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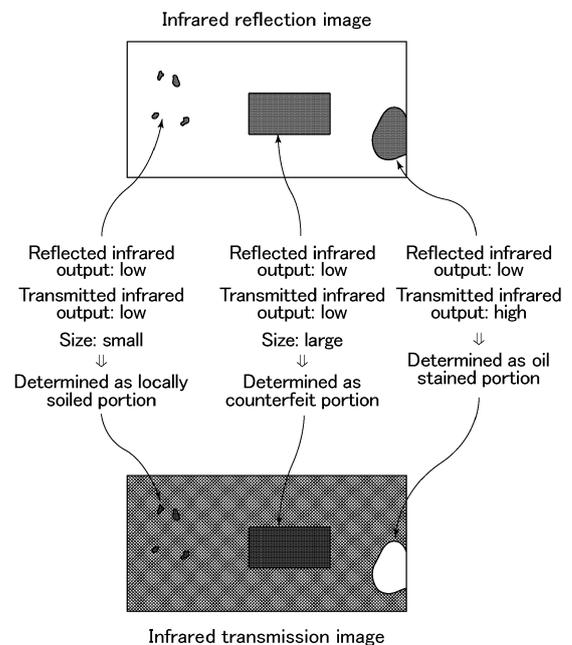
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(54) **BANKNOTE RECOGNITION UNIT, BANKNOTE HANDLING DEVICE, AND BANKNOTE RECOGNITION METHOD**

(57) The present invention provides a banknote recognition unit capable of reducing misdetermination of a soiled note as a counterfeit note, a banknote handling device, and a banknote recognition method. The banknote recognition unit includes a first determination unit that compares an infrared reflection image and a first reference data set to determine whether the infrared reflection image includes an abnormal area that is outside a tolerance relative to the first reference data set, a second determination unit that compares a determination target area, corresponding to the abnormal area, of an infrared transmission image with a second reference data set to determine whether the determination target area is within a tolerance relative to the second reference data set, and a main determination unit that executes authenticity determination processing on an area at least excluding the abnormal area of the infrared reflection image when the determination target area is within the tolerance.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to banknote recognition units, banknote handling devices, and banknote recognition methods. The present invention specifically relates to a banknote recognition unit and a banknote recognition method suitable for determining the authenticity of a banknote under transport, and a banknote handling device including such a banknote recognition unit.

BACKGROUND ART

[0002] Current banknote handling devices including a banknote recognition unit execute processes such as recognition of the denominations of banknotes, authenticity determination, fitness determination, and serial number recognition during transport of banknotes. For example, a banknote is read by an optical line sensor and an image thereof is analyzed, so that processes are executed such as recognition of the denomination of the banknote, determination of the authenticity of the banknote, determination of the fitness of the banknote, and letter recognition of the serial number printed on the banknote.

[0003] For example, JP H06-90750 B discloses a sheet soil recognition device configured to emit light to a sheet such as a banknote, to receive light reflected on or light transmitted through the sheet by a light receiving sensor, and to recognize the presence or absence of soil on the sheet based on an output signal from the light receiving sensor. This device is configured to set any detection area for detecting soil on a sheet along a scanning line, to add a binarized signal of the output signal from the light receiving sensor in the detection area at each reference timing and add the output signal from the light receiving sensor in the detection area at each reference timing, and to recognize the sheet as a sheet without soil, a partially soiled sheet, or an entirely soiled sheet based on the results of these two additions.

[0004] JP 2006-202075 A discloses multiple banknote recognition methods for recognizing a banknote by comparing an output pattern of an electric signal output from a light receiving unit that receives light reflected on the banknote or light transmitted through the banknote with a reference output pattern that has been stored in advance. For example, the patent literature discloses a method of excluding an area where the output of an electric signal from the light receiving unit is greater than the predetermined value is excluded from the comparison target for recognizing a banknote. The patent literature also discloses a method for correcting the reference output pattern in accordance with the output of an electric signal from the light receiving unit.

SUMMARY OF INVENTION

[0005] In order to prevent counterfeiting, infrared non-absorbing ink may be used for printing of banknotes in some cases. A portion printed with infrared non-absorbing ink absorbs visible light and does not absorb infrared light. Thus, the pattern printed with this ink is visually observable under a visible light source, while the pattern cannot be imaged even with an optical line sensor under an infrared light source and the banknote is imaged with the pattern disappeared. The portion printed with infrared non-absorbing ink has a relatively high output (hereinafter, also referred to as a reflected infrared output) from the optical line sensor based on the light generated by reflection of infrared light on a banknote and has a relatively low output (hereinafter, also referred to as a transmitted infrared output) from the optical line sensor based on the light generated by transmission of infrared light through the banknote. In contrast, a counterfeit portion printed not with infrared non-absorbing ink but with infrared absorbing ink absorbs infrared light. Thus, the reflected infrared output and the transmitted infrared output are both low.

[0006] Accordingly, a portion having a low reflected infrared output relative to a reference template prepared in advance by learning from a genuine note can be determined as a suspect counterfeit portion. This determination may be specifically achieved as follows, for example. First, a reflected infrared output (infrared reflection image) is collected for the entire printed area of a banknote to be determined. The collected reflected infrared output is then compared with the reference template. Pixels each having an output outside a threshold tolerance are defined as counterfeit pixels, and the counterfeit pixels are counted. The number of the counterfeit pixels is then compared with a separately set threshold, whereby the authenticity determination is performed.

[0007] Unfortunately, in the above determination method, only the reflected infrared output is used and the authenticity determination is performed based only on the number of pixels having an output outside the threshold tolerance. Thus, the above determination method may misdetermine a medium as a counterfeit note in a case that the medium has an oil-stained portion that is difficult to observe visually but has an influence on the reflected infrared output and the transmitted infrared output.

[0008] In a case that a banknote has a soiled portion, this portion absorbs infrared light and the reflected infrared output becomes low. Unfortunately, in the above determination method, only the reflected infrared output is used and the authenticity determination is performed based only on the number of pixels having an output outside the threshold tolerance. Thus, even a medium having multiple locally soiled portions may be misdetermined as a counterfeit note in a case that the sum of the areas of the soiled portions is large.

[0009] The sheet soil recognition device disclosed in JP H06-90750 B is configured to recognize the presence

or absence of soil on a sheet. This literature fails to disclose both the issue of misdetermination of a soiled medium as a counterfeit note and the solution thereto.

[0010] In the banknote recognition method disclosed in JP 2006-202075 A, the comparison target for recognizing a banknote is limited based on the output value of an electric signal by reflective light or transmissive light. Thus, a counterfeit portion may be highly possibly excluded from the comparison target. Further, a banknote having multiple locally soiled portions may be misdetermined as a counterfeit note.

[0011] In response to the above current state of the art, an object of the present invention is to provide a banknote recognition unit capable of reducing misdetermination of a soiled note as a counterfeit note, a banknote handling device, and a banknote recognition method.

[0012] In order to solve the above issue and to achieve the object, one aspect of the present invention is a banknote recognition unit for recognizing a banknote, including:

an image acquisition unit configured to acquire an infrared reflection image and an infrared transmission image of a banknote;

a storage unit configured to store a reference data set for an infrared reflection image and a reference data set for an infrared transmission image each based on a fit banknote;

a first determination unit configured to compare a first infrared image with a first reference data set to determine whether the first infrared image includes an abnormal area that is outside a tolerance relative to the first reference data set, the first infrared image being one selected from the infrared reflection image and the infrared transmission image each acquired by the image acquisition unit, and the first reference data set being one selected from the reference data set for an infrared reflection image and the reference data set for an infrared transmission image;

a second determination unit configured to compare, in a case that the first infrared image includes the abnormal area, a determination target area of a second infrared image with a second reference data set to determine whether the determination target area is within a tolerance relative to the second reference data set, the determination target area being an area corresponding to the abnormal area, the second infrared image being the other of the infrared reflection image and the infrared transmission image, and the second reference data set being the other of the reference data set for an infrared reflection image and the reference data set for an infrared transmission image; and

a main determination unit configured to execute authenticity determination processing on an area at least excluding the abnormal area of the first infrared image in a case that the second determination unit determines that the determination target area is with-

in the tolerance relative to the second reference data set.

[0013] In another aspect of the present invention, the storage unit further stores a reference value of a size of the abnormal area and, in a case that the first infrared image includes the abnormal area and the second determination unit determines that the determination target area is not within the tolerance relative to the second reference data set, the main determination unit is configured to compare the size of the abnormal area with the reference value stored in the storage unit and to execute, in a case that the size of the abnormal area is smaller than the reference value, authenticity determination processing on an area at least excluding the abnormal area of the first infrared image.

[0014] In another aspect of the present invention, the first infrared image is the infrared reflection image, the first determination unit is configured to compare the infrared reflection image with the reference data set for an infrared reflection image, the second infrared image is the infrared transmission image, and the second determination unit is configured to compare the determination target area of the infrared transmission image with the reference data set for an infrared transmission image.

[0015] In another aspect of the present invention, the reference data set for an infrared reflection image includes a reference value of a pixel value of each pixel of the infrared reflection image, the reference data set for an infrared transmission image includes a reference value of a pixel value of each pixel of the infrared transmission image, the first determination unit is configured to determine, as the abnormal area, an area including pixels each having a pixel value smaller than the respective reference value that is included in the reference data set for an infrared reflection image in the infrared reflection image, and the second determination unit is configured to determine that the determination target area is within the tolerance relative to the reference data set for an infrared transmission image in a case that the pixel value of each pixel of the determination target area is greater than the respective reference value that is included in the reference data set for an infrared transmission image.

[0016] In another aspect of the present invention, the first infrared image is the infrared transmission image, the first determination unit is configured to compare the infrared transmission image with the reference data set for an infrared transmission image, the second infrared image is the infrared reflection image, and the second determination unit is configured to compare the determination target area of the infrared reflection image with the reference data set for an infrared reflection image.

[0017] Another aspect of the present invention is directed to a banknote handling device including the above banknote recognition unit.

[0018] Another aspect of the present invention is directed to a banknote recognition method for recognizing a banknote, including:

an image acquisition step of acquiring an infrared reflection image and an infrared transmission image of a banknote;

a first determination step of comparing a first infrared image with a first reference data set to determine whether the first infrared image includes an abnormal area that is outside a tolerance relative to the first reference data set, the first infrared image being one selected from the infrared reflection image and the infrared transmission image each acquired in the image acquisition step, and the first reference data set being one selected from a reference data set for an infrared reflection image and a reference data set for an infrared transmission image each based on a fit banknote;

a second determination step of comparing, in a case that the first infrared image includes the abnormal area, a determination target area of a second infrared image with a second reference data set to determine whether the determination target area is within a tolerance relative to the second reference data set, the determination target area being an area corresponding to the abnormal area, the second infrared image being the other of the infrared reflection image and the infrared transmission image, and the second reference data set being the other of the reference data set for an infrared reflection image and the reference data set for an infrared transmission image; and

a main determination step of executing authenticity determination processing on an area at least excluding the abnormal area of the first infrared image in a case that the determination target area is determined as being within the tolerance relative to the second reference data set in the second determination step.

[0019] In another aspect of the present invention, in a case that the first infrared image includes the abnormal area and the second determination step determines that the determination target area is not within the tolerance relative to the second reference data set, the main determination step includes comparing a size of the abnormal area with a reference value of the size of the abnormal area and executing, in a case that the size of the abnormal area is smaller than the reference value, authenticity determination processing on an area at least excluding the abnormal area of the first infrared image.

[0020] In another aspect of the present invention, the first infrared image is the infrared reflection image, the first determination step includes comparing the infrared reflection image with the reference data set for an infrared reflection image, the second infrared image is the infrared transmission image, and the second determination step includes comparing the determination target area of the infrared transmission image with the reference data set for an infrared transmission image.

[0021] In another aspect of the present invention, the reference data set for an infrared reflection image in-

cludes a reference value of a pixel value of each pixel of the infrared reflection image, the reference data set for an infrared transmission image includes a reference value of a pixel value of each pixel of the infrared transmission image, the first determination step includes determining, as the abnormal area, an area including pixels each having a pixel value smaller than the respective reference value that is included in the reference data set for an infrared reflection image in the infrared reflection image, and the second determination step includes determining that the determination target area is within the tolerance relative to the reference data set for an infrared transmission image in a case that the pixel value of each pixel of the determination target area is greater than the respective reference value that is included in the reference data set for an infrared transmission image.

[0022] In another aspect of the present invention, the first infrared image is the infrared transmission image, the first determination step includes comparing the infrared transmission image with the reference data set for an infrared transmission image, the second infrared image is the infrared reflection image, and the second determination step includes comparing the determination target area of the infrared reflection image with the reference data set for an infrared reflection image.

[0023] The banknote recognition unit, the banknote handling device, and the banknote recognition method of the present invention can reduce misdetermination of a soiled note as a counterfeit note.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Fig. 1 is a diagram illustrating the outline of a banknote recognition unit and a banknote recognition method according to Embodiment 1.

[0025] Fig. 2 is a schematic perspective view of the appearance of the banknote handling device according to Embodiment 1.

[0026] Fig. 3 is a block diagram of the structure of the banknote recognition unit according to Embodiment 1.

[0027] Fig. 4 is a schematic cross-sectional view of the structure of an image acquisition unit in the banknote recognition unit according to Embodiment 1.

[0028] Fig. 5 is a schematic view of an exemplary infrared reflection image acquired by the image acquisition unit in the banknote recognition unit according to Embodiment 1.

[0029] Fig. 6 is a schematic view of an exemplary infrared transmission image acquired by the image acquisition unit in the banknote recognition unit according to Embodiment 1.

[0030] Fig. 7 is a diagram of an exemplary method for calculating the size of an abnormal area of the infrared reflection image by a second determination unit in the banknote recognition unit according to Embodiment 1.

[0031] Fig. 8 is a flow chart of the procedure of banknote recognition processing with the banknote recognition unit and in the banknote recognition method accord-

ing to Embodiment 1.

DESCRIPTION OF EMBODIMENTS

[0032] Preferred embodiments of the banknote recognition unit, the banknote handling device, and the banknote recognition method of the present invention are described hereinbelow with reference to the drawings.

[0033] In the description, the reflection image means an image based on the intensity distribution of light generated by reflection of light on a banknote. In the case of applying infrared light to a banknote, the reflection image is also referred to as an infrared reflection image. The transmission image means an image based on the intensity distribution of light generated by transmission of light through a banknote. In the case of applying infrared light to a banknote, the transmission image is also referred to as an infrared transmission image.

[0034] <Outline of banknote recognition unit and banknote recognition method>

[0035] The outlines of a banknote recognition unit and a banknote recognition method of the present embodiment are first described with reference to Fig. 1. Main features of the present embodiment are the following features I and II.

[0036] I. Both the reflected infrared output and the transmitted infrared output (the infrared reflection image and the infrared transmission image) are checked, so that a soiled portion due to oil stain and a counterfeit portion are distinguished from each other (see the center and right of each image in Fig. 1).

[0037] II. Based on the conditions around a pixel outside a threshold tolerance, a locally soiled portion and a counterfeit portion are distinguished from each other (see the center and left of each image in Fig. 1).

[0038] These features can reduce misdetermination of a soiled note as a counterfeit note. Each of the features is described in more detail below.

[0039] (I) As oil soaks into a banknote, the unevenness of fibers of the banknote decreases and the amount of light transmitted increases, i.e., the amount of light reflected decreases. Thus, a soiled portion due to oil stain has a relatively low reflected infrared output and a relatively high transmitted infrared output. As described above, a portion having a low reflected infrared output relative to the reference template is suspected to be counterfeit. Thus, the reflected infrared output alone may cause misdetermination of a soiled portion due to oil stain as a counterfeit portion. Still, in the present embodiment, the transmitted infrared output of this portion is also checked. When the transmitted infrared output of the portion is high, the portion is determined not as a counterfeit portion but as a soiled portion due to oil stain. This enables exclusion of the portion determined as a soiled portion due to oil stain from counterfeit pixels, reducing misdetermination of a soiled note as a counterfeit note.

[0040] (II) A counterfeit feature often appears as a large portion. Thus, a portion suspected to be counterfeit

(= the reflected infrared output and/or the transmitted infrared output are/is outside the tolerance) is determined as a counterfeit portion in a case that another portion therearound is also suspected to be counterfeit, otherwise it is determined as a locally soiled portion. This can reduce misdetermination of a locally soiled portion as a counterfeit portion.

<Structure of banknote handling device>

[0041] The structure of the banknote handling device of the present embodiment is described with reference to Fig. 2. The banknote handling device of the present embodiment may have a structure illustrated in Fig. 2, for example. A banknote handling device 300 illustrated in Fig. 2 is a small banknote handling device to be used on a table, and includes a banknote recognition unit (not illustrated in Fig. 2) configured to execute recognition processing on banknotes, a hopper 301 configured to hold a plurality of banknotes to be processed in the form of a stack, two rejection units 302 configured to dispense rejected banknotes, such as counterfeit notes and suspect notes, among the banknotes fed from the hopper 301 into a housing 310, an operation unit 303 configured to receive instructions from an operator, four stacking units 306a to 306d configured to stack sorted banknotes whose denomination, authenticity, and fitness are recognized in the housing 310, and a display 305 configured to display information such as the results of recognizing and counting banknotes and the stacking conditions of the stacking units 306a to 306d. Based on the results of fitness determination by the banknote recognition unit, the stacking units 306a to 306c among the four stacking units 306a to 306d store fit notes, while the stacking unit 306d stores soiled notes. Any method may be used to sort banknotes into the stacking units 306a to 306d.

<Structure of banknote recognition unit>

[0042] The structure of the banknote recognition unit of the present embodiment is described with reference to Fig. 3. As illustrated in Fig. 3, a banknote recognition unit 1 of the present embodiment includes a control unit 10, a detection unit 20, and a storage unit 30.

[0043] The control unit 10 includes programs for achieving a variety of processing stored in the storage unit 30, a central processing unit (CPU) that executes the programs, a variety of hardware controlled by the CPU, and a logical device such as a field programmable gate array (FPGA). The control unit 10 controls the components of the banknote recognition unit 1 based on signals output from the components of the banknote recognition unit 1 and a control signal from the control unit 10 in accordance with the programs stored in the storage unit 30. The control unit 10 also has functions as a recognition unit 11, an authenticity determination unit 12, and a fitness determination unit 13 owing to the programs stored in the storage unit 30.

[0044] The detection unit 20 includes an image acquisition unit 21, a magnetism detection unit 22, and a UV detection unit 23. The image acquisition unit 21 acquires an image of a banknote. The magnetism detection unit 22 includes a magnetism sensor (not illustrated) to detect the magnetism and detects the magnetism of magnetic ink printed on a banknote and a security thread, for example, with the magnetism sensor. The magnetism sensor is a magnetism line sensor of a plurality of magnetism detection elements arranged in line. The UV detection unit 23 includes a ultraviolet light emitting unit (not illustrated) and a light receiving unit (not illustrated) and detects, with the light receiving unit, fluorescence generated when the ultraviolet light emitting unit emits ultraviolet light to a banknote and ultraviolet light passed through the banknote.

[0045] The storage unit 30 includes a nonvolatile storage unit such as a semiconductor memory or a hard disk, and stores a variety of programs and a variety of data for controlling the banknote recognition unit 1. The storage unit 30 also stores a reference data set for an infrared reflection image, a reference data set for an infrared transmission image, and a reference value (hereinafter, also referred to as a size reference value) of the size of an abnormal area.

[0046] The reference data set for an infrared reflection image and the reference data set for an infrared transmission image are reference templates to be used as determination references in authenticity determination processing by the authenticity determination unit 12, and are each a parameter group prepared for each denomination of a banknote to be recognized. Each parameter group is prepared by machine learning in advance based on the pixel value (output value) of each pixel of the infrared reflection images and the infrared transmission images of fit banknotes (genuine notes). Thus, the reference data set for an infrared reflection image and the reference data set for an infrared transmission image each indicate a reference value of the pixel value of each pixel of the infrared reflection image or the infrared transmission image of a banknote to be subjected to authenticity determination.

[0047] The size reference value is a threshold to be used as a determination reference of the size of an abnormal area in the authenticity processing by the authenticity determination unit 12.

[0048] The recognition unit 11 compares a characteristic pattern of an image of a banknote acquired by the image acquisition unit 21 with a denomination recognition template that is a characteristic pattern for each denomination of a banknote and determines the denomination of the banknote.

[0049] The authenticity determination unit 12 determines the authenticity of a banknote based on an image of the banknote obtained by infrared irradiation. The specification thereof is described later. The authenticity determination unit 12 also matches a detection signal from the magnetism detection unit 22 and a detection

signal from the UV detection unit 23 to a respective reference data set for authenticity recognition, and determines the authenticity of the banknote. As described, the authenticity determination unit 12 executes a plurality of authenticity determination processes on a banknote and determines the banknote as a genuine note in a case that all determination results demonstrate that the banknote is genuine, while it determines the banknote as a counterfeit note in a case that any one of the determination results demonstrates that the banknote is counterfeit.

<Structure of image acquisition unit>

[0050] The structure of the image acquisition unit 21 is described with reference to Fig. 4. As illustrated in Fig. 4, the image acquisition unit 21 includes optical line sensors 110 and 120 arranged to face each other. Between the optical line sensors 110 and 120 is formed a gap through which a banknote BN is to be transported. This gap is a portion of a transport path 311 of the banknote handling device. The optical line sensors 110 and 120 are respectively placed on the upper and lower sides of the transport path 311.

[0051] The optical line sensor 110 includes a reflection light source 111, a condenser 112, and a light receiving unit 113. The reflection light source 111 emits light at predetermined wavelengths (invisible light such as infrared light and visible light such as single-color light of red, green, blue, or the like, or white light) to the upper surface of a banknote BN. The condenser 112 gathers light emitted from the reflection light source 111 and reflected on the banknote BN. The light receiving unit 113 includes a plurality of light receiving elements (not illustrated) arranged in line along the direction (main scanning direction) perpendicular to the direction (subscanning direction) of transporting a banknote BN, and converts the light gathered by the condenser 112 into an electric signal. The optical line sensor 110 converts the electric signal generated by conversion by the light receiving unit 113 into a digital signal and outputs this digital signal.

[0052] The optical line sensor 120 includes a reflection light source 121, a condenser 122, a light receiving unit 123, and a transmission light source 124. The reflection light source 121 and the transmission light source 124 each emit light at predetermined wavelengths (invisible light such as infrared light and visible light such as single-color light of red, green, blue, or the like, or white light) to the lower surface of a banknote BN. The condenser 122 gathers light emitted from the reflection light source 121 and reflected on the banknote BN. The light receiving unit 123 includes a plurality of light receiving elements (not illustrated) arranged in line along the direction perpendicular to the direction of transporting a banknote BN, and converts the light gathered by the condenser 122 into an electric signal. The optical line sensor 120 converts the electric signal generated by conversion by the light receiving unit 123 into a digital signal and outputs this digital signal.

[0053] The transmission light source 124 is placed on the optical axis of the condenser 112 of the optical line sensor 110. Part of the light emitted from the transmission light source 124 passes through the banknote BN, gathered by the condenser 112 of the optical line sensor 110, and detected by the light receiving unit 113.

[0054] The optical line sensors 110 and 120 each repetitively image a banknote BN (expose the light receiving elements to light) under transport in the transport direction at predetermined time intervals and output a signal. Thereby, the image acquisition unit 21 can acquire an image of the whole banknote BN (image acquisition step). Specifically, the image acquisition unit 21 acquires a reflection image of the upper surface of the banknote BN and a transmission image of the banknote BN based on the output signal from the optical line sensor 110 and acquires a reflection image of the lower surface of the banknote BN based on the output signal from the optical line sensor 120. The image acquisition unit 21 acquires as reflection images of the banknote BN an infrared reflection image of the upper surface of the banknote BN and an infrared reflection image of the lower surface of the banknote BN. The image acquisition unit 21 further acquires as a transmission image of the banknote BN an infrared transmission image of the banknote BN.

<Structure of authenticity determination unit>

[0055] The structure (function) of the authenticity determination unit 12 is described with reference to Figs. 5 and 6. As illustrated in Fig. 3, the authenticity determination unit 12 includes a first determination unit 12a, a second determination unit 12b, and a main determination unit 12c.

[0056] As illustrated in Fig. 5, the first determination unit 12a executes a first determination processing (first determination step) of comparing an infrared reflection image 210 as a first infrared image of a banknote (the whole printed area) with a reference data set for an infrared reflection image as a first reference data set (a reference data set for an infrared reflection image corresponding to the denomination recognized by the recognition unit 11) to determine whether the infrared reflection image 210 includes an abnormal area 211 that is outside a tolerance relative to the reference data set for an infrared reflection image. This enables detection of a soiled portion due to oil stain, a locally soiled portion, and/or a counterfeit portion as an abnormal area 211.

[0057] Specifically, the first determination unit 12a compares the pixel value of each pixel of the infrared reflection image 210 with the respective reference value included in the reference data set for an infrared reflection image and, in a case that a pixel having a pixel value smaller than the reference value is present, determines the area including such a pixel as an abnormal area 211.

[0058] As illustrated in Fig. 6, in a case that the infrared reflection image 210 includes one or more abnormal areas 211, the second determination unit 12b executes, on

an infrared transmission image 220 as a second infrared image of the banknote (the whole printed area), a second determination processing (second determination step) of comparing each of one or more determination target areas 221 corresponding to the one or more abnormal areas 211 with a reference data set for an infrared transmission image as a second reference data set (a reference data set for an infrared transmission image corresponding to the denomination recognized by the recognition unit 11) to determine whether each determination target area 221 is within a tolerance relative to the reference data set for an infrared transmission image. This enables determination of whether each of the abnormal areas 211 and the determination target areas 221 is a soiled portion due to oil stain.

[0059] Specifically, the second determination unit 12b determines one or more areas in the infrared transmission image 220 corresponding to the one or more abnormal areas 211 (i.e., one or more areas at the same positions as the one or more abnormal areas 211) as the determination target areas 221. The second determination unit 12b then compares the pixel value of each pixel of each determination target area 221 with the respective reference value included in the reference data set for an infrared transmission image to determine that the determination target area 221 is within the tolerance relative to the reference data set for an infrared transmission image in a case that the pixel value of each pixel is greater than the respective reference value, while it determines that the determination target area 221 is not within the tolerance relative to the reference data set for an infrared transmission image in a case that the pixel value of each pixel is not higher than the respective reference value.

[0060] When the second determination unit 12b determines that at least one determination target area 221 is within the tolerance relative to the reference data set for an infrared transmission image, the main determination unit 12c executes authenticity determination processing (main determination step) on the infrared reflection image 210 at least excluding one or more abnormal areas 211 corresponding to the one or more determination target areas 221 determined as being within the tolerance. This enables authenticity determination on an area excluding a soiled portion due to oil stain in a case that the abnormal area 211 is such a portion, capable of reducing misdetermination of a soiled note due to oil stain as a counterfeit note.

[0061] Specifically, in a case that the second determination unit 12b determines that at least one determination target area 221 is within the tolerance relative to the reference data set for an infrared transmission image, the main determination unit 12c defines an area at least excluding one or more abnormal areas 211 in the infrared reflection image 210 corresponding to the one or more determination target areas 221 determined as being within the tolerance (i.e., one or more areas at the same positions as the one or more determination target areas 221) as an authenticity determination area to be proc-

essed in authenticity determination processing. The main determination unit 12c then executes authenticity determination processing on the authenticity determination area by a common method. For example, in an example illustrated in Figs. 5 and 6, the abnormal area 211 on the right side of the infrared reflection image 210 is excluded from the authenticity determination area because the pixel value of each pixel of the corresponding determination target area 221 on the right side of the infrared transmission image 220 is greater than the respective reference value.

[0062] When the second determination unit 12b determines that at least one determination target area 221 is not within the tolerance relative to the reference data set for an infrared transmission image, the main determination unit 12c executes the following processing. Specifically, the main determination unit 12c compares the size of each of one or more abnormal areas 211 corresponding to the one or more determination target areas 221 determined as being not within the tolerance with the size reference value stored in the storage unit 30. When the size of an abnormal area 211 is smaller than the size reference value, the main determination unit 12c executes authenticity determination processing (second main determination step) on the infrared reflection image 210 at least excluding this abnormal area 211. This enables authenticity determination on an area excluding a locally soiled portion having a small size in a case that the abnormal area 211 is such a portion, capable of reducing misdetermination of a soiled note due to local soil as a counterfeit note.

[0063] More specifically, in a case that the second determination unit 12b determines that at least one determination target area 221 is not within the tolerance relative to the reference data set for an infrared transmission image, the main determination unit 12c specifies one or more abnormal areas 211 corresponding to the one or more determination target areas 221 determined as being not within the tolerance (i.e., one or more areas at the same portions as the one or more determination target areas 221) and calculates the size of each area. The main determination unit 12c compares the calculated size of each abnormal area 211 with the size reference value stored in the storage unit 30. When the size of an abnormal area 211 is smaller than the size reference value, the main determination unit 12c determines the area excluding this abnormal area 211 (the abnormal area having a size smaller than the size reference value) in the infrared reflection image 210 as the authenticity determination area. The main determination unit 12c then executes authenticity determination processing on the authenticity determination area by a common method. For example, in an example illustrated in Figs. 5 and 6, the pixel value of each pixel of the determination target areas 221 at the center and on the left side of the infrared transmission image 220 is not higher than the respective reference value, but the size of each corresponding abnormal area 211 on the left side in the infrared reflection

image 210 is smaller than the size reference value. Thus, these abnormal areas 211 are excluded from the authenticity determination area. In contrast, the size of the corresponding abnormal area 211 at the center in the infrared reflection image 210 is not smaller than the size reference value. Thus, this abnormal area 211 is not excluded from the authenticity determination area.

[0064] Calculation of the size of each abnormal area 211 by the second determination unit 12b may be performed by a method in which the infrared reflection image 210 is binarized, followed by filtering or labelling, and the number of pixels constituting each abnormal area 211 is calculated, for example.

[0065] In the case of filtering, for example, the infrared reflection image 210 is first binarized and the binarized banknote area is subjected to black-white inversion. Thereby, as illustrated in the upper case of Fig. 7, portions having a low infrared reflection output, i.e., suspected as being counterfeit, become white pixels. Then, a predetermined filtering operation is performed. The pixel values of the respective pixels are compared with a predetermined threshold. Pixels exceeding the threshold are determined as counterfeit pixels and the number thereof is counted. Provided that the threshold is set to 3, for example, the four pixels at the center in the left case of Fig. 7 are within the tolerance of the threshold and no counterfeit pixel is detected. In contrast, the four pixels at the center in the right case of Fig. 7 are outside the tolerance of the threshold and detected as counterfeit pixels.

<Banknote recognition processing>

[0066] The processing by the banknote recognition unit 1 is described with reference to Fig. 8. This processing is performed on banknotes fed into the banknote recognition unit 1 one by one in a repetitive manner.

[0067] As a banknote is fed into the banknote recognition unit 1 (S11: YES), the recognition unit 11 recognizes, as described above, the denomination of the banknote based on images of the upper and lower surfaces of the banknote acquired by the image acquisition unit 21 and a template for denomination recognition (S12).

[0068] Then, as described above, the first determination unit 12a executes a first determination processing of comparing the infrared reflection image (first infrared image) 210 of the banknote with a reference data set for an infrared reflection image (first reference data set) corresponding to the denomination recognized in Step S12 to determine whether the infrared reflection image 210 includes an abnormal area 211 that is outside a tolerance relative to the reference data set for an infrared reflection image (S13).

[0069] When the infrared reflection image 210 includes one or more abnormal areas 211, as described above, the second determination unit 12b executes a second determination processing of comparing one or more determination target areas 221 in the infrared transmission

image (second infrared image) 220 of the banknote corresponding to the one or more abnormal areas 211 with a reference data set for an infrared transmission image (second reference data set) corresponding to the denomination recognized in Step S12 to determine whether each determination target area 221 is within a tolerance relative to the reference data set for an infrared transmission image (S14).

[0070] When at least one determination target area 221 is determined as being within the tolerance relative to the reference data set for an infrared transmission image in Step S14, the main determination unit 12c excludes, as described above, one or more abnormal areas 211 corresponding to the one or more determination target areas 221 determined as being within the tolerance from the authenticity determination area of the infrared reflection image 210 (S15).

[0071] When at least one determination target area 221 is determined as being not within the tolerance relative to the reference data set for an infrared transmission image in Step S14, the size of each of one or more abnormal areas 211 corresponding to the one or more determination target areas 221 determined as being not within the tolerance is compared with the size reference value. When the size of an abnormal area 211 is smaller than the size reference value, this abnormal area 211 is also excluded from the authenticity determination area of the infrared reflection image 210 (S15).

[0072] Then, as described above, the main determination unit 12c executes authenticity determination processing on the authenticity determination area defined in Step S15 to determine the authenticity of the banknote (S16).

[0073] The processing relating to the authenticity determination through Steps S13 to S16 is performed on both the upper surface and the lower surface of the banknote.

[0074] In other words, the aforementioned authenticity determination processing based on the infrared reflection image 210 of the upper surface of the banknote and the infrared transmission image 220 of the banknote is performed and the aforementioned authenticity determination processing based on the infrared reflection image 210 of the lower surface of the banknote and the infrared transmission image 220 of the banknote is performed.

[0075] The authenticity determination unit 12 matches each of the detection signal from the magnetism detection unit 22 and the detection signal from the UV detection unit 23 to the respective reference data set for authenticity recognition to determine the authenticity of the banknote (S17).

[0076] When the authenticity determination results in Steps S16 and S17 each demonstrate that the banknote is genuine (S18: YES), the authenticity determination unit 12 determines the banknote as a genuine note (S19). When at least one of the authenticity determination results in Steps S16 and S17 demonstrates that the banknote is counterfeit (S18: NO), the authenticity determi-

nation unit 12 determines the banknote as a counterfeit note (S20).

[0077] When the banknote is determined as a genuine note, the fitness determination unit 13 determines the fitness of the banknote (S21).

[0078] Then, the control unit 10 feeds the banknote after the authenticity determination and the fitness determination out of the banknote recognition unit 1 (S22), completing the processing by the banknote recognition unit 1.

[0079] As described above, in the present embodiment, the first determination unit 12a detects, as an abnormal area 211, a portion suspected as being counterfeit based on the infrared reflection image 210 of a banknote; the second determination unit 12b determines whether the determination target area 221 corresponding to the abnormal area 211 is a soiled portion due to oil stain based on the infrared transmission image 220; and in a case that the determination target area 221 is determined as a soiled portion due to oil stain, the main determination unit 12c executes authenticity determination processing on an authenticity determination area at least excluding the abnormal area 211 in the infrared reflection image 210. This can reduce misdetermination of a soiled note due to oil stain as a counterfeit note.

[0080] Further, in the present embodiment, even in a case that the second determination unit 12b determines the determination target area 221 as a counterfeit portion, the main determination unit 12c determines whether the abnormal area 211 is a locally soiled portion based on the size of the abnormal area 211 corresponding to the determination target area 221. When the abnormal area 211 is a locally soiled portion, the main determination unit 12c executes authenticity determination processing with the abnormal area 211 also being excluded from the authenticity determination area. This can reduce misdetermination of a soiled note due to local soil as a counterfeit note.

[0081] Described in the above embodiment is the case where the determination is performed first on the infrared reflection image 210 and then on the infrared transmission image 220, i.e., the case where the first infrared image is the infrared reflection image 210, the first determination unit 12a compares the infrared reflection image 210 with the reference data set for an infrared reflection image, the second infrared image is the infrared transmission image 220, and the second determination unit 12b compares the determination target area 221 of the infrared transmission image 220 with the reference data set for an infrared transmission image. Alternatively, the determination may be performed first on the infrared transmission image 220 and then on the infrared reflection image 210. In other words, the first infrared image may be the infrared transmission image 220, the first determination unit 12a may compare the infrared transmission image 220 with the reference data set for an infrared transmission image, the second infrared image may be the infrared reflection image 210, and the second deter-

mination unit 12b may compare the determination target area of the infrared reflection image 210 with the reference data set for an infrared reflection image. This case is fundamentally the same as the case where the determination is performed first on the infrared reflection image 210 and then on the infrared transmission image 220, except that the order of the processes is inverted. For example, the following processes (1) to (3) may be performed in the stated order:

- (1) a first determination of comparing the infrared transmission image 220 with the reference data set for an infrared transmission image to determine whether the infrared transmission image 220 includes an abnormal area that is outside the tolerance relative to the reference data set for an infrared transmission image;
- (2) a second determination of comparing, in a case that the infrared transmission image 220 includes an abnormal area, a determination target area of the infrared reflection image 210 corresponding to the abnormal area with the reference data set for an infrared reflection image to determine whether the determination target area is within the tolerance relative to the reference data set for an infrared reflection image; and
- (3) authenticity determination processing on an area at least excluding the abnormal area of the infrared transmission image 220 in a case that the second determination demonstrates that the determination target area is within the tolerance relative to the reference data set for an infrared reflection image.

[0082] As described hereinabove, embodiments of the present invention are described with reference to the drawings. Still, the above embodiments are not intended to limit the present invention. The structures of the embodiments may be combined or modified as appropriate within the spirit of the present invention.

INDUSTRIAL APPLICABILITY

[0083] As described above, the present invention provides a technique useful for reducing misdetermination of determining a soiled note as a counterfeit note using a banknote recognition unit and in a banknote recognition method.

REFERENCE SIGNS LIST

[0084]

- 1: banknote recognition unit
- 10: control unit
- 11: recognition unit
- 12: authenticity determination unit
- 12a: first determination unit
- 12b: second determination unit

- 12c: main determination unit
- 13: fitness determination unit
- 20: detection unit
- 21: image acquisition unit
- 5 22: magnetism detection unit
- 23: UV detection unit
- 30: storage unit
- 110, 120: optical line sensor
- 111, 121: reflection light source
- 10 112, 122: condenser
- 113, 123: light receiving unit
- 124: transmission light source
- 210: infrared reflection image
- 211: abnormal area
- 15 220: infrared transmission image
- 221: determination target area
- 300: banknote handling device
- 301: hopper
- 302: rejection unit
- 20 303: operation unit
- 305: display
- 306a to 306d: stacking unit
- 310: housing
- 25 311: transport path
- BN: banknote

Claims

- 30 1. A banknote recognition unit (1) for recognizing a banknote, comprising:

an image acquisition unit (21) configured to acquire an infrared reflection image (210) and an infrared transmission image (220) of a banknote (BN);

a storage unit (30) configured to store a reference data set for an infrared reflection image and a reference data set for an infrared transmission image each based on a fit banknote;

a first determination unit (12a) configured to compare a first infrared image (210, 220) with a first reference data set to determine whether the first infrared image (210, 220) includes an abnormal area (211) that is outside a tolerance relative to the first reference data set, the first infrared image (210, 220) being one selected from the infrared reflection image (210) and the infrared transmission image (220) each acquired by the image acquisition unit, and the first reference data set being one selected from the reference data set for an infrared reflection image and the reference data set for an infrared transmission image;

a second determination unit (12b) configured to compare, in a case that the first infrared image (210, 220) includes the abnormal area (211), a

- determination target area (221) of a second infrared image (210, 220) with a second reference data set to determine whether the determination target area (221) is within a tolerance relative to the second reference data set, the determination target area (221) being an area corresponding to the abnormal area (211), the second infrared image (210, 220) being the other of the infrared reflection image and the infrared transmission image, and the second reference data set being the other of the reference data set for an infrared reflection image and the reference data set for an infrared transmission image; and a main determination unit (12c) configured to execute authenticity determination processing on an area at least excluding the abnormal area (211) of the first infrared image (210, 220) in a case that the second determination unit (12b) determines that the determination target area (221) is within the tolerance relative to the second reference data set.
2. The banknote recognition unit according to claim 1, wherein
the storage unit (30) further stores a reference value of a size of the abnormal area (211), and in a case that the first infrared image (210, 220) includes the abnormal area (221) and the second determination unit (12b) determines that the determination target area (221) is not within the tolerance relative to the second reference data set, the main determination unit (12c) is configured to compare the size of the abnormal area (211) with the reference value stored in the storage unit and to execute, in a case that the size of the abnormal area (211) is smaller than the reference value, authenticity determination processing on an area at least excluding the abnormal area (211) of the first infrared image.
 3. The banknote recognition unit according to claim 1 or 2, wherein
the first infrared image (210, 220) is the infrared reflection image (210),
the first determination unit (12a) is configured to compare the infrared reflection image (210) with the reference data set for an infrared reflection image,
the second infrared image (210, 220) is the infrared transmission image (220), and
the second determination unit (12b) is configured to compare the determination target area (221) of the infrared transmission image (220) with the reference data set for an infrared transmission image.
 4. The banknote recognition unit according to claim 3, wherein
the reference data set for an infrared reflection image includes a reference value of a pixel value of each pixel of the infrared reflection image,
- the reference data set for an infrared transmission image includes a reference value of a pixel value of each pixel of the infrared transmission image,
the first determination unit (12a) is configured to determine, as the abnormal area (211), an area including pixels each having a pixel value smaller than the respective reference value that is included in the reference data set for an infrared reflection image in the infrared reflection image, and
the second determination unit (12b) is configured to determine that the determination target area (221) is within the tolerance relative to the reference data set for an infrared transmission image in a case that the pixel value of each pixel of the determination target area (221) is greater than the respective reference value that is included in the reference data set for an infrared transmission image.
5. The banknote recognition unit according to claim 1 or 2, wherein
the first infrared image (210, 220) is the infrared transmission image (220),
the first determination unit (12a) is configured to compare the infrared transmission image (220) with the reference data set for an infrared transmission image,
the second infrared image (210, 220) is the infrared reflection image (210), and
the second determination unit (12b) is configured to compare the determination target area (221) of the infrared reflection image with the reference data set for an infrared reflection image.
 6. A banknote handling device comprising the banknote recognition unit according to any one of claims 1 to 5.
 7. A banknote recognition method for recognizing a banknote, comprising:

an image acquisition step (S12) of acquiring an infrared reflection image (210) and an infrared transmission image (220) of a banknote (BN);
a first determination step (S13) of comparing a first infrared image (210, 220) with a first reference data set to determine whether the first infrared image (210, 220) includes an abnormal area (211) that is outside a tolerance relative to the first reference data set, the first infrared image (210, 220) being one selected from the infrared reflection image (210) and the infrared transmission image (220) each acquired in the image acquisition step (S12), and the first reference data set being one selected from a reference data set for an infrared reflection image and a reference data set for an infrared transmission image each based on a fit banknote;
a second determination step (S14) of compar-

ing, in a case that the first infrared image (210, 220) includes the abnormal area (211), a determination target area (221) of a second infrared image (210, 220) with a second reference data set to determine whether the determination target area (221) is within a tolerance relative to the second reference data set, the determination target area (221) being an area corresponding to the abnormal area, the second infrared image (210, 220) being the other of the infrared reflection image (210) and the infrared transmission image, and the second reference data set being the other of the reference data set for an infrared reflection image and the reference data set for an infrared transmission image; and a main determination step (S16-S21) of executing authenticity determination processing on an area at least excluding the abnormal area (211) of the first infrared image (210, 220) in a case that the determination target area (221) is determined as being within the tolerance relative to the second reference data set in the second determination step (S14).

8. The banknote recognition method according to claim 7, wherein

in a case that the first infrared image (210, 220) includes the abnormal area (221) and the second determination step (S14) determines that the determination target area (221) is not within the tolerance relative to the second reference data set, the main determination step (S16-S21) includes comparing a size of the abnormal area (211) with a reference value of the size of the abnormal area and executing, in a case that the size of the abnormal area (211) is smaller than the reference value, authenticity determination processing on an area at least excluding the abnormal area (211) of the first infrared image.

9. The banknote recognition method according to claim 7 or 8, wherein

the first infrared image (210, 220) is the infrared reflection image (210), the first determination step (S13) includes comparing the infrared reflection image (210) with the reference data set for an infrared reflection image, the second infrared image (210, 220) is the infrared transmission image (220), and the second determination step (S14) includes comparing the determination target area (221) of the infrared transmission image (220) with the reference data set for an infrared transmission image.

10. The banknote recognition method according to claim 9, wherein

the reference data set for an infrared reflection image includes a reference value of a pixel value of each pixel of the infrared reflection image,

the reference data set for an infrared transmission image includes a reference value of a pixel value of each pixel of the infrared transmission image, the first determination step (S13) includes determining, as the abnormal area (211), an area including pixels each having a pixel value smaller than the respective reference value that is included in the reference data set for an infrared reflection image in the infrared reflection image, and the second determination step (S14) includes determining that the determination target area (221) is within the tolerance relative to the reference data set for an infrared transmission image in a case that the pixel value of each pixel of the determination target area (221) is greater than the respective reference value that is included in the reference data set for an infrared transmission image.

11. The banknote recognition unit according to claim 7 or 8, wherein

the first infrared image (210, 220) is the infrared transmission image (220), the first determination step (S13) includes comparing the infrared transmission image (220) with the reference data set for an infrared transmission image, the second infrared image (210, 220) is the infrared reflection image (210), and the second determination step (S14) includes comparing the determination target area (221) of the infrared reflection image with the reference data set for an infrared reflection image.

FIG. 1

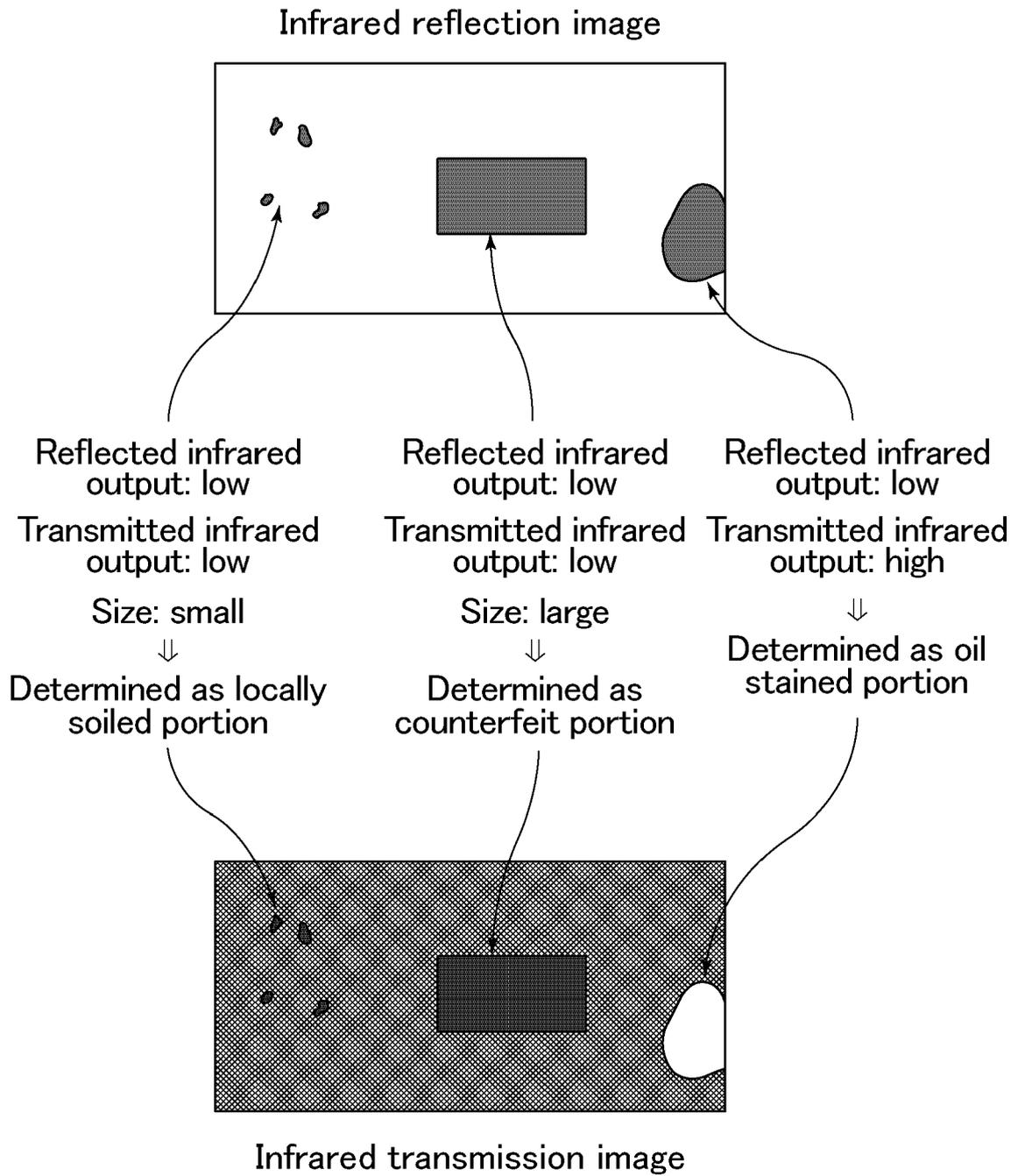


FIG. 2

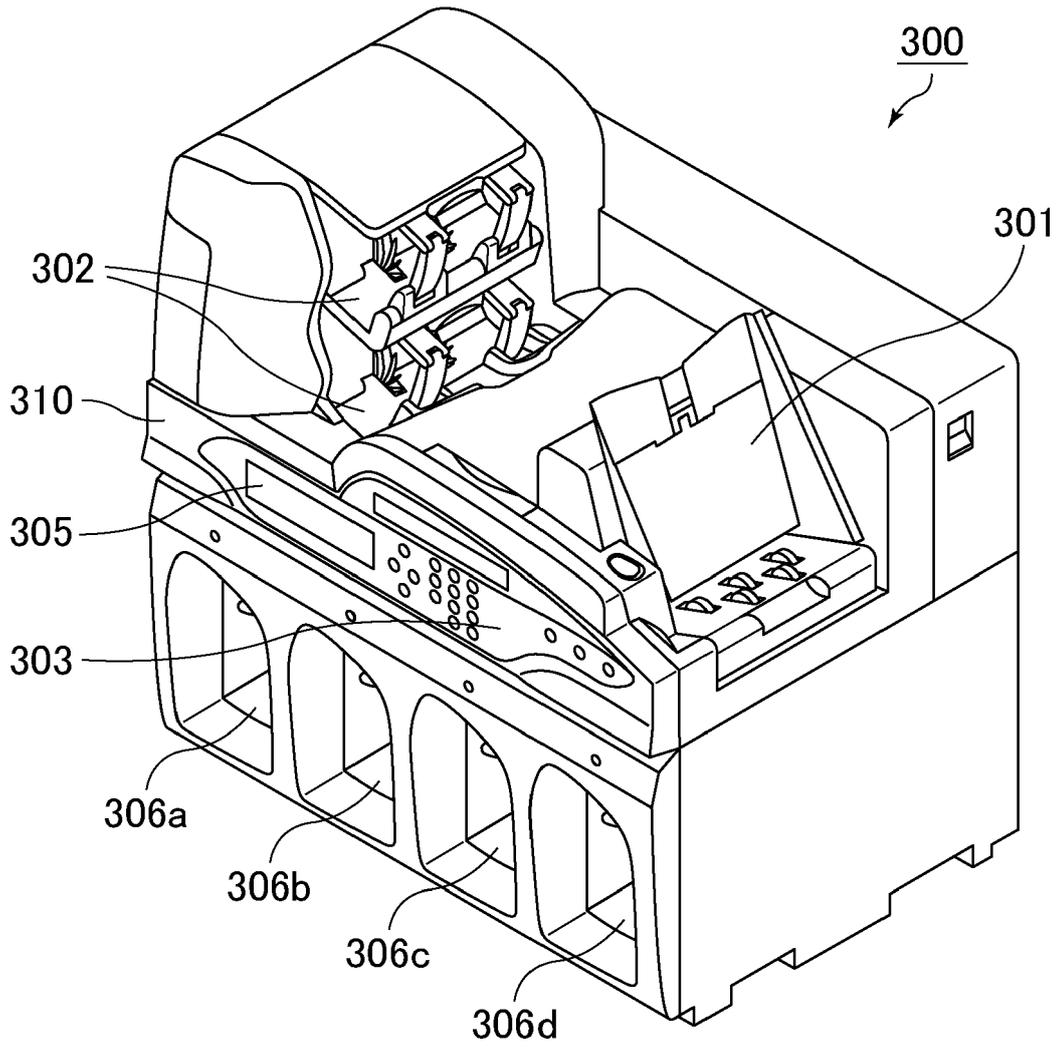


FIG. 3

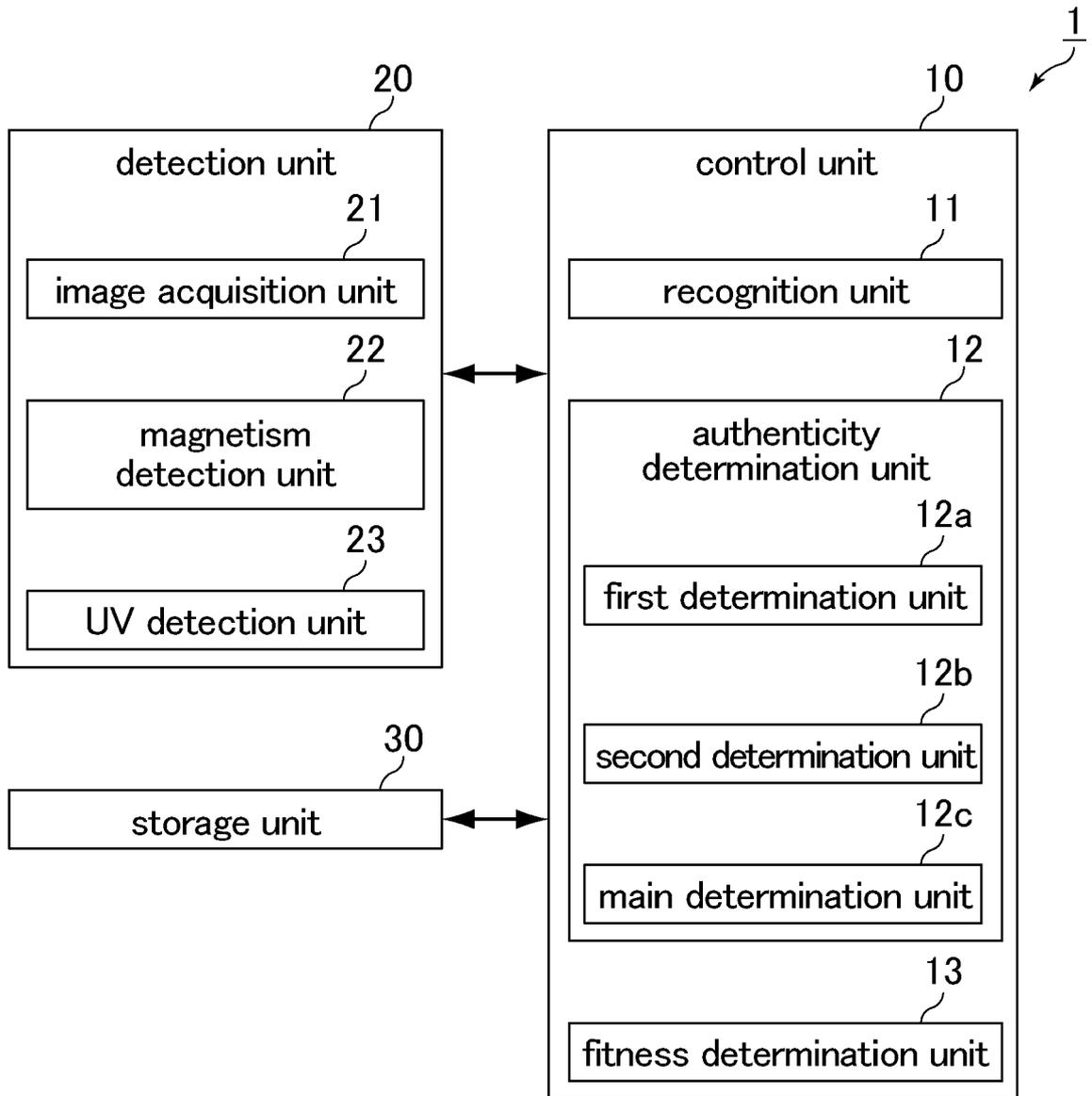


FIG. 4

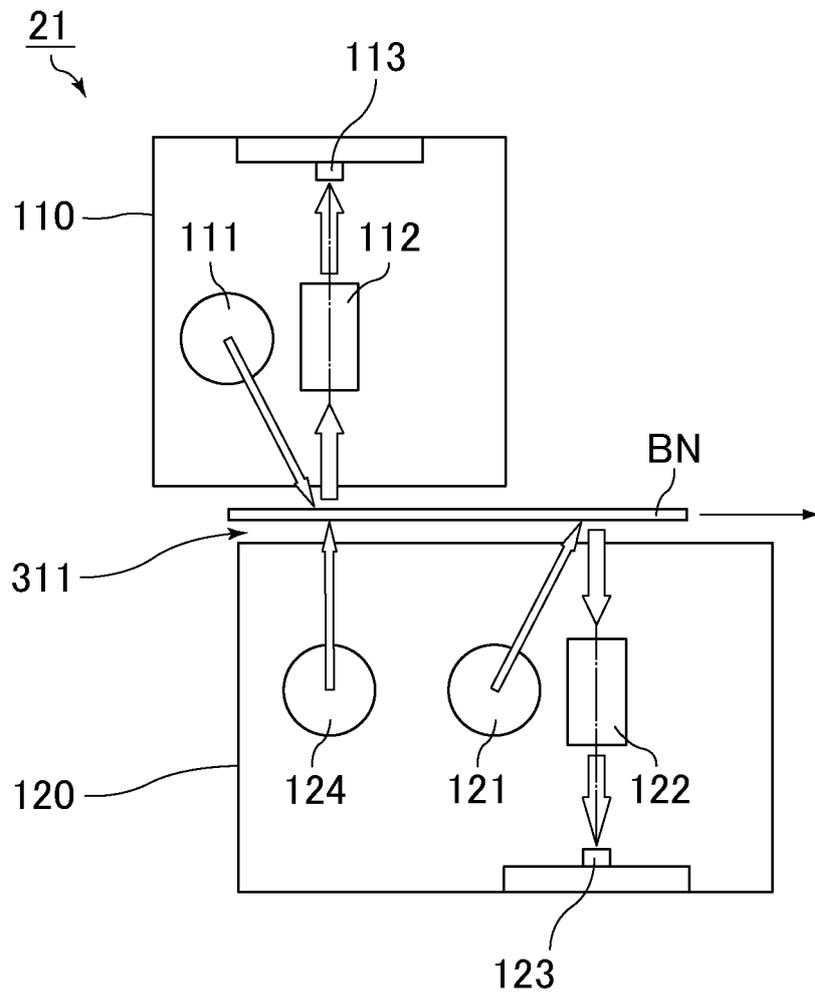


FIG. 5

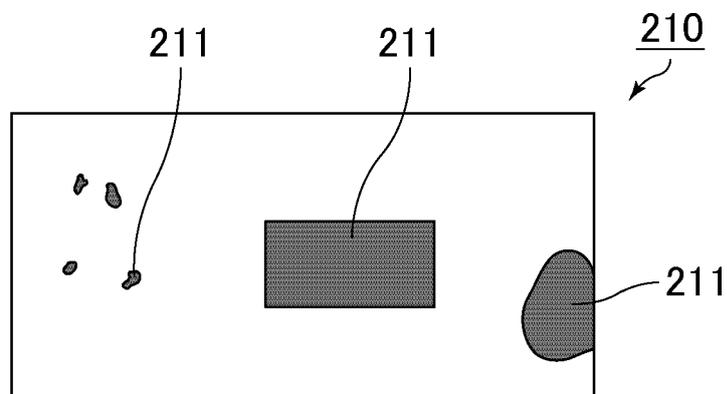


FIG. 6

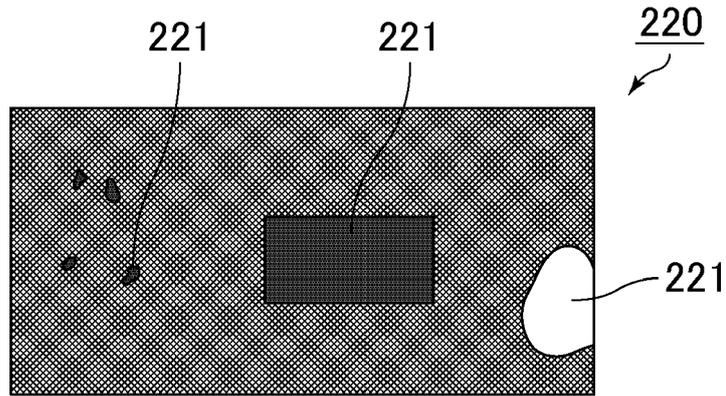


FIG. 7

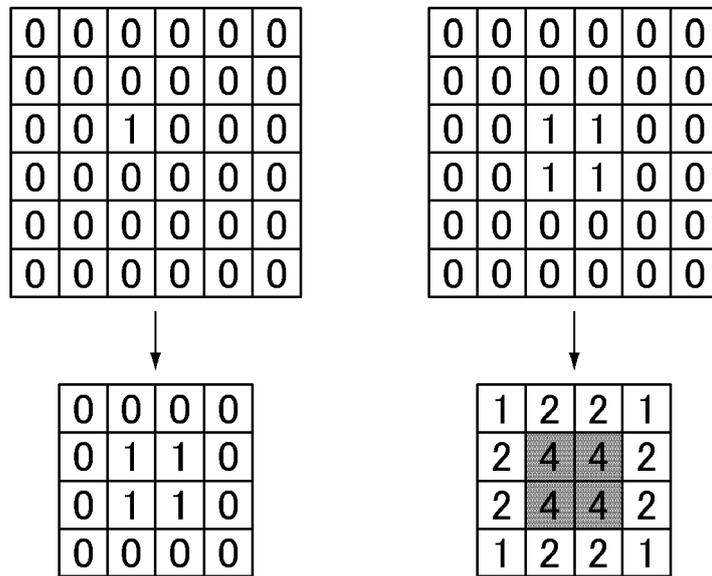
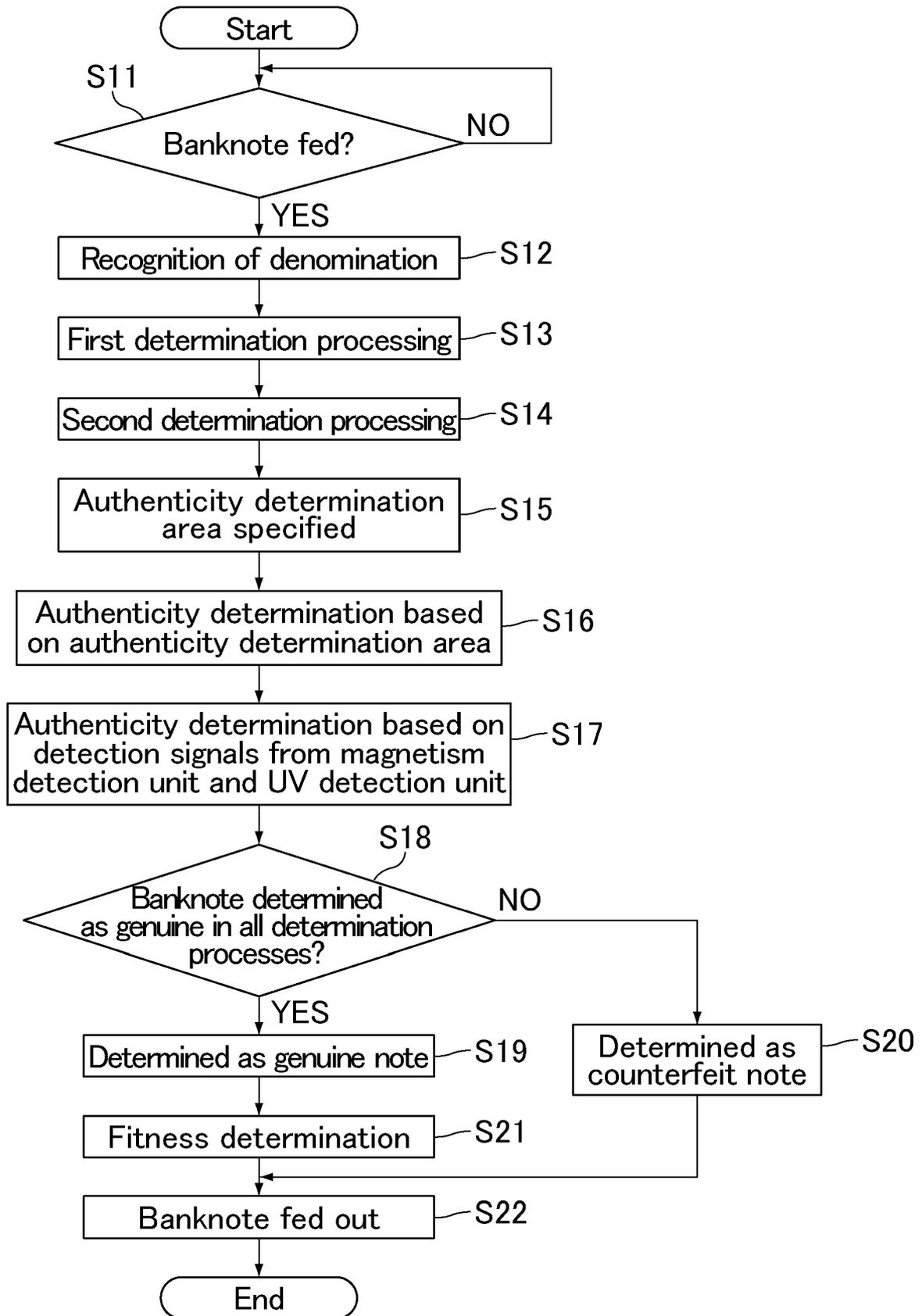


FIG.8





EUROPEAN SEARCH REPORT

Application Number
EP 20 16 5227

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/247308 A1 (MIAO MIKE [US] ET AL) 30 August 2018 (2018-08-30) * paragraph [0011] - paragraph [0039] * * figures 3-5 * -----	1-11	INV. G07D7/12 G07D7/187 G07D7/185 G07D7/20
A	CN 105 096 446 B (SHENZHEN YIHUA COMP CO LTD ET AL.) 5 December 2017 (2017-12-05) * paragraph [0001] - paragraph [0022] * -----	1-11	
			TECHNICAL FIELDS SEARCHED (IPC)
			G07D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 1 September 2020	Examiner Seifi, Mozhdeh
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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ON EUROPEAN PATENT APPLICATION NO.**

EP 20 16 5227

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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01-09-2020

10	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
15	US 2018247308 A1	30-08-2018	CN 108520586 A EP 3367347 A1 US 2018247308 A1	11-09-2018 29-08-2018 30-08-2018
20	CN 105096446 B	05-12-2017	NONE	
25				
30				
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40				
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Patent documents cited in the description

- JP H0690750 B [0003] [0009]
- JP 2006202075 A [0004] [0010]