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(54) **ELECTRONIC DEVICE AND IMAGE PROCESSING METHOD FOR ELECTRONIC DEVICE**

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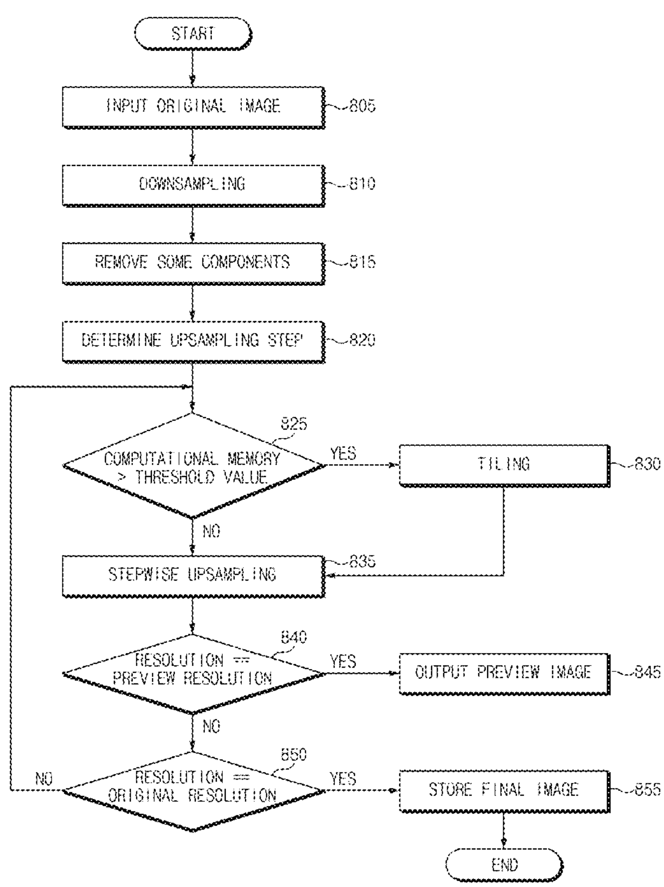
(57) **ABSTRACT**

An electronic device may include a communication circuit, a memory, and a processor(s). The processor(s) may be configured to generate a first image by downsampling an original image, to generate a second image by removing a partial component included in the first image from the first image, to generate a difference image between the first image and the second image, to determine a number of times that the difference image is stepwise upsampled to have a resolution corresponding to a resolution of the original image, to generate an upsampled difference image by stepwise upsampling the difference image the determined number of times, to generate a final/resulting image, which corresponds to a resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image, and to store the final/resulting image in the memory. Besides, other various embodiments identified through the specification are also possible.



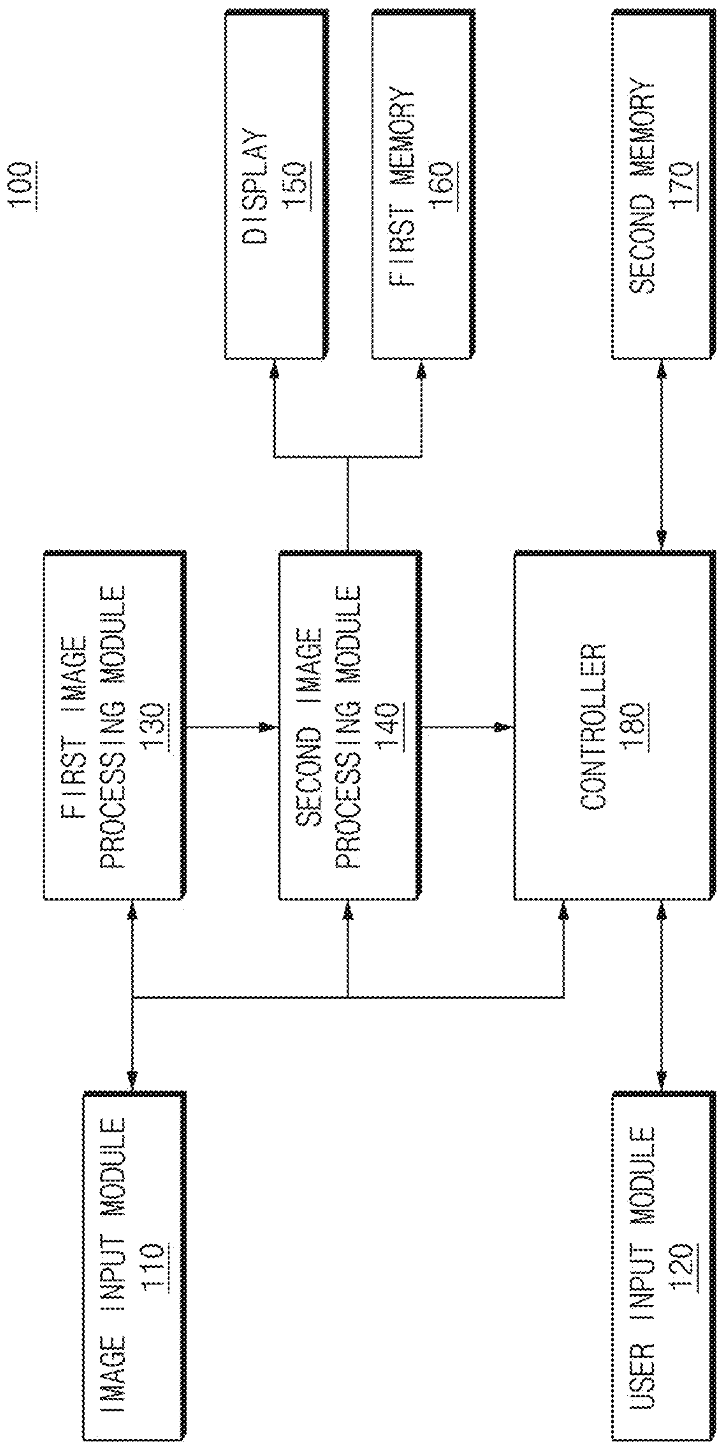

100
DISPLAY 150
FIRST MEMORY 160
SECOND MEMORY 170
FIRST IMAGE PROCESSING MODULE 130
SECOND IMAGE PROCESSING MODULE 140
CONTROLLER 180
IMAGE INPUT MODULE 110
USER INPUT MODULE 120

FIG. 1

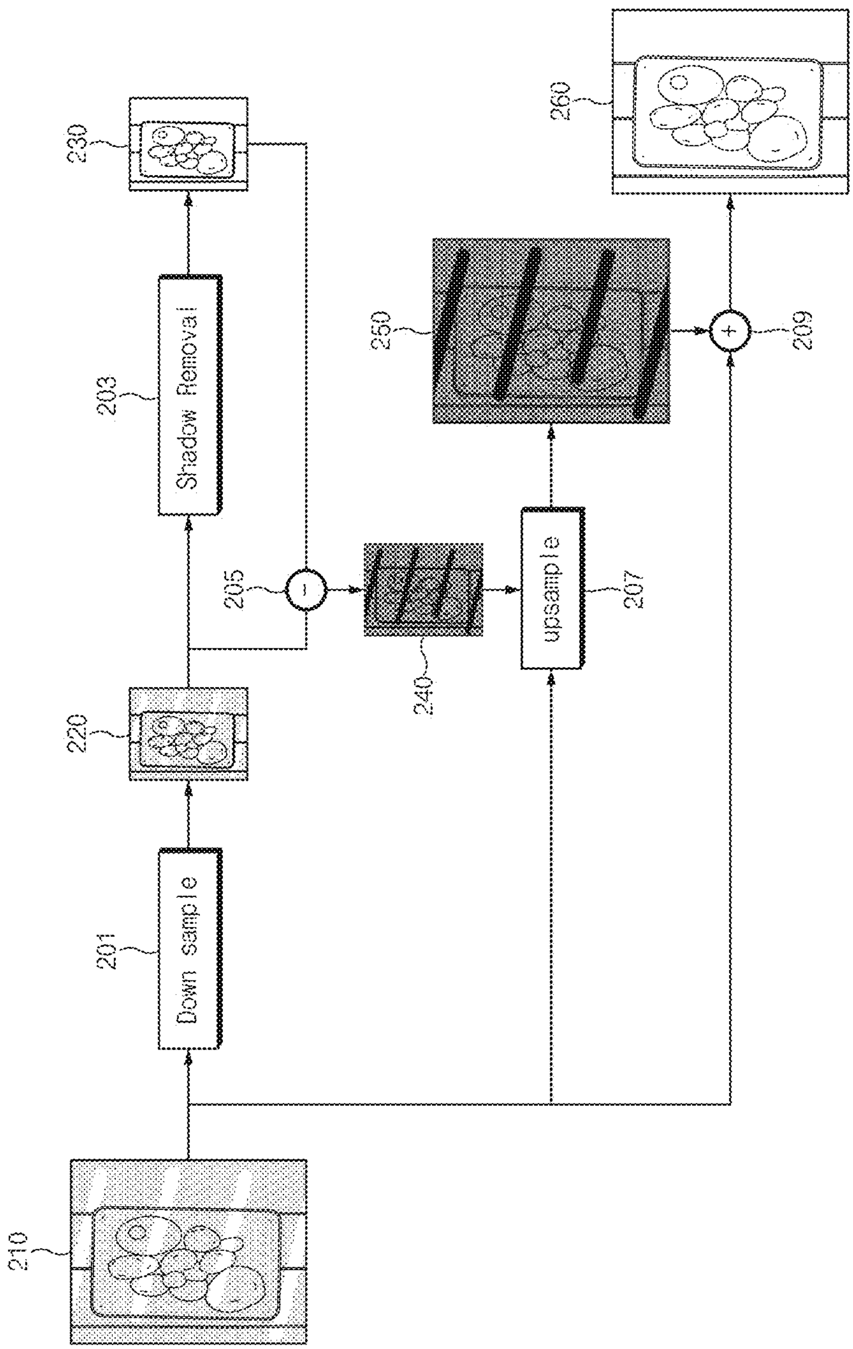

210
201
Down sample
220
205
203
Shadow Removal
230
240
upsample
207
250
209
260

FIG. 2

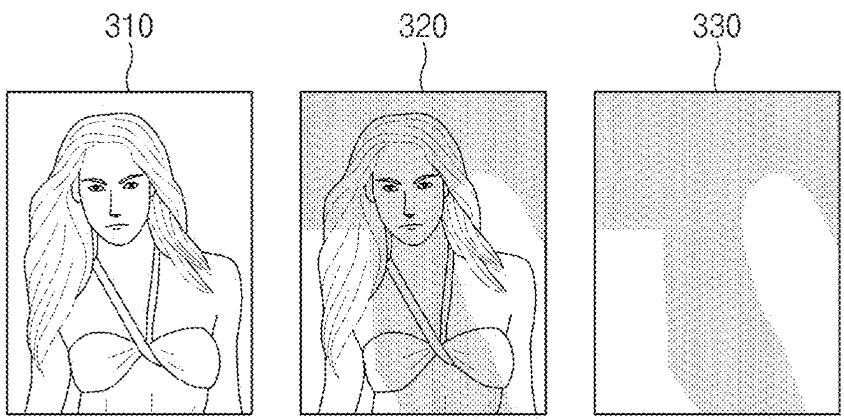


FIG.3

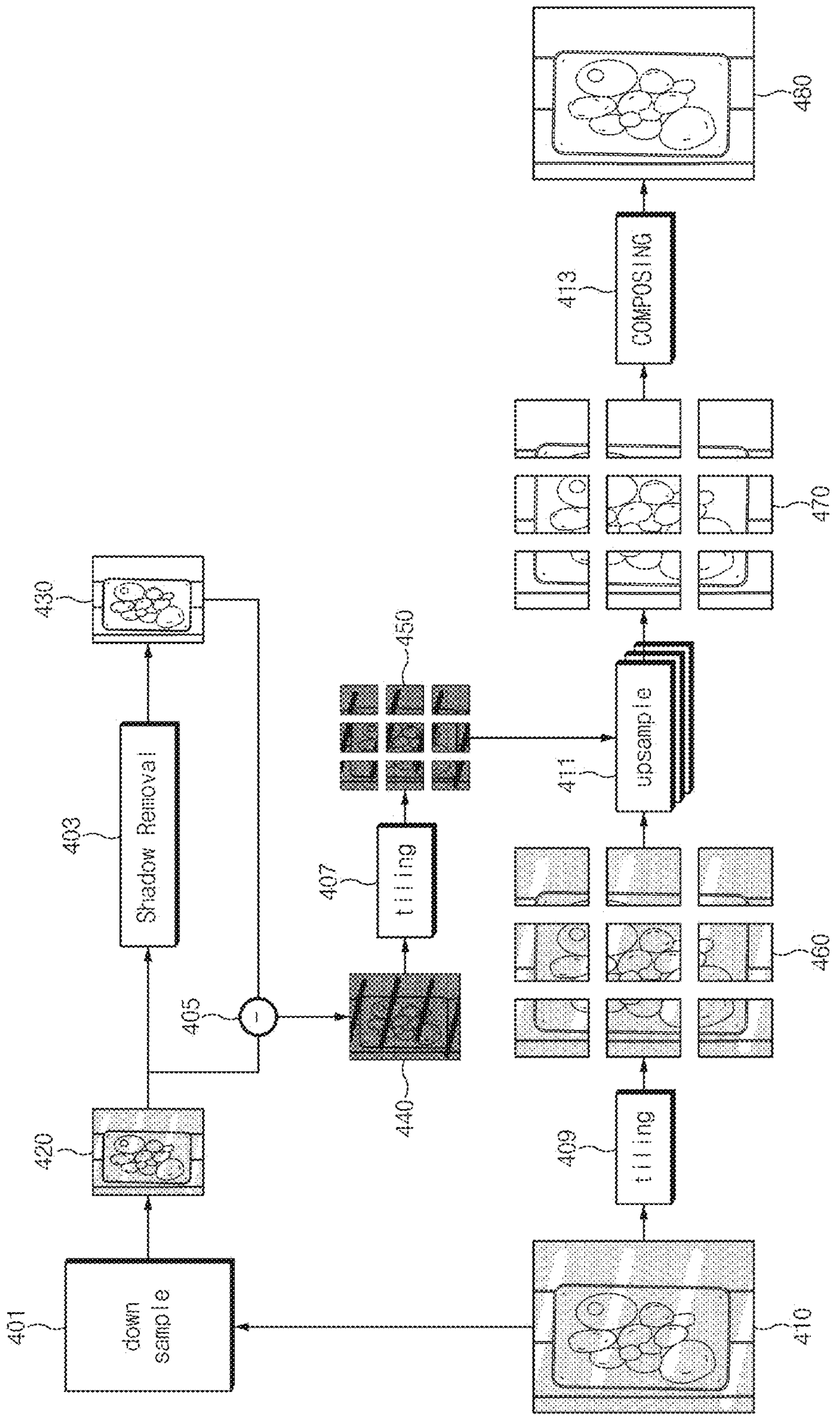

401
down sample
420
403
Shadow Removal
430
405
440
407
tiling
450
409
tiling
410
460
411
upsample
470
413
COMPOSING
480

FIG. 4

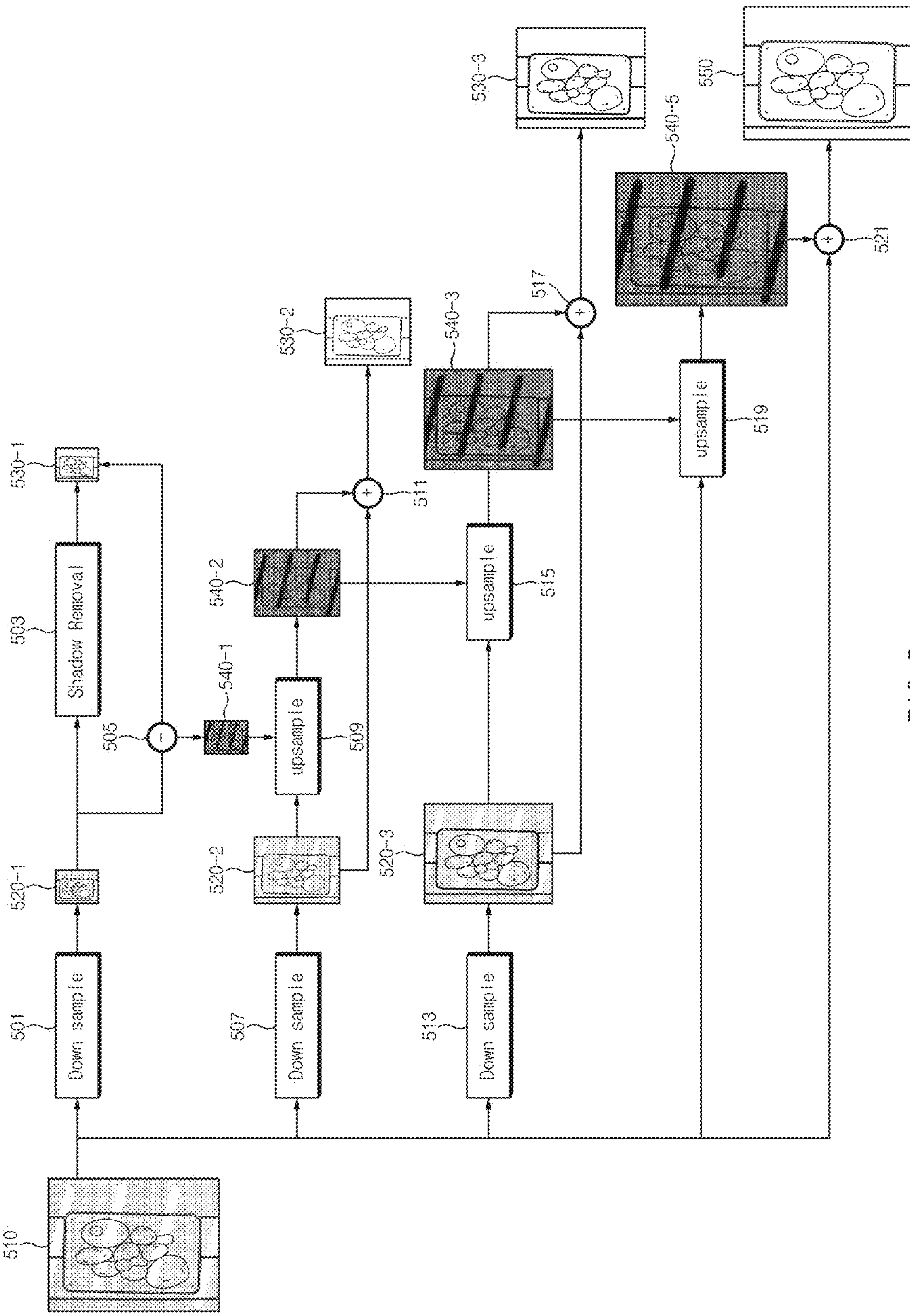

510
501
Down sample
520-1
503
Shadow Removal
530-1
505
540-1
507
Down sample
520-2
509
upsample
540-2
511
530-2
513
Down sample
520-3
515
upsample
540-3
517
530-3
519
upsample
540-5
521
550

FIG. 5

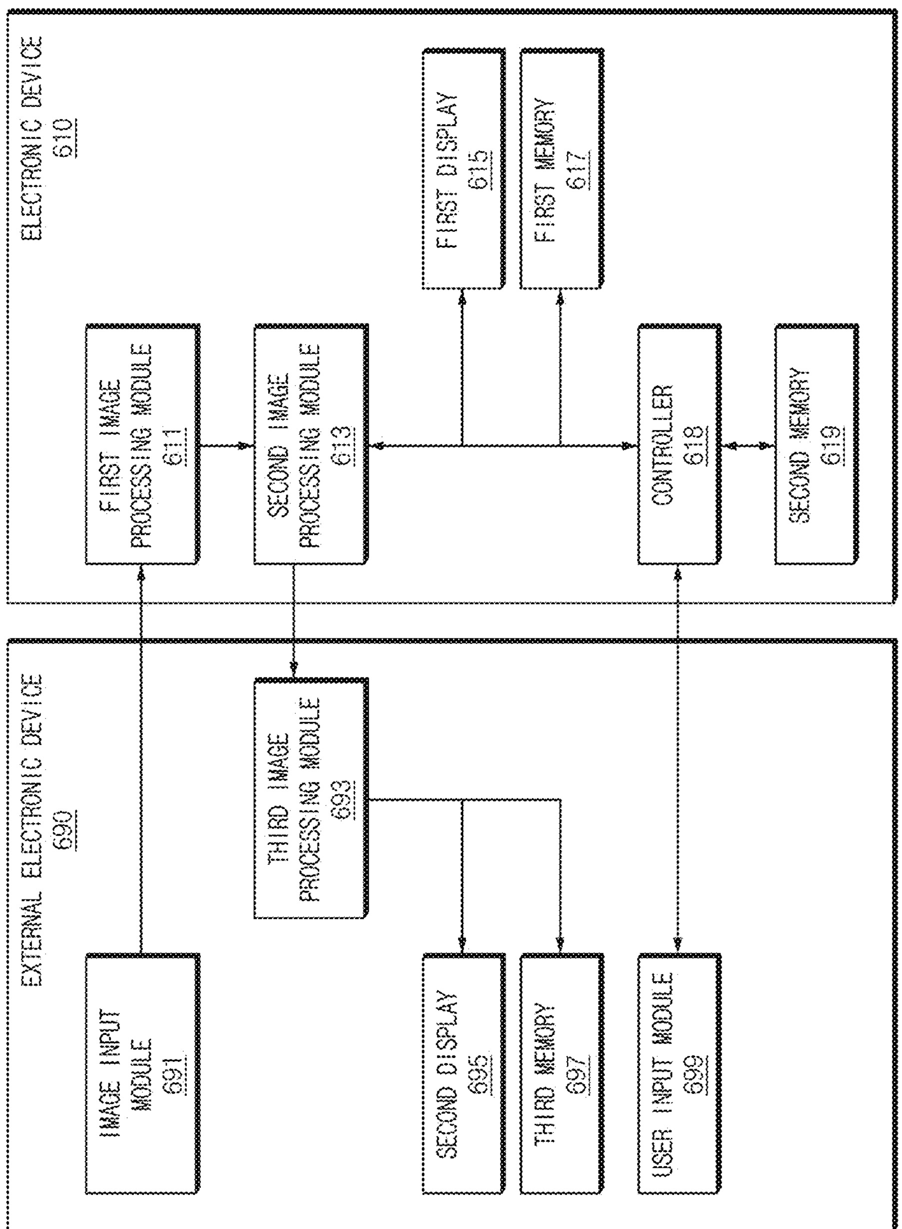

ELECTRONIC DEVICE 610
FIRST IMAGE PROCESSING MODULE 611
SECOND IMAGE PROCESSING MODULE 613
FIRST DISPLAY 615
FIRST MEMORY 617
CONTROLLER 618
SECOND MEMORY 619
EXTERNAL ELECTRONIC DEVICE 690
IMAGE INPUT MODULE 691
THIRD IMAGE PROCESSING MODULE 693
SECOND DISPLAY 695
THIRD MEMORY 697
USER INPUT MODULE 699

FIG.6

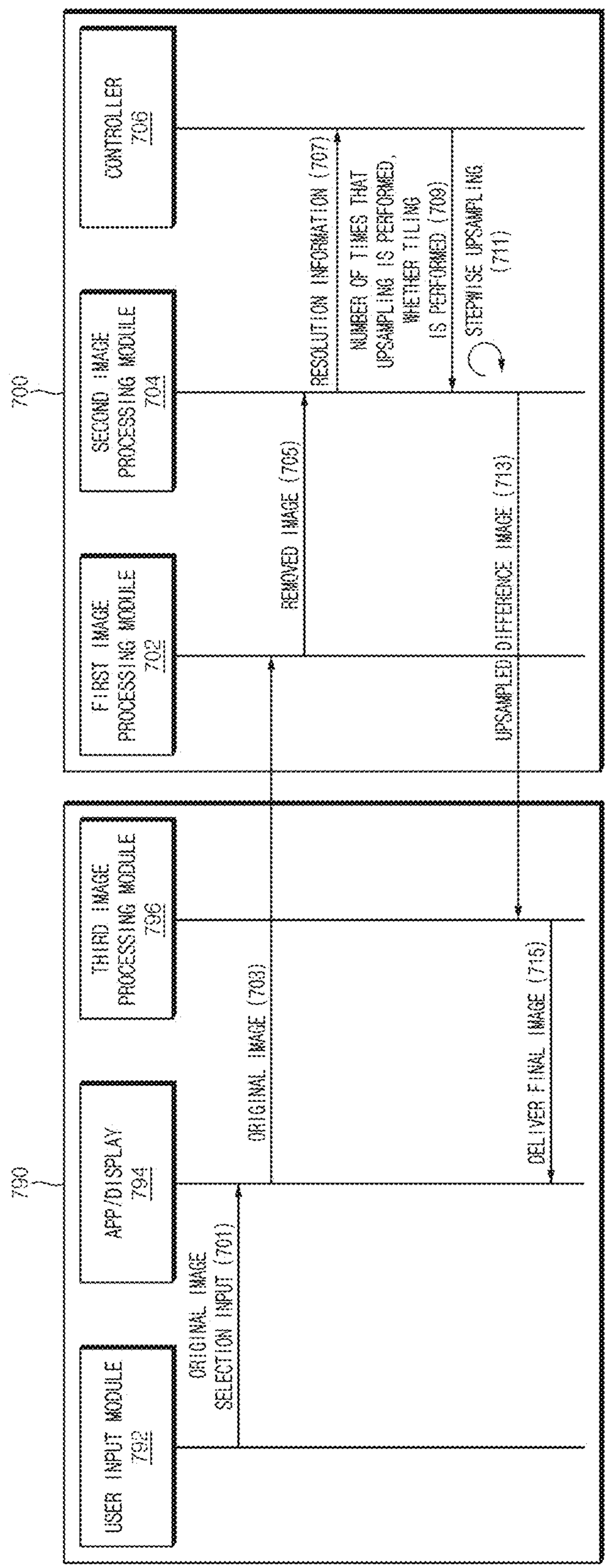

700
CONTROLLER 706
SECOND IMAGE PROCESSING MODULE 704
FIRST IMAGE PROCESSING MODULE 702
RESOLUTION INFORMATION (707)
NUMBER OF TIMES THAT UPSAMPLING IS PERFORMED, WHETHER TILING IS PERFORMED (709)
STEPWISE UPSAMPLING (711)
REMOVED IMAGE (705)
UPSAMPLED DIFFERENCE IMAGE (713)
790
THIRD IMAGE PROCESSING MODULE 796
APP/DISPLAY 794
USER INPUT MODULE 792
ORIGINAL IMAGE (703)
DELIVER FINAL IMAGE (715)
ORIGINAL IMAGE SELECTION INPUT (701)

FIG.7

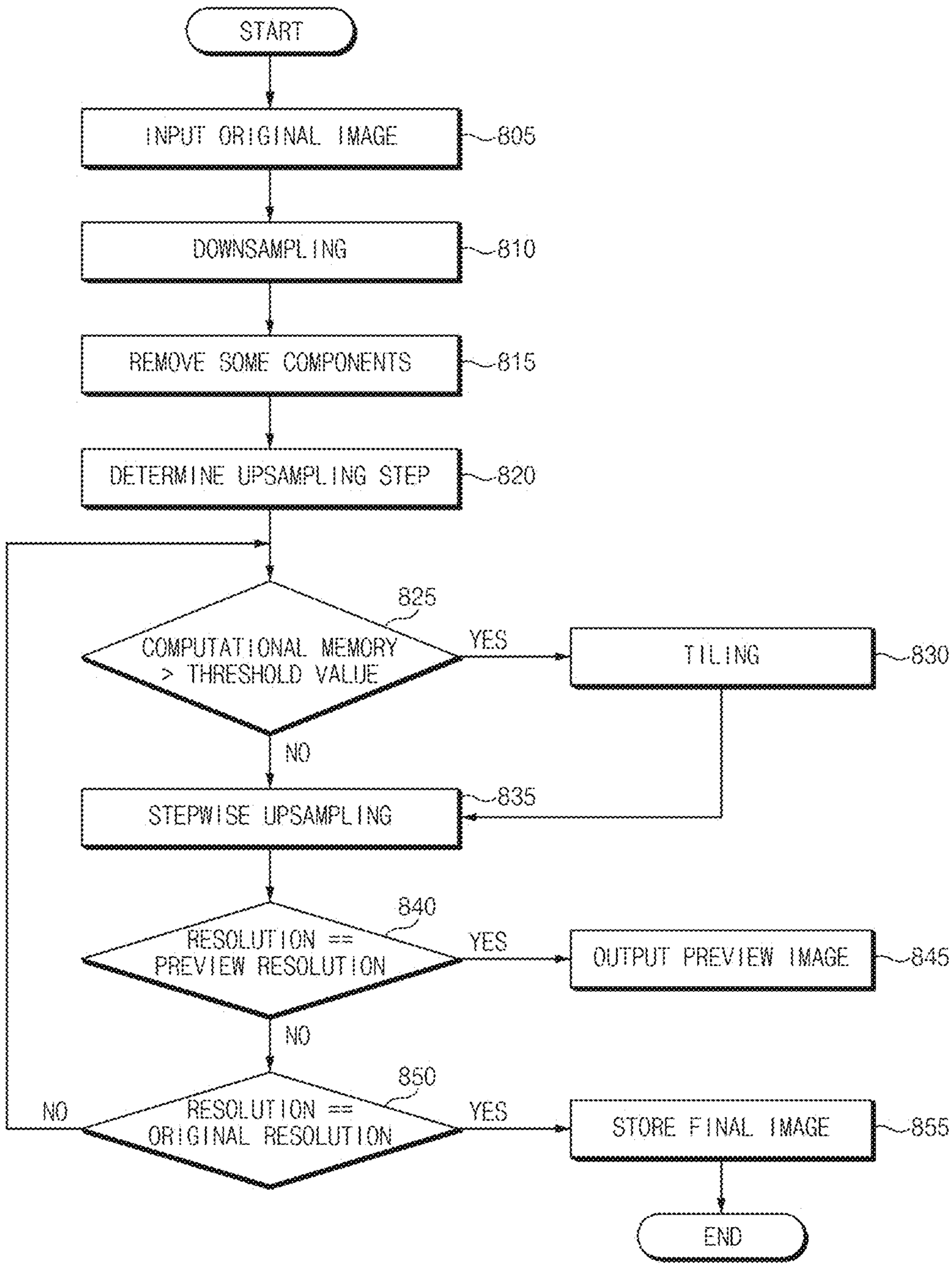

START
INPUT ORIGINAL IMAGE
805
DOWNSAMPLING
810
REMOVE SOME COMPONENTS
815
DETERMINE UPSAMPLING STEP
820
825
COMPUTATIONAL MEMORY > THRESHOLD VALUE
YES
TILING
830
NO
STEPWISE UPSAMPLING
835
840
RESOLUTION == PREVIEW RESOLUTION
YES
OUTPUT PREVIEW IMAGE
845
NO
850
RESOLUTION == ORIGINAL RESOLUTION
NO
YES
STORE FINAL IMAGE
855
END

FIG.8

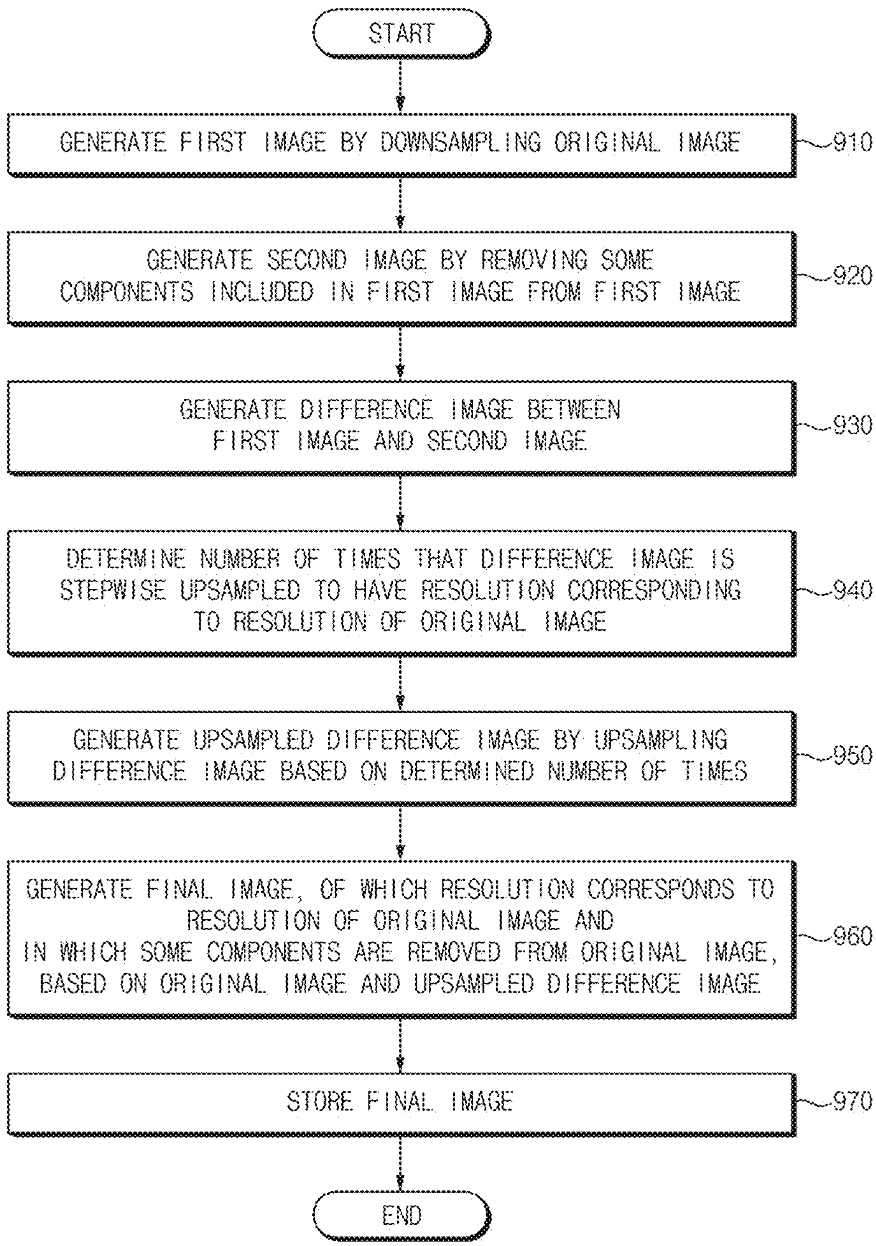

START
GENERATE FIRST IMAGE BY DOWNSAMPLING ORIGINAL IMAGE
910
GENERATE SECOND IMAGE BY REMOVING SOME COMPONENTS INCLUDED IN FIRST IMAGE FROM FIRST IMAGE
920
GENERATE DIFFERENCE IMAGE BETWEEN FIRST IMAGE AND SECOND IMAGE
930
DETERMINE NUMBER OF TIMES THAT DIFFERENCE IMAGE IS STEPWISE UPSAMPLED TO HAVE RESOLUTION CORRESPONDING TO RESOLUTION OF ORIGINAL IMAGE
940
GENERATE UPSAMPLED DIFFERENCE IMAGE BY UPSAMPLING DIFFERENCE IMAGE BASED ON DETERMINED NUMBER OF TIMES
950
GENERATE FINAL IMAGE, OF WHICH RESOLUTION CORRESPONDS TO RESOLUTION OF ORIGINAL IMAGE AND IN WHICH SOME COMPONENTS ARE REMOVED FROM ORIGINAL IMAGE, BASED ON ORIGINAL IMAGE AND UPSAMPLED DIFFERENCE IMAGE
960
STORE FINAL IMAGE
970
END

FIG.9

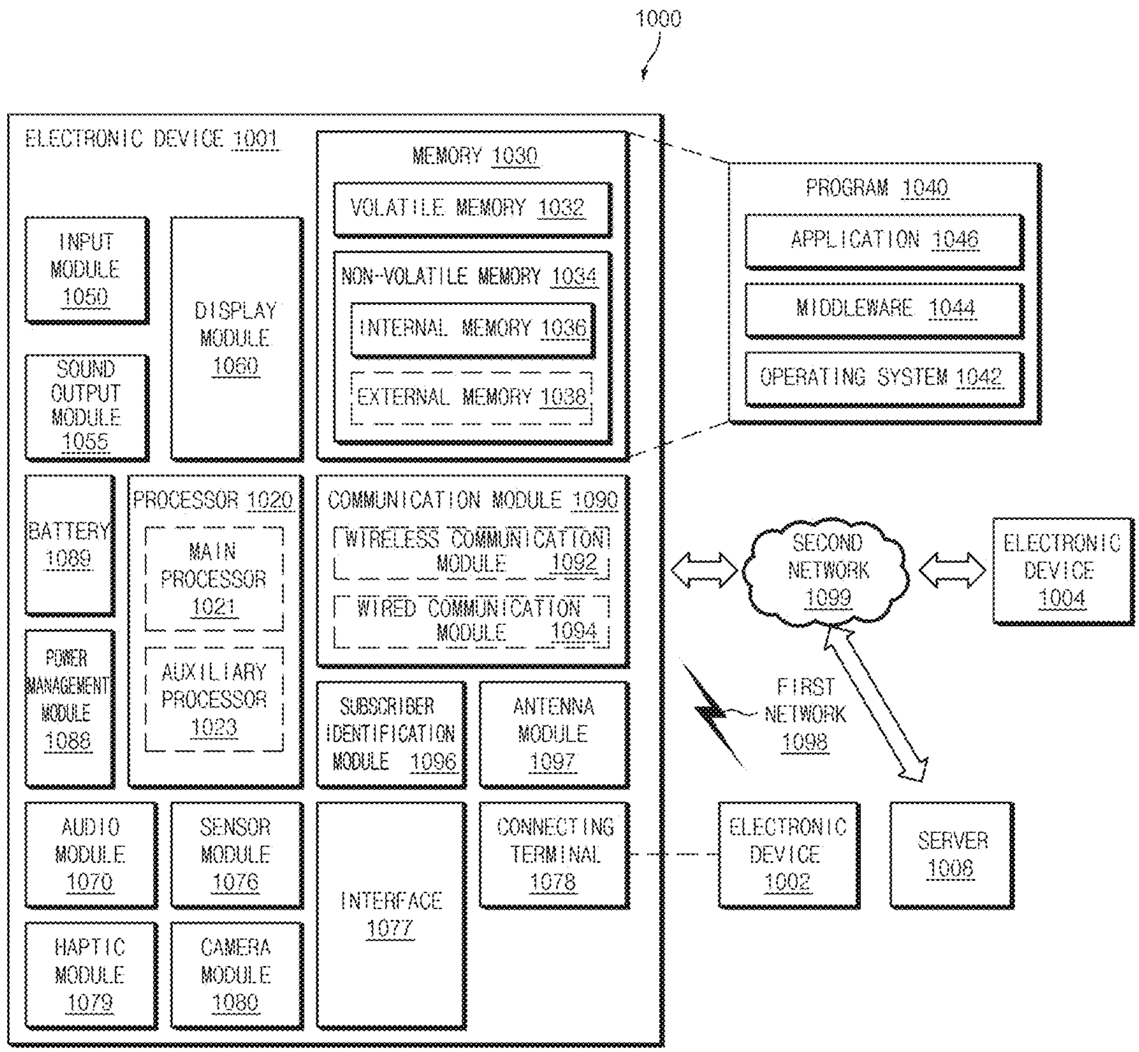

1000
ELECTRONIC DEVICE 1001
MEMORY 1030
VOLATILE MEMORY 1032
NON-VOLATILE MEMORY 1034
INTERNAL MEMORY 1036
EXTERNAL MEMORY 1038
PROGRAM 1040
APPLICATION 1046
MIDDLEWARE 1044
OPERATING SYSTEM 1042
INPUT MODULE 1050
SOUND OUTPUT MODULE 1055
DISPLAY MODULE 1060
BATTERY 1089
POWER MANAGEMENT MODULE 1088
PROCESSOR 1020
MAIN PROCESSOR 1021
AUXILIARY PROCESSOR 1023
COMMUNICATION MODULE 1090
WIRELESS COMMUNICATION MODULE 1092
WIRED COMMUNICATION MODULE 1094
SUBSCRIBER IDENTIFICATION MODULE 1096
ANTENNA MODULE 1097
SECOND NETWORK 1099
ELECTRONIC DEVICE 1004
FIRST NETWORK 1098
AUDIO MODULE 1070
SENSOR MODULE 1076
INTERFACE 1077
CONNECTING TERMINAL 1078
ELECTRONIC DEVICE 1002
SERVER 1008
HAPTIC MODULE 1079
CAMERA MODULE 1080

FIG.10

ELECTRONIC DEVICE AND IMAGE PROCESSING METHOD FOR ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of International Application No. PCT/KR2023/017889 designating the United States, filed on Nov. 8, 2023, in the Korean Intellectual Property Receiving Office and claiming priority to Korean Patent Application No. 10-2022-0148237, filed on Nov. 8, 2022, and Korean Patent Application No. 10-2022-0180735, filed on Dec. 21, 2022, the disclosures of which are all hereby incorporated by reference herein in their entireties.

BACKGROUND

Technical Field

[0002] Certain example embodiments may relate to a technology for processing an original image.

Background Art

[0003] An electronic device may capture a high-resolution image by using a camera or may provide a function of editing an image. Nowadays, a technology has been developed to create an image that a user wants, by correcting the captured image when an electronic device captures the image. The electronic device may correct images by using an artificial intelligence (AI)-based model. When the AI-based model is used, the operating time and resource requirements may increase, and thus there is a need for a technology that converts an original image into a low-resolution image when the image is corrected, corrects the low-resolution image, and upsamples the corrected image such that the upsampled image has the resolution of the original image.

SUMMARY

[0004] An electronic device according to an example embodiment may include a communication circuit, a memory, and a at least one processor comprising processing circuitry. The at least one processor may be individually and/or collectively configured to generate a first image by at least downsampling an original image, to generate a second image by at least removing a partial component included in the first image from the first image, to generate a difference image between the first image and the second image, to determine a number of times that the difference image is stepwise upsampled to have a resolution corresponding to a resolution of the original image, to generate an upsampled difference image by at least stepwise upsampling the difference image the determined number of times, to generate a final image, which corresponds to a resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image, and to store the final image in the memory.

[0005] An image processing method of an electronic device according to an example embodiment may include generating a first image by downsampling an original image, generating a second image by removing a partial component included in the first image from the first image, generating a difference image between the first image and the second image, determining a number of times that the difference image is stepwise upsampled to have a resolution corresponding to a resolution of the original image, generating an upsampled difference image by stepwise upsampling the difference image the determined number of times, generating a final and/or resulting image, which corresponds to the resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image, and storing the final and/or resulting image.

[0006] According to an example embodiment, a storage medium may store instructions that, when executed by a processor, cause an electronic device to perform the image processing method.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. **1** is a block diagram of an electronic device, according to an example embodiment.

[0008] FIG. **2** is a drawing for describing an operation of an electronic device, according to an example embodiment.

[0009] FIG. **3** is a drawing for describing an operation of an electronic device, according to an example embodiment.

[0010] FIG. **4** is a drawing for describing an operation of an electronic device, according to an example embodiment.

[0011] FIG. **5** is a drawing for describing an operation of an electronic device, according to an example embodiment.

[0012] FIG. **6** is a block diagram of an electronic device, according to an example embodiment.

[0013] FIG. **7** is a diagram for describing an operation of an electronic device, according to an example embodiment.

[0014] FIG. **8** is a flowchart of an image processing method of an electronic device, according to an example embodiment.

[0015] FIG. **9** is a flowchart of an image processing method of an electronic device, according to an example embodiment.

[0016] FIG. **10** illustrates an electronic device in a network environment, according to various example embodiments.

[0017] With regard to description of drawings, the same or similar components will be marked by the same or similar reference signs.

DETAILED DESCRIPTION

[0018] FIG. **1** is a block diagram of an electronic device, according to an embodiment.

[0019] According to an embodiment, an electronic device **100** (e.g., an electronic device **610** of FIG. **6**, an electronic device **700** of FIG. **7**, or an electronic device **1001** of FIG. **10**) may include an image input module **110**, a user input module **120** (e.g., an input module **1050** of FIG. **10**), a first image processing module **130** (e.g., a first image processing module **611** of FIG. **6**, a first image processing module **702** of FIG. **7**, or a processor **1020** of FIG. **10**), a second image processing module **140** (e.g., a second image processing module **613** of FIG. **6**, a second image processing module **704** of FIG. **7**, or the processor **1020** of FIG. **10**), a display **150** (e.g., a first display **615** of FIG. **6**, a display module **1060** of FIG. **10**), a first memory **160** (e.g., a first memory **617** of FIG. **6** or a memory **1030** of FIG. **10**), a second memory **170** (e.g., a second memory **619** of FIG. **6** or a volatile memory **1032** of FIG. **10**), and a controller **180** (e.g., a controller **618** of FIG. **6**, a controller **706** of FIG. **7**, or the processor **1020** of FIG. **10**).

[0020] According to an embodiment, the image input module **110** may obtain an original image. For example, the image input module **110** may include a camera. The image input module **110** may capture the original image by using the camera. For example, the image input module **110** may include a communication circuit. The image input module **110** may receive the original image from an external device through the communication circuit. The image input module **110** may provide the original image to the first image processing module **130**, the second image processing module **140**, and/or the controller **180**.

[0021] According to an embodiment, the user input module **120** may receive a user input. For example, the user input module **120** may receive, from a user, an input for selecting the original image, an input for editing an image, and/or an input for displaying an image (e.g., an original image, a difference image, an intermediate image generated during stepwise upsampling, and/or a final image). The user input module **120** may receive various inputs for controlling an operation of the electronic device **100**.

[0022] According to an embodiment, the first image processing module **130** may generate a first image by downsampling the original image. The first image processing module **130** may generate a second image by removing some components from the downsampled first image. According to an embodiment, some components may include a shadow image and/or a light reflection image. For example, the first image processing module **130** may remove some components from the first image by using the trained AI learning model (e.g., an image processing model trained through machine learning (e.g., deep learning)). For example, the first image processing module **130** may reduce the time and the amount of computation required to correct an image (e.g., removing some components) by removing some components from the downsampled first image without directly removing some components from the original image. The first image processing module **130** may generate a difference image based on the first image and the second image. For example, the first image processing module **130** may generate a difference image by subtracting a value of each of pixels of the corresponding first image from a value of each of the pixels of the second image. For example, the first image processing module **130** may generate the difference image by subtracting the value of each of the pixels of the second image from the value of each of the pixels of the first image and then inverting the values of the pixels (e.g., conversion to a value symmetrical to a reference value). The difference image may correspond to the removed components (e.g., the shadow image and/or the light reflection image). The first image processing module **130** may provide the second image and/or the difference image to the second image processing module **140**.

[0023] According to an embodiment, the second image processing module **140** may perform a stepwise upsampling operation. For example, the second image processing module **140** may generate a final image of a resolution corresponding to the resolution of the original image by correcting (editing) the downsampled image and then stepwise upsampling the corrected image. The second image processing module **140** may perform upsampling based on information, which is received from the controller **180** and which is related to the number of times that stepwise upsampling is performed, whether to perform tiling, whether a tile image is padded/cropped, the number of tile images, and/or the size of the tile image.

[0024] According to an embodiment, the second image processing module **140** may split the difference image (and the original image) into a plurality of first tile images. When a computational memory of a processor exceeds a predetermined threshold value, the second image processing module **140** may split the difference image into a plurality of tile images. The second image processing module **140** may stepwise upsample each of the tile images. The second image processing module **140** may not perform upsampling of a tile image satisfying a specified condition (e.g., a case where the sum of values of pixels of a tile image is 0). In this case, the second image processing module **140** may generate the final image by using the corresponding original tile image instead of the tile image. The second image processing module **140** may generate the final image, of which the resolution corresponds to the resolution of the original image and in which some components are removed from the original image, based on the original image and the upsampled difference image. For example, the second image processing module **140** may generate the final image by adding the upsampled difference image to the original image. For example, the second image processing module **140** may generate the final image by adding a value of each pixel of the upsampled difference image to a value of each pixel of the original image. The second image processing module **140** may store the final image in a memory.

[0025] In FIG. **1**, the first image processing module **130** and the second image processing module **140** are illustrated as separate configurations from each other, but are not limited thereto. For example, the first image processing module **130** and the second image processing module **140** may be implemented as one module and may be implemented integrally with the controller **180**. The electronic device **100** may further include an image processing module.

[0026] According to an embodiment, the display **150** may display an image. For example, the display **150** may display the original image, the downsampled image, the difference image, the intermediate image, and/or the final image. According to an embodiment, the display **150** and the user input module **120** may be implemented with one module (e.g., a touch screen display **150**).

[0027] According to an embodiment, the first memory **160** may store instructions that control the operation of the electronic device **100** when executed by the processor. According to an embodiment, the first memory **160** may at least temporarily store an image. For example, the first memory **160** may store, at least temporarily, the original image, the downsampled image, the difference image, the intermediate image, and/or the final image. The first memory **160** may store information and/or data related to the operation of the electronic device **100**.

[0028] According to an embodiment, the second memory **170** may store data for the calculation of the processor. For example, the second memory **170** may include the computational memory (e.g., RAM) of the processor. According to an embodiment, the first memory **160** and the second memory **170** may be implemented as one physical memory.

For example, the first memory **160** and the second memory **170** may be implemented as different storage areas in one memory.

[0029] According to an embodiment, the controller **180** may control the overall operation of the electronic device **100**. The controller **180** may determine the number of times that the difference image is stepwise upsampled to have a resolution corresponding to the resolution of the original image. The electronic device **100** may determine the number of times that upsampling is performed, based on a specified upsampling (resolution) multiple (e.g., 'n' times), the resolution of the original image, and the resolution (e.g., a first resolution) of the downsampled image. The controller **180** may determine whether to tile the difference image (and the original image). For example, the controller **180** may recognize whether the computational memory (or an operating memory) of the controller **180** exceeds a predetermined threshold value. The controller **180** may recognize whether out-of-memory (OOM) occurs. When the computational memory exceeds the predetermined threshold value, the controller **180** may determine to split the difference image (and the original image) into a plurality of tile images. When the computational memory is smaller than or equal the predetermined threshold value, the controller **180** may determine not to split the difference image (and the original image) into the plurality of tile images. The controller **180** may determine the number and/or sizes of tiles under the condition that the operating memory does not exceed a specified free memory. For example, the controller **180** may determine the number and/or sizes of tiles based on the resolution of the original image and/or the output resolution (e.g., a downsampling resolution) of the AI learning model used to remove components. For example, the controller **180** may determine the number of tile images as one of divisors of the resolution of the model output (e.g., the downsampled first image). The controller **180** may determine not to perform upsampling of a tile image that satisfies a specified condition (e.g., a case where the sum of values of pixels of a tile image is 0). In this case, the controller **180** may use a tile image (e.g., the original tile image) of the original image corresponding to the tile image, on which upsampling is not performed to generate the final image. The controller **180** may determine whether to pad the difference image and/or to crop the upsampled difference image. The controller **180** may transmit information related to the number of times that stepwise upsampling is performed, whether to perform tiling, whether a tile image is padded/cropped, the number of tile images, and/or the size of the tile image. The controller **180** may control operations of the first image processing module **130** and/or the second image processing module **140** based on the number of times that stepwise upsampling is performed, whether to perform tiling, whether a tile image is padded/cropped, the number of tile images, and/or the size of the tile image. The controller **180** may perform the specified operation (e.g., outputting a thumbnail image, outputting a preview image, and/or editing an image) based on an intermediate image (e.g., an image generated at each step of upsampling) generated during the stepwise upsampling.

[0030] According to an embodiment, the first image processing module **130**, the second image processing module **140**, and/or the controller **180** may be implemented as a single integrated configuration (e.g., a processor (not shown) (e.g., the processor **1020** of FIG. **10**)). According to an embodiment, the first image processing module **130**, the second image processing module **140**, and/or the controller **180** may be implemented as at least one hardware module and may be implemented as at least one software module so as to be executed by at least one processor (not shown) (e.g., the processor **1020** of FIG. **10**) of an electronic device.

[0031] According to an embodiment, the electronic device **100** may reduce the damage and loss of details of the original image capable of being generated during upsampling by upsampling the difference image and utilizing the original image when the final image is generated. The electronic device **100** may reduce the amount of computation (e.g., operating memory consumption) and image processing time of the processor by tiling an original image and a difference image and upsampling and/or compositing the tiled result. The electronic device **100** may prevent or reduce chances of an image from being damaged at a border of a tile image by applying padding and cropping to the tile image. The electronic device **100** may reduce image damage capable of occurring during upsampling by performing recursive upsampling, and may utilize the intermediate image generated during upsampling for a specified function and/or a specified operation.

[0032] FIG. **2** is a drawing for describing an operation of an electronic device, according to an embodiment.

[0033] According to an embodiment, in operation **201**, an electronic device (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, the electronic device **700** of FIG. **7**, or the electronic device **1001** of FIG. **10**) may generate a first image **220** by downsampling an original image **210**. For example, an electronic device may generate the first image **220** by downscaling the resolution of the original image **210**.

[0034] According to an embodiment, in operation **203**, the electronic device may generate a second image **230** by removing some components (e.g., shadow image and/or light reflection image) from the first image **220**. For example, the electronic device may remove some components from the first image **220** based on the trained artificial intelligence model.

[0035] According to an embodiment, in operation **205**, the electronic device may generate a difference image **240** based on the first image **220** and the second image **230**. For example, an electronic device may generate the difference image **240** by subtracting a value of each of pixels in the first image **220** from a value of each of pixels in the second image **230**. For example, the electronic device may generate the difference image **240** by subtracting the value of each of the pixels of the second image **230** from the value of each of the pixels of the first image **220** and then inverting the values of the pixels (e.g., conversion to a value symmetrical to a reference value).

[0036] According to an embodiment, in operation **207**, the electronic device may generate a third image **250** by upsampling the difference image **240**. For example, the difference image **240** may have a smaller capacity than the third image **250**. For example, an electronic device may upsample the difference image **240** by using a joint up-sampling method. An electronic device may generate the third image **250** having a resolution corresponding to the resolution of the original image **210** by upsampling the difference image **240**. For example, the difference image **240** may not have details (e.g., contours and/or boundaries) as many as the second image **230**. Accordingly, the loss or damage of the image according to upsampling may be reduced in the case where the difference image **240** is upsampled, compared to the case where the second image **230** is upsampled. Moreover, because pixel values of areas without components (e.g., shadows and/or light reflections) in the difference image become 0, image damage capable of occurring during upsampling may be reduced.

[0037] According to an embodiment, in operation **209**, the electronic device may generate a final image **260** based on the original image **210** and the third image **250**. For example, the electronic device may generate the final image **260** by adding the third image **250** to the original image **210**. For example, the electronic device may generate the final image **260** by adding a value of each of pixels of the third image **250** to a value of each of pixels of the original image **210**.

[0038] For example, the above-described operations in which the electronic device generates the final image **260** may be expressed in an equation as follows.

$$O = I + \mathrm{Up}(\mathrm{Down}(I) - f(\mathrm{Down}(I))) \qquad \text{[Equation 1]}$$

[0039] Here, 'O' denotes the final image **260**; 'I' denotes the original image **210**; 'f' denotes component removal (e.g., shadow removal and/or light reflection removal) using an AI model; 'Down' denotes downsampling; and 'Up' denotes upsampling.

[0040] According to an embodiment, at least some of the operations of FIG. **2** may be performed, simultaneously or in a different order, and at least some operations may be omitted or new operations (e.g., operations of FIG. **4** or FIG. **5**) may be added.

[0041] According to an embodiment, the electronic device may not directly upsample the second image **230**, but may generate the third image **250** by generating and upsampling the difference image **240** and may generate the final image **260** based on the original image **210** and the third image **250**, thereby reducing the processing time and computational amount required for image processing compared to the case where the second image **230** is upsampled. According to an embodiment, the electronic device may upsample the difference image **240** and may utilize the original image **210** when generating the final image **260**, thereby reducing damage and loss of details of the original image **210** capable of occurring during upsampling compared to the case where the second image **230** is upsampled.

[0042] FIG. **3** is a drawing for describing an operation of an electronic device, according to an embodiment.

[0043] According to an embodiment, an electronic device (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, the electronic device **700** of FIG. **7**, or the electronic device **1001** of FIG. **10**) may generate a difference image by removing some components from an original image. The electronic device may generate a final image, in which some components are removed, based on the difference image. For example, some components may include a shadow image and/or a light reflection image included in the original image. For example, '320' represents the original image; '330' represents a difference image; and '310' represents the final image.

[0044] FIG. **3** shows an example, and the original image, the difference image, and the final image are not limited to those shown in FIG. **3**.

[0045] FIG. **4** is a drawing for describing an operation of an electronic device, according to an embodiment. Hereinafter, descriptions the same as those in FIG. **2** are briefly given or omitted.

[0046] According to an embodiment, in operation **401**, an electronic device (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, the electronic device **700** of FIG. **7**, or the electronic device **1001** of FIG. **10**) may generate a first image **420** by downsampling an original image **410**.

[0047] According to an embodiment, in operation **403**, the electronic device may generate a second image **430** by removing some components (e.g., shadow image or light reflection image) from the first image **420**.

[0048] According to an embodiment, in operation **405**, the electronic device may generate a difference image **440** corresponding to the removed component based on the first image **420** and the second image **430**.

[0049] According to an embodiment, in operation **407**, the electronic device may split the difference image **440** into a plurality of first tile images **450**. For example, the electronic device may recognize whether the computational memory (or an operating memory) of a processor exceeds a predetermined threshold value. The electronic device may recognize whether OOM occurs. When the computational memory of the processor exceeds the predetermined threshold value, the electronic device may split the difference image **440** into the first tile image **450**. When the computational memory of the processor does not exceed the predetermined threshold value, the electronic device may not split the difference image **440** (and the original image **410**) into a plurality of tile images.

[0050] According to an embodiment, the electronic device may determine the number and/or sizes of tiles under the condition that the operating memory of the processor does not exceed a specified free memory. For example, the electronic device may determine the number and/or sizes of tiles based on the resolution of the original image **410** and/or the output resolution (e.g., a downsampling resolution) of the AI learning model used to remove components.

[0051] For example, the electronic device may determine the number and/or sizes of tiles satisfying Equation 2 below.

$$N_w E \frac{\mathrm{Original}_w}{\mathrm{Output}_w}, N_h D \frac{\mathrm{Original}_h}{\mathrm{Output}_h} \qquad \text{[Equation 2]}$$

[0052] N_w denotes the number of divisions in a horizontal (width) direction; N_h denotes the number of divisions in a vertical (height) direction; $\mathrm{Original}_w$ denotes a resolution of the original image **410** in the horizontal (width) direction; Output_w denotes the resolution of a model (e.g., the downsampled image) in the horizontal (width) direction; $\mathrm{Original}_h$ denotes the resolution of the original image **410** in the vertical (height) direction; and Output_h denotes the resolution of the model (e.g., the downsampled image) in the vertical (height) direction.

[0053] For example, when the resolution of the original image **410** is 3000×4000 and the model output (the resolution of the downsampled image) is 312×416, the electronic device may determine that the number of tiles is 10 or more horizontally and 10 or more vertically. For example, the electronic device may determine the number of tiles in the horizontal direction to be 10 or more and the number of tiles in the vertical direction to be 10 or more and may split the difference image **440** into the plurality of first tile images **450**.

[0054] For example, the size of the first tile image **450** may be an integer. As the number of the first tile images **450** increases, the size of each first tile image **450** may decrease. When the number of tile images does not match the resolution of the model output (e.g., the downsampled image), the original image **410** or the difference image **440** may not be evenly split, and thus decimal point operations may occur, resulting in calculation errors. For example, the electronic device may determine the number of tile images as one, which satisfies Equation 2, from among divisors of the resolution of the model output (e.g., downsampled image). For example, when the model output is 312×416, 12 satisfying Equation 2 from among "2, 3, 4, 6, 8, 12, . . . , 312" being divisors of 312 in the horizontal direction, and 13 satisfying Equation 2 from among "2, 4, 8, 13, 16, . . . , 416" being divisors of 416 in the vertical direction may be determined as the number of tiles. For example, the electronic device may split the difference image **440** into 12 (12 columns) in the horizontal direction and 13 (13 rows) in the vertical direction into the first tile images **450**. In this case, the size (resolution) of the first tile image **450** may be 26×32.

[0055] According to an embodiment, in operation **409**, the electronic device may identify the original image **410** as a plurality of original tile images **460**. As in operation **407**, the electronic device may determine the number and/or size of the original tile image **460** based on Equation 2. For example, the electronic device may split the original image **410** into the plurality of original tile images **460** based on the number of tile images determined in operation **407**.

[0056] According to an embodiment, in operation **411**, the electronic device may generate a second tile image (not shown) by upsampling the first tile image **450**. The electronic device may generate a third tile image **470** by combining the original tile image **460** and the second tile image.

[0057] According to an embodiment, the electronic device may skip upsampling of at least part of the first tile image **450**. For example, when the sum of values of pixels constituting the first tile image **450** is 0, there is no need to upsample the first tile image **450** and to add the upsampled result to the corresponding original pixel image, and thus the upsampling of the first tile image **450** may not be performed.

$$\text{if SUM}\,(D_i)DThreshold\text{: } O_i = I_i\text{, else: } O_i = I_i + \text{Up}(D_i) \quad \text{[Equation 3]}$$

[0058] D_i denotes the i-th first tile image **450**; O_i denotes the i-th output image; I_i denotes the i-th original tile image **460**; 'SUM' denotes the sum of pixel values; 'Threshold' denotes the reference value (e.g., 0); and 'Up' denotes upsampling. For example, the output image may indicate the third tile image **470** composed to generate a final image **480**. According to an embodiment, the electronic device may determine whether to perform upsampling by using the mean or standard deviation of pixel values instead of the sum of pixel values of the first tile image **450**.

[0059] For example, referring to Equation 3, when the sum of pixel values of the i-th first tile image **450** is less than or equal to the threshold value, the electronic device may use the i-th original tile image **460** for composition to generate the final image **480** without performing upsampling of the i-th first tile image **450** (e.g., without generating the i-th second tile image). For example, the electronic device may not generate a second tile image by upsampling the first tile image **450** that is not related to a component (e.g., shadow image and/or light reflection image) to be removed. In this case, the electronic device may use the original tile image **460** itself to compose the final image **480** without merging the original tile image **460** with the second tile image.

[0060] For example, when the difference image **440** is split into the plurality of first tile images **450**, a mismatch problem may occur at a boundary between the first tile images **450**. After adding padding to the top, bottom, left, and right of each of the first tile images **450**, the electronic device may upsample each of the first tile images **450**. The electronic device may upsample the first tile image **450** to which padding is added, and then may crop the upsampled first tile image **450**. The electronic device may remove a portion corresponding to the added padding from the upsampled first tile image **450**. The electronic device may prevent or reduce chances of the first image **420** from being significantly damaged at the boundary of the first tile image **450** through padding (and cropping) operations.

[0061] This may be expressed by Equation 4 below.

$$O_i = I_i + \text{crop}(\text{Up}(\text{pad}(D_i))) \quad \text{[Equation 4]}$$

[0062] O_i denotes the i-th output image (e.g., the third tile image **470**); I_i denotes the i-th original tile image **460**; D_i denotes the i-th first tile image **450**; 'crop' denotes cropping; 'Up' denotes upsampling; and 'pad' denotes padding.

[0063] According to an embodiment, in operation **413**, the electronic device may generate the final image **480** by composing the third tile image **470**. According to an embodiment, when the electronic device does not generate the second tile image by upsampling the specific first tile image **450** in operation **411**, the electronic device may generate the final image **480** by using the corresponding original tile image **460** instead of the second tile image. For example, the electronic device may generate the final image **480** by composing at least one original tile image **460** and the plurality of third tile images **470**.

[0064] For example, the final image **480** may be an image, which has a resolution corresponding to the original image **410**, and in which some components (e.g., a shadow image and/or a light reflection image) are removed from the original image **410**.

[0065] According to an embodiment, at least some of the operations of FIG. **4** may be performed, simultaneously or in a different order, and at least some operations (e.g., a padding operation and/or a cropping operation) may be omitted or new operations (e.g., operations of FIG. **2** or FIG. **5**) may be added.

[0066] According to an embodiment, the electronic device may upsample the difference image **440** and may utilize the original image **410** when generating the final image **480**, thereby reducing damage and loss of details of the original image **410** capable of occurring during upsampling compared to the case where the second image **430** is upsampled. The electronic device may reduce the amount of computation (e.g., operating memory consumption) and image processing time of the processor by tiling the original image **410** and the difference image **440** and upsampling and/or compositing the tiled result. The electronic device may prevent or reduce chances of an image from being damaged at a border of a tile image by applying padding and cropping to the tile image.

[0067] FIG. **5** is a drawing for describing an operation of an electronic device, according to an embodiment. Below, the descriptions given in FIGS. **2** and **4** are briefly given or omitted. For example, FIG. **5** illustrates an operation of performing stepwise upsampling of an electronic device.

[0068] According to an embodiment, in operation **501**, an electronic device (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, the electronic device **700** of FIG. **7**, or the electronic device **1001** of FIG. **10**) may generate a first image **520-1** by downsampling an original image **510** so as to have a first resolution. The electronic device may determine the number of times that stepwise upsampling is performed, based on the first resolution and the resolution of the original image **510**. The electronic device may determine to perform stepwise upsampling by a specified multiple. For example, when the electronic device determine to perform recursive upsampling by a factor of 'n', the electronic device **100** may determine the number of times that stepwise upsampling is performed, based on a specified upsampling (resolution) multiple (e.g., 'n' times), the resolution of the original image **510**, and the resolution (e.g., the first resolution) of the downsampled image. For example, the electronic device may determine the number of times that upsampling is performed, based on Equation 5 below.

$$N_{up} = \mathrm{ceil}\left(\log_n\left(\frac{res_{original}}{res_{down}}\right)\right) \quad \text{[Equation 5]}$$

[0069] N_{up} denotes the number of times that upsampling is performed; $res_{original}$ denotes the resolution (Width×Height) of the original image **510**; res_{down} denotes the resolution (e.g., a first resolution) of the downsampled image; 'n' denotes a specified multiple; and, 'ceil' denotes a rounding-up function. The electronic device may determine the resolution of each stepwise upsampling based on Equation 5. For example, the resolution (e.g., a second resolution) of the first-step upsampling may be $res1=n*res_{down}$; the resolution (e.g., a third resolution) of the second-step upsampling may be $res2=n*res1$; and, the resolution (e.g., the resolution of the original image **510**) of the N_{up}-step upsampling may be $res_{Nup}=res_{original}$.

[0070] According to an embodiment, in operation **503**, the electronic device may generate a first intermediate image **530-1** by removing some components (e.g., a shadow image and/or a light reflection image) from the first image **520-1**. For example, the electronic device may remove some components from the first image **520-1** by processing the first image **520-1** by using a trained artificial intelligence model. According to an embodiment, the electronic device may use the first intermediate image **530-1** for a specified operation. When the first intermediate image **530-1** satisfies the specified resolution corresponding to the specified operation, the electronic device may perform the specified operation based on the first intermediate image **530-1**. For example, when the resolution of the first intermediate image **530-1** corresponds to the resolution of a thumbnail image, the electronic device may use the first intermediate image **530-1** as the thumbnail image.

[0071] According to an embodiment, in operation **505**, the electronic device may generate a first difference image **540-1** based on the first image **520-1** and the first intermediate image **530-1**. For example, the electronic device may generate the first difference image **540-1** by subtracting the first image **520-1** (e.g., each pixel value of the first image **520-1**) from the first intermediate image **530-1** (e.g., each pixel value of the first intermediate image **530-1**).

[0072] According to an embodiment, in operation **507**, the electronic device may generate a second image **520-2** by downsampling the original image **510** so as to have a second resolution.

[0073] According to an embodiment, in operation **509**, the electronic device may generate a second difference image **540-2** by upsampling the first difference image **540-1** so as to have a second resolution.

[0074] According to an embodiment, in operation **511**, the electronic device may generate a second intermediate image **530-2** by combining the second image **520-2** and the second difference image **540-2**. For example, when the second intermediate image **530-2** satisfies the specified resolution corresponding to the specified operation, the electronic device may perform the specified operation based on the second intermediate image **530-2**. For example, when the resolution of the second intermediate image **530-2** corresponds to the resolution of a preview image, the electronic device may use the second intermediate image **530-2** as the preview image.

[0075] According to an embodiment, in operation **513**, the electronic device may generate a third image **520-3** by downsampling the original image **510** so as to have a third resolution.

[0076] According to an embodiment, in operation **515**, the electronic device may generate a third difference image **540-3** by upsampling the second difference image **540-2** so as to have a third resolution.

[0077] According to an embodiment, in operation **517**, the electronic device may generate a third intermediate image **530-3** by combining the third image **520-3** and the third difference image **540-3**. For example, when the third intermediate image **530-3** satisfies the specified resolution corresponding to the specified operation, the electronic device may perform the specified operation based on the third intermediate image **530-3**. For example, when the resolution of the third intermediate image **530-3** corresponds to the resolution of an image (e.g., an image used in an image editing application) for editing, the electronic device may use the third intermediate image **530-3** as the image for editing.

[0078] According to an embodiment, in operation **519**, the electronic device may generate a fourth difference image **540-5** by upsampling the third difference image **540-3** so as to have a resolution corresponding to the resolution of the original image **510**.

[0079] According to an embodiment, in operation **521**, the electronic device may generate a final image **550** by combining the original image **510** and the fourth difference image **540-5**. The electronic device may store the final image **550** in a memory. According to an embodiment, at least some of the operations of FIG. **5** may be performed in background by a processor of the electronic device.

[0080] According to an embodiment, at least some of the operations of FIG. **5** may be performed, simultaneously or in a different order, and at least some operations (e.g., at least some operations (e.g., operation **511** and/or operation **517**) that generate an intermediate image) may be omitted or new operations (e.g., operations of FIG. **2** or FIG. **3**) may be added. For example, when there is no specified operation capable of being performed by using the second intermediate image **530-2** and/or the third intermediate image **530-3**, the electronic device may omit operation **511** and/or operation **517** and may not generate the second intermediate image **530-2** and/or the third intermediate image **530-3**.

[0081] According to an embodiment, the electronic device may upsample the difference image and may utilize the original image **510** when generating the final image **550**, thereby reducing damage and loss of details of the original image **510** capable of occurring during upsampling. The electronic device may reduce image damage capable of occurring during upsampling by performing recursive upsampling, and may utilize the intermediate image generated during upsampling for a specified function and/or a specified operation.

[0082] FIG. **6** is a block diagram of an electronic device, according to an embodiment.

[0083] According to an embodiment, the electronic device **610** (e.g., the electronic device **100** of FIG. **1**, the electronic device **700** of FIG. **7**, or the electronic device **1001** of FIG. **10**) may include the first image processing module **611** (e.g., the first image processing module **130** of FIG. **1**, the first image processing module **702** of FIG. **7**, or the processor **1020** of FIG. **10**), the second image processing module **613** (e.g., the second image processing module **140** of FIG. **1**, the second image processing module **704** of FIG. **7**, or the processor **1020** of FIG. **10**), a first display (e.g., the display **150** of FIG. **1** or the display module **1060** of FIG. **10**), a first memory (e.g., the first memory **160** of FIG. **1** or the memory **1030** of FIG. **10**), a controller (e.g., the controller **180** of FIG. **1**, the controller **706** of FIG. **7**, or the processor **1020** of FIG. **10**), and a second memory (e.g., the second memory **170** of FIG. **1** or the volatile memory **1032** of FIG. **10**).

[0084] The first image processing module **611** may receive an original image from an image input module **691**. The first image processing module **611** may generate a first image by downsampling the original image. The first image processing module **611** may generate a second image by removing some components from the downsampled first image. According to an embodiment, some components may include a shadow image and/or a light reflection image. For example, the first image processing module **611** may remove some components from the first image by using the trained AI learning model (e.g., an image processing model trained through machine learning (e.g., deep learning)). The first image processing module **611** may generate a difference image based on the first image and the second image. For example, the first image processing module **611** may generate a difference image by subtracting a value of each of pixels of the corresponding first image from a value of each of the pixels of the second image. For example, the first image processing module **611** may generate the difference image by subtracting the value of each of the pixels of the second image from the value of each of the pixels of the first image and then inverting the values of the pixels (e.g., conversion to a value symmetrical to a reference value). The difference image may correspond to the removed components (e.g., the shadow image and/or the light reflection image). The first image processing module **611** may deliver the difference image to the second image processing module **613**.

[0085] According to an embodiment, the second image processing module **613** may perform a stepwise upsampling operation based on information and/or commands received from the controller **618**. For example, the second image processing module **613** may generate a final image of a resolution corresponding to the resolution of the original image by correcting (editing) the downsampled image and then stepwise upsampling the corrected image. The second image processing module **613** may perform upsampling based on information, which is received from the controller **618** and which is related to the number of times that stepwise upsampling is performed, whether to perform tiling, whether a tile image is padded/cropped, the number of tile images, and/or the size of the tile image. According to an embodiment, the second image processing module **613** may split the difference image (and the original image) into a plurality of first tile images. When a computational memory of a processor exceeds a predetermined threshold value, the second image processing module **613** may split the difference image into a plurality of tile images. The second image processing module **613** may stepwise upsample each of the tile images. The second image processing module **613** may not perform upsampling of a tile image satisfying a specified condition (e.g., a case where the sum of values of pixels of a tile image is 0). According to an embodiment, when the second image processing module **613** receives a command for performing tiling from the controller **618**, the second image processing module **613** may split the difference image into a plurality of tile images. The second image processing module **613** may stepwise upsample each of the tile images. The second image processing module **613** may generate a difference image (a plurality of tile images corresponding to the difference image) having a resolution corresponding to the resolution of the original image as the result of stepwise upsampling. The second image processing module **613** may transmit the upsampled difference image to a third image processing module **693**.

[0086] The first display **615** may display an image. For example, the first display **615** may display an original image, a downsampled image (e.g., a first image), a difference image, an intermediate image generated during stepwise upsampling, and/or a final image.

[0087] According to an embodiment, the first memory **617** may store instructions that control the operation of the electronic device **610** when executed by the processor. According to an embodiment, the first memory **617** may at least temporarily store an image. For example, the first memory **617** may store, at least temporarily, the original image, the downsampled image, the difference image, the intermediate image, and/or the final image. The first memory **617** may store information and/or data related to the operation of the electronic device **610**.

[0088] According to an embodiment, the controller **618** may receive resolution information from the second image processing module **613**. The resolution information may include the resolution of the original image and/or the resolution of the downsampled image (e.g., the first image and/or the removed image). The controller **618** may determine the number of times that stepwise upsampling is performed and/or whether to perform tiling, based on the resolution information. The controller **618** may transmit information about the determined number of times that stepwise upsampling is performed and/or whether to perform tiling, to the second image processing module **613**.

[0089] According to an embodiment, the second memory **619** may store data for the calculation of the processor. For example, the second memory **619** may include the computational memory (e.g., RAM) of the processor. According to an embodiment, the first memory **617** and the second memory **619** may be implemented as one physical memory.

[0090] According to an embodiment, an external electronic device **690** (e.g., an external electronic device **790** of FIG. **7** or the electronic device **1002** or **1004** of FIG. **10**) may include the image input module **691**, the third image processing module **693**, a second display **695**, a third memory **697**, and a user input module **699**.

[0091] The image input module **691** may obtain an original image. For example, the image input module **691** may include a camera. The image input module **691** may capture the original image by using the camera. For example, the image input module **691** may include a communication circuit. The image input module **691** may receive the original image from an external device through the communication circuit. The image input module **691** may provide the original image to the first image processing module **611**, the second image processing module **613**, the third image processing module **693**, and/or the controller **618**.

[0092] The third image processing module **693** may generate a final image based on the original image and the upsampled difference image. The final image may be an image which has a resolution corresponding to the resolution of the original image, and in which some components are removed from the original image. For example, the third image processing module **693** may generate the final image by adding the difference image to the original image. When the third image processing module **693** receives a plurality of upsampled tile images from the second image processing module **613**, the third image processing module **693** may split the original image into original tile images of which the number is the same as the number of upsampled tile images. The third image processing module **693** may generate a plurality of combined images by combining the original tile images with the corresponding upsampled tile images, respectively. The third image processing module **693** may generate the final image by composing the plurality of combined images.

[0093] The second display **695** may display an image. For example, the second display **695** may display an original image, a downsampled image (e.g., a first image), a difference image, an intermediate image generated during stepwise upsampling, and/or a final image.

[0094] According to an embodiment, the third memory **697** may store instructions that control the operation of the external electronic device **690** when executed by the processor. According to an embodiment, the third memory **697** may at least temporarily store an image. For example, the third memory **697** may store, at least temporarily, the original image, the downsampled image, the difference image, the intermediate image, and/or the final image. The third memory **697** may store information and/or data related to the operation of the external electronic device **690**.

[0095] According to an embodiment, the user input module **699** may receive a user input. The user input module **699** may receive a user input for selecting an original image for correction from among images stored in the external electronic device **690** (e.g., the third memory **697**). The user input module **120** may receive, from a user, an input for selecting the original image, an input for editing an image, and/or an input for displaying an image (e.g., an original image, a difference image, an intermediate image generated during stepwise upsampling, and/or a final image). The user input module **699** may provide the user input to the image input module **691** and/or the controller **618**.

[0096] According to various embodiments, operations of the electronic device **610** and the external electronic device **690** are not limited to that illustrated in FIG. **6**, and the electronic device **610** and the external electronic device **690** may perform at least some of the operations described in FIGS. **1**, **2**, **4**, and **5**. For example, the electronic device **610** and the external electronic device **690** may distribute and perform a series of operations of generating a final image by correcting an original image based on the performance of each device. For example, each of the electronic device **610** (e.g., the first image processing module **611** and/or the second image processing module **613**) and the external electronic device **690** (e.g., the third image processing module **693**) may separately perform at least some steps of the stepwise upsampling operation. For example, the third image processing module **693** of the external electronic device **690** may perform an operation of generating a removed image or a difference image, and the first image processing module **611** and/or the second image processing module **613** may perform a stepwise upsampling operation. For example, the electronic device **610** may not perform the stepwise upsampling operation, but the external electronic device **690** may perform the stepwise upsampling operation.

[0097] According to various embodiments, configurations of the electronic device **610** and the external electronic device **690** are not limited to that illustrated in FIG. **6**. Some configurations of each of the electronic device **610** and the external electronic device **690** may be omitted or at least one configuration thereof may be added.

[0098] According to an embodiment, the electronic device **610** may distribute a processing load and may perform image processing efficiently in consideration of the performance of a device, by correcting an original image through stepwise upsampling in conjunction with the external electronic device **690**. According to an embodiment, the first image processing module **611**, the second image processing module **613**, the third image processing module **693** and/or the controller **618** may be implemented as at least one hardware module and may be implemented as at least one software module so as to be executed by at least one processor (not shown) (e.g., the processor **1020** of FIG. **10**) of an electronic device and/or an external electronic device.

[0099] FIG. **7** is a diagram for describing an operation of an electronic device, according to an embodiment. Hereinafter, portions overlapping descriptions of FIG. **6** are briefly given or omitted.

[0100] According to an embodiment, the electronic device **700** (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, or the electronic device **1001** of FIG. **10**) may include the first image processing module **702** (e.g., the first image processing module **130** of FIG. **1** or the first image processing module **611** of FIG. **6**), the second image processing module **704** (e.g., the second image processing module **140** of FIG. **1** or the second image processing module **613** of FIG. **6**), and the controller **706** (e.g., the controller **180** of FIG. **1** or the controller **618** of FIG. **6**). The external electronic device **790** (e.g., the external electronic device **690** of FIG. **6** or the electronic device **1002** or **1004** of FIG. **10**) may include a user input module **792**, an app/display **794**, and a third image processing module **796**.

[0101] According to an embodiment, in operation **701**, the user input module **792** may deliver an original image selection input to the app/display **794**. For example, the user input module **792** may receive a user input for selecting an original image to be corrected from among pre-stored images.

[0102] According to an embodiment, in operation **703**, the app/display **794** may transmit the original image to the first image processing module **702** in response to the original image selection input.

[0103] According to an embodiment, in operation **705**, the first image processing module **702** may generate a first image by downsampling the original image. The first image processing module **702** may generate a removed image by removing some components (e.g., a shadow image and/or a light reflection image) from the first image. The first image processing module **702** may remove some components from the first image by using a trained artificial intelligence learning model. The first image processing module **702** may deliver the removed image to the second image processing module **704**.

[0104] According to an embodiment, in operation **707**, the second image processing module **704** may provide resolution information to the controller **706** based on the removed image. The resolution information may include the resolution of the original image and/or the resolution of the downsampled image (e.g., the first image and/or the removed image).

[0105] According to an embodiment, in operation **709**, the controller **706** may determine the number of times that stepwise upsampling is performed and/or whether to perform tiling, based on the resolution information. The controller **706** may transmit information about the determined number of times that stepwise upsampling is performed and/or whether to perform tiling, to the second image processing module **704**.

[0106] According to an embodiment, in operation **711**, the second image processing module **704** may perform stepwise upsampling based on information received from the controller **706**. For example, the second image processing module **704** may generate a difference image based on the first image and the removed image. For example, the second image processing module **704** may generate a difference image by subtracting the first image from the removed image. The second image processing module **704** may stepwise upsample the difference image. According to an embodiment, when the second image processing module **704** receives a command for performing tiling from the controller **706**, the second image processing module **704** may split the difference image into a plurality of tile images. The second image processing module **704** may stepwise upsample each of the tile images. The second image processing module **704** may generate a difference image (a plurality of tile images corresponding to the difference image) having a resolution corresponding to the resolution of the original image as the result of stepwise upsampling.

[0107] According to an embodiment, in operation **713**, the second image processing module **704** may transmit the upsampled difference image to the third image processing module **796**.

[0108] According to an embodiment, in operation **715**, the third image processing module **796** may generate a final image based on the original image and the upsampled difference image. The final image may be an image which has a resolution corresponding to the resolution of the original image, and in which some components are removed from the original image. For example, the third image processing module **796** may generate the final image by adding the difference image to the original image. When the third image processing module **796** receives a plurality of upsampled tile images from the second image processing module **704**, the third image processing module **693** may split the original image into original tile images of which the number is the same as the number of upsampled tile images. The third image processing module **796** may generate a plurality of combined images by combining the original tile images with the corresponding upsampled tile images, respectively. The third image processing module **796** may generate the final image by composing the plurality of combined images. The third image processing module **796** may deliver the final image to the app/display **794**. The app/display **794** may store and/or output the final image.

[0109] According to various embodiments, operations of the electronic device **700** and the external electronic device **790** are not limited to that illustrated in FIG. **7**, and the electronic device **700** and the external electronic device **790** may perform at least some of the operations described in FIGS. **1**, **2**, **4**, and **5**. For example, each of the electronic device **700** (e.g., the first image processing module **702** and/or the second image processing module **704**) and the external electronic device **790** (e.g., the third image processing module **796**) may separately perform at least some steps of the stepwise upsampling operation. For example, the electronic device **700** may deliver an intermediate image generated during stepwise upsampling to the external electronic device **790**, and the external electronic device **790** may perform stepwise upsampling based on the received intermediate image. For example, the third image processing module **796** of the external electronic device **790** may perform operation **705**, and the first image processing module **702** and/or the second image processing module **704** may perform operation **711**. For example, the electronic device **700** may not perform operation **711**, but the external electronic device **790** may perform operation **711**.

[0110] According to various embodiments, configurations of the electronic device **700** and the external electronic device **790** are not limited to that illustrated in FIG. **6**. Some configurations of each of the electronic device **700** and the external electronic device **790** may be omitted or at least one configuration thereof may be added.

[0111] According to an embodiment, the electronic device **700** may distribute a processing load and may perform image processing efficiently in consideration of the performance of a device, by correcting an original image through stepwise upsampling in conjunction with the external electronic device **790**.

[0112] When the resolution of an image is changed, details of the image may be lost or the image may be damaged. Various embodiments of the disclosure aim to provide an electronic device capable of removing unwanted components included in an image, and an image processing method of the electronic device. Various embodiments of the disclosure aim to provide an electronic device capable of minimizing or reducing loss and damage of an image when the resolution of the image is changed, and an image processing method of the electronic device. The technical problems to be solved in this specification are not limited to the aforementioned problem, and other technical problems that are not mentioned will be clearly understood by those skilled in the art, to which the disclosure pertains, from the following description.

[0113] According to an embodiment, an electronic device may include a communication circuit, a memory, and a processor. According to an embodiment, the processor may be configured to generate a first image by downsampling an original image. According to an embodiment, the processor may be configured to generate a second image by removing a partial component included in the first image from the first image. According to an embodiment, the processor may be configured to generate a difference image between the first image and the second image. According to an embodiment, the processor may be configured to determine the number of times that the difference image is stepwise upsampled to have a resolution corresponding to the resolution of the original image. According to an embodiment, the processor may be configured to generate an upsampled difference image by stepwise upsampling the difference image the determined number of times. According to an embodiment, the processor may be configured to generate a final image, which corresponds to a resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image. According to an embodiment, the processor may be configured to store the final image in the memory.

[0114] According to an embodiment, the processor may be configured to recognize whether the computational memory of the processor exceeds a predetermined threshold value. According to an embodiment, the processor may be configured to split the difference image into a plurality of tile images when the computational memory exceeds the threshold value. According to an embodiment, the processor may be configured to stepwise upsample the plurality of tile images the determined number of times. According to an embodiment, the processor may be configured to generate the final image based on the original image and the upsampled plurality of tile images.

[0115] According to an embodiment, the processor may be configured to add padding to edges of the plurality of tile images. According to an embodiment, the processor may be configured to stepwise upsample the padding-added plurality of tile images. According to an embodiment, the processor may be configured to crop the upsampled padding-added plurality of tile images. According to an embodiment, the processor may be configured to generate the final image based on the original image and the cropped plurality of tile images. According to an embodiment, the processor may be configured to generate an intermediate original image by downsampling an original image to have a resolution corresponding to an intermediate difference image upsampled by a number of times less than the determined number of times while stepwise upsampling the difference image. According to an embodiment, the processor may be configured to generate an intermediate result image based on the intermediate difference image and the intermediate original image. According to an embodiment, the processor may be configured to recognize whether the generated intermediate result image corresponds to a specified resolution. According to an embodiment, the processor may be configured to perform a specified operation based on the intermediate result image when the intermediate result image corresponds to the specified resolution.

[0116] According to an embodiment, the specified operation may include an operation of providing the intermediate result image as an image for editing.

[0117] According to an embodiment, the electronic device may include a display. According to an embodiment, the specified resolution may include a resolution of a specified preview image. According to an embodiment, the specified operation may include an operation of outputting the intermediate result image as the preview image through the display.

[0118] According to an embodiment, the electronic device may include a camera. According to an embodiment, the processor may be configured to obtain the original image through the camera.

[0119] According to an embodiment, the processor may be configured to obtain the original image from an external electronic device through the communication circuit.

[0120] According to an embodiment, the processor may be configured to determine the number of times based on a ratio between a resolution of the original image and a resolution of the first image, and a specified upsampling magnification.

[0121] According to an embodiment, the processor may be configured to request an external electronic device to perform at least some of a stepwise upsampling operation the determined number of times. According to an embodiment, the processor may be configured to receive a result of performing at least some of the stepwise upsampling operation the determined number of times from the external electronic device.

[0122] According to an embodiment, the processor may be configured to remove the partial component included in the first image from the first image by using a trained artificial intelligence learning model.

[0123] According to an embodiment, the partial component may include at least one of a shadow image and a light reflection image that are included in the first image.

[0124] According to embodiments disclosed in the specification, unwanted components included in an image may be removed. According to embodiments disclosed in the specification, the time, resources, and computational amount consumed for image correction may be reduced. According to embodiments disclosed in the specification, the loss and damage of an image may be minimized or reduced when a resolution of the image is changed. Besides, a variety of effects directly or indirectly understood through the disclosure may be provided. Effects obtained in the disclosure are not limited to the above-mentioned effects, and other effects that are not mentioned will be clearly understood by those skilled in the art, to which the disclosure belongs, from the following description.

[0125] FIG. **8** is a flowchart of an image processing method of an electronic device, according to an embodiment.

[0126] According to an embodiment, in operation **805**, an electronic device (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, the electronic device **700**

of FIG. **7**, or the electronic device **1001** of FIG. **10**) (e.g., a processor (e.g., the controller **180** of FIG. **1**, the controller **618** of FIG. **6**, the controller **706** of FIG. **7**, or the processor **1020** of FIG. **10**) of the electronic device) may receive an original image. For example, the electronic device may capture the original image by using a camera, or may receive the original image from an external device. The electronic device may select (or determine) at least one original image from among images previously stored in a memory of the electronic device based on a user input.

[0127] According to an embodiment, in operation **810**, the electronic device (e.g., a processor of the electronic device) may downsample the original image. The electronic device may generate a first image by downsampling the original image so as to have a specified resolution.

[0128] According to an embodiment, in operation **815**, the electronic device (e.g., the processor of the electronic device) may generate a second image by removing some components (e.g., a shadow image and/or a light reflection image) from the first image. The electronic device may generate the second image by removing some components from the first image by using a trained artificial intelligence learning model (e.g., a machine learning (e.g., deep learning) model). The electronic device may generate a difference image based on the original image and the second image. The difference image may correspond to the removed components (e.g., the shadow image and/or the light reflection image). For example, an electronic device may generate the difference image by subtracting the first image (e.g., each pixel value of the first image) from the second image (e.g., each pixel value of the second image).

[0129] According to an embodiment, in operation **820**, the electronic device (e.g., the processor of the electronic device) may determine an upsampling step. The electronic device may determine the number of times that stepwise upsampling is performed. The electronic device may determine the number of times that stepwise upsampling is performed, based on a specified upsampling multiple, the resolution of the original image, and the resolution of the downsampled image (e.g., the first image). According to an embodiment, the specified multiple may vary based on the state of the electronic device, the user input, the resolution of the original image, and/or the resolution of the downsampled image.

[0130] According to an embodiment, in operation **825**, the electronic device (e.g., the processor of the electronic device) may determine whether a computational memory of the processor exceeds a threshold value. The electronic device may determine whether to perform tiling based on whether the amount of computation (e.g., an operational memory) of the processor exceeds the threshold value. The electronic device may perform operation **830** when the computational memory exceeds the threshold value. The electronic device may skip operation **830** and may perform operation **835** when the computational memory is less than or equal to the threshold value.

[0131] According to an embodiment, in operation **830**, the electronic device (e.g., the processor of the electronic device) may split the original image and the difference image into a plurality of tile images. The electronic device may determine the number and/or sizes of tile images based on the resolution of the original image and the resolution of the first image (alternatively, the second image or the difference image).

[0132] According to an embodiment, in operation **835**, the electronic device (e.g., the processor of the electronic device) may perform stepwise upsampling. The electronic device may upsample the difference image multiple times based on the specified upsampling multiple. For example, when the difference image is split into the plurality of tiles in operation **830**, the electronic device may perform stepwise upsampling on each of the split tile images. The electronic device may generate an intermediate image and/or a final image by combining the original image and the difference image having a resolution corresponding to each upsampling step. For example, when the difference image is split into the plurality of tile images, the electronic device may generate the intermediate image and/or the final image by splitting the original image into a plurality of original tile images, of which the number is the same as the number of tile images, and combining the tile images corresponding to each other. According to an embodiment, to prevent or reduce image damage at a boundary of a tile image, the electronic device may add padding to each direction of the tile image and may crop an area corresponding to the padding after upsampling the tile image.

[0133] According to an embodiment, in operation **840**, the electronic device (e.g., the processor of the electronic device) may determine whether a resolution of an intermediate image generated during the stepwise upscaling corresponds to a specified resolution. The intermediate image may refer to an image generated at each stage of stepwise upsampling before generating the final image. For example, the electronic device may determine whether the resolution of the intermediate image corresponds to the resolution of the preview image. When the resolution of the intermediate image corresponds to the specified resolution, the electronic device may perform operation **845**. When the resolution of the intermediate image does not correspond to the specified resolution, the electronic device may perform operation **850**. For example, in FIG. **8**, the specified operation is described as outputting a preview image, but is not limited thereto. The specified operation may include various operations (e.g., editing an image and/or outputting a thumbnail image) capable of being performed by the electronic device.

[0134] According to an embodiment, in operation **845**, the electronic device (e.g., the processor of the electronic device) may perform the specified operation based on the intermediate image. For example, the electronic device may output the intermediate image as a preview image.

[0135] According to an embodiment, in operation **850**, the electronic device (e.g., the processor of the electronic device) may determine whether the resolution of the generated image corresponds to the resolution of the original image. For example, the electronic device may determine whether to generate a final image with a desired resolution (e.g., the resolution of the original image) as the result of performing stepwise upscaling. When the resolution of the generated image corresponds to the resolution of the original image, the electronic device may perform operation **855**. When the resolution of the generated image does not correspond to the resolution of the original image, the electronic device may repeatedly perform stepwise upscaling operations following operation **825**.

[0136] According to an embodiment, in operation **855**, the electronic device (e.g., the processor of the electronic device) may store the final image in a memory.

[0137] According to various embodiments, the order of the operations in FIG. **8** may be changed, and at least some of the operations may be performed simultaneously. At least some (e.g., operation **840** and operation **845**) of the operations of FIG. **8** may be skipped, and at least one operation (e.g., at least one of the operations of FIGS. **2**, **4**, **5**, and/or **10**) may be added.

[0138] According to an embodiment, the electronic device may reduce the damage and loss of details of the original image capable of being generated during upsampling by upsampling the difference image and utilizing the original image when the final image is generated. The electronic device may reduce the amount of computation (e.g., operating memory consumption) and image processing time of the processor by tiling an original image and a difference image and upsampling and/or compositing the tiled result. The electronic device may prevent or reduce chances of an image from being damaged at a border of a tile image by applying padding and cropping to the tile image. The electronic device may reduce image damage capable of occurring during upsampling by performing recursive upsampling, and may utilize the intermediate image generated during upsampling for a specified function and/or a specified operation.

[0139] FIG. **9** is a flowchart of an image processing method of an electronic device, according to an embodiment.

[0140] According to an embodiment, in operation **910**, an electronic device (e.g., the electronic device **100** of FIG. **1**, the electronic device **610** of FIG. **6**, the electronic device **700** of FIG. **7**, or the electronic device **1001** of FIG. **10**) (e.g., a processor (e.g., the controller **180** of FIG. **1**, the controller **618** of FIG. **6**, the controller **706** of FIG. **7**, or the processor **1020** of FIG. **10**) of the electronic device) may generate a first image by downsampling an original image. For example, the electronic device may generate the first image by lowering the resolution of the original image.

[0141] According to an embodiment, in operation **920**, the electronic device (e.g., a processor of the electronic device) may generate a second image by removing some components (e.g., a shadow image and/or a light reflection image) included in the first image from the first image. For example, the electronic device may remove some components from the first image based on the trained artificial intelligence model.

[0142] According to an embodiment, in operation **930**, the electronic device (e.g., the processor of the electronic device) may generate a difference image between the first image and the second image. For example, the electronic device may generate a difference image by subtracting a value of each of pixels of the corresponding first image from a value of each of pixels of the second image. For example, the electronic device may generate the difference image by subtracting the value of each of the pixels of the second image from the value of each of the pixels of the first image and then inverting the values of the pixels (e.g., conversion to a value symmetrical to a reference value).

[0143] According to an embodiment, in operation **940**, the electronic device (e.g., the processor of the electronic device) may determine the number of times that the difference image is stepwise upsampled to have a resolution corresponding to the resolution of the original image. The electronic device may determine the number of times that stepwise upsampling is performed, based on a specified upsampling (resolution) multiple (e.g., 'n' times), the resolution of the original image, and the resolution (e.g., a first resolution) of the downsampled image.

[0144] According to an embodiment, in operation **950**, the electronic device (e.g., the processor of the electronic device) may generate an upsampled difference image by upsampling the difference image based on the determined number of times. For example, the electronic device may upsample the difference image by using a joint up-sampling method. The electronic device may finally generate an upsampled difference image having a resolution corresponding to the resolution of the original image through stepwise upsampling. According to an embodiment, the electronic device may split the difference image (and the original image) into a plurality of first tile images. For example, the electronic device may recognize whether the computational memory (or an operating memory) of a processor exceeds a predetermined threshold value. The electronic device may recognize whether OOM occurs. When a computational memory of a processor exceeds a predetermined threshold value, the electronic device may split the difference image into a plurality of tile images. When the computational memory of the processor does not exceed the predetermined threshold value, the electronic device may not split the difference image (and the original image) into a plurality of tile images. For example, the electronic device may determine the number and/or sizes of tiles under the condition that the operating memory of the processor does not exceed a specified free memory. For example, the electronic device may determine the number and/or sizes of tiles based on the resolution of the original image and/or the output resolution (e.g., a downsampling resolution) of the AI learning model used to remove components. For example, the electronic device may determine the number of tile images as one of divisors of the resolution of the model output (e.g., the downsampled first image). The electronic device may stepwise upsample each of the tile images. The electronic device may not perform upsampling of a tile image satisfying a specified condition (e.g., a case where the sum of values of pixels of a tile image is 0). In this case, in operation **960**, the electronic device may generate the final image by using the corresponding original tile image instead of the tile image.

[0145] According to an embodiment, the electronic device may recognize the resolution of an intermediate image generated during stepwise upsampling. When the resolution of the intermediate image corresponds to a specified resolution (e.g., an image resolution for thumbnail, an image resolution for preview, and/or an image resolution for editing), the electronic device may perform the specified operation and/or the specified function (e.g., outputting a thumbnail image, outputting a preview image, and/or editing an image) based on the intermediate image.

[0146] According to an embodiment, in operation **960**, the electronic device (e.g., the processor of the electronic device) may generate the final image, of which the resolution corresponds to the resolution of the original image and in which some components are removed from the original image, based on the original image and the upsampled difference image. For example, the electronic device may generate the final image by adding the upsampled difference image to the original image. For example, the electronic device may generate the final image by adding a value of each pixel of the upsampled difference image to a value of each pixel of the original image.

[0147] According to an embodiment, in operation **970**, the electronic device (e.g., the processor of the electronic device) may store the final image in a memory.

[0148] According to various embodiments, the order of the operations in FIG. **9** may be changed, and at least some of the operations may be performed simultaneously. At least some (e.g., operation **840** and operation **845**) of the operations of FIG. **8** may be skipped, and at least one operation (e.g., at least one of the operations of FIGS. **2**, **4**, **5**, and/or **9**) may be added.

[0149] According to an embodiment, the electronic device **100** may reduce the damage and loss of details of the original image capable of being generated during upsampling by upsampling the difference image and utilizing the original image when the final image is generated. The electronic device **100** may reduce the amount of computation (e.g., operating memory consumption) and image processing time of the processor by tiling an original image and a difference image and upsampling and/or compositing the tiled result. The electronic device **100** may prevent or reduce chances of an image from being damaged at a border of a tile image by applying padding and cropping to the tile image. The electronic device **100** may reduce image damage capable of occurring during upsampling by performing recursive upsampling, and may utilize the intermediate image generated during upsampling for a specified function and/or a specified operation.

[0150] A method for image processing of an electronic device according to an embodiment may include an operation of generating a first image by downsampling an original image. According to an embodiment, the method may include an operation of generating a second image by removing a partial component included in the first image from the first image. According to an embodiment, the method may include an operation of generating a difference image between the first image and the second image; According to an embodiment, the method may include an operation of determining the number of times that the difference image is stepwise upsampled to have a resolution corresponding to a resolution of the original image. According to an embodiment, the method may include an operation of generating an upsampled difference image by stepwise upsampling the difference image the determined number of times. According to an embodiment, the method may include an operation of generating a final image, which corresponds to a resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image. According to an embodiment, the method may include an operation of storing the final image.

[0151] According to an embodiment, the generating of the final image may include recognizing whether a computational memory of a processor of the electronic device exceeds a predetermined threshold value. According to an embodiment, the generating of the final image may include splitting the difference image into a plurality of tile images when the computational memory exceeds the threshold value. According to an embodiment, the generating of the final image may include stepwise upsampling the plurality of tile images the determined number of times. According to an embodiment, the generating of the final image may include generating the final image based on the original image and the upsampled plurality of tile images.

[0152] According to an embodiment, the method may include generating an intermediate original image by downsampling an original image so as to have a resolution corresponding to an intermediate difference image upsampled by a number of times less than the determined number of times while stepwise upsampling the difference image. According to an embodiment, the method may include generating an intermediate result image based on the intermediate difference image and the intermediate original image; According to an embodiment, the method may include recognizing whether the generated intermediate result image corresponds to a specified resolution. According to an embodiment, the method may include performing a specified operation based on the intermediate result image when the intermediate result image corresponds to the specified resolution.

[0153] According to an embodiment, the performing of the specified operation may include at least one of providing the intermediate result image as an image for editing and outputting the intermediate result image as a preview image.

[0154] According to an embodiment, the determining of the number of times may include determining the number of times based on a ratio between the resolution of the original image and a resolution of the first image, and a specified upsampling magnification. "Based on" as used herein covers based at least on.

[0155] According to an embodiment, the generating of the second image may include removing the partial component included in the first image from a first image by using a trained artificial intelligence learning model.

[0156] According to an embodiment, the partial component may include at least one of a shadow image and a light reflection image that are included in the first image.

[0157] A recording medium according to an embodiment may store a program (or instructions) that, when executed by a processor of an electronic device, causes the electronic device to perform the image processing method.

[0158] According to embodiments disclosed in the specification, unwanted components included in an image may be removed. According to embodiments disclosed in the specification, the time, resources, and computational amount consumed for image correction may be reduced. According to embodiments disclosed in the specification, the loss and damage of an image may be minimized or reduced when a resolution of the image is changed. Besides, a variety of effects directly or indirectly understood through the disclosure may be provided. Effects obtained in the disclosure are not limited to the above-mentioned effects, and other effects that are not mentioned will be clearly understood by those skilled in the art, to which the disclosure belongs, from the following description.

[0159] FIG. **10** is a block diagram of an electronic device **1001** in a network environment **1000**, according to various embodiments. Referring to FIG. **1**, the electronic device **1001** in the environment information **1000** may communicate with an electronic device **1002** over a first network **1098** (e.g., a short range wireless communication network) or may communicate with at least one of an electronic device **1004** or a server **1008** over a second network **1099** (e.g., a long distance wireless communication network). According to an embodiment, the electronic device **1001** may communicate with the electronic device **1004** through the server **1008**. According to an embodiment, the electronic device **1001** may include a processor **1020**, a memory **1030**, an input module **1050**, a sound output module **1055**, a display module **1060**, an audio module **1070**, a sensor module **1076**, an interface **1077**, a connecting terminal **1078**, a haptic module **1079**, a camera module **1080**, a power management module **1088**, a battery **1089**, a communication module **1090**, a subscriber identification module **1096**, or an antenna module **1097**. In any embodiment, the electronic device **1001** may not include at least one (e.g., the connecting terminal **1078**) of the above-described components or may further include one or more other components. In some embodiments, some (e.g., the sensor module **1076**, the camera module **1080**, or the antenna module **1097**) of these components may be integrated into a single component (e.g., the display module **1060**).

[0160] For example, the processor **1020** may execute software (e.g., a program **1040**) to control at least another component (e.g., hardware or software component) of the electronic device **1001** connected to the processor **1020**, and may process and calculate various types of data. According to an embodiment, as at least part of data processing or calculation, the processor **1020** may store instructions or data received from other components (e.g., the sensor module **1076** or the communication module **1090** comprising communication circuitry) into a volatile memory **1032**, may process instructions or data stored in the volatile memory **1032**, and may store the result data in a nonvolatile memory **1034**. According to an embodiment, the processor **1020** may include a main processor **1021** (e.g., a central processing unit or an application processor) and an auxiliary processor **1023** (e.g., a graphic processing unit, a neural processing unit (NPU), an image signal processor, a sensor hub processor, or a communication processor) capable of operating independently or together with the main processor. For example, when the electronic device **1001** includes the main processor **1021** and the auxiliary processor **1023**, the auxiliary processor **1023** may be configured to use less power than the main processor **1021** or to be specialized for a specified function. The auxiliary processor **1023** may be implemented separately from the main processor **1021** or as part of the main processor **121**.

[0161] For example, the auxiliary processor **1023** may control at least part of the functions or states associated with at least one (e.g., the display module **1060**, the sensor module **1076**, or the communication module **1090**) of the components of the electronic device **1001**, instead of the main processor **1021** while the main processor **1021** is in an inactive (e.g., sleep) state or together with the main processor **1021** while the main processor **1021** is in an active (e.g., the execution of an application) state. According to an embodiment, the auxiliary processor **1023** (e.g., an image signal processor or a communication processor) may be implemented as a part of operatively associated other components (e.g., the camera module **1080** or the communication module **1090**). According to an embodiment, the auxiliary processor **1023** (e.g., a neural network processing unit) may include a hardware structure specialized to process an artificial intelligence model. The artificial intelligence model may be generated through machine learning. For example, the learning may be performed in the electronic device **1001**, in which an artificial intelligence model is performed, or may be performed through a separate server (e.g., the server **1008**). For example, the learning algorithm may include supervised learning, unsupervised learning, semi-supervised learning, or reinforcement learning, but is not limited to the above example. The artificial intelligence model may include a plurality of artificial neural network layers. The artificial neural network may be one of a deep neural network (DNN), a convolutional neural network (CNN), a recurrent neural network (RNN), a restricted Boltzmann machine (RBM), a deep belief network (DBN), a bidirectional recurrent deep neural network (BRDNN), a deep Q-network, or a combination of two or more of the networks, but may not be limited to the above-described example. In addition to a hardware structure, additionally or alternatively, the artificial intelligence model may include a software structure.

[0162] The memory **1030** may store various pieces of data used by at least one component (e.g., the processor **1020** or the sensor module **1076**) of the electronic device **1001**. For example, data may include software (e.g., the program **1040**) and input data or output data for instructions associated with the software. The memory **1030** may include the volatile memory **1032** or the nonvolatile memory **1034**.

[0163] The program **1040** may be stored in the memory **1030** as software, and may include, for example, an operating system **1042**, a middleware **1044**, or an application **1046**.

[0164] The input module **1050** may receive instructions or data to be used for the component (e.g., the processor **1020**) of electronic device **1001**, from the outside (e.g., a user) of the electronic device **1001**. The input module **1050** may include, for example, a microphone, a mouse, a keyboard, a key (e.g., a button), or a digital pen (e.g., a stylus pen).

[0165] The sound output module **1055** may output a sound signal to the outside of the electronic device **1001**. The sound output module **1055** may include, for example, a speaker or a receiver. The speaker may be used for a general purpose, such as multimedia play or recording play. The receiver may be used to receive an incoming call. According to an embodiment, the receiver may be implemented separately from the speaker or may be implemented as a part of the speaker.

[0166] The display module **1060** may visually provide information to the outside (e.g., the user) of the electronic device **1001**. The display module **1060** may include, for example, a display, a hologram device, or a control circuit for controlling a projector and a corresponding device. According to an embodiment, the display module **1060** may include a touch sensor configured to sense a touch, or a pressure sensor configured to measure the strength of force generated by the touch.

[0167] The audio module **1070** may convert sound to an electrical signal, or reversely, may convert an electrical signal to sound. According to an embodiment, the audio module **1070** may obtain sound through the input module **1050**, or may output sound through the sound output module **1055**, or through an external electronic device (e.g., the electronic device **1002**) (e.g., a speaker or a headphone) directly or wirelessly connected with the electronic device **1001**.

[0168] The sensor module **1076** may sense an operation state (e.g., power or a temperature) of the electronic device **1001** or an external environment state (e.g., a user state), and may generate an electrical signal or a data value corresponding the sensed state. According to an embodiment, the sensor module **1076** may include, for example, a gesture sensor, a grip sensor, a barometric pressure sensor, a magnetic sensor, an acceleration sensor, a grip sensor, a proximity sensor, a color sensor, an infrared (IR) sensor, a biometric sensor, a temperature sensor, a humidity sensor, or an illumination sensor.

[0169] The interface **1077** may support one or more specified protocols that may be used to directly and wirelessly connect the electronic device **1001** with an external electronic device (e.g., the electronic device **1002**). According to an embodiment, the interface **1077** may include, for example, a high definition multimedia interface (HDMI), a universal serial bus (USB) interface, a secure digital (SD) card interface, or an audio interface.

[0170] The connecting terminal **1078** may include a connector that may allow the electronic device **1001** to be physically connected with an external electronic device (e.g., the electronic device **1002**). According to an embodiment, the connecting terminal **1078** may include, for example, a HDMI connector, an USB connector, an SD card connector, or an audio connector (e.g., a headphone connector).

[0171] The haptic module **1079** may convert an electrical signal to a mechanical stimulation (e.g., vibration or movement) or an electrical stimulation which the user may perceive through the sense of touch or the sense of movement. According to an embodiment, the haptic module **1079** may include, for example, a motor, a piezoelectric sensor, or an electrical stimulation device.

[0172] The camera module **1080** may shoot a still image or a video image. According to an embodiment, the camera module **1080** may include one or more lenses, image sensors, image signal processors, or flashes (or electrical flashes).

[0173] The power management module **1088** may manage the power which is supplied to the electronic device **1001**. According to an embodiment, the power management module **1088** may be implemented, for example, as at least part of a power management integrated circuit (PMIC).

[0174] The battery **1089** may power at least one component of the electronic device **1001**. According to an embodiment, the battery **1089** may include, for example, a primary cell not recharged, a secondary cell rechargeable, or a fuel cell.

[0175] The communication module **1090** may establish a direct (or wired) communication channel or a wireless communication channel between the electronic device **1001** and an external electronic device (e.g., the electronic device **1002**, the electronic device **1004**, or the server **1008**) and may perform communication through the established communication channel. The communication module **1090** may include one or more communication processors which are operated independently of the processor **1020** (e.g., an application processor) and support direct (or wired) communication or wireless communication. According to an embodiment, the communication module **1090** may include a wireless communication module **1092** (e.g., a cellular communication module, a short range wireless communication module, or a global navigation satellite system (GNSS) communication module) or a wired communication module **1094** (e.g., a local area network (LAN) communication module or a power line communication module). The corresponding communication module among these communication modules may communicate with an external electronic device **1004** through a first network **1098** (e.g., a short-range communication network such as Bluetooth, wireless fidelity (WiFi) direct or infrared data association (IrDA)) or a second network **1099** (e.g., long-range wireless communication network such as a legacy cellular network, 5G networks, next-generation communication networks, Internet, or computer networks (e.g., LAN or WAN)). The above-described kinds of communication modules may be integrated in one component (e.g., a single chip) or may be implemented with a plurality of components (e.g., a plurality of chips) which are independent of each other. The wireless communication module **1092** may identify or authenticate the electronic device **1001** within a communication network, such as the first network **1098** or the second network **1099**, by using subscriber information (e.g., international mobile subscriber identity (IMSI)) stored in the subscriber identification module **1096**.

[0176] The wireless communication module **1092**, comprising communication circuitry, may support a 5G network and a next-generation communication technology after a 4G network, for example, a new radio (NR) access technology. The NR access technology may support enhanced mobile broadband (eMBB), massive machine type communications (mMTC), or ultra-reliable and low-latency communications (URLLC). For example, the wireless communication module **1092** may support a high frequency band (e.g., mmWave band) to achieve a high data transfer rate. The wireless communication module **1092** may support various technologies for securing performance in a high frequency band, for example, technologies such as beamforming, massive multiple-input and multiple-output (massive MIMO), full dimensional MIMO (FD-MIMO), an array antenna, analog beam-forming, and a large scale antenna. The wireless communication module **1092** may support various requirements regulated in the electronic device **1001**, an external electronic device (e.g., the electronic device **1004**) or a network system (e.g., the second network **1099**). According to an embodiment, the wireless communication module **1092** may support peak data rate (e.g., 20 Gbps or more) for eMBB implementation, loss coverage (e.g., 164 dB or less) for mMTC implementation, or U-plane latency (e.g., downlink (DL) of 0.5 ms or less and uplink (UL) of 0.5 ms or less, or round trip of 1 ms or less) for URLLC implementation.

[0177] The antenna module **1097** may transmit a signal or a power to the outside (e.g., an external electronic device) or may receive a signal or a power from the outside. According to an embodiment, the antenna module **1097** may include an antenna including a radiator formed of a conductor or a conductive pattern formed on a substrate (e.g., PCB). According to an embodiment, the antenna module **1097** may include a plurality of antennas (e.g., an array antenna). In this case, at least one antenna suitable for a communication scheme used in a communication network such as the first network **1098** or the second network **1099** may be selected, for example, by the communication module **1090** from the plurality of antennas. The signal or power may be exchanged between the communication module **1090** and an external electronic device through the selected at least one antenna or may be received from the external electronic device through the selected at least one antenna and the communication module **190**. According to some embodiments, other parts (e.g., radio frequency integrated circuit (RFIC)) may be additionally formed as a part of the antenna module **1097** in addition to the radiator.

[0178] According to various embodiments, the antenna module **1097** may form an mmWave antenna module. According to an embodiment, the mmWave antenna module may include a printed circuit board (PCB), a radio frequency integrated circuit (RFIC), and a plurality of antennas (e.g., an array antenna). The RFIC may be disposed on or adjacent to a first surface (e.g., a bottom surface) of the PCB and may support a specified high frequency band (e.g., mm Wave band). The plurality of antennas may be disposed on or adjacent to a second surface (e.g., a top surface or a side surface) of the PCB and may transmit or receive a signal in the specified high frequency band.

[0179] At least some of the components may be connected, directly or indirectly, to each other through a communication scheme (e.g., a bus, a general purpose input and output (GPIO), a serial peripheral interface (SPI), or a mobile industry processor interface (MIPI)) between peripheral devices and may exchange signals (e.g., commands or data) with each other.

[0180] According to an embodiment, the command or data may be transmitted or received between the electronic device **1001** and the external electronic device **1004** through the server **1008** connected, directly or indirectly, to the second network **1099**. Each of the external electronic device **1002** or **104** may be a device of which the type is the same as or different from that of the electronic device **1001**. According to an embodiment, all or a part of operations to be executed by the electronic device **1001** may be executed in one or more external electronic devices among the external electronic devices **1002**, **104**, or **108**. For example, when the electronic device **1001** needs to perform any function or service automatically or in response to a request from the user or any other device, the electronic device **1001** may additionally request one or more external electronic devices to perform at least part of the function or service, instead of internally executing the function or service. The one or more external electronic devices which receive the request may execute at least a part of the function or service thus requested or an additional function or service associated with the request, and may provide a result of the execution to the electronic device **1001**. The electronic device **1001** may process received result as it is or additionally, and may provide a result of the processing as at least a part of the response to the request. To this end, for example, cloud computing, distributed computing, mobile edge computing (MEC), or client-server computing may be used. For example, the electronic device **1001** may provide an ultra-low latency service by using distributed computing or mobile edge computing. In another embodiment, the external electronic device **1004** may include an Internet of Things (IoT) device. The server **1008** may be an intelligent server using machine learning and/or a neural network. According to an embodiment, the external electronic device **1004** or the server **1008** may be included in the second network **1099**. The electronic device **1001** may be applied to an intelligent service (e.g., a smart home, a smart city, a smart car, or a healthcare) based on 5G communication technology and IoT-related technology.

[0181] The electronic device according to various embodiments disclosed in the disclosure may be various types of devices. The electronic device may include, for example, a portable communication device (e.g., a smartphone), a computer device, a portable multimedia device, a mobile medical appliance, a camera, a wearable device, or a home appliance. An electronic device according to an embodiment of this specification may not be limited to the above-described electronic devices.

[0182] Various embodiments of the disclosure and terms used herein are not intended to limit the technical features described in the disclosure to specific embodiments, and it should be understood that the embodiments and the terms include modification, equivalent, or alternative on the corresponding embodiments described herein. With regard to description of drawings, similar or related components may be marked by similar reference marks/numerals. The singular form of the noun corresponding to an item may include one or more of items, unless interpreted otherwise in context. In the disclosure, the expressions "A or B", "at least one of A and B", "at least one of A or B", "A, B, or C", "at least one of A, B, and C", and "at least one of A, B, or C" may include any and all combinations of one or more of the associated listed items. The terms, such as "first" or "second" may be used to simply distinguish the corresponding component from the other component, but do not limit the corresponding components in other aspects (e.g., importance or order). When a component (e.g., a first component) is referred to as being "coupled with/to" or "connected to" another component (e.g., a second component) with or without the term of "operatively" or "communicatively", it may mean that a component is connectable to the other component, directly (e.g., by wire), wirelessly, or through the third component. Thus, for example, "connected" as used herein covers direct and indirect connections.

[0183] In various embodiments of the disclosure, the term "module" used herein may include a unit, which is implemented with hardware, software, or firmware, and may be interchangeably used with the terms "logic", "logical block", "part", or "circuit". The "module" may be a minimum unit of an integrated part or may be a minimum unit of the part for performing one or more functions or a part thereof. For example, according to an embodiment, the module may be implemented in the form of an application-specific integrated circuit (ASIC). Thus, each "module" herein may comprise circuitry.

[0184] Various embodiments of the disclosure may be implemented with software (e.g., program **1040**) including one or more instructions stored in a storage medium (e.g., the embedded memory **1036** or the external memory **1038**) readable by a machine (e.g., the electronic device **1001**). For example, the processor (e.g., the processor **1020**) of the machine (e.g., the electronic device **1001**) may call at least one instruction of the stored one or more instructions from a storage medium and then may execute the at least one instruction. This enables the machine to operate to perform at least one function depending on the called at least one instruction. The one or more instructions may include a code generated by a compiler or a code executable by an interpreter. The machine-readable storage medium may be provided in the form of a non-transitory storage medium. Herein, 'non-transitory' just means that the storage medium is a tangible device and does not include a signal (e.g., electromagnetic waves), and this term does not distinguish between the case where data is semipermanently stored in the storage medium and the case where the data is stored temporarily.

[0185] According to an embodiment, a method according to various embodiments disclosed herein may be provided to be included in a computer program product. The computer program product may be traded between a seller and a buyer as a product. The computer program product may be distributed in the form of a machine-readable storage medium (e.g., compact disc read only memory (CD-ROM)) or may be distributed (e.g., downloaded or uploaded), through an application store (e.g., PlayStore™), directly between two user devices (e.g., smartphones), or online. In the case of on-line distribution, at least part of the computer program product may be at least temporarily stored in the machine-readable storage medium such as the memory of a manufacturer's server, an application store's server, or a relay server or may be generated temporarily.

[0186] According to various embodiments, each component (e.g., a module or a program) of the above-described components may include a single entity or a plurality of entities, and some of the plurality of objects may be separately arranged on other components. According to various embodiments, one or more components of the above-described components or operations may be omitted, or one or more other components or operations may be added. Alternatively or additionally, a plurality of components (e.g., a module or a program) may be integrated into one component. In this case, the integrated component may perform one or more functions of each component of the plurality of components in the manner same as or similar to being performed by the corresponding component of the plurality of components prior to the integration. According to various embodiments, operations executed by modules, programs, or other components may be executed by a successive method, a parallel method, a repeated method, or a heuristic method. Alternatively, at least one or more of the operations may be executed in another order or may be omitted, or one or more operations may be added.

[0187] While the disclosure has been illustrated and described with reference to various embodiments, it will be understood that the various embodiments are intended to be illustrative, not limiting. It will further be understood by those skilled in the art that various changes in form and detail may be made without departing from the true spirit and full scope of the disclosure, including the appended claims and their equivalents. It will also be understood that any of the embodiment(s) described herein may be used in conjunction with any other embodiment(s) described herein.

1. An electronic device comprising:

a communication circuit;

a memory; and

at least one processor, comprising processing circuitry, individually and/or collectively configured to:

generate a first image by at least downsampling an original image;

generate a second image by at least removing a partial component included in the first image from the first image;

generate a difference image between the first image and the second image;

determine a number of times that the difference image is stepwise upsampled to have a resolution corresponding to a resolution of the original image;

generate an upsampled difference image by at least stepwise upsampling the difference image the determined number of times;

generate a final image, which corresponds to the resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image; and

store the final image in the memory.

2. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

recognize whether a computational memory exceeds a predetermined threshold value;

split the difference image into a plurality of tile images when the computational memory exceeds the threshold value;

stepwise upsample the plurality of tile images the determined number of times; and

generate the final image based on the original image and the upsampled plurality of tile images.

3. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

add padding to edges of the plurality of tile images;

stepwise upsample the padding-added plurality of tile images;

crop the upsampled padding-added plurality of tile images; and

generate the final image based on the original image and the cropped plurality of tile images.

4. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

generate an intermediate original image by at least downsampling the original image so as to have a resolution corresponding to an intermediate difference image upsampled by a number of times less than the determined number of times while stepwise upsampling the difference image;

generate an intermediate result image based on the intermediate difference image and the intermediate original image;

recognize whether the generated intermediate result image corresponds to a specified resolution; and

perform a specified operation based on the intermediate result image when the intermediate result image corresponds to the specified resolution.

5. The electronic device of claim **4**, wherein the specified operation includes an operation of providing the intermediate result image as an image for editing.

6. The electronic device of claim **4**, further comprising:

a display,

wherein the specified resolution includes a resolution of a specified preview image, and

wherein the specified operation includes an operation of outputting the intermediate result image as the preview image through the display.

7. The electronic device of claim **1**, further comprising:

a camera,

wherein the at least one processor is individually and/or collectively configured to:

obtain the original image through the camera.

8. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

obtain the original image from an external electronic device through the communication circuit.

9. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

determine the number of times based on a ratio between the resolution of the original image and a resolution of the first image, and a specified upsampling magnification.

10. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

request an external electronic device to perform at least some of a stepwise upsampling operation the determined number of times; and

receive a result of performing at least some of the stepwise upsampling operation the determined number of times from the external electronic device.

11. The electronic device of claim **1**, wherein the at least one processor is individually and/or collectively configured to:

remove the partial component included in the first image from the first image using a trained artificial intelligence learning model.

12. The electronic device of claim **1**, the partial component includes at least one of a shadow image and a light reflection image that are included in the first image.

13. An image processing method of an electronic device, the method comprising:

generating a first image by at least downsampling an original image;

generating a second image by at least removing a partial component included in the first image from the first image;

generating a difference image between the first image and the second image;

determining a number of times that the difference image is stepwise upsampled to have a resolution corresponding to a resolution of the original image;

generating an upsampled difference image by at least stepwise upsampling the difference image the determined number of times;

generating a resulting image, based on the resolution of the original image and in which the partial component is removed from the original image, based on the original image and the upsampled difference image; and

storing the resulting image.

14. The method of claim **13**, wherein the generating of the resulting image includes:

recognizing whether a computational memory of a processor of the electronic device exceeds a predetermined threshold value;

splitting the difference image into a plurality of tile images when the computational memory exceeds the threshold value;

stepwise upsampling the plurality of tile images the determined number of times; and

generating the resulting image based on the original image and the upsampled plurality of tile images.

15. The method of claim **13**, further comprising:

generating an intermediate original image by at least downsampling the original image so as to have a resolution corresponding to an intermediate difference image upsampled by a number of times less than the determined number of times while stepwise upsampling the difference image;

generating an intermediate result image based on the intermediate difference image and the intermediate original image;

recognizing whether the generated intermediate result image corresponds to a specified resolution; and

performing a specified operation based on the intermediate result image when the intermediate result image corresponds to the specified resolution.

16. The method of claim **15**, wherein the performing of the specified operation includes at least one of: providing the intermediate result image as an image for editing, and outputting the intermediate result image as a preview image.

17. The method of claim **13**, wherein the determining of the number of times includes:

determining the number of times based on a ratio between the resolution of the original image and a resolution of the first image, and a specified upsampling magnification.

18. The method of claim **13**, wherein the generating of the second image includes:

removing the partial component included in the first image from the first image by using a trained artificial intelligence learning model.

19. The method of claim **18**, wherein the partial component includes at least one of a shadow image and a light reflection image that are included in the first image.

20. The method of claim **14**, wherein the stepwise upsampling of the plurality of tile images includes:

adding padding to edges of the plurality of tile images; and

stepwise upsampling the padding-added plurality of tile images, and wherein the generating of the resulting image includes:

cropping the upsampled padding-added plurality of tile images; and

generating the resulting image based on the original image and the cropped plurality of tile images.

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