(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 September 2017 (08.09.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/151366 A2

(51) International Patent Classification:
G01J 3/46 (2006.01) *G01J 3/02* (2006.01)

(21) International Application Number:
PCT/US2017/018997

(22) International Filing Date:
23 February 2017 (23.02.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/303,428 4 March 2016 (04.03.2016) US

(71) Applicant: **3M INNOVATIVE PROPERTIES COMPANY** [US/US]; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(72) Inventors: **FURUSAWA, Masaaki**; 6-7-29, Kitashinagawa, Shinagawa-ku, Tokyo 141-8684 (JP). **KARASAWA, Fumio**; 6-7-29, Kitashinagawa, Shinagawa-ku, Tokyo 141-8684 (JP). **MORITA, Yoshinori**; 6-7-29, Kitashinagawa, Shinagawa-ku, Tokyo 141-8684 (JP). **NOJIRI, Yukio**; 6-7-29, Kitashinagawa, Shinagawa-ku, Tokyo 141-8684 (JP). **SAITO, Koji**; 6-7-29, Kitashinagawa, Shinagawa-ku, Tokyo 141-8684 (JP). **SUMIDE, Makoto**; 6-7-29, Kitashinagawa, Shinagawa-ku, Tokyo 141-8684 (JP).

(74) Agents: **VAN VLIET, Emily M.** et al.; 3M Center, Office of Intellectual Property Counsel Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

[Continued on next page]

(54) Title: DEVICE FOR MEASURING COLOR DIFFERENCE, SYSTEM, AND RECORDING MEDIUM

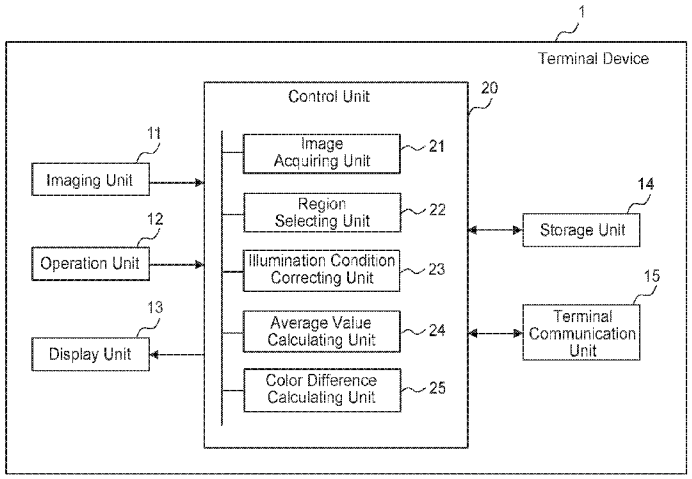


FIG. 1

(57) Abstract: Provided is a device, a system, and a recording medium capable of easily measuring a color difference between an average color value of a target object and a color value of a comparison target. The device includes: an image acquiring unit that acquires image data of an image shot of a target object; a region selecting unit that selects a prescribed image region on the target object within the image; an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region; a color difference calculating unit that calculates a color difference between the average color value and a color value of a comparison target in the same color space as the average color value; and an outputting unit that outputs information regarding the color difference.

WO 2017/151366 A2

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

DEVICE FOR MEASURING COLOR DIFFERENCE, SYSTEM, AND RECORDING MEDIUM

Technical Field

The present invention relates to a device, a system, and a recording medium for measuring a color difference.

Background Art

U.S. Patent Application No. 2014/0022535 discloses a device and method for measuring optical properties of a measurement subject, such as a saturation value, a total spectral radiation coefficient, and the like. In U.S. Patent Application No. 2014/0022535, a spectral intensity distribution of prescribed ambient light entering through a measurement aperture is measured and stored before measuring the optical properties of the measurement object. Then, when measuring the optical properties, the stored spectral intensity distribution of the ambient light is used to find optical properties in the case where the measured ambient light is employed as an observation light source.

Summary of Invention

When viewing target objects such as outdoor signage, wall coverings used on exteriors or interiors of structures, and the like from afar in order to grasp overall color trends in such target objects when the target objects are in an installed state, there is demand for a technique for finding an average color value of a comparatively broad region of the target object and then measuring a color

difference among a plurality of color values. If there is a pattern on the surface of the target object, color values obtained through the measurement can vary depending on the location and size of the region of the target object being measured. Therefore, a spectrophotometer that measures a single specific point is not suitable for measuring an average color value as described here. Meanwhile, although some commercially-available colorimeters can measure broader regions, such devices are large and expensive and are therefore not portable. This has made it difficult to measure objects such as outdoor signage while the signage remains installed. What is needed, therefore, is the ability to easily find an average color value in a measurement region and measure a color difference between a plurality of color values using, for example, a commercially-available mobile terminal provided with an imaging unit.

An object of the present invention is to provide a device, a system, and a recording medium capable of easily measuring a color difference between an average color value of a target object and a color value of a comparison target.

Provided is a device including: an image acquiring unit that acquires image data of an image shot of a target object; a region selecting unit that selects a prescribed image region on the target object within the image; an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region; a color difference calculating unit that calculates a color difference between the average color value and a color value of a comparison target in the same color space as the average color value; and an outputting unit that outputs information regarding the color difference.

In the above-described device, it is possible that the region selecting unit select, as the image region, a region having an area and shape at which the average color value does not vary more than a predetermined permissible range depending on a position of the image region within the image.

In the above-described device, it is possible that the region selecting unit select, as the image region, a region having a specific area and shape at a position where, when the region having the specific area and shape is moved within the image, the average color values within the region do not vary more than a predetermined permissible range.

It is possible that the above-described device further include an accepting unit that accepts a region in the image being specified through a user operation, and that the region selecting unit select the image region in accordance with the user operation accepted by the accepting unit.

In the above-described device, it is possible that the region selecting unit select the entire target object within the image as the image region.

In the above-described device, it is possible that the region selecting unit acquire a distance between an imaging unit that shot the image and the target object from imaging information added to the image data, and select an image region having a greater area the shorter the distance is.

In the above-described device, it is possible that the region selecting unit select the image region excluding a pixel region in which a luminance value within the image exceeds a luminance value limit.

It is possible that the device further include an illumination condition correcting unit that calculates an illumination condition under which the image is

shot on the basis of the image data and corrects the color value of the image data in accordance with the calculated illumination condition, and that the average value calculating unit calculate the average color value from the color value corrected by the illumination condition correcting unit.

It is possible that the device further include an imaging unit that shoots an image.

It is possible that the device further include a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other, an identification information acquiring unit that acquires the identification information of the target object within the image, and a determining unit that determines whether or not the color difference is within a predetermined color difference range. Here, it is possible that of the plurality of reference color values, the color difference calculating unit calculate a color difference between the reference color value corresponding to the identification information and the average color value; and that the outputting unit output a result of the determination made by the determining unit.

In the above-described device, it is possible that the image acquiring unit acquire, as the image data, first image data obtained by shooting a first target object and second image data obtained by shooting a second target object; that the average value calculating unit calculate a first average color value for the first image data as the average color value, and calculate a second average color value for the second image data as the color value of the comparison target; that the color difference calculating unit calculate a color difference between the first average

color value and the second average color value; and that the outputting unit output information indicating whether or not the color difference is within a predetermined color difference range.

In the above-described device, it is possible that the first target object be a printed material, and that the device further comprise a print data correcting unit that corrects a color value of print data for the printed material so as to reduce the color difference in the case where the color difference is not within the color difference range.

It is possible that the above-described device further include a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other, and a reference unit that references the identification information in accordance with a result of calculating the color difference. Here, it is possible that the color difference calculating unit calculate a color difference between each of the plurality of reference color values and the average color value, and that the outputting unit output the referenced identification information.

In the above-described device, it is possible that the storage unit further store, for each of the plurality of target objects, a frequency distribution obtained by converting a spatial distribution of the color values in the image obtained by shooting the target object into a spatial frequency spectral domain; that the device further include a comparison processing unit that, for each of the plurality of target objects, compares a frequency distribution stored in the storage unit with the frequency distribution obtained by converting a spatial distribution of the color

values in the image of the image data acquired by the image acquiring unit into a spatial frequency spectral domain; and that the reference unit further reference the identification information in accordance with a result of the comparison made by the comparison processing unit.

In addition, provided is a system including a terminal device and a server device communicably connected to each other. The terminal device includes an image acquiring unit that acquires image data of an image shot of a target object; a region selecting unit that selects a prescribed image region on the target object within the image; an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region; a color difference calculating unit that calculates a color difference between a reference color value received from the server device and the average color value; a terminal communicating unit that sends identification information of the target object within the image to the server device and receives, from the server device, a reference color value corresponding to the target object indicated by the identification information; and an outputting unit that outputs information regarding the color difference. The server device includes a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other; and a server communicating unit that receives the identification information from the terminal device and sends, of the plurality of reference color values, the reference color value corresponding to the target object indicated by the identification information, to the terminal device.

In addition, provided is a system including a terminal device and a server device communicably connected to each other. The terminal device includes an image acquiring unit that acquires image data of an image shot of a target object; a region selecting unit that selects a prescribed image region on the target object within the image; an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region; a terminal communicating unit that sends the average color value to the server device and receives identification information of the target object from the server device; and an outputting unit that outputs the identification information. The server device includes a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other; a color difference calculating unit that calculates a color difference between the average color value received from the terminal device and the reference color value; a reference unit that references the identification information in accordance with a result of calculating the color difference; and a server communicating unit that receives the average color value from the terminal device and sends the identification information referenced by the reference unit to the terminal device.

In addition, provided is a system including a terminal device and a server device communicably connected to each other. The terminal device includes an image acquiring unit that acquires image data of an image shot of a target object; a region selecting unit that selects a prescribed image region on the target object within the image; a terminal communicating unit that sends the image data to the

server device and receives identification information of the target object from the server device; and an outputting unit that outputs the identification information. The server device includes a storage unit that stores a plurality of reference color values and identification information of a plurality of target objects in association with each other; an average value calculating unit that calculates an average color value from color values of the image data received from the terminal device, the average color value being an average of the color values in the image region; a color difference calculating unit that calculates a color difference between the average color value and the reference color value; a reference unit that references the identification information in accordance with a result of calculating the color difference; and a server communicating unit that receives the image data from the terminal device and sends the identification information referenced by the reference unit to the terminal device.

In addition, provided is a system including a terminal device and a server device communicably connected to each other. The terminal device includes an image acquiring unit that acquires first image data obtained by shooting a first target object that is a printed material; a region selecting unit that selects a prescribed image region on the first target object within the first image data; and a terminal communicating unit that sends, to the server device, image data of the image region selected by the region selecting unit. The server device includes a storage unit that stores second image data obtained by shooting a second target object; an average value calculating unit that calculates a first average color value for the first image data and a second average color value for the second image data; a color difference calculating unit that calculates a color difference between the

first average color value and the second average color value; a print data correcting unit that corrects a color value of print data for the printed material so as to reduce the color difference in the case where the color difference is not within a predetermined color difference range; and a server communicating unit that receives the first image data from the terminal device.

In addition, provided is a non-transitory computer-readable recording medium in which is recorded a program that causes a computer to realize the functions of: acquiring image data of an image shot of a target object; selecting a prescribed image region on the target object within the image; calculating an average color value from color values of the image data, the average color value being an average of the color values in the image region; calculating a color difference between the average color value and a color value of a comparison target in the same color space as the average color value; and outputting information regarding the color difference.

According to the above-described device, system, and recording medium, a color difference between an average color value of a target object and a color value of a comparison target can be measured with ease.

Brief Description of Drawings

FIG. 1 is a diagram schematically illustrating the configuration of a terminal device 1.

FIG. 2 is a diagram illustrating an example of a screen displayed in a display unit 13.

FIG. 3 is a diagram illustrating examples of the selection of an image region by a region selecting unit 22.

FIG. 4 is a graph showing variation in an average color value depending on an area of an image region.

FIG. 5 is a diagram illustrating another method for selecting an image region by the region selecting unit 22.

FIG. 6 is a flowchart illustrating an example of operations performed by the terminal device 1.

FIG. 7 is a diagram schematically illustrating the configuration of a terminal device 1A.

FIG. 8 is a diagram illustrating an example of information stored in a storage unit 14 of the terminal device 1A.

FIG. 9 is a flowchart illustrating an example of operations performed by the terminal device 1A.

FIG. 10 is a diagram schematically illustrating the configuration of a terminal device 1B.

FIG. 11 is a schematic diagram illustrating a function of the terminal device 1B.

FIG. 12 is a flowchart illustrating an example of operations performed by the terminal device 1B.

FIG. 13 is a diagram schematically illustrating the configuration of a terminal device 1C.

FIG. 14 is a diagram illustrating an example of information stored in the storage unit 14 of the terminal device 1C.

FIG. 15 is a diagram illustrating examples of wall covering images and their corresponding frequency distribution images.

FIG. 16 is a flowchart illustrating an example of operations performed by the terminal device 1C.

FIG. 17 is a diagram schematically illustrating the configuration of a communication system 3D.

FIG. 18 is a diagram schematically illustrating the configuration of a communication system 3E.

FIG. 19 is a diagram illustrating an example of an operating sequence of the communication system 3E.

FIG. 20 is a diagram schematically illustrating the configuration of a communication system 3F.

FIG. 21 is a diagram illustrating an example of an operating sequence of the communication system 3F.

FIG. 22 is a diagram schematically illustrating the configuration of a communication system 3G.

FIG. 23 is a diagram illustrating an example of an operating sequence of the communication system 3G.

Description of Embodiments

A device, system, and recording medium for measuring a color difference will be described in detail hereinafter with reference to the appended drawings. However, please note that the technical scope of the present invention is not limited

to these embodiments, but the technical scope extends to the invention as disclosed in the scope of the patent claims and their equivalents.

FIG. 1 is a diagram schematically illustrating the configuration of a terminal device 1. The terminal device 1 is realized by a mobile terminal such as a camera-equipped smartphone, and functions as a color difference meter that finds an average color value in a comparatively broad range of a captured image of a target object several cm to several m in size, for example, and measures a color difference between a plurality of color values. The "comparatively broad range" referred to here is part or all of the target object in the image, and corresponds to a region at approximately several mm square in the image, for example. The terminal device 1 includes an imaging unit 11, an operation unit 12, a display unit 13, a storage unit 14, a terminal communication unit 15, and a control unit 20.

The imaging unit 11 corresponds to the camera provided in the terminal device 1, and shoots an image of the target object to acquire image data of the target object for measurement in RAW (DNG) data, JPEG (JFIF) data, sRGB data, or a similar format. Any of these data formats may be used, but the following mainly describes an example where the imaging unit 11 acquires sRGB data.

The operation unit 12 is constituted of, for example, a touch panel, a keyboard, or the like, and receives operations from a user. The display unit 13 is, for example, a liquid crystal display, and may be integrated with the operation unit 12 as a touch panel display. The display unit 13 is an example of an outputting unit, and outputs information regarding a color difference calculated by the control unit 20.

FIG. 2 is a diagram illustrating an example of a screen displayed in the display unit 13. In the example illustrated here, two images 50A and 50B shot by the imaging unit 11 are displayed in an upper area of the display unit 13. Meanwhile, an average color value 61 in a rectangular image region 51 within the image 50A, an average color value 62 in a rectangular image region 52 within the image 50B, and a color difference 63 between the average color values 61 and 62 are displayed in a lower area of the display unit 13. The "average color value" referred to here is an average of the sRGB values of each pixel in the image region 51 or the image region 52.

The storage unit 14 is, for example, a semiconductor memory that stores the image data acquired by the imaging unit 11, data necessary for operation of the terminal device 1, and the like. The terminal communication unit 15 is an interface used by the terminal device 1 to send and receive data to and from an external device.

The control unit 20 is constituted of a CPU, a RAM, a ROM, and the like, and controls the operation of the terminal device 1. As illustrated in FIG. 1, the control unit 20 includes as function blocks an image acquiring unit 21, a region selecting unit 22, an illumination condition correcting unit 23, an average value calculating unit 24, and a color difference calculating unit 25.

The image acquiring unit 21 acquires image data of an image of the target object shot by the imaging unit 11. However, the image acquiring unit 21 may acquire image data shot by another imaging device, for example, through the terminal communication unit 15.

The region selecting unit 22 selects a prescribed image region in the image, in which an average color value of the target object is to be calculated. At that time, the region selecting unit 22 selects the image region in response to the user of the terminal device 1 using the operation unit 12 to specify a range in the image displayed in the display unit 13, for example. For example, in the case where the operation unit 12 and the display unit 13 constitute a touch panel display, the region selecting unit 22 selects a range in the displayed image that the user has specified with his/her finger as the image region. In this case, the operation unit 12 functions as an accepting unit that accepts a region of an image being specified by a user operation.

Alternatively, the region selecting unit 22 may automatically select the image region without a user operation. At this time, it is possible that the region selecting unit 22 select, as the prescribed image region, a region having an area and shape at which the average color value does not vary from location to location in the image by more than a predetermined permissible range. This selection method will be described using FIGS. 3 and 4.

FIG. 3 is a diagram illustrating examples of the selection of the image region by the region selecting unit 22, and FIG. 4 is a graph showing variation in the average color value depending on the area of the image region. FIG. 3 illustrates cases where square image regions 51, 52, and 53, having side lengths of x1, x2, and x3, respectively (where $x1 < x2 < x3$), have been selected in an image 50 of a checkerboard pattern. The horizontal axis in FIG. 4 represents the scale x of the image region (the length of one side thereof), and the vertical axis in FIG. 4 represents the average sRGB value within the image region. In the example

showed in FIG. 4, in ranges where the scale x of the image region is equal to or less than 3, the respective RGB average color values vary in accordance with the scale x as a result of the pattern in the image 50. However, in ranges where the scale x is 3 or greater, each average color value is substantially constant. In the case where the image has a checkerboard pattern, the average color value will be constant regardless of the location and area of the region as long as that region is a square containing at least four checks in at least a 2 x 2 pattern. Accordingly, the region selecting unit 22 may apply a region having a specific shape, such as a rectangle or a circle, in the target object within the image, calculate the respective RGB average color values while gradually expanding the area of that region, and then select a region having an area and shape at which variations in the respective average color values depending on the area fall within the permissible range.

Alternatively, when a region having a specific area and shape within the image is moved, a region having that area and shape at a position where the average color values within that region do not vary beyond a predetermined permissible range may be selected by the region selecting unit 22 as the prescribed image region. This selection method will be described using FIG. 5.

FIG. 5 is a diagram illustrating another method for selecting an image region by the region selecting unit 22. FIG. 5 illustrates an example of a case where six square image regions 51 to 56 having the same sizes are indicated in the image 50, which includes both lattice-like regions and blank regions. In this example, the image regions 51 to 53 are within the lattice-like regions, and thus the average color value of each image region is substantially constant. On the other hand, a ratio of the area of lattice-like regions to blank regions is different in each of the

image regions 54 to 56, and thus the average color value in each those image regions varies from region to region, unlike the values in the image regions 51 to 53. Accordingly, the region selecting unit 22 may select a region having a specific area and shape such as a square or a circle (in the case where the image has been enlarged or reduced, a similar shape based on the magnification thereof) in a position where even if the region having the specific area and shape is moved up, down, left, or right in the image by no less than a set number of pixels, the resulting average color values are substantially constant.

Alternatively, the region selecting unit 22 may select an image region having a greater area the shorter a distance between the imaging unit 11 that shot the image and the target object is. At this time, for example, the region selecting unit 22 acquires a focal distance value from image information such as Exif data added to image data such as RAW data, JPEG data, and the like, and selects an image region having a greater surface area the shorter that focal distance is. The pattern in the surface of the target object appears in the image with more detail the shorter the distance from the target object is, and thus increasing the area of the image region suppresses variations in the average color value caused by the pattern depending on how the image region is applied.

Alternatively, the region selecting unit 22 may select image regions having different areas depending on whether the image was shot with a telephoto lens or a wide-angle lens. Generally speaking, if the imaging unit 11 and a subject (the target object) are far away from each other, shooting the subject with a telephoto lens will make the subject appear large, and thus even detailed patterns can be seen in the image. Conversely, if the imaging unit 11 and the subject are close to each

other, shooting the subject with a wide-angle lens will make the subject appear small, and thus detailed patterns cannot be seen in the image. Accordingly, it is possible that the region selecting unit 22 select an image region having a greater area in the case of an image shot by a telephoto lens than in the case of an image shot by a wide-angle lens, even if the distance between the imaging unit 11 and the target object is the same.

Alternatively, the region selecting unit 22 may select image regions having different areas depending on the resolution of the shot image. Generally speaking, detailed patterns of the subject will not be visible in the case where the image resolution is low, and thus a substantially constant average color value can be obtained regardless of how the region is applied, even if a comparatively narrow region is selected. On the other hand, detailed patterns of the subject will be visible in the case where the image resolution is high, and thus the average color value will vary depending on the position of the region or the like unless a comparatively broad region is selected. Accordingly, it is possible that the region selecting unit 22 select an image region having a greater area the higher the image resolution is, even if the distance between the imaging unit 11 and the target object is the same.

Alternatively, the region selecting unit 22 may select an image region having excluded a pixel region within the image in which a luminance value is greater than a luminance value limit. "Luminance value limit" refers to a luminance value at which contrast differences cannot be recognized, as with blown out highlights, blocked up shadows, and the like. In a subject within an image, whites at a limit brightness at which portions brighter than the limit become completely white are

referred to as an upper luminance value limit, or what is known as "highlights that are not blown out". Generally speaking, a region having blown out highlights is a pixel region corresponding to, for example, a subject reflectivity of greater than or equal to 85%, greater than or equal to 90%, or the like. Meanwhile, in a subject within an image, blacks at a limit darkness at which portions darker than the limit become completely black are referred to as a lower luminance value limit, or what is known as "shadows that are not blocked up". Generally speaking, a region having blocked up shadows is a pixel region corresponding to, for example, a subject reflectivity of less than or equal to 3%, less than or equal to 5%, or the like. The region selecting unit 22 may select an image region excluding pixel regions considered to be completely white or completely black in this manner.

Alternatively, the region selecting unit 22 may select the entire target object within the image as the image region.

The illumination condition correcting unit 23 calculates an illumination condition under which the image was shot on the basis of the image data acquired by the image acquiring unit 21 and corrects the color values of that image data in accordance with the calculated illumination condition. To that end, the measurement target object and an approximately 18% reflectivity standard gray card for illumination correction are shot together, or independently shot under the same illumination condition, in advance, for example. Using this standard gray data, the illumination condition correcting unit 23 then corrects the color values of the image data of the target object according to, for example, the principle described below.

First, a difference between linear sRGB values $(R, G, B)_{Gray\text{-}Measured}$ obtained by shooting and measuring the standard gray under a given illumination condition and linear sRGB values $(R, G, B)_{Gray\text{-}Standard}$ measured or calculated in advance in a color space in which the same standard gray is defined (normally D65 or D50) is taken as a correction value $(R, G, B)_{Correction\text{-}Factor}$.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Correction \\ Factor}} = \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Gray \\ Measured}} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Gray \\ Standard}}$$

Using the correction value $(R, G, B)_{Correction\text{-}Factor}$, the illumination condition correcting unit 23 corrects sRGB values $(R, G, B)_{Measured}$ of the target object image data as indicated by the following formula.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix}_{Corrected} = \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{Measured} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Correction \\ Factor}}$$

Meanwhile, the illumination condition correcting unit 23 may convert the color values of the image data shot by the imaging unit 11 into L*a*b* color system values and then correct the color values of the image data of the target object according to the principle described below using the standard gray data.

In this case, a difference between chromaticity values $(L, a, b)_{Gray\text{-}Measured}$ obtained by shooting and measuring the standard gray under a given illumination condition and chromaticity values $(L, a, b)_{Gray\text{-}Standard}$ measured or calculated in advance in a color space in which the same standard gray is defined (normally D65 or D50) is taken as a correction value $(L, a, b)_{Correction\text{-}Factor}$.

$$\begin{bmatrix} L \\ a \\ b \end{bmatrix}_{\substack{\text{Correction} \\ \text{Factor}}} = \begin{bmatrix} L \\ a \\ b \end{bmatrix}_{\substack{\text{Gray} \\ \text{Measured}}} - \begin{bmatrix} L \\ a \\ b \end{bmatrix}_{\substack{\text{Gray} \\ \text{Standard}}}$$

Using the correction value $(L, a, b)_{\text{Correction-Factor}}$, the illumination condition correcting unit 23 corrects chromaticity values $(L, a, b)_{\text{Measured}}$ of the target object image data as indicated by the following formula.

$$\begin{bmatrix} L \\ a \\ b \end{bmatrix}_{\text{Corrected}} = \begin{bmatrix} L \\ a \\ b \end{bmatrix}_{\text{Measured}} - \begin{bmatrix} L \\ a \\ b \end{bmatrix}_{\substack{\text{Correction} \\ \text{Factor}}}$$

Through this, a difference between a reference light source and a shooting light source is easily corrected, and thus the color difference measured by the terminal device 1 can always be assumed to be a color difference from the gray value under the reference light source, even when the image has been shot under a light source having a different color temperature than that of the reference light source.

The average value calculating unit 24 calculates, from the color values of the image data corrected by the illumination condition correcting unit 23, an average color value that is an average of the color values in the image region selected by the region selecting unit 22. At this time, the average value calculating unit 24 calculates, for example, an average value for the sR value, the sG value, and the sB value of each pixel in the selected image region. However, the average value calculating unit 24 is not limited to handling RGB values in the target image

region, and may calculate an average value of color values in any desired color space, such as L*a*b* values or the like.

For example, in the case where an average value of the color values in the L*a*b* color space is to be calculated, the average value calculating unit 24 converts the sRGB values of the image data corrected by the illumination condition correcting unit 23 through the formula described below.

First, the average value calculating unit 24 takes gamma-corrected sRGB values sR, sG, and sB of the original image data, and reverses the gamma correction according to the sRGB standard to find linear sRGB values R, G, B, as indicated by the following formula.

$$R = \begin{cases} sR / 12.92 & (sR \leq 0.040450) \\ [(sR + 0.055) / 1.055]^{2.4} & (sR > 0.040450) \end{cases}$$

G and B can be calculated through a similar formula as that used for R.

Next, the average value calculating unit 24 converts the acquired RGB values into XYZ values through a matrix transform, as indicated by the following formula.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{XYZ(D65)} = \begin{bmatrix} r_X & g_X & b_X \\ r_Y & g_Y & b_Y \\ r_Z & g_Z & b_Z \end{bmatrix}_{XYZ(D65)-sRGBlinear(D65)} \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{sRGB_{linear}(D65)}$$

At that time, the average value calculating unit 24 may convert the color temperature of the XYZ values using a color temperature transformation matrix such as those proposed by Bradford and Von Kries.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{XYZ(D50)} = \begin{bmatrix} X_X & Y_X & Z_X \\ X_Y & Y_Y & Z_Y \\ X_Z & Y_Z & Z_Z \end{bmatrix}_{XYZ(D50)-XYZ(D65)} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{XYZ(D65)}$$

Furthermore, the average value calculating unit 24 calculates L*a*b* values from the stated XYZ values through the following formula, on the basis of a standard CIE calculation.

$$L^* = F(Y/Yn)$$
$$a^* = (500/116)\,[F(X/Xn) - F(Y/Yn)]$$
$$b^* = (200/116)\,[F(Y/Yn) - F(Z/Zn)]$$

$$F(t) = \begin{cases} 116\,t\,1/3 - 16 & \text{When } t > (6/29)3 = 0.008856\ldots \\ (29/3)3\,t & \text{Aside from the above} \end{cases}$$

Here, Xn, Yn, and Zn are white point coordinates. Having done so, the average value calculating unit 24 calculates average values of the L* value, a* value, and b* value of each pixel within the image region selected by the region selecting unit 22, for example.

The color difference calculating unit 25 calculates a color difference between the average color value calculated by the average value calculating unit 24 and the average color value of the color values of a comparison target in the same color space. The color value of the comparison target may be, for example, an average color value of a reference stored in the storage unit 14 in advance, or may be an average color value obtained by the average value calculating unit 24 for a different image. For example, in the case of finding a color difference for sRGB

values, the color difference calculating unit 25 calculates a color difference ΔE according to the following formula, assuming the average color value calculated by the average value calculating unit 24 is represented by (R_1, G_1, B_1) and the color value of the comparison target is represented by (R_2, G_2, B_2).

$$\Delta E = \sqrt{(R_1 - R_2)^2 + (G_1 - G_2)^2 + (B_1 - B_2)^2}$$

Meanwhile, in the case of finding a color difference for L*a*b* values, the color difference calculating unit 25 calculates the color difference ΔE according to the following formula, assuming the average color value calculated by the average value calculating unit 24 is represented by (L_1, a_1, b_1) and the color value of the comparison target is represented by (L_2, a_2, b_2).

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2}$$

Then, the color difference calculating unit 25 causes the value of the calculated color difference ΔE to be displayed in the display unit 13, as indicated by reference numeral 63 in FIG. 2, for example.

FIG. 6 is a flowchart illustrating an example of operations performed by the terminal device 1. The process in each step of FIG. 6 is executed by the control unit 20 in cooperation with each element of the terminal device 1 based on a program stored in the storage unit 14.

First, the image acquiring unit 21 acquires image data of an image of the target object shot by the imaging unit 11 (S1). Then, using any one of the above-described methods, the region selecting unit 22 selects an image region in which an

average of the color values in the target object within the image is to be calculated (S2). The illumination condition correcting unit 23 calculates the illumination condition under which the image was shot on the basis of the image data acquired in S1 and corrects the color values of that image data in accordance with the calculated illumination condition (S3). The average value calculating unit 24 then calculates, from the color values of the image data corrected in S3, the average color value that is the average of the color values in the image region selected in S2 (S4). The color difference calculating unit 25 then calculates the color difference between the average color value calculated in S4 and the average color value of the color values in the comparison target in the same color space (S5), and causes information of the color difference calculated in S5 to be displayed in the display unit 13 (S6). The processing in FIG. 6 then ends.

Note that the terminal device does not absolutely have to include the imaging unit 11. In other words, the terminal device may be a mobile terminal not equipped with a camera. Even in this case, a color difference and average color values can be measured as described above by acquiring image data shot by another imaging device.

In addition, the output of the information regarding the color difference is not limited to display in the display unit 13, and may be in another format, such as audio output or data output to an external device.

FIG. 7 is a diagram schematically illustrating the configuration of a terminal device 1A. The terminal device 1A calculates an average color value of a target object such as outdoor signage or a wall covering used on the exterior or interior of a structure from image data of an image shot of the target object, and by comparing

that value with the average color value of a new piece or a limit sample of the same target object, determines whether or not the target object is at its end of life. The hardware configuration of the terminal device 1A is substantially the same as that of the terminal device 1, differing from the terminal device 1 only in that an identification information acquiring unit 21A and a determining unit 26A are included as function blocks of a control unit 20A in addition to the image acquiring unit 21, the region selecting unit 22, the illumination condition correcting unit 23, the average value calculating unit 24, and the color difference calculating unit 25. Accordingly, only parts of the terminal device 1A that are different from the terminal device 1 will be described below, and descriptions of parts that are the same as in the terminal device 1 will be omitted.

FIG. 8 is a diagram illustrating an example of information stored in the storage unit 14 of the terminal device 1A. The storage unit 14 of the terminal device 1A stores a plurality of reference color values, which are color values in the same color space as the average color value calculated by the average value calculating unit 24, in association with identification information of a plurality of target objects. In the example illustrated in FIG. 8, the identification information is product numbers (No. 1, No. 2, and so on) of the target object, such as a wall covering. Meanwhile, the reference color values are an average color value An of the target object at the time of production (new) and an average color value Bn of a limit sample in a state where the color of the target object has faded over time and the target object is at its end of life (where n = 1, 2, and so on). These reference color values may be, for example, sRGB values or L*a*b* values, or may be color values in yet another color space. The stored average color values An and Bn are

values obtained by correcting the illumination condition through the same method as that used by the illumination condition correcting unit 23, or values obtained from image data of an image shot under the reference light source.

The identification information acquiring unit 21A acquires the identification information such as the product number of the target object within the image acquired by the image acquiring unit 21. The identification information acquiring unit 21A may acquire the identification information in response to an input operation made by the user of the terminal device 1A, a barcode being read, or the like, for example.

The color difference calculating unit 25 of the terminal device 1A acquires the reference color value, of the plurality of reference color values stored in the storage unit 14, that corresponds to the identification information acquired by the identification information acquiring unit 21A. Then, the color difference calculating unit 25 calculates a color difference between that reference color value and the average color value calculated by the average value calculating unit 24 from the image data of the image region selected by the region selecting unit 22 and whose illumination condition has been corrected by the illumination condition correcting unit 23.

The determining unit 26A determines whether or not the color difference ΔE calculated by the color difference calculating unit 25 is within a predetermined color difference range. At this time, in the case where ΔE is a value outside of the predetermined color difference range, the determining unit 26A causes an indication that the target object has faded and is at its end of life to be displayed in the display unit 13. On the other hand, in the case where ΔE is a value within the

predetermined color difference range, the determining unit 26A causes an indication that the target object has not faded and is not at its end of life to be displayed in the display unit 13. The color difference range may be a range at which a difference in color between target objects cannot be discerned by the human eye when the target objects are viewed simultaneously (for example, $\Delta E < 2$, when using the L*a*b* color space), or may be a range at which differences in patterns on the surface of the target object containing structures and colors cannot be recognized by a person when the target object is viewed from afar (for example, $\Delta E < 10$, when using the L*a*b* color space).

Even when a target object does not have a reference color value stored in the storage unit 14, the determining unit 26A can make a similar determination as to whether or not the color of the target object has faded by shooting the target object and a new piece or a limit sample of the same target object together and then finding the color difference between the two.

FIG. 9 is a flowchart illustrating an example of operations performed by the terminal device 1A. The process in each step of FIG. 9 is executed by the control unit 20A in cooperation with each element of the terminal device 1A based on a program stored in the storage unit 14.

The acquisition of the image data of the target object, the selection of the image region, the correction of the color values in the image data in accordance with the illumination condition, and the calculation of the average color value in S11 to S14 are the same as in S1 to S4 in FIG. 6. After S14, the identification information acquiring unit 21A acquires the identification information of the target object in the image acquired in S11 (S15). Then, the color difference calculating

unit 25 acquires, from the storage unit 14, the reference color value corresponding to the identification information acquired in S15 (S16), and calculates a color difference between that reference color value and the average color value calculated in S14 (S17). Furthermore, the determining unit 26A determines whether or not the color difference ΔE calculated in S17 is lower than a predetermined threshold value T (S18). In the case where $\Delta E < T$ (Yes in S18), the determining unit 26A causes an indication that the target object has not faded and is not at its end of life to be displayed in the display unit 13 (S19), whereas in the case where $\Delta E \geq T$ (No in S18), the determining unit 26A causes an indication that the target object has faded and is at its end of life to be displayed in the display unit 13 (S20). The processing in FIG. 9 then ends.

FIG. 10 is a diagram schematically illustrating the configuration of a terminal device 1B. The terminal device 1B calculates, for example, a first average color value of a first image obtained by shooting a first target object that is a printed material such as a wall covering, calculates a second average color value of a second image obtained by shooting a second target object such as a wall surface to which the printed material is affixed, and corrects print data of the printed material so as to cancel out a color difference between the two. The hardware configuration of the terminal device 1B is substantially the same as that of the terminal device 1, differing from the terminal device 1 only in that a print data correcting unit 26B is included as a function block of a control unit 20B in addition to the image acquiring unit 21, the region selecting unit 22, the illumination condition correcting unit 23, the average value calculating unit 24, and the color difference calculating unit 25. Accordingly, only parts of the terminal

device 1B that are different from the terminal device 1 will be described below, and descriptions of parts that are the same as in the terminal device 1 will be omitted.

FIG. 11 is a schematic diagram illustrating a function of the terminal device 1B. The terminal device 1B is used, for example, for color matching when creating, through printing, a wall covering having the same color and pattern as a brick-patterned wall surface 72. The user uses the imaging unit 11 of the terminal device 1B to shoot a printed material 71 of a wall covering to be affixed to the wall surface 72 along with (or separate from but under the same illumination condition) a standard gray card 73 for illumination correction, and shoots the wall surface 72 and the standard gray card 73 in the same manner. The terminal device 1B calculates the first average color value and the second average color value, whose illumination conditions have been corrected, for the image 50A of the printed material 71 and the image 50B of the wall surface 72, respectively. Furthermore, the terminal device 1B calculates the color difference ΔE between the two average color values, and corrects the print data of the printed material 71 to be sent to a printer 4 so as to cancel out the color difference ΔE. When the printed material 71 is created so that the color difference between the average color values is eliminated, a person will be able to see a difference between the printed material 71 and the wall surface 72 at close range. However, because detailed patterns cannot be seen from afar, the printed material 71 will appear as a wall covering having the same color and pattern as the wall surface 72 when viewed from afar. Accordingly, a wall covering that does not stand out even when affixed to the wall surface 72 can be obtained as a printed material as a result of this color matching.

The image acquiring unit 21 of the terminal device 1B acquires, as image data, first image data obtained by shooting the first target object that is the printed material 71, and second image data obtained by shooting the second target object that is the wall surface 72 serving as a comparison target for the color of that printed material. These instances of image data may be shot by the imaging unit 11 or may be shot by a different imaging device.

The average value calculating unit 24 calculates the first and second average color values, which are average color values of the image region selected by the region selecting unit 22, from the color values of the image data corrected by the illumination condition correcting unit 23, for both the first and second image data.

The color difference calculating unit 25 calculates the color difference ΔE between the first average color value and the second average color value calculated by the average value calculating unit 24, and then causes the display unit 13 to display information indicating whether or not the color difference ΔE is within a predetermined color difference range.

In the case where the color difference ΔE calculated by the color difference calculating unit 25 is not within the predetermined color difference range, the print data correcting unit 26B corrects color values (YMCK) of the print data of the printed material 71, so as to reduce that color difference, in accordance with a formula described below. This color difference range may be, for example, a range at which a difference between the patterns of the printed material 71 and the wall surface 72 cannot be recognized from afar (for example, $\Delta E < 10$ in the L*a*b* color space).

Print data $(Y, M, C, K)_{Printed\text{-}YMCK}$ of the printed material 71 sent to the printer 4 is found (converted from an additive mixture of colors to a subtractive mixture of colors) from linear sRGB values $(R, G, B)_{Original\text{-}Photo}$ of the image data, according to the following formula.

$$\begin{bmatrix} Y \\ M \\ C \\ K \end{bmatrix}_{\substack{Printed \\ YMCK}} = \begin{bmatrix} Y_R & Y_G & Y_B \\ M_R & M_G & M_B \\ C_R & C_G & C_B \\ K_R & K_G & K_B \end{bmatrix}_{YMCK-RGB} \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Original \\ Photo}}$$

It is possible that the original sRGB values $(R, G, B)_{Original\text{-}Photo}$ be values in which the illumination condition has been corrected according to the standard gray data, using the same method as that used by the illumination condition correcting unit 23. The printer 4 prints the printed material 71 in accordance with the print data $(Y, M, C, K)_{Printed\text{-}YMCK}$, and the resulting image is then shot using the imaging unit 11.

As indicated by the following formula, a difference between linear sRGB values $(R, G, B)_{1st\text{-}Print\text{-}Photo}$ of the shot image 50A and the original sRGB values $(R, G, B)_{Original\text{-}Photo}$ is taken as an $(R, G, B)_{1st\text{-}Compensation\text{-}Factor}$.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{1stCompensation \\ Factor}} = \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{1stPrint \\ Photo}} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Original \\ Photo}}$$

In the case where the color difference between the $(R, G, B)_{1st\text{-}Print\text{-}Photo}$ and the sRGB values of the image 50B serving as a comparison target does not fall within a predetermined color difference range, the print data correcting unit 26B

finds a next print data $(Y, M, C, K)_{2nd\text{-}Printed\text{-}YMCK}$ by subtracting the difference $(R, G, B)_{1st\text{-}Compensation\text{-}Factor}$ from the original sRGB values $(R, G, B)_{Original\text{-}Photo}$, as indicated by the following formula. In other words, the print data correcting unit 26B carries out the correction of excessive colors in the additive mixture of colors by relatively increasing complementary colors in the subtractive mixture of colors.

$$\begin{bmatrix} Y \\ M \\ C \\ K \end{bmatrix}_{\substack{2nd\text{Printed} \\ YMCK}} = \begin{bmatrix} Y_R & Y_G & Y_B \\ M_R & M_G & M_B \\ C_R & C_G & C_B \\ K_R & K_G & K_B \end{bmatrix}_{YMCK-RGB} \left\{ \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Original \\ Photo}} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{1stCompenasation \\ Factor}} \right\}$$

Then, the printer 4 re-prints the printed material 71 in accordance with the print data $(Y, M, C, K)_{2nd\text{-}Printed\text{-}YMCK}$, and the resulting image is then shot using the imaging unit 11.

In the case where a color difference between the linear sRGB values of the second shot image 50A and the sRGB values of the image 50B serving as a comparison target does not fall within a predetermined color difference range, the print data correcting unit 26B finds a next print data $(Y, M, C, K)_{3rd\text{-}Printed\text{-}YMCK}$ by subtracting a difference $(R, G, B)_{2nd\text{-}Compensation\text{-}Factor}$ obtained in the same manner as the first time from the original sRGB values $(R, G, B)_{Original\text{-}Photo}$, as indicated in the following formula.

$$\begin{bmatrix} Y \\ M \\ C \\ K \end{bmatrix}_{\substack{3rdPrinted \\ YMCK}} = \begin{bmatrix} Y_R & Y_G & Y_B \\ M_R & M_G & M_B \\ C_R & C_G & C_B \\ K_R & K_G & K_B \end{bmatrix}_{YMCK-RGB} \left\{ \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{Original \\ Photo}} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}_{\substack{2ndCompenasation \\ Factor}} \right\}$$

Thereafter, in the same manner, the print data correcting unit 26B repeatedly corrects the print data until the color difference between the linear sRGB values of

the shot image 50A and the sRGB values of the image 50B serving as a comparison target falls within the predetermined color difference range.

FIG. 12 is a flowchart illustrating an example of operations performed by the terminal device 1B. The process in each step of FIG. 12 is executed by the control unit 20B in cooperation with each element of the terminal device 1B based on a program stored in the storage unit 14.

First, the image acquiring unit 21 acquires the image data of the image 50A of the printed material 71 printed according to the print data YMCK and the image data of the image 50B of the wall surface 72 or the like serving as a comparison target (S21). Then, using any one of the above-described methods, the region selecting unit 22 selects an image region in each of the images 50A and 50B in which an average of the color values is to be calculated (S22). The illumination condition correcting unit 23 calculates the illumination conditions under which the images 50A and 50B were respectively shot on the basis of the image data acquired in S21, and corrects the color values of that image data in accordance with the calculated illumination conditions (S23). The average value calculating unit 24 then calculates a first average color values $R_1G_1B_1$ and a second average color values $R_2G_2B_2$ from the respective color values of the image data of the images 50A and 50B corrected in S23, for the image regions selected in S22 (S24).

Next, the color difference calculating unit 25 calculates a color difference between the first average color values $R_1G_1B_1$ and the second average color values $R_2G_2B_2$ calculated in S24 (S25). The print data correcting unit 26B determines whether or not the color difference ΔE calculated in S25 is lower than the predetermined threshold value T (S26). The processing in FIG. 12 ends in the

case where $\Delta E < T$ (Yes in S26). On the other hand, in the case where $\Delta E \geq T$ (No in S26), the print data correcting unit 26B corrects the print data YMCK of the printed material 71 in accordance with the above-described formula so as to reduce that color difference (S27). The process then returns to S21 and the above-described steps are repeated.

FIG. 13 is a diagram schematically illustrating the configuration of a terminal device 1C. The terminal device 1C calculates, for example, an average color value of a target object, such as a wall covering used on the exterior or the interior of a structure, from image data of an image obtained by shooting that target object, references a wall covering among a plurality of wall coverings stored in the storage unit 14 whose average color value is close to that of the target object, and displays information regarding the referenced wall covering in the display unit 13. The hardware configuration of the terminal device 1C is substantially the same as that of the terminal device 1, differing from the terminal device 1 only in that a frequency converting unit 26C, a comparison processing unit 27C, and a reference unit 28C are included as function blocks of a control unit 20C in addition to the image acquiring unit 21, the region selecting unit 22, the illumination condition correcting unit 23, the average value calculating unit 24, and the color difference calculating unit 25. Accordingly, only parts of the terminal device 1C that are different from the terminal device 1 will be described below, and descriptions of parts that are the same as in the terminal device 1 will be omitted.

FIG. 14 is a diagram illustrating an example of information stored in the storage unit 14 of the terminal device 1C. The storage unit 14 of the terminal device 1C stores, for each of a plurality of wall coverings (target objects), a product

number (identification information) of the wall covering, a name, an image (photograph) from the time of production, shooting conditions of that image, an average color value of the wall covering in that image, and a frequency distribution obtained by converting a spatial distribution of the color values in the image into a spatial frequency spectral domain, all in association with each other. In the example illustrated in FIG. 14, the stored shooting conditions include a shooting magnification, a resolution, and a light source color temperature. Meanwhile, the average color value in a reference color value that serves as a comparison target when the color difference calculating unit 25 calculates a color difference, and is a color value in the same color space as the average color value calculated by the average value calculating unit 24. These reference color values may be, for example, sRGB values or L*a*b* values, or may be color values in yet another color space.

FIG. 15 is a diagram illustrating examples of wall covering images and their corresponding frequency distribution images. Reference numerals 80A to 80C indicate images of wall coverings having wood, marble, and fabric patterns, and reference numerals 90A to 90C indicate images of frequency distributions corresponding to the images indicated by reference numerals 80A to 80C, respectively. These frequency distribution images are images obtained by performing Fourier transforms on the spatial distributions of luminance values in the x and y directions in the original images, and points having higher frequency components are represented by brighter points. Images such as those indicated by reference numerals 90A to 90C are stored in the storage unit 14 of the terminal device 1C as frequency distributions.

The color difference calculating unit 25 of the terminal device 1C calculates, for each of the plurality of reference color values stored in the storage unit 14, a color difference from the average color value calculated by the average value calculating unit 24 from the image data of the image region selected by the region selecting unit 22 and whose illumination condition has been corrected by the illumination condition correcting unit 23.

The frequency converting unit 26C acquires a frequency distribution by converting the spatial distribution of the color values in the image expressed by the image data acquired by the image acquiring unit 21 into the spatial frequency spectral domain. This color value spatial distribution may be a spatial distribution including luminance values. Meanwhile, although a Fourier transform is given as a representative example of conversion from a spatial distribution to a frequency distribution, another transform such as an integral transform, a Laplace transform, a discrete cosine transform, or a discrete wavelet transform, may be used as well.

The comparison processing unit 27C compares the frequency distributions of the plurality of wall coverings (target objects) stored in the storage unit 14 with the frequency distribution acquired by the frequency converting unit 26C. Specifically, the comparison processing unit 27C carries out pattern matching between the frequency distribution of each wall covering stored in the storage unit 14 and the frequency distribution acquired by the frequency converting unit 26C, and determines whether or not the patterns match.

Alternatively, the comparison processing unit 27C may carry out the pattern matching while varying the spectral intensity of each frequency distribution by a constant factor. Because it is highly likely that the spectral intensity of a

luminance value frequency distribution will vary under different shooting conditions, the comparison processing unit 27C may determine whether or not there is a match on the basis of whether or not the patterns resemble each other.

Alternatively, the comparison processing unit 27C may carry out statistical processing on a histogram of the frequency distribution of each wall covering stored in the storage unit 14 and the frequency distribution acquired by the frequency converting unit 26C, and then compare the two. Comparing after the statistical processing refers to, for example, comparing peak frequencies in each spectrum, half-widths thereof, or both. In the case where a plurality of peaks are present in each spectrum, sets of individual peak frequencies and half-widths may be compared between respective spectra.

The reference unit 28C references the identification information of each wall covering stored in the storage unit 14 in accordance with the result of the calculation performed by the color difference calculating unit 25 and the result of the comparison made by the comparison processing unit 27C. For example, the reference unit 28C extracts the product number of each wall covering in the storage unit 14, in order from the lowest color difference and the lowest difference in frequency distributions found through the pattern matching, and causes information of those product numbers as well as the names, images at the time of production, and the like to be displayed in the display unit 13. In other words, the reference unit 28C finds the same wall covering as that shot by the imaging unit 11 in the storage unit 14, sorts the plurality of wall covering images, and then presents those images to the user in order from the image having the lowest color difference and frequency distribution difference. However, the display is not limited to being in

order from the lowest color difference and frequency distribution difference, and only the wall covering having the lowest color difference and frequency distribution difference may be displayed, or wall coverings having a color difference and a frequency distribution difference that is lower than a threshold value may be displayed.

There is a tendency for there to be greater differences between images when carrying out pattern matching between images converted into the frequency domain than between the original wall covering images. Accordingly, by narrowing down candidates through two levels of image pattern matching, namely by color difference and by frequency distribution, the same wall covering or a wall covering similar to the target wall covering can be found accurately.

Note that the reference unit 28C may cause a website regarding the wall covering at which the color difference calculated by the color difference calculating unit 25 and the difference in the frequency distribution found through the pattern matching by the comparison processing unit 27C is lowest to be displayed in the display unit 13. Through this, a control program of the terminal device 1C functions as an application that, upon an image of the wall covering being shot, guides the user to an online catalog for the wall covering or an e-commerce site where that wall covering can be purchased.

FIG. 16 is a flowchart illustrating an example of operations performed by the terminal device 1C. The process in each step of FIG. 16 is executed by the control unit 20C in cooperation with each element of the terminal device 1C based on a program stored in the storage unit 14.

The acquisition of the image data of the target object, the selection of the image region, the correction of the color values in the image data in accordance with the illumination condition, and the calculation of the average color value in S31 to S34 are the same as in S1 to S4 in FIG. 6. After S34, the color difference calculating unit 25 calculates a color difference between each reference color value stored in the storage unit 14 and the average color values calculated in S34 (S35). The frequency converting unit 26C converts a spatial distribution of the color values in the image region selected in S32 into a frequency distribution (S36). The comparison processing unit 27C then compares the frequency distribution of each wall covering stored in the storage unit 14 with the frequency distribution obtained through the conversion in S36 (that is, carries out pattern matching) (S37). The reference unit 28C references the product number (identification information) of each wall covering in the storage unit 14 in order from the lowest color difference in the calculation result of S35 and the lowest difference in the comparison result in S37, and causes the product numbers thereof to be displayed in the display unit 13 along with the names, images, and the like of the wall coverings (S38). Furthermore, the reference unit 28C causes a website regarding the wall covering having the lowest color difference in the calculation result of S35 and the lowest difference in the comparison result in S37 to be displayed in the display unit 13 (S39). The processing in FIG. 16 then ends.

Although the terminal devices 1A to 1C can carry out the functions of end of life determination, printed material color matching, and wall covering searches as terminal devices alone, these functions can also be implemented by a system including a terminal device and a server device connected to each other over a

communication network. Examples of cases where the above-described functions are implemented by such a system will be described hereinafter.

FIG. 17 is a diagram schematically illustrating the configuration of a communication system 3D. The communication system 3D is, like the terminal device 1A, a system for determining the end of life of a wall covering or the like serving as a target object. The communication system 3D includes a terminal device 1D and a server device 2D, and these devices are communicably connected to each other over a wired or wireless communication network 5.

The hardware configuration of the terminal device 1D is the same as that of the terminal device 1A, and the function blocks of a control unit 20D of the terminal device 1D are the same as those of the control unit 20A in the terminal device 1A. The terminal communication unit 15 of the terminal device 1D sends, to the server device 2D, identification information of the target object such as a wall covering acquired by the identification information acquiring unit 21A, and receives, from the server device 2D, a reference color value corresponding to the target object indicated by that identification information. The color difference calculating unit 25 of the terminal device 1D calculates a color difference between the reference color value received from the server device 2D and the average color value calculated by the average value calculating unit 24. The determining unit 26A of the terminal device 1D causes information indicating a determination result regarding the color difference to be displayed in the display unit 13.

The server device 2D includes a storage unit 34, a server communicating unit 35, and a control unit 40D. Like the storage unit 14 of the terminal device 1A, the storage unit 34 stores a plurality of reference color values, which are color

values in the same color space as the average color value calculated by the average value calculating unit 24 of the terminal device 1D, in association with identification information of a plurality of target objects. The specific details of the information stored in the storage unit 34 are the same as those illustrated in FIG. 8. The server communicating unit 35 receives the identification information from the terminal device 1D and sends the reference color values corresponding to the target object indicated by that identification information to the terminal device 1D. The control unit 40D includes a CPU, a RAM, a ROM, and the like, and of the plurality of reference color values stored in the storage unit 34, extracts the reference color values corresponding to the target object indicated by the identification information received from the terminal device 1D.

According to the communication system 3D, the size of a database can be increased by storing the identification information and reference color values of a plurality of wall coverings in the server device 2D, which has a greater storage capacity than that of the terminal device 1D. Furthermore, consolidating the database in a single location, namely the server device 2D, makes operations for updating the database and the like easier.

FIG. 18 is a diagram schematically illustrating the configuration of a communication system 3E. The communication system 3E is, like the terminal device 1B, a system for correcting print data so that the color of a printed material matches a target color. The communication system 3E includes a terminal device 1E and a server device 2E, and these devices are communicably connected to each other over a wired or wireless communication network 5. Furthermore, the printer 4 is connected to the server device 2E using a communication cable or the like.

The hardware configuration of the terminal device 1E is the same as that of the terminal device 1B, and the terminal device 1E differs from the terminal device 1B in that only the image acquiring unit 21 and the region selecting unit 22 are included as function blocks of a control unit 20E. The functions of the image acquiring unit 21 and the region selecting unit 22 are the same as those in the terminal device 1B. The terminal communication unit 15 of the terminal device 1E sends, to the server device 2E, image data including the image region selected by the region selecting unit 22.

The hardware configuration of the server device 2E is the same as that of the server device 2D. The server communicating unit 35 of the server device 2E receives, from the terminal device 1E, the first image data obtained by shooting the first target object, which is printed material. The storage unit 34 of the server device 2E stores second image data obtained by shooting the second target object, which is a wall surface or the like serving as a target of comparison with the color of the printed material. A control unit 40E of the server device 2E includes an illumination condition correcting unit 43, an average value calculating unit 44, a color difference calculating unit 45, and a print data correcting unit 46E as function blocks. The functions of these function blocks are the same as those of the illumination condition correcting unit 23, the average value calculating unit 24, the color difference calculating unit 25, and the print data correcting unit 26B, respectively, of the terminal device 1B.

FIG. 19 is a diagram illustrating an example of an operating sequence of the communication system 3E. The process in each step of FIG. 19 is executed by the control units 20E and 40E in cooperation with the respective elements of the

terminal device 1E and the server device 2E based on programs stored in the storage units 14 and 34.

First, the image acquiring unit 21 of the terminal device 1E acquires the first image data, which is an image of the printed material printed according to the print data YMCK (S41). Then, using any one of the above-described methods, the region selecting unit 22 selects an image region in which an average of the color values within the image acquired in S41 is to be calculated (S42). The control unit 20E of the terminal device 1E then sends the first image data for the image region selected in S42 to the server device 2E using the terminal communication unit 15 (S43).

The illumination condition correcting unit 43 of the server device 2E calculates the illumination condition under which the received first image data was shot on the basis of that image data and corrects the color values of that image data in accordance with the calculated illumination condition (S44). The, for the image region selected in S42, the average value calculating unit 44 calculates the first average color values $R_1G_1B_1$ from the color values of the first image data corrected in S44, and calculates the second average color values $R_2G_2B_2$ from the color values of the second image data in the storage unit 34 (S45).

Next, the color difference calculating unit 45 calculates a color difference between the first average color values $R_1G_1B_1$ and the second average color values $R_2G_2B_2$ calculated in S45 (S46). In the case where the color difference ΔE calculated in S46 is greater than the predetermined threshold value T, the print data correcting unit 46E corrects the print data YMCK of the printed material in accordance with the above-described formula so as to reduce that color difference

(S47). Then, the control unit 40E of the server device 2E outputs the print data corrected in S47 to the printer 4 using the server communicating unit 35 (S48). The processing in FIG. 19 then ends. The steps of FIG. 19 are repeated a plurality of times as necessary until the color difference ΔE drops below the threshold value T in S47.

According to the communication system 3E, the print data of the printer 4 is corrected by the print data correcting unit 46E of the server device 2E. Executing the correction process on the print data using the server device 2E, which has a faster processing speed and greater storage capacity than the terminal device 1E, makes it possible to make the process faster and more accurate.

FIG. 20 is a diagram schematically illustrating the configuration of a communication system 3F. The communication system 3F is, like the terminal device 1C, a system for finding the same wall covering as a wall covering that has been shot and presenting that wall covering to a user. The communication system 3F includes a terminal device 1F and a server device 2F, and these devices are communicably connected to each other over a wired or wireless communication network 5.

The hardware configuration of the terminal device 1F is the same as that of the terminal device 1C, and the terminal device 1F differs from the terminal device 1C in that only the image acquiring unit 21, the region selecting unit 22, the illumination condition correcting unit 23, the average value calculating unit 24, and a frequency converting unit 26F are included as function blocks of a control unit 20F. The functions of these function blocks are the same as those of the image acquiring unit 21, the region selecting unit 22, the illumination condition correcting

unit 23, the average value calculating unit 24, and the frequency converting unit 26C, respectively, of the terminal device 1C. The terminal communication unit 15 of the terminal device 1F sends the average color values calculated by the average value calculating unit 24 and the image data of the frequency distributions calculated by the frequency converting unit 26C to the server device 2F, and receives identification information (a product number of the wall covering) and the like of the target object referenced by the server device 2F from the server device 2F. The control unit 20F of the terminal device 1F causes the identification information and the like of the target object received from the server device 2F to be displayed in the display unit 13.

The hardware configuration of the server device 2F is the same as that of the server device 2D. Like the storage unit 14 of the terminal device 1C, the storage unit 34 of the server device 2F stores a plurality of reference color values, which are color values in the same color space as the average color values calculated by the average value calculating unit 24 of the terminal device 1F, in association with identification information of a plurality of target objects. The specific details of the information stored in the storage unit 34 are the same as those illustrated in FIG. 14. The server communicating unit 35 receives the average color values and the frequency distribution image data from the terminal device 1F, and sends the identification information referenced by a control unit 40F to the terminal device 1F.

The control unit 40F of the server device 2F includes the color difference calculating unit 45, a comparison processing unit 47F, and a reference unit 48F as function blocks. The functions of these function blocks are the same as those of

the color difference calculating unit 25, the comparison processing unit 27C, and the reference unit 28C, respectively, of the terminal device 1C. In particular, the color difference calculating unit 45 calculates a color difference between each of the plurality of reference color values stored in the storage unit 34 and the average color values received from the terminal device 1F.

FIG. 21 is a diagram illustrating an example of an operating sequence of the communication system 3F. The process in each step of FIG. 21 is executed by the control units 20F and 40F in cooperation with the respective elements of the terminal device 1F and the server device 2F based on programs stored in the storage units 14 and 34.

The acquisition of the target object image data, selection of the image region, calculation of the average color value, and conversion to a frequency distribution in S51 to S54 are the same as S31, S32, S34, and S36, respectively, in FIG. 16. Although not illustrated in FIG. 21, it is possible that prior to S53, the illumination condition correcting unit 23 of the terminal device 1F correct the color values of the image data in accordance with the illumination condition in the same manner as in S33 in FIG. 16. After S54, the control unit 20F of the terminal device 1F sends the average color values calculated in S53 and the frequency distribution image data obtained from the conversion in S54 to the server device 2F using the terminal communication unit 15 (S55).

The color difference calculating unit 45 of the server device 2F calculates a color difference between each reference color value stored in the storage unit 34 and the average color values received from the terminal device 1F (S56). The comparison processing unit 47F then compares the frequency distribution of each

wall covering stored in the storage unit 34 with the frequency distribution received from the terminal device 1F (that is, carries out pattern matching) (S57). The reference unit 48F references the target object identification information (wall covering product number) of each wall covering stored in the storage unit 34 in order from the lowest color difference in the calculation result of S56 and the lowest difference in the comparison result in S57 (S58). The control unit 40F of the server device 2F then sends the identification information and the like referenced in S58 to the terminal device 1F using the server communicating unit 35 (S59). Upon doing so, the control unit 20F of the terminal device 1F causes the received identification information and the like to be displayed in the display unit 13 (S60). The processing in FIG. 21 then ends.

According to the communication system 3F, the size of a database can be increased by storing the identification information and reference color values of a plurality of wall coverings in the server device 2F, which has a greater storage capacity than that of the terminal device 1F. Furthermore, executing the search process using the server device 2F, which has a faster processing speed than the terminal device 1F, makes it possible to make the process faster and more accurate.

FIG. 22 is a diagram schematically illustrating the configuration of a communication system 3G. The communication system 3G is, like the terminal device 1C, a system for finding the same wall covering as a wall covering that has been shot and presenting that wall covering to a user. The communication system 3G includes a terminal device 1G and a server device 2G, and these devices are communicably connected to each other over a wired or wireless communication network 5.

The hardware configuration of the terminal device 1G is the same as that of the terminal device 1C, and the terminal device 1G differs from the terminal device 1C in that only the image acquiring unit 21 and the region selecting unit 22 are included as function blocks of a control unit 20G. The functions of the image acquiring unit 21 and the region selecting unit 22 are the same as those in the terminal device 1C. The terminal communication unit 15 of the terminal device 1G sends the image data acquired by the image acquiring unit 21 to the server device 2G, and receives the target object identification information (wall covering product number) and the like reference by the server device 2G from the server device 2G. The control unit 20G of the terminal device 1F causes the identification information and the like of the target object received from the server device 2G to be displayed in the display unit 13.

The hardware configuration of the server device 2G is the same as that of the server device 2D. Like the storage unit 14 of the terminal device 1C, the storage unit 34 of the server device 2G stores a plurality of reference color values, which are color values in the same color space as the average color values calculated by a control unit 40G of the server device 2G, in association with identification information of a plurality of target objects. The specific details of the information stored in the storage unit 34 are the same as those illustrated in FIG. 14. The server communicating unit 35 receives the target object image data from the terminal device 1G, and sends the identification information referenced by the control unit 40G to the terminal device 1G.

The control unit 40G of the server device 2G includes the illumination condition correcting unit 43, the average value calculating unit 44, the color

difference calculating unit 45, a frequency converting unit 46G, a comparison processing unit 47G, and a reference unit 48G as function blocks. The functions of these function blocks are the same as those of the illumination condition correcting unit 23, the average value calculating unit 24, the color difference calculating unit 25, the frequency converting unit 26C, the comparison processing unit 27C, and the reference unit 28C, respectively, of the terminal device 1C. In particular, the average value calculating unit 44 calculates average color values that are averages of the color values in the image region selected by the region selecting unit 22, from the color values of the image data received from the terminal device 1G and whose illumination condition has been corrected by the illumination condition correcting unit 43.

FIG. 23 is a diagram illustrating an example of an operating sequence of the communication system 3G. The process in each step of FIG. 23 is executed by the control units 20G and 40G in cooperation with the respective elements of the terminal device 1G and the server device 2G based on programs stored in the storage units 14 and 34.

The acquisition of the target object image data and image region selection in S61 and S62 are the same as those in S31 and S32 in FIG. 16. After S62, the control unit 20F of the terminal device 1F sends image data including the image region selected in S62 to the server device 2G using the terminal communication unit 15 (S63).

The average value calculating unit 44 of the server device 2G calculates average color values that are averages of the color values in the image region selected by the region selecting unit 22, from the color values of the image data

received from the terminal device 1G (S64). Although not illustrated in FIG. 23, it is possible that prior to S64, the illumination condition correcting unit 43 correct the color values of the image data in accordance with the illumination condition in the same manner as in S33 in FIG. 16. Next, the color difference calculating unit 45 calculates a color difference between each reference color value stored in the storage unit 34 and the average color values calculated in S64 (S65). The frequency converting unit 46G converts a spatial distribution of the color values in the image region selected in S62 into a frequency distribution (S66). The comparison processing unit 47C then compares the frequency distribution of each wall covering stored in the storage unit 34 with the frequency distribution obtained through the conversion in S66 (that is, carries out pattern matching) (S67). The reference unit 48F references the target object identification information (wall covering product number) of each wall covering stored in the storage unit 34 in order from the lowest color difference in the calculation result of S65 and the lowest difference in the comparison result in S67 (S68).

The control unit 40G of the server device 2G then sends the identification information and the like referenced in S68 to the terminal device 1G using the server communicating unit 35 (S69). Upon doing so, the control unit 20G of the terminal device 1G causes the received identification information and the like to be displayed in the display unit 13 (S70). The processing in FIG. 23 then ends.

According to the communication system 3G, the size of a database can be increased by storing the identification information and reference color values of a plurality of wall coverings in the server device 2G, which has a greater storage capacity than that of the terminal device 1G. Furthermore, executing the process

of converting into a frequency distribution and the search process using the server device 2G, which has a faster processing speed than the terminal device 1G, makes it possible to make the process even faster and more accurate than the communication system 3F.

A computer program for realizing each of the functions of control units 20 to 20G of the terminal devices 1 to 1G and the control units 40D to 40G of the server devices 2D to 2G on a computer may be provided recorded on a recording medium such as a magnetic recording medium or an optical recording medium that can be read by a computer.

The embodiments described above can be modified in a variety of ways without departing from the essential spirit of the present invention. For example, although FIG. 2 illustrates an example of a case where a color difference between two images 50A and 50B is found, the color difference may be found between two target objects shot in a single image, or the color difference may be found between an image shot by the imaging unit 11 and an image stored in the storage unit 14 in advance. Meanwhile, the image that is the target of measurement is not limited to an image shot by the imaging unit 11, and may be an image shot by a different terminal from the terminal devices 1 to 1G.

In addition, the information acquired from the image information by the region selecting unit 22 is not limited to a focal distance, and may include an effective aperture value (F stop), shutter speed and ISO sensitivity values, a reference luminance value calculated from those values, and the like, for example.

In addition, the information sent in S43 in FIG. 19, S55 in FIG. 21, and S63 in FIG. 23 may include, in addition to the image data, image information regarding

shooting conditions of that image. Even in the case where instances of image data are acquired under mutually-different shooting conditions (for example, different terminal devices or the same terminal device but different scenes), the color difference calculation or frequency distribution comparison may be carried out upon the server device correcting the differences in the shooting conditions. For example, in the case where the color temperature of the light source at the time of shooting is different between images, the comparison processing units 47F and 47G may carry out the comparison processes upon the control unit of the server device having processed one of the instances of image data on the basis of the sent image information so that the respective color temperatures match. Likewise, in the case where the ISO sensitivity at the time of shooting is different between images, the comparison processing units 47F and 47G may carry out the comparison processes upon the control unit of the server device having processed one of the instances of image data on the basis of the sent image information so that the respective ISO sensitivities match.

Claims

1. A device comprising:

an image acquiring unit that acquires image data of an image shot of a target object;

a region selecting unit that selects a prescribed image region on the target object within the image;

an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region;

a color difference calculating unit that calculates a color difference between the average color value and a color value of a comparison target in the same color space as the average color value; and

an outputting unit that outputs information regarding the color difference.

2. The device according to claim 1, wherein

the region selecting unit selects, as the image region, a region having an area and shape at which the average color value does not vary more than a predetermined permissible range depending on a position of the image region within the image.

3. The device according to claim 1, wherein

the region selecting unit selects, as the image region, a region having a specific area and shape at a position where, when the region having the specific

area and shape is moved within the image, the average color values within the region do not vary more than a predetermined permissible range.

4. The device according to claim 1 further comprising

an accepting unit that accepts a region in the image being specified through a user operation,

wherein the region selecting unit selects the image region in accordance with the user operation accepted by the accepting unit.

5. The device according to claim 1, wherein

the region selecting unit selects the entire target object within the image as the image region.

6. The device according to claim 1, wherein

the region selecting unit acquires a distance between an imaging unit that shot the image and the target object from imaging information added to the image data, and selects an image region having a greater area the shorter the distance is.

7. The device according to claim 1, wherein

the region selecting unit selects the image region excluding a pixel region in which a luminance value within the image exceeds a luminance value limit.

8. The device according to claim 1 further comprising

an illumination condition correcting unit that calculates an illumination condition under which the image is shot on the basis of the image data and corrects the color value of the image data in accordance with the calculated illumination condition,

wherein the average value calculating unit calculates the average color value from the color value corrected by the illumination condition correcting unit.

9. The device according to claim 1 further comprising an imaging unit that shoots an image.

10. The device according to claim 1 further comprising

a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other;

an identification information acquiring unit that acquires the identification information of the target object within the image; and

a determining unit that determines whether or not the color difference is within a predetermined color difference range,

wherein of the plurality of reference color values, the color difference calculating unit calculates a color difference between the reference color value corresponding to the identification information and the average color value; and

the outputting unit outputs a result of the determination made by the determining unit.

11. The device according to claim 1, wherein

the image acquiring unit acquires, as the image data, first image data obtained by shooting a first target object and second image data obtained by shooting a second target object;

the average value calculating unit calculates a first average color value for the first image data as the average color value, and calculates a second average color value for the second image data as the color value of the comparison target;

the color difference calculating unit calculates a color difference between the first average color value and the second average color value; and

the outputting unit outputs information indicating whether or not the color difference is within a predetermined color difference range.

12. The device according to claim 11, wherein

the first target object is a printed material; and

the device further comprises a print data correcting unit that corrects a color value of print data for the printed material so as to reduce the color difference in the case where the color difference is not within the color difference range.

13. The device according to claim 1 further comprising

a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other; and

a reference unit that references the identification information in accordance with a result of calculating the color difference,

wherein the color difference calculating unit calculates a color difference between each of the plurality of reference color values and the average color value; and

the outputting unit outputs the referenced identification information.

14. The device according to claim 13, wherein

the storage unit further stores, for each of the plurality of target objects, a frequency distribution obtained by converting a spatial distribution of the color values in the image obtained by shooting the target object into a spatial frequency spectral domain;

the device further comprises a comparison processing unit that, for each of the plurality of target objects, compares a frequency distribution stored in the storage unit with the frequency distribution obtained by converting a spatial distribution of the color values in the image of the image data acquired by the image acquiring unit into a spatial frequency spectral domain; and

the reference unit further references the identification information in accordance with a result of the comparison made by the comparison processing unit.

15. A system comprising:

a terminal device; and

a server device;

the terminal device and the server device being communicably connected to each other,

wherein the terminal device includes:

an image acquiring unit that acquires image data of an image shot of a target object;

a region selecting unit that selects a prescribed image region on the target object within the image;

an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region;

a color difference calculating unit that calculates a color difference between a reference color value received from the server device and the average color value;

a terminal communicating unit that sends identification information of the target object within the image to the server device and receives, from the server device, a reference color value corresponding to the target object indicated by the identification information; and

an outputting unit that outputs information regarding the color difference, and

wherein the server device includes:

a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other; and

a server communicating unit that receives the identification information from the terminal device and sends, of the plurality of reference color values, the reference color value corresponding to the target object indicated by the identification information, to the terminal device.

16. A system comprising:

a terminal device; and

a server device;

the terminal device and the server device being communicably connected to each other,

wherein the terminal device includes:

an image acquiring unit that acquires image data of an image shot of a target object;

a region selecting unit that selects a prescribed image region on the target object within the image;

an average value calculating unit that calculates an average color value from color values of the image data, the average color value being an average of the color values in the image region;

a terminal communicating unit that sends the average color value to the server device and receives identification information of the target object from the server device; and

an outputting unit that outputs the identification information, and

wherein the server device includes:

a storage unit that stores a plurality of reference color values that are color values in the same color space as the average color value and identification information of a plurality of target objects in association with each other;

a color difference calculating unit that calculates a color difference between the average color value received from the terminal device and the reference color value;

a reference unit that references the identification information in accordance with a result of calculating the color difference; and

a server communicating unit that receives the average color value from the terminal device and sends the identification information referenced by the reference unit to the terminal device.

17. A system comprising:

a terminal device; and

a server device;

the terminal device and the server device being communicably connected to each other,

wherein the terminal device includes:

an image acquiring unit that acquires image data of an image shot of a target object;

a region selecting unit that selects a prescribed image region on the target object within the image;

a terminal communicating unit that sends the image data to the server device and receives identification information of the target object from the server device; and

an outputting unit that outputs the identification information, and

wherein the server device includes:

a storage unit that stores a plurality of reference color values and identification information of a plurality of target objects in association with each other;

an average value calculating unit that calculates an average color value from color values of the image data received from the terminal device, the average color value being an average of the color values in the image region;

a color difference calculating unit that calculates a color difference between the average color value and the reference color value;

a reference unit that references the identification information in accordance with a result of calculating the color difference; and

a server communicating unit that receives the image data from the terminal device and sends the identification information referenced by the reference unit to the terminal device.

18. A system comprising:

a terminal device; and

a server device;

the terminal device and the server device being communicably connected to each other,

wherein the terminal device includes:

an image acquiring unit that acquires first image data obtained by shooting a first target object that is a printed material;

a region selecting unit that selects a prescribed image region on the first target object within the first image data; and

a terminal communicating unit that sends, to the server device, image data of the image region selected by the region selecting unit, and

wherein the server device includes:

a storage unit that stores second image data obtained by shooting a second target object;

an average value calculating unit that calculates a first average color value for the first image data and a second average color value for the second image data;

a color difference calculating unit that calculates a color difference between the first average color value and the second average color value;

a print data correcting unit that corrects a color value of print data for the printed material so as to reduce the color difference in the case where the color difference is not within a predetermined color difference range; and

a server communicating unit that receives the first image data from the terminal device.

19. A non-transitory computer-readable recording medium in which is recorded a program that causes a computer to realize the functions of:

acquiring image data of an image shot of a target object;

selecting a prescribed image region on the target object within the image;

calculating an average color value from color values of the image data, the average color value being an average of the color values in the image region;

calculating a color difference between the average color value and a color value of a comparison target in the same color space as the average color value; and

outputting information regarding the color difference.

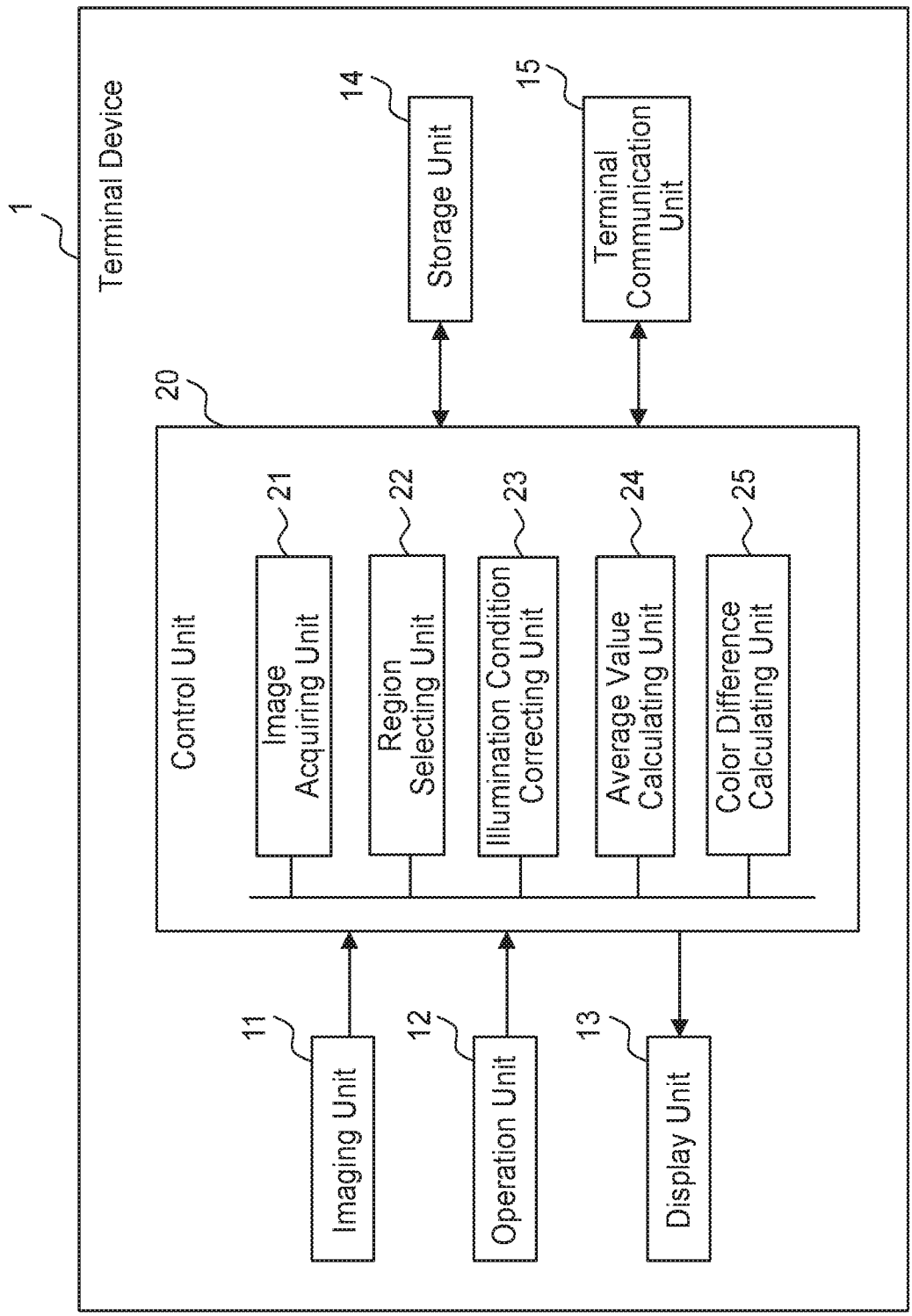

1
Terminal Device
14
Storage Unit
15
Terminal Communication Unit
20
Control Unit
21
Image Acquiring Unit
22
Region Selecting Unit
23
Illumination Condition Correcting Unit
24
Average Value Calculating Unit
25
Color Difference Calculating Unit
11
Imaging Unit
12
Operation Unit
13
Display Unit

FIG. 1

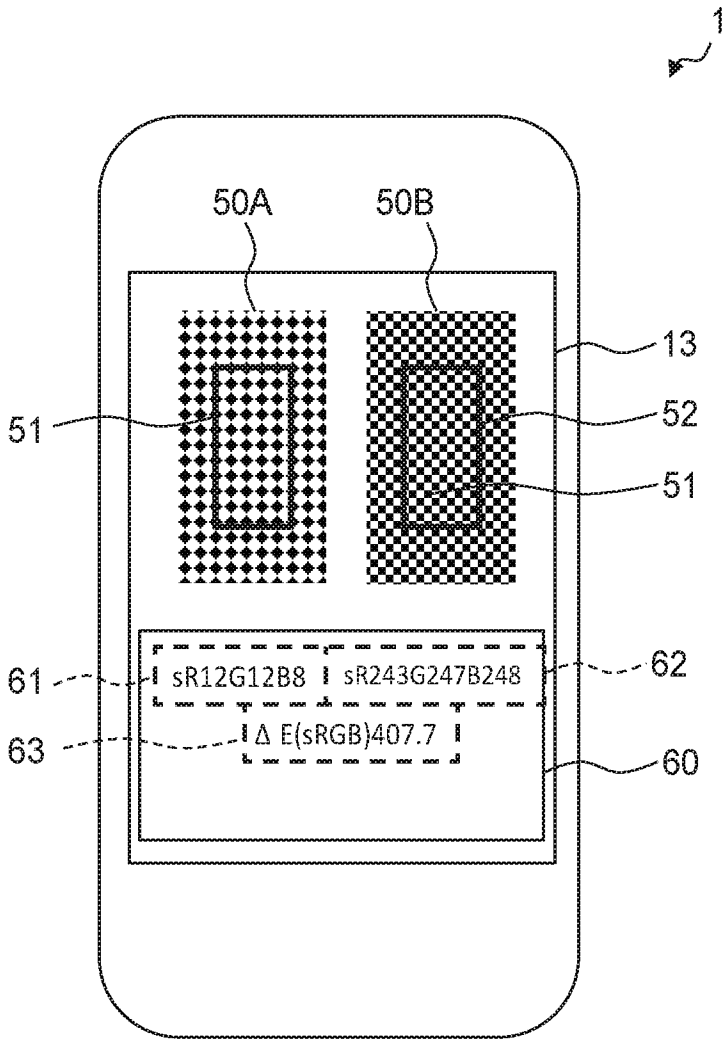

1
50A
50B
13
51
52
51
61
sR12G12B8
sR243G247B248
62
63
Δ E(sRGB)407.7
60

FIG. 2

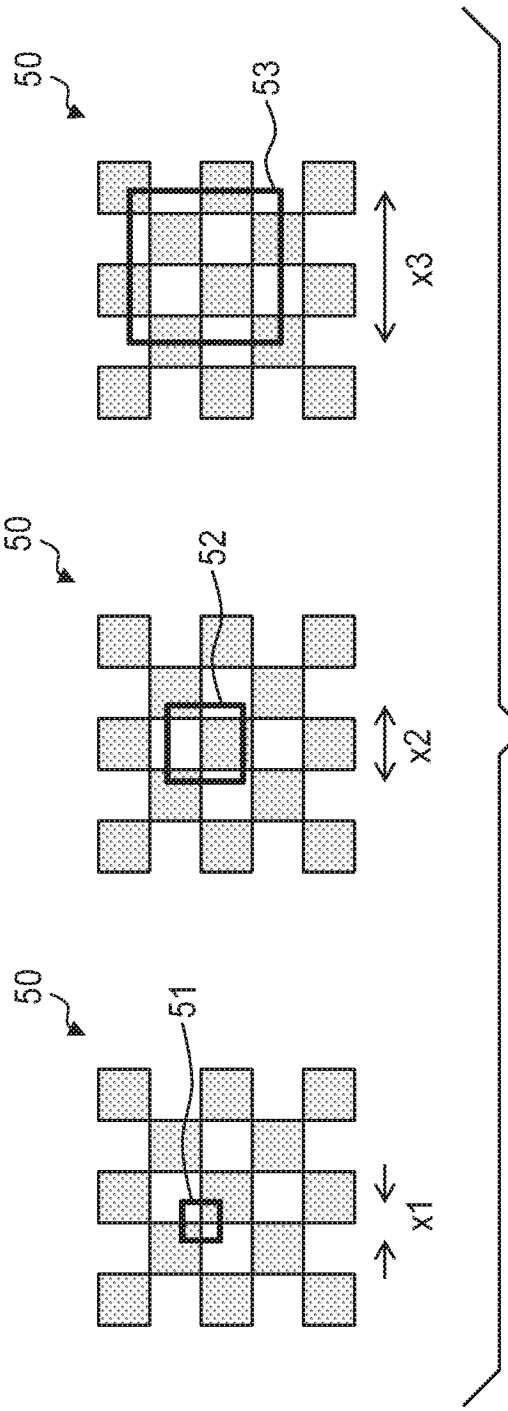


FIG. 3

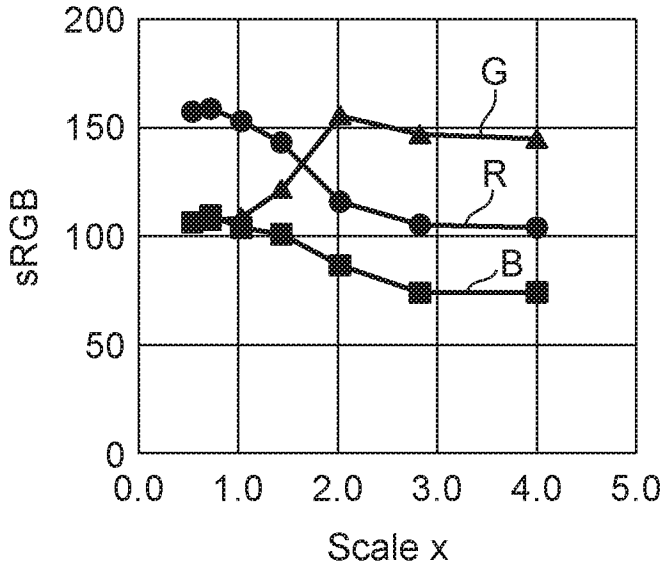

200
150
100
50
0
sRGB
G
R
B
0.0
1.0
2.0
3.0
4.0
5.0
Scale x

FIG. 4

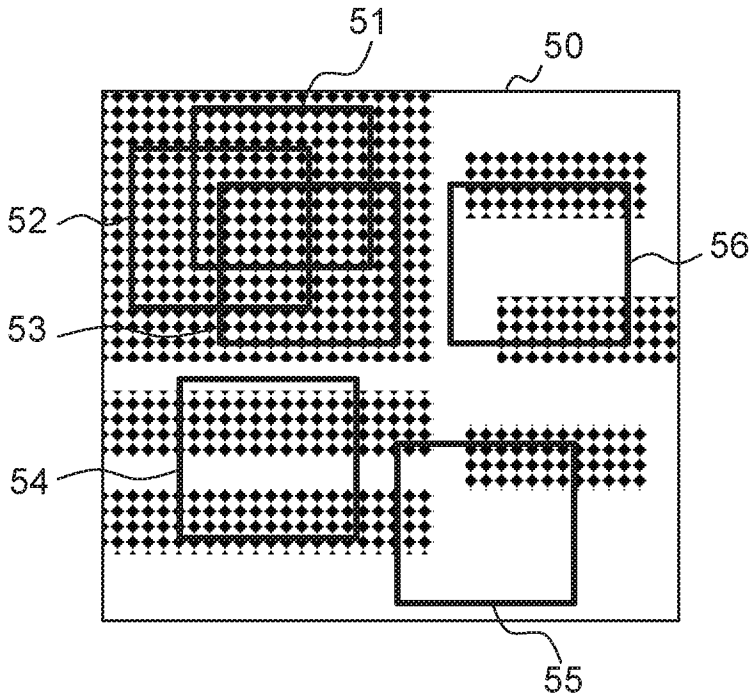

51
50
52
56
53
54
55

FIG. 5

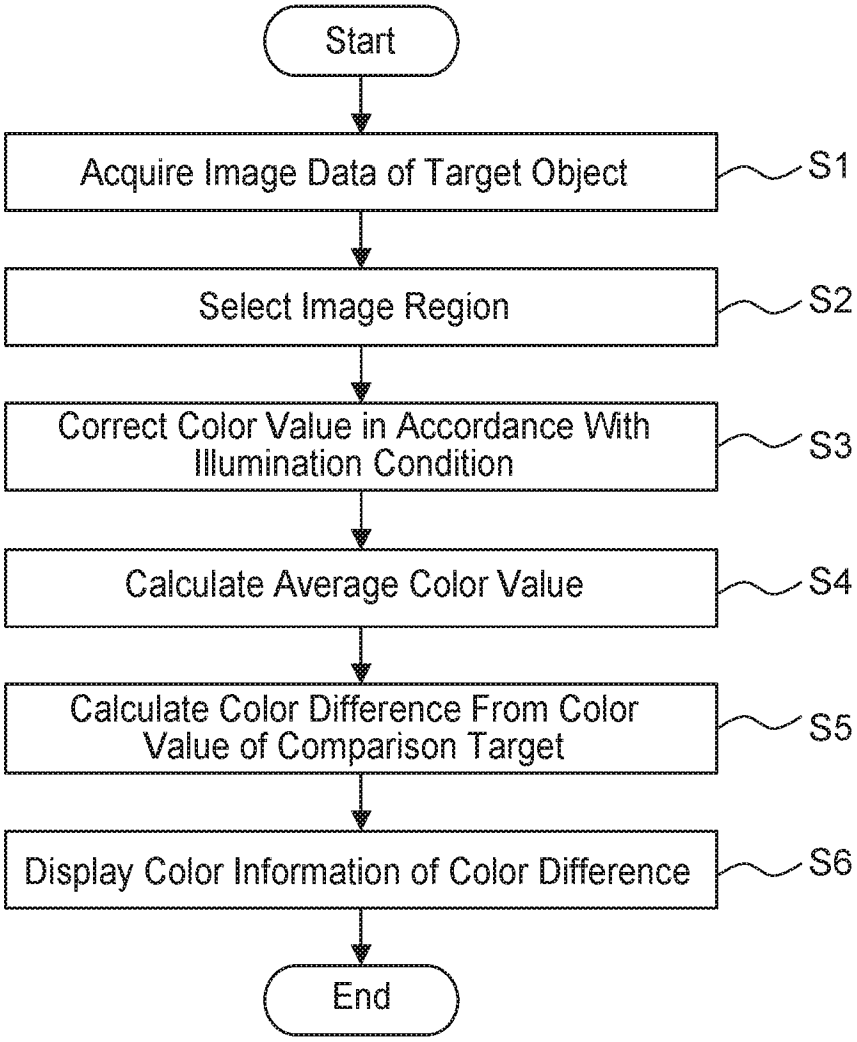

Start
Acquire Image Data of Target Object
S1
Select Image Region
S2
Correct Color Value in Accordance With Illumination Condition
S3
Calculate Average Color Value
S4
Calculate Color Difference From Color Value of Comparison Target
S5
Display Color Information of Color Difference
S6
End

FIG. 6

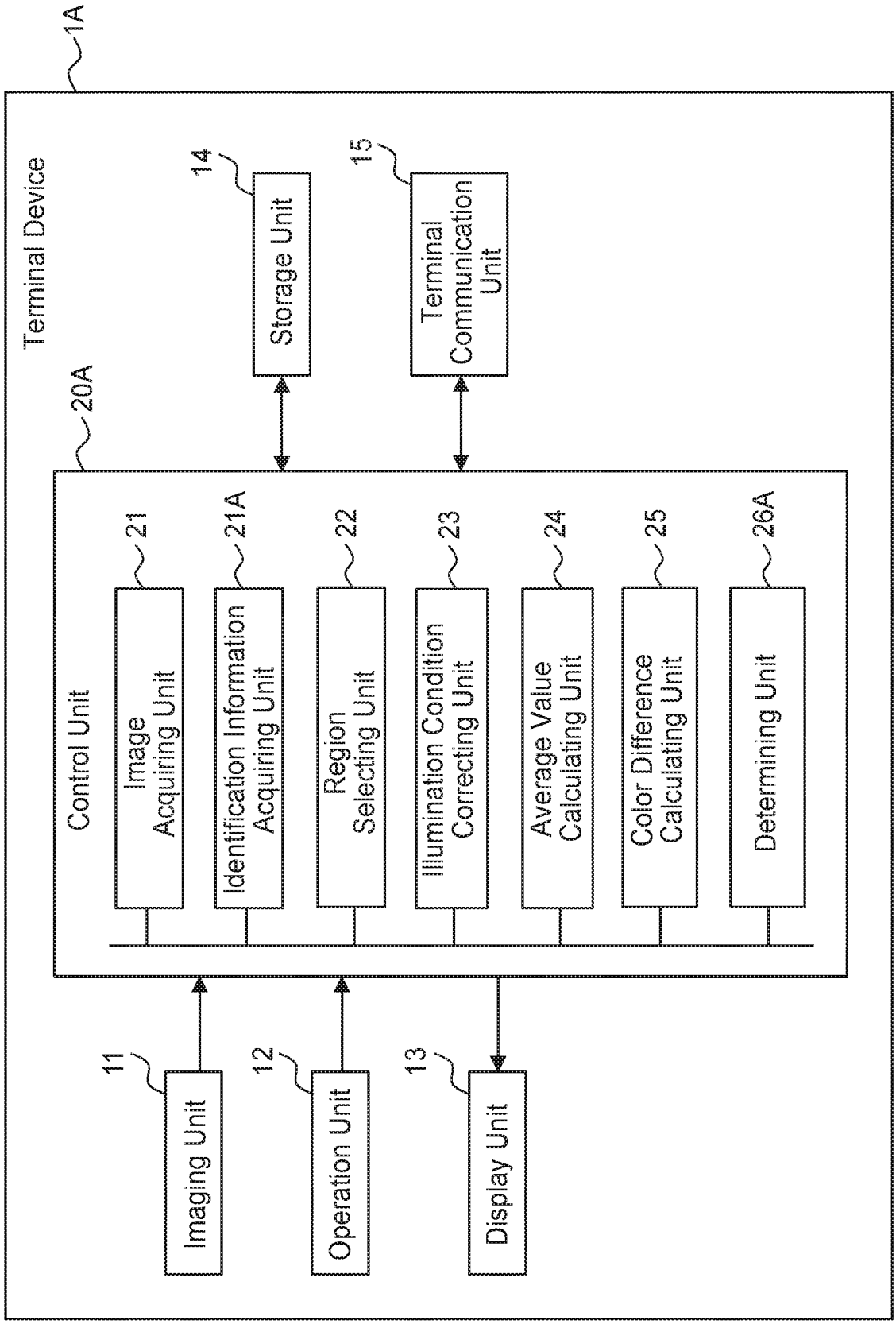

1A
Terminal Device
14
Storage Unit
15
Terminal Communication Unit
20A
Control Unit
21
Image Acquiring Unit
21A
Identification Information Acquiring Unit
22
Region Selecting Unit
23
Illumination Condition Correcting Unit
24
Average Value Calculating Unit
25
Color Difference Calculating Unit
26A
Determining Unit
11
Imaging Unit
12
Operation Unit
13
Display Unit

FIG. 7

Product Number	Average Color Value At Time of Production	Average Color Value of Limit Sample
No. 1	A1	B1
No. 2	A2	B2
No. 3	A3	B3
:	:	:

FIG. 8

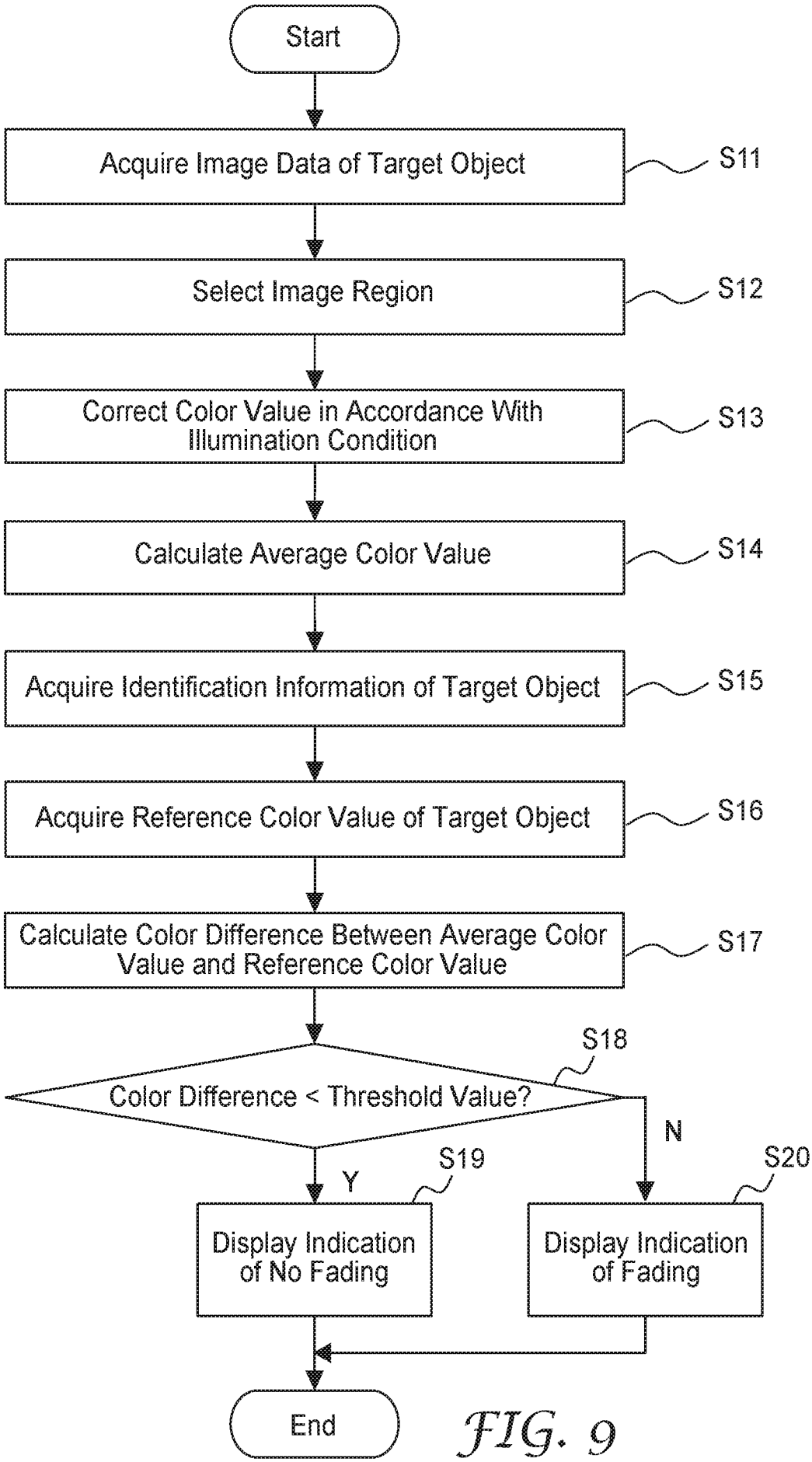

Start
Acquire Image Data of Target Object
S11
Select Image Region
S12
Correct Color Value in Accordance With Illumination Condition
S13
Calculate Average Color Value
S14
Acquire Identification Information of Target Object
S15
Acquire Reference Color Value of Target Object
S16
Calculate Color Difference Between Average Color Value and Reference Color Value
S17
S18
Color Difference < Threshold Value?
Y
N
S19
S20
Display Indication of No Fading
Display Indication of Fading
End

FIG. 9

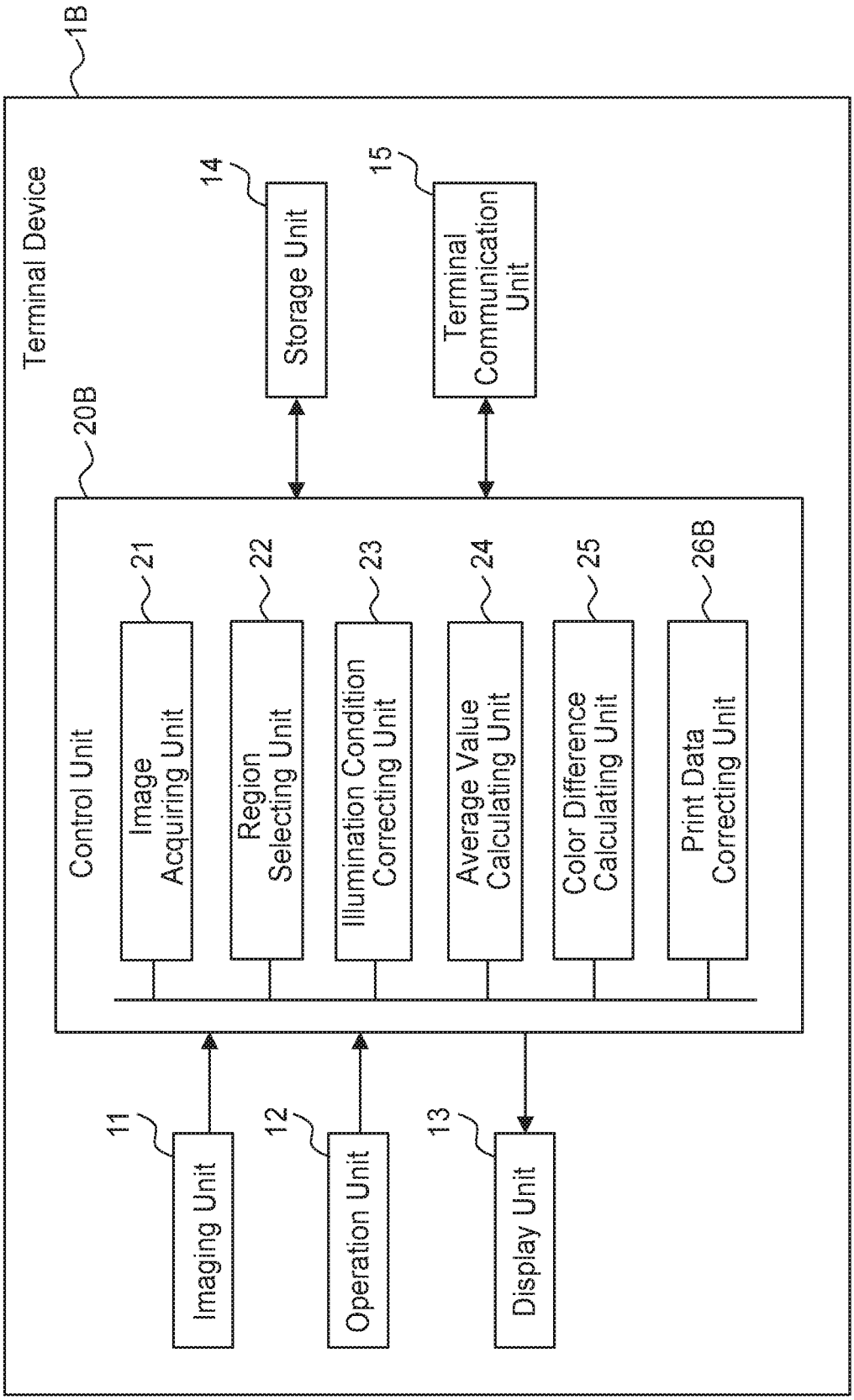

1B
Terminal Device
20B
Control Unit
Image Acquiring Unit
21
Region Selecting Unit
22
Illumination Condition Correcting Unit
23
Average Value Calculating Unit
24
Color Difference Calculating Unit
25
Print Data Correcting Unit
26B
Storage Unit
14
Terminal Communication Unit
15
Imaging Unit
11
Operation Unit
12
Display Unit
13

FIG. 10

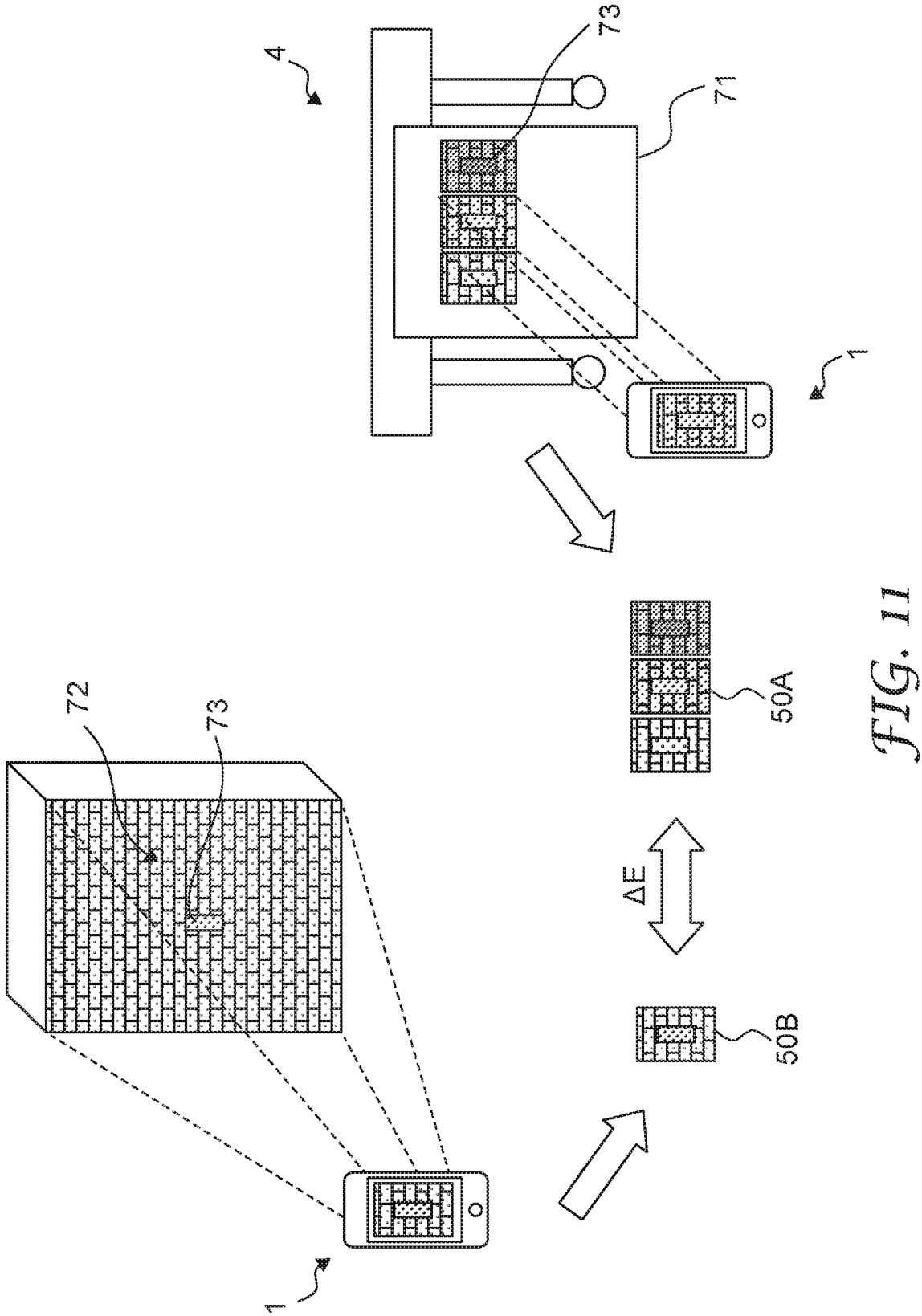


FIG. 11

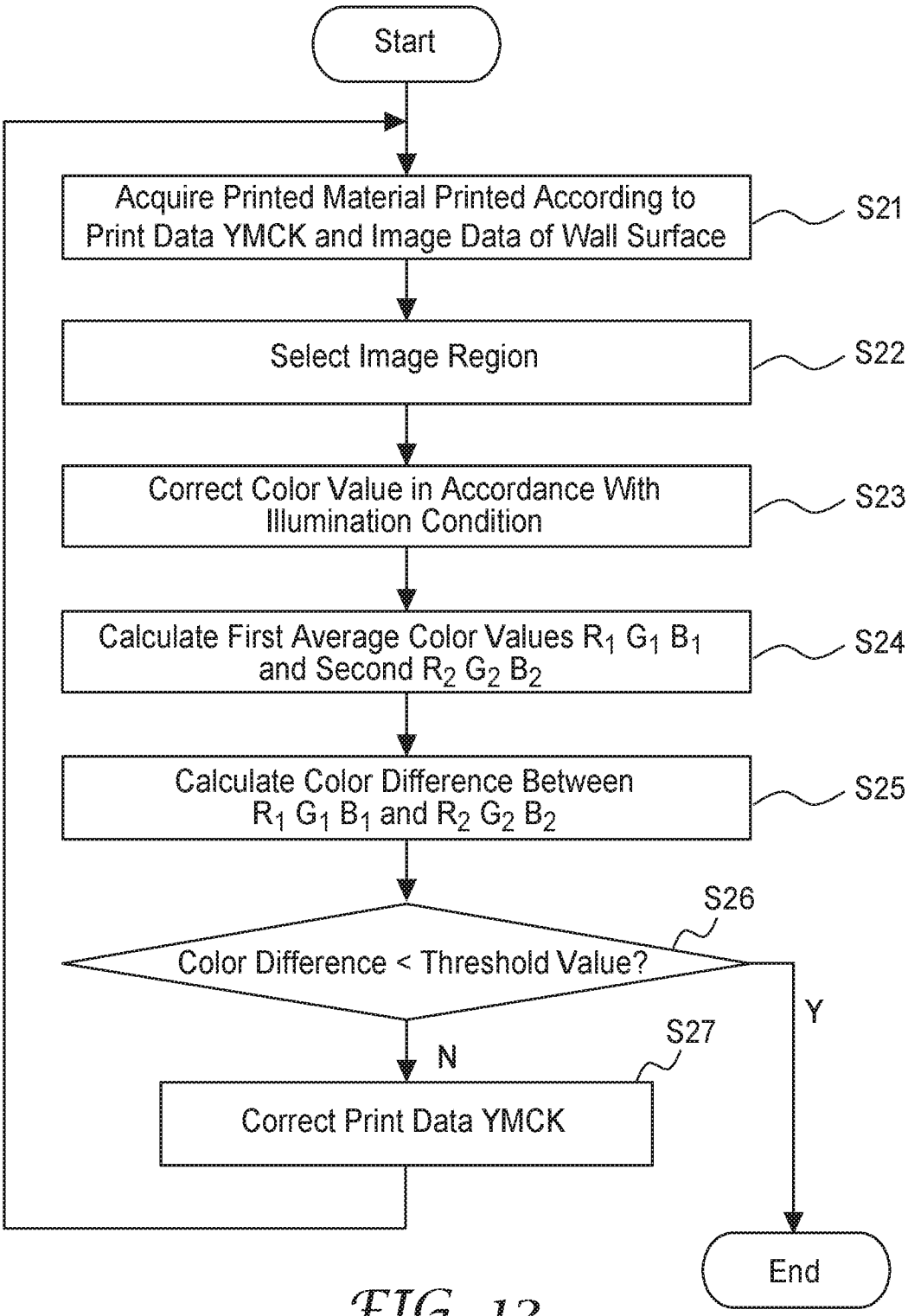

Start
Acquire Printed Material Printed According to Print Data YMCK and Image Data of Wall Surface
S21
Select Image Region
S22
Correct Color Value in Accordance With Illumination Condition
S23
Calculate First Average Color Values R_1 G_1 B_1 and Second R_2 G_2 B_2
S24
Calculate Color Difference Between R_1 G_1 B_1 and R_2 G_2 B_2
S25
S26
Color Difference < Threshold Value?
Y
N
S27
Correct Print Data YMCK
End

FIG. 12

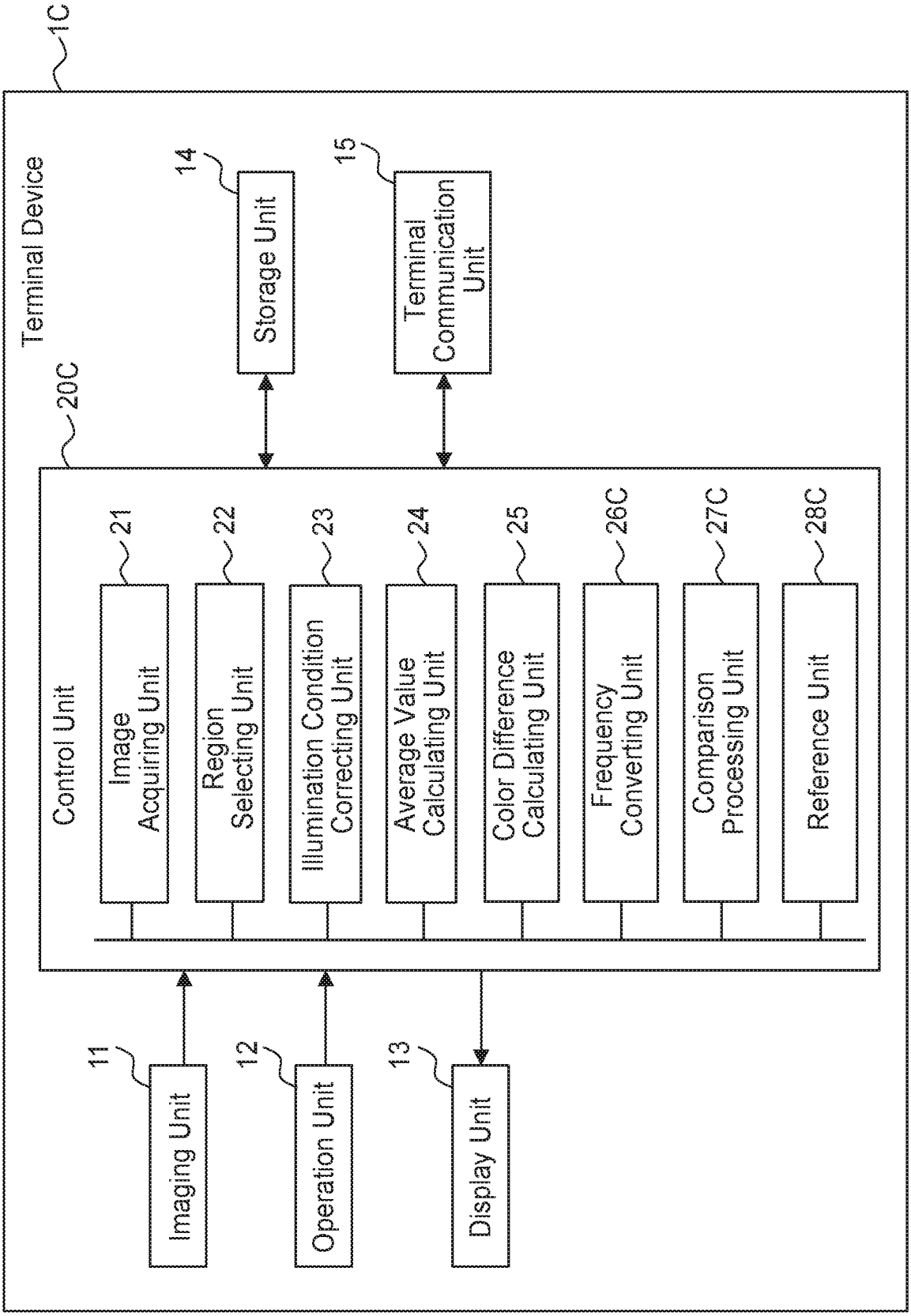

1C
Terminal Device
20C
Control Unit
14
Storage Unit
15
Terminal Communication Unit
21
Image Acquiring Unit
22
Region Selecting Unit
23
Illumination Condition Correcting Unit
24
Average Value Calculating Unit
25
Color Difference Calculating Unit
26C
Frequency Converting Unit
27C
Comparison Processing Unit
28C
Reference Unit
11
Imaging Unit
12
Operation Unit
13
Display Unit

FIG. 13

Product Number	Name	Photograph at Time of Production	Shooting Conditions			Average Color Value	Frequency Distribution
			Shooting Magnification	Resolution	Color Temperature		
No. 1	Name 1	P1	n1	m1	T1	A1	F1
No. 2	Name 2	P2	n2	m2	T2	A2	F2
No. 3	Name 3	P3	n3	m3	T3	A3	F3
:	:	:	:	:	:	:	:

FIG. 14

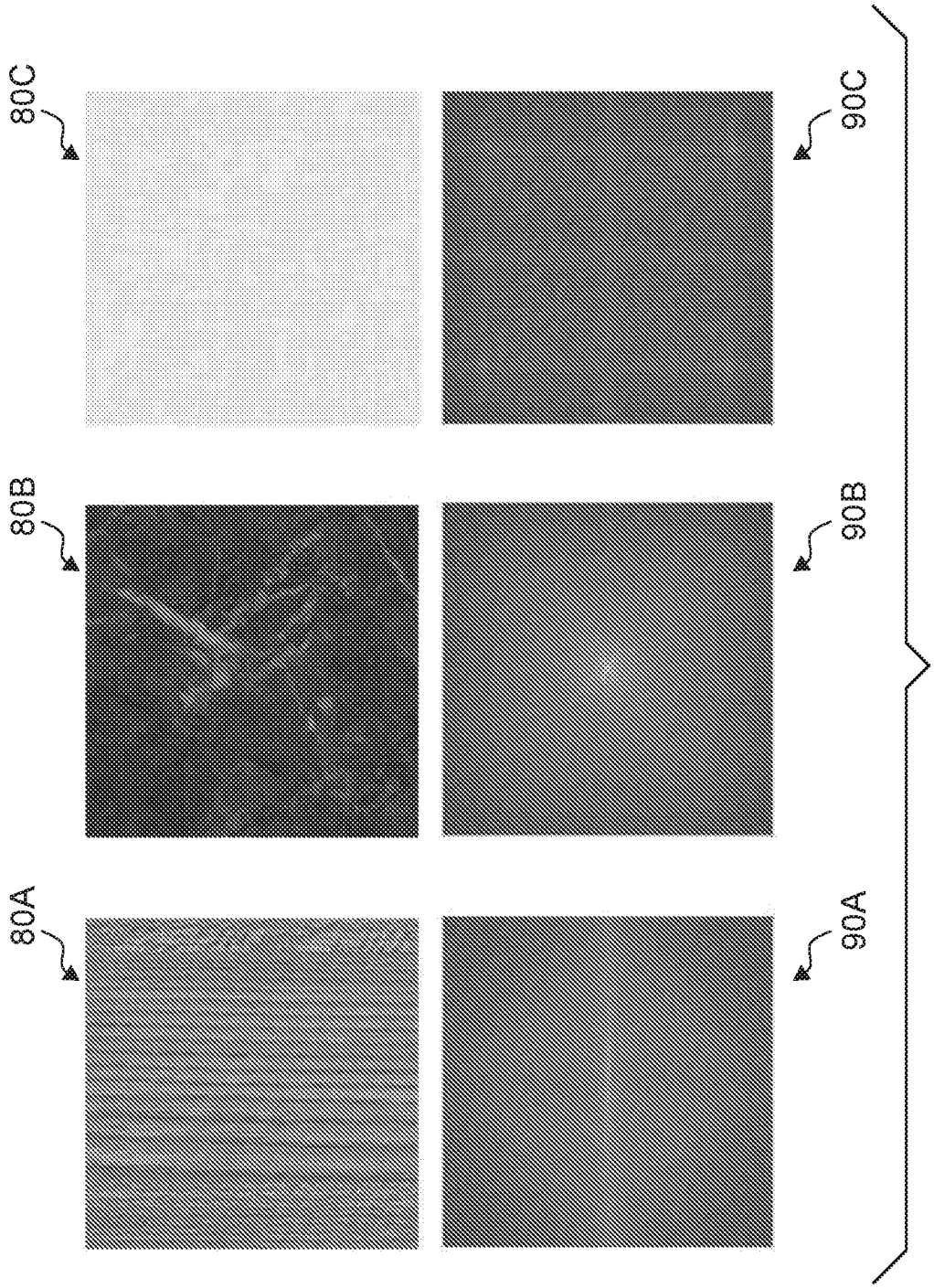


FIG. 15

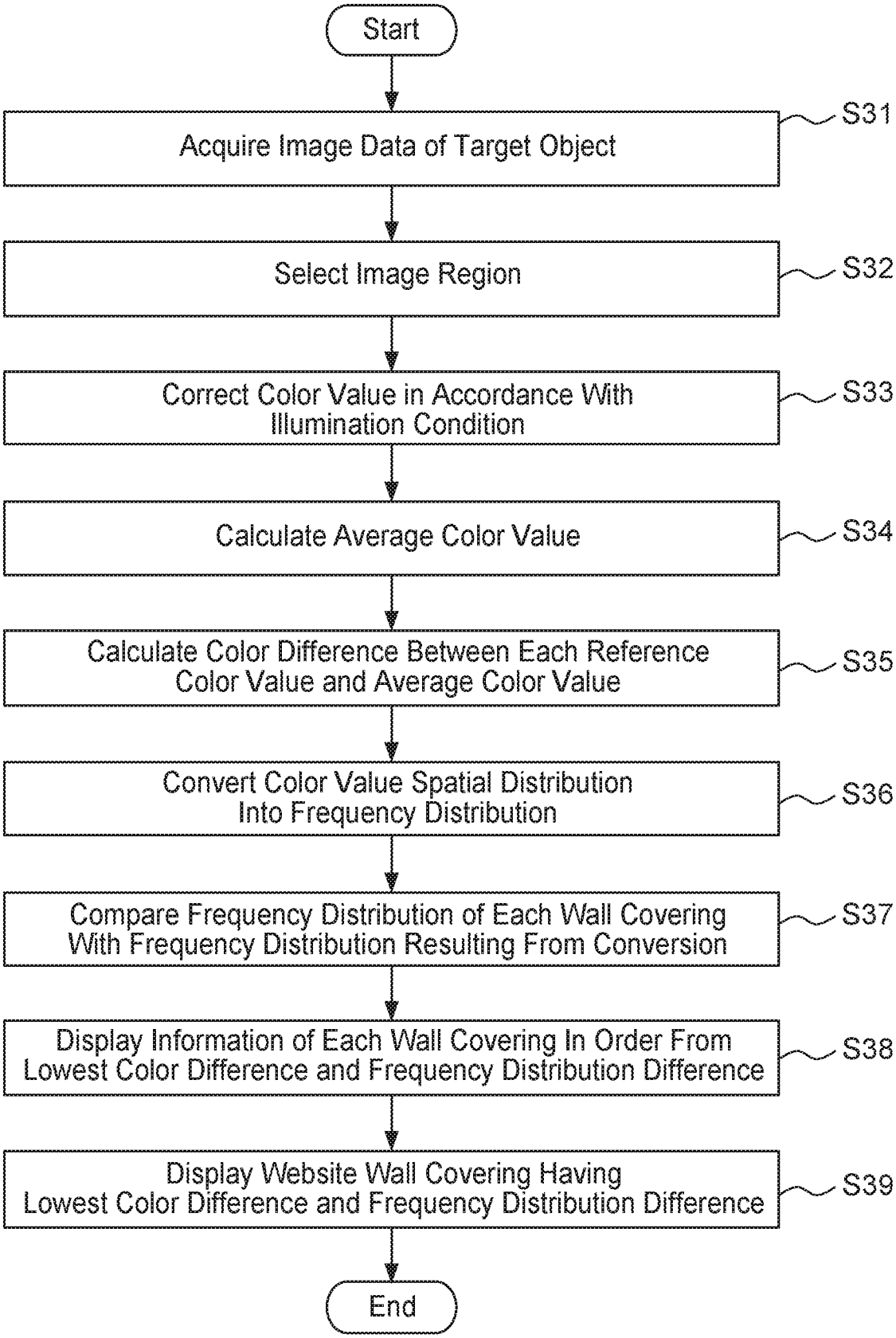

Start
Acquire Image Data of Target Object
S31
Select Image Region
S32
Correct Color Value in Accordance With Illumination Condition
S33
Calculate Average Color Value
S34
Calculate Color Difference Between Each Reference Color Value and Average Color Value
S35
Convert Color Value Spatial Distribution Into Frequency Distribution
S36
Compare Frequency Distribution of Each Wall Covering With Frequency Distribution Resulting From Conversion
S37
Display Information of Each Wall Covering In Order From Lowest Color Difference and Frequency Distribution Difference
S38
Display Website Wall Covering Having Lowest Color Difference and Frequency Distribution Difference
S39
End

FIG. 16

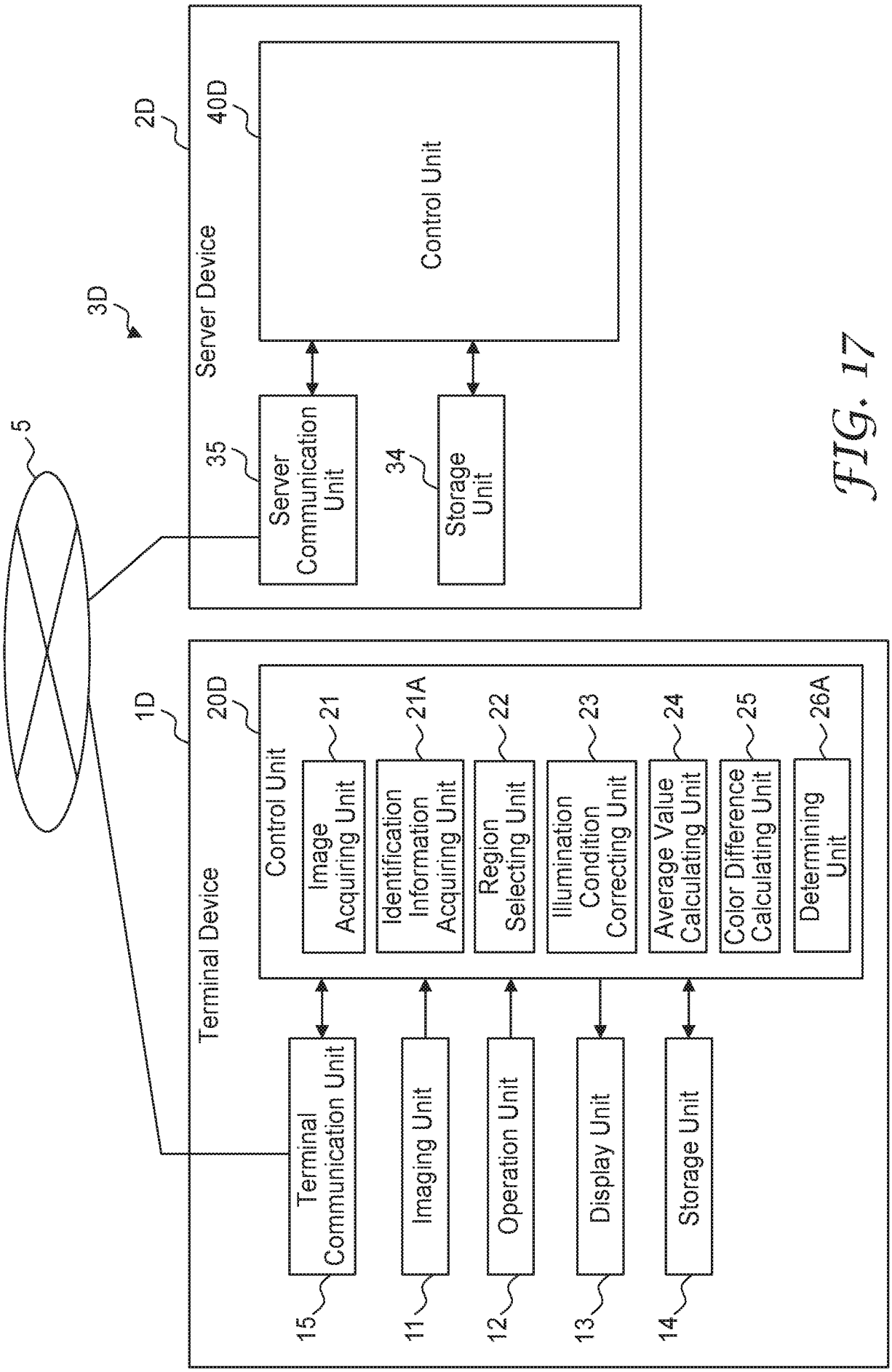

3D
2D
Server Device
40D
Control Unit
35
Server Communication Unit
34
Storage Unit
5
1D
Terminal Device
20D
Control Unit
21
Image Acquiring Unit
21A
Identification Information Acquiring Unit
22
Region Selecting Unit
23
Illumination Condition Correcting Unit
24
Average Value Calculating Unit
25
Color Difference Calculating Unit
26A
Determining Unit
15
Terminal Communication Unit
11
Imaging Unit
12
Operation Unit
13
Display Unit
14
Storage Unit

FIG. 17

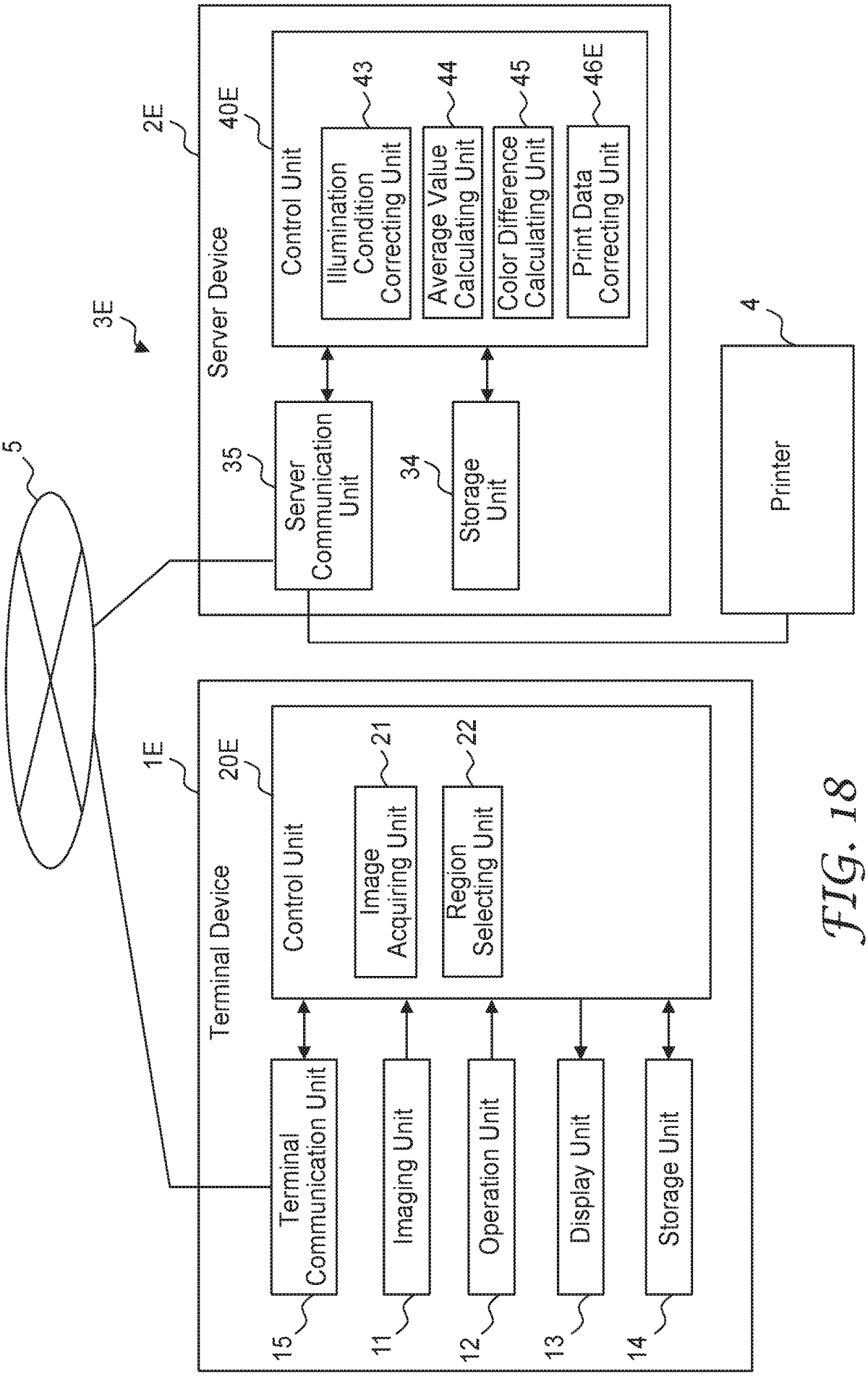

5
3E
2E
Server Device
40E
Control Unit
43
Illumination Condition Correcting Unit
44
Average Value Calculating Unit
45
Color Difference Calculating Unit
46E
Print Data Correcting Unit
35
Server Communication Unit
34
Storage Unit
4
Printer
1E
Terminal Device
20E
Control Unit
21
Image Acquiring Unit
22
Region Selecting Unit
Terminal Communication Unit
Imaging Unit
Operation Unit
Display Unit
Storage Unit
15
11
12
13
14

FIG. 18

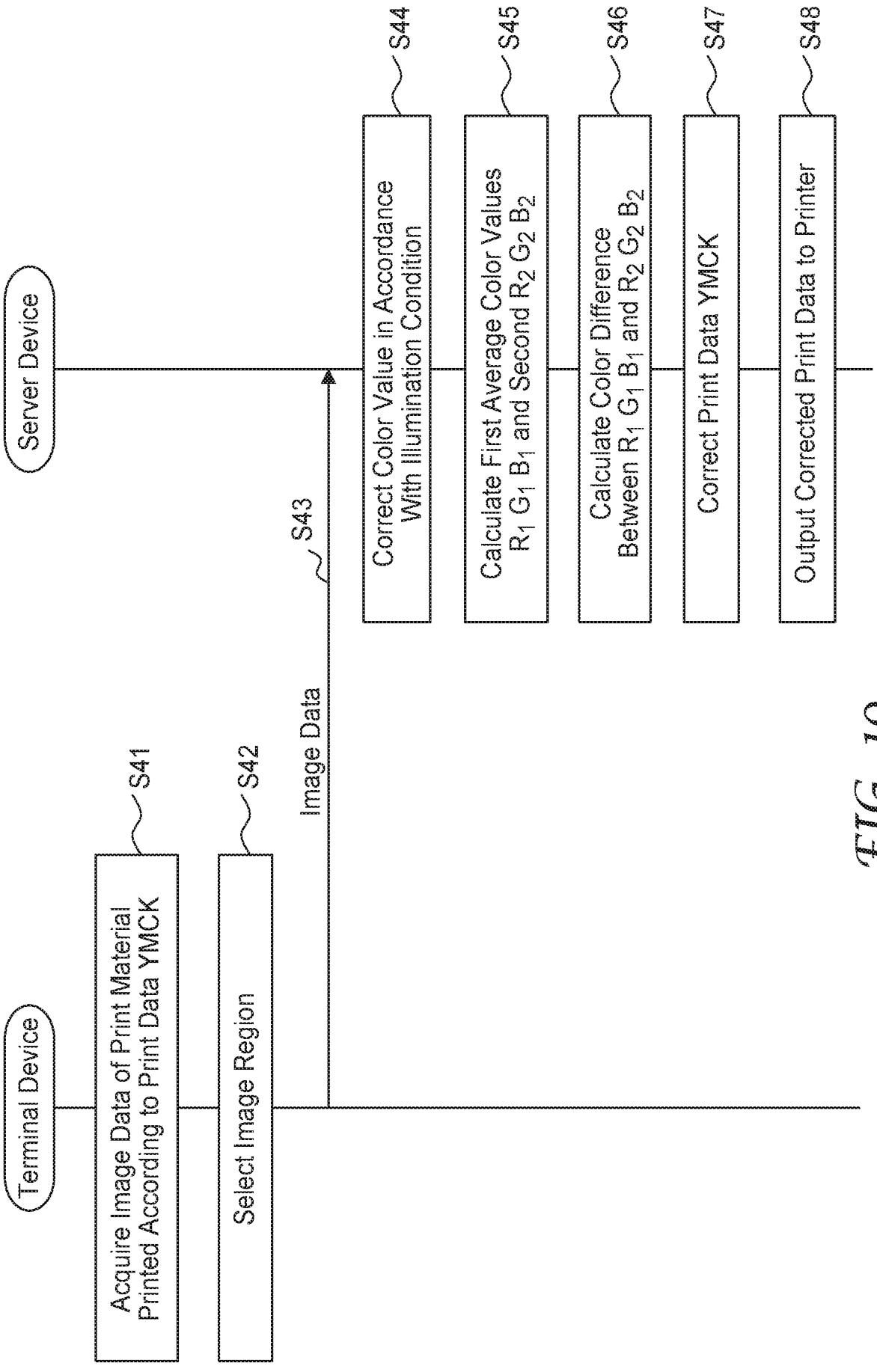

Terminal Device
Acquire Image Data of Print Material Printed According to Print Data YMCK
S41
Select Image Region
S42
Image Data
S43
Server Device
Correct Color Value in Accordance With Illumination Condition
S44
Calculate First Average Color Values R_1 G_1 B_1 and Second R_2 G_2 B_2
S45
Calculate Color Difference Between R_1 G_1 B_1 and R_2 G_2 B_2
S46
Correct Print Data YMCK
S47
Output Corrected Print Data to Printer
S48

FIG. 19

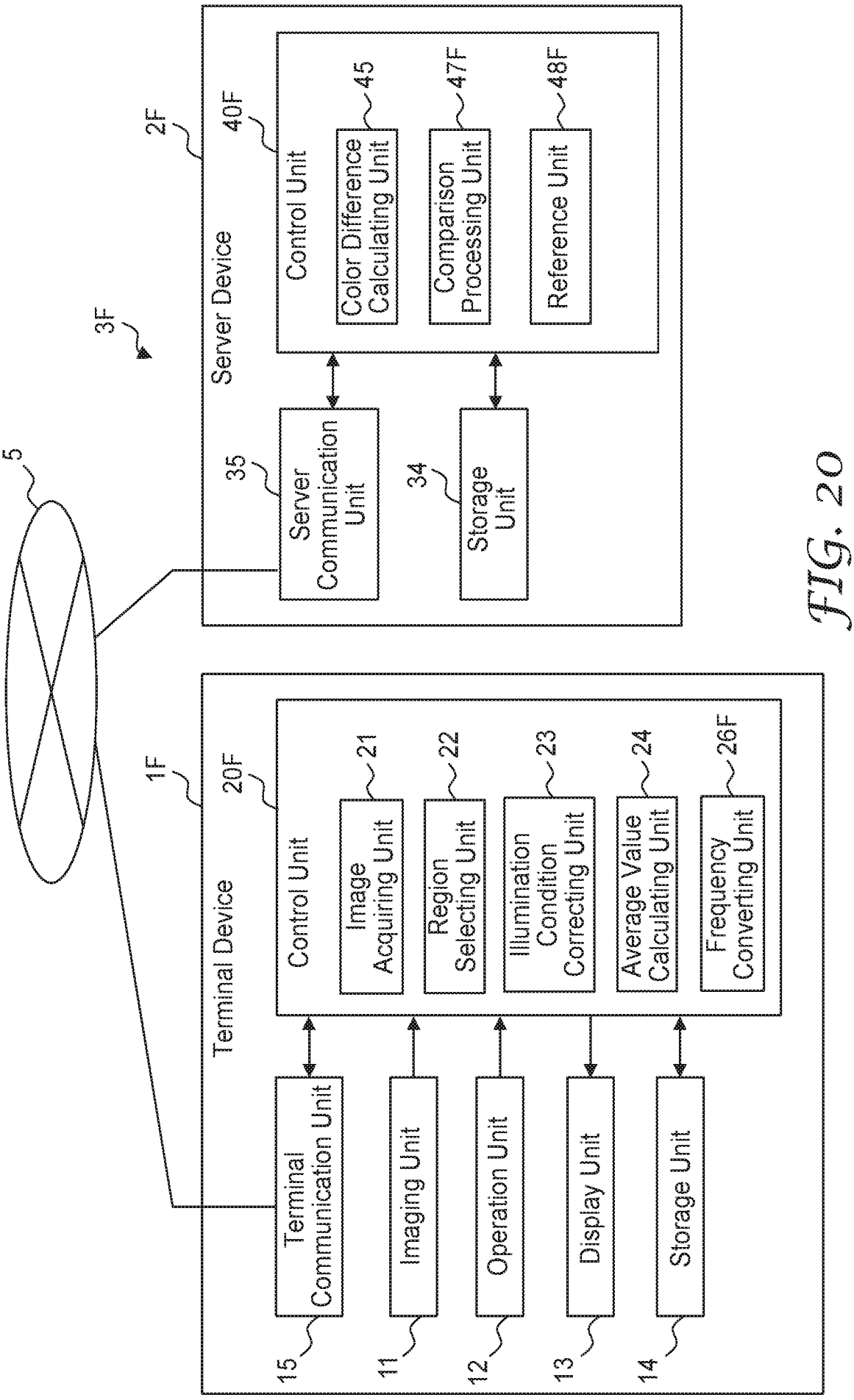

3F
2F
Server Device
40F
Control Unit
45
Color Difference Calculating Unit
47F
Comparison Processing Unit
48F
Reference Unit
5
35
Server Communication Unit
34
Storage Unit
1F
Terminal Device
20F
Control Unit
21
Image Acquiring Unit
22
Region Selecting Unit
23
Illumination Condition Correcting Unit
24
Average Value Calculating Unit
26F
Frequency Converting Unit
Terminal Communication Unit
Imaging Unit
Operation Unit
Display Unit
Storage Unit
15
11
12
13
14

FIG. 20

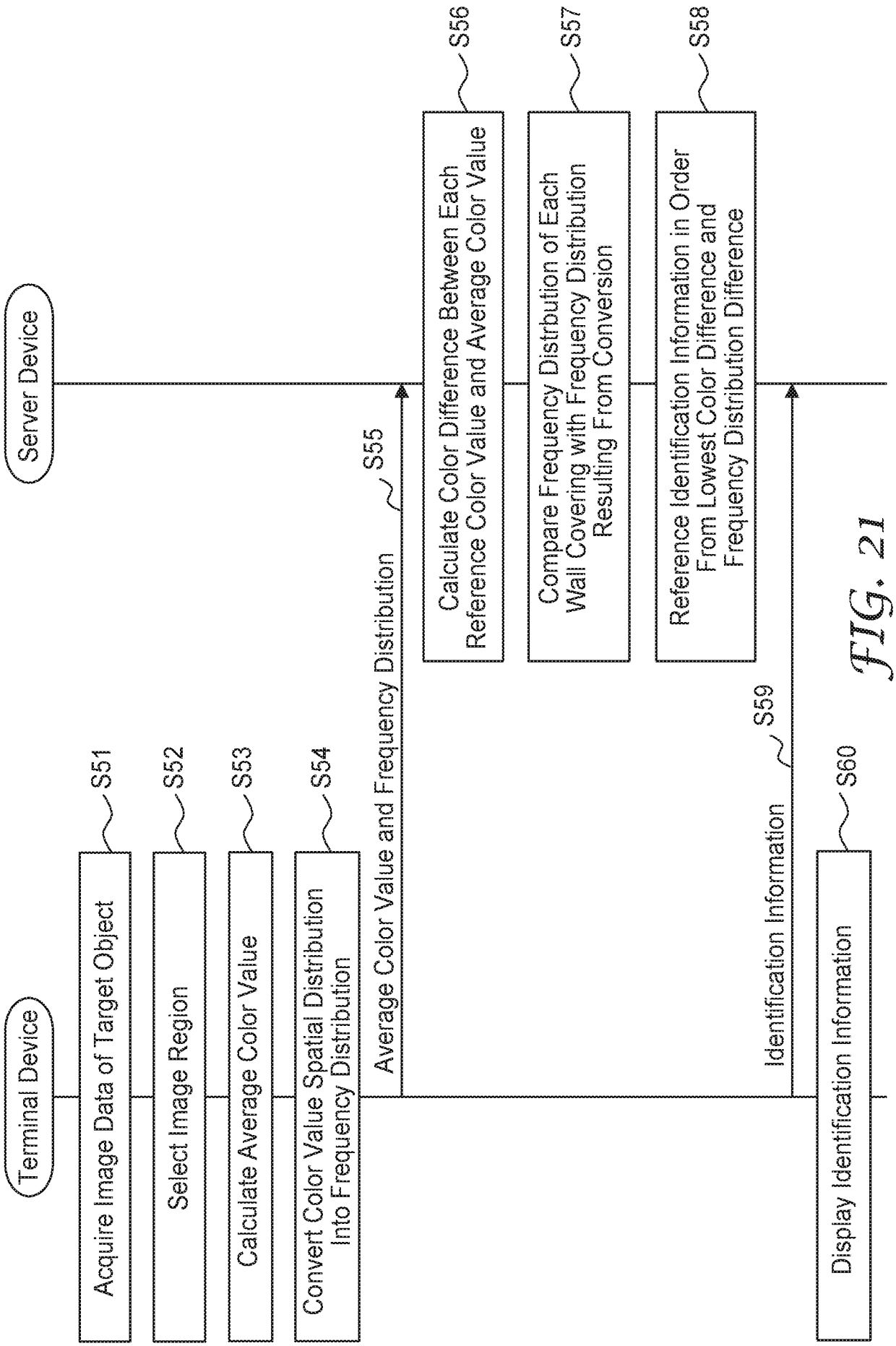

Terminal Device
Server Device
Acquire Image Data of Target Object
S51
Select Image Region
S52
Calculate Average Color Value
S53
Convert Color Value Spatial Distribution Into Frequency Distribution
S54
Average Color Value and Frequency Distribution
S55
Calculate Color Difference Between Each Reference Color Value and Average Color Value
S56
Compare Frequency Distrbution of Each Wall Covering with Frequency Distribution Resulting From Conversion
S57
Reference Identification Information in Order From Lowest Color Difference and Frequency Distribution Difference
S58
Identification Information
S59
Display Identification Information
S60

FIG. 21

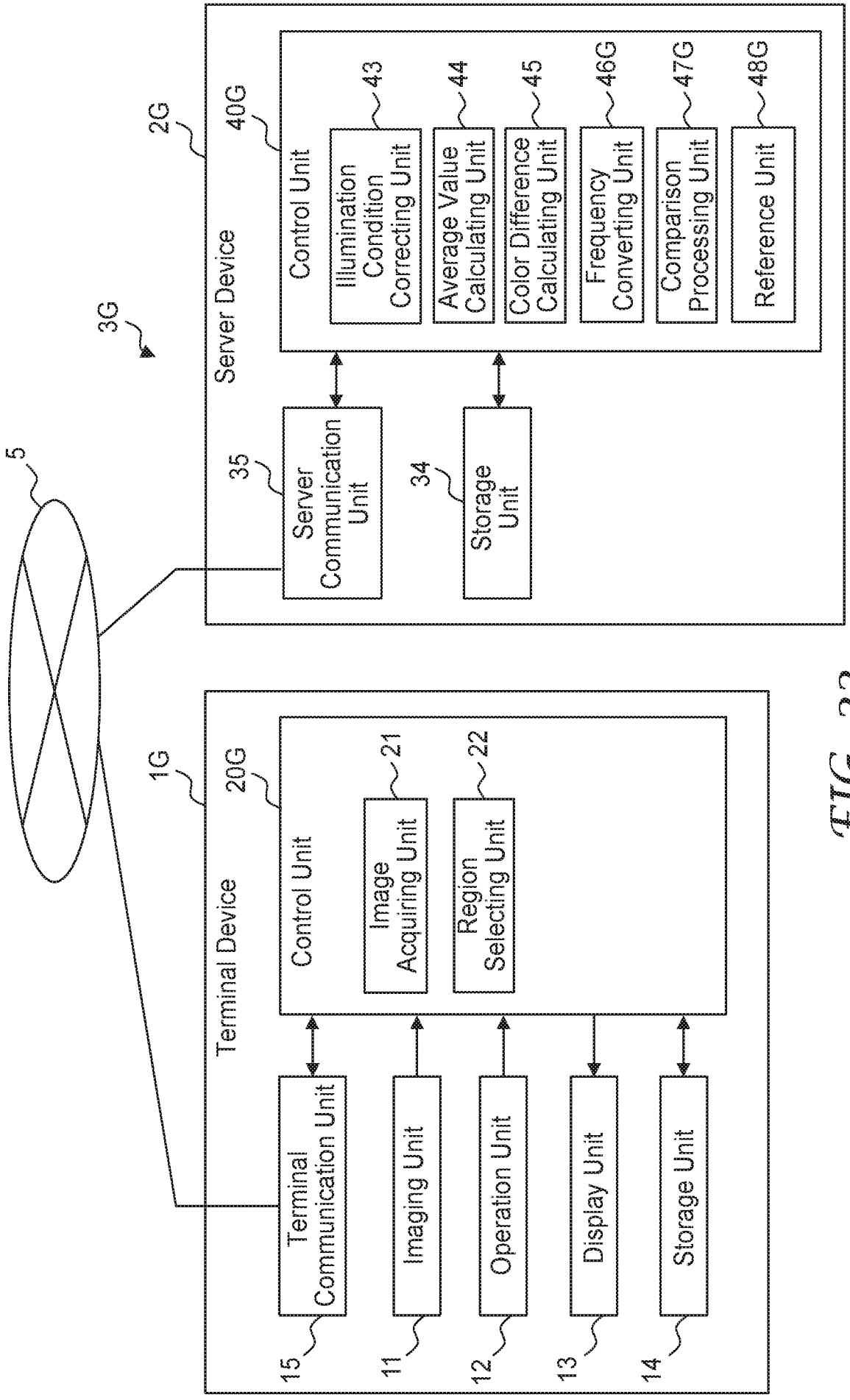

5
3G
2G
Server Device
40G
Control Unit
Illumination Condition Correcting Unit
43
Average Value Calculating Unit
44
Color Difference Calculating Unit
45
Frequency Converting Unit
46G
Comparison Processing Unit
47G
Reference Unit
48G
35
Server Communication Unit
34
Storage Unit
1G
Terminal Device
20G
Control Unit
21
Image Acquiring Unit
22
Region Selecting Unit
Terminal Communication Unit
15
Imaging Unit
11
Operation Unit
12
Display Unit
13
Storage Unit
14

FIG. 22

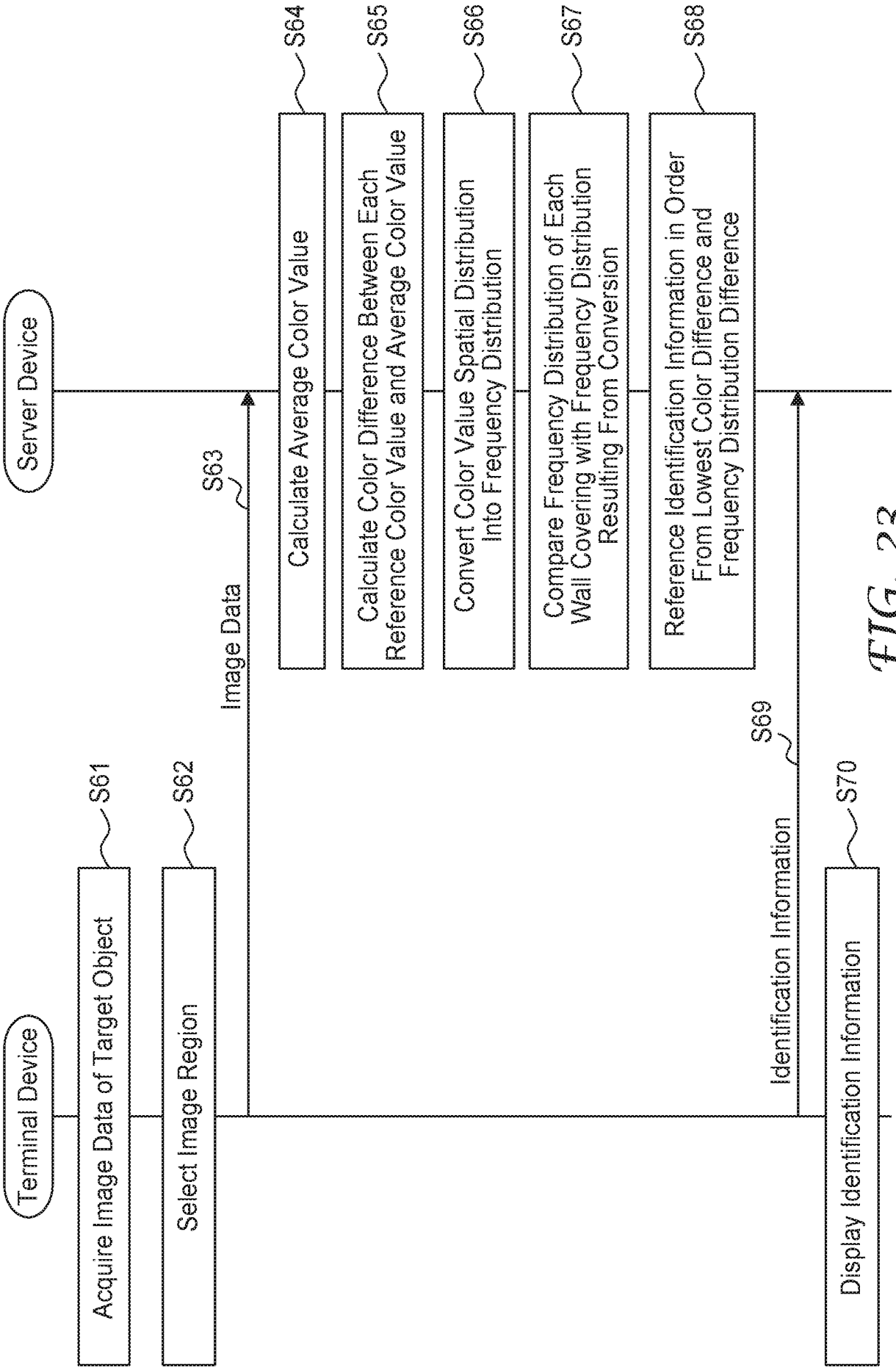

Terminal Device
Server Device
Acquire Image Data of Target Object
S61
Select Image Region
S62
Image Data
S63
Calculate Average Color Value
S64
Calculate Color Difference Between Each Reference Color Value and Average Color Value
S65
Convert Color Value Spatial Distribution Into Frequency Distribution
S66
Compare Frequency Distribution of Each Wall Covering with Frequency Distribution Resulting From Conversion
S67
Reference Identification Information in Order From Lowest Color Difference and Frequency Distribution Difference
S68
Identification Information
S69
Display Identification Information
S70

FIG. 23