resolution image data according to the coordinate transformation relationship, to obtain the target pixel coordinates of the respective pixels in the initial super-resolution image data.

It should be noted that for the specific implementations of determining the coordinate transformation relationship and performing transformation processing on the pixel coordinates of the respective pixels in the initial super-resolution image data according to the coordinate transformation relationship, reference may be made to the embodiment of FIG. 5, and details are not repeated here.

S403, generate target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data.

The target image data is image data of the super-resolution image corresponding to the initial image.

The target pixel coordinates of the respective pixels in the initial super-resolution image data may be the spatial coordinates of the respective pixels in a three-dimensional tensor corresponding to the image data of the super-resolution image of the initial image.

As can be known from the embodiment of FIG. 1, the elements in a tensor may be sequentially stored in a storage space in order. In this embodiment, the pixels included in the target image data are the same as the pixels included in the initial super-resolution image data. The image processing device may determine the storage order of the respective pixels based on the target pixel coordinates of the respective pixels in the initial super-resolution image data and the target image size, and store the respective pixels in the initial super-resolution image data according to the storage order of the respective pixels, to generate the target image data.

It should be noted that for the method of determining the storage order of the respective pixels based on the target pixel coordinates of the respective pixels in the initial super-resolution image data and the target image size, reference may be made to the embodiment of FIG. 1, and details are not repeated here.

In the image processing method provided by this embodiment, the image processing device may: determine the initial super-resolution image data of the initial image; perform transformation processing on the pixel coordinates of the respective pixels in the initial super-resolution image data according to the target image size, to obtain the target pixel coordinates of the respective pixels in the initial super-resolution image data; and generate the target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data. Through the above method, during the super-resolution processing on the initial image, pixel shuffle is not required, avoiding a large number of storage and reading operations, thereby reducing read and write overhead, and improving image processing efficiency.

In another optional embodiment, the present disclosure further provides an image processing method applied to an image processor, where the method includes: determining initial super-resolution image data of an initial image, where the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction, and the initial image is an image to be subjected to artificial intelligence super-resolution; performing transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and generating target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, where the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

On the basis of the above embodiments, in an image processing method provided by the embodiments of the present disclosure, one-dimensional coordinates of respective pixels in an intermediate image may further be determined, and the target image data may be generated according to the one-dimensional coordinates of the respective pixels. The image processing method provided by the embodiments of the present disclosure is further described below with reference to FIG. 5.

FIG. 5 is a schematic flowchart of another image processing method provided by an exemplary embodiment of the present disclosure. Referring to FIG. 5, the method may include:

S501, determine initial super-resolution image data of an initial image.

The executing entity of the embodiments of the present disclosure may be an image processing device, or a processing chip disposed in the image processing device. For

example, the processing chip may be a GPU. For ease of understanding, the image processing device serving as the executing entity is taken as an example in the following description.

It should be noted that for the specific implementation of S501, reference may be made to S401, and details are not repeated here.

S502, determine an initial super-resolution image size corresponding to the initial super-resolution image data.

The initial super-resolution image data may be represented by a tensor. The initial super-resolution image size corresponding to the initial super-resolution image data may be a size of the tensor corresponding to the initial super-resolution image data.

In this embodiment, the image processing device may perform convolution processing on the initial image to achieve the purpose of expanding the number of channels of the initial image without changing the number of vertical elements and the number of horizontal elements corresponding to the initial image. Further, the image processing device may perform convolution processing on the initial image to expand the number of channels of the initial image to 4 times the original number.

Specifically, the number of channels corresponding to the initial super-resolution image data may be 4 times the number of channels corresponding to the initial image, the number of vertical elements corresponding to the initial super-resolution image data is the same as the number of vertical elements corresponding to the initial image, and the number of horizontal elements corresponding to the initial super-resolution image data is the same as the number of horizontal elements corresponding to the initial image.

Exemplarily, assuming that an initial image size corresponding to the initial image is [H, W, C], the initial super-resolution image size corresponding to the initial super-resolution image data may be [H, W, 4C].

S503, determine a coordinate transformation relationship according to the initial super-resolution image size and the target image size.

The target image size may be an image size of a super-resolution image corresponding to the initial image.

It should be noted that, as can be known from the embodiment of FIG. 2, the pixel shuffle process included in the image super-resolution processing process may be a process of changing the arrangement order of elements in a tensor and changing the size of the tensor. As can be known from FIG. 2, after pixel shuffle is performed on a tensor, the number of channels may become one quarter of the original number of channels, the number of vertical elements may become twice the original number of vertical elements, and the number of

horizontal elements may also become twice the original number of horizontal elements. If an image size before pixel shuffle is [H, W, 4C], an image size after pixel shuffle may be [2H, 2W, C]. In this embodiment, pixel shuffle may not be performed in the image super-resolution processing process, but the image size after pixel shuffle in the related art may be determined as the target image size.

The coordinate transformation relationship is used to convert three-dimensional pixel coordinates corresponding to the initial super-resolution image size into three-dimensional pixel coordinates corresponding to the target image size.

The coordinate transformation relationship includes a vertical coordinate transformation relationship, a horizontal coordinate transformation relationship, and a channel coordinate transformation relationship.

The three-dimensional pixel coordinates corresponding to the initial super-resolution image size may be spatial coordinates of respective elements in a tensor corresponding to the initial super-resolution image data.

The three-dimensional pixel coordinates corresponding to the target image size may be spatial coordinates of respective elements in a tensor corresponding to the super-resolution image of the initial image.

In this embodiment, the initial super-resolution image size may be represented as [H, W, 4C], and the target image size may be [2H, 2W, C]. The three-dimensional pixel coordinates corresponding to the initial super-resolution image size may be represented by (p, q, r), and the three-dimensional pixel coordinates corresponding to the target image size may be represented by (i, j, k), where

$p \in [0, H)$, $q \in [0, W)$, $r \in [0, 4C)$; $i \in [0, 2H)$, $j \in [0, 2W)$, $k \in [0, C)$, then

the vertical coordinate transformation relationship may be: $i=(r/(2C))*H+p$;

the horizontal coordinate transformation relationship may be: $j=(r\%(2C)/C)*W+q$;

the channel coordinate transformation relationship may be: $k=r\%(2C)\%(C)$, where / is a floor division operator and % is a modulo operator.

Specifically, the coordinate transformation relationship may include: $i=(r/(2C))*H+p$, $j=(r\%(2C)/C)*W+q$, $k=r\%(2C)\%(C)$.

S504, for any pixel in the initial super-resolution image data, determine a target pixel coordinate of the pixel according to a pixel coordinate of the pixel in the initial super-resolution image data and the coordinate transformation relationship.

In this embodiment, a target vertical coordinate may be determined according to a vertical coordinate in initial super-resolution pixel coordinates and the vertical coordinate transformation relationship; a target horizontal coordinate is determined according to a horizontal coordinate in the initial super-resolution pixel coordinates and the horizontal coordinate transformation relationship; a target channel coordinate is determined according to a channel coordinate in the initial super-resolution pixel coordinates and the channel coordinate transformation relationship; and the target pixel coordinate, including the target vertical coordinate, the target horizontal coordinate, and the target channel coordinate, is determined.

Specifically, according to the three-dimensional pixel coordinates of the respective pixels corresponding to the initial super-resolution image data and the coordinate transformation relationship in S503, the target pixel coordinates of the respective pixels may be determined.

Exemplarily, assuming that H=1, W=1, C=1, then $p \in [0, 1)$, $q \in [0, 1)$, $r \in [0, 4)$; $i \in [0, 2)$, $j \in [0, 2)$, $k \in [0, 1)$, where

if the three-dimensional pixel coordinates corresponding to the initial super-resolution image size are (0, 0, 0), the target pixel coordinates may be (0, 0, 0);

if the three-dimensional pixel coordinates corresponding to the initial super-resolution image size are (0, 0, 1), the target pixel coordinates may be (0, 1, 0);

if the three-dimensional pixel coordinates corresponding to the initial super-resolution image size are (0, 0, 2), the target pixel coordinates may be (1, 0, 0);

if the three-dimensional pixel coordinates corresponding to the initial super-resolution image size are (0, 0, 3), the target pixel coordinates may be (1, 1, 0).

S505, determine one-dimensional coordinates of the respective pixels in the initial super-resolution image according to the target pixel coordinates of the respective pixels in the initial super-resolution image.

The one-dimensional coordinates of the respective pixels in the initial super-resolution image may be linear offsets of the respective pixels in the image data of the super-resolution image corresponding to the initial image.

In this embodiment, the method of determining the one-dimensional coordinate of each pixel in the initial super-resolution image is the same. Using any one pixel as an example, the method of determining the one-dimensional coordinate of a pixel in the initial super-resolution image according to the target pixel coordinate of the pixel is described below.

For any pixel in the initial super-resolution image, a coordinate mapping relationship may be determined, where the coordinate mapping relationship is used to map a three-dimensional coordinate to a one-dimensional coordinate; and the one-dimensional coordinate of the pixel is determined according to the target pixel coordinate of the pixel and the coordinate mapping relationship.

The target pixel coordinate of the pixel may be the spatial coordinates of the pixel in the three-dimensional tensor corresponding to the super-resolution image.

Specifically, for any pixel in the initial super-resolution image, the target pixel coordinate of the pixel may be mapped to the one-dimensional coordinate through the coordinate mapping relationship.

In this embodiment, the target pixel coordinate may be represented by (i, j, k), and the target image size may be [2H, 2W, C], then the stride array corresponding to the target image size may be (2W*C, C, 1), and the coordinate mapping relationship may be:

the one-dimensional coordinate of the pixel=i*2W*C+j* C+k.

Exemplarily, assuming that H=1, W=1, C=1, then i∈[0, 2), j∈[0, 2), k∈[0, 1), where

if the target pixel coordinate may be (0, 0, 0), the one-dimensional coordinate may be 0;

if the target pixel coordinate may be (0, 1, 0), the one-dimensional coordinate may be 1;

if the target pixel coordinate may be (1, 0, 0), the one-dimensional coordinate may be 2;

if the target pixel coordinate may be (1, 1, 0), the one-dimensional coordinate may be 3.

S506, generate target image data according to the one-dimensional coordinates of the respective pixels in the initial super-resolution image and based on the pixel values of the respective pixels in the initial super-resolution image data.

In this embodiment, for any pixel in the initial super-resolution image data, the pixel value of the pixel in the initial super-resolution image data is the same as the pixel value of the pixel in the super-resolution image.

In a specific implementation, the pixels in the initial super-resolution image may be sorted in ascending order of the one-dimensional coordinates, to obtain the target image data.

In this embodiment, the target image data may also be stored into a preset storage space. Specifically, the respective pixels in the initial super-resolution image may be stored into the preset storage space in ascending order of the one-dimensional coordinates.

Optionally, in this embodiment, the super-resolution image may be generated according to the target image data.

In the image processing method provided by the present embodiment, an image processing device may: determine initial super-resolution image data of an initial image; determine an initial super-resolution image size corresponding to the initial super-resolution image data; determine a coordinate transformation relationship according to the initial super-resolution image size and a target image size; for any pixel in the initial super-resolution image data, determine a target pixel coordinate of the pixel according to a pixel coordinate of the pixel in the initial super-resolution image data and the coordinate transformation relationship; determine one-dimensional coordinates of the respective pixels in the initial super-resolution image according to the target pixel coordinates of the respective pixels in the initial super-resolution image; and generate target image data according to the one-dimensional coordinates of the respective pixels in the initial super-resolution image and based on pixel values of the respective pixels in the initial super-resolution image data. Through the above method, during image super-resolution processing, pixel shuffle is not required, avoiding a large number of storage and read operations, thereby reducing read and write overhead, and improving image processing efficiency.

On the basis of any of the above embodiments, the image processing method provided by the embodiments of the present disclosure is described below with reference to FIG. 6 through specific examples.

Assuming H=2, W=2, and C=1, the initial super-resolution image size may be [2, 2, 4], and the target image size may be [4, 4, 1]. Assuming that three-dimensional pixel coordinates corresponding to the initial super-resolution image size may be represented by (p, q, r), and three-dimensional pixel coordinates corresponding to the target image size may be represented by (i, j, k), then:

the vertical coordinate transformation relationship may be: i=(r/2)*2+p;

the horizontal coordinate transformation relationship may be: j=(r%(2)/1)*2+q;

the channel coordinate transformation relationship may be: k=r%(2)%(1); where / is a floor division operator, and % is a modulo operator.

In addition, a stride array corresponding to the target image size may be (4, 4, 1), and the coordinate mapping relationship may be:

One-dimensional coordinate of the pixel = i*4 + j + k.

FIG. 6 is a schematic diagram of image processing provided by an exemplary embodiment of the present disclosure. Referring to FIG. 6, a tensor corresponding to the initial super-resolution image may include 4 channels, and each channel may include a 2*2 matrix. Channel 0 may include elements a0, b0, c0, and d0, channel 1 may include elements

a1, b1, c1, and d1, channel 2 may include elements a2, b2, c2, and d2, and channel 3 may include elements a3, b3, c3, and d3. The spatial coordinates of the pixels in the initial super-resolution image data may be as shown in Table 3:

Table 3

Elements	Three-dimensional pixel coordinates corresponding to the initial super-resolution image size
Element a0	(0, 0, 0)
Element b0	(0, 1, 0)
Element c0	(1, 0, 0)
Element d0	(1, 1, 0)
Element a1	(0, 0, 1)
Element b1	(0, 1, 1)
Element c1	(1, 0, 1)
Element d1	(1, 1, 1)
Element a2	(0, 0, 2)
Element b2	(0, 1, 2)
Element c2	(1, 0, 2)
Element d2	(1, 1, 2)
Element a3	(0, 0, 3)
Element b3	(0, 1, 3)
Element c3	(1, 0, 3)
Element d3	(1, 1, 3)

According to the coordinate transformation relationship and the three-dimensional pixel coordinates corresponding to the initial super-resolution image size, the three-dimensional pixel coordinates corresponding to the target image size may be determined to be as shown in Table 4:

Table 4

Elements	Three-dimensional pixel coordinates corresponding to the target image size
Element a0	(0, 0, 0)
Element b0	(0, 1, 0)
Element c0	(1, 0, 0)
Element d0	(1, 1, 0)
Element a1	(0, 2, 0)
Element b1	(0, 3, 0)
Element c1	(1, 2, 0)
Element d1	(1, 3, 0)
Element a2	(2, 0, 0)
Element b2	(2, 1, 0)
Element c2	(3, 0, 0)
Element d2	(3, 1, 0)
Element a3	(2, 2, 0)
Element b3	(2, 3, 0)
Element c3	(3, 2, 0)
Element d3	(3, 3, 0)

As can be known from Table 4, the tensor corresponding to the target image may include one channel, and the channel may include a 4*4 matrix. The channel may include elements a0, b0, c0, d0, a1, b1, c1, d1, a2, b2, c2, d2, a3, b3, c3, and d3. For the positions of the elements in the tensor corresponding to the target image, a reference may be made to FIG. 6.

According to the coordinate mapping relationship and the three-dimensional pixel coordinates corresponding to the target image size, the one-dimensional coordinates of the respective pixels may be determined as shown in Table 5:

Table 5

Elements	One-dimensional coordinates
Element a0	0
Element b0	1
Element c0	4
Element d0	5
Element a1	2
Element b1	3
Element c1	6
Element d1	7
Element a2	8
Element b2	9
Element c2	12
Element d2	13
Element a3	10
Element b3	11
Element c3	14
Element d3	15

As can be known from the Table 5, the respective pixels are arranged in ascending order of one-dimensional coordinates as follows: a0, b0, a1, b1, c0, d0, c1, d1, a2, b2, a3, b3, c2, d2, c3, and d3. Referring to FIG. 6, the target image data may be as shown in FIG. 6.

FIG. 7 is a schematic structural diagram of an image processing apparatus according to an exemplary embodiment of the present disclosure. Referring to FIG. 7, the image processing apparatus 10 includes: a determination module 11, a transformation module 12, and a generation module 13, where:

the determination module 11 is configured to determine initial super-resolution image data of an initial image, where the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction;

the transformation module 12 is configured to perform transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data;

the generation module 12 is configured to generate target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, where the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

The image processing apparatus provided by the embodiments of the present disclosure can execute the technical solutions shown in the above method embodiments, of which the implementation principles and beneficial effects are similar, and details are not repeated here.

In a possible implementation, the transformation module 12 is specifically configured to:

determine an initial super-resolution image size corresponding to the initial super-resolution image data;

determine a coordinate transformation relationship according to the initial super-resolution image size and the target image size, where the coordinate transformation relationship is used to convert three-dimensional pixel coordinates corresponding to the initial super-resolution image size into three-dimensional pixel coordinates corresponding to the target image size;

for any pixel in the initial super-resolution image data, determine a target pixel coordinate of the pixel according to a pixel coordinate of the pixel in the initial super-resolution image data and the coordinate transformation relationship.

In a possible implementation, the coordinate transformation relationship includes a vertical coordinate transformation relationship, a horizontal coordinate transformation relationship, and a channel coordinate transformation relationship; the transformation module 12 is specifically configured to:

determine a target vertical coordinate according to a vertical coordinate in the initial super-resolution pixel coordinates and the vertical coordinate transformation relationship;

determine a target horizontal coordinate according to a horizontal coordinate in the initial super-resolution pixel coordinates and the horizontal coordinate transformation relationship;

determine a target channel coordinate according to a channel coordinate in the initial super-resolution pixel coordinates and the channel coordinate transformation relationship;

determine the target pixel coordinate including the target vertical coordinate, the target horizontal coordinate, and the target channel coordinate.

In a possible implementation, the generation module 13 is specifically configured to:

determine one-dimensional coordinates of the respective pixels in the initial super-resolution image according to the target pixel coordinates of the respective pixels in the initial super-resolution image;

generate the target image data according to the one-dimensional coordinates of the respective pixels in the initial super-resolution image and based on pixel values of the respective pixels in the initial super-resolution image data.

In a possible implementation, for any pixel in the initial super-resolution image, the generation module 13 is specifically configured to:

determine a coordinate mapping relationship, where the coordinate mapping relationship is used to map a three-dimensional coordinate to a one-dimensional coordinate;

determine a one-dimensional coordinate of the pixel according to the target pixel coordinate of the pixel and the coordinate mapping relationship.

In a possible implementation, the generation module 13 is specifically configured to:

sorting the pixels in the initial super-resolution image in ascending order of the one-dimensional coordinates, to obtain the target image data.

In a possible implementation, the determination module 11 is specifically configured to:

perform convolution processing on the initial image to obtain the initial super-resolution image data.

FIG. 8 is a structural schematic diagram of another image processing apparatus according to an exemplary embodiment of the present disclosure. Referring to FIG. 8, based on FIG. 7, the image processing apparatus 10 further includes a storage module 14, and the storage module 14 is configured to:

store the target image data into a preset storage space.

In a possible implementation, the generation module 13 is further configured to:

generate the super-resolution image according to the target image data.

The image processing apparatus provided by the embodiments of the present disclosure can execute the technical solutions shown in the above method embodiments, of which the implementation principles and beneficial effects are similar, and details are not repeated here.

FIG. 9 is a schematic structural diagram of an image processing device according to an exemplary embodiment of the present disclosure. Referring to FIG. 9, the image processing

device 20 may include a processor 21 and a memory 22. Exemplarily, the processor 21, the memory 22, and various components are interconnected through a bus 23.

The memory 22 stores computer-executable instructions.

The processor 21 executes the computer-executable instructions stored in the memory 22, such that the processor 21 executes the method as shown in the above method embodiments.

Accordingly, an embodiment of the present disclosure provides an image processing system, where the image processing system includes an image processor and a memory chip, where:

the image processor is configured to execute the method as shown in the above method embodiments to determine image data of a super-resolution image corresponding to an initial image, and store the image data of the super-resolution image into the memory chip.

Accordingly, an embodiment of the present disclosure provides a computer-readable storage medium, where computer-executable instructions are stored in the computer-readable storage medium, and when the computer-executable instructions are executed by a processor, the method described in the above method embodiments is implemented.

Accordingly, an embodiment of the present disclosure further provides a computer program product, including a computer program, where when the computer program is executed by a processor, the method as shown in the above method embodiments can be implemented.

Those skilled in the art should understand that the embodiments of the present disclosure may be provided as methods, systems, or computer program products. Accordingly, the present disclosure may be embodied in the form of a complete hardware embodiment, a complete software embodiment, or an embodiment combining software and hardware aspects. Moreover, the present disclosure may be embodied in the form of a computer program product implemented on one or more computer-usable storage media (including but not limited to disk storage, CD-ROM, optical storage, and the like) containing computer-usable program codes.

The present disclosure is described with reference to flowcharts and/or block diagrams of methods, devices (systems), and computer program products according to embodiments of the present disclosure. It should be understood that each process and/or block in the flowcharts and/or block diagrams, and combinations of processes and/or blocks in the flowcharts and/or block diagrams, may be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general-purpose

computer, a special-purpose computer, an embedded processor, or other programmable data processing device to produce a machine, such that the instructions executed by the processor of the computer or other programmable data processing device create an apparatus for implementing the functions specified in one or more processes of the flowcharts and/or one or more blocks of the block diagrams.

These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing device to operate in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including an instruction apparatus that implements the functions specified in one or more processes of the flowcharts and/or one or more blocks of the block diagrams.

These computer program instructions may also be loaded onto a computer or other programmable data processing device, such that a series of operational steps are executed on the computer or other programmable device to produce computer-implemented processes, such that the instructions executed on the computer or other programmable device provide steps for implementing the functions specified in one or more processes of the flowcharts and/or one or more blocks of the block diagrams.

In a typical configuration, a computing device includes one or more processors (CPU), input/output interfaces, network interfaces, and memory.

The memory may include non-permanent memory in a computer-readable medium, random access memory (RAM), and/or non-volatile memory or the like, such as read-only memory (ROM) or flash memory (flash RAM). The memory is an example of a computer-readable medium.

Computer-readable media include permanent and non-permanent, removable and non-removable media implementable by any method or technology for information storage. The information may be computer-readable instructions, data structures, program modules, or other data. Examples of computer storage media include, but are not limited to, phase change memory (PRAM), static random access memory (SRAM), dynamic random access memory (DRAM), other types of random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), flash memory or other memory technologies, compact disc read-only memory (CD-ROM), digital versatile disc (DVD) or other optical storage, magnetic cassettes, magnetic tape storage or other magnetic storage devices, or any other non-transmission media usable for storing information accessible by a computing device. As defined herein, computer-readable media do not

include transitory computer-readable media (transitory media), such as modulated data signals and carrier waves.

It should further be noted that the terms "including," "comprising," or any other variations thereof are intended to cover non-exclusive inclusion, such that a process, method, article, or device including a series of elements includes not only those elements but also other elements not explicitly listed, or also includes elements inherent to such a process, method, article, or device. Without further limitations, an element defined by the phrase "including a ..." does not preclude the existence of additional identical elements in the process, method, article, or device that includes the element.

The above descriptions are merely embodiments of the present disclosure and are not intended to limit the present disclosure. For those skilled in the art, the present disclosure is susceptible to various modifications and variations. Any modifications, equivalent replacements, improvements, and the like made within the spirit and principles of the present disclosure should be included within the scope of the claims of the present disclosure.

CLAIMS

1. An image processing method, comprising:

determining initial super-resolution image data of an initial image, wherein the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction;

performing transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and

generating target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, wherein the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

2. An image processing method applied to an image processor, wherein the method comprises:

determining initial super-resolution image data of an initial image, wherein the initial super-resolution image data is image data obtained after performing super-resolution processing on the initial image in a channel direction, and the initial image is an image to be subjected to artificial intelligence super-resolution;

performing transformation processing on pixel coordinates of respective pixels in the initial super-resolution image data according to a target image size, to obtain target pixel coordinates of the respective pixels in the initial super-resolution image data; and

generating target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data, wherein the target image data is image data of a super-resolution image corresponding to the initial image, and an image size of the super-resolution image is the target image size.

3. The method according to claim 1 or 2, wherein the performing the transformation processing on the pixel coordinates of the respective pixels in the initial super-resolution image data according to the target image size to obtain the target pixel coordinates of the respective pixels in the initial super-resolution image data comprises:

determining an initial super-resolution image size corresponding to the initial super-resolution image data;

determining a coordinate transformation relationship according to the initial super-resolution image size and the target image size, wherein the coordinate transformation

relationship is used to convert three-dimensional pixel coordinates corresponding to the initial super-resolution image size into three-dimensional pixel coordinates corresponding to the target image size; and

for any pixel in the initial super-resolution image data, determining a target pixel coordinate of the pixel according to a pixel coordinate of the pixel in the initial super-resolution image data and the coordinate transformation relationship.

4. The method according to claim 3, wherein the coordinate transformation relationship comprises a vertical coordinate transformation relationship, a horizontal coordinate transformation relationship, and a channel coordinate transformation relationship; and the determining the target pixel coordinate of the pixel according to the pixel coordinate of the pixel in the initial super-resolution image data and the coordinate transformation relationship comprises:

determining a target vertical coordinate according to a vertical coordinate in the initial super-resolution pixel coordinates and the vertical coordinate transformation relationship;

determining a target horizontal coordinate according to a horizontal coordinate in the initial super-resolution pixel coordinates and the horizontal coordinate transformation relationship;

determining a target channel coordinate according to a channel coordinate in the initial super-resolution pixel coordinates and the channel coordinate transformation relationship; and

determining the target pixel coordinate comprising the target vertical coordinate, the target horizontal coordinate, and the target channel coordinate.

5. The method according to any one of claims 1 to 4, wherein the generating the target image data according to the target pixel coordinates of the respective pixels in the initial super-resolution image data comprises:

determining one-dimensional coordinates of the respective pixels in the initial super-resolution image according to the target pixel coordinates of the respective pixels in the initial super-resolution image; and

generating the target image data according to the one-dimensional coordinates of the respective pixels in the initial super-resolution image and based on pixel values of the respective pixels in the initial super-resolution image data.

6. The method according to claim 5, wherein for any pixel in the initial super-resolution image, determining a one-dimensional coordinate of the pixel according to the target pixel coordinate of the pixel in the initial super-resolution image comprises:

determining a coordinate mapping relationship, wherein the coordinate mapping relationship is used to map a three-dimensional coordinate to a one-dimensional coordinate; and

determining the one-dimensional coordinate of the pixel according to the target pixel coordinate of the pixel and the coordinate mapping relationship.

7. The method according to claim 5 or 6, wherein the generating the target image data according to the one-dimensional coordinates of the respective pixels in the initial super-resolution image and based on the pixel values of the respective pixels in the initial super-resolution image data comprises:

sorting the pixels in the initial super-resolution image in ascending order of the one-dimensional coordinates to obtain the target image data.

8. The method according to any one of claims 1 to 7, wherein the determining the initial super-resolution image data of the initial image comprises:

performing convolution processing on the initial image to obtain the initial super-resolution image data.

9. The method according to any one of claims 1 to 8, wherein the method further comprises:

storing the target image data into a preset storage space.

10. The method according to any one of claims 1 to 9, wherein the method further comprises:

generating the super-resolution image according to the target image data.

11. An image processing system, wherein the image processing system comprises an image processor and a memory chip, wherein

the image processor is configured to execute the method according to any one of claims 1 to 10 to determine image data of a super-resolution image corresponding to an initial image, and store the image data of the super-resolution image into the memory chip.

12. An image processing device, comprising: a memory and a processor, wherein

the memory stores computer-executable instructions; and

the processor executes the computer-executable instructions stored in the memory to cause the image processing device to perform the method according to any one of claims 1 to 10.

13. A computer-readable storage medium, wherein computer-executable instructions are stored in the computer-readable storage medium, and when the computer-executable

instructions are executed by a processor, the method according to any one of claims 1 to 10 is implemented.

14. A computer program product, comprising a computer program, wherein when the computer program is executed by a processor, the method according to any one of claims 1 to 10 is implemented.