US Patent & Trademark Office
Patent Public Search | Text View

United States Patent Application Publication 20250267219
Kind Code A1
Publication Date August 21, 2025
Inventor(s) NAKAYOSHI; ASAHIRO

IMAGE FORMING APPARATUS

Abstract

An image forming apparatus includes an image forming circuit that forms a chart image on a first sheet, a reader that reads the formed chart image, and a controller. If an inclination amount of the first sheet is greater than a first amount and is less than a second amount greater than the first amount, the controller performs a rotation correction on the read image to reduce the inclination amount, and stores an image of a first sheet area in the image after the correction, in a memory. If the inclination amount is less than the first amount, the controller stores an image of a predetermined area including the first sheet area, in the memory without the correction. The image forming circuit forms an image on a second sheet so as to reduce a difference in position between the stored image and an image used to form the chart image.

Inventors: **NAKAYOSHI; ASAHIRO (Chiba, JP)**

Applicant: **CANON KABUSHIKI KAISHA** (Tokyo, JP)

Family ID: **1000008578068**

Appl. No.: **19/201428**

Filed: **May 07, 2025**

Foreign Application Priority Data

JP	2022-156132	Sep. 29, 2022

Related U.S. Application Data

parent US continuation 18476160 20230927 parent-grant-document US 12323562 child US 19201428

Publication Classification

Int. Cl.: **H04N1/00** (20060101)

U.S. Cl.:

CPC **H04N1/00005** (20130101); **H04N1/00013** (20130101); **H04N1/00037** (20130101); **H04N1/00074** (20130101); **H04N1/00082** (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application is a continuation of U.S. patent application Ser. No. 18/476,160, filed on Sep. 27, 2023, which claims priority from Japanese Patent Application No. 2022-156132, filed Sep. 29, 2022, which are hereby incorporated by reference herein in their entireties.

BACKGROUND
Technical Field
[0002] One disclosed aspect of the embodiments relates to an image forming apparatus including an image reader that reads a chart image used to adjust a position of an image to be formed on a sheet.
Description of the Related Art
[0003] Conventionally, there is known a technique in which a chart image formed on a recording medium by an image forming apparatus is read by an image reader, and a position of an image to be formed on a recording medium is adjusted based on a result of the reading. Japanese Patent Application Laid-Open No. 2015-29186 discusses a configuration in which a chart image formed on a recording medium by an image forming apparatus is read while the recording medium is conveyed by a document feeder provided on an upper part of the image forming apparatus. According to the configuration discussed in Japanese Patent Application Laid-Open No. 2015-29186, trimming processing is performed on an image obtained by reading the chart image so that the trimmed image includes an edge portion of a document, thereby creating image data that includes a part of a document image and a part of an out-of-document image. Such a configuration enables the trimmed image to include corners of the document, for example, even in a case where the document is read in an inclined state as illustrated in FIG. **11**.
[0004] Conventionally, there is also known a configuration in which a shadow of a leading edge of a document in a conveyance direction is detected from image data representing a reading result, and a rotation correction is performed on the image data based on an inclination angle of the detected shadow of the leading edge of the document relative to a main scanning direction as discussed in United States Patent Application Publication No. 20170126929.
[0005] According to the configuration discussed in Japanese Patent Application Laid-Open No. 2015-29186, a blank part other than the document image is included in the trimmed image, which increases a required capacity of an image memory storing the image data.
[0006] In a case where the rotation correction discussed in United States Patent Application Publication No. 20170126929 is performed on the read chart image, the following issues may occur. More specifically, for example, when the rotation correction is performed on the read chart image, an image output after the rotation correction may be coarse. The image after the rotation correction becomes coarser as a rotation angle in the rotation correction increases. As a result, adjustment accuracy of the position of the image to be formed on the recording medium may be lowered.
SUMMARY
[0007] The disclosure is directed to a technique for preventing the adjustment accuracy of the

position of the image to be formed on a sheet from being lowered while suppressing an increase in capacity of the memory storing the image data.

[0008] According to an aspect of the embodiments, an image forming apparatus includes an image forming circuit, a reader, and a controller. The image forming circuit is configured to form, on a first sheet, a chart image used to adjust a position of an image. The reader is configured to read the chart image on the first sheet while the first sheet is conveyed. The controller is configured to determine, based on an image obtained by the reader reading the chart image, an inclination amount corresponding to an inclination angle of a leading edge of the first sheet in a conveyance direction in which the first sheet is conveyed, relative to a predetermined direction orthogonal to the conveyance direction. In a case where the inclination amount is greater than a first predetermined amount and is less than a second predetermined amount greater than the first predetermined amount, the controller is configured to perform a rotation correction on the image obtained by the reader to reduce the inclination amount, and cut out and store an image of an area of the first sheet in the image subjected to the rotation correction in a memory. In a case where the inclination amount is less than the first predetermined amount, the controller is configured to cut out and store an image of a predetermined area including the area of the first sheet in the image obtained by the reader, in the memory without performing the rotation correction. The predetermined area has a size smallest among standard sizes including the area of the first sheet. The image forming circuit forms an image on a second sheet so as to reduce a difference in position between the image stored in the memory and an image used to form the chart image on the first sheet.

[0009] Further features of the disclosure will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a diagram illustrating a configuration of an image forming apparatus according to an exemplary embodiment.

[0011] FIG. **2** is a block diagram illustrating a control configuration of the image forming apparatus according to the exemplary embodiment.

[0012] FIG. **3** is a diagram illustrating acquisition timings of image data to be stored in an image memory according to the exemplary embodiment.

[0013] FIGS. **4**A and **4**B are diagrams illustrating processing by an edge detection unit according to the exemplary embodiment.

[0014] FIG. **5** is a diagram illustrating an image represented by binary data input to a document information determination unit according to the exemplary embodiment.

[0015] FIG. **6** is a diagram illustrating an image read out by a correction unit according to the exemplary embodiment.

[0016] FIGS. **7**A and **7**B are diagrams illustrating an adjustment chart according to the exemplary embodiment.

[0017] FIG. **8** is a diagram illustrating a notification indicating occurrence of an error in reading a document image according to the exemplary embodiment.

[0018] FIG. **9** is a flowchart illustrating processing performed by a system controller according to the exemplary embodiment.

[0019] FIG. **10** is a flowchart illustrating processing for reading a chart image according to the exemplary embodiment.

[0020] FIG. **11** is a diagram illustrating an image obtained by reading an image of an inclined document.

DESCRIPTION OF THE EMBODIMENTS

[0021] An exemplary embodiment of the disclosure will be described below with reference to the drawings. Shapes, relative arrangements, and the like of components described in the exemplary embodiment can be changed as appropriate based on a configuration of an apparatus to which the exemplary embodiment is applied and various conditions, and the scope of the disclosure is not intended to be limited to the following exemplary embodiment. In the following, the term “unit” may have different meanings depending on the context. The usual meaning is an individual element, single and complete. The phrase “units of”' may refer to a plurality of elements or a group of elements. In addition, the term “unit” may refer to a software context, a hardware context, or a combination of software and hardware contexts. In the software context, the term “unit” refers to a functionality, an application, a software module, a function, a routine, a set of instructions, or a program that can be executed by a programmable processor such as a microprocessor, a central processing unit (CPU), or a specially designed programmable device or controller. A memory contains instructions or program that, when executed by the CPU, cause the CPU to perform operations corresponding to units or functions. In the hardware context, the term “unit” refers to a hardware element, a circuit, an assembly, a physical structure, a system, a module, or a subsystem. It may include mechanical, optical, or electrical components, or any combination of them. It may include active (e.g., transistors) or passive (e.g., capacitor) components. It may include semiconductor devices having a substrate and other layers of materials having various concentrations of conductivity. It may include a CPU or a programmable processor that can execute a program stored in a memory to perform specified functions. It may include logic elements (e.g., AND, OR) implemented by transistor circuits or any other switching circuits. In the combination of software and hardware contexts, the term “unit” or “circuit” refers to any combination of the software and hardware contexts as described above. In addition, the term “element,” “assembly,” “component,” or “device” may also refer to “circuit” with or without integration with packaging materials. Furthermore, depending on the context, the term “portion,” “part,” “device,” “switch,” or similar terms may refer to a circuit or a group of circuits. The circuit or group of circuits may include electronic, mechanical, or optical elements such as capacitors, diodes, transistors. For example, a switch is a circuit that turns on and turns off a connection. It can be implemented by a transistor circuit or similar electronic devices.

Image Forming Apparatus

[0022] FIG. **1** is a cross-sectional diagram illustrating a configuration of a monochrome electrophotographic copier (hereinafter referred to as an image forming apparatus) **100** used in the present exemplary embodiment. The image forming apparatus **100** is not limited to the copier, and may be, for example, a facsimile apparatus, a printing machine, or a printer. A recording method used by the image forming apparatus **100** is also not limited to the electrophotographic method, and may be, for example, an inkjet method. The image forming apparatus **100** may be of either a monochrome type or a color type.

[0023] The configuration and functions of the image forming apparatus **100** will be described next with reference to FIG. **1**. As illustrated in FIG. **1**, the image forming apparatus **100** includes an image reader **200** including a document feeder **201** and a reader **202**, and an image printer **301**. The document feeder **201** is pivotable relative to the reader **202**.

Image Reader

[0024] A pickup roller **103** serving as a feeding unit feeds a document **101** stacked on a tray **102** serving as a stacking portion, to an inside of the document feeder **201**. Separation rollers **104** and **105** are provided to prevent a plurality of sheets of the document **101** from being fed at a time by the pickup roller **103**. The document **101** fed to a conveyance path is conveyed toward a reading position A by conveyance rollers **106** and read rollers **107**. The separation rollers **104** and **105**, the conveyance rollers **106**, and the read rollers **107** are included in a conveyance unit.

[0025] A transparent glass **108** is disposed at the reading position A, and a reading unit or circuit

109A is provided on a side of the transparent glass **108** opposite to a side of the transparent glass **108** on which the conveyance path is provided. The reading unit **109**A includes a light-emitting diode (LED) **110**, an image sensor **111**, and an optical component group **112**. The image sensor **111** includes, in a main scanning direction, a plurality of pixels configured to receive light of red (R), green (G), and blue (B).

[0026] The reading unit **109**A reads an image on a front side (a first side) of the document **101** in the following manner.

[0027] More specifically, the LED **110** serving as a light source applies (emits) light to the front side of the document **101** through the transparent glass **108**. The optical component group **112** guides reflected light from the document **101** received through the transparent glass **108**, to the image sensor **111**. The image sensor **111** outputs analog image data based on the received reflected light. The image sensor **111** reads an image corresponding to one line extending in the main scanning direction at a time. Thus, the image sensor **111** can output image data including the entire document **101** by reading the image corresponding to one line a plurality of times while the document **101** is conveyed. An analog-to-digital (A/D) conversion unit (not illustrated) in the reading unit **109**A converts the analog image data into digital image data, and outputs the digital image data to a controller **213** (see FIG. **2**).

[0028] On an upstream side of the reading position A in a conveyance direction of the document **101**, a detection sensor **113** for detecting the document **101** is provided. The controller **213** determines timing for the reading unit **109**A to start reading the document **101**, based on timing when the detection sensor **113** has detected the document **101**.

[0029] Pressing rollers **114** and **115** press the document **101** against the transparent glass **108**. At a position facing the reading unit **109**A between the pressing rollers **114** and **115**, namely, at a position opposite to the reading unit **109**A across the conveyance path where the document **101** is conveyed, a white guide plate **116** as an opposing member is disposed.

[0030] The document **101** having passed the reading position A is conveyed toward a reading position B by conveyance rollers **117**. A transparent glass **118** is disposed at the reading position B, and a reading unit or circuit **109**B is provided on a side of the transparent glass **118** opposite to a side of the transparent glass **118** on which the conveyance path is provided. The reading unit **109**B has a configuration similar to the configuration of the reading unit **109**A, and reads an image on a back side (a second side) of the document **101**. Timing for the reading unit **109**B to start reading the document **101** is also determined based on the timing when the detection sensor **113** has detected the document **101**. A white guide plate **119** is disposed at a position facing the reading unit **109**B.

[0031] The document **101** having passed the reading position B is discharged to a discharge tray **121** by discharge rollers **120**.

[0032] A white reference plate **122** serving as a reference reading member in shading data acquisition is provided on a right side of the transparent glass **108**.

Image Printer

[0033] Sheet storage trays **302** and **304** are provided inside the image printer **301**.

[0034] The sheet storage trays **302** and **304** can store different types of recording media. For example, A 4-size plain paper is stored in the sheet storage tray **302**, and A 4-size cardboard is stored in the sheet storage tray **304**. The recording media is media on which images are to be formed by the image forming apparatus **100**, and for example, a paper sheet, a resin sheet, a cloth, an overhead projector (OHP) sheet, and a label are included in the recording media.

[0035] The recording medium stored in the sheet storage tray **302** is fed by a pickup roller **303**, and is conveyed to registration rollers **308** by conveyance rollers **306**. The recording medium stored in the sheet storage tray **304** is fed by a pickup roller **305**, and is conveyed to the registration rollers **308** by conveyance rollers **307** and the conveyance rollers **306**.

[0036] Image data output from the image reader **200** is input to an optical scanner **311** including a semiconductor laser and a polygonal mirror. An outer peripheral surface of a photosensitive drum **309** is charged by a charger **310** in a charging unit **316**. After the outer peripheral surface of the photosensitive drum **309** is charged, a laser beam corresponding to the image data (the image signal) input from the image reader **200** to the optical scanner **311** is applied from the optical scanner **311** to the outer peripheral surface of the photosensitive drum **309** through the polygonal mirror and mirrors **312** and **313**. As a result, an electrostatic latent image is formed on the outer peripheral surface of the photosensitive drum **309**.

[0037] Subsequently, the electrostatic latent image is developed with toner by a developing unit **314** included in an image forming unit or circuit, so that a toner image is formed on the outer peripheral surface of the photosensitive drum **309**. The toner image formed on the photosensitive drum **309** is transferred to the recording medium by a transfer charger **315** provided at a position (a transfer position) facing the photosensitive drum **309**. The registration rollers **308** convey the recording medium to the transfer position in synchronization with transfer timing for the transfer charger **315** to transfer the toner image to the recording medium. As described below, the registration rollers **308** adjust timing for conveying the recording medium to the transfer position, based on a result of reading an adjustment chart **500** (see FIG. **7**A) by the image reader **200**.

[0038] The recording medium to which the toner image has been transferred in the above-described manner is conveyed to a fixing unit or circuit **318** by a conveyance belt **317**, and is heated and pressurized by the fixing unit **318**. As a result, the toner image is fixed to the recording medium. In this manner, image formation is performed on the recording medium by the image forming apparatus **100**.

[0039] In a case where image formation is performed in a simplex print mode, the recording medium having passed through the fixing unit **318** is discharged to a discharge tray (not illustrated) by discharge rollers **319** and **324**. In a case where image formation is performed in a duplex print mode, after fixing processing is performed on the first side of the recording medium by the fixing unit **318**, the recording medium is conveyed to an inversion path **325** by the discharge rollers **319**, conveyance rollers **320**, and inversion rollers **321**. The recording medium is then conveyed to the registration rollers **308** again via a duplex conveyance path **326** by conveyance rollers **322** and **323**, so that an image is formed on the second side of the recording medium using the above-described method. The recording medium is then discharged to the discharge tray (not illustrated) by the discharge rollers **319** and **324**.

[0040] In a case where the recording medium on which the image has been formed on the first side is discharged in a face-down state to an outside of the image forming apparatus **100**, the recording medium having passed through the fixing unit **318** is conveyed in a direction toward the conveyance rollers **320** through the discharge rollers **319**. Thereafter, the conveyance rollers **320** are inversely rotated immediately before a trailing edge of the recording medium passes through a nip portion of the conveyance rollers **320**, whereby the recording medium is discharged to the outside of the image forming apparatus **100** through the discharge rollers **324** in a state where the first side of the recording medium faces downward.

[0041] The above is the description of the configuration and the functions of the image forming apparatus **100**.

Control Configuration

[0042] FIG. **2** is a block diagram illustrating an example of a control configuration of the image forming apparatus **100**. Various functions to be described below are implemented by at least one application specific integrated circuit (ASIC).

[0043] As illustrated in FIG. **2**, a system controller **151** includes a central processing unit (CPU) **151***a*, a read only memory (ROM) **151***b*, and a random access memory (RAM) **151***c*. The system controller **151** is connected to an analog-to-digital (A/D) converter **153**, a high-voltage control unit or circuit **155**, a motor control device **600**, sensors **159**, and an alternating-current (AC) driver **160**. The system controller **151** can transmit and receive data and commands to and from each of the units connected thereto.

[0044] The CPU **151**_a_ performs various sequences relating to a predetermined image formation sequence by reading out and executing various programs stored in the ROM **151**_b_.

[0045] The RAM **151**_c_ is a storage device. The RAM **151**_c_ stores various kinds of data such as setting values for the high-voltage control unit **155** and command values for the motor control device **600**.

[0046] The system controller **151** receives signals from the sensors **159**, and sets the setting values for the high-voltage control unit **155** based on the received signals.

[0047] The high-voltage control unit **155** supplies appropriate voltages to high-voltage units **156** (e.g., the charger **310**, the developing unit **314**, and the transfer charger **315**) based on the setting values set by the system controller **151**.

[0048] The motor control device **600** controls a motor **509** for driving a load provided in the image printer **301**, in response to a command output from the CPU **151**_a_.

[0049] The A/D converter **153** receives a signal detected by a thermistor **154** that detects a temperature of a fixing heater **161**, converts the detected signal from an analog signal into a digital signal, and transmits the digital signal to the system controller **151**. The system controller **151** controls the A C driver **160** based on the digital signal received from the A/D converter **153**. The AC driver **160** controls the fixing heater **161** so that the temperature of the fixing heater **161** becomes an appropriate temperature for the fixing processing. The fixing heater **161** is a heater used for the fixing processing and is included in the fixing unit **318**.

[0050] In the above-described manner, the system controller **151** controls an operation sequence of the image forming apparatus **100**.

[0051] Next, a control configuration of the image reader **200** will be described. A CPU **203** controls the image reader **200** by executing programs stored in a nonvolatile memory **209**.

[0052] A conveyance motor **211** is a driving source for the rollers provided in the document feeder **201**, and is rotationally driven under control of the controller **213**.

[0053] An operation unit or circuit **212** provides a user interface. The CPU **203** controls the operation unit **212** to display an operation screen on which the user can set information such as the type of recording medium to be used (hereinafter referred to as a sheet type), on a display provided in the operation unit **212**. The CPU **203** receives the information set by the user from the operation unit **212**, and outputs the information set by the user to the system controller **151**.

[0054] The system controller **151** transmits information indicating the state of the image forming apparatus **100** to the operation unit **212**. The information indicating the state of the image forming apparatus **100** is information about, for example, the number of sheets on which images are to be formed, a progress status of an image forming operation, and jamming and double feeding of sheets in the image printer **301** and the document feeder **201**. The operation unit **212** displays, on the display, the information received from the system controller **151**.

[0055] The reading units or circuits **109**A and **109**B output digital image data to the controller **213**. The image data has a higher numerical value as intensity of the reflected light increases. The level of this numerical value is hereinafter referred to as a luminance level. Further, in the following, the image data output from the reading unit **109**A is referred to as front-side image data, and the image data output from the reading unit **109**B is referred to as back-side image data.

[0056] The front-side image data output from the reading unit **109**A is input to a shading circuit **204**A, and the back-side image data output from the reading unit **109**B is input to a shading circuit **204**B.

[0057] Each of the shading circuits **204**A and **204**B corrects non-uniformity of a light quantity of the LED **110** and influence of sensitivity unevenness among pixels of the image sensor **111** (which is referred to as a shading correction) by performing addition or subtraction processing or multiplication or division processing on the image data, thereby generating image data uniform in the main scanning direction.

[0058] The front-side image data after the shading correction by the shading circuit **204**A is stored in an image memory **205**. The back-side image data after the shading correction by the shading circuit **204**B is input to an image inversion circuit **210**.
[0059] The image inversion circuit **210** inverts the back-side image data in the main scanning direction. This is because, in the present exemplary embodiment, the reading units **109**A and **109**B have configurations similar to each other, and an image read by the reading unit **109**B is inverted in the main scanning direction relative to an image read by the reading unit **109**A. The back-side image data after the processing by the image inversion circuit **210** is stored in the image memory **205**. In other words, the image memory **205** functions as a first storage unit or circuit.
[0060] FIG. **3** is a diagram illustrating acquisition timings of the front-side image data and the back-side image data to be stored in the image memory **205**. After conveyance of the document **101** is started at a time t**0**, the detection sensor **113** detects a leading edge of the document **101** at time t**1**. The CPU **203** determines a time t**2** before the document **101** reaches the reading position A, based on the time t**1** and, for example, a conveyance speed of the document **101**. The CPU **203** then stores the front-side image data output from the reading unit **109**A into the image memory **205** for a predetermined period from the time t**2**. The predetermined period is a period until at least the trailing edge of the document **101** passes the reading position A. The predetermined period is determined based on the conveyance speed of the document **101**. Likewise, the CPU **203** determines a time t**3** before the document **101** reaches the reading position B, based on the time t**1**. The CPU **203** then stores the back-side image data output from the reading unit **109**B into the image memory **205** for the predetermined period from the time t**3**. The CPU **203** may start the reading by the reading unit **109**A and store the front-side image data into the image memory **205** at the time t**2**, or may start the reading by the reading unit **109**A at a time before the time t**2** and store the front-side image data into the image memory **205** at the time t**2**. The CPU **203** may start the reading by the reading unit **109**B and store the back-side image data into the image memory **205** at the time t**3**, or may start the reading by the reading unit **109**B at a time before time t**3** and store the back-side image data into the image memory **205** at the time t**3**. In the following description, an image represented by the front-side image data is also referred to as a front-side image, and an image represented by the back-side image data is also referred to as a back-side image.
[0061] As illustrated in FIG. **2**, the front-side image data output from the shading circuit **204**A is also input to an edge detection unit or circuit **206**. The back-side image data output from the image inversion circuit **210** is also input to the edge detection unit **206**. In the following, correction of the front-side image data will be described, but the back-side image data is corrected in a similar manner.
Rotation Correction of Image in First Reading Mode
[0062] Rotation correction of the front-side image and the back-side image in a first reading mode according to the present exemplary embodiment will be described next. The first reading mode is a reading mode used to, for example, when a copy operation of forming an image on the recording medium based on a read document image or a scan operation of transmitting the read document image to an external apparatus such as a personal computer (PC) is performed.
[0063] FIGS. **4**A and **4**B are diagrams illustrating processing by the edge detection unit **206**. FIGS. **4**A and **4**B each illustrate an image in which pixel lines in the main scanning direction obtained by the reading unit **109**A at predetermined intervals from the time t**2** are combined in a sub-scanning direction orthogonal to the main scanning direction. As described above, the front-side image data input to the edge detection unit **206** is the data obtained starting from the time t**2** before the leading edge of the document **101** in the conveyance direction reaches the reading position A. More specifically, when the reading by the reading unit **109**A is started, the white guide plate **116** is read first. The image of the document **101** is then read while the document **101** is conveyed. In other words, the front-side image data input to the edge detection unit **206** includes image data representing the white guide plate **116** and image data representing the leading edge of the

document **101**.

[0064] The edge detection unit **206** performs binarization processing on the front-side image data while setting an area of a total of nine pixels including three pixels in the main scanning direction and three pixels in the sub-scanning direction, as one block. In the following, the number of pixels of each of the reading units **109**A and **109**B in the main scanning direction is N (where N is a positive integer, e.g., 7488), and each of the reading units **109**A and **109**B performs the reading M (where M is a positive integer, e.g., 12000) times during the above-described predetermined period. A pixel position in the main scanning direction is denoted by n ($0 \le n \le N-1$), and a pixel position in the sub-scanning direction is denoted by m ($0 \le m \le M-1$). Luminance values of the nine pixels in one block are denoted by px (x=0 to P where P is a positive integer, e.g., 8), and the maximum value and the minimum value of the luminance values are denoted by p max and p min.

[0065] At a position where all of the nine pixels correspond to the white guide plate **116** like a point A in FIG. **4**A, all of the nine pixels are white pixels. Thus, a difference between the maximum value p max and the minimum value p min is small. On a boundary between the white guide plate **116** and a shadow (in gray) of the leading edge of the document **101** like a point B in FIG. **4**A, white pixels and gray pixels are included in the nine pixels. Thus, the difference between the maximum value p max and the minimum value p min is larger. Accordingly, in a case where the difference between the maximum value p max and the minimum value p min is greater than a predetermined threshold pth, it can be determined that the block includes a pixel that is a candidate of the shadow caused by the leading edge of the document **101** (hereinafter referred to as a candidate pixel). In the present exemplary embodiment, when the difference between the maximum value p max and the minimum value p min in a block is greater than the predetermined threshold pth, a center pixel (a pixel at coordinates (n, m)) of the block is determined to be the candidate pixel. The edge detection unit **206** performs this determination processing on each pixel position n and each pixel position m except for n=0, n=N−1,m=0, and m=M−1. In the present exemplary embodiment, one scale in each of an x axis and a y axis corresponds to a distance between center positions of two adjacent pixels.

[0066] FIG. **4**A illustrates an image represented by image data of K bits (with a luminance level of 0 to 2.sup.K−1), and FIG. **4**B illustrates an image represented by image data obtained by binarizing the image data of the image illustrated in FIG. **4**A, based on the predetermined threshold pth of 14. White portions in FIG. **4**B indicate pixels determined to be the candidates of the shadow caused by the leading edge of the document **101** by the above-described processing. Among the plurality of candidate pixels illustrated in FIG. **4**B, a line of the candidate pixels in the main scanning direction positioned closest to the leading edge side in the sub-scanning direction (i.e., a pixel line in the main scanning direction that is first determined to be the candidate pixels in the sub-scanning direction) is determined to be the shadow caused by the leading edge of the document **101**.

[0067] FIG. **5** illustrates an image represented by binary data input to a document information determination unit **207**. The image represented by the binary data input to the document information determination unit **207** is an image within a range indicated by a dashed line in FIG. **5**, and encompasses the document **101**. The range indicated by the dashed line corresponds to the pixel positions n from 0 to N−1 and the pixel positions m from 0 to M−1

[0068] The document information determination unit **207** determines a distance (a width) W between two corners of the leading edge of the document **101** in the main scanning direction. The document information determination unit **207** then outputs front- side document information including the width W to the CPU **203**. The front-side document information also includes a position and an angle of the document **101** in the front-side image. The position of the document **101** is a position (x**1**, y**1**) corresponding to a first position of the document **101** in the front-side image. In the present exemplary embodiment, one (on the left side in FIG. **5**) of the two corners of the leading edge of the shadow caused by the document **101** is set as the first position. The angle of the document **101** is an angle of a predetermined edge of the document **101** in the front-side image, relative to a reference direction of the front-side image. In the present exemplary embodiment, the shadow caused by the leading edge of the document **101** is set as the predetermined edge, and the main scanning direction (the predetermined direction) is set as the reference direction. In other words, the angle of the document **101** is θ**1** in FIG. **5**. In a case where the shadow caused by the leading edge of the document **101** is inclined on an upstream side of the position (x**1**, y**1**) in the conveyance direction, the angle θ**1** has a negative value. In a case where the shadow caused by the leading edge of the document **101** is inclined on a downstream side of the position (x**1**, y**1**), the angle θ**1** has a positive value.

[0069] The CPU **203** outputs, as the front-side document information, the position (x**1**, y**1**), the width W, and the angle θ**1** to a correction unit **208**.

[0070] The correction unit **208** reads out the front-side image data stored in the image memory **205** based on the position (x**1**, y**1**), the width W, and the angle θ**1**, and outputs the front-side image data to the system controller **151**. More specifically, the correction unit **208** reads out the image data along a direction parallel to the shadow caused by the leading edge of the document **101** with the position (x**1**, y**1**) as a starting point.

[0071] The correction unit **208** reads out the front-side image data stored in the image memory **205**, covering the trailing-edge of the document **101** in the above-described manner. In other words, the correction unit **208** functions as a readout unit.

[0072] FIG. **6** is a diagram illustrating the image read out by the correction unit **208**. As illustrated in FIG. **6**, the image data is read out in an amount corresponding to the width W along the direction parallel to the shadow, whereby the leading edge of the document **101** is made parallel to the main scanning direction. Similar processing is performed on the back-side image data.

[0073] The system controller **151** cuts out an image area to be printed, from the image data output from the correction unit **208**. For example, the system controller **151** trims the image data with the position (**0**, **0**) of the image data output from the correction unit **208** in FIG. **6** as a reference position, based on the size of the recording medium set by the user through the operation unit **212**. More specifically, for example, in a case where the size of the document **101** illustrated in FIG. **6** is A4, and the size of the recording medium set by the user through the operation unit **212** is A4, the system controller **151** can cut out the image of the document **101** in which the shadow of the right edge of the document **101** and the shadow of the trailing edge of the document **101** are removed. The system controller **151** controls the image printer **301** to perform printing based on the trimmed image data. In other words, the system controller **151** can function as an external apparatus. Examples of the external device include, in addition to the system controller **151** provided in the image forming apparatus **100**, a smartphone, a tablet, and a PC.

Adjustment of Position of Image to be Formed on Recording Medium

[Adjustment Chart]

[0074] In the present exemplary embodiment, when an instruction to output the adjustment chart **500**, which is used to adjust the position of the image to be formed on the recording medium, is issued through the operation unit **212**, the system controller **151** controls the image printer **301** to form the adjustment chart **500** on the recording medium. The system controller **151** also displays, on the display of the operation unit **212**, a notification prompting the user to place, on the tray **102** of the document feeder **201**, the recording medium on which the adjustment chart **500** is formed. When the user inputs a reading start instruction through the operation unit **212** after placing, on the tray **102**, the recording medium on which the adjustment chart **500** is formed, the reading is started.

[0075] FIGS. **7**A and **7**B are diagrams illustrating the adjustment chart **500** according to the present exemplary embodiment. More specifically, FIG. **7**A illustrates an entire image of the adjustment chart **500**, and FIG. **7**B is an enlarged view of an adjustment patch **501** (a top-left adjustment patch) illustrated in FIG. **7**A. Adjustment patches **502** to **504** (a top-right adjustment patch, a bottom-left adjustment patch, and a bottom-right adjustment patch) illustrated in FIG. **7**A are similar in configuration to the adjustment patch **501**.

[0076] As illustrated in FIG. **7**A, the adjustment chart **500** according to the present exemplary embodiment includes the adjustment patches **501**, **502**, **503**, and **504**, a document side determination patch **505**, and a grid patch **506**. The adjustment patches **501**, **502**, **503**, and **504** are used to detect a displacement amount of the position of the image formed on the recording medium. The document side determination patch **505** is used to determine the front side or back side of the adjustment chart **500**. For example, the document side determination patch **505** formed on the back side of the recording medium is an image laterally inverted from the document side determination patch **505** formed on the front side of the recording medium. The grid patch **506** is used to detect a distortion of the image formed on the recording medium.
[Rotation Correction of Image in Second Reading Mode]
[0077] Rotation correction of the front-side image and the back-side image in a second reading mode according to the present exemplary embodiment will be described below. The second reading mode is a reading mode for reading the adjustment chart **500**.
[0078] The recording medium on which the adjustment chart **500** is formed by the image printer **301** is placed on the tray **102** of the document feeder **201** by the user. When the user inputs a reading start instruction through the operation unit **212**, the adjustment chart **500** is read by the reader **202** while the recording medium is conveyed by the document feeder **201**.
[0079] Processing on an image obtained by reading the adjustment chart **500** will be described next. In the present exemplary embodiment, the following configuration is applied, whereby the output of a coarse image from the image reader **200** is prevented while an increase in capacity of the memory storing the image data is suppressed.
[0080] In a case where the angle θ**1** calculated by the document information determination unit **207** is less than a first predetermined amount (e.g., 0.5 degrees), the correction unit **208** reads out and outputs an image of a predetermined area from the image memory **205** without performing the rotation correction. The predetermined area is, for example, a rectangular area including the document image. More specifically, for example, a length of the predetermined area in the main scanning direction is a length from a position shifted left by 2 mm from the left edge of the document image in the main scanning direction to a position shifted right by 2 mm from the right edge of the document image in the main scanning direction. For example, a length of the predetermined area in the sub-scanning direction is a length from a position shifted up by 2 mm from the top edge of the document image in the sub-scanning direction to a position shifted down by 2 mm from the bottom edge of the document image in the sub-scanning direction. The length of 2 mm is set as a length to prevent an edge portion of the document **101** from protruding from the predetermined area even if the document is skewed by the first predetermined amount.
[0081] The predetermined area may correspond to, for example, the smallest among standard rectangular sizes including the document image. Alternatively, the predetermined area may correspond to, for example, a size smaller than the smallest among the standard rectangular sizes including the document image.
[0082] In a case where the angle θ**1** calculated by the document information determination unit **207** is greater than or equal to the first predetermined amount and is less than a second predetermined amount (e.g., 2 degrees), the correction unit **208** performs the rotation correction on the document image, and reads out and outputs a resultant document image from the image memory **205**.
[0083] In a case where the angle θ**1** calculated by the document information determination unit **207** is greater than or equal to the second predetermined amount, the system controller **151** serving as a notification unit provides a notification indicating occurrence of an error in reading the document image. More specifically, a notification illustrated in FIG. **8** is provided.
[0084] The correction unit **208** also performs well-known corrections, such as a squareness correction and a trapezoidal correction, based on the grid patch **506** in addition to performing the rotation correction on the image data to reduce the angle θ**1**.
[0085] The system controller **151** compares the image transmitted from the correction unit **208**

with original image data used to print the adjustment chart **500** on the recording medium. More specifically, the system controller **151** calculates a displacement amount of the image transmitted from the correction unit **208**, relative to the image of the original image data used to print the adjustment chart **500** on the recording medium. The system controller **151** adjusts the timing for the registration rollers **308** to convey the recording medium to the transfer position, the timing for the optical scanner **311** to form the electrostatic latent image on the surface of the photosensitive drum **309**, and the like so as to reduce the displacement amount.
[0086] FIG. **9** is a flowchart illustrating processing performed by the system controller **151** according to the present exemplary embodiment.
[0087] In step S**101**, in a case where an adjustment chart printing instruction is input through the operation unit **212** (YES in step S**101**), the processing proceeds to step S**102**. In step S**102**, the system controller **151** controls the image printer **301** to print the adjustment chart **500** on the recording medium.
[0088] In step S**103**, the system controller **151** displays, on the display of the operation unit **212**, a notification prompting the placement of the printed adjustment chart **500** on the tray **102** of the document feeder **201**.
[0089] In step S**104**, the system controller **151** transmits an adjustment chart reading instruction to the CPU **203**.
[0090] In step S**105**, in a case where a notification indicating occurrence of an error in reading the adjustment chart **500** is provided from the CPU **203** (YES in step S**105**), the processing proceeds to step S**106**. In step S**106**, the system controller **151** provides the notification illustrated in FIG. **8**.
[0091] In a case where a notification indicating occurrence of an error in reading the adjustment chart **500** is not provided from the CPU **203** (NO in step S**105**), the processing proceeds to step S**107**.
[0092] In step S**107**, in a case where an image obtained by reading the adjustment chart **500** is transmitted from the CPU **203** (YES in step S**107**), the processing proceeds to step S**108**. In step S**108**, the system controller **151** compares the image with the original image data used to print the adjustment chart **500** on the recording medium, thereby calculating the displacement amount. The displacement amount (the adjustment amount) calculated in step S**108** is stored in a memory (not illustrated). In a case where an image obtained by reading the adjustment chart **500** is not transmitted from the CPU **203** (NO in step S**107**), the processing returns to step S**105**. When image formation is to be performed on the recording medium, the timing for the registration rollers **308** to convey the recording medium to the transfer position, the timing for the optical scanner **311** to form the electrostatic latent image on the surface of the photosensitive drum **309**, and the like are adjusted so as to reduce the displacement amount.
[0093] FIG. **10** is a flowchart illustrating processing for reading the chart image (the adjustment chart **500**) according to the present exemplary embodiment. The processing in the flowchart illustrated in FIG. **10** is performed by the CPU **203** when the adjustment chart reading instruction is transmitted to the CPU **203** (in step S**104** in FIG. **9**).
[0094] In step S**201**, the CPU **203** causes the document feeder **201** to start conveyance of the document **101** placed on the tray **102**.
[0095] In step S**202**, the CPU **203** causes the reading units **109**A and **109**B to read the document image.
[0096] In step S**203**, the CPU **203** acquires information about the angle θ**1**.
[0097] In step S**204**, in a case where the angle θ**1** is less than the first predetermined amount (e.g., 0.5 degrees) (YES in step S**204**), the processing proceeds to step S**205**. In step S**205**, the CPU **203** controls the correction unit **208** to read out and output the image of the predetermined area from the image memory **205** without the rotation correction.
[0098] In a case where the angle θ**1** is greater than or equal to the first predetermined amount (NO in step S**204**), the processing proceeds to step S**206**.

[0099] In step S**206**, in a case where the angle θ**1** is less than the second predetermined amount (e.g., 2 degrees) (YES in step S**206**), the processing proceeds to step S**207**. In step S**207**, the CPU **203** controls the correction unit **208** to perform the rotation correction on the document image and to read out and output the resultant document image from the image memory **205**.
[0100] In a case where the angle θ**1** is greater than or equal to the second predetermined amount (NO in step S**206**), the processing proceeds to step S**208**. In step S**208**, the CPU **203** notifies the system controller **151** of occurrence of a reading error.
[0101] As described above, in the present exemplary embodiment, in the case where the angle θ**1** is less than the first predetermined amount (e.g., 0.5 degrees), the correction unit **208** reads out and outputs the image of the predetermined area from the image memory **205** without the rotation correction. In the case where the angle θ**1** is greater than or equal to the first predetermined amount and is less than the second predetermined amount (e.g., 2 degrees), the correction unit **208** performs the rotation correction on the document image and reads out and outputs the resultant document image from the image memory **205**. As a result, the output of a coarse image from the image reader **200** is prevented while an increase in capacity of the memory storing the image data is suppressed.
[0102] According to the exemplary embodiment of the disclosure, it is possible to prevent reduction of adjustment accuracy of a position of an image to be formed on a sheet while suppressing an increase in capacity of a memory storing image data.
[0103] While the disclosure has been described with reference to exemplary embodiments, it is to be understood that the disclosure is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

Claims

1. An image forming apparatus comprising: an image forming unit configured to form, on a sheet, a chart image used to adjust a position of an image in a case where an image adjustment processing is performed; a reader configured to read the chart image on the sheet while the sheet is conveyed; and a controller configured to: determine, based on an image obtained by the reader reading the chart image, an inclination amount corresponding to an inclination angle of a leading edge of the sheet in a conveyance direction in which the sheet is conveyed, relative to a predetermined direction orthogonal to the conveyance direction; in a case where the inclination amount is greater than a predetermined amount, display a notification indicating occurrence of an error in the image adjustment processing on display.
2. The image forming apparatus according to claim 1, further comprising a document feeder including a stacking portion configured to stack the sheet on which the chart image is formed, and a feeding circuit configured to feed the sheet stacked on the stacking portion, the document feeder being pivotable relative to the reader.
3. The image forming apparatus according to claim 1, wherein, in a case where the inclination amount is greater than the predetermined amount, the controller does not perform a rotation processing on the read image to reduce the inclination amount.
4. The image forming apparatus according to claim 1, wherein the controller further displays a notification promoting reading the sheet again on the display.
5. The image forming apparatus according to claim 1, wherein, in a case where the inclination amount is less than the predetermined amount, the controller does not display the notification indicating occurrence of an error in the image adjustment processing on the display.
6. The image forming apparatus according to claim 1, wherein the controller compares the image

obtained by reading the chart image with original image data of the chart image and calculates a displacement amount.