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(54) **SYSTEM AND METHOD OF DETERMINING
IMAGE SKEW USING CONNECTED
COMPONENTS**

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(52) **U.S. Cl.** **382/139**; 382/186; 356/71

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382/106, 112-116, 123, 168, 135-140, 176,
382/181, 203, 232, 274, 276, 287-302, 321,
382/321.66, 186; 705/64; 235/472.01; 356/71
See application file for complete search history.

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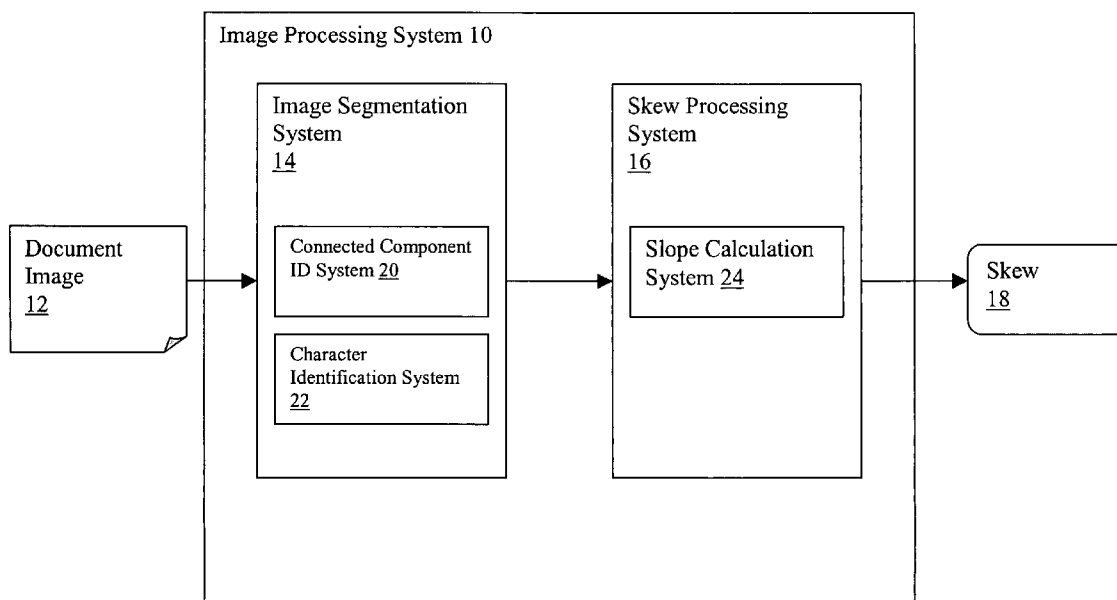
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(57) **ABSTRACT**

A system and method for determining skew of a document image. An image processing system is provided, comprising: an image segmentation system that identifies and segments a line of printed characters; and a skew processing system that determines the skew by calculating slope values for pairs of characters in the line.

22 Claims, 8 Drawing Sheets



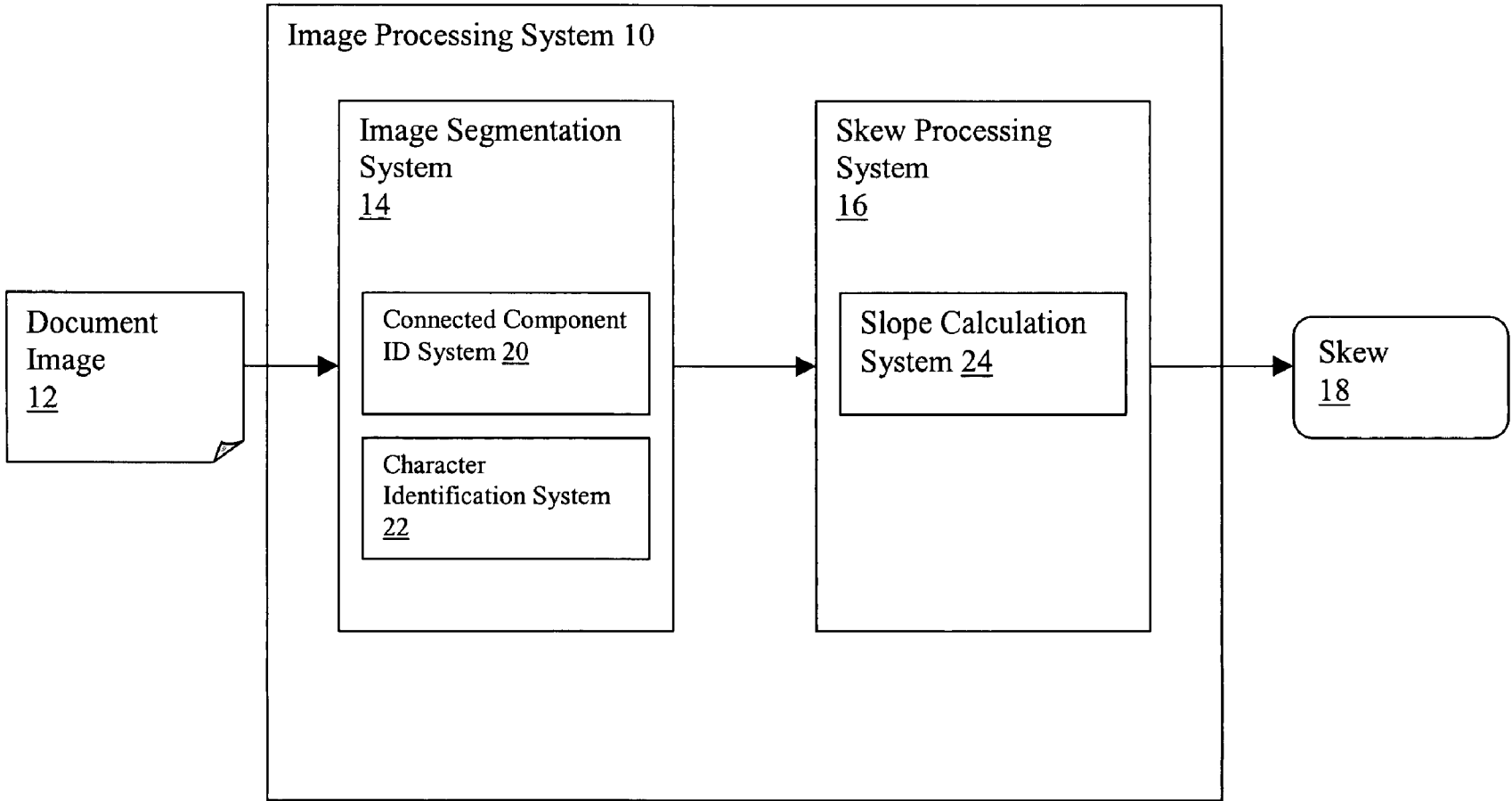


FIG. 1

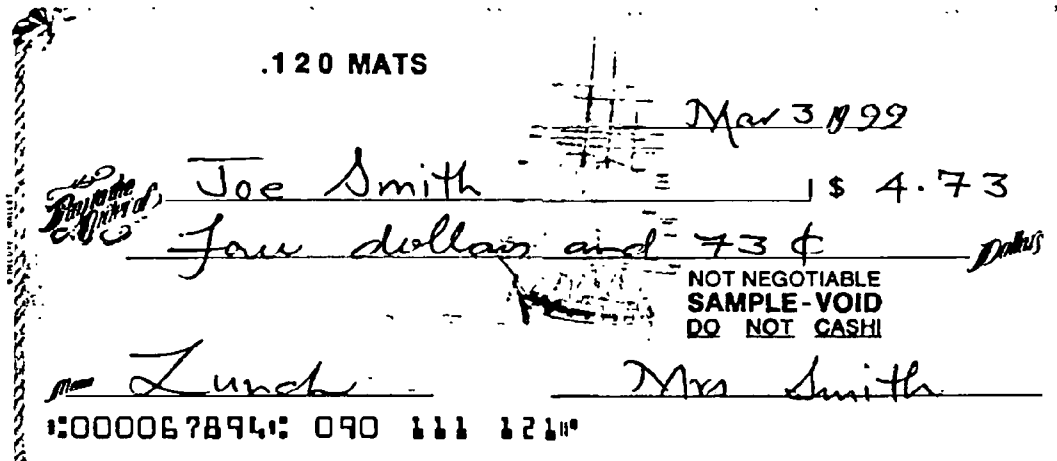


FIG. 2

⑆000067894⑆ 090 111 121⑈

FIG. 3

FIG. 4



Lunch *Mrs Smith*
⑈000067894⑈ 090 111 121⑈

FIG. 5

⑈000067894⑈ 090 111 121⑈

FIG. 6

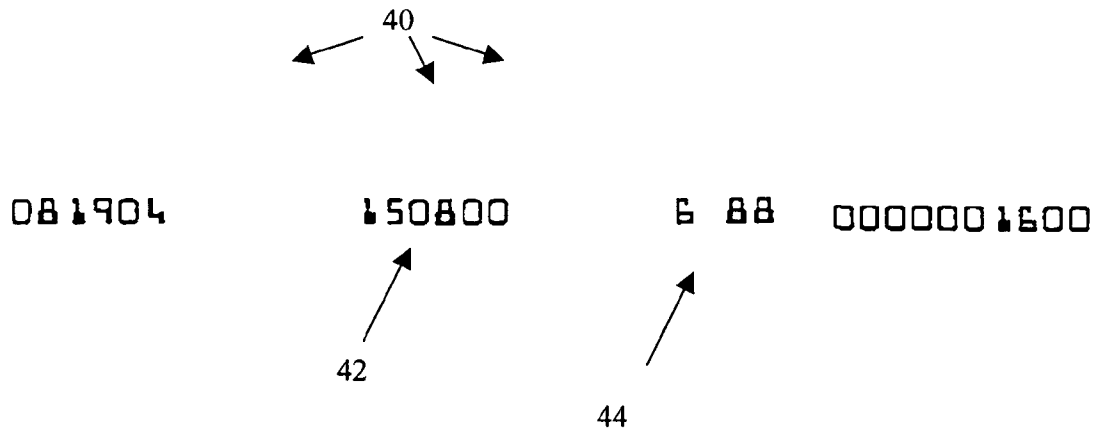


FIG. 7

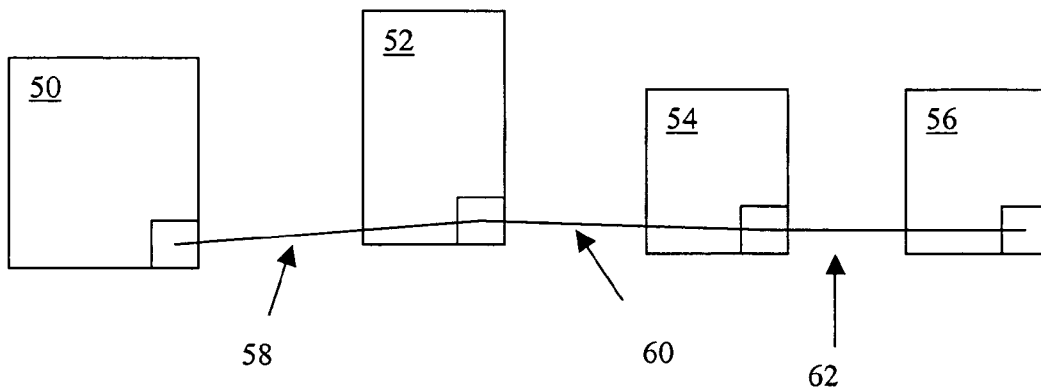


FIG. 8

Comp #	Micr char	TopLx	TopLy	BottomRx	BottomRy	Slope in degrees
0	0	87	466	105	489	0
1	8	112	465	130	489	0
2	1	145	465	156	489	0
3	9	165	465	181	489	0
4	0	188	465	206	489	0
5	4	216	465	231	488	-2.28
6	8	238	465	256	488	0
7	0	263	465	281	489	2.28
8	8	288	465	306	488	-2.28
9	0	364	465	382	489	0.75
10	1	397	465	407	488	-2.28
11	1	422	465	432	489	2.28
12	5	444	465	457	489	0
13	0	464	466	482	490	2.28
14	8	489	466	507	490	0
15	0	515	466	532	490	0
16	0	540	466	557	490	0
17	5	570	466	583	490	0
18	0	590	466	608	490	0
19	8	615	465	633	489	-2.28
20	9	643	466	658	490	2.28
21	6	718	466	733	490	0
22	8	765	465	783	489	-1.14
23	8	791	465	809	489	0
24	0	867	472	885	496	5.25
25	0	892	473	909	496	0
26	0	916	473	934	496	0
27	0	941	473	959	496	0
28	0	966	473	984	496	0
29	0	991	474	1008	497	2.375
30	1	1023	474	1033	497	0
31	6	1042	474	1058	497	0
32	0	1064	474	1082	497	0
33	0	1089	474	1107	497	0

FIG. 9

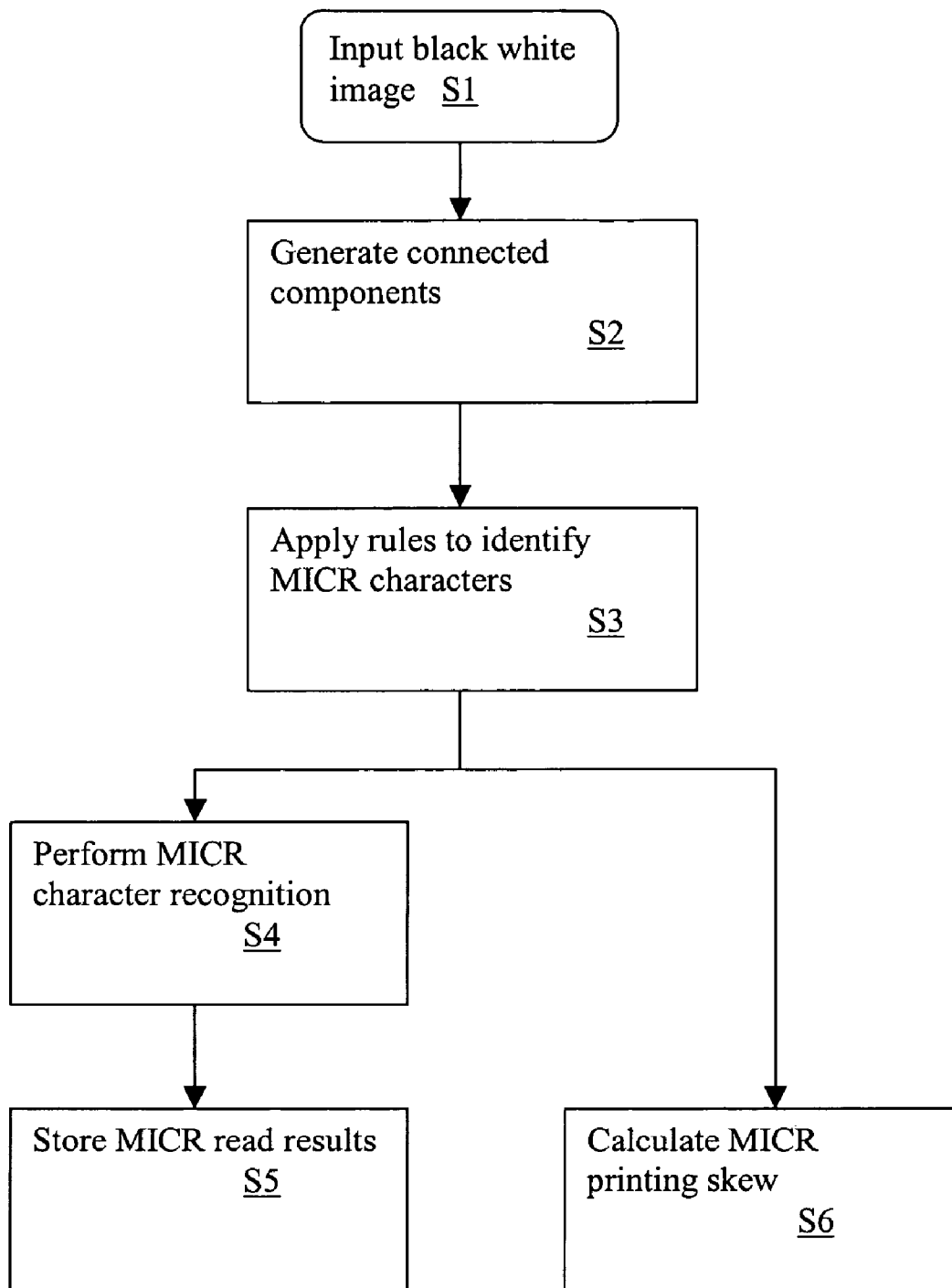


FIG. 10

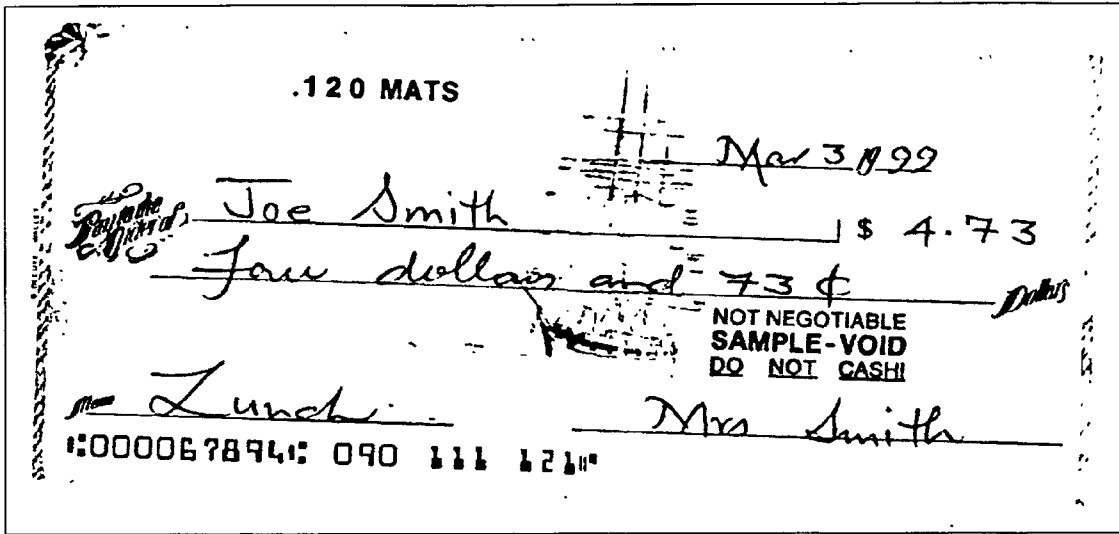


FIG. 11

Comp #	MICR char	TopLx	TopLy	BottomRx	BottomRy	Slope in degrees (column G)
1	0	110	559	133	588	
2	0	138	560	161	590	4.071428571
3	0	167	561	190	590	0
4	0	196	562	219	592	3.931034483
5	?	228	563	246	593	2.111111111
6	7	259	564	276	593	0
7	8	282	565	303	595	4.222222222
8	9	313	566	333	596	1.9
9	4	342	567	361	597	2.035714286
10	0	427	570	450	599	1.280898876
11	9	460	571	479	601	3.931034483
12	0	485	572	508	602	1.965517241
13	1	553	575	567	604	1.93220339
14	1	582	576	595	605	2.035714286
15	1	610	577	624	607	3.931034483
16	1	669	580	683	609	1.93220339
17	2	698	581	713	609	0
18	1	726	583	740	613	8.444444444

FIG. 12

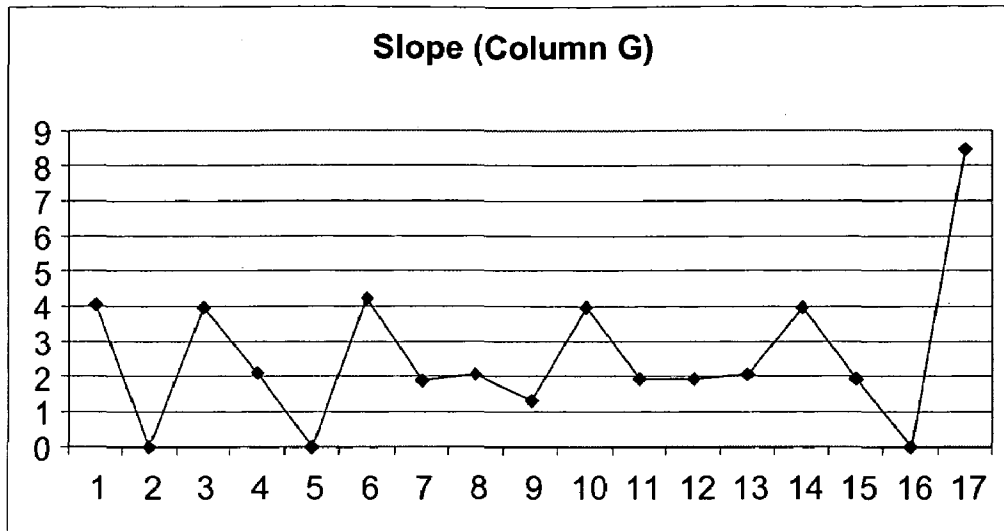


FIG. 13

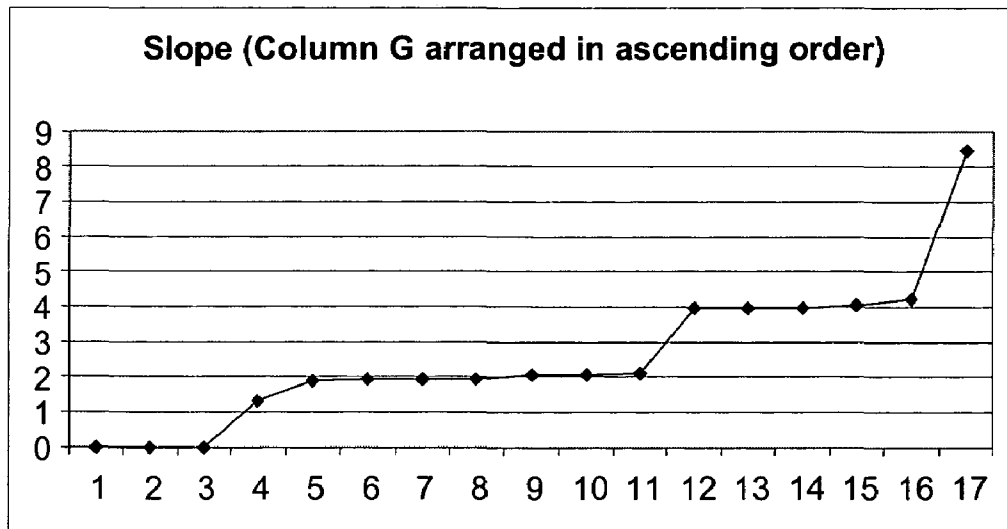


FIG. 14

SYSTEM AND METHOD OF DETERMINING IMAGE SKEW USING CONNECTED COMPONENTS

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates generally to processing document images, and more specifically relates to a system and method for measuring a skew of an image by analyzing the slope of printed information in the image.

2. Related Art

Handling and processing document images is becoming more and more important with the advancement of electronic commerce in environments such as banking. For example, under the "Check 21 Act," which goes into law in October of 2004, banks will be allowed to exchange check images, without actually having to present the original check, for conducting transactions. An important challenge for handling such images includes measuring the image quality of the check. If for example, the check code line, which contains account information and the like, cannot be read, the image must be identified as being unacceptable. Given the high volume of checks that will be processed electronically, automated systems that efficiently measure image quality are required.

One important area of image quality involves document skew. The ability to accurately measure skew can help determine whether printed information can be accurately read in an automated fashion. Too much skew may indicate that the document is unacceptable and/or needs correction before the data can be read.

Known methods for measuring skew typically rely on use of the scanned document image edges to establish image skew. However, it is not unusual for images to be cropped such that the document edges have been removed. In these cases, skew measurements cannot be reliably obtained. Accordingly, a need exists for a system and method for measuring a skew angle of a black white document image.

SUMMARY OF THE INVENTION

The present invention addresses the above-mentioned problems, as well as others, by providing a system and method for measuring the skew of a black white image by analyzing the slope of, for example, MICR (Magnetic Ink Character Recognition) characters printed in the image. The described technique can be used with any printed string of characters. In a first aspect, the invention provides an image processing system for determining a skew of a document image, comprising: an image segmentation system that identifies and segments a line of printed characters; and a skew processing system that determines the skew by calculating slope values for pairs of characters in the line.

In a second aspect, the invention provides a method for determining a skew of a document image, comprising: identifying and segmenting a line of printed characters in the document image; and determining the skew of the document image by calculating slope values for pairs of characters in the line.

In a third aspect, the invention provides a program product stored on a recordable medium for determining a skew of a document image, comprising: means for identifying and segmenting a line of printed characters on the document image; and means for determining the skew of the document image by calculating slope values for pairs of characters in the line.

In a fourth aspect, invention provides an image processing system for determining a skew of a document image, comprising: a system for inputting a segmented set of printed

characters; a system that calculates slope values for pairs of characters in the set; and a system that identifies a median slope value among all the calculated slope values.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of this invention will be more readily understood from the following detailed description of the various aspects of the invention taken in conjunction with the accompanying drawings in which:

FIG. 1 depicts an image processing system in accordance with the present invention.

FIG. 2 depicts an exemplary document image.

FIG. 3 depicts a MICR code line.

FIG. 4 depicts a set of connected components taken from the document image in accordance with the present invention.

FIG. 5 depicts a set of connected components that includes a MICR code line taken from the document image in accordance with the present invention.

FIG. 6 depicts a further reduced set of the connected components of FIG. 5.

FIG. 7 depicts the MICR code line taken from connected components of FIG. 6.

FIG. 8 depicts two respective slopes determined from three exemplary connected components.

FIG. 9 depicts a table of component data for the MICR code line of FIG. 7.

FIG. 10 depicts a flow diagram of an OCR process in accordance with the present invention.

FIG. 11 depicts a skewed check image.

FIG. 12 depicts a data set table containing slope values for the segmented MICR characters obtained from the skewed check image of claim 11.

FIG. 13 depicts a graph of the slope values from the data set table of FIG. 12.

FIG. 14 depicts a graph of the slope values of FIG. 13 placed in ascending order.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, FIG. 1 depicts an image processing system 10 that reads in a document image 12 and outputs a skew value 18 of the document. In general, document image 12 comprises a black white image, however, it should be noted that the invention could be applied to any bitonal image. Image processing system 10 includes: (1) an image segmentation system 14 that identifies and segments printed characters, and (2) a skew processing system 16 that calculates the skew value 18 based on slope calculations for pairs of segmented characters.

In the development of any optical character reader (OCR) engine, an important challenge is in image segmentation. Simply stated, if one can carve out characters, without any background pollution, machine readability becomes easy. For example, to read the code line from the check shown in FIG. 2, the main challenge is in extracting the code line as shown in FIG. 3, followed by separation into individual characters.

In one illustrative embodiment of the present invention, image segmentation system 14 utilizes a connected component identification system 20 that first identifies all of the connected components in the image. For example, in the check shown in FIG. 2, there are 334 connected components. The connected components are defined as printed areas where more than one black pixel is touching; diagonally connected pixels may also be considered touching. For example, FIG. 4 depicts five connected components that form a cable-like border taken from the left side of the check

image. Any method for identifying connected components in the document image **12** could be utilized. Information about each connected component is then stored as part of a data set that defines the component. For instance, the data set may include a component number, a pixel size, a width, a height, and positional data such as a top left X-axis coordinate, a top left Y-axis coordinate, a bottom right X-axis coordinate, a bottom right Y-axis coordinate, etc.

Character identification system **22** utilizes the connected component information to identify and segment characters from the document image **12**, e.g., MICR characters contained in the code line. To achieve this, character identification system **22** applies a set of rules to identify a desired subset of connected components. All other components are eliminated from the component data set. Any appropriate set of rules can be utilized for this process.

For instance, the MICR code line of the check shown in FIG. **2** is identifiable as being printed in a defined area of the check, namely the bottom $\frac{5}{8}$ of an inch, i.e., 150 pixels at 240 dpi. In this embodiment, the bottom 190 pixels are taken for analysis. Thus, to identify the MICR code line, character identification system **22** first identifies those connected components that fall in a relevant region of the image, i.e., those in the bottom 190 pixels. This results a reduced data set of components, shown graphically in FIG. **5**.

In a next step, character identification system **22** examines the reduced data set and compares each of the resulting components to predetermined size criteria. For instance, only the components satisfying the MICR character height (0.116 inch or approximately 28 pixels at 240 dpi) are considered. In this case, components with feature height in the range of 26 to 30 pixels (28+/-2) are extracted, which results in a further reduced data set, shown graphically in FIG. **6**.

In a further step, the top left X-axis coordinate of the component is considered. Since the printing margin must be a minimum of 0.236 inches, i.e., approximately 60 pixels, any component with top left location of less than 50 pixels is discarded. Similarly, the right edge is considered. It is required that the bottom right X-axis coordinate of the right most component must be placed at least 60 pixels away from the document right edge (in this case, 1432 pixels). All components in this example satisfy this requirement. The corresponding image is shown in FIG. **6**. Next, the code line can be segmented into individual components that are then subjected to OCR and/or further processing.

In this embodiment, once the relevant character data in image **12** has been segmented by image segmentation system **14**, the segmentation information can be passed to skew processing system **16** to determine the rotational skew of the image **12**. To implement this, the slopes of different pairs of components are calculated by slope calculation system **24**. In one illustrative embodiment, individual slope values of adjacent code line character pairs are determined. The outputted document skew **18** is then determined by taking the median of the individually calculated slopes.

In a typical check, the code line includes printed MICR characters that comprise a plurality of fields, which are not always printed at the same time. Accordingly, in some cases, these fields can be vertically misaligned. However, because the described invention uses a median slope value of adjacent character pairs, as described herein, the discrepancy can be overcome.

Consider the MICR code line **40** shown in FIG. **7**. It can be seen that the account number **42** has been considerably shifted. In addition, note that the second character ("6 88") is missing in the third field from the left, because, e.g., the character did not satisfy the height and width criterion of the image segmentation system **14**. Such failures do not present a problem for the skew angle processing system **16**.

Skew angle processing system **16** includes a slope calculation system **24** that calculates a slope value for each consecutive character pair using, e.g., the bottom right X-axis coordinate and bottom right Y-axis coordinate for each character, which will ensure an accurate calculation due to the consistency of the vertical coordinate of each of the MICR characters. FIG. **8** depicts a simplified example that includes four connected components **50**, **52**, **54** and **56**, which have been identified as characters of a MICR code line. First, three slope values **58**, **60** and **62** are calculated by examining the bottom right location of consecutive components **50/52**, **52/54** and **54/56**. Then, a median value is calculated, and outputted as the skew **18** for the document image **12**.

FIG. **9** depicts a data set that includes the slope for each of the **34** components (i.e., characters) of the code line **40** shown in FIG. **7**. The median slope value can be determined in any known manner, e.g., the slope values can be arranged either in ascending or descending order to determine the median. Note that due to the significant vertical shift in the account number field **42**, the slope between individual component **#23** (MICR char 8) and component **#24** (MICR char 0) is 5.25 degrees. However, since the account number field **42** itself is almost horizontally aligned, the slope between the components (**#25**), (**#26**), (**#27**) is 0. Using this median technique helps discard such shifts that are introduced.

These principles can be used to determine skew for any document image that includes printed characters, or connected components that are known to lay in a horizontal, vertical or uniform manner. For instance, instead of using the MICR code line, the address block printed on the left top region of a check could be used to determine the skew angle. In this case, by taking a horizontal projection of the address window, different lines of the address block can be identified. Looking at one line, similar calculations as above can be used to determine the skew angle.

Skew measurements based on the address block works very well with block letters. In case of lower case characters, with only a few characters having descender strokes, the median concept works effectively to provide the slope of the written text and thus the document skew.

FIG. **10** depicts a flow diagram showing how the process may be implemented in a typical OCR application. At step **S1**, a black white image is inputted. At step **S2**, connected components from the black white image are identified and generated. Next, at step **S3**, rules (e.g., size, location, etc.) are applied to identify MICR characters from the set of connected components. At this point, two operational paths may occur in parallel. In a first path, shown at steps **S4** and **S5**, MICR character recognition is performed and the MICR read results are stored. In a second path, shown at step **S6**, the MICR printing skew is calculated as described herein.

FIGS. **11-14** describe a further example of calculating skew based on a median slope value. FIG. **11** depicts a skewed check image. As is typically the case, the MICR printed characters (in the code line at the bottom of the image) are right justified at a pitch of 0.125". A data set (in the form of a table) is depicted in FIG. **12** that shows **18** connected components, corresponding to **18** characters of the MICR code line. Note that any special symbols in the code line are excluded. In this case, the recognition algorithm successfully read every character except **#5**; which was the printed number "6" in the MICR code line. Column **G** shows the measured slope of the line joining the character's bottom right corner to the previous character's bottom right corner. Thus, the slope between character **#2** and character **#1** is 4.071428571 degrees.

FIG. **13** depicts a graph showing the angle in degrees of each calculated slope. In FIG. **14**, the results from column **G**

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are placed in ascending order and plotted. As can be seen, the median of the data shows a skew of 2 degrees, and corresponds to data point #8. To further reduce the video noise sensitivity, the skew corresponding to data points #8 (skew of 1.966) and #9 (skew of 2.036) could be averaged, leading to a result of 2.001 degrees.

It is understood that the systems, functions, mechanisms, methods, engines and modules described herein can be implemented in hardware, software, or a combination of hardware and software. They may be implemented by any type of computer system or other apparatus adapted for carrying out the methods described herein. A typical combination of hardware and software could be a general-purpose computer system with a computer program that, when loaded and executed, controls the computer system such that it carries out the methods described herein. Alternatively, a specific use computer, containing specialized hardware for carrying out one or more of the functional tasks of the invention could be utilized. In a further embodiment, part of all of the invention could be implemented in a distributed manner, e.g., over a network such as the Internet.

The present invention can also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods and functions described herein, and which—when loaded in a computer system—is able to carry out these methods and functions. Terms such as computer program, software program, program, program product, software, etc., in the present context mean any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: (a) conversion to another language, code or notation; and/or (b) reproduction in a different material form.

The foregoing description of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously, many modifications and variations are possible. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

The invention claimed is:

1. An image processing system for determining a skew of a document image, comprising:
 - an image segmentation system that identifies and segments a line of printed characters captured from the document image by identifying connected components that reside in a predetermined region of the document image and that meet predetermined size criteria; and
 - a skew processing system that determines the skew of the document image by calculating a slope value between a pair of characters in the line.
2. The image processing system of claim 1, wherein each pair of characters comprises a first and a second character printed adjacent to each other.
3. The image processing system of claim 1, wherein the skew is further determined based on a median slope value calculated from each of the pairs of characters in the line.
4. The image processing system of claim 1, wherein the slope value for each pair of characters is calculated based on a position of a lower right coordinate of each character in the pair.
5. The image processing system of claim 1, wherein the document image comprises a black white image.
6. The image processing system of claim 1, wherein the line of printed characters comprises a magnetic ink character recognition (MICR) code line.
7. A method for determining a skew of a document image, comprising:

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identifying and segmenting a line of printed characters on the document image by identifying connected components that reside in a predetermined region of the document image and that meet predetermined size criteria; and

determining the skew of the document image by calculating a slope value between a pair of characters in the line.

8. The method of claim 7, wherein each pair of characters comprises a first and a second character printed adjacent to each other.

9. The method of claim 7, wherein the skew is further determined based on a median slope value calculated for each of the pairs of characters in the line.

10. The method of claim 7, wherein the slope for each pair of characters is calculated based on a position of a lower right coordinate of each character in the pair.

11. The method of claim 7, wherein the document image comprises a black white image.

12. The method of claim 7, wherein the line of printed characters comprises a magnetic ink character recognition (MICR) code line.

13. A program product stored on a computer readable medium for determining a skew of a document image, comprising:

means for identifying and segmenting a line of printed characters on the document image by identifying connected components that reside in a predetermined region of the document image and that meet predetermined size criteria; and

means for determining the skew of the document image by calculating a slope value between a pair of characters in the line.

14. The program product of claim 13, wherein each pair of characters comprises a first and a second character printed adjacent to each other.

15. The program product of claim 13, wherein the skew is further determined based on a median slope value calculated for each of the pairs of characters in the line.

16. The program product of claim 13, wherein the slope for each pair of characters is calculated based on a position of a lower right coordinate of each character in the pair.

17. The program product of claim 13, wherein the document image comprises a black white image.

18. The program product of claim 13, wherein the line of printed characters comprises a magnetic ink character recognition (MICR) code line.

19. An image processing system for determining a skew of a document image, comprising:

a system for inputting a segmented set of printed characters, which were segmented by identifying connected components that reside in a predetermined region of the document image and that met predetermined size criteria;

a system that calculates a slope value between a pair of characters in the set; and

a system that identifies a medium slope value among all the calculated slope values.

20. The image processing system of claim 19, wherein the segmented set of printed characters comprises a magnetic ink character recognition (MICR) code line.

21. The image processing system of claim 19, wherein each character pair comprises adjacent characters.

22. The image processing system of claim 19, wherein the slope for each pair of characters is calculated based on a position of a lower right coordinate of each character in the pair.