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(54) **METHODS AND APPARATUS FOR BLENDING IMAGES**

(76) Inventor: **Vikas Yadav**, Noida (IN)

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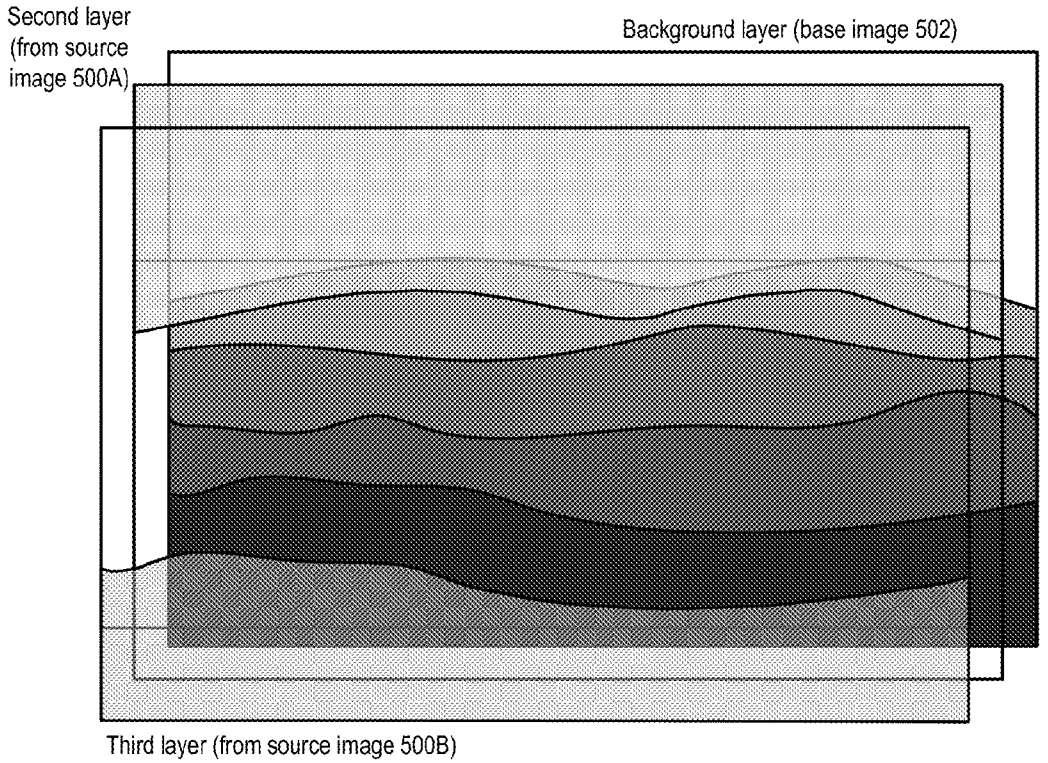
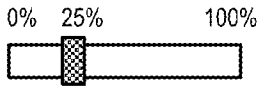
G06K 9/36 (2006.01)

(52) **U.S. Cl.**
USPC **382/164**; 382/284

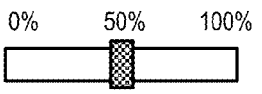
(57) **ABSTRACT**

Methods and apparatus for blending regions from multiple images to produce a blended image. An image blending module may obtain multiple digital images of a scene. A base image and a source image are selected, and a stroke is applied to the source image to indicate a desired region which is to be blended with the base image. A region in the source image is identified from the stroke using a segmentation technique such as a graph cut algorithm, and the identified region is blended with the corresponding region of the base image, for example using alpha blending. Additional strokes may be applied to the source image to select other regions to be blended with the base image. A different image may be selected as a source image, and a region from the different image may be selected for blending with the base image.





Second layer alpha blending level



Third layer alpha blending level

GOOGLE EXHIBIT 1009

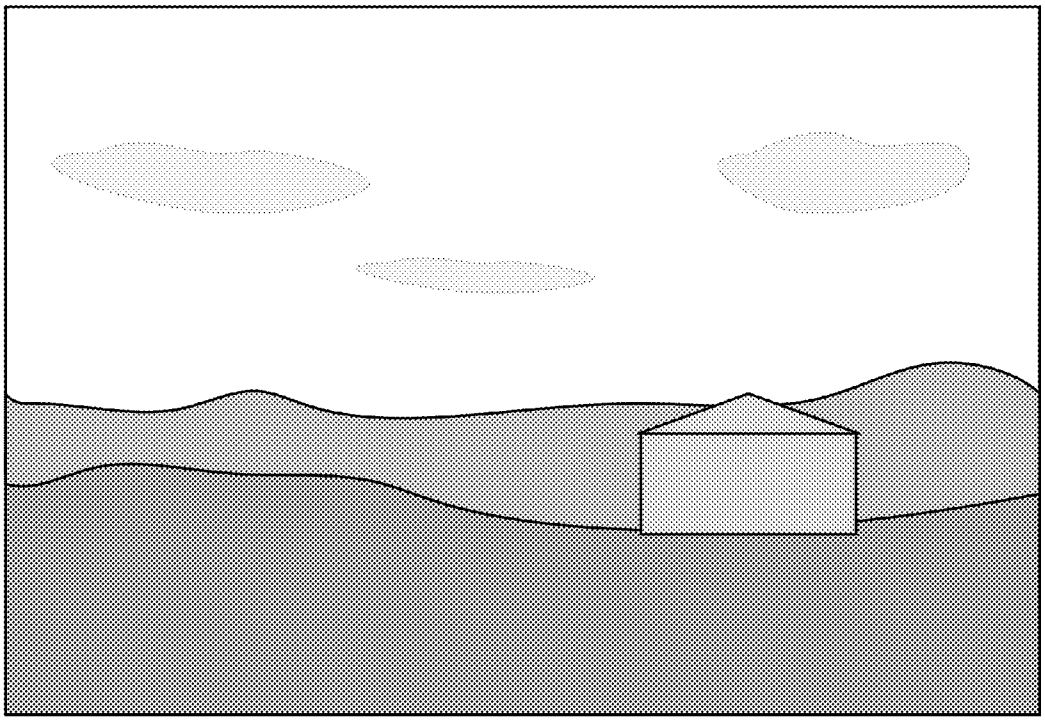


FIG. 1A

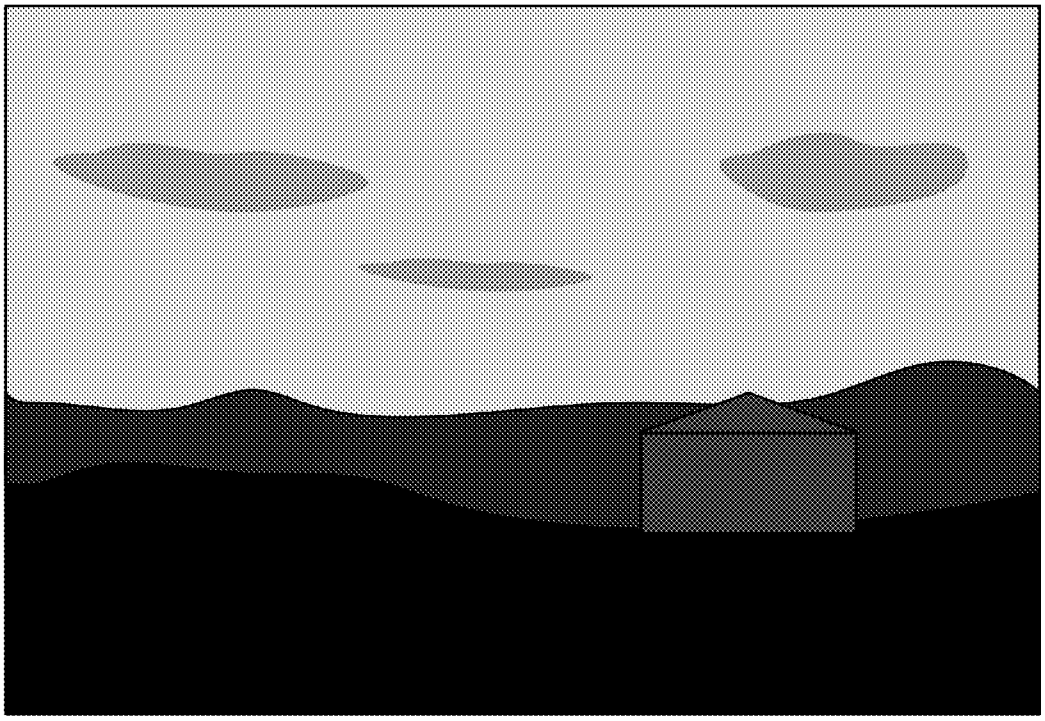


FIG. 1B

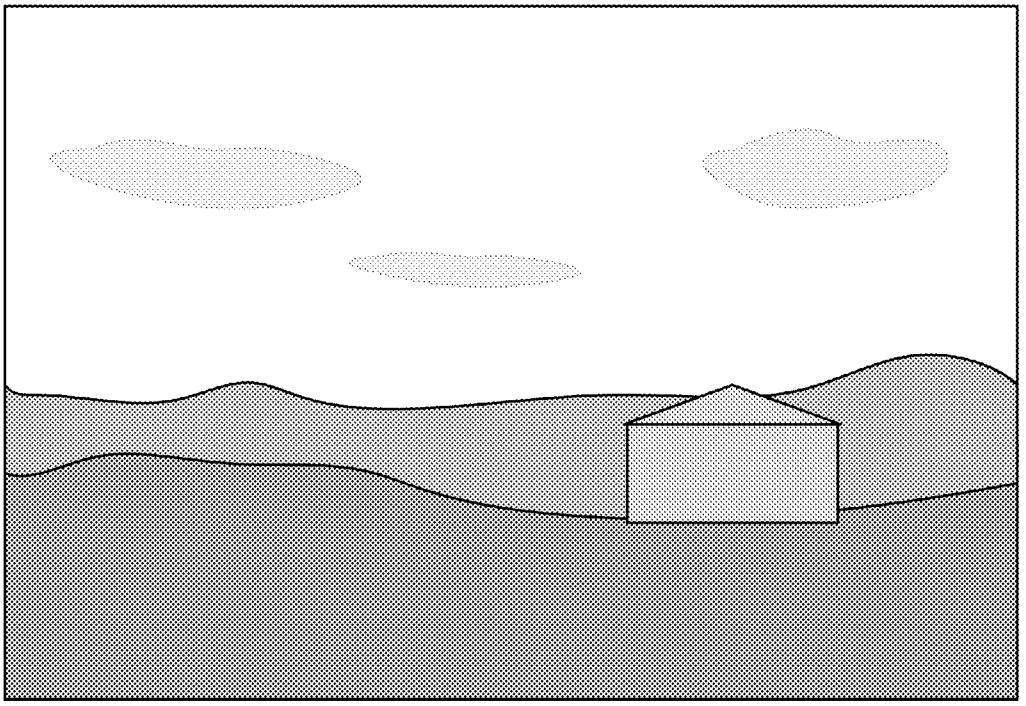


FIG. 2A

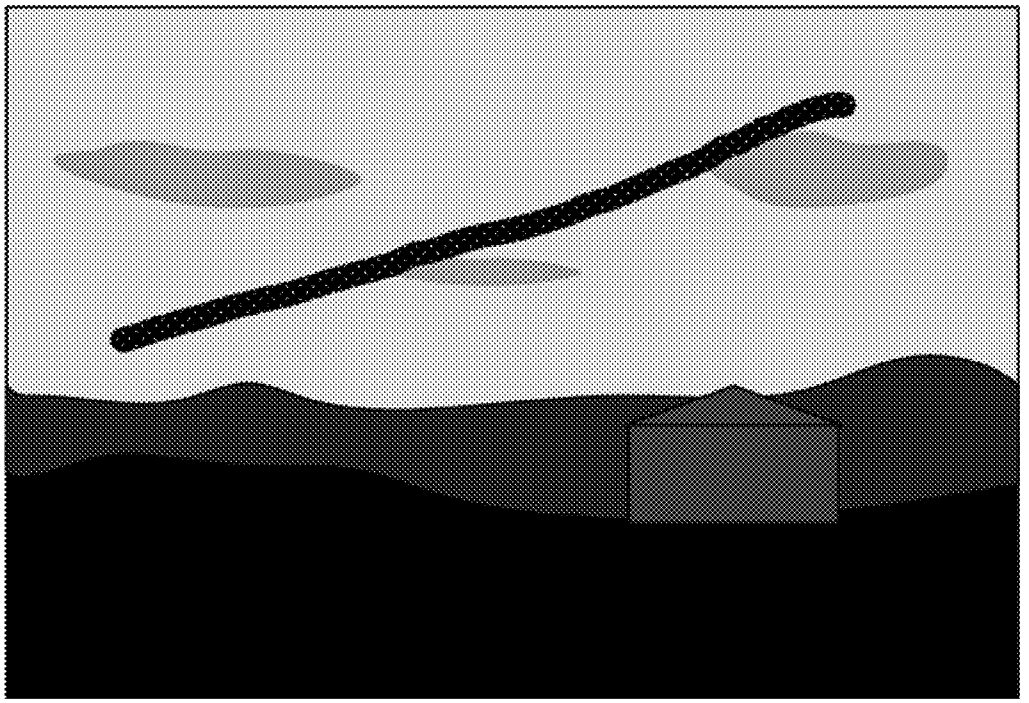


FIG. 2B

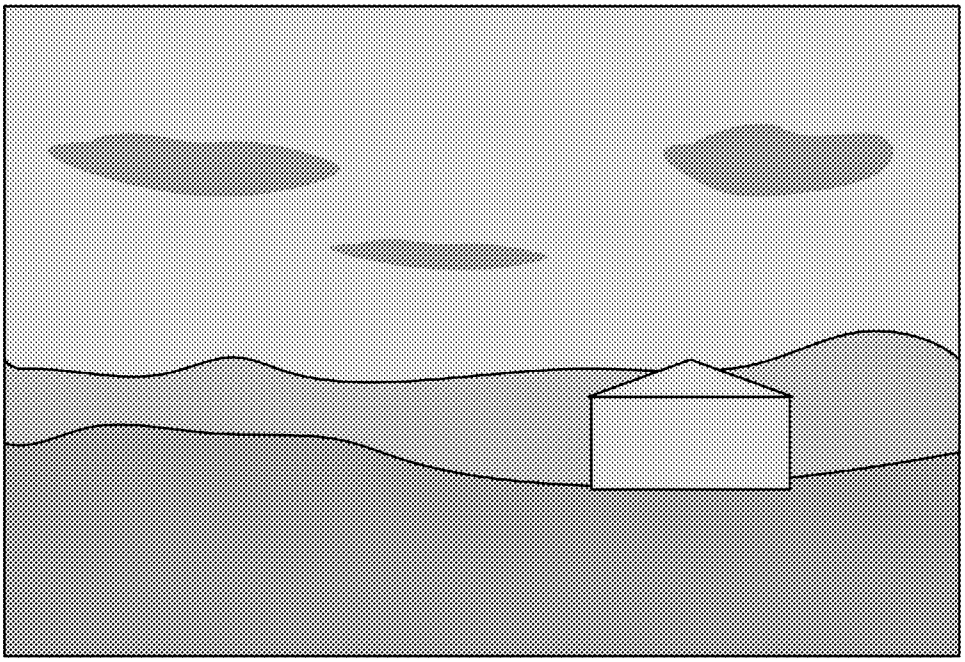


FIG. 2C

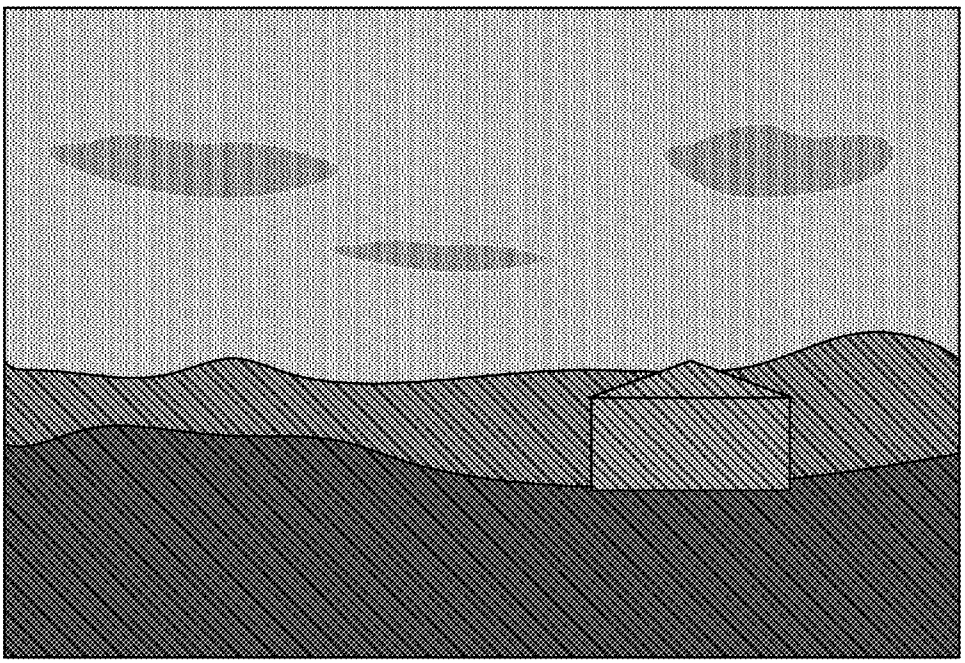


FIG. 2D

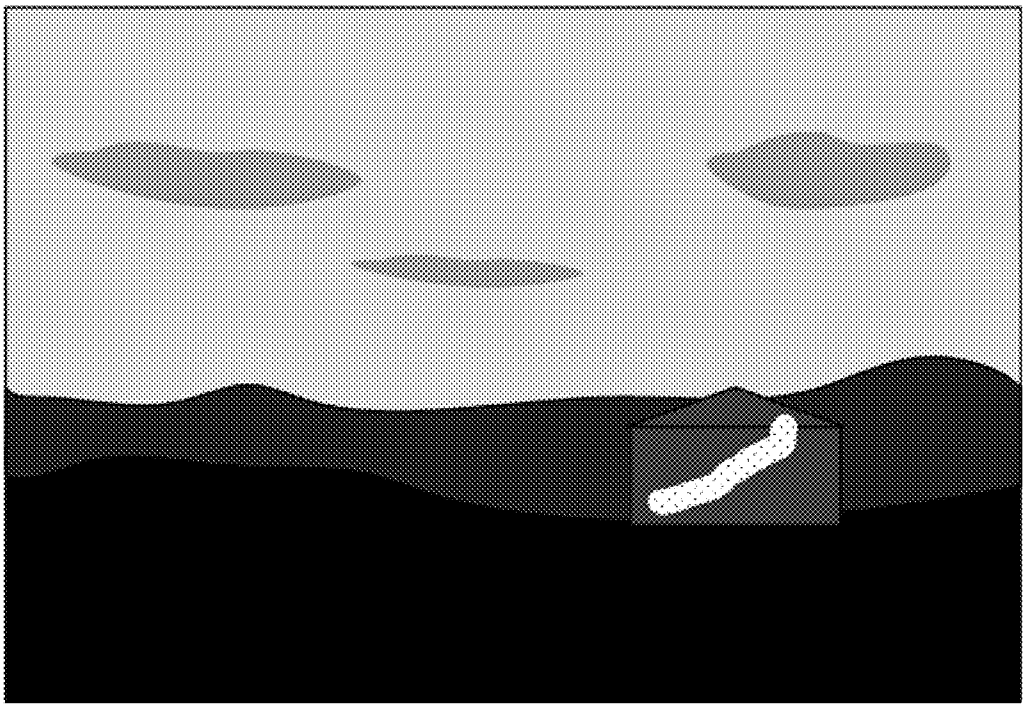


FIG. 3A

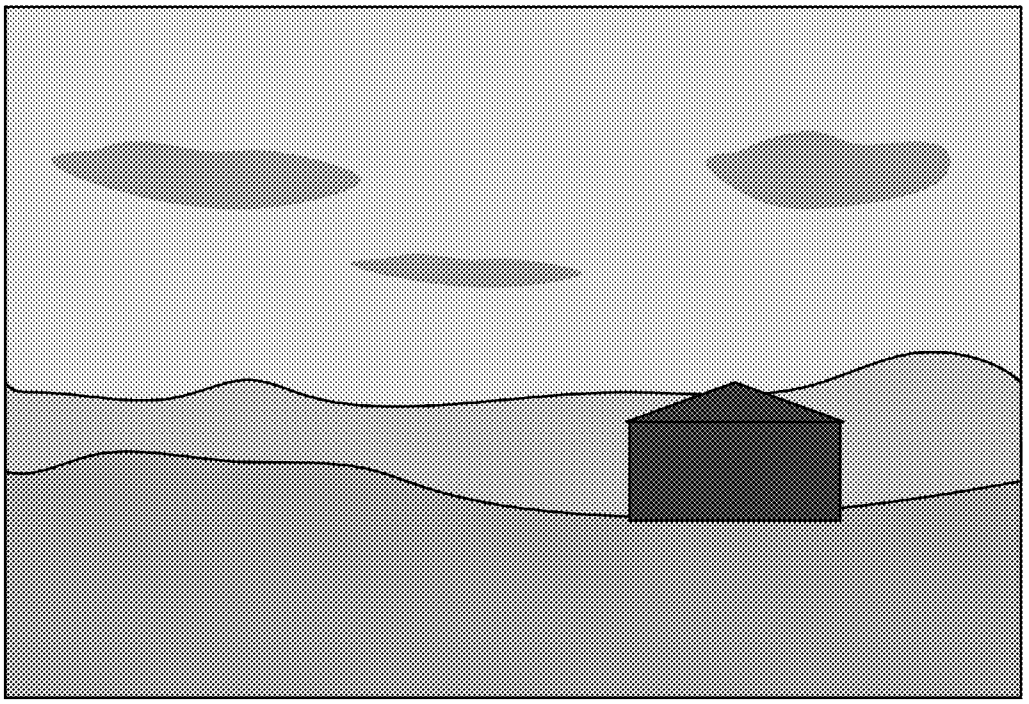


FIG. 3B

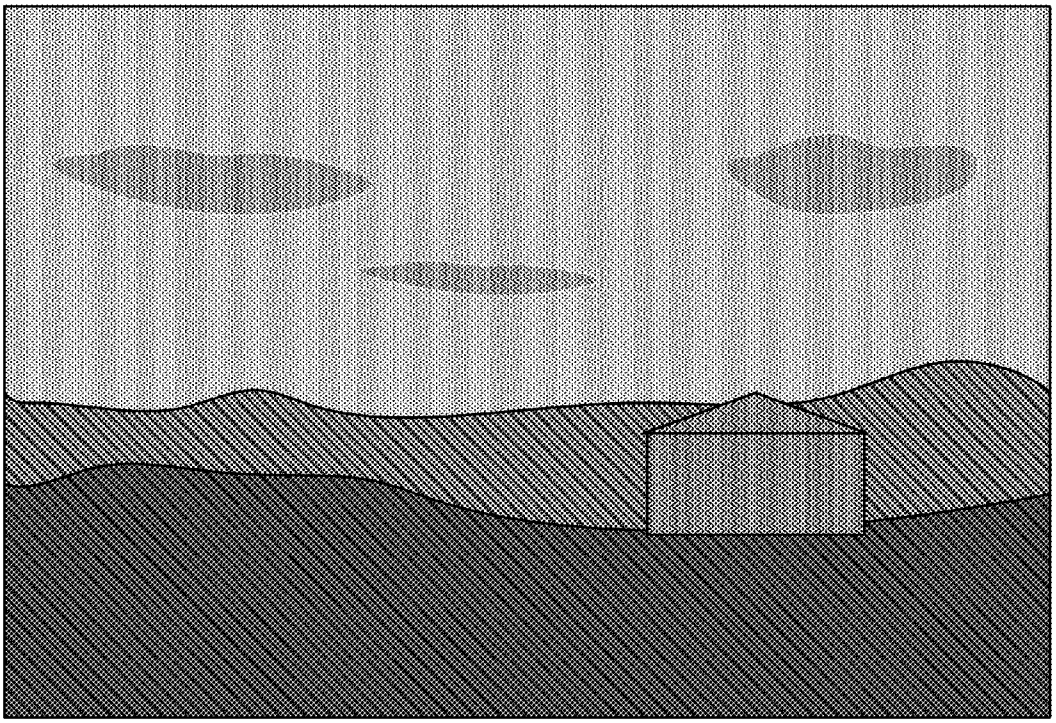


FIG. 3C

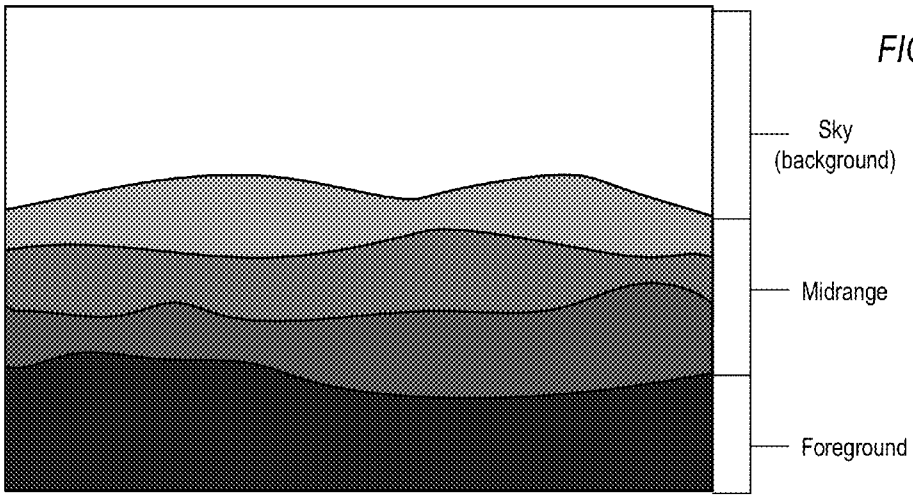


FIG. 4A

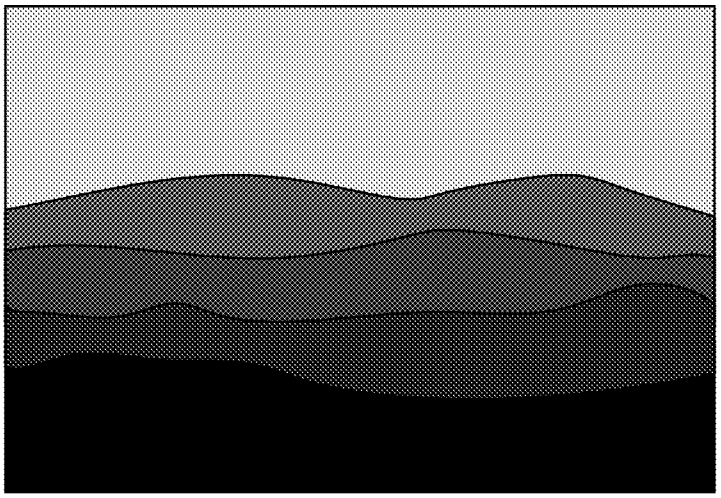


FIG. 4B

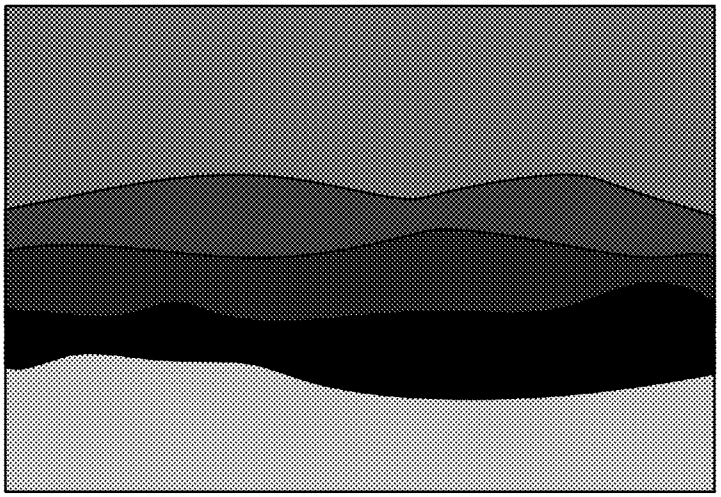


FIG. 4C

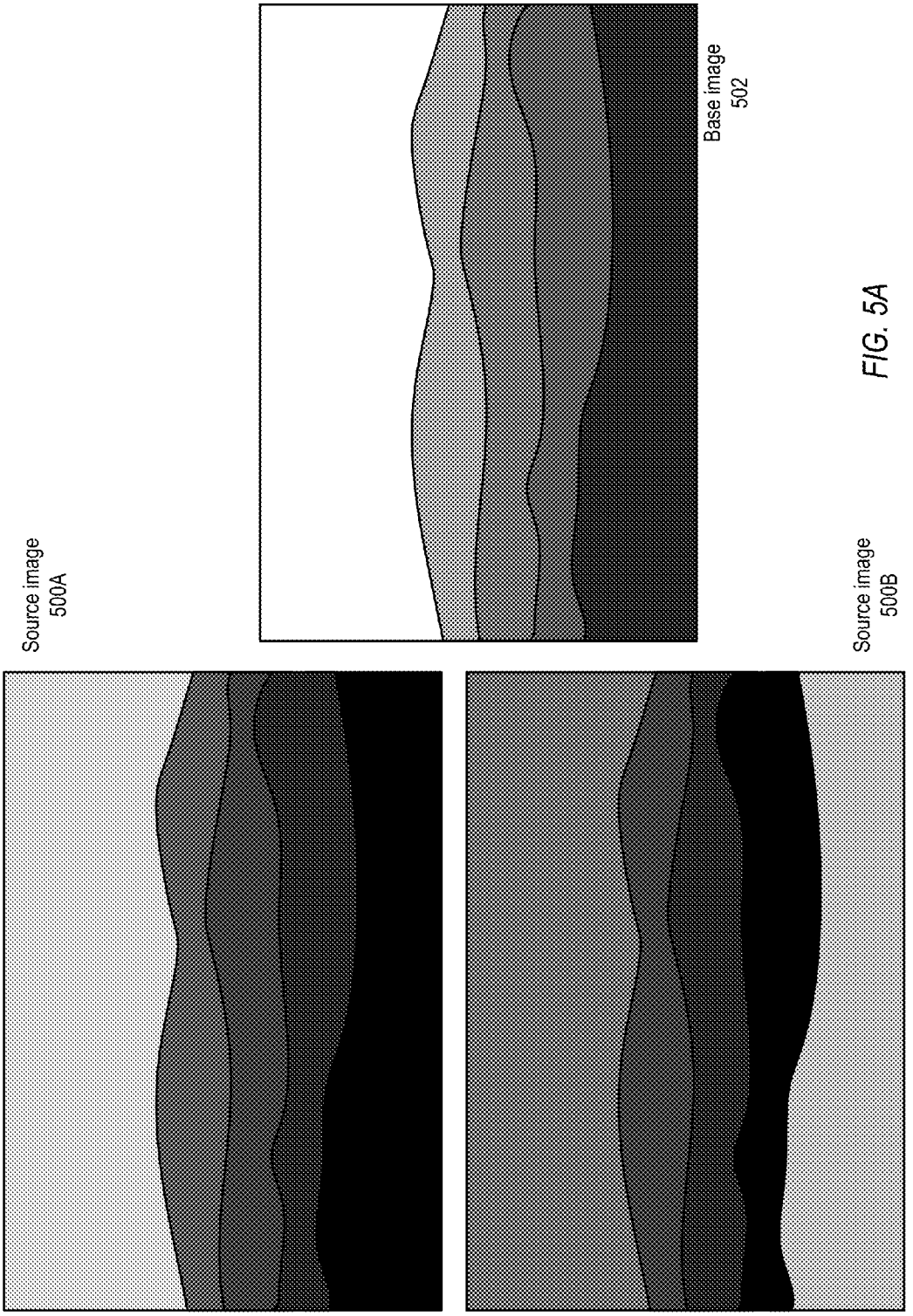


FIG. 5A

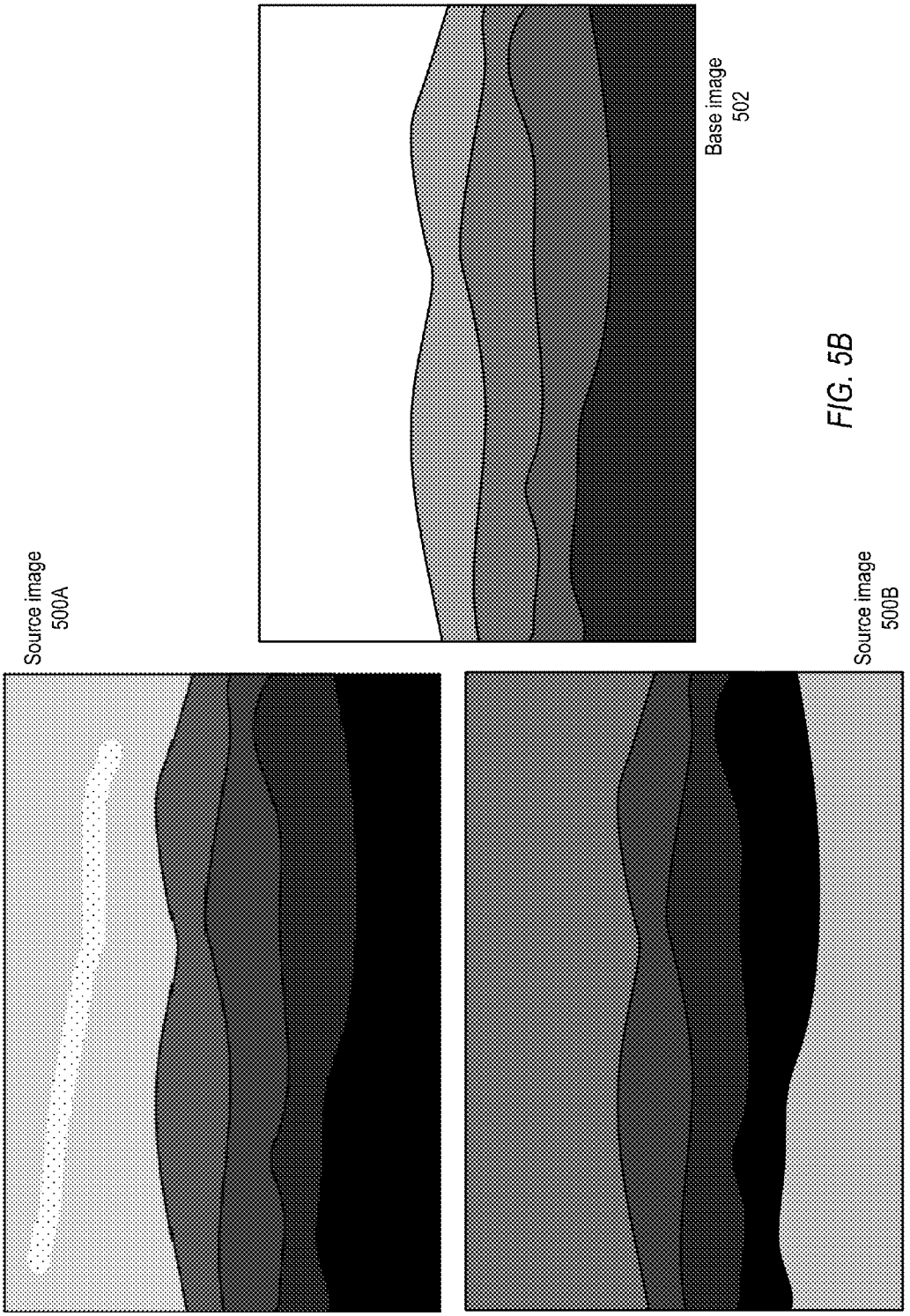


FIG. 5B

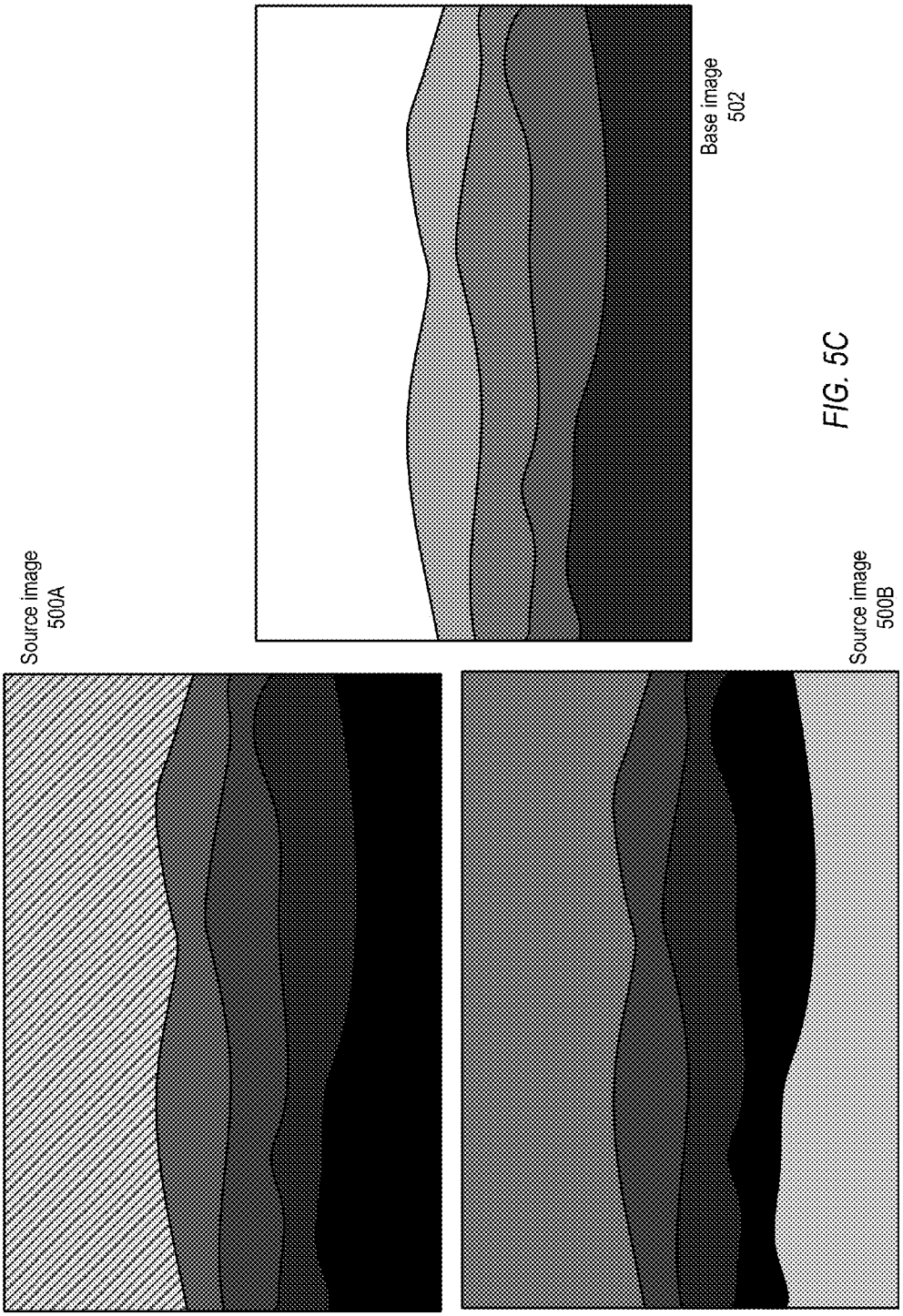


FIG. 5C

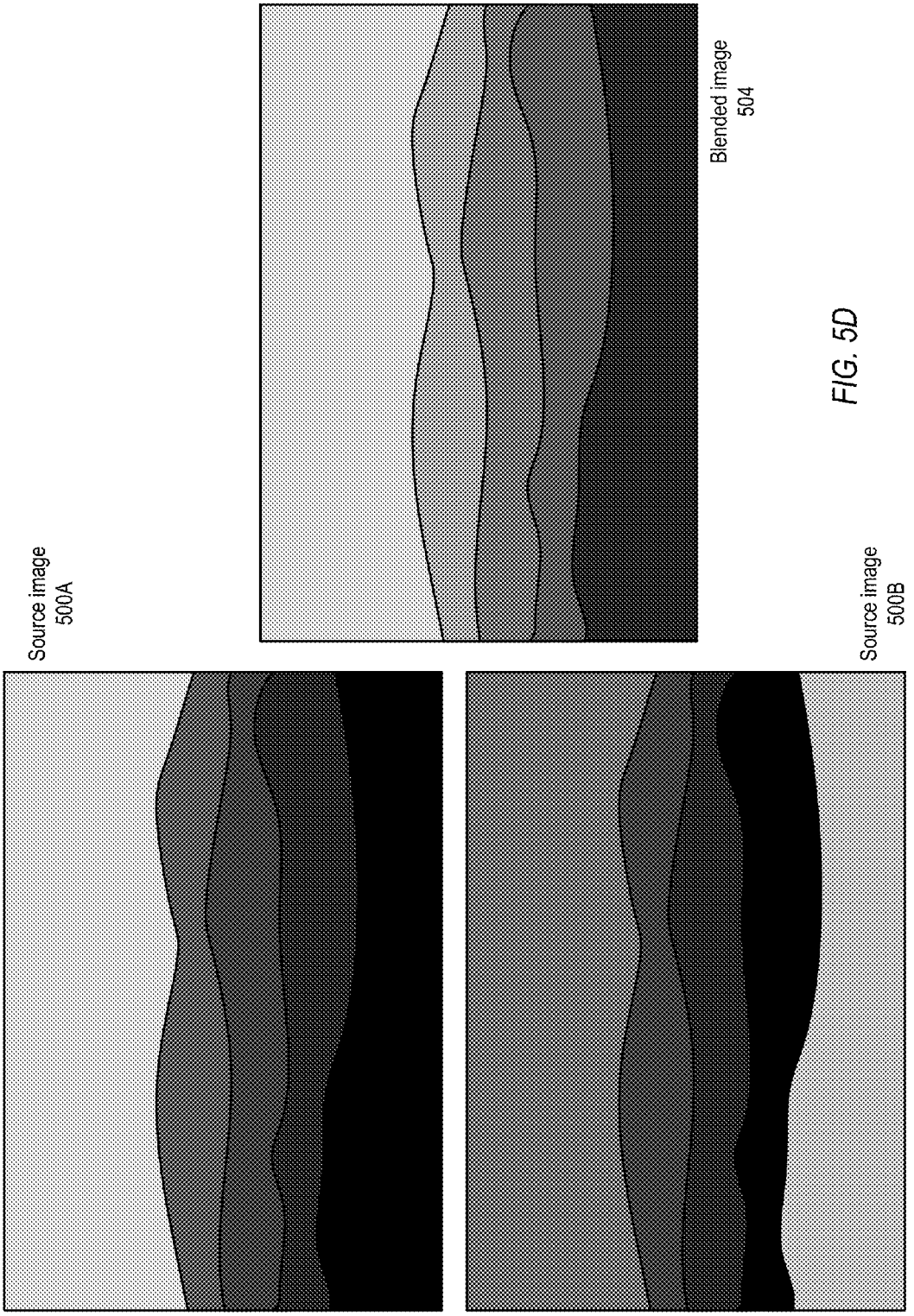


FIG. 5D

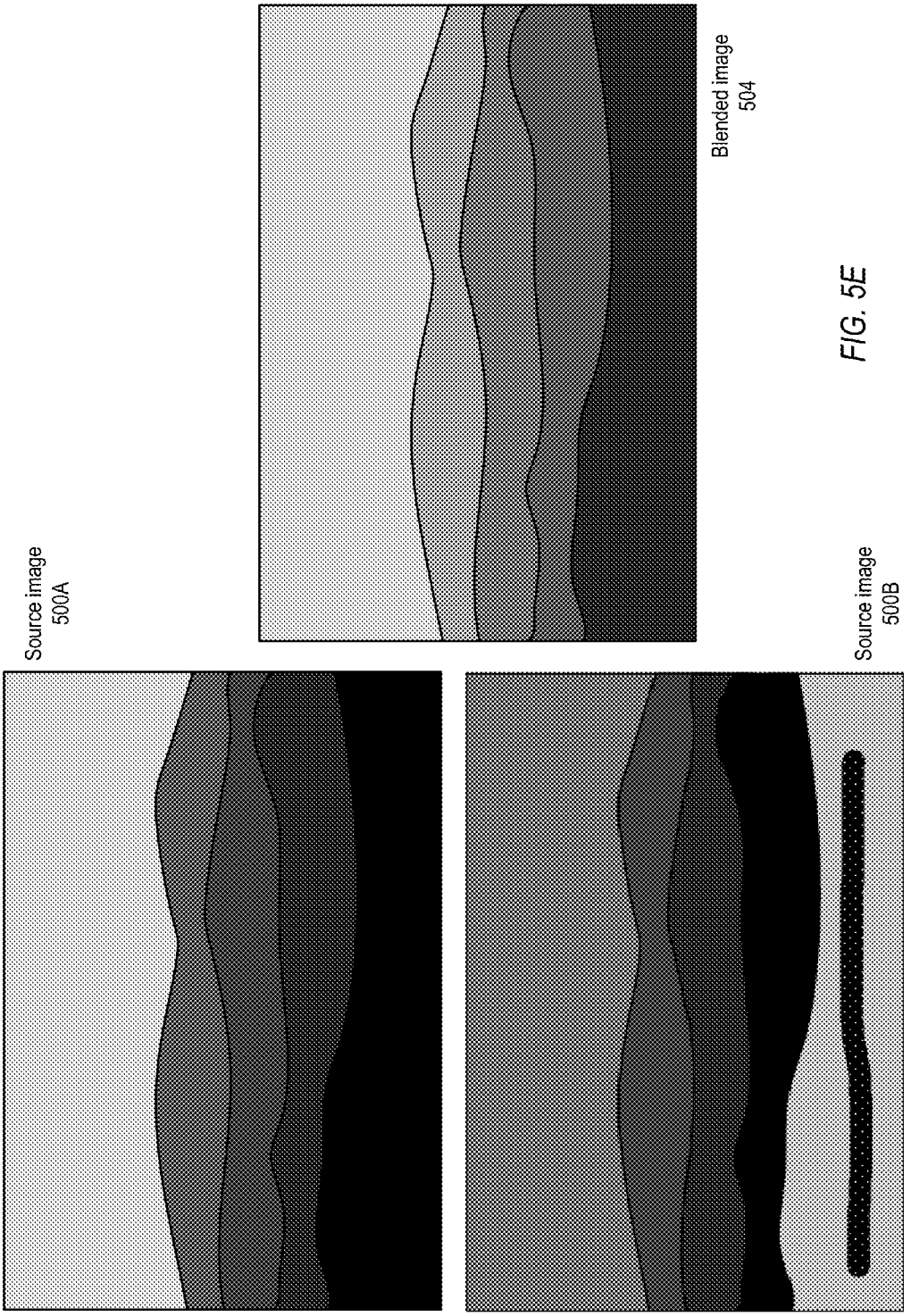


FIG. 5E

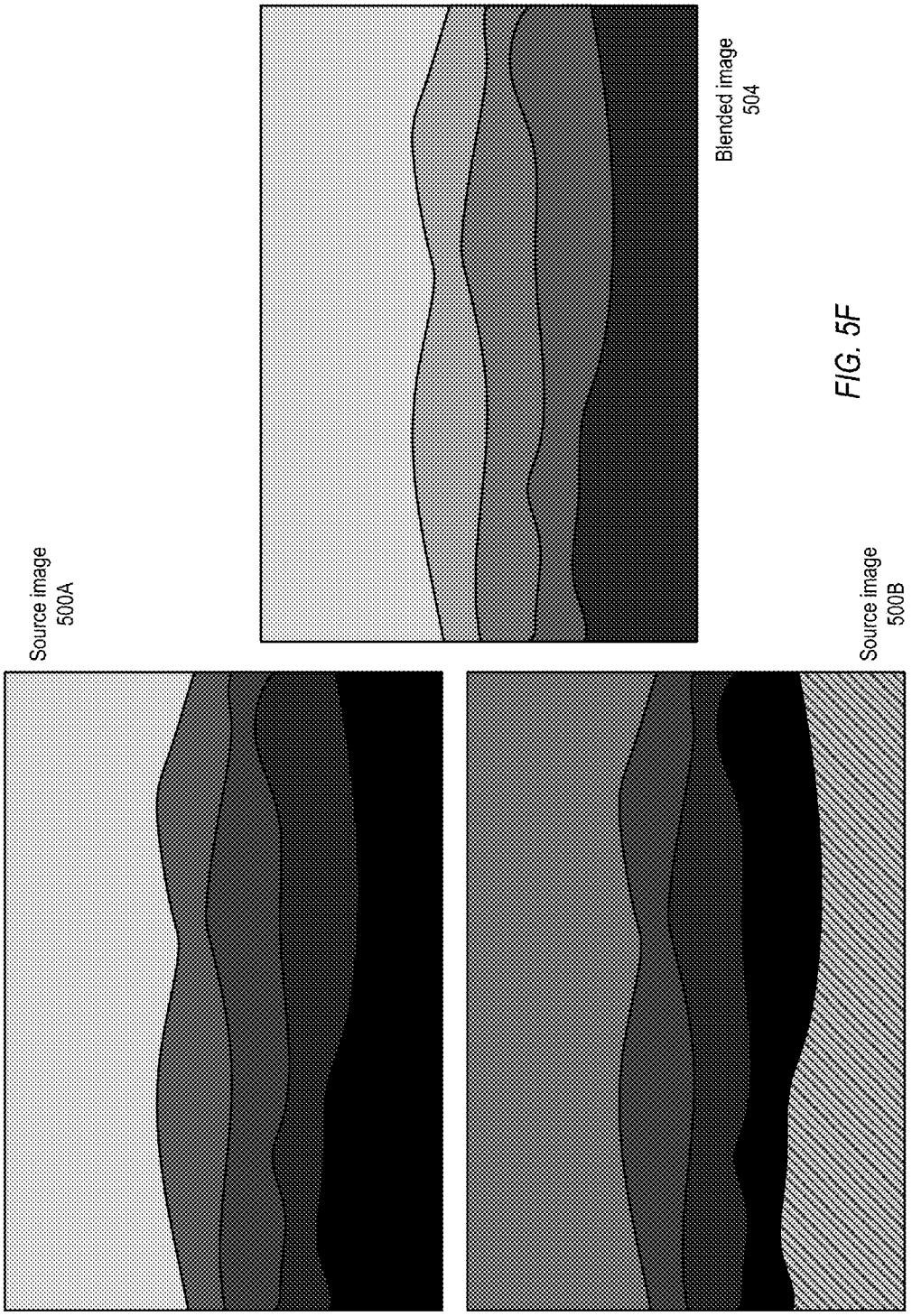


FIG. 5F

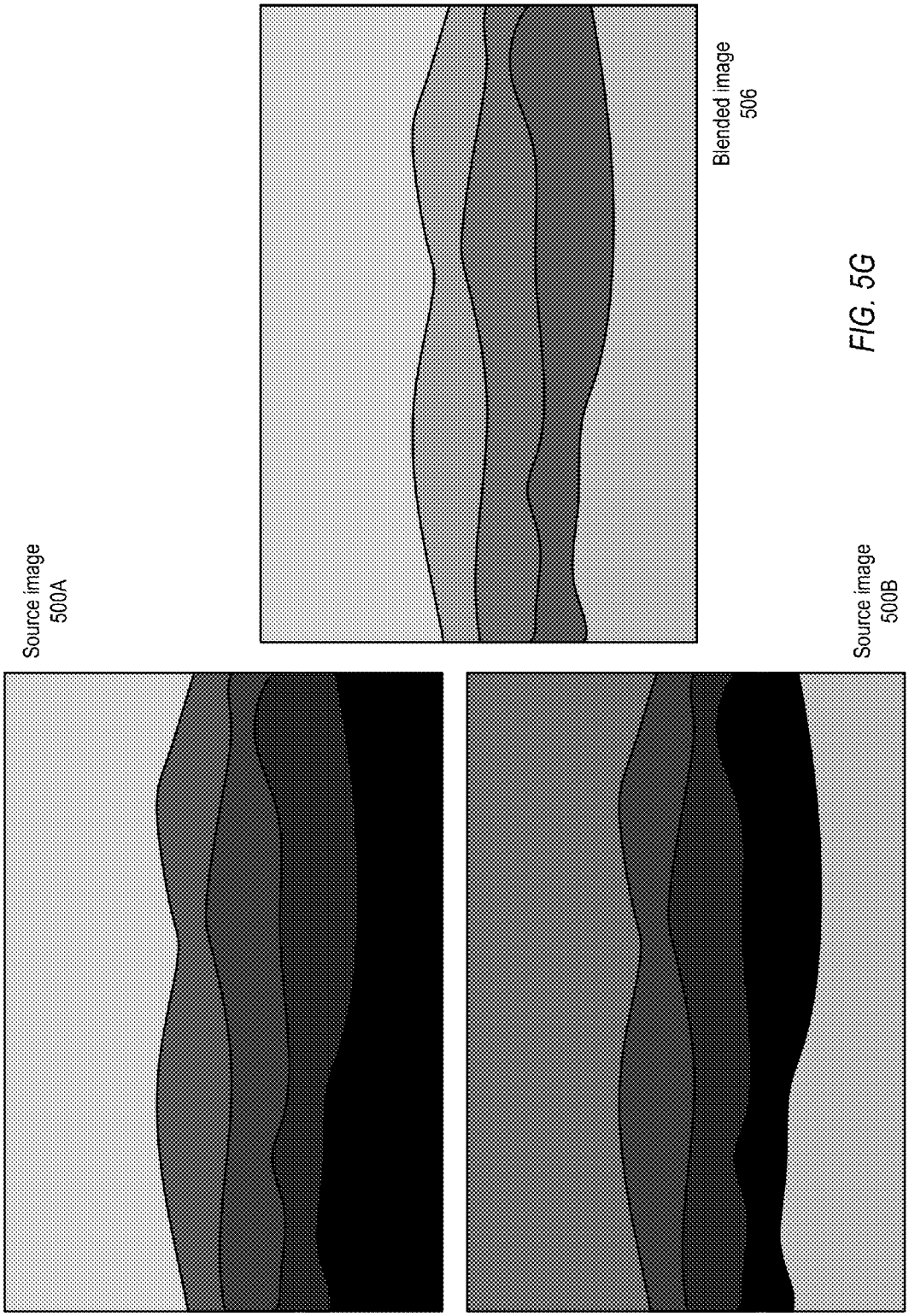


FIG. 5G

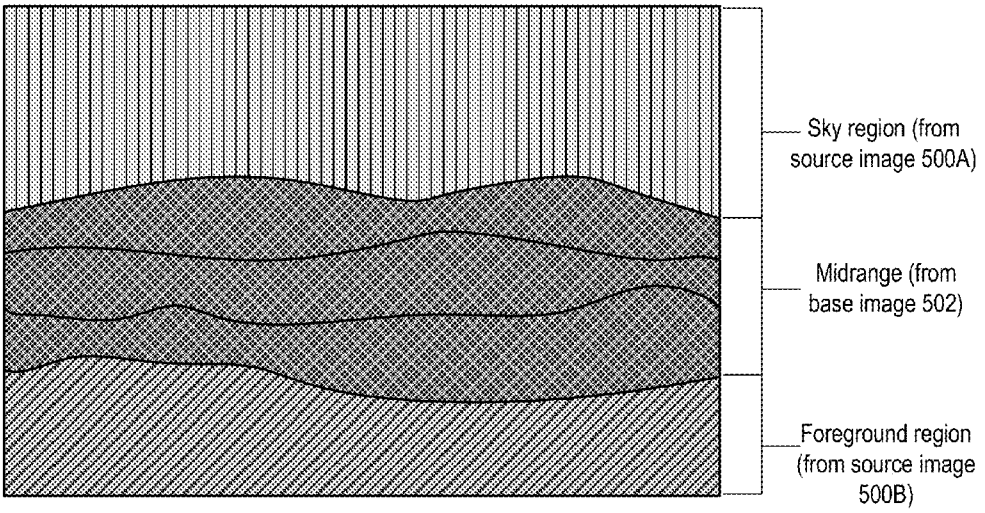

Sky region (from source image 500A)
Midrange (from base image 502)
Foreground region (from source image 500B)

FIG. 6

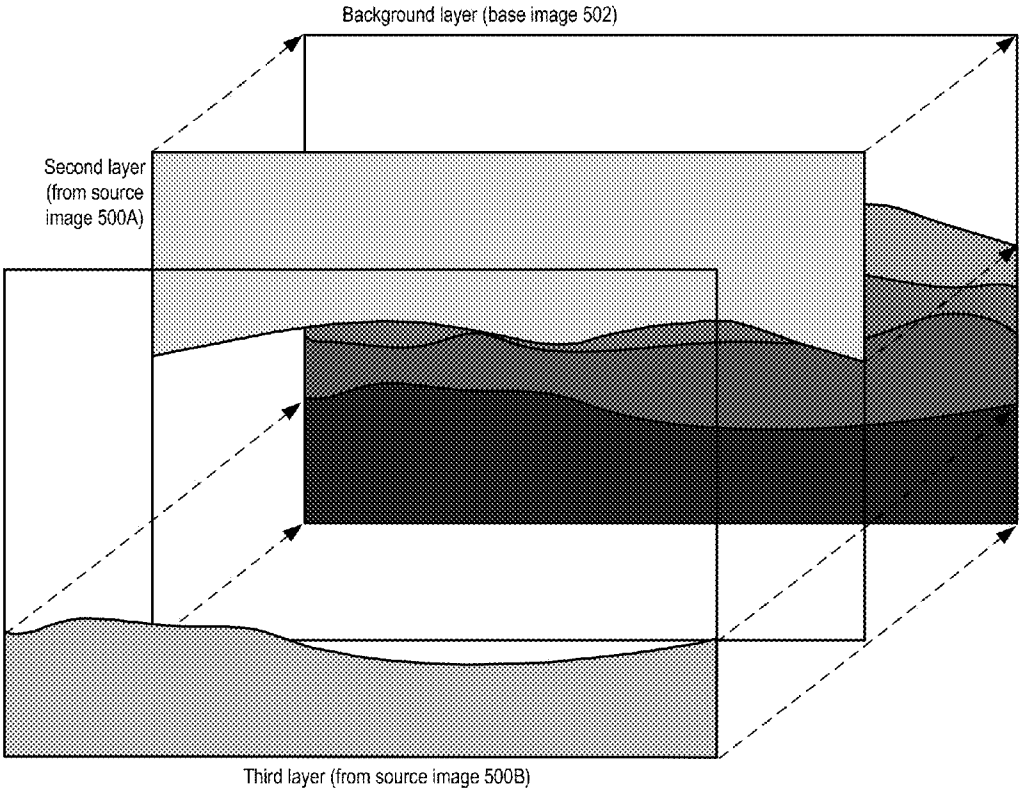

Background layer (base image 502)
Second layer (from source image 500A)
Third layer (from source image 500B)

FIG. 7

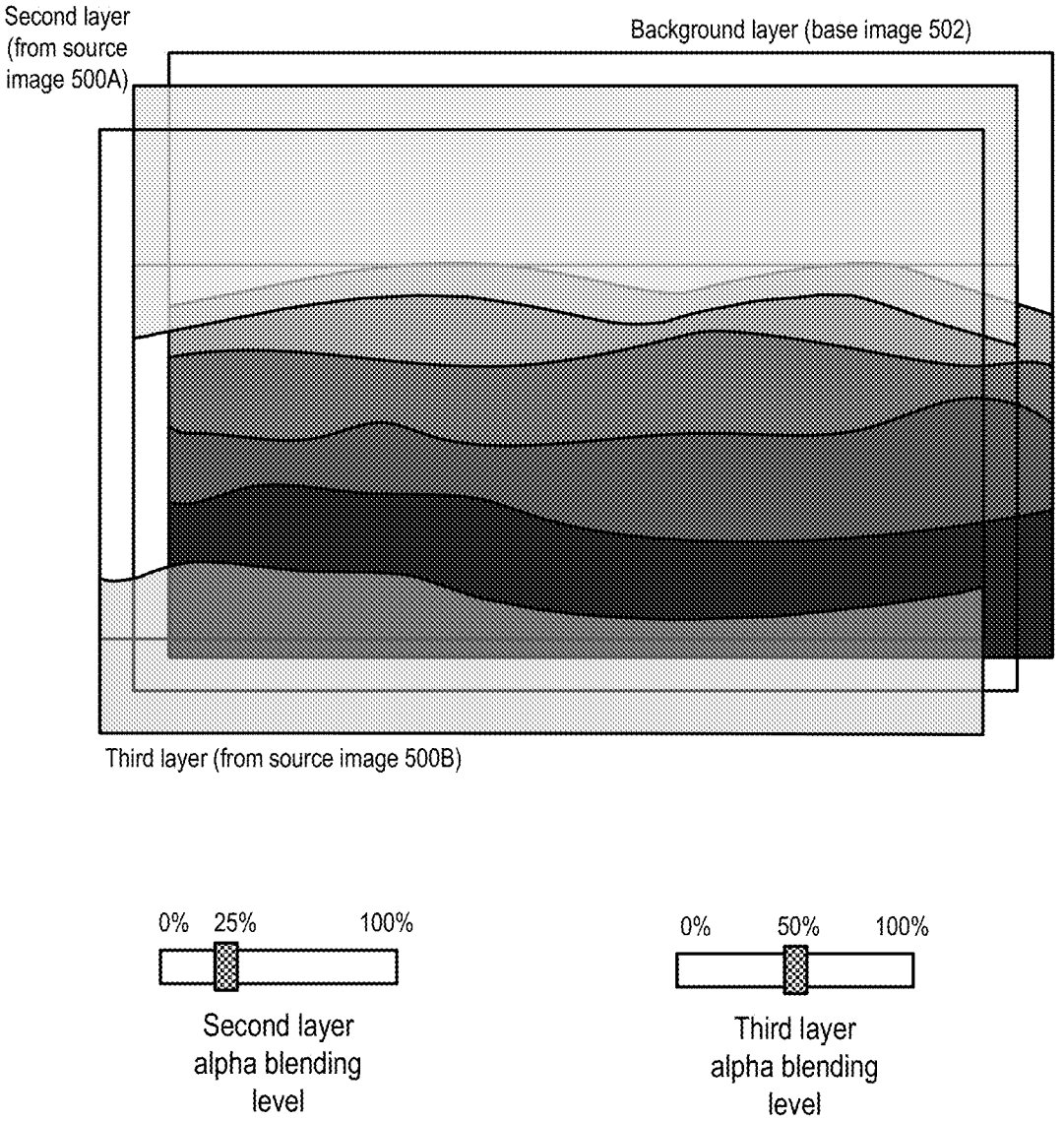

Second layer (from source image 500A)
Background layer (base image 502)
Third layer (from source image 500B)
0% 25% 100%
Second layer alpha blending level
0% 50% 100%
Third layer alpha blending level

FIG. 8

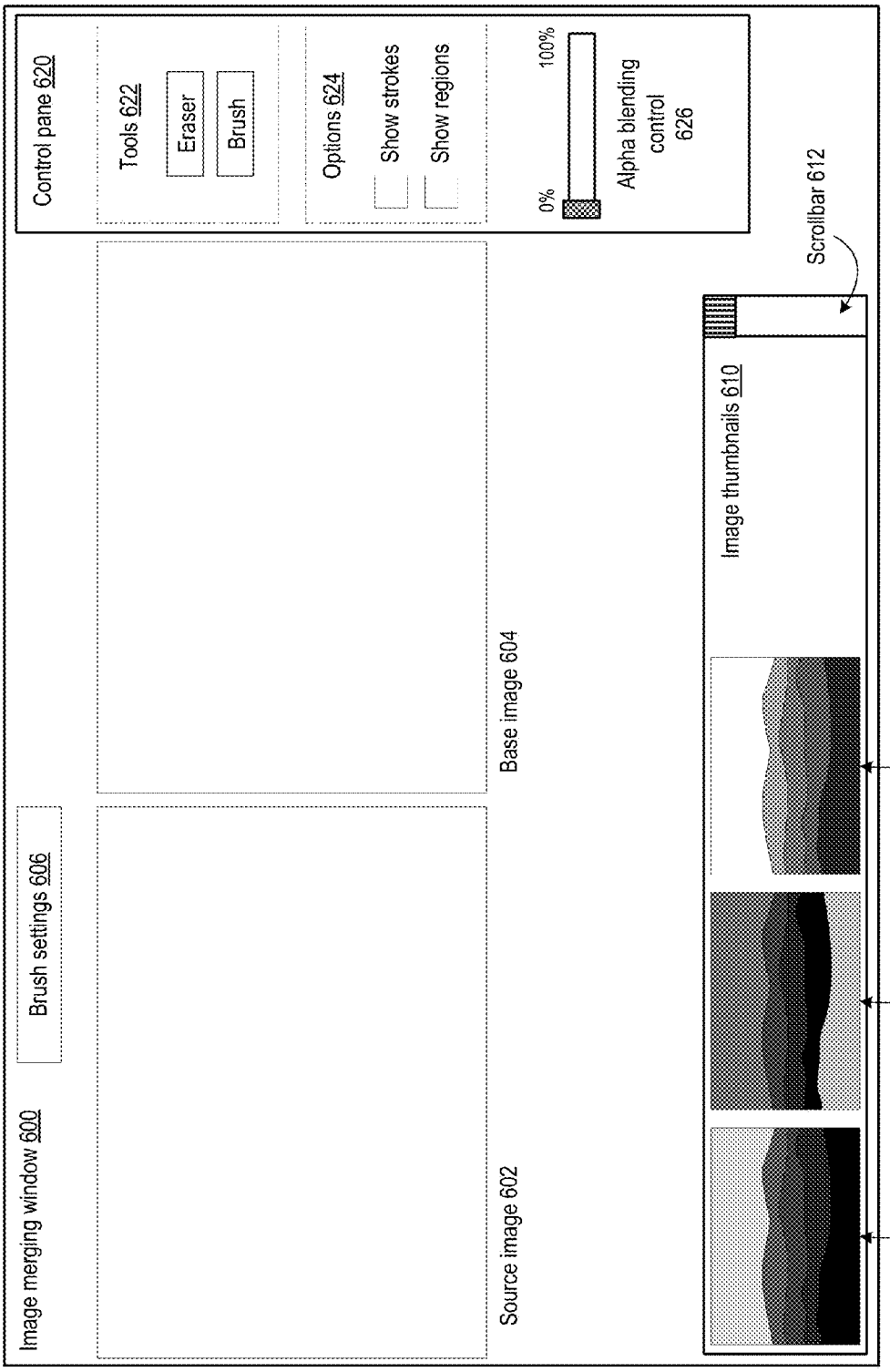


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
Source image 602
Base image 604
Scrollbar 612
Image thumbnails 610
Image 612A
Image 612B
Image 612C

FIG. 9A

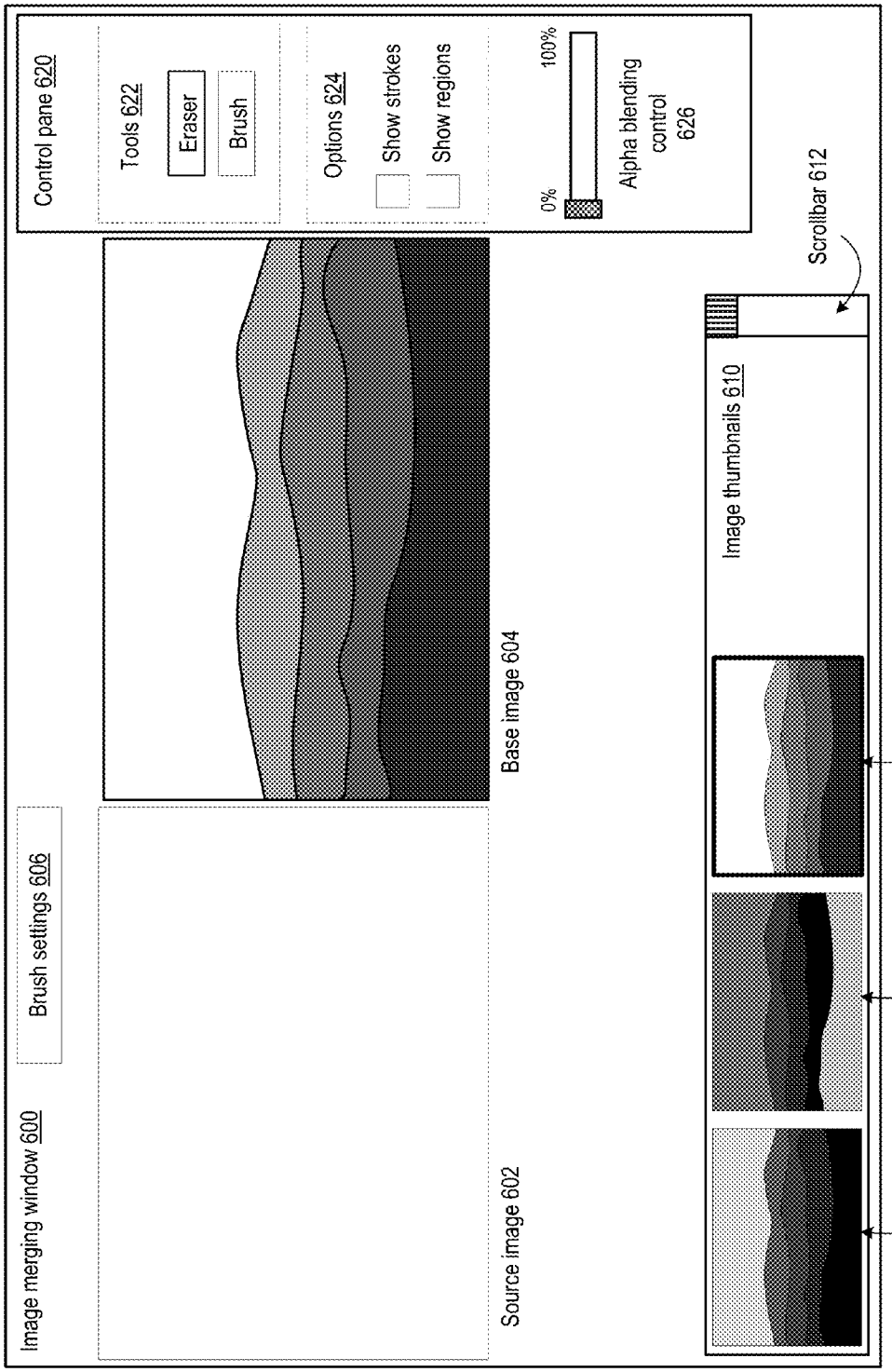


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
Source image 602
Base image 604
Image thumbnails 610
Scrollbar 612
Image 612A
Image 612B
Image 612C

FIG. 9B

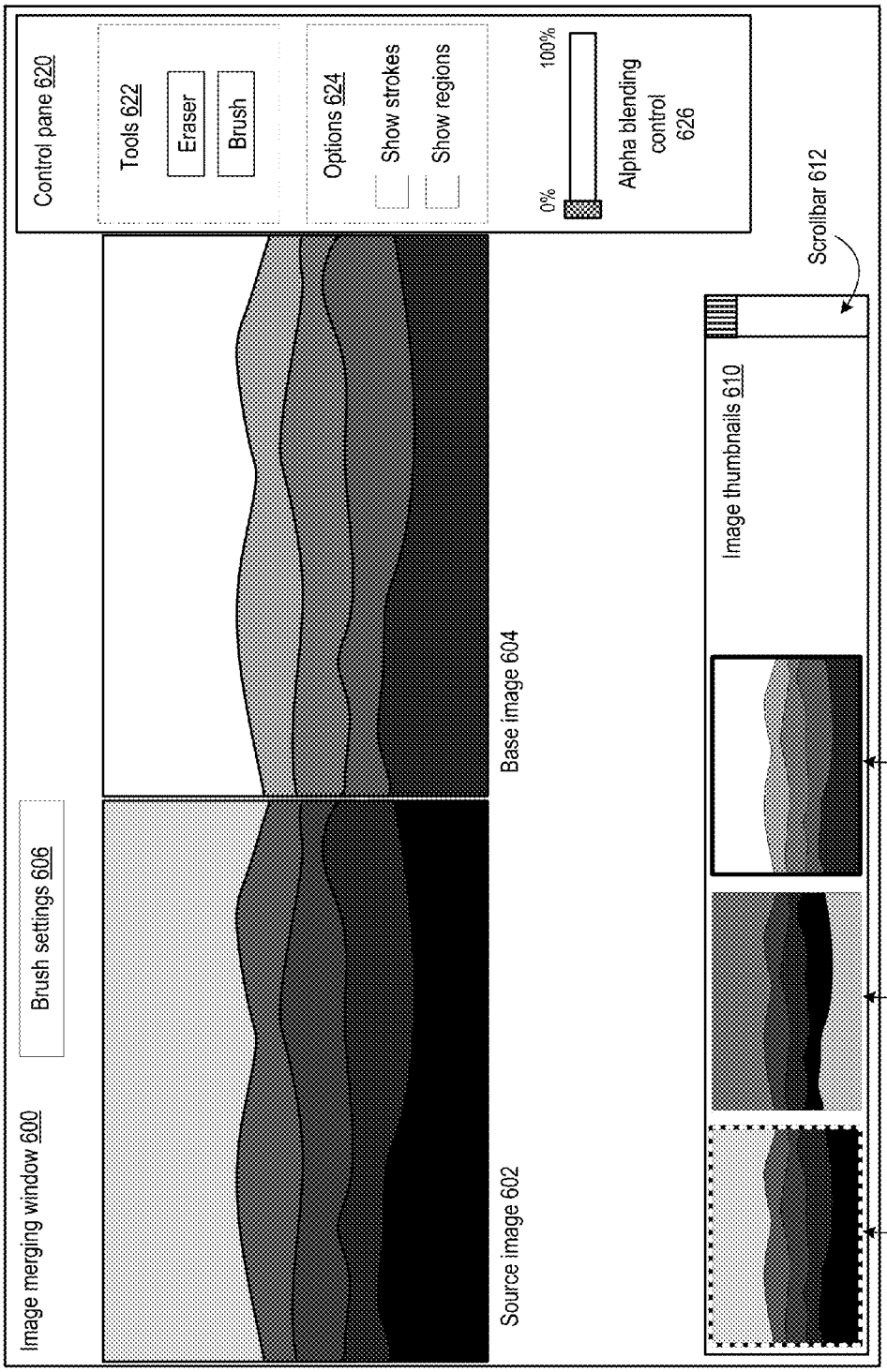


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
Source image 602
Base image 604
Image thumbnails 610
Scrollbar 612
Image 612A
Image 612B
Image 612C

FIG. 9C

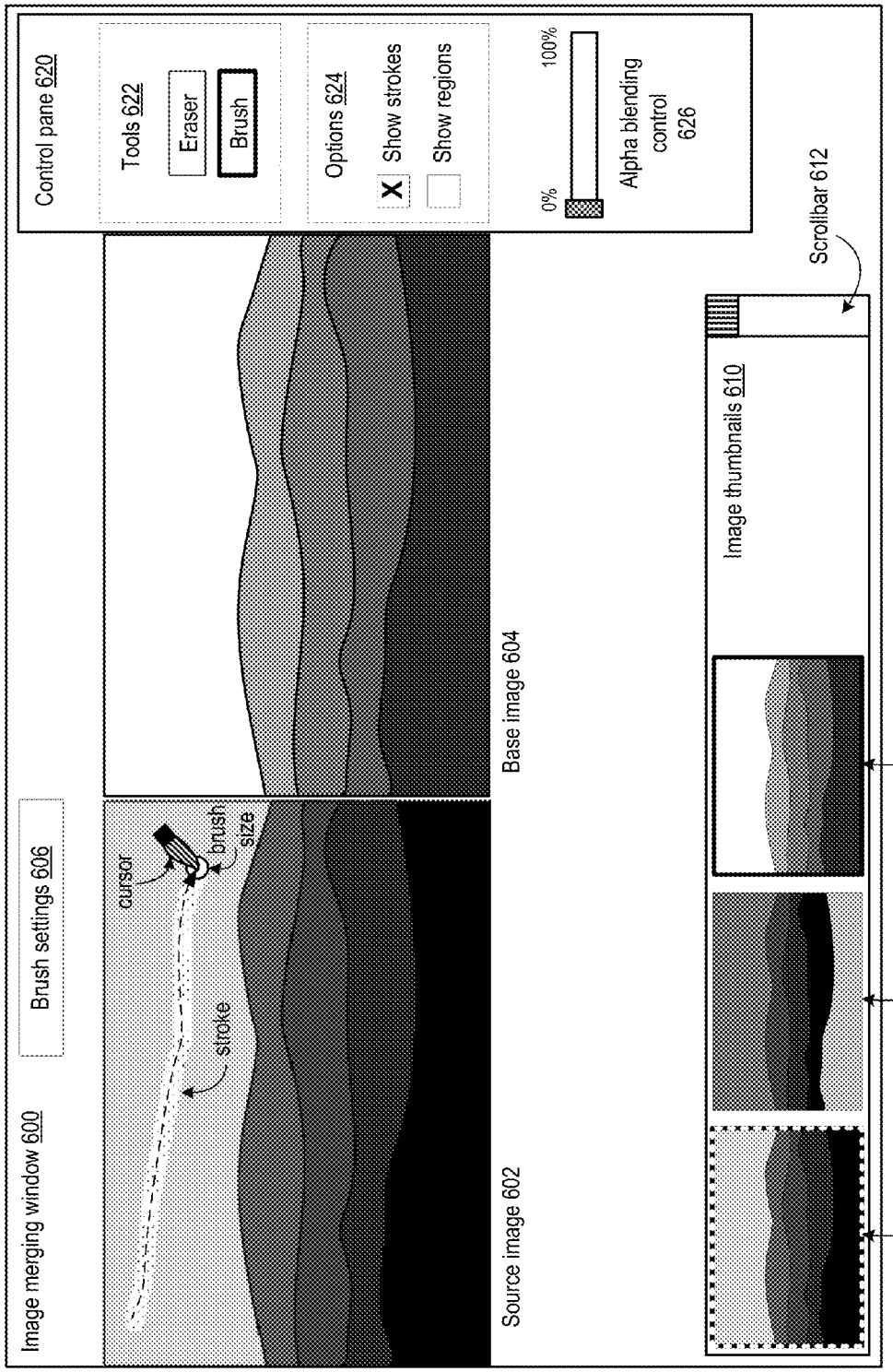


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
cursor
brush size
stroke
Base image 604
Source image 602
Scrollbar 612
Image thumbnails 610
Image 612C
Image 612B
Image 612A

FIG. 9D

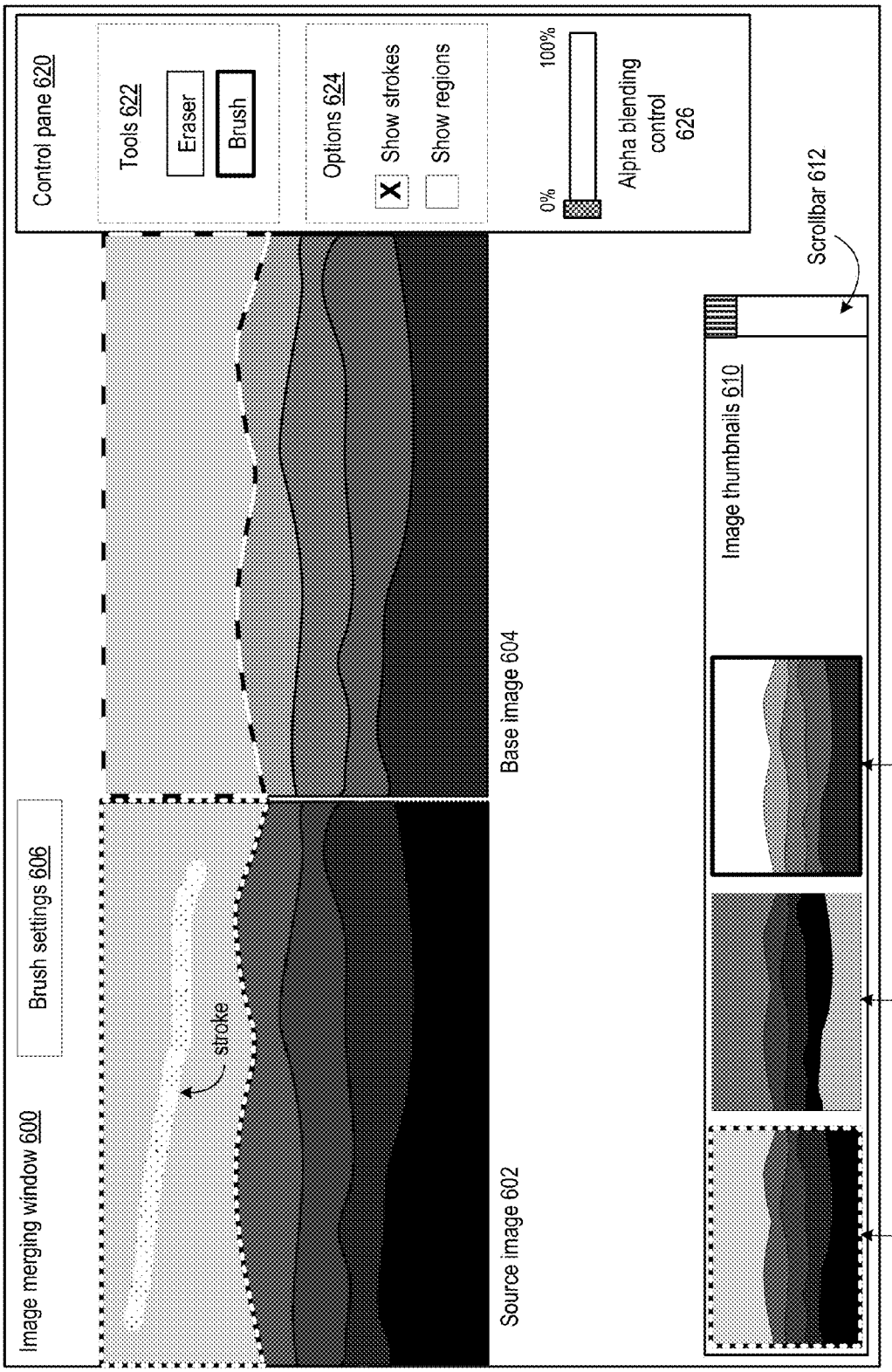


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
stroke
Source image 602
Base image 604
Scrollbar 612
Image thumbnails 610
Image 612A
Image 612B
Image 612C

FIG. 9E

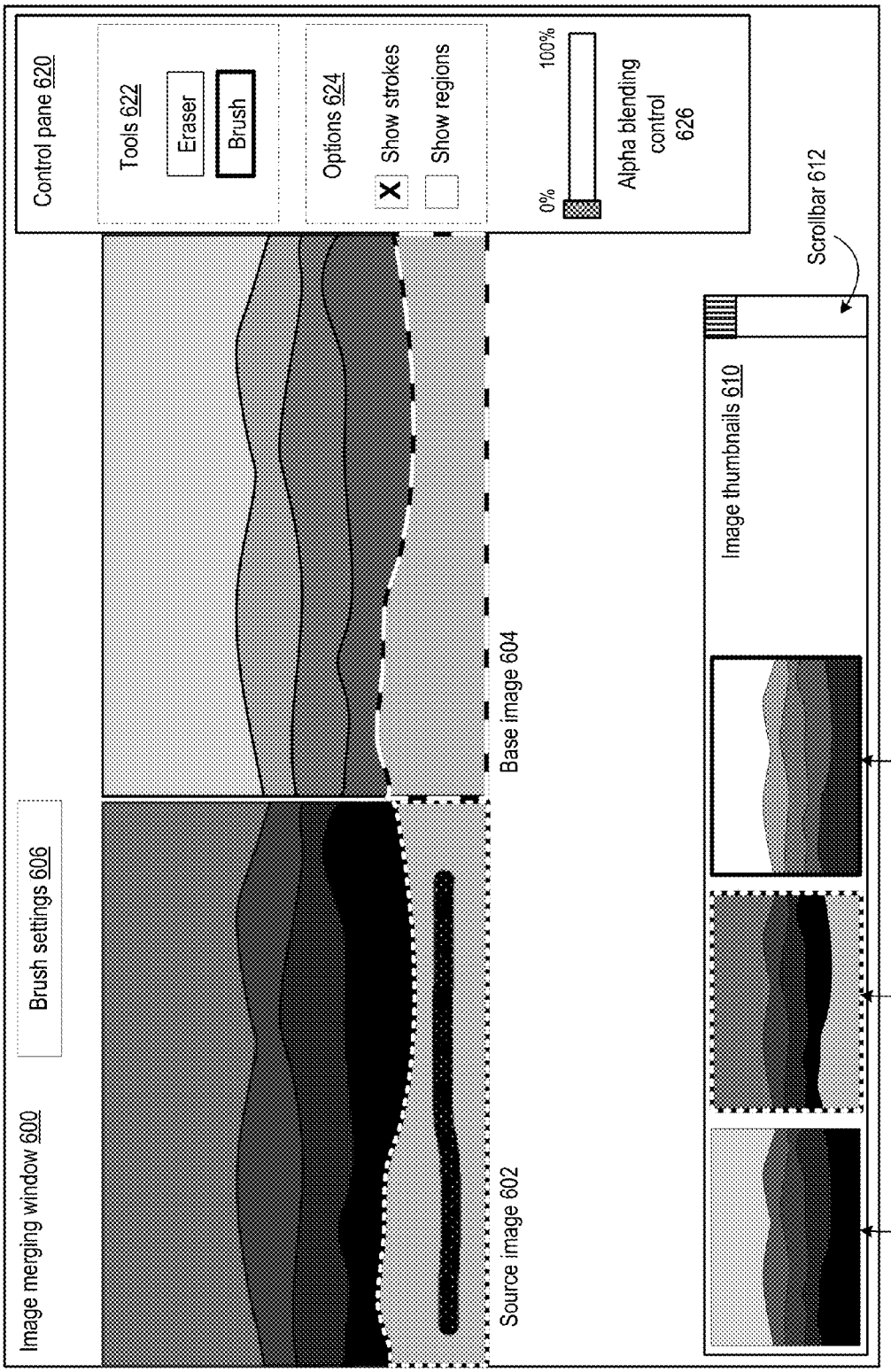


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
Source image 602
Base image 604
Scrollbar 612
Image thumbnails 610
Image 612A
Image 612B
Image 612C

FIG. 9F

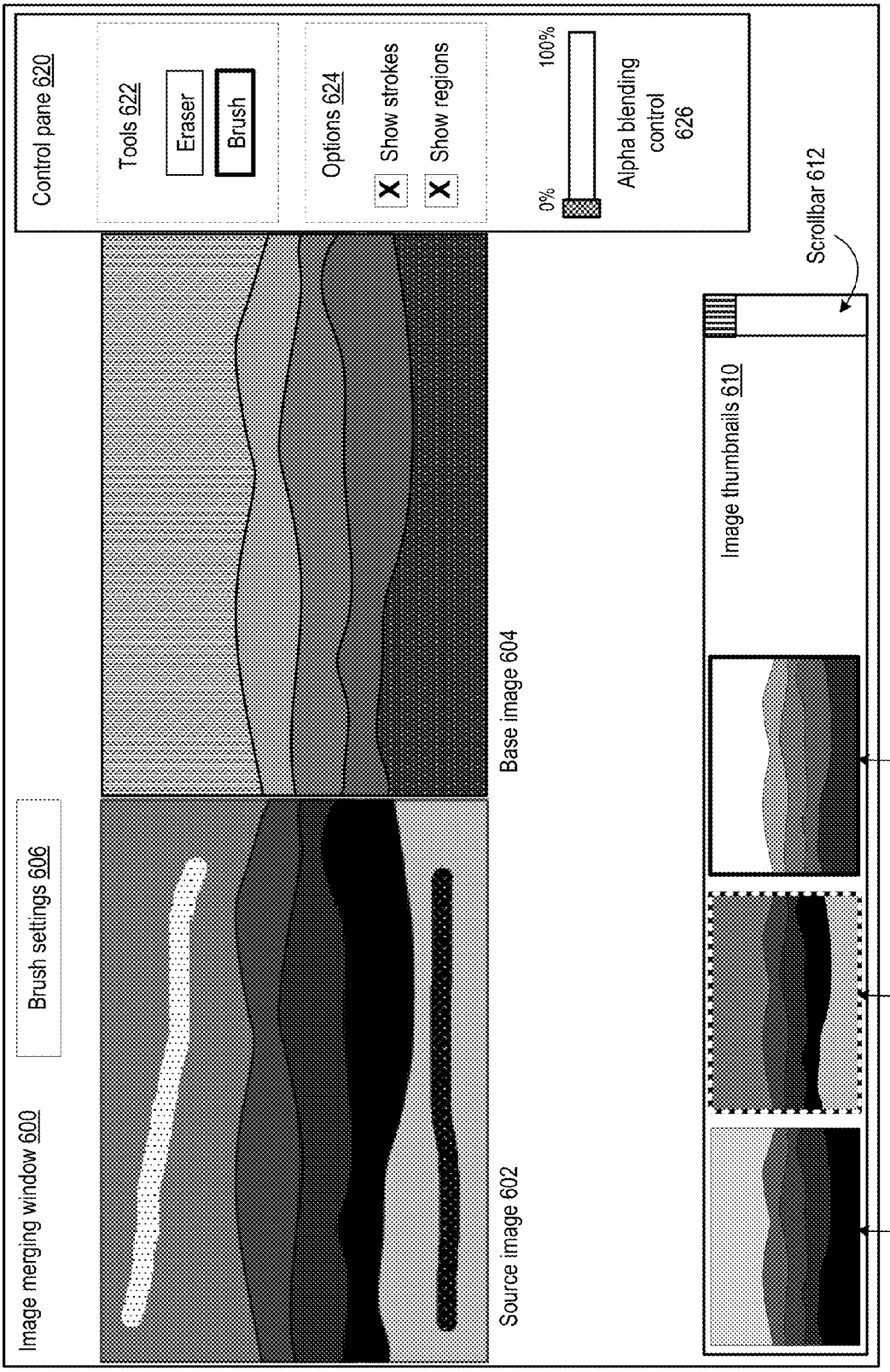
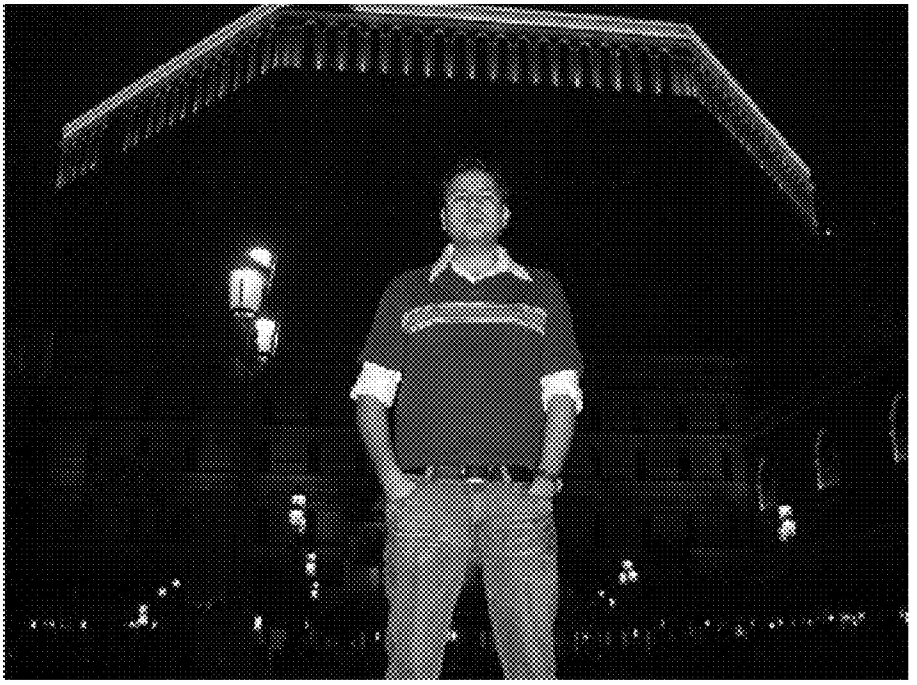


Image merging window 600
Brush settings 606
Control pane 620
Tools 622
Eraser
Brush
Options 624
Show strokes
Show regions
0%
100%
Alpha blending control 626
Source image 602
Base image 604
Scrollbar 612
Image thumbnails 610
Image 612A
Image 612B
Image 612C

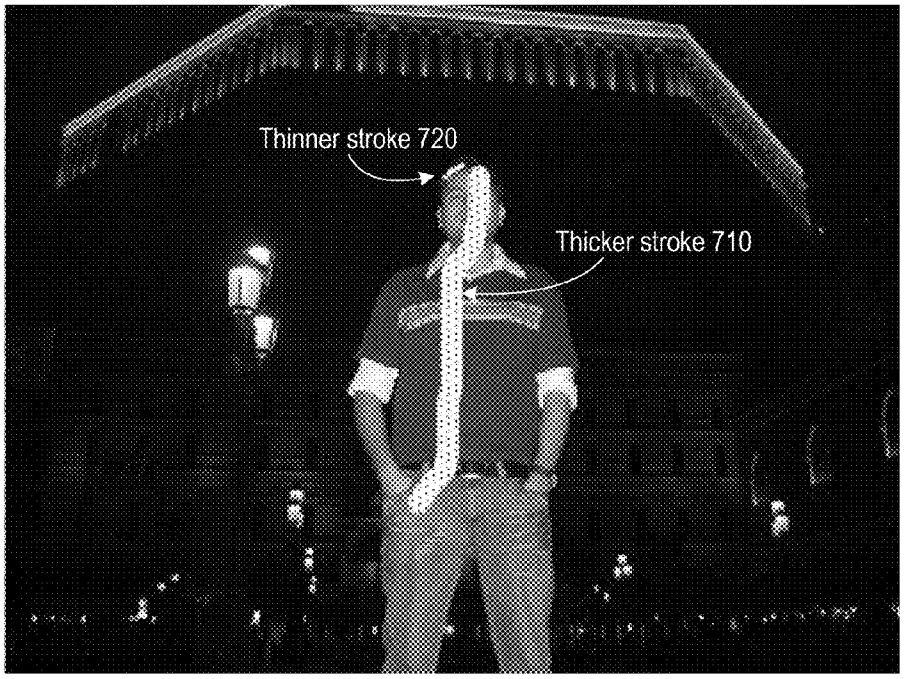
FIG. 9G



Source image 700

Base image 702

FIG. 10A



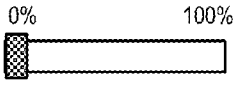
Source image 700

Base image 702

FIG. 10B

Source image 700

Blended base image 704

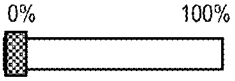


alpha blending level

FIG. 10C

Source image 706

Blended base image 704

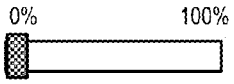


alpha blending level

FIG. 10D

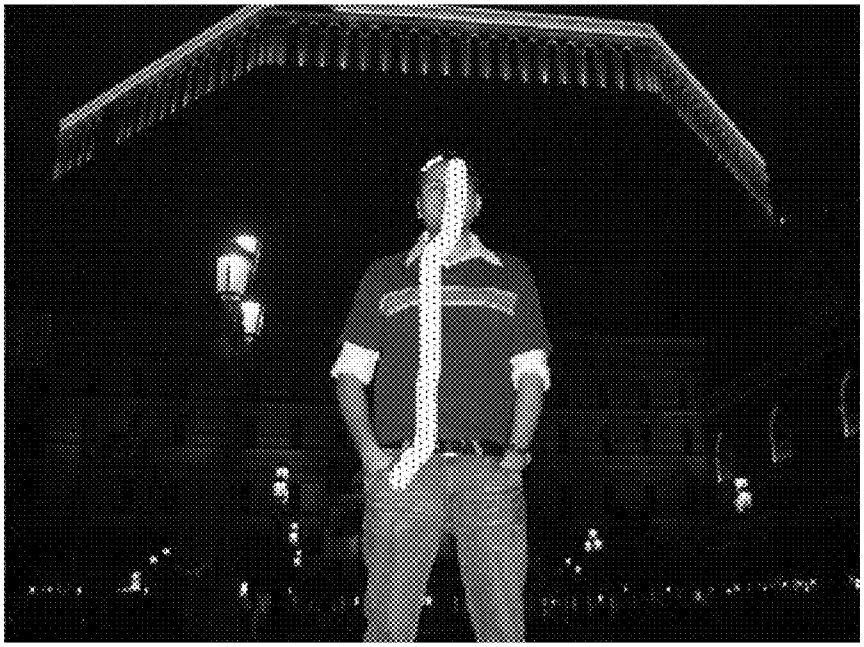
Source image 700

Blended base image 704



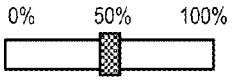
alpha blending level

FIG. 10E



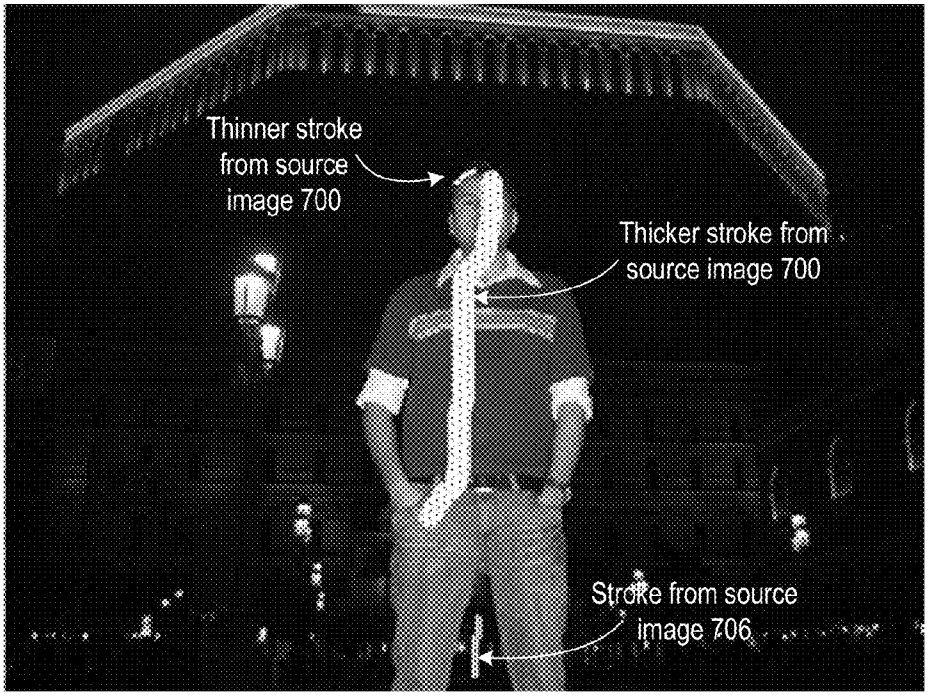
Source image 700

Blended base image 704



alpha blending level

FIG. 10F



Source image 700

Blended base image 704

X Show strokes

X Show regions

FIG. 10G

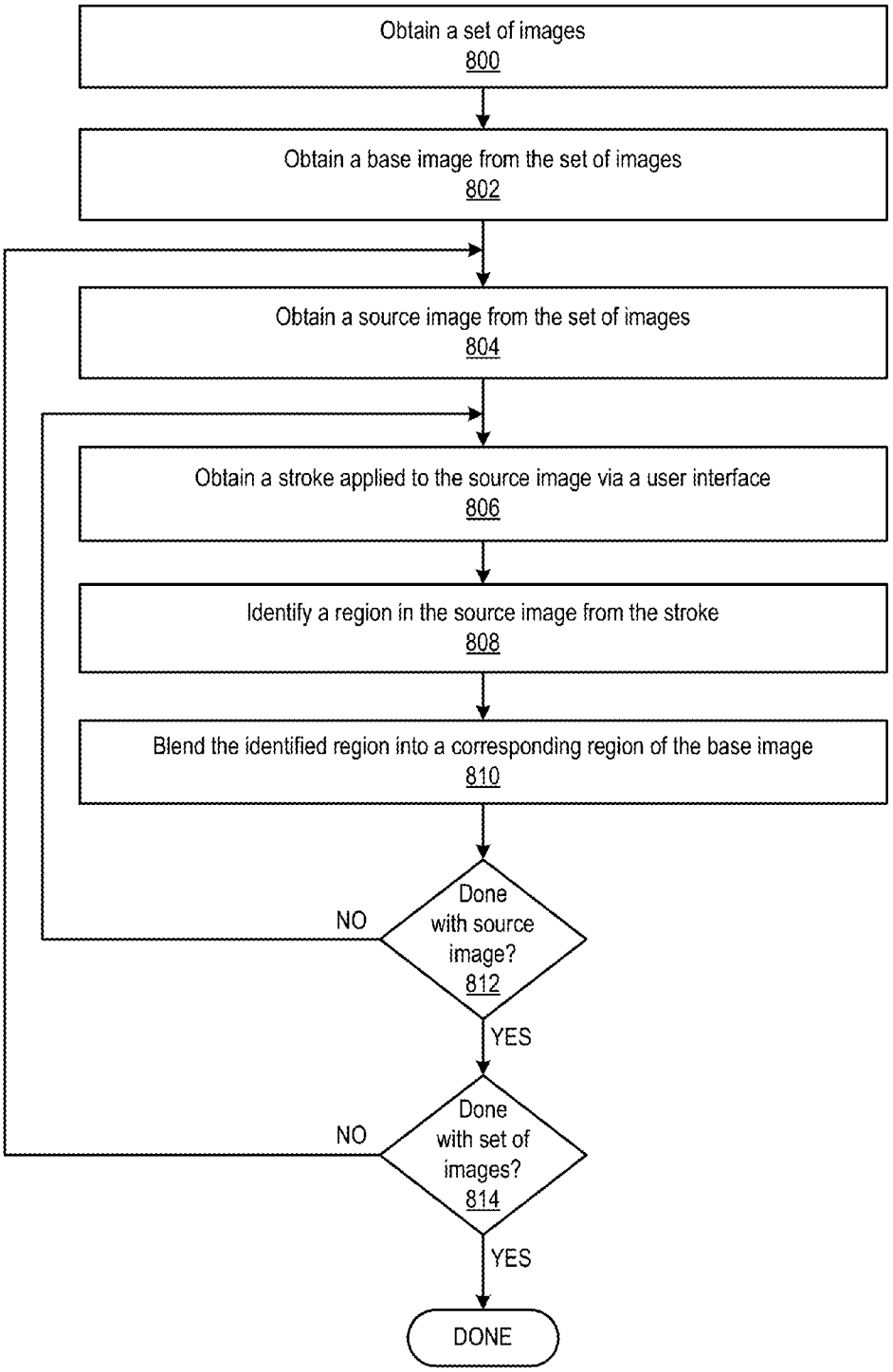

Obtain a set of images
800
Obtain a base image from the set of images
802
Obtain a source image from the set of images
804
Obtain a stroke applied to the source image via a user interface
806
Identify a region in the source image from the stroke
808
Blend the identified region into a corresponding region of the base image
810
Done with source image?
812
NO
YES
Done with set of images?
814
NO
YES
DONE

FIG. 11

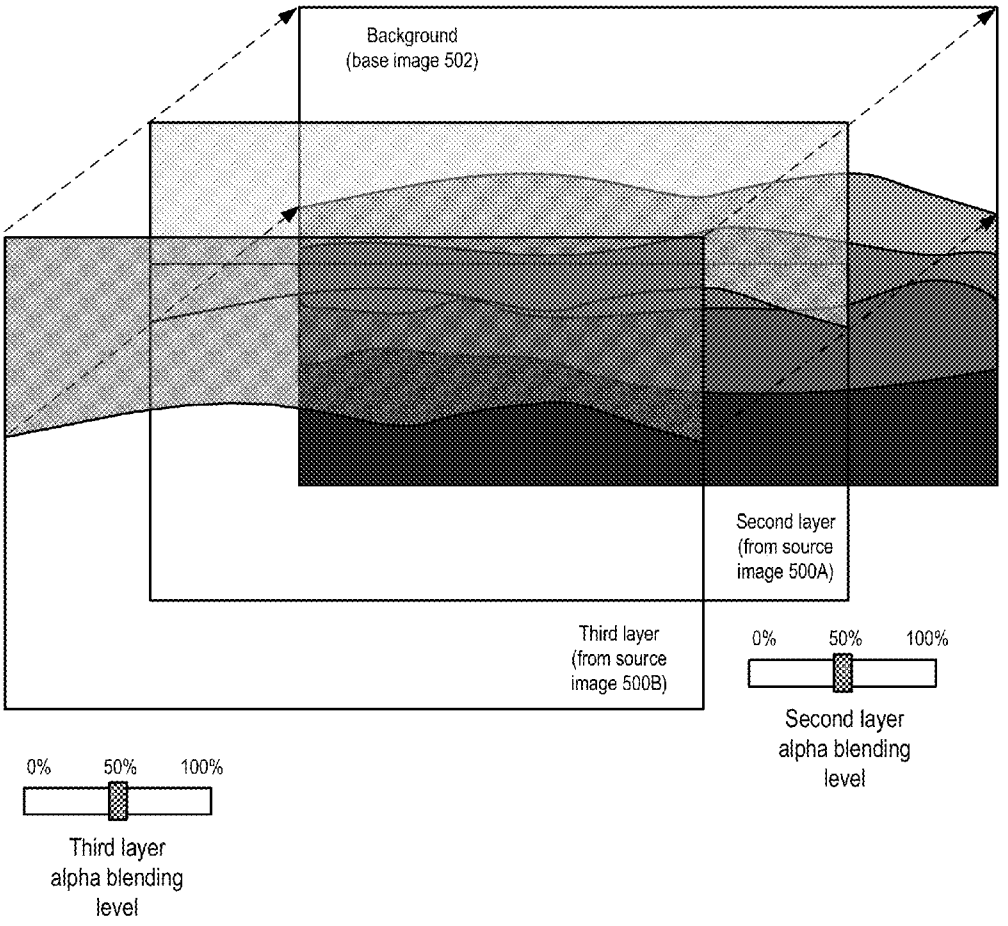

Background
(base image 502)
Second layer
(from source
image 500A)
Third layer
(from source
image 500B)
0%
50%
100%
Second layer
alpha blending
level
0%
50%
100%
Third layer
alpha blending
level

FIG. 12

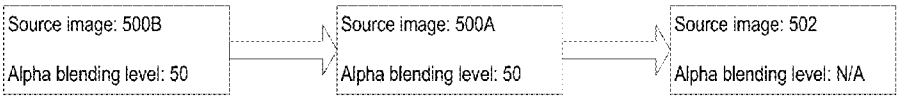

Source image: 500B
Alpha blending level: 50
Source image: 500A
Alpha blending level: 50
Source image: 502
Alpha blending level: N/A

FIG. 13

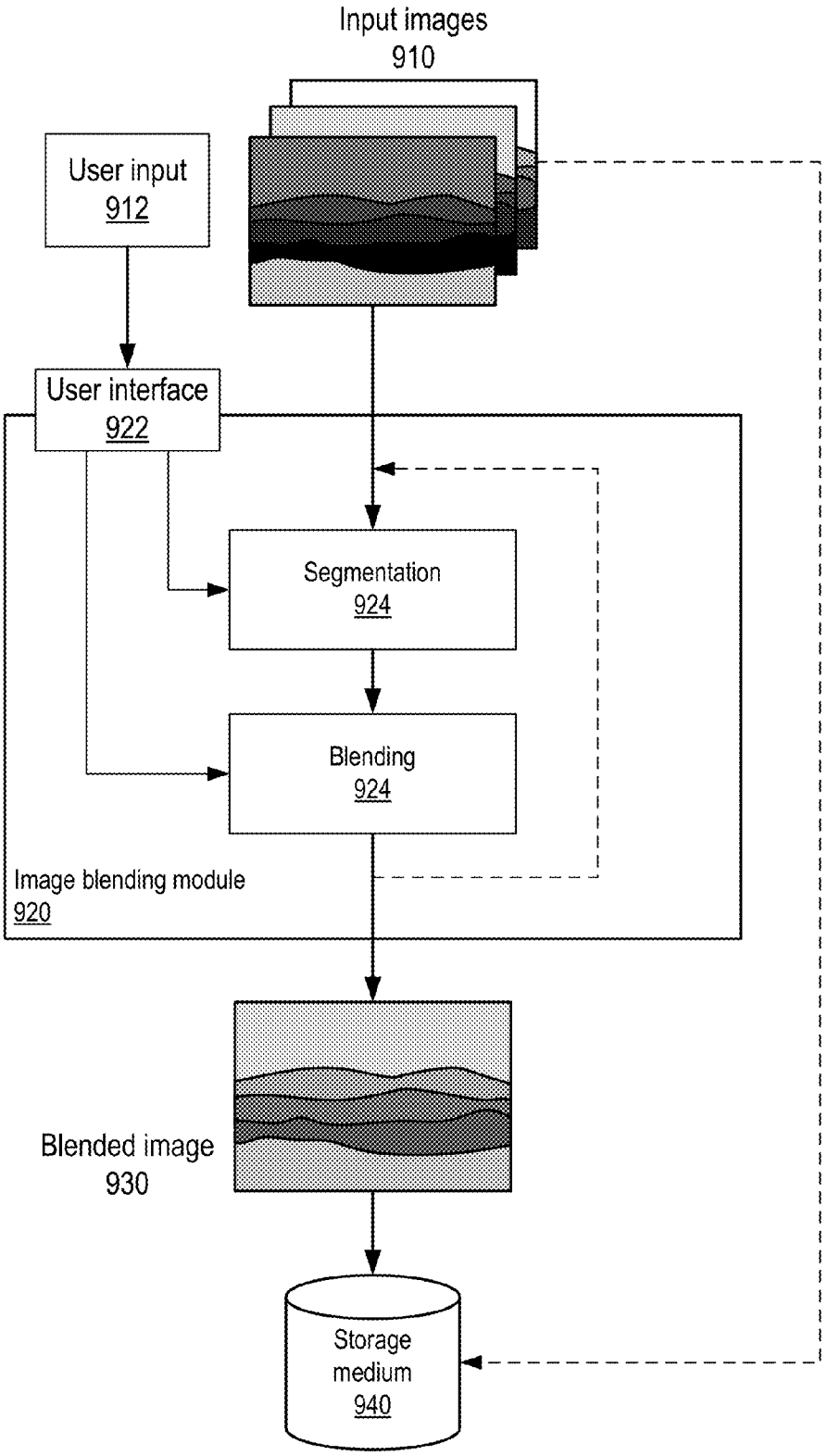

Input images
910
User input
912
User interface
922
Segmentation
924
Blending
924
Image blending module
920
Blended image
930
Storage
medium
940

FIG. 14

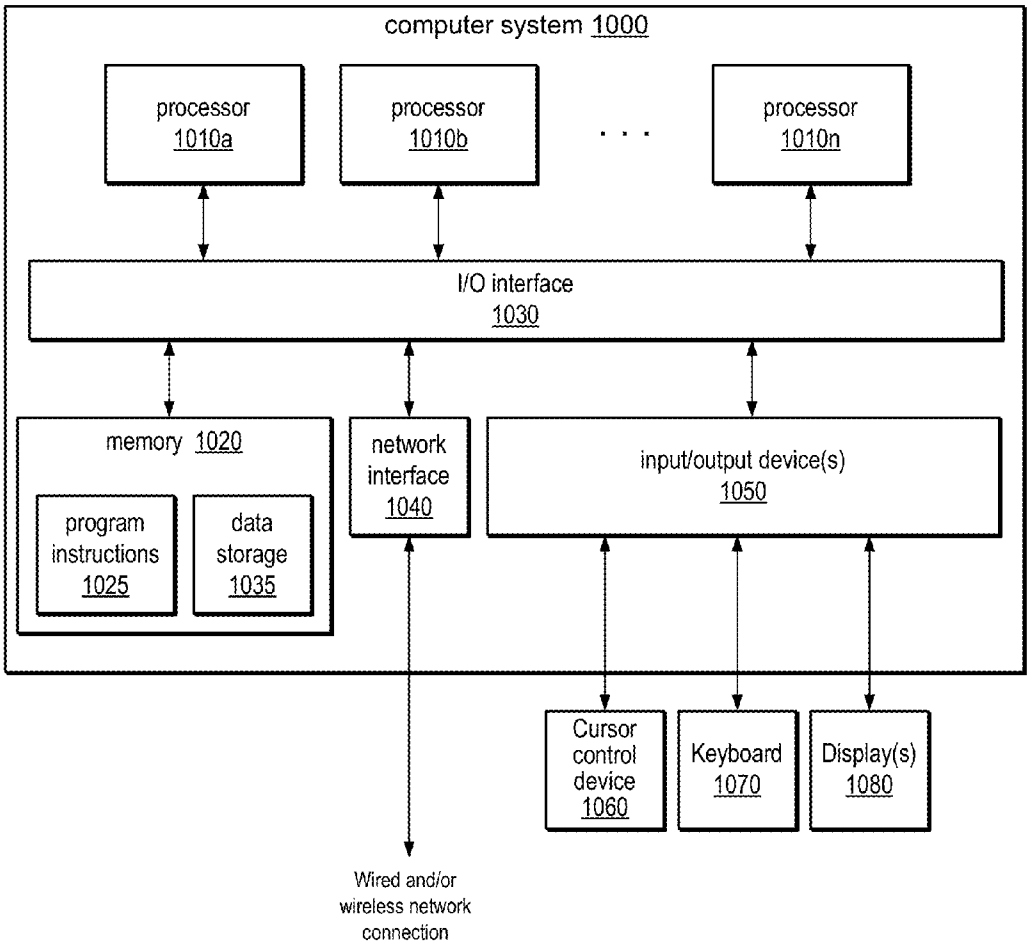

computer system 1000
processor 1010a
processor 1010b
. . .
processor 1010n
I/O interface 1030
memory 1020
program instructions 1025
data storage 1035
network interface 1040
input/output device(s) 1050
Cursor control device 1060
Keyboard 1070
Display(s) 1080
Wired and/or wireless network connection

FIG. 15

METHODS AND APPARATUS FOR BLENDING IMAGES

BACKGROUND

Description of the Related Art

[0001] There are many photographic situations where the range of luminosity values spanning shadows and highlights in a scene is large and thus difficult to capture in a single exposure. For example, objects deep in a room, seen through a small window from outside, can be very dark compared to the outside wall of the house illuminated by direct sunlight. As another example, a single landscape photograph taken near dusk will tend to be either overexposed in the region of the sky to capture detail in the foreground or underexposed in the region of the foreground to capture detail of the sky. In such situations, photographers may capture two or more images of a scene, for example at different exposures (e.g., using different F-stops and/or shutter speeds) or using a flash or other light source to illuminate foreground objects in one image but not in other images. After capturing the two or more images of the scene, various regions from different ones of the two or more images may be combined into a blended image. Using the landscape photograph example, the better-exposed region of the foreground from one image may be merged with the better-exposed region of the sky from another image to produce a blended image that better captures detail throughout the scene.

[0002] In conventional, film-based photography, combining multiple negatives to produce a single print, for example captured at different exposures, requires complicated darkroom techniques. Digital photography technology and digital image processing technology have enabled the development of "digital darkroom" techniques via which multiple images may be merged without requiring the tedious darkroom processing of conventional photography. However, conventional digital image processing techniques for merging images tend to either require the user to manually generate several separate masks that each entirely cover one of the various regions in the multiple images, or are automated and thus do not give the user much if any control over the output.

Alpha Blending

[0003] In computer graphics, alpha blending, or alpha channel blending, refers to the use of an alpha channel with other channels in an image in order to show translucency. The alpha channel is an additional set of bits, for example eight bits in a 32-bit graphics system, used with each pixel that can represent multiple levels of translucency, for example 256 levels if eight bits are used. Generally, black and white are used to represent opaque and fully transparent, respectively, while various gray levels represent various levels of translucency between opaque and fully transparent. In a multilayered image, more than one layer may contain a translucent component; thus, multiple levels of blending may be required.

SUMMARY

[0004] Various embodiments of methods and apparatus for blending regions from multiple images to produce a blended image are described. Embodiments of a method for blending regions of multiple source images to produce a blended image may be implemented as or in an image blending module. In embodiments, two or more different digital images of a scene may be obtained. A background or base image is selected from among the two or more images. Another image is selected from among the two or more images as a current source image, and a stroke is applied to the current source image via a user interface to indicate a desired region of the source image which is to be blended with the base image; one stroke is used to indicate one region, and the stroke does not need to cover the entire region. A stroke may be applied to a source image, for example, via a brush provided by a user interface to the image blending module. The brush may, for example be manipulated by the user to draw the stroke via a cursor control device. A region in the source image is identified from the stroke, and the identified region is alpha blended with the corresponding region of the base image. Additional strokes may be applied to the current source image to select other regions of the current source image to be blended with the base image.

[0005] A different one of the two or more images may be selected as the current source image, and one or more regions from this source image may be selected for blending with the base image using one or more strokes, the corresponding regions identified, and the identified regions from this source image may then be alpha blended with the base image.

[0006] To identify a region in the source image from an input stroke applied to the source image, some embodiments may employ a graph cut algorithm in a segmentation technique. In some embodiments, pixel color values from pixels specified by the stroke may be used by the segmentation technique to locate a region around the stroke that includes similar pixels. As an alternative to, or in addition to, pixel color values, some embodiments may use other pixel values, for example hue or intensity values, in segmenting the image. In some embodiments, the pixel values of pixels specified by a stroke may be used in the segmentation technique to determine a range of pixel values used to identify pixels that are to be included in the region specified by the stroke. In some embodiments, one or more characteristics of the stroke applied by the user to the source image may be used to specify parameters used in the segmentation technique. For example, in some embodiments, a wider brush tip may result in a larger region than a narrower brush tip. As another example, in some embodiments, the length of the stroke may be used to specify one or more segmentation parameters.

[0007] Embodiments may use alpha blending to blend one or more regions selected from one or more source images with a base image. Embodiments may provide one or more blending level user interface elements via which a user may adjust the alpha blending level for a region overlaid on the base image from fully opaque to fully transparent. In some embodiments, layering may be used to blend stroke-specified regions of source images with a base image to produce a blended image. In layering, one or more layers may be added on top of a base image; modifications may be made in the one or more layers rather than to the base image, thus preserving the original base image. In some embodiments, in a multilayered image, one or more regions selected from a first source image may be applied to the base image in a first layer, and one or more regions selected from a second source image may be applied to the base image in a second layer. Regions from additional source images, if any, may be applied to the base image in additional layers. Thus, in a multilayered image, a blending level user interface element may be used to independently adjust the blending levels for region(s) from dif-

ferent source images applied to the base image in different layers. In some embodiments, the alpha blending level for all regions selected from one source image may be adjusted together via a blending level user interface element. In some embodiments, different regions from one source image may be applied to the base image in separate layers; in these embodiments, a blending level user interface element may be used to independently adjust the blending levels for different regions from the same source image if the different regions are applied to the base image in different layers.

[0008] Some embodiments of an image blending module may maintain a label map that maps each pixel in the blended base image to its corresponding source image. An image blending module may, for example, use this label map to determine all of the regions in the blended base image that are from the same source image. By determining all of the regions in the blended base image that are from a particular source image, the alpha blending level for all of these regions may be modified at one time by the user via an alpha blending level user interface element, even if regions from the same source image are in different layers in a layered image.

[0009] Some embodiments may provide a method and one or more user interface elements via which the user may select a single region from multiple source images and alpha blend the region from the source images with the selected base image to obtain the various details in the region captured in the different images. To accomplish this, some embodiment of an image blending module may maintain a label map in which each pixel in the blended image may be mapped to multiple source images using a vector that indicates all of the source images used to blend the respective pixel. An indication of each source image that is a source for the particular pixel in the blended image may be included in the source vector.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIGS. **1**A and **1**B illustrate two synthesized images that represent two digital images of a landscape scene captured at different exposures.

[0011] FIGS. **2**A through **2**C illustrate a workflow for selecting a region from the image shown in FIG. **1**B and applying the region to the image shown in FIG. **1**A to produce a blended image, according to some embodiments.

[0012] FIG. **2**D illustrates two regions of the blended image shown in FIG. **2**C, according to some embodiments.

[0013] FIGS. **3**A and **3**B illustrate the selection of another region from the source image shown in FIG. **1**B and applying the selected region to the blended image shown in FIG. **2**C, according to some embodiments.

[0014] FIG. **3**C illustrates the regions of the blended image shown in FIG. **3**B which include a region from the image shown in FIG. **1**B, selected by strokes shown in FIGS. **2**B and **3**A, and a region from the base image shown in FIG. **1**A, according to some embodiments.

[0015] FIGS. **4**A through **4**C illustrate three synthesized images that represent three digital images of a landscape scene captured at three different exposures.

[0016] FIGS. **5**A through **5**G illustrate a workflow that may be used to generate a blended image from the three images shown in FIGS. **4**A through **4**C according to some embodiments.

[0017] FIG. **6** illustrates the regions of multiple source images that are blended with a base image to produce a blended image, according to some embodiments.

[0018] FIG. **7** illustrates using layers to compose a blended image according to some embodiments.

[0019] FIG. **8** illustrates adjusting the alpha blending levels of layers in a blended image according to some embodiments.

[0020] FIGS. **9**A through **9**G illustrate an example user interface to a image blending module that may be used to perform image blending workflows as described herein, according to some embodiments.

[0021] FIGS. **10**A through **10**G illustrate application of the image blending methods and workflows as described herein on example digital photographs, according to some embodiments.

[0022] FIG. **11** is a flowchart of an example method for blending images, according to some embodiments.

[0023] FIG. **12** illustrates the same region selected from multiple source images and blended with a base image, according to some embodiments.

[0024] FIG. **13** is a block diagram illustrating an example source vector from a label map that indicates each source image that is a source for a particular pixel in a blended image, according to some embodiments.

[0025] FIG. **14** illustrates an image blending module that may implement image blending methods and workflows, according to some embodiments.

[0026] FIG. **15** illustrates an example computer system that may be used in embodiments.

[0027] While the invention is described herein by way of example for several embodiments and illustrative drawings, those skilled in the art will recognize that the invention is not limited to the embodiments or drawings described. It should be understood, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention. The headings used herein are for organizational purposes only and are not meant to be used to limit the scope of the description. As used throughout this application, the word "may" is used in a permissive sense (i.e., meaning having the potential to), rather than the mandatory sense (i.e., meaning must). Similarly, the words "include", "including", and "includes" mean including, but not limited to.

DETAILED DESCRIPTION OF EMBODIMENTS

[0028] In the following detailed description, numerous specific details are set forth to provide a thorough understanding of claimed subject matter. However, it will be understood by those skilled in the art that claimed subject matter may be practiced without these specific details. In other instances, methods, apparatuses or systems that would be known by one of ordinary skill have not been described in detail so as not to obscure claimed subject matter.

[0029] Some portions of the detailed description which follow are presented in terms of algorithms or symbolic representations of operations on binary digital signals stored within a memory of a specific apparatus or special purpose computing device or platform. In the context of this particular specification, the term specific apparatus or the like includes a general purpose computer once it is programmed to perform particular functions pursuant to instructions from program software. Algorithmic descriptions or symbolic representations are examples of techniques used by those of ordinary skill in the signal processing or related arts to convey the substance of their work to others skilled in the art. An algo-

rithm is here, and is generally, considered to be a self-consistent sequence of operations or similar signal processing leading to a desired result. In this context, operations or processing involve physical manipulation of physical quantities. Typically, although not necessarily, such quantities may take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared or otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to such signals as bits, data, values, elements, symbols, characters, terms, numbers, numerals or the like. It should be understood, however, that all of these or similar terms are to be associated with appropriate physical quantities and are merely convenient labels. Unless specifically stated otherwise, as apparent from the following discussion, it is appreciated that throughout this specification discussions utilizing terms such as "processing," "computing," "calculating," "determining" or the like refer to actions or processes of a specific apparatus, such as a special purpose computer or a similar special purpose electronic computing device. In the context of this specification, therefore, a special purpose computer or a similar special purpose electronic computing device is capable of manipulating or transforming signals, typically represented as physical electronic or magnetic quantities within memories, registers, or other information storage devices, transmission devices, or display devices of the special purpose computer or similar special purpose electronic computing device.

[0030] Various embodiments of methods and apparatus for blending regions of multiple images to produce a blended image are described. Embodiments of a method for blending regions of multiple source images to produce a blended image as described herein may be implemented as or in an image blending module. Embodiments of the image blending module may, for example, be implemented as a stand-alone image processing application, as a module of an image processing application, as a plug-in for applications including image processing applications, and/or as a library function or functions that may be called by other applications. Embodiments of the image blending module may be implemented in any image processing application, including but not limited to Adobe® PhotoShop® Adobe® PhotoShop® Elements®, and Adobe® After Effects®. An example image blending module is illustrated in FIG. **14**. An example system on which an image blending module may be implemented is illustrated in FIG. **15**.

[0031] In embodiments of a method for blending regions of multiple source images to produce a blended image, two or more different digital images of a scene may be obtained. For example multiple images may be captured at different exposures to better capture detail of different regions of the scene according to the lighting of the regions. The digital images may be color images or grayscale ("black and white") images. The digital images may be digitally-captured images such as digital photographs, digitized images such as digitized conventional photographs or negatives, digital video frames, or in general any digital images. FIGS. **1**A and **1**B illustrate two synthesized images that represent two digital images of a landscape scene captured at different exposures. FIG. **1**A simulates an image that was taken at a longer exposure so that details of the foreground are well illuminated; however, the sky is overexposed. FIG. **1**B simulates a second image that was taken of the same scene at a shorter exposure so that the sky is better exposed to capture more detail; however, the foreground is underexposed.

[0032] FIGS. **2**A through **2**D illustrate a workflow for selecting a region from the image shown in FIG. **1**B and applying the region to the image shown in FIG. **1**A to produce a blended image, according to some embodiments. In embodiments, a background or base image is selected from among the two or more images. FIG. **2**A shows the image shown in FIG. **1**A selected as the base image. Another image is selected as a source image, and one or more strokes are applied to the source image via a user interface to specify region(s) of the source image which are to be blended with the base image; one stroke is used to specify one region, and the stroke does not need to cover the entire region. FIG. **2**B shows the image shown in FIG. **1**B selected as a source image. The broad black dotted line across the sky region of the image in FIG. **2**B represents a stroke applied by the user to the sky region of the source image. The stroke may be applied to the source image, for example, via a brush provided by a user interface to the image blending module. The brush may be manipulated by the user to draw the stroke via a cursor control device such as a mouse, trackball, touchpad, or keyboard. Other methods of applying a brush stroke may be used. For example, a stylus, finger, or other implement may be used to draw the stroke on the touch-sensitive surface of a touch-enabled input device, such as a touchpad, tablet, or touch-sensitive screen.

[0033] FIG. **2**C shows the sky region of FIG. **2**B, selected by the user in FIG. **2**B using a single stroke, blended with the base image shown in FIG. **2**A to produce a blended image that is better-exposed across the entire image than any single one of the source images.

[0034] To identify a region in the source image from an input stroke applied to the source image, some embodiments may employ any one of several image processing algorithms, known collectively as graph cut algorithms, in a segmentation technique to segment the source image into two regions (the region specified by the stroke is one region, and the rest of the image is the other region). However, other types of image processing algorithms than graph cut algorithms may be used in a segmentation technique in other embodiments to locate region(s) in the source image. In some embodiments, pixel color values from pixels specified by a stroke may be obtained and used by the segmentation technique to segment an image into two regions. As an alternative to, or in addition to, pixel color values, some embodiments may use other pixel values, for example hue or intensity values, in segmenting the image. Some embodiments may provide one or more user interface elements via which the user may specify what pixel values or range of pixel values are to be used to segment an image. Some embodiments may provide one or more user interface elements via which the user may adjust one or more segmentation parameters, such as thresholds to be used when segmenting an image.

[0035] In some embodiments, one or more characteristics of the stroke applied by the user to the source image may be used to specify parameters used in the segmentation technique. For example, in some embodiments, the width of the brush tip used to draw the stroke may be used to specify one or more segmentation parameters. In some embodiments, for example, a wider brush tip may specify that a wider range of pixel values is to be used in identifying pixels to be included in the region, while a narrower brush tip may specify a narrower range; thus, a wider brush tip may result in a larger region than a narrower brush tip. Some embodiments may provide one or more user interface elements via which the

user may set or change the width of the brush tip to be used when drawing a stroke. As another example, in some embodiments, the length of the stroke may be used to specify one or more segmentation parameters. In some embodiments, the width of the brush tip and the length of the stroke may both be used to specify one or more segmentation parameters. Other characteristics of the stroke, for example stroke speed and/or direction, or even the color used for the stroke, may be used specify one or more segmentation parameters in some embodiments.

[0036] In some embodiments, the pixel values of pixels defined by a stroke may be used to determine a range of pixel values used to identify pixels that are to be included in the region specified by the stroke. In some embodiments, the identified region is contiguous; that is, the segmentation technique searches out from the stroke, and does not cross any boundaries to identify other separate areas of the image that may satisfy the pixel value criteria identified from the stroke. FIG. **2**D illustrates two regions of the blended image shown in FIG. **2**C: the sky region, indicated by a dotted texture, which was selected by the single stroke shown in FIG. **2**B and located by the segmentation technique from the stroke; and the rest of the image, in this example the foreground from the base image shown in FIG. **2**A, indicated by diagonal lines. Some embodiments may provide one or more user interface elements via which a user may optionally view a visual indication of the various regions in a blended image, for example by shading, outlining, or texturing the regions, with different regions shaded, outlined, or textured differently to indicate that the regions are sourced from different images.

[0037] In some embodiments, a digital image processing technique referred to as layering may be used to blend stroke-specified regions of source images with a base image to produce a blended image such as the example blended image shown in FIG. **2**C. In layering, one or more layers may be added on top of a base image; modifications may be made in the one or more layers rather than to the base image, thus preserving the original base image. For example, to blend a region of a source image with the base image, pixel values from the region may be applied in a separate layer on top of the base image. Layering thus preserves the base image; the pixels of a selected region are not applied directly to the pixels of the base image. Using layering simplifies operations such as "undo" operations, modifications of applied regions such as adding to or erasing parts of applied regions, and blending adjustments.

[0038] Alpha blending refers to the use of an alpha channel with other channels in an image in order to show translucency. Embodiments may use alpha blending to blend one or more regions selected from one or more source images with a base image. Embodiments may provide one or more blending level user interface elements via which a user may adjust the alpha blending level (e.g., from 0% (opaque) to 100% (fully transparent)) used for a region or regions overlaid on the base image. A blending level user interface element may, for example, be implemented as a slider bar, a text entry box, a dial, a menu, or in general any type of control user interface element that may be used to select from a specified range.

[0039] In some embodiments, in a multilayered image, one or more regions selected from a first source image may be applied to the base image in a first layer, and one or more regions selected from a second source image may be applied to the base image in a second layer. Regions from additional source images, if any, may be applied to the base image in additional layers. Thus, in a multilayered image, a blending level user interface element may be used to independently adjust the blending levels for region(s) from different source images applied to the base image in different layers. In some embodiments, the alpha blending level for all regions selected from one source image may be adjusted together via a blending level user interface element. In some embodiments, different regions from one source image may be applied to the base image in separate layers; in these embodiments, a blending level user interface element may be used to independently adjust the blending levels for different regions from the same source image if the different regions are applied to the base image in different layers.

[0040] While FIGS. **2**A through **2**C illustrate the selection of one region of a source image to be applied to a base image to produce a blended image as shown in FIG. **2**C, embodiments may allow a user to select one or more additional regions from a source image to be blended with the base image. FIGS. **3**A through **3**C illustrate the selection of another region from the source image shown in FIGS. **1**B and **2**B and applying the selected region to the blended image shown in FIG. **2**C, according to some embodiments. For example, the user may prefer the appearance of the house in the image shown in FIG. **1**B to the appearance of the house in the image shown in FIG. **1**A, which was used as the base image. In FIG. **3**A, the user has applied a stroke to the source image to select the "house" in the image as another region to be applied to the base image. The broad white dotted line across the house represents the stroke applied by the user to the source image. FIG. **3**B shows that the region selected in FIG. **3**A has been blended, along with the region selected as indicated in **2**B, with the base image to produce a blended image that is differently exposed across different regions according to the preferences of the user. FIG. **3**C illustrates the regions of the image shown in FIG. **3**B: the region from the image shown in FIG. **1**B, selected by strokes shown in FIGS. **2**B and **3**A, indicated by a dotted texture; and the rest of the image, in this example the foreground from the image shown in FIG. **1**A, indicated by diagonal lines.

[0041] Some embodiments of an image blending module may maintain a label map that maps each pixel in the blended base image to its corresponding source image. The image blending module may, for example, use this label map to determine all of the regions in the blended base image that are from the same source image. This blended image region information may be used, for example, to display an indication of regions from a source image in the blended image, as shown in FIG. **3**C. The blended image region information may also be used in setting alpha blending levels. By determining all of the regions in the blended base image that are from a particular source image, the alpha blending level for all of these regions may be modified at one time by the user via an alpha blending level user interface element, even if regions from the same source image are in different layers in a layered image.

[0042] While FIGS. **2**A through **2**D and FIGS. **3**A through **3**C illustrate the selection of one or more regions from a single source image to be applied to a base image to produce a blended image, some embodiments may allow regions selected from multiple source images to be blended into a base image to produce a blended image. FIGS. **4**A through **4**C and FIGS. **5**A through **5**G illustrate the selection of regions from multiple source images and blending the selected regions into a base image to produce a blended image, accord-

ing to some embodiments. While FIGS. **4**A through **4**C and FIGS. **5**A through **5**G show three images with two source images and one base image, embodiments may be applied to sets of more than three images, and content from more than two source images may be blended with a base image using embodiments.

[0043] FIGS. **4**A through **4**C illustrate three synthesized images that represent three digital images of a landscape scene captured at three different exposures. FIG. **4**A simulates an image that was taken at a longer exposure so that details of the midrange region are well exposed; however, the sky is overexposed, and the foreground is slightly underexposed due to the foreground lighting. FIG. **4**B simulates a second image that was taken of the same scene at a shorter exposure than that used for FIG. **4**A so that the sky is better exposed to capture more detail; however, the midrange and foreground are underexposed. FIG. **4**C simulates a third image that was taken of the same scene using artificial lighting, for example a flash, at an even shorter exposure so that the foreground is better exposed; however, the midrange and sky are underexposed.

[0044] FIGS. **5**A through **5**G illustrate a workflow that may be used to generate a blended image from the three images shown in FIGS. **4**A through **4**C according to some embodiments. The workflow may be performed via a user interface to an image blending module that implements a method for blending regions of multiple source images to produce a blended image as described herein. An example user interface to an image blending module is illustrated in FIGS. **9**A through **9**G.

[0045] In FIG. **5**A, the user selects one of the images to use as a base image **502**. In this example, the image from FIG. **4**A has been selected as the base image **502**. The other two images may be used as source images **500**. In this example, the image from FIG. **4**B is shown as source image **500**A, and the image from FIG. **4**C is shown as source image **500**B. In FIG. **5**B, the user has applied a stroke to the sky region of source image **500**A via the user interface to select the sky region of the source image **500**A for blending with the base image. The broad white dotted line across the sky represents the stroke applied by the user to the source image **500**A. The image blending module applies a segmentation technique that uses the selection stroke of FIG. **5**B to determine all pixels in source image **500**A that are to be included in the region. The diagonal lines in FIG. **5**C indicate the region thus determined by the segmentation technique. In FIG. **5**D, the region of source image **500**A determined by the segmentation technique from the stroke has been overlaid onto base image **502** to produce blended image **504**.

[0046] In FIG. **5**E, the user has applied a stroke to the foreground region of source image **500**B via the user interface. The broad black dotted line across the foreground represents the stroke applied by the user to the source image **500**B. The image blending module applies the segmentation technique which uses the selection stroke of FIG. **5**E to determine all pixels in source image **500**B that are to be included in the region. The diagonal lines in FIG. **5**F indicate the region thus determined by the segmentation technique. In FIG. **5**G, the foreground region of source image **500**B has been overlaid onto blended image **504** to produce blended image **506**.

[0047] While not shown in FIGS. **5**A through **5**G, after a region is selected from a source image and blended with the base image, there may be areas that are either blended into or not blended into in the base image that the user desires to fix or touch up. For example, some small areas around the border of a selected region may be missed by the segmentation technique. In some embodiments, to fix such a missed area, a thinner stroke may be applied to the source image to select the region, and the selected region may be blended with the base image. See FIG. **10**C for an example. In addition to missed areas, a thicker stroke may cause some areas of the source image to be blended with the base image that the user does not want to be blended. In some embodiments, such undesired areas in the blended base image may be removed by selecting the original base image as the current source image and applying a stroke to reselect the region from the original base image. The selected region from the original base image may then be blended with the blended base image. See FIGS. **10**C and **10**D for an example. Some embodiments may provide other methods and tools via which the user may make desired corrections to a blended base image.

[0048] FIG. **6** illustrates the regions of source images **500**A and **500**B that are blended with base image **502** to produce blended image **506** shown in FIG. **5**G. The sky region from source image **500**A is indicated by vertical lines. The foreground region from source image **500**B is indicated by diagonal lines. The rest of the image, in this example the midrange region from base image **502**, is indicated by crosshatched lines. Some embodiments may provide one or more user interface elements via which a user may optionally view a visual indication of the various regions in a blended image, for example by shading, outlining, or texturing the regions, with different regions shaded, outlined, or textured differently.

[0049] FIG. **7** illustrates using layers to compose a blended image according to some embodiments. Base image **502** is used as a background layer. A second layer includes the sky region from source image **500**A. The rest of the second layer is fully transparent so that portions of the background layer that are not behind the sky region are displayed. A third layer includes the foreground region from source image **500**B. The rest of the third layer is fully transparent so that portions of the layers underneath the third layer that are not behind the foreground region are displayed (if not covered by portions of layers underneath the third layer). Note that the regions in the second and third layer in this Figure are shown with the alpha blending set to opaque (0%); the pixels in these regions will completely cover or "paint over" corresponding pixels of underlying layers.

[0050] FIG. **8** illustrates adjusting the alpha blending levels of layers in a blended image according to some embodiments. Embodiments may use alpha blending to blend one or more regions selected from one or more source images with a base image. Embodiments may provide one or more blending level user interface elements via which a user may adjust the alpha blending level (e.g., from 0% (opaque) to 100% (fully transparent)) used for layers overlaid on the base image. A blending level user interface element may, for example, be implemented as a slider bar, a text entry box, a dial, a menu, or in general any type of user interface element that may be used to select from a range. FIG. **8** shows slider bars used as blending level user interface elements. In FIG. **8**, the alpha blending level for the second layer is set to 25% so that the second layer is partially translucent, and the alpha blending level for the third layer is set to 50%, so that the translucency of the third layer is 50%.

[0051] While FIG. **8** shows two separate user interface elements that may be used to independently adjust the alpha

blending levels for different regions, some embodiments may provide one or more user interface elements via which a user may adjust the alpha blending levels for all regions.

[0052] Furthermore, while FIGS. **2**A through **8** show different, non-overlapping regions selected from source images, different, but overlapping, regions may be selected from the same source image or from different source images. In addition, in some embodiments, the same region may be selected from two or more source images. See, for example, FIG. **12**.

Example User Interface

[0053] FIGS. **9**A through **9**G illustrate an example user interface to a image blending module that may be used to perform image blending workflows as described herein, according to some embodiments. The user interface is provided as an example, and is not intended to be limiting.

[0054] FIG. **9**A shows an image merging window according to some embodiments. Image merging window **600** may include an image thumbnails area **610** and a control pane **620**. Image merging window **600** may also include two panes where selected images may be displayed. One pane may be a base image pane **604** where an image selected as a base or background image may be displayed. The other pane may be a source image pane **602** where a selected source image may be displayed. Window **600** may include one or more other user interface elements, such as a brush settings **606** user interface element via which the user may specify one or more settings, such as width, for a brush tool to be used to paint strokes on source images to select regions.

[0055] The image thumbnails **610** user interface element may be used to display thumbnails of a set of images that the user has selected to work on. In this example, image thumbnails **610** shows, from left to right, thumbnails for the images from FIGS. **4**B, **4**C, and **4**A, respectively, selected as a set of images to be worked on. In this example, the images from FIGS. **4**B, **4**C, and **4**A are labeled as images **612**A, **612**B, and **612**C, respectively. While this example shows three images in the set, two, three or more images may be included in a set of images to be blended according to the methods described herein. The image thumbnails **610** user interface element may include a scrollbar **612** via which the user may scroll to see additional thumbnails if all thumbnails for a selected set of images cannot be displayed at one time in the image thumbnails **610** user interface element. While not shown in the example interface, embodiments may provide one or more user interface elements via which a user may select sets of images to be displayed in image thumbnails **610**. Thumbnails displayed in image thumbnails **610** may be selected for the image panes **602** and **604** described above. Selecting a thumbnail for an image pane causes the corresponding image to be displayed in the respective image pane. User interface methods for selecting a thumbnail to be displayed in either source image pane **602** or base image pane **604** are described below.

[0056] Example control pane **620** may include one or more user interface elements via which the user may perform various aspects of an image blending workflow as described herein. In this example, control pane **620** includes tools **622**, options **624**, and an alpha blending control **626** that may be used to adjust alpha blending levels. While FIGS. **9**A through **9**G show alpha blending control **626** set to 0% (fully opaque) so that regions from the source images applied to the base image completely cover the similar regions in the base image, alpha blending control **626** may be manipulated by the user when performing the workflow operations as described for FIGS. **9**A through **9**G to adjust the alpha blending level for a region or regions in the range from 0% (fully opaque) to 100% (fully transparent) as described in regards to FIG. **8**. Also, while FIGS. **9**A through **9**G show alpha blending control **626** as a slider bar, other types of controls may be used instead of or in addition to a slider bar to adjust the alpha blending level. Furthermore, some embodiments may not provide alpha blending adjustment and thus may not provide an alpha blending control **626**.

[0057] In the example control pane **620**, tools **622** includes a brush tool that may be selected by the user to draw a stroke or strokes on a selected source image according to the current settings of the brush that the user has specified via brush settings **606**. Tools **622** also includes an eraser tool that may be selected by the user to, for example, erase portions of regions from source images overlaid on the base image. Some embodiments may provide one or more user interface elements via which the user may control settings of the eraser tool. In some embodiments, brush settings **606** may apply to both the brush tool and the eraser tool. While this example shows an eraser tool, some embodiments may not provide an eraser tool. Some embodiments may provide one or more other user-selectable tools via which the user may perform other operations on images displayed in the image panes.

[0058] In the example control pane **620**, options **624** includes a show strokes user interface element via which the user may choose to show or hide strokes on a source image, and a show regions user interface element via which the user may choose to show or hide indications of regions overlaid on the base image. While these option user interface element are shown as checkboxes, other types of user interface elements may be used to provide options to the user. Some embodiments may not provide one or both of the shown options, and some embodiments may provide one or more other options.

[0059] FIG. **9**B shows the example image merging window **600** with an image selected and displayed as base image **604**, according to some embodiments. In this example, image **612**C has been selected as the base image. In some embodiments, the user interface may allow the user to select a thumbnail from thumbnails **610** and drag the selected thumbnail onto base image **604** pane to select, and display, the image as the base image. In some embodiments, other methods may be used to select an image from thumbnails **610** as the base image. In some embodiments, an indication that an image has been selected as a base image may be provided. For example, a colored border of a particular color and/or texture may be displayed around the thumbnail corresponding to the selected base image. In this example, a black border is shown around the thumbnail corresponding to the selected base image **612**C.

[0060] FIG. **9**C shows the example image merging window **600** with an image selected and displayed as a current source image **602**, according to some embodiments. In this example, image **612**A has been selected as the current source image. In some embodiments, the user interface may allow the user to select a thumbnail from thumbnails **610** to be used as the source image by positioning the cursor over the thumbnail and clicking on the thumbnail. In some embodiments, the user interface may allow the user to select a thumbnail from thumbnails **610** and drag the selected thumbnail onto source image **602** pane to select, and display, the image as the current source image. In some embodiments, other methods may be used to select an image from thumbnails **610** as the current

source image. In some embodiments, an indication that an image has been selected as the current source image may be provided. For example, a colored border of a particular color and/or texture may be displayed around the thumbnail corresponding to the selected source image. In this example, a black-and-white dashed border is shown around the thumbnail corresponding to the selected source image **612**A.

[0061] FIG. **9**D illustrates the user drawing a stroke, indicated by the broad white line with black dots, in a region of the current source image **602** displayed in the example image merging window **600** to specify a region of the source image **602** that is to be blended with base image **604**, according to some embodiments. In this example, the user has selected the sky region of the current source image **602**, which corresponds to thumbnail **612**A. In some embodiments, to draw a stroke, the user may select the stroke tool from tools **622**, if necessary. In addition, the user may, if necessary or desired, modify settings of the brush using the brush settings **606** user interface. The user may also change the alpha blending setting using alpha blending control **626**, if desired. The user may then position the cursor over a desired starting point in the source image **602** using a cursor control device, depress and hold down a cursor control device button, and move the cursor, in this example shown as a paint brush head, along a path in the source image **602**, shown as the dashed line down the center of the stroke, using the cursor control device. Alternatively, a keyboard button, or a combination of keyboard buttons and/or cursor control buttons, may be used in drawing a stroke. In this example, the cursor is shown at the end of the stroke. The user may then release the depressed button(s) to complete the stroke.

[0062] FIG. **9**E shows a selected region in the source image **602**, identified by the image blending module from the stroke entered by the user, blended with the corresponding region in base image **604**. For illustrative purposes, the selected region in source image **602** is shown bordered by a black-and-white dotted line, and the corresponding region in base image **605** is shown bordered by a black-and-white dashed line. In some embodiments, visual indications of the selected region in source image **602** and/or of the corresponding region in base image **604** may be displayed on the respective images. Note that the coloring of the corresponding region in base image **604** is now different than the coloring of the region shown in FIGS. **9**A through **9**D; the pixels from the selected region in current source image **602** have been blended with the corresponding region in base image **604**. Alpha blending control **626** is shown as currently set to 0% (fully opaque), so the pixels from the selected region are in effect "painted over" the pixels in the base image region.

[0063] To identify a region in the source image **602** from the stroke applied to the source image **602**, some embodiments may employ a graph cut algorithm in a segmentation technique. However, other types of image processing algorithms than graph cut algorithms may be used in a segmentation technique in some embodiments. In some embodiments, pixel color values from pixels specified by the stroke may be obtained and used by the segmentation technique to segment the source image **602**. As an alternative to, or in addition to, pixel color values, some embodiments may use other pixel values, for example hue or intensity values, in segmenting the image.

[0064] In some embodiments, one or more characteristics or settings of the brush used to draw a stroke may be used by the segmentation technique. For example, in some embodiments, a wider or narrower brush may be used to broaden or narrow the scope of the segmentation technique when locating a region. Thus, a broader brush may result in a larger region being located for a stroke than would be located for a similar stroke drawn with a smaller brush.

[0065] FIG. **9**F shows that the user has selected the image corresponding to thumbnail **612**B as the new source image **602**. The user has drawn a stroke, indicated by the broad black line with white dots, in the foreground region of source image **602**. The image blending module has identified a region in source image **602** from the stroke drawn by the user and blended the selected region, indicated by the black-and-white dotted line, from the current source image **602** with the corresponding region, indicated by the black-and-white dashed line line, in base image **604**. The alpha blending level for this region is shown as 0% (fully opaque).

[0066] FIG. **9**G shows that the user has selected both "show strokes" and "show regions" in options **624**. In some embodiments, selecting the "show strokes" option causes visual indications of the strokes the user has drawn to be displayed in source image **602**. In some embodiments, selecting the "show regions" option causes visual indications of the regions that have been blended from the source image(s) into the base image **604** to be displayed on base image **604**, for example by outlining, coloring, shading, or texturing the regions. In some embodiments, the show strokes option and the show regions option only show strokes and regions for the current source image **602**. In other embodiments, the show strokes option and the show regions option show strokes and regions from all source images that have been processed.

[0067] The user may optionally change the alpha blending level within the range of 0% (fully opaque) to 100% (fully transparent) for one or more of the regions that have been blended from the source image(s) onto the base image **604** using alpha blending control **626**. FIG. **8** illustrates changing the alpha blending level for regions overlaid on a base image using layers.

[0068] Some embodiments may provide an eraser tool (or similar tool), as shown in tools **622**, via which the user may erase portions of a region overlaid on base image **604**. For example, in some embodiments, locations in a layer overlaid on base image **604** that are part of a selected region indicated by the layer may be modified using an eraser tool provided by the interface to change the locations from partially or fully opaque to fully transparent. While not shown, some embodiments may provide a painting or drawing tool via which the user may add to a region overlaid on base image **604**. For example, in some embodiments, locations in a layer overlaid on base image **604** that are not part of a selected region indicated by the layer may be modified using a painting or drawing tool provided by the interface to change the locations from fully transparent to partially or fully opaque to cause portions of the source image corresponding to the layer to be blended with the base image. Other methods for erasing overlaid pixels and/or for adding pixels to the overlay may be used in various embodiments.

[0069] While not shown in FIGS. **9**A through **9**G, after a region is selected from a source image and blended with the base image, there may be areas that are either blended into or not blended into in the base image that the user desires to fix or touch up. For example, some small areas around the border of a selected region may be missed by the segmentation technique. In some embodiments, to fix such a missed area, a thinner stroke may be applied to the source image to select the

region, and the selected region may be blended with the base image. See FIG. **10**C for an example. In addition to missed areas, a thicker stroke may cause some areas of the source image to be blended with the base image that the user does not want to be blended. In some embodiments, such undesired areas in the blended base image may be removed by selecting the original base image (in FIGS. **9**A through **9**G, the image corresponding to thumbnail **512**C) as the current source image **602** and applying a stroke to reselect the region from the original base image. The selected region from the original base image may then be blended with the blended base image **604**. See FIGS. **10**C and **10**D for an example. Some embodiments may provide other methods and tools via which the user may make corrections to a blended base image.

[0070] Various embodiments of a user interface to an image blending module may provide other user interface elements for performing other tasks in an image blending workflow as described herein. As just one example, some embodiments may provide an "undo" user interface element via which a user may choose to undo one or more previous actions performed via the user interface as described above.

[0071] FIGS. **10**A through **10**G illustrate application of the image blending methods and workflows as described herein on example digital photographs, according to some embodiments. FIG. **10**A shows a set of two digital images captured of a scene, for example using a digital camera. Alternatively, the images may have been originally captured using a conventional film camera, and the prints or negatives subsequently digitized. For illustrative purposes, the images have been converted from the original color images to grayscale images. However, note that the methods for blending images as described herein will work for grayscale and color images. The first image, labeled as source image **700**, may have been captured with a flash or other light source to illuminate the foreground, and using a relatively short exposure time, so that a good exposure of the foreground of the scene is captured; however, the background of the scene is underexposed. The second image, labeled as base image **702**, may have been captured with a longer exposure time so that the background of the scene is better exposed, showing more detail; however, the foreground is less well exposed than in the first image. As shown, the user has selected the second image as the base image **702**, and the first image as the current source image **700**.

[0072] FIG. **10**B shows two strokes that the user has drawn on the source image **700**. The thicker stroke was applied first to select the person in the foreground. After the selected foreground region from the source image **700** (the person) is blended with the base image **702**, there may be areas in the base image **702** that the user desires to fix or touch up. In this example, a small blemish around the head, caused by the hair and the background being similar in color, has been cleaned up by applying a thinner stroke to source image **700**.

[0073] FIG. **10**C shows the selected regions from source image **700** blended onto the base image **702** to produce blended base image **704** with an alpha level setting of 0% (fully opaque). However, a thicker stroke such as the stroke used to select the person in FIG. **10**B may cause some areas of the source image **700** to be blended that the user does not want to be blended with the base image **702**. For example, the triangular region below the person and between the person's legs from the source image **700** has been undesirably selected along with the person by the thicker stroke and blended with the base image **702** to produce blended base image **704** in FIG. **10**C. In some embodiments, such undesired regions in the blended base image **704** may be removed as shown in FIG. **10**D. In FIG. **10**D, the user has selected the original base image **702** as current source image **706** and has applied a stroke to reselect the region from the original base image **702**. The selected region from current source image **706** (i.e., base image **702**) is blended with blended base image **704** to produce the results shown.

[0074] FIG. **10**E shows that the user has switched the source image from source image **706** back to source image **702**; blended base image **704** includes the regions selected from the source images as illustrated in FIGS. **10**C and **10**D. The alpha blending level is 0% (fully opaque). FIG. **10**F shows the blended base image with the alpha blending level changed by the user to 50%.

[0075] FIG. **10**G shows that the user has selected to show strokes in the current source image and regions in the blended base image. This example shows all strokes made in all source images displayed on the current source image **700**, and the regions from source image **700** and base image displayed on the blended base image **704**.

[0076] FIG. **11** is a flowchart of an example method for blending images, according to some embodiments. The workflow method may be implemented via an embodiment of an image blending module. An example image blending module that may be used to implement the workflow method is shown in FIG. **14**.

[0077] As indicated at **800** the image blending module may obtain a set of two or more images. An example set of two images is shown in FIG. **10**A. In some embodiments, thumbnails for the images may be displayed via a user interface to the image blending module, for example as shown in FIG. **9**A.

[0078] As indicated at **802**, the image blending module may obtain a base image from the set of images. In some embodiments, a user interface to the image blending module may provide one or more user interface elements via which the user may select an image from among the set of images as the base image. For example, one embodiment may allow a user to select a thumbnail corresponding to the desired image from among a set of image thumbnails and drag the selected thumbnail onto a base image location of the user interface to select, and display, the corresponding image as the base image. In some embodiments, other methods may be used to select a base image.

[0079] As indicated at **804** the image blending module may obtain a source image from the set of images. In some embodiments, a user interface to the image blending module may provide one or more user interface elements via which the user may select an image from among the set of images as a source image. For example, one embodiment may allow a user to select a thumbnail corresponding to the desired image from among a set of image thumbnails to select the corresponding image as a source image. In some embodiments, other methods may be used to select a source image.

[0080] As indicated at **806** the image blending module may obtain a stroke applied to the source image via the user interface to the image blending module. The stroke may be generated, for example, by the user positioning the cursor over a desired starting point in the source image using a cursor control device, depressing and hold down a button, and moving the cursor along a path in the source image using the cursor control device.

[0081] As indicated at **808**, the image blending module may identify a region in the source image from the stroke. To

identify a region in the source image from the stroke applied to the source image, some embodiments may employ a graph cut algorithm in a segmentation technique. However, other types of image processing algorithms than graph cut algorithms may be used in a segmentation technique in some embodiments. In some embodiments, pixel color values from pixels specified by the stroke may be obtained and used by the segmentation technique to segment the source image. As an alternative to, or in addition to, pixel color values, some embodiments may use other pixel values, for example hue or intensity values, in segmenting the image. In some embodiments, one or more characteristics or settings of the brush used to draw a stroke may be used by the segmentation technique. For example, in some embodiments, a wider or narrower brush may be used to broaden or narrow the scope of the segmentation technique when locating a region. Thus, a broader brush may result in a larger region being located for a stroke than would be located for a similar stroke drawn with a smaller brush.

[0082] As indicated at **810**, the image blending module may blend the identified region into a corresponding region of the base image. In some embodiments, to blend the identified region of the source image with the base image, pixel values from the region may be applied in a separate layer on top of the base image. Layering preserves the base image; the pixels of a selected region are not applied directly to the pixels of the base image. Other embodiments may use other methods than layering when blending the images. The image blending module may provide one or more user interface elements via which the alpha blending level for a region may be adjusted over a range from fully opaque to fully transparent.

[0083] Some embodiments of an image blending module may maintain a label map that maps each pixel in the blended base image to its corresponding source image. While not shown in FIG. **11**, the method may include mapping the selected region in a label map. The image blending module may, for example, use this label map to determine all of the regions in the blended base image that are from the same source image. By determining all of the regions in the blended base image that are from a particular source image, the alpha blending level for all of these regions may be modified at one time by the user via an alpha blending level user interface element, even if regions from the same source image are in different layers in a layered image.

[0084] At **812**, if the user is not done with the current source image, the user may draw another stroke on the source image, and the method may return to **806** to process the new stroke. At **812**, if the user is done with the current source image, at **814**, if the user is not done with the set of images, the user may select a new source image, and the method may return to **804** to process one or more strokes applied to the new source image. Otherwise, the workflow for this set of images is done. Note that the original base image may be selected as the source image, for example to reselect one or more regions from the original source image for blending with the blended source image.

[0085] The above method describes the user applying a stroke to a source image, the image blending module identifying a region in the source image from the stroke, the image blending module blending the identified region into a corresponding region of the base image, and repeating the process for the source image if desired. Some embodiments may allow variations on the above method. Examples of variations on the above method may include, but are not limited to, the following. As one example, in some embodiments, the user may select a source image and apply multiple strokes to select various regions from that source image. After selecting the regions, an alpha blending level user interface element may be used to blend the regions with the base image. As another example, in some embodiments, the user may first select an alpha blending level using an alpha blending level user interface element and then apply strokes to select various regions from a source image. Each of the selected regions may then be automatically blended with the base image to the extent specified by the selected alpha blending level. As yet another example, in some embodiments, the user may apply a first stroke that selects a first region, and use an alpha blending level user interface element to select a first blending level. The user may then apply a second stroke and select a second region from the same source image. The second region may be automatically blended with the base image with the first blending level. The user may then change the blending level. In response, the blending of both the first region and the second region is automatically changed from the first blending level to the new blending level.

Selecting and Blending the Same Region from Multiple Source Images

[0086] Exposure bracketing is a fairly advanced photographic technique in which a photographer captures multiple images at different exposure levels to capture detail at several different levels. Three, four, five or even more images may be captured, with the exposure levels appropriately spaced. In some such images, different details of a region may be visible in different ones of the images. In order to capture all the details in a final image, the user needs a way in which the region can be selected from all of the source images that include some details in that region. Thus, some embodiments may provide a method and one or more user interface elements via which the user may select a single region from multiple source images and alpha blend the region from the source images with the selected base image to obtain the various details in the region captured in the different images. A user interface to an image blending module such as the interface illustrated in FIGS. **9**A through **9**G may be used to select the same region from multiple source images for blending with a base image. FIG. **12** illustrates the same region (the sky region) selected from multiple source images (in this example, source images **500**A and **500**B from FIG. **5**A) and blended with a base image (in this example, base image **502** from FIG. **5**A), with the alpha blending level for the sky region in both source images set to 50%. To accomplish this, some embodiment may provide a label map in which each pixel in the blended image may be mapped to multiple source images using a vector that indicates all of the source images used to blend the respective pixel. FIG. **13** is a block diagram illustrating an example source vector from a label map for a pixel that is blended from a source pixel in image **500**B and a source pixel in image **500**A with a base or background pixel in base image **502**. An indication of each source image that is a source for the particular pixel in the blended image may be included in the source vector. Other information may be indicated in the source vector for each source image, for example the alpha blending level for the region from the respective source image may be indicated. The vector may also indicate the order in which the regions from the source images are applied to the base image (i.e., from a top source image to a bottom source image, with the bottom source image being the first layer above the base image).

[0087] While FIG. **12** shows the regions from the different source images as identical (both corresponding to exactly the same region in the base image), in practice, the regions may be identical as shown or the regions may be overlapping regions that are not identical (each corresponding to a different but overlapping region in the base image).

Example Implementations

[0088] FIG. **14** illustrates an example image blending module **920** that may implement image blending methods and workflows as illustrated in FIGS. **1**A through **13**. Embodiments of an image blending module **920** may, for example, be implemented as a stand-alone image processing application, as a module of an image processing application, as a plug-in for applications including image processing applications, and/or as a library function or functions that may be called by other applications. Embodiments of image blending module **920** may be implemented in any image processing application, including but not limited to Adobe® PhotoShop® Adobe® PhotoShop® Elements®, and Adobe® After Effects®. FIG. **15** illustrates an example computer system on which embodiments of image blending module **920** may be implemented.

[0089] Image blending module **920** receives as input a set of two or more digital images **910**. An example set of input images is shown in FIG. **10**A. Image blending module **920** facilitates workflows and methods as described herein for blending input images **910** according to user input **912** received via user interface **922**. An example user interface **922** to an image blending module **920**, and an example of an image blending workflow to blend an example set of images, is illustrated in FIGS. **9**A through **9**G. Image blending module **920** generates as output one or more blended images **930**. Example blended images are shown in FIGS. **10**E and **10**F as blended base image **704**. A blended image **930** may, for example, be printed, displayed on a display device, transmitted to other computer systems via wired or wireless communication media, and/or stored to a storage medium **940**, such as system memory, a disk drive, DVD, CD, etc. A blended image **930** may be further processed according to the image blending methods described herein, and/or may be further processed according to other image processing methods and techniques.

[0090] Program instructions and/or data for implementing embodiments of an image blending module as described herein may, for example, be stored on a computer-readable storage medium. A computer-readable storage medium may include storage media or memory media such as magnetic or optical media, e.g., disk or DVD/CD-ROM, volatile or nonvolatile media such as RAM (e.g. SDRAM, DDR, RDRAM, SRAM, etc.), ROM, etc.

Example System

[0091] Embodiments of an image blending module as described herein may be executed on one or more computer systems, which may interact with various other devices. One such computer system is illustrated by FIG. **15**. In different embodiments, computer system **700** may be any of various types of devices, including, but not limited to, a personal computer system, desktop computer, laptop, notebook, or netbook computer, mainframe computer system, handheld computer, workstation, network computer, a camera, a set top box, a mobile device, a consumer device, video game console, handheld video game device, application server, storage device, a peripheral device such as a switch, modem, router, or in general any type of computing or electronic device.

[0092] In the illustrated embodiment, computer system **1000** includes one or more processors **1010** coupled to a system memory **1020** via an input/output (I/O) interface **1030**. Computer system **1000** further includes a network interface **1040** coupled to I/O interface **1030**, and one or more input/output devices **1050**, such as cursor control device **1060**, keyboard **1070**, and display(s) **1080**. In some embodiments, it is contemplated that embodiments may be implemented using a single instance of computer system **1000**, while in other embodiments multiple such systems, or multiple nodes making up computer system **1000**, may be configured to host different portions or instances of embodiments. For example, in one embodiment some elements may be implemented via one or more nodes of computer system **1000** that are distinct from those nodes implementing other elements.

[0093] In various embodiments, computer system **1000** may be a uniprocessor system including one processor **1010**, or a multiprocessor system including several processors **1010** (e.g., two, four, eight, or another suitable number). Processors **1010** may be any suitable processor capable of executing instructions. For example, in various embodiments, processors **1010** may be general-purpose or embedded processors implementing any of a variety of instruction set architectures (ISAs), such as the x86, PowerPC, SPARC, or MIPS ISAs, or any other suitable ISA. In multiprocessor systems, each of processors **1010** may commonly, but not necessarily, implement the same ISA.

[0094] In some embodiments, at least one processor **1010** may be a graphics processing unit. A graphics processing unit or GPU may be considered a dedicated graphics-rendering device for a personal computer, workstation, game console or other computing or electronic device. Modern GPUs may be very efficient at manipulating and displaying computer graphics, and their highly parallel structure may make them more effective than typical CPUs for a range of complex graphical algorithms. For example, a graphics processor may implement a number of graphics primitive operations in a way that makes executing them much faster than drawing directly to the screen with a host central processing unit (CPU). In various embodiments, the image processing methods disclosed herein may, at least in part, be implemented by program instructions configured for execution on one of, or parallel execution on two or more of, such GPUs. The GPU(s) may implement one or more application programmer interfaces (APIs) that permit programmers to invoke the functionality of the GPU(s). Suitable GPUs may be commercially available from vendors such as NVIDIA Corporation, ATI Technologies (AMD), and others.

[0095] System memory **1020** may be configured to store program instructions and/or data accessible by processor **1010**. In various embodiments, system memory **1020** may be implemented using any suitable memory technology, such as static random access memory (SRAM), synchronous dynamic RAM (SDRAM), nonvolatile/Flash-type memory, or any other type of memory. In the illustrated embodiment, program instructions and data implementing desired functions, such as those described above for embodiments of an image blending module are shown stored within system memory **1020** as program instructions **1025** and data storage **1035**, respectively. In other embodiments, program instruc-

tions and/or data may be received, sent or stored upon different types of computer-accessible media or on similar media separate from system memory **1020** or computer system **1000**. Generally speaking, a computer-accessible medium may include storage media or memory media such as magnetic or optical media, e.g., disk or CD/DVD-ROM coupled to computer system **1000** via I/O interface **1030**. Program instructions and data stored via a computer-accessible medium may be transmitted by transmission media or signals such as electrical, electromagnetic, or digital signals, which may be conveyed via a communication medium such as a network and/or a wireless link, such as may be implemented via network interface **1040**.

[0096] In one embodiment, I/O interface **1030** may be configured to coordinate I/O traffic between processor **1010**, system memory **1020**, and any peripheral devices in the device, including network interface **1040** or other peripheral interfaces, such as input/output devices **1050**. In some embodiments, I/O interface **1030** may perform any necessary protocol, timing or other data transformations to convert data signals from one component (e.g., system memory **1020**) into a format suitable for use by another component (e.g., processor **1010**). In some embodiments, I/O interface **1030** may include support for devices attached through various types of peripheral buses, such as a variant of the Peripheral Component Interconnect (PCI) bus standard or the Universal Serial Bus (USB) standard, for example. In some embodiments, the function of I/O interface **1030** may be split into two or more separate components, such as a north bridge and a south bridge, for example. In addition, in some embodiments some or all of the functionality of I/O interface **1030**, such as an interface to system memory **1020**, may be incorporated directly into processor **1010**.

[0097] Network interface **1040** may be configured to allow data to be exchanged between computer system **1000** and other devices attached to a network, such as other computer systems, or between nodes of computer system **1000**. In various embodiments, network interface **1040** may support communication via wired or wireless general data networks, such as any suitable type of Ethernet network, for example; via telecommunications/telephony networks such as analog voice networks or digital fiber communications networks; via storage area networks such as Fibre Channel SANs, or via any other suitable type of network and/or protocol.

[0098] Input/output devices **1050** may, in some embodiments, include one or more display terminals, keyboards, keypads, touchpads, scanning devices, voice or optical recognition devices, or any other devices suitable for entering or retrieving data by one or more computer system **1000**. Multiple input/output devices **1050** may be present in computer system **1000** or may be distributed on various nodes of computer system **1000**. In some embodiments, similar input/output devices may be separate from computer system **1000** and may interact with one or more nodes of computer system **1000** through a wired or wireless connection, such as over network interface **1040**.

[0099] As shown in FIG. **15**, memory **1020** may include program instructions **1025**, configured to implement embodiments of an image blending module as described herein, and data storage **1035**, comprising various data accessible by program instructions **1025**. In one embodiment, program instructions **1025** may include software elements of embodiments of an image blending module as illustrated in the above Figures. Data storage **1035** may include data that may be used in embodiments. In other embodiments, other or different software elements and data may be included.

[0100] Those skilled in the art will appreciate that computer system **1000** is merely illustrative and is not intended to limit the scope of an image blending module as described herein. In particular, the computer system and devices may include any combination of hardware or software that can perform the indicated functions, including a computer, personal computer system, desktop computer, laptop, notebook, or netbook computer, mainframe computer system, handheld computer, workstation, network computer, a camera, a set top box, a mobile device, network device, internet appliance, PDA, wireless phones, pagers, a consumer device, video game console, handheld video game device, application server, storage device, a peripheral device such as a switch, modem, router, or in general any type of computing or electronic device. Computer system **1000** may also be connected to other devices that are not illustrated, or instead may operate as a stand-alone system. In addition, the functionality provided by the illustrated components may in some embodiments be combined in fewer components or distributed in additional components. Similarly, in some embodiments, the functionality of some of the illustrated components may not be provided and/or other additional functionality may be available.

[0101] Those skilled in the art will also appreciate that, while various items are illustrated as being stored in memory or on storage while being used, these items or portions of them may be transferred between memory and other storage devices for purposes of memory management and data integrity. Alternatively, in other embodiments some or all of the software components may execute in memory on another device and communicate with the illustrated computer system via inter-computer communication. Some or all of the system components or data structures may also be stored (e.g., as instructions or structured data) on a computer-accessible medium or a portable article to be read by an appropriate drive, various examples of which are described above. In some embodiments, instructions stored on a computer-accessible medium separate from computer system **1000** may be transmitted to computer system **1000** via transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as a network and/or a wireless link. Various embodiments may further include receiving, sending or storing instructions and/or data implemented in accordance with the foregoing description upon a computer-accessible medium. Accordingly, the present invention may be practiced with other computer system configurations.

CONCLUSION

[0102] Various embodiments may further include receiving, sending or storing instructions and/or data implemented in accordance with the foregoing description upon a computer-accessible medium. Generally speaking, a computer-accessible medium may include storage media or memory media such as magnetic or optical media, e.g., disk or DVD/CD-ROM, volatile or non-volatile media such as RAM (e.g. SDRAM, DDR, RDRAM, SRAM, etc.), ROM, etc., as well as transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as network and/or a wireless link.

[0103] The various methods as illustrated in the Figures and described herein represent example embodiments of methods. The methods may be implemented in software, hard-

ware, or a combination thereof. The order of method may be changed, and various elements may be added, reordered, combined, omitted, modified, etc.

[0104] Various modifications and changes may be made as would be obvious to a person skilled in the art having the benefit of this disclosure. It is intended that the invention embrace all such modifications and changes and, accordingly, the above description to be regarded in an illustrative rather than a restrictive sense.

1. A computer-implemented method, comprising:

obtaining a plurality of images of a scene, wherein one of the images is a base image and a different one of the images is a source image;

obtaining input indicating a stroke applied to the source image, wherein the stroke specifies a set of pixels in the source image;

identifying a region of the source image from the stroke, wherein the region comprises a plurality of contiguous pixels in the source image, and wherein said identifying a region comprises determining that each of the plurality of pixels in the region is similar to the pixels in the set of pixels specified by the stroke according to one or more characteristics of the pixels;

blending the pixels from the region of the source image with pixels in a corresponding region of the base image to generate a blended image;

performing iteratively said obtaining input indicating a stroke, said identifying a region of the source image from the stroke, and said blending the pixels for a plurality of different strokes identifying a plurality of regions from the plurality of images of the scene, wherein each performance updates mapping information that maps pixels in the blended image to one or more of the plurality of regions used to blend each respective pixel; and

in response to input modifying a blending level used to blend at least one of the plurality of regions, blending pixels from the plurality of images with the corresponding pixels of the base image to generate a new blended image based on the mapping information and according to the modified blending level.

2. The computer-implemented method as recited in claim **1**, wherein at least one of the plurality of different strokes is another stroke applied to the source image, wherein the stroke specifies a different set of pixels in the source image.

3. The computer-implemented method as recited in claim **1**, wherein at least one of the plurality of different strokes is a stroke applied to an image different from the source image.

4. The computer-implemented method as recited in claim **1**, wherein the at least some of the plurality of regions correspond to the same region of the base image.

5. The computer-implemented method as recited in claim **1**, wherein the at least some of the plurality of regions correspond to different, non-overlapping regions of the base image.

6. The computer-implemented method as recited in claim **1**, wherein the at least some of the plurality of regions correspond to different, overlapping regions of the base image.

7. (canceled)

8. The computer-implemented method as recited in claim **1**, wherein said blending pixels from the plurality of images with the corresponding pixels of the base image to generate a new blended image based on the mapping information comprises:

wherein said input modifying a blending level specifies a different blending level for the at least one region than a blending level that was used to blend the at least one region, wherein a blending level for a region is adjustable within a range from fully opaque to fully transparent, inclusive; and

blending the pixels from the plurality of images with the corresponding pixels of the base image according to the different blending level to generate the new blended image.

9. The computer-implemented method as recited in claim **1**, wherein said determining that each of the plurality of pixels in the region is similar to the pixels in the set of pixels specified by the stroke according to one or more characteristics of the pixels is performed according to a graph cut algorithm.

10. The computer-implemented method as recited in claim **9**, wherein the one or more characteristics of the pixels include color of the pixels.

11. The computer-implemented method as recited in claim **1**, wherein said blending the pixels from the region of the source image with pixels in a corresponding region of the base image to generate a blended image comprises applying the pixels in the region of the source image to the base image in a layer overlaid on the base image.

12. The computer-implemented method as recited in claim **1**, wherein said blending the pixels from the region of the source image with pixels in a corresponding region of the base image to generate a blended image is performed according to alpha channel blending.

13. The computer-implemented method as recited in claim **1**, wherein the stroke is applied to the source image via a user interface using a cursor controlled by a cursor control device, wherein the user interface provides one or more user interface elements via which the width of a stroke applied to a source image via the cursor control device is adjustable to different widths, and wherein, in said identifying a region of the source image from the stroke, the width of the stroke applied to the source image affects the size of the region that is identified.

14. The computer-implemented method as recited in claim **1**, wherein, in said identifying a region of the source image from the stroke, one or more characteristics of the stroke applied to the source image affect the size of the region that is identified.

15. The computer-implemented method as recited in claim **14**, wherein the one or more characteristics of the stroke include the width of the stroke and the length of the stroke.

16. The computer-implemented method as recited in claim **1**, further comprising:

wherein said input modifying a blending level specifies a different blending level for the at least one region than a blending level that was used to blend the at least one region, wherein a blending level for a region is adjustable within a range from fully opaque to fully transparent, inclusive; and

wherein said blending the pixels from the plurality of images with the corresponding pixels of the base image to generate a new blended image based on the mapping information comprises:

identifying one or more additional regions from the same source image as the at least one region; and

blending the pixels from the at least one region and the one or more additional regions with the correspond-

ing pixels in the base image according to the different blending level to generate the new blended image.

17. A system, comprising:

at least one processor; and

a memory comprising program instructions, wherein the program instructions are executable by the at least one processor to:

obtain a plurality of images of a scene, wherein one of the images is a base image and a different one of the images is a source image;

obtain input indicating one or more strokes applied to the source image, wherein the strokes each specify a distinct set of pixels in the source image;

identify one or more regions of the source image from the one or more strokes, wherein each of the one or more regions comprises a plurality of contiguous pixels in the source image, and wherein, to identify a region, the program instructions are executable by the at least one processor to determine that each of the plurality of pixels in the region is similar to the pixels in the set of pixels specified by the respective stroke according to one or more characteristics of the pixels;

blend the pixels from the one or more regions of the source image with pixels in one or more corresponding regions of the base image to generate a blended image;

perform iteratively said obtaining input indicating a stroke, said identifying a region of the source image from the stroke, and said blending the pixels for a plurality of different strokes identifying a plurality of regions from the plurality of images of the scene, wherein each performance updates mapping information that maps pixels in the blended image to one or more of the plurality of regions used to blend each respective pixel; and

in response to input modifying a blending level used to blend at least one of the plurality of regions, blend pixels from the plurality of images with the corresponding pixels of the base image to generate a new blended image based on the mapping information and according to the modified blending level.

18. The system as recited in claim **17**, wherein at least one of the plurality of different strokes is a stroke applied to an image different from the source image.

19. A non-transitory, computer-readable storage medium storing program instructions, wherein the program instructions are computer-executable to implement an image blending module configured to:

obtain a plurality of images of a scene, wherein one of the images is a base image and a different one of the images is a source image;

obtain input indicating one or more strokes applied to the source image, wherein the strokes each specify a distinct set of pixels in the source image;

identify one or more regions of the source image from the one or more strokes, wherein each of the one or more regions comprises a plurality of contiguous pixels in the source image, and wherein, to identify a region, the program instructions are executable by the at least one processor to determine that each of the plurality of pixels in the region is similar to the pixels in the set of pixels specified by the respective stroke according to one or more characteristics of the pixels;

blend the pixels from the one or more regions of the source image with pixels in one or more corresponding regions of the base image to generate a blended image;

perform iteratively said obtaining input indicating a stroke, said identifying a region of the source image from the stroke, and said blending the pixels for a plurality of different strokes identifying a plurality of regions from the plurality of images of the scene, wherein each performance updates mapping information that maps pixels in the blended image to one or more of the plurality of regions used to blend each respective pixel; and

in response to input modifying a blending level used to blend at least one of the plurality of regions, blend pixels from the plurality of images with the corresponding pixels of the base image to generate a new blended image based on the mapping information and according to the modified blending level.

20. The non-transitory, computer-readable storage medium as recited in claim **19**, wherein at least one of the plurality of different strokes is a stroke applied to an image different from the source image.

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