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(54) **IMAGE DISTORTION COMPENSATION TECHNIQUE AND APPARATUS**

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Related U.S. Patent Documents

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Appl. No.: **10/189,443**
Filed: **Jul. 8, 2002**

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G06K 9/00 (2006.01)
G06K 9/36 (2006.01)
G06K 9/40 (2006.01)

(52) **U.S. Cl.** **382/124**; 382/275; 382/284

(58) **Field of Classification Search** 382/124, 382/232, 254, 275, 298, 284; 359/17, 30
See application file for complete search history.

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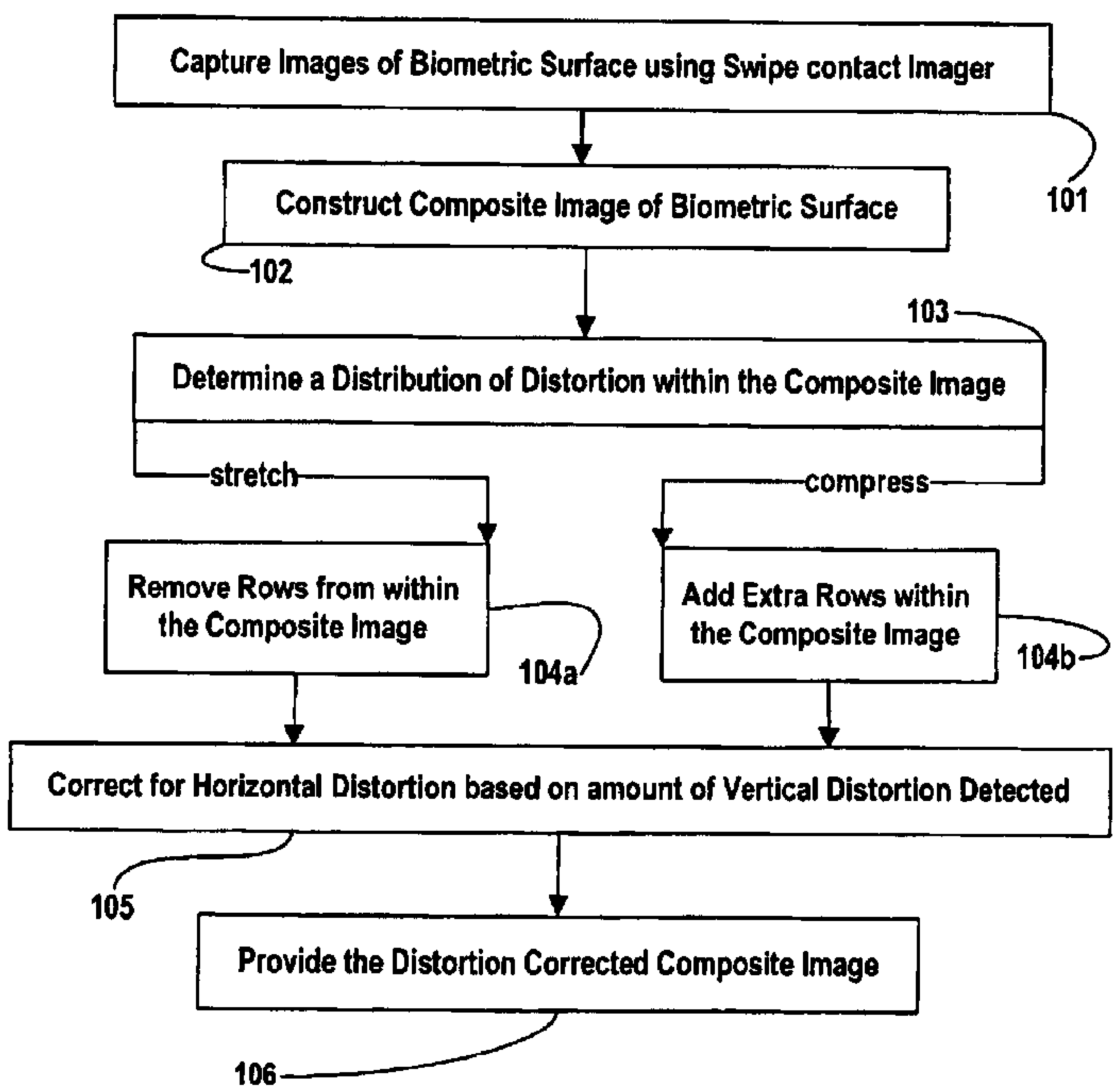
(57) **ABSTRACT**

A method of compensating for distortion within a composite image is disclosed. A biometric surface is sensed with a swipe imager. The images so provided are assembled into a composite image of the biometric surface. The composite image is then adjusted by insertion or deletion of rows therein to result in an image with a different number of rows.

59 Claims, 11 Drawing Sheets



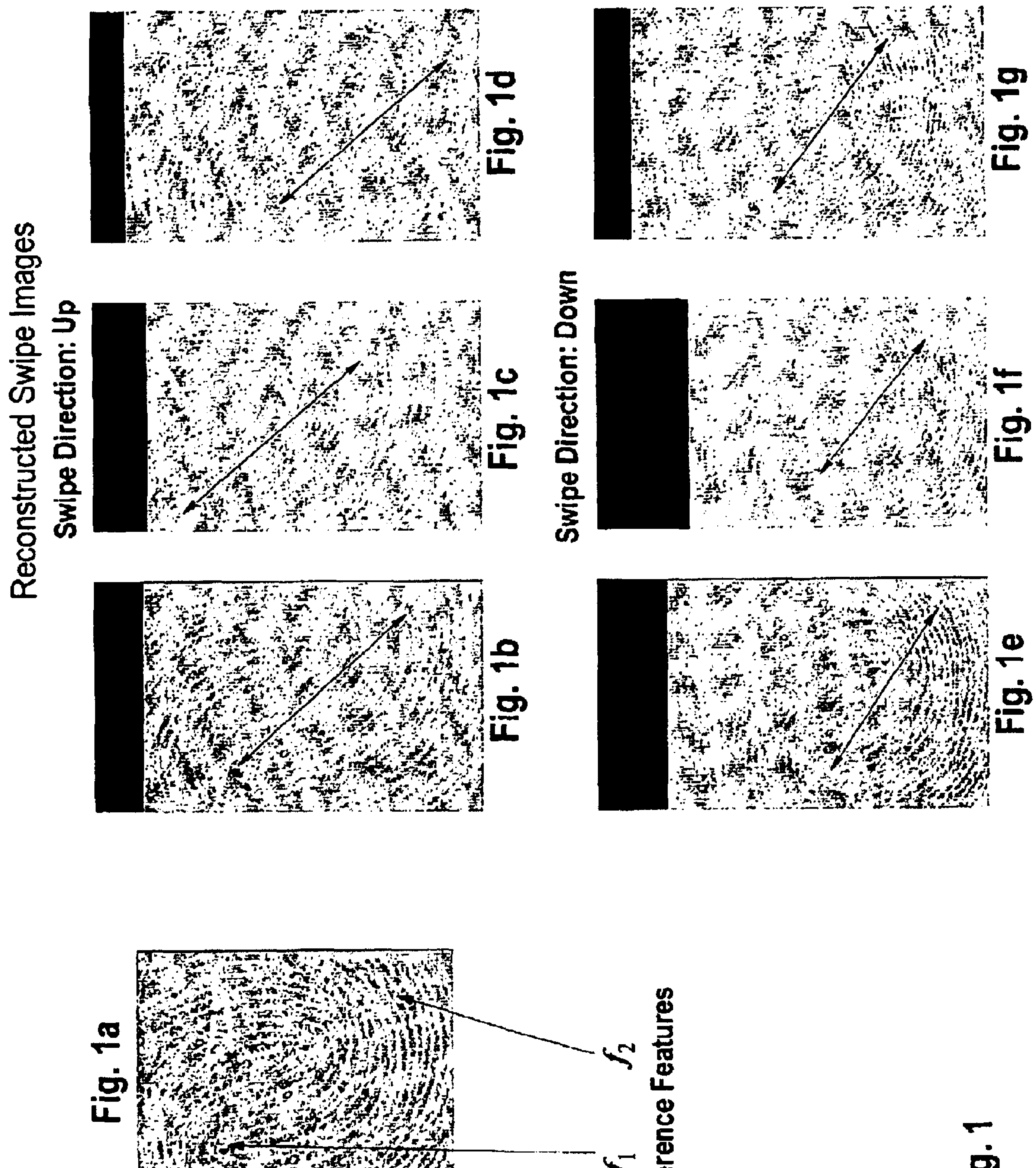

Reconstructed Swipe Images
Swipe Direction: Up
Fig. 1b
Fig. 1c
Fig. 1d
Swipe Direction: Down
Fig. 1e
Fig. 1f
Fig. 1g
Fig. 1a
f_1
f_2
Reference Features

Fig. 1

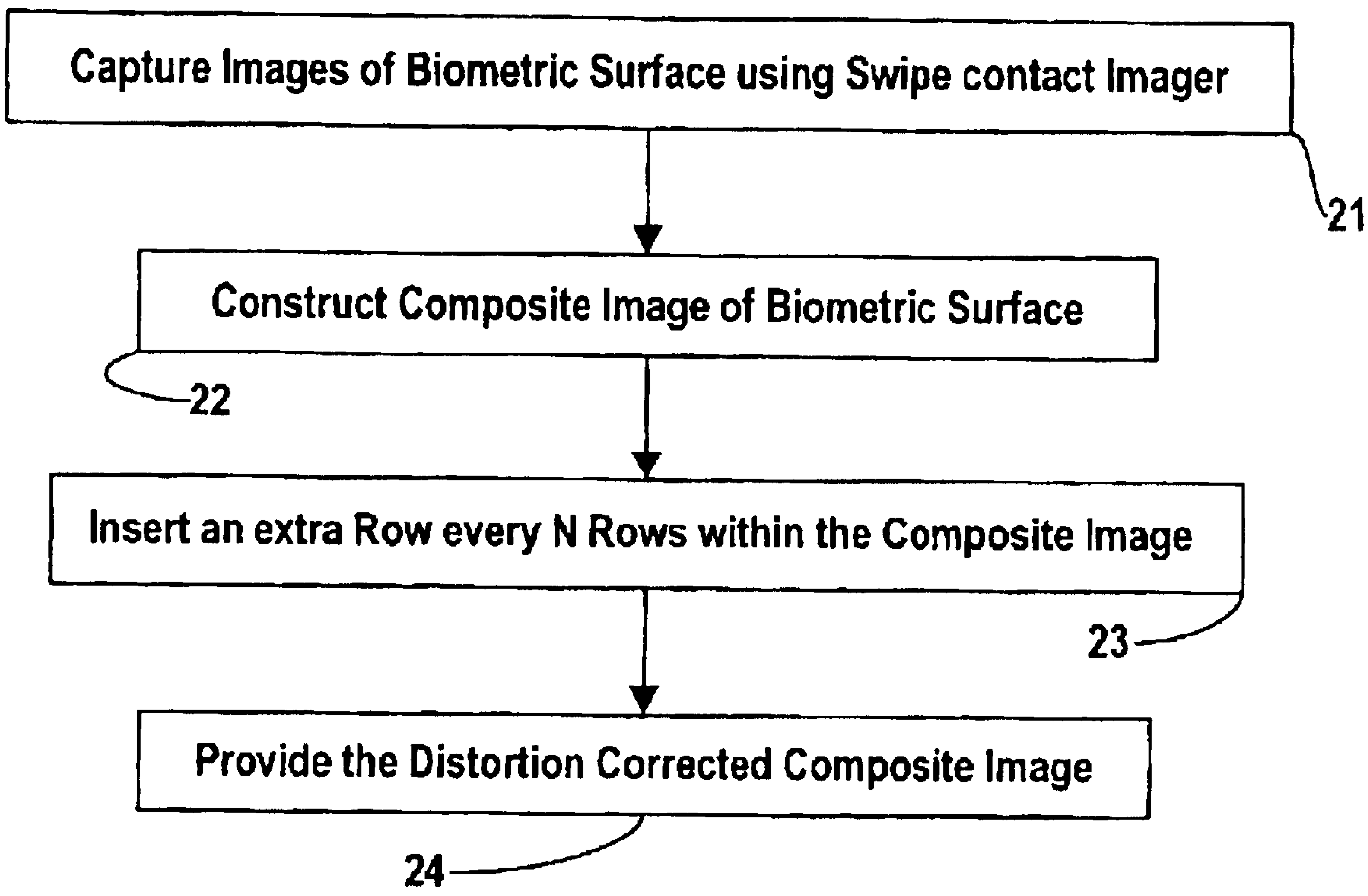

Capture Images of Biometric Surface using Swipe contact Imager
21
Construct Composite Image of Biometric Surface
22
Insert an extra Row every N Rows within the Composite Image
23
Provide the Distortion Corrected Composite Image
24

Fig. 2

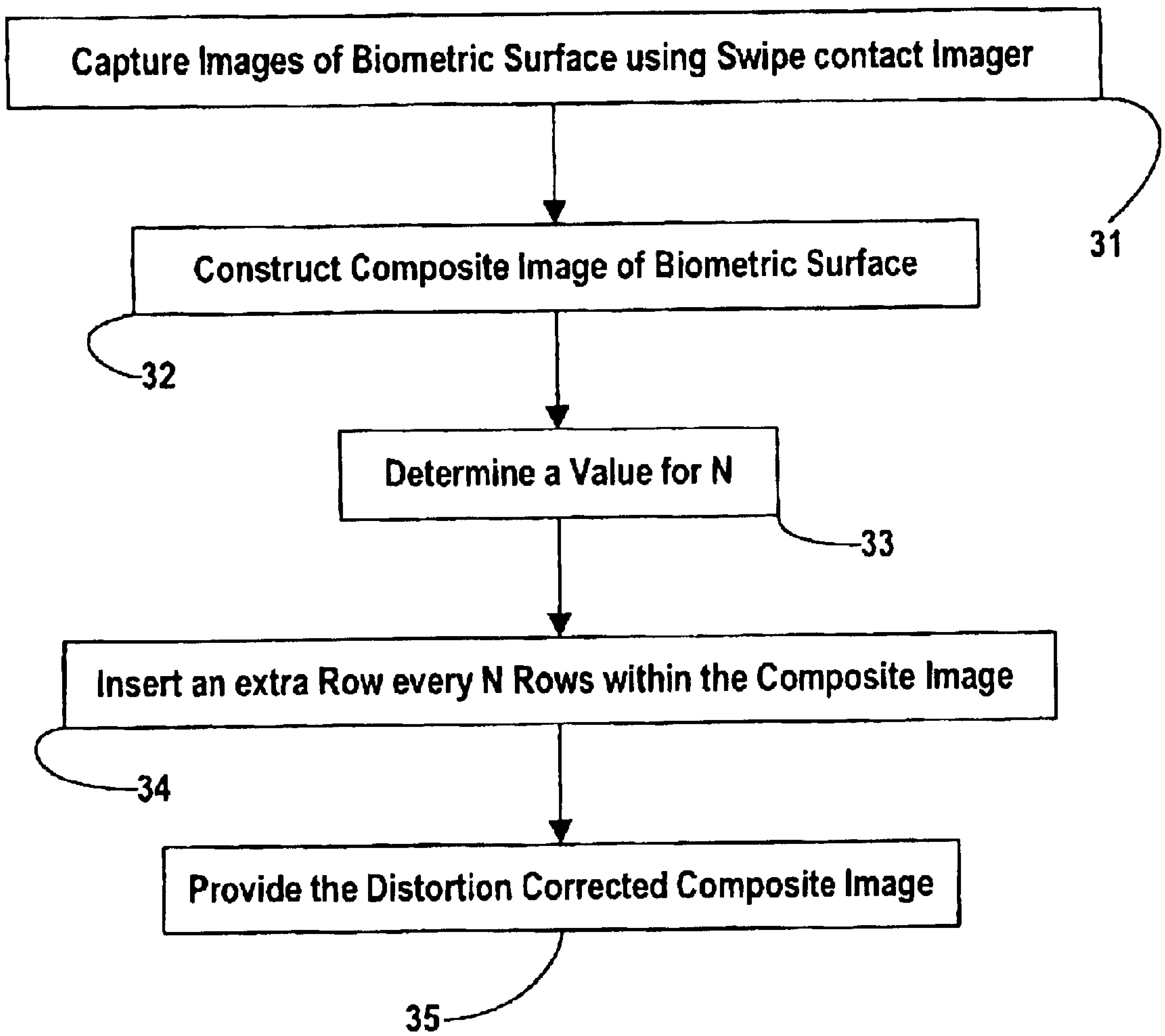

Capture Images of Biometric Surface using Swipe contact Imager
31
Construct Composite Image of Biometric Surface
32
Determine a Value for N
33
Insert an extra Row every N Rows within the Composite Image
34
Provide the Distortion Corrected Composite Image
35

Fig. 3

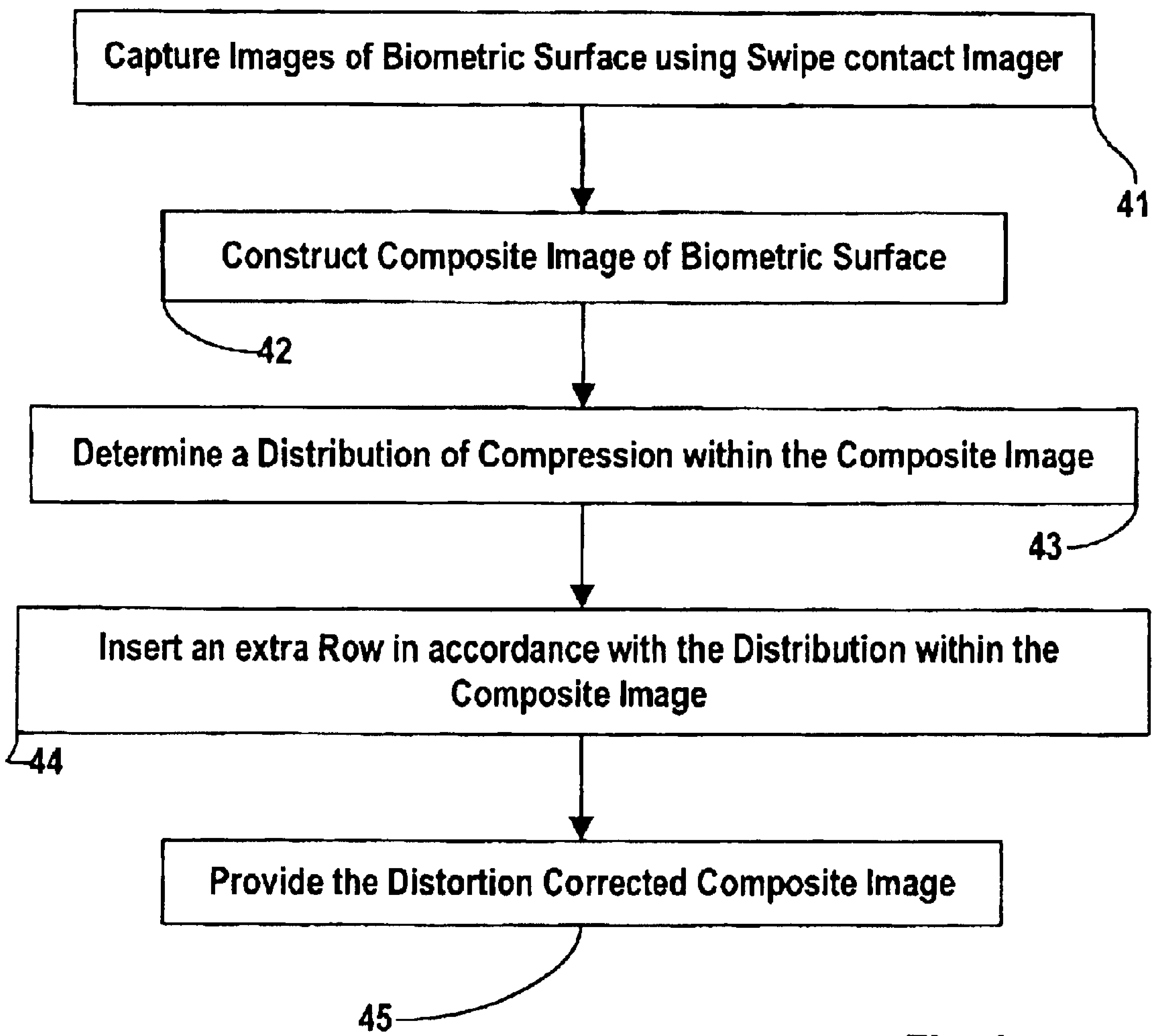

Capture Images of Biometric Surface using Swipe contact Imager
41
Construct Composite Image of Biometric Surface
42
Determine a Distribution of Compression within the Composite Image
43
Insert an extra Row in accordance with the Distribution within the Composite Image
44
Provide the Distortion Corrected Composite Image
45

Fig. 4

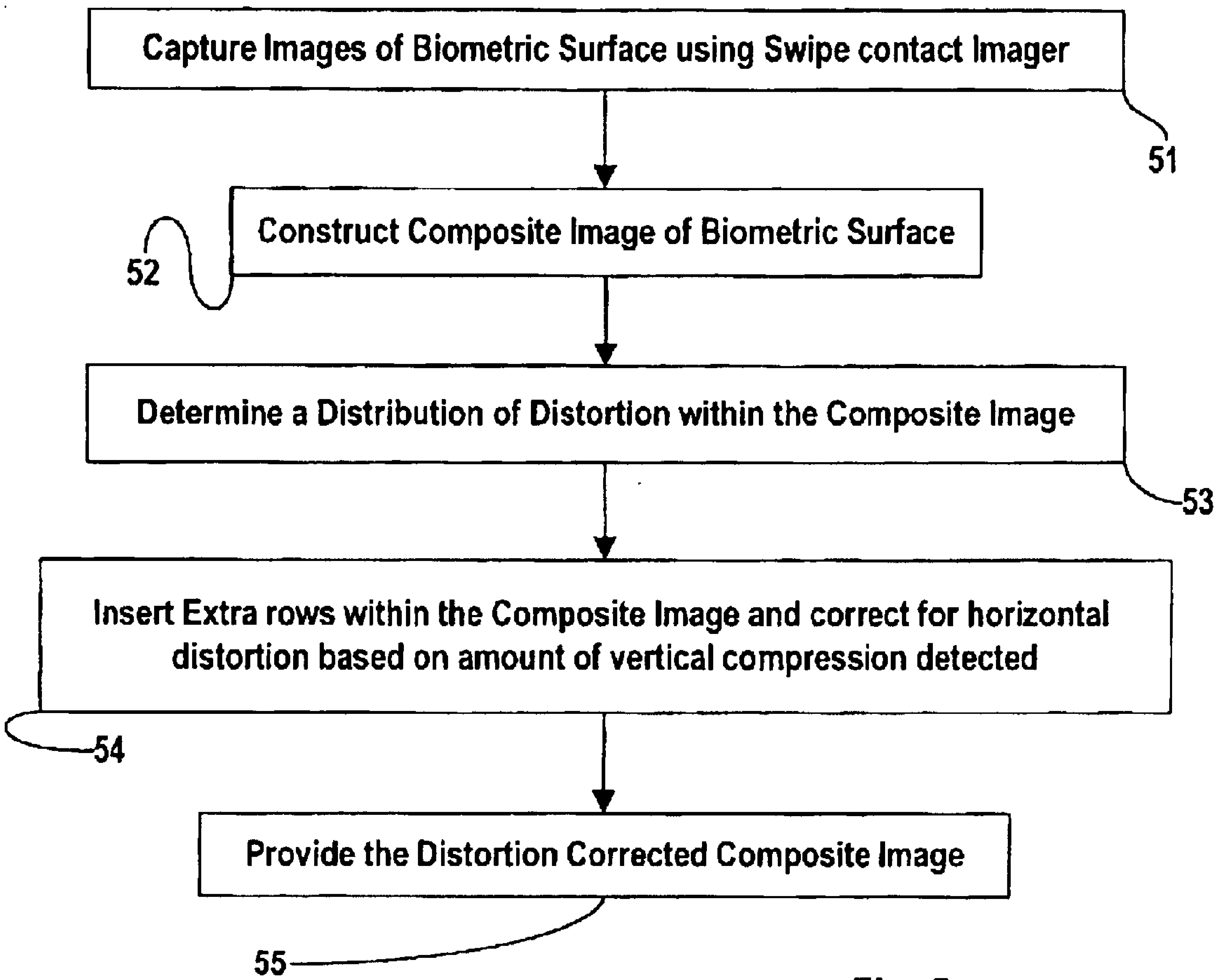

Capture Images of Biometric Surface using Swipe contact Imager
51
Construct Composite Image of Biometric Surface
52
Determine a Distribution of Distortion within the Composite Image
53
Insert Extra rows within the Composite Image and correct for horizontal distortion based on amount of vertical compression detected
54
Provide the Distortion Corrected Composite Image
55

Fig. 5

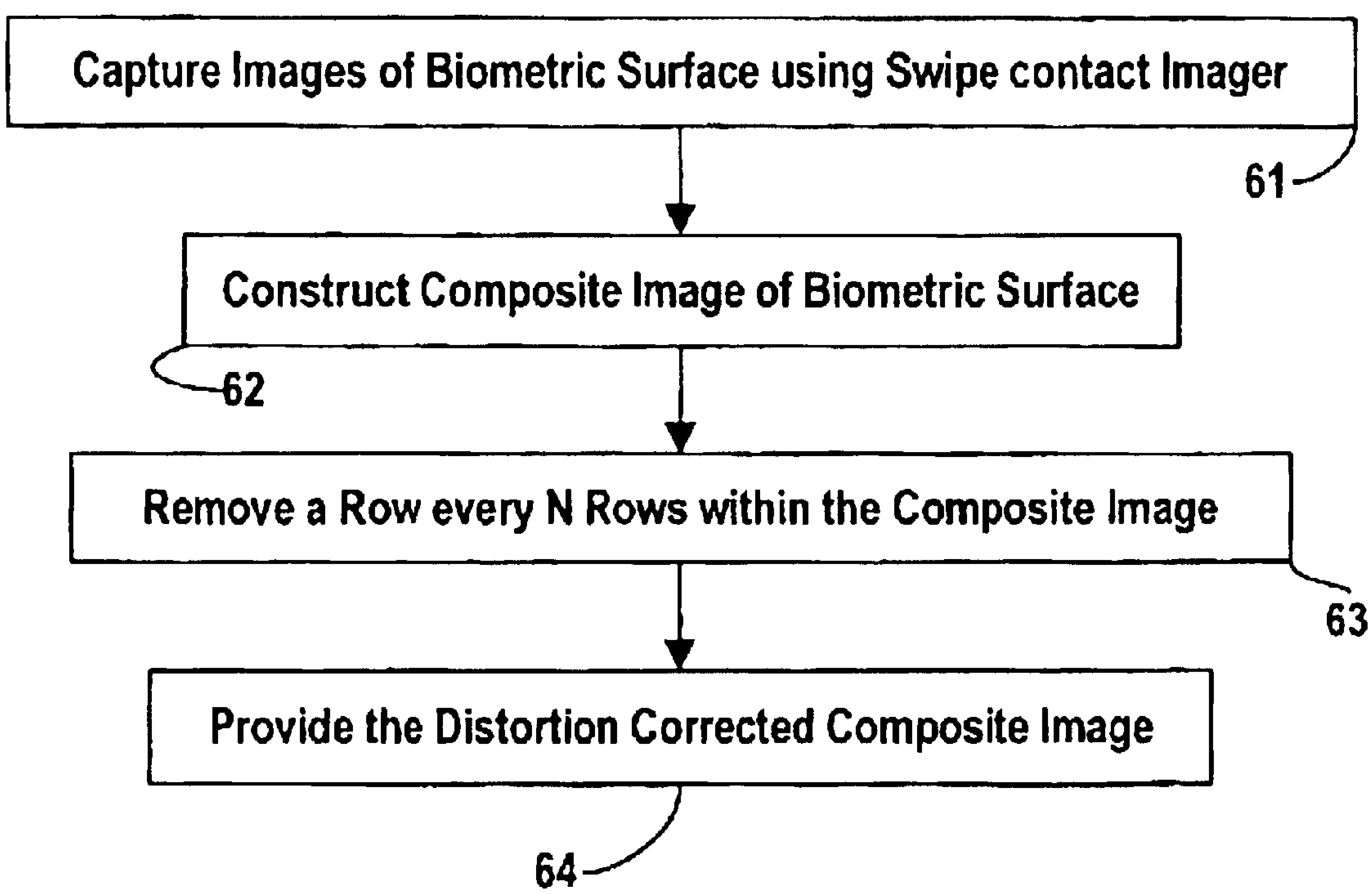

Capture Images of Biometric Surface using Swipe contact Imager
61
Construct Composite Image of Biometric Surface
62
Remove a Row every N Rows within the Composite Image
63
Provide the Distortion Corrected Composite Image
64

Fig. 6

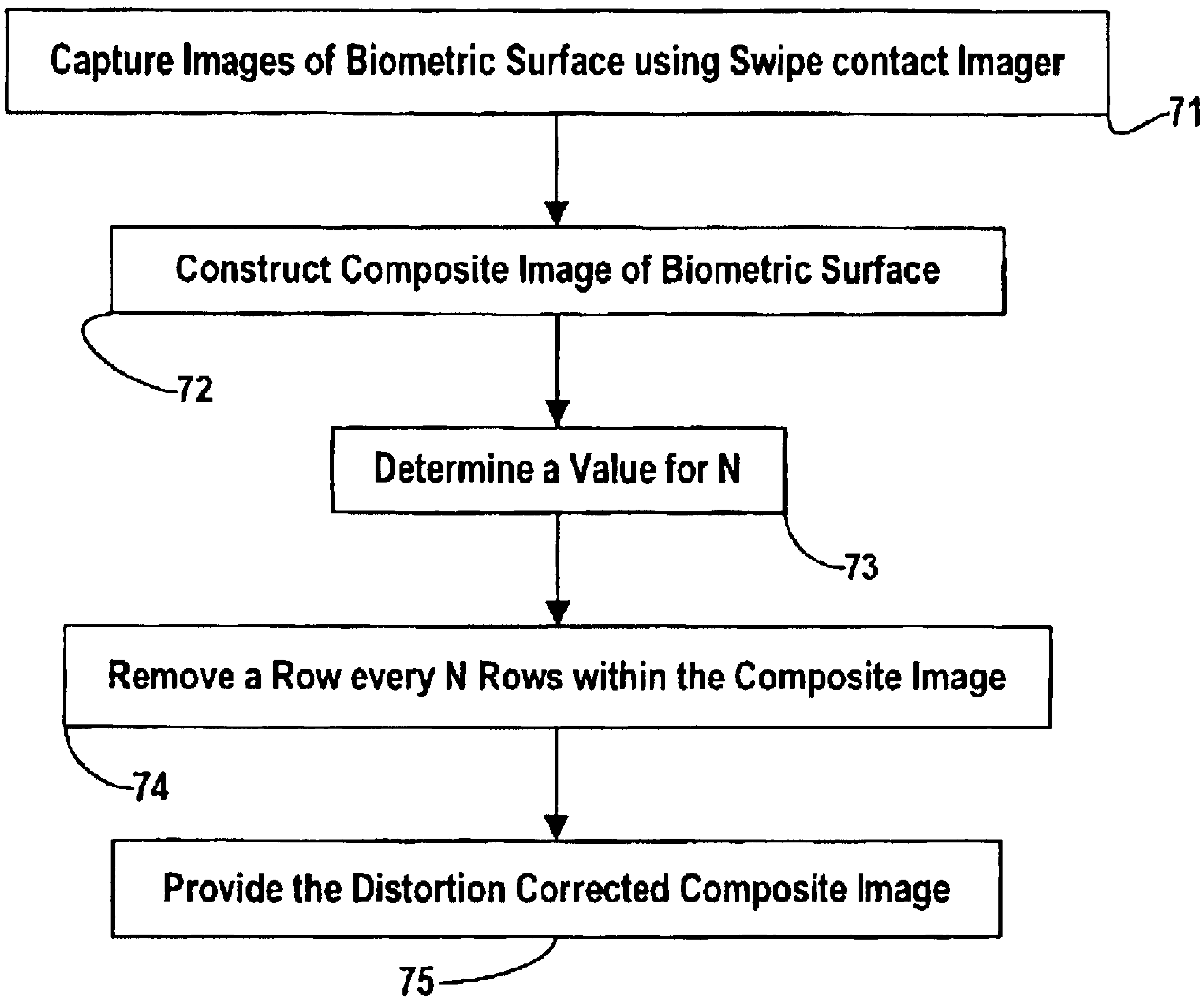

Capture Images of Biometric Surface using Swipe contact Imager
71
Construct Composite Image of Biometric Surface
72
Determine a Value for N
73
Remove a Row every N Rows within the Composite Image
74
Provide the Distortion Corrected Composite Image
75

Fig. 7

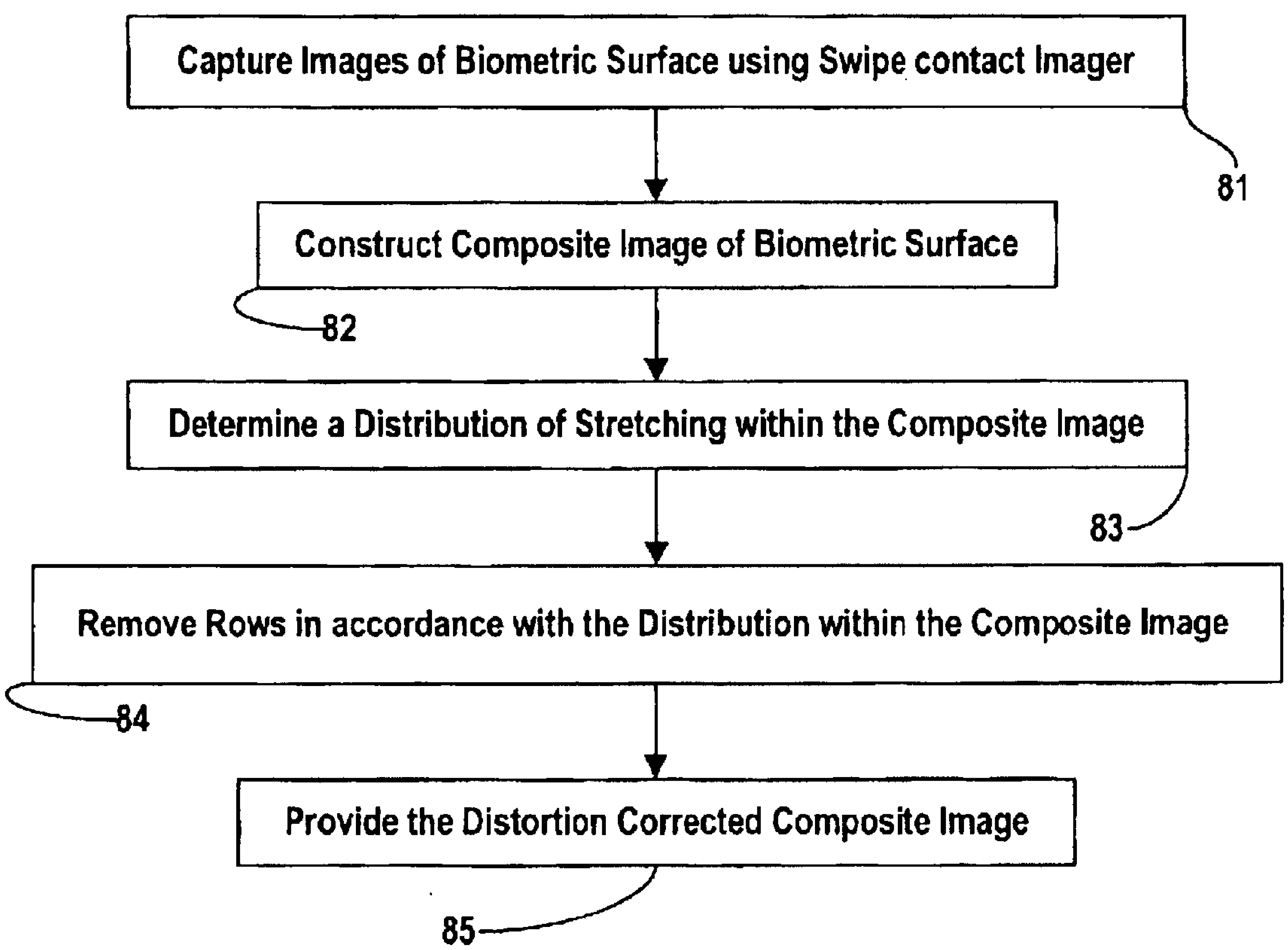

Capture Images of Biometric Surface using Swipe contact Imager
81
Construct Composite Image of Biometric Surface
82
Determine a Distribution of Stretching within the Composite Image
83
Remove Rows in accordance with the Distribution within the Composite Image
84
Provide the Distortion Corrected Composite Image
85

Fig. 8

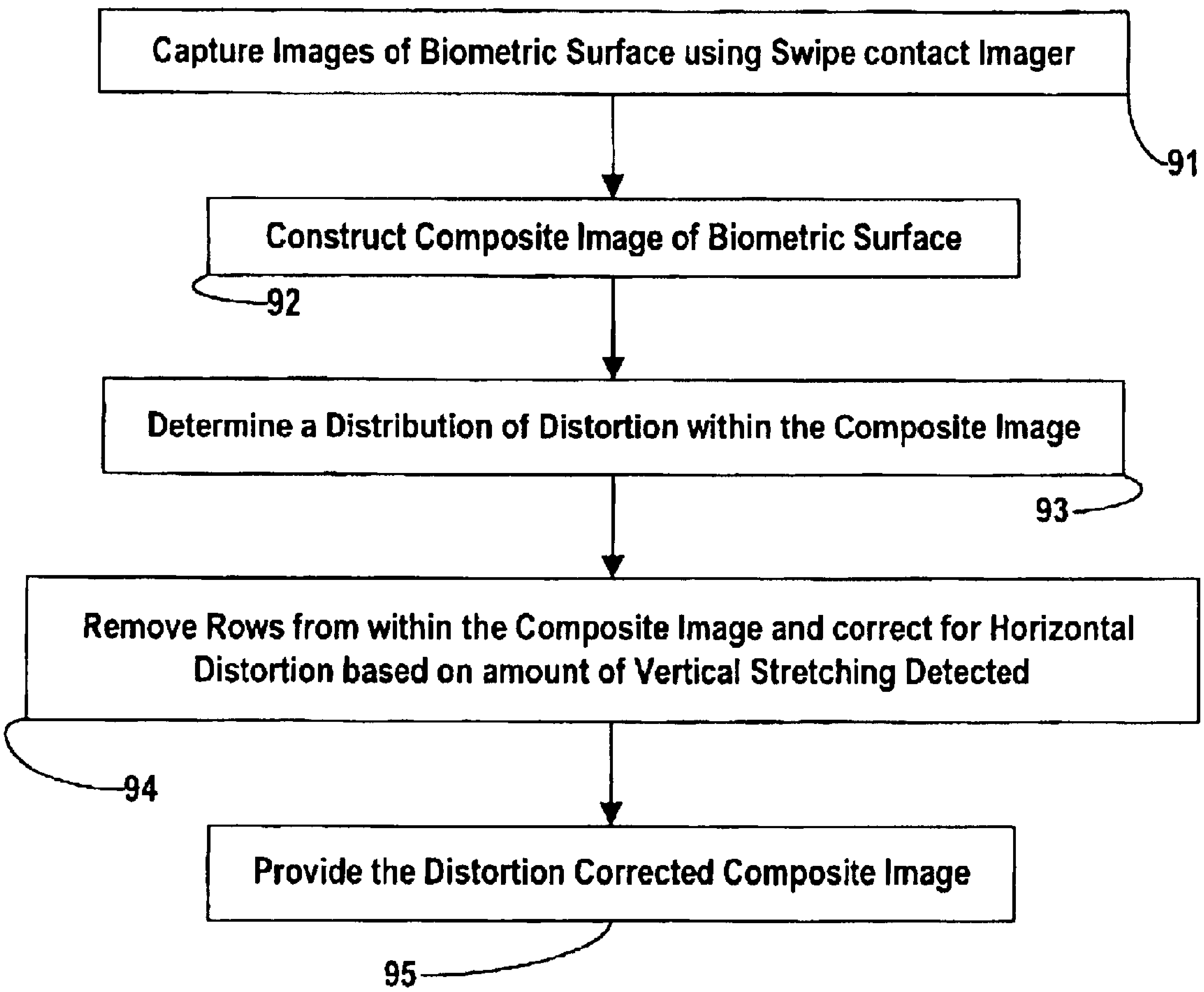
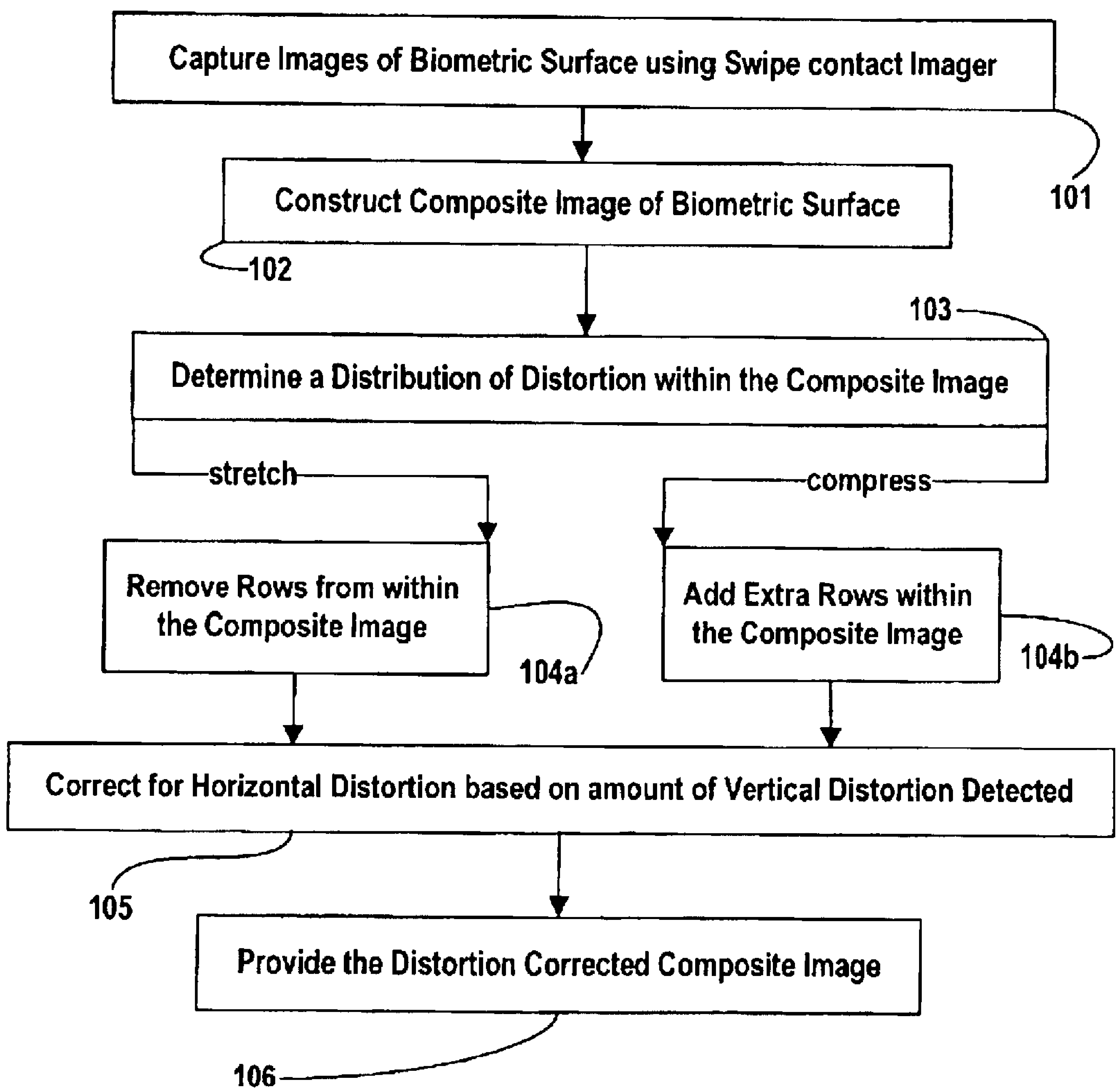

Capture Images of Biometric Surface using Swipe contact Imager
91
Construct Composite Image of Biometric Surface
92
Determine a Distribution of Distortion within the Composite Image
93
Remove Rows from within the Composite Image and correct for Horizontal Distortion based on amount of Vertical Stretching Detected
94
Provide the Distortion Corrected Composite Image
95

Fig. 9



Capture Images of Biometric Surface using Swipe contact Imager
101
Construct Composite Image of Biometric Surface
102
103
Determine a Distribution of Distortion within the Composite Image
stretch
compress
Remove Rows from within the Composite Image
104a
Add Extra Rows within the Composite Image
104b
Correct for Horizontal Distortion based on amount of Vertical Distortion Detected
105
Provide the Distortion Corrected Composite Image
106

Fig. 10

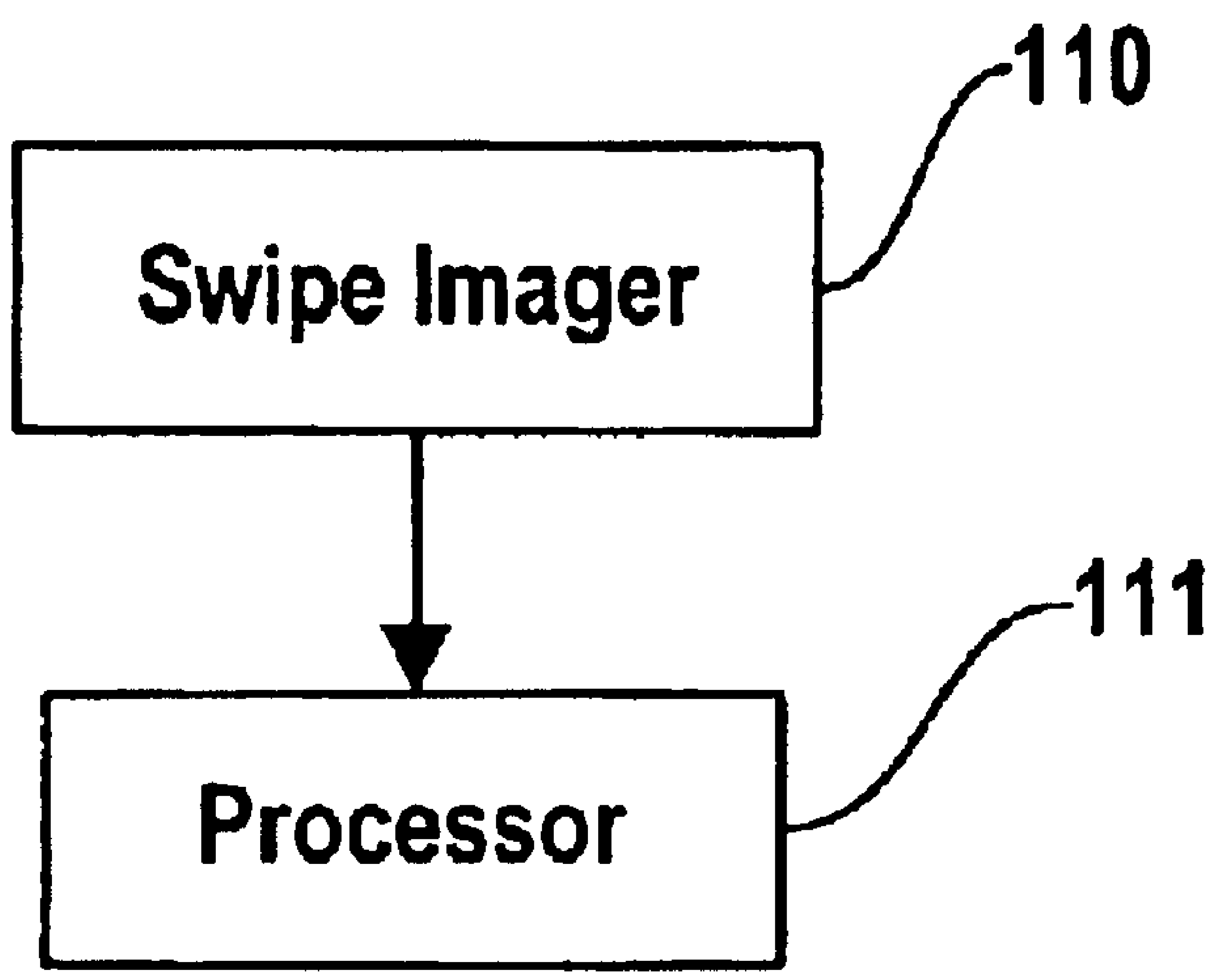


Fig. 11

IMAGE DISTORTION COMPENSATION TECHNIQUE AND APPARATUS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application claims priority from the U.S. Provisional Application No. 60/306,448 filed Jul. 20, 2001.

FIELD OF THE INVENTION

The invention relates generally to contact imagers and more particularly to swipe contact imagers.

BACKGROUND OF THE INVENTION

Biometric techniques for determining the identity of individuals are being used increasingly in authentication, recognition, and/or access systems. These techniques use biometric identifiers or human characteristics to verify or identify an individual. The fact that most human characteristics are unique to each individual, are difficult to reproduce by others, and are easily converted to electronic data, is particularly advantageous in biometric identification applications.

Historically, fingerprints have been the most widely used biometric identifiers, as is evident from law enforcement's extensive use of fingerprinting. The recent trends in biometric identification have been toward automating the above-mentioned authentication, recognition, and/or access systems. Most current techniques rely upon correlation methods that use automated detection systems connected to a computer database, for comparing detected biometric data to biometric data stored in the database, to confirm or determine the identity of an individual. Such automated systems have been used to identify individuals before granting access to cars, computers, home or business offices, hotel rooms, and in general, any sensitive or restricted area.

Various optical devices are known which employ prisms upon which a finger whose print is to be identified is placed. For example, the prism has a first surface upon which a finger is placed, a second surface disposed at an acute angle to the first surface through which the fingerprint is viewed and a third illumination surface through which light is directed into the prism. In some cases, the illumination surface is at an acute angle to the first surface, as seen for example, in U.S. Pat. Nos. 5,187,482 and 5,187,748. In other cases, the illumination surface is parallel to the first surface, as seen for example, in U.S. Pat. Nos. 5,109,427 and 5,233,404.

An alternative type of contact imaging device is disclosed in U.S. Pat. No. 4,353,056 in the name of Tsikos issued Oct. 5, 1982, herein incorporated by reference. The imaging device that is described by Tsikos uses a capacitive sensing approach. To this end, the imaging device comprises a two dimensional, row and column, array of capacitors, each comprising a pair of spaced apart electrodes, carried in a sensing member and covered by an insulating film. The sensors rely upon deformation to the sensing member caused by a finger being placed thereon so as to vary locally the spacing between capacitor electrodes, according to the ridge/trough pattern of the fingerprint, and hence, the capacitance of the capacitors.

A further contact imaging device is described in U.S. Pat. No. 5,325,442 in the name of Knapp, issued Jun. 28, 1994, herein incorporated by reference. Knapp discloses a capacitance measuring contact imaging device in the form of a single large active matrix array, formed by the deposition and definition by photolithographic processes of a number of layers on a single large insulating substrate. Electrodes and sets of address conductors formed of metal and field effect transistors are formed as amorphous silicon or polycrystalline silicon thin film transistors (TFTs) using an appropriate substrate of, for example, glass or quartz.

Additionally, a fingerprint sensing device and recognition system that includes an array of closely spaced apart sensing elements, each comprising a sensing electrode and an amplifier circuit, is described in U.S. Pat. No. 5,778,089 in the name of Borza, issued Jul. 7, 1998, herein incorporated by reference.

"Swipe imagers" are also known, wherein an individual places a fingertip into contact with a surface of a contact imaging device and then draws, or "swipes", the fingertip across a sensing portion of the surface. Images from adjacent portions of the fingertip are captured and combined in order to construct a composite image of the fingertip having an area that is greater than the area of a single captured image. In this way, an area of the fingertip that is substantially larger than the sensing portion is imaged. Such an arrangement allows a smaller capacitive fingerprint scanner to be used, which is advantageous due to lower manufacturing costs, improved robustness, and so forth. Also, the small area required is highly advantageous for embedded applications such as with a cell phone, a telephone, a computer (laptop) and so forth. Unfortunately, images acquired with conventional swipe imagers are typically distorted relative to images captured with static imaging techniques.

It is an object of the invention to image a biometric surface using a swipe contact imager and to provide a composite image having less distortion than the raw composite image formed through mere image concatenation.

SUMMARY OF THE INVENTION

In accordance with the invention there is provided a method of compensating for distortion within a composite image comprising the steps of: sensing a biometric surface with a swipe imager to provide sensed data; forming a composite image of the biometric surface from the sensed data; and, adjusting the composite image along a dimension thereof to one of expand or decrease the composite image size along said dimension by one of removing composite image elements along a line perpendicular to said dimension within the composite image and adding additional image elements along a line perpendicular to said dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension therein.

In accordance with another aspect of the invention there is provided a swipe contact imager comprising: a platen across which a biometric surface is to be passed for imaging thereof; an imaging circuit for sensing a biometric surface passing across the platen and for providing image data relating to portions thereof; and a processor for forming a composite image from the image data and for adjusting the composite image along a dimension thereof to one of expand or decrease the composite image size along said dimension by one of removing composite image elements along a line perpendicular to said dimension within the composite image and adding additional image elements along a line perpendicular to said dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension therein.

In accordance with yet another aspect of the invention there is provided a storage medium having stored therein data, the data indicative of instructions for performing the steps of: sensing a biometric surface with a swipe imager to provide sensed data; forming a composite image of the biometric surface from the sensed data; and, adjusting the composite image along a dimension thereof to one of expand or decrease the composite image size along said dimension by one of removing composite image elements along a line perpendicular to said dimension within the composite image and adding additional image elements along a line perpendicular to said dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension therein.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the attached drawings in which:

FIG. **1** is a computer generated diagram of a plurality of images of a same fingerprint each acquired with different parameters;

FIG. **1**a is a fingerprint as imaged by a flat contact imager of a non-swipe configuration;

FIG. **1**b is same fingerprint as FIG. **1**a with heavy pressure applied in an upward swipe direction;

FIG. **1**c is the same fingerprint as FIG. **1**a with medium pressure applied in an upward swipe direction;

FIG. **1**d is the same fingerprint as FIG. **1**a with light pressure applied in an upward swipe direction;

FIG. **1**e is the same fingerprint as FIG. **1**a with heavy pressure applied in an downward swipe direction;

FIG. **1**f is the same fingerprint as FIG. **1**a with medium pressure applied in an downward swipe direction;

FIG. **1**g is the same fingerprint as FIG. **1**a with light pressure applied in an downward swipe direction;

FIG. **2** is a simplified flow diagram of a method of reducing compression related distortion within some of the images of FIG. **1** according to the invention;

FIG. **3** is a simplified flow diagram of a generalized method of reducing compression related distortion within some of the images of FIG. **1** according to the invention;

FIG. **4** is a simplified flow diagram of a method of reducing compression related distortion within some of the images of FIG. **1** according to the invention;

FIG. **5** is a simplified flow diagram of a method of reducing compression related distortion along both the direction of swiping and along a direction orthogonal thereto;

FIG. **6** is a simplified flow diagram of a method of reducing stretching related distortion within some of the images of FIG. **1** according to the invention;

FIG. **7** is a simplified flow diagram of a generalized method of reducing stretching related distortion within some of the images of FIG. **1** according to the invention;

FIG. **8** is a simplified flow diagram of a method of reducing stretching related distortion within some of the images of FIG. **1** according to the invention;

FIG. **9** is a simplified flow diagram of a method of reducing stretching related distortion along both the direction of swiping and along a direction orthogonal thereto;

FIG. **10** is a simplified flow diagram of a method of reducing both compression and stretching related distortion along a direction of swiping as well as distortion along a direction orthogonal thereto; and,

FIG. **11** is a simplified block diagram of an apparatus for performing the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Referring to FIG. **1**, a set of computer generated images of a fingerprint are shown. Each is presented upside down as that is how they are stored electronically and, as such, a top of each image is shown at a bottom of each image within the figure. FIG. **1**(a) shows the fingerprint as imaged by a flat contact imager of a non-swipe configuration. Such an imager maintains an approximately distortionless relation between features and is used in the description that follows as a reference fingerprint image.

In FIG. **1**(b) the same fingerprint is shown reconstructed. The fingertip was swiped in a generally upward direction along the swipe contact imager and during swiping thereof, a heavy pressure was applied by the individual. Thus, the distortion is significant therein causing a stretching of the fingerprint as is noted by the increased distance between the features f**1** and f**2**.

In FIG. **1**(c), a same fingerprint is again shown reconstructed. The fingertip was swiped in a generally upward direction along the swipe contact imager and during swiping thereof, a medium pressure was applied by the individual. Thus, the distortion is significant therein causing a stretching of the fingerprint as is noted by the increased distance between the features f**1** and f**2**.

In FIG. **1**(d), a same fingerprint is again shown reconstructed. The fingertip was swiped in a generally upward direction along the swipe contact imager and during swiping thereof, a light pressure was applied by the individual. Thus, the distortion is less significant than in either of the two previous images though a stretching of the fingerprint is evident as is noted by the increased distance between the features f**1** and f**2**.

In FIG. **1**(e) the same fingerprint is again shown reconstructed. The fingertip was swiped in a generally downward direction along the swipe contact imager and during swiping thereof, a heavy pressure was applied by the individual. Thus, the distortion is significant therein causing a compressing of the fingerprint as is noted by the decreased distance between the features f**1** and f**2**.

In FIG. **1**(f), a same fingerprint is again shown reconstructed. The fingertip was swiped in a generally downward direction along the swipe contact imager and during swiping thereof, a medium pressure was applied by the individual. Thus, the distortion is significant therein causing a compressing of the fingerprint as is noted by the decreased distance between the features f**1** and f**2**.

In FIG. **1**(g), a same fingerprint is again shown reconstructed. The fingertip was swiped in a generally downward direction along the swipe contact imager and during swiping thereof, a light pressure was applied by the individual. Thus, the distortion is less significant than in either of the two previous images though a compressing of the fingerprint is evident as is noted by the decreased distance between the features f**1** and f**2**.

Of course, for a swipe contact fingerprint imager to be a drop in replacement to existing platen based contact imaging devices, the resulting fingerprint image is preferably as similar as possible to those captured by a non-swipe contact imager. As such, it would be advantageous to transform the image to reduce effects of stretching and compressing visible in reconstructed swipe images.

Table 1 below sets out the effects of distortion. It is observed that swiping a finger upwards causes stretching while swiping a finger downwards causes compression. Further, the compression in a downward swiped fingertip is more acute near a top of the fingerprint **[**that**]** *than* elsewhere. There is also some horizontal distortion, more so in the upward swipe direction **[**that**]** *than* in the downward swiped fingerprints.

TABLE 1

Distortion Effects Summary							
Type	Dir/Press	Abs (f_{1x}-f_{2x})	Abs (f_{1y}-f_2)	abs (f_1-f_2)	$Error_x$	$Error_y$	Error
Flat	n/a	129	153	200	n/a	n/a	n/a
Swipe	Up/Heavy	147	172	226	14.0%	12.4%	13.0%
Swipe	Up/Medium	151	188	241	17.0%	22.9%	20.5%
Swipe	Up/Light	150	182	236	16.3%	19.0%	18.0%
Swipe	Down/Heavy	151	110	187	17.0%	−28.1%	−6.5%
Swipe	Down/Medium	134	112	175	3.9%	−26.8%	−12.5%
Swipe	Down/Light	140	113	180	8.5%	−26.1%	−10.0%

Referring to FIG. **2**, a simplified flow diagram of a method for correcting vertical distortion in a swipe image captured with a fingertip moving downward across a swipe contact imager is shown. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **21**. The image portions are assembled into a composite image at **22**.

Once the composite image is constructed, one row is inserted within the image for every N image rows at **23**. For example, N=4. Thus, the image is increased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is increased to compensate for compressing of the image occurring during image capture. Finally, the corrected composite image is provided at **24**.

Of course, the use of a single fixed row insertion rate is not equally beneficial to each of the images **1**(e), (f), and (g) since the compression ratio for each is different. That said, it was found to sufficiently improve the imaging results in general as shown in Table 2 and to therefore be advantageous.

TABLE 2

Distortion Correction Summary							
Type	Dir/Press	Abs (f_{1x}-f_{2x})	Abs (f_{1y}-f_2)	abs (f_1-f_2)	$Error_x$	$Error_y$	Error
Flat	n/a	129	153	200	n/a	n/a	n/a
Swipe	Down/Heavy	151	158	218	17.0%	3.3%	8.5%
Swipe	Down/Medium	134	140	194	3.9%	−8.5%	−3.2%
Swipe	Down/Light	140	141	199	8.5%	−7.8%	−0.7%

Referring to FIG. **3**, a simplified flow diagram of a more complicated but generalized method is shown. Here a plurality of image portions is sensed during a downward swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **31**. The image portions are assembled into a composite image at **32**.

Once the composite image is constructed, an analysis of the image is performed to determine an amount of compression therein at **33**. The determined amount of compression is used to estimate N. At step **34**, one row is inserted within the image for every N image rows. Thus, the image is increased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is increased to compensate for compressing of the image occurring during image capture. Finally, the corrected composite image is provided at **35**.

Referring to FIG. **4**, a simplified flow diagram of a more complicated but generalized method is shown. Here a plurality of image portions is sensed during a downward swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **41**. The image portions are assembled into a composite image at **42**.

Once the composite image is constructed, an amount of compression therein is determined. For example, an analysis of the image compared to a known image of the same biometric surface is performed to determine an amount of compression therein. Alternatively, the compression is determined based on a measured force applied during sensing of the image of the biometric surface. The amount of compression is then used with further image analysis to determine a distribution of compression within the image at **43**. The distribution may be constant such as 1 in every 4 rows or may be a segmented distribution such as 1 in 3 for the top third and 1 in 5 for the remaining portion of the image. Alternatively, the distribution may be mathematical in nature following a linear or non linear relation with a location within the image.

The determined amount of compression is used to estimate where to insert additional rows within the image. At step **44**, one row is inserted within the image for each estimated location wherein a row is to be inserted. Thus, the image is increased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is increased to compensate for compressing of the image occurring during image capture. Finally, the corrected composite image is provided at **45**.

Referring to FIG. **5**, a simplified flow diagram of a more complicated method for correcting vertical and horizontal distortion is shown. As is evidenced from the tables 1 and 2, there is a correlation between vertical and horizontal distortion for a sensed downward swiped fingertip. Here a plurality of image portions is sensed during a downward swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **51**. The image portions are assembled into a composite image at **52**.

Once the composite image is constructed, an amount of compression therein is determined. For example, an analysis of the image compared to a known image of the same biometric surface is performed to determine an amount of compression therein. Alternatively, the compression is determined based on a measured force applied during sensing of the image of the biometric surface. The amount of compression is then used with further image analysis to determine a distribution of vertical compression within the image and horizontal distortion within the image at **53**.

The determined amount of compression is used to estimate where to insert additional rows within the image. At step **54**, one row is inserted within the image for each estimated location wherein a row is to be inserted and horizontal distortion compensation is performed. Thus, the image is increased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is increased to compensate for compressing of the image occurring during image capture and distortion along the horizontal axis is compensated for in dependence upon the amount of compression. Finally, the corrected composite image is provided at **55**.

Referring to FIG. **6**, a simplified flow diagram of a method for correcting vertical distortion in a swipe image captured with a fingertip moving upward across a swipe contact imager is shown. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **61**. The image portions are assembled into a composite image at **62**.

Once the composite image is constructed, one row is removed within the image for every N image rows at **63**. For example, N=4. Thus, the image is decreased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is decreased to compensate for stretching of the image occurring during image capture. Finally, the corrected composite image is provided at **64**.

Referring to FIG. **7**, a simplified flow diagram of a more complicated but generalized method is shown. Here a plurality of image portions is sensed during an upward swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **71**. The image portions are assembled into a composite image at **72**.

Once the composite image is constructed, an amount of stretching therein is determined. For example, an analysis of the image compared to a known image of the same biometric surface is performed to determine an amount of stretching therein. Alternatively, the stretching is determined based on a measured force applied during sensing of the image of the biometric surface. The determined amount of stretching is used to estimate N. At step **74**, one row is removed from within the image for every N image rows. Thus, the image is decreased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is decreased to compensate for stretching of the image occurring during image capture. Finally, the corrected composite image is provided at **75**.

Referring to FIG. **8**, a simplified flow diagram of a more complicated but generalized method is shown. Here a plurality of image portions is sensed during an upward swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **81**. The image portions are assembled into a composite image at **82**.

Once the composite image is constructed, an amount of stretching therein is determined. For example, an analysis of the image compared to a known image of the same biometric surface is performed to determine an amount of stretching therein. Alternatively, the stretching is determined based on a measured force applied during sensing of the image of the biometric surface. The amount of stretching is then used with further image analysis to determine a distribution of stretching within the image at **83**. The distribution may be constant such as 1 in every 4 rows or may be a segmented distribution such as 1 in 3 for the top third and 1 in 5 for the remaining portion of the image. Alternatively, the distribution may be mathematical in nature following a linear or non linear relation with a location within the image.

The determined amount of stretching is used to estimate where to remove extra rows within the image. At step **84**, one row is removed from within the image for each estimated location wherein a row is to be removed. Thus, the image is decreased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is decreased to compensate for stretching of the image occurring during image capture. Finally, the corrected composite image is provided at **85**.

Referring to FIG. **9**, a simplified flow diagram of a more complicated method for correcting vertical and horizontal distortion is shown. Here a plurality of image portions is sensed during an upward swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **91**. The image portions are assembled into a composite image at **92**.

Once the composite image is constructed, an amount of stretching therein is determined. For example, an analysis of the image compared to a known image of the same biometric surface is performed to determine an amount of stretching therein. Alternatively, the stretching is determined based on a measured force applied during sensing of the image of the biometric surface. The amount of stretching is then used with further image analysis to determine a distribution of vertical stretching within the image and horizontal distortion within the image at **93**.

The determined amount of stretching is used to estimate where to remove rows from within the image. At step **94**, one row is removed from within the image for each estimated location wherein a row is to be removed and horizontal distortion compensation is performed. Thus, the image is decreased in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is decreased to compensate for stretching of the image occurring during image capture and distortion along the horizontal axis is compensated for in dependence upon the amount of stretching. Finally, the corrected composite image is provided at **95**.

Referring to FIG. **10**, a simplified flow diagram of a more complicated method for correcting vertical and horizontal distortion is shown. Here a plurality of image portions is sensed during a swipe of a fingertip across an imager. A biometric surface is passed across a swipe contact imager and a plurality of image portions are captured at **101**. The image portions are assembled into a composite image at **102**.

Once the composite image is constructed, an amount of vertical distortion therein is determined. For example, an analysis of the image compared to a known image of the same biometric surface is performed to determine an amount of vertical distortion therein. Alternatively, the vertical distortion is determined based on a measured force applied during sensing of the image of the biometric surface. The amount of stretching or compression is then used with further image analysis to determine a distribution of vertical stretching or compression within the image and horizontal distortion within the image at **103**.

The determined amount of vertical distortion is used to estimate whether to add or remove rows and where within the image to do so. At step **104**a, one row is removed from within the image for each estimated location wherein a row is to be removed when vertical stretching is detected. Alternatively at step **104**b, one row is added within the image for each estimated location wherein a row is to be inserted when vertical compression is detected. At **105**, horizontal distortion compensation is performed. Thus, the image is adjusted in vertical direction. By doing so, the feature spacing along the vertical direction—the y axis—is adjusted to compensate for detected vertical distortion of the image occurring during image capture and distortion along the horizontal axis is compensated for in dependence upon the amount of vertical distortion. Finally, the corrected composite image is provided at **106**.

Referring to FIG. **11**, a block diagram of an apparatus for performing the invention is shown. The apparatus includes a swipe imager **110** and a processor **111**.

Of course, other forms of detectable distortion are compensatable according to the invention as are other forms of distortion highly correlated to detectable forms of distortion. The improvement in the composite image quality for a particular purpose is a function of the biometric surface imaged, the quality of image reconstruction, and the particular purpose.

Numerous other embodiments may be envisaged without departing from the spirit or scope of the invention.

What is claimed is:

1. A method of compensating for distortion within a composite image comprising[the steps of]:

[sensing a biometric surface with a swipe imager to provide sensed data;]

forming a composite image *from sensed data* of [the] *a* biometric surface[from the sensed data]; and,

adjusting the composite image along a dimension thereof to [one of] expand or decrease the composite image size along said dimension by [one of] removing composite image elements along a line perpendicular to said dimension within the composite image [and] *or* adding [additional] image elements along a line perpendicular to said dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension[therein].

2. A method according to claim **1** wherein [the step of] adjusting the composite image includes [the step of] adding rows interspersed at row intervals within the image.

3. A method according to claim **2** wherein the additional rows are added to compensate for compression of the biometric surface during imaging[thereof].

4. A method according to claim **3** wherein the surface is a fingertip and wherein the compression results from a downward swipe direction of the fingertip.

5. A method according to claim **4** wherein a row is added to the composite image for every N rows within the composite image.

6. A method according to claim **5** wherein the rows are added at consistent row intervals.

7. A method according to claim **6** wherein the row interval is 4.

8. A method according to claim **6** including [the step of] determining a row interval based on an amount of compression within the composite image.

9. A method according to claim **2** wherein a row is added to the composite image for every N rows within the composite image.

10. A method according to claim **9** wherein the rows are added at consistent row intervals.

11. A method according to claim **1** further comprising[the steps of]:

determining an amount of compression within the composite image;

adding lines of image elements within the composite image based on the determined *amount of* compression; and

compensating for image distortion along *an* axis orthogonal to the dimension.

12. A method according to claim **11** wherein [the step of] compensating is performed in dependence upon the determined amount of compression.

13. A method according to claim **11** comprising [the step of] determining a distribution of the compression within the composite image.

14. A method according to claim **13** wherein [the step of] adding is performed in dependence upon the determined distribution of the compression within the composite image and [the step of] compensating is performed in dependence upon the determined amount of the compression within the composite image.

15. A method according to claim **1** further comprising [the step of] determining a distribution of compression within the composite image.

16. A method according to claim **15** wherein [the step of] adjusting includes [a step of] inserting additional lines of elements within the composite image in dependence upon the determined distribution of the compression within the composite image, the lines perpendicular to the dimension.

17. A method according to claim **1** wherein [the step of] adjusting the composite image includes [the step of] removing rows interspersed at row intervals within the composite image.

18. A method according to claim **17** wherein the rows are removed to compensate for stretching of the biometric surface during imaging[thereof].

19. A method according to claim **18** wherein the surface is a fingertip and wherein the stretching results from an upward swipe direction of the fingertip.

20. A method according to claim **19** wherein a row is removed from the composite image for every N rows within the composite image.

21. A method according to claim **20** wherein the rows are removed at consistent row intervals.

22. A method according to claim **21** including [the step of] determining a row interval based on an amount of stretching within the composite image.

23. A method according to claim **17** wherein a row is removed from the composite image for every N rows within the composite image.

24. A method according to claim **23** wherein the rows are removed at consistent row intervals.

25. A method according to claim **1** further comprising[the steps of]:

determining an amount of stretching;

removing lines of image elements from the composite image based on the determined *amount of* stretching; and compensating for image distortion along an axis orthogonal to the dimension.

26. A method according to claim **25** wherein [the step of] compensating is performed in dependence upon the determined amount of stretching.

27. A method according to claim **25** comprising [the step of] determining a distribution of the stretching within the composite image.

28. A method according to claim **27** wherein [the step of] removing is performed in dependence upon the determined distribution of the stretching within the composite image and [the step of] compensating is performed in dependence upon the determined amount of the stretching within the composite image.

29. A method according to claim **16** comprising [the step of] determining a distribution of stretching within the composite image.

30. A method according to claim **29** wherein [the step of] adjusting includes [a step of] removing lines of composite image elements in dependence upon the determined distribution of the stretching within the composite image, the lines perpendicular to the dimension.

31. A method according to claim **1** wherein [the step of] adjusting comprises[the steps of]:

determining whether the composite image is stretched or compressed along the dimension;

when the composite image is compressed, adjusting the composite image along the dimension to expand the composite image size along said dimension by adding [additional] image elements along a line perpendicular to said [a] dimension within the composite image to result in the second composite image with a different number of parallel lines of image elements perpendicular to said dimension; and,

when the composite image is stretched, adjusting the composite image along the dimension to decrease the composite image size along said dimension by removing image elements along a line perpendicular to said [a] dimension within the composite image to result in the second composite image with a different number of parallel lines of image elements perpendicular to said [at least one] dimension[therein].

32. A method according to claim **1** further comprising [a step of] determining an amount of [one of] compression [and] *or* stretching along the dimension of the composite image and wherein [the step of] adjusting *of* the composite image is performed in order to compensate for a determined amount of the [one of] compression [and] *or* stretching along said dimension.

33. A method according to claim **1** further comprising [a step of] determining an amount and distribution of [one of] compression [and] *or* stretching along the dimension of the composite image and wherein [the step of] adjusting *of* the composite image is performed in order to compensate for a determined amount and distribution of the [one of] compression [and] *or* stretching along said dimension.

34. A swipe contact imager comprising:

a platen across which a biometric surface is to be passed for imaging thereof;

an imaging circuit for sensing a biometric surface passing across the platen and for providing image data relating to portions thereof; and

a processor [for forming] *that forms* a composite image from the image data and [for adjusting] *adjusts* the composite image along a dimension thereof to [one of] expand or decrease the composite image size along said dimension by [one of] removing composite image elements along a line perpendicular to said dimension within the composite image [and] *or* adding [additional] image elements along a line perpendicular to said dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension[therein].

35. A storage medium [having stored therein data, the data indicative of instructions for performing the steps of] *whose contents cause a computing system to perform a method, comprising*:

[sensing a biometric surface with a swipe imager to provide sensed data;]

forming a composite image [of the] *from sensed data of a* biometric surface[from the sensed data]; and[,]

adjusting the composite image along a dimension thereof to [one of] expand or decrease the composite image size along [said] *the* dimension by [one of] removing composite image elements along a line perpendicular to [said] *the* dimension within the composite image [and] *or* adding [additional] image elements along a line perpendicular to [said] *the* dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension[therein].

36. [A] *The* storage medium [according to] *of* claim **35** wherein [the data relating to the step of] adjusting the composite image includes [data relating to a step of] adding rows interspersed at row intervals within the image.

37. [A] *The* storage medium [according to] *of* claim **36**[wherein the instructions relate to]*, the method further comprising* adding a row to the composite image for every N rows within the composite image.

38. [A] *The* storage medium [according to] *of* claim **37**[wherein the instructions relate to]*, the method further comprising* adding the rows at consistent row intervals.

39. [A] *The* storage medium [according to] *of* claim **38** wherein the row interval is 4.

40. [A] *The* storage medium [according to] *of* claim **38**[wherein the data relates to instructions for performing the step of]*, the method further comprising* determining a row interval based on an amount of compression within the composite image.

41. [A] *The* storage medium [according to] *of* claim **35**[wherein the data relates to instructions for performing the comprising the step of]*, the method further comprising*:

determining an amount of compression within the composite image;

adding lines of image elements within the composite image based on the determined compression; and

compensating for image distortion along *an* axis orthogonal to the dimension in dependence upon the determined amount of compression.

42. [A] *The* storage medium [according to] *of* claim **41**[wherein the data relates to instructions for performing the step of]*, the method further comprising* determining a distribution of the compression within the composite image.

43. [A] *The* storage medium [according to] *of* claim **42** wherein [the data relating to instructions for performing the step of] adding includes [data relating to instructions for performing the step of] adding in dependence upon the determined distribution of the compression within the composite image.

44. [A] *The* storage medium [according to] *of* claim **35**[wherein the data relates to instructions for performing the step of], *the method further comprising* determining a distribution of compression within the composite image.

45. [A] *The* storage medium according to claim **44** wherein [the data relating to instructions for performing the step of] adjusting the composite image includes [data relating to instructions for performing the step of] inserting additional lines of elements within the composite image in dependence upon the determined distribution of the compression within the composite image, the lines *being* perpendicular to the dimension.

46. [A] *The* storage medium [according to] *of* claim **35** wherein [the data relating to instructions for performing the step of] adjusting the composite image includes [data relating to instructions for performing the step of] removing rows interspersed at row intervals within the composite image.

47. [A] *The* storage medium [according to] *of* claim **46**[wherein the data relates to instructions for performing the step of], *the method further comprising* determining a row interval based on an amount of stretching within the composite image.

48. [A] *The* storage medium [according to] *of* claim **35**[wherein the data relates to instructions for performing the steps of], *the method further comprising*:

determining an amount of stretching;

removing lines of image elements from the composite image based on the determined *amount of* stretching; and

compensating for image distortion along an axis orthogonal to the dimension in dependence upon the determined amount of stretching.

49. [A] *The* storage medium [according to] *of* claim **48** [wherein the data relates to instructions for performing the step of], *the method further comprising* determining a distribution of the stretching within the composite image.

50. [A] *The* storage medium [according to] *of* claim **49** wherein [the data relates to instructions for performing the step of] removing in dependence upon the determined distribution of the stretching within the composite image and [the step of] compensating is performed in dependence upon the determined amount of the stretching within the composite image.

51. [A] *The* storage medium [according to] *of* claim **45** [wherein the data relates to instructions for performing the step of], *the method further comprising* determining a distribution of stretching within the composite image.

52. [A] *The* storage medium [according to] *of* claim **51** wherein [the data relating to instructions for performing the step of] adjusting includes [data relating to performing a step of] removing lines of composite image elements in dependence upon the determined distribution of the stretching within the composite image, the lines *being* perpendicular to the dimension.

53. [A] *The* storage medium [according to] *of* claim **35** wherein [the data relating to instructions for performing the step of] adjusting [include instructions relating to performing the steps of] *further comprises*:

determining whether the composite image is stretched or compressed along the dimension;

when the composite image is compressed, adjusting the composite image along the dimension to expand the composite image size along [said] *the* dimension by adding additional image elements along a line perpendicular to [said] *the* a dimension within the composite image to result in the second composite image with a different number of parallel lines of image elements perpendicular to [said] *the* dimension; and,

when the composite image is stretched, adjusting the composite image along the dimension to decrease the composite image size along [said] *the* dimension by removing image elements along a line perpendicular to [said] *the* a dimension within the composite image to result in the second composite image with a different number of parallel lines of image elements perpendicular to [said] *the* at least one dimension therein.

54. [A] *The* storage medium [according to] *of* claim **35** wherein [the data relates to instructions for performing the step of] determining an amount of [one of] compression [and] *or* stretching along the dimension of the composite image and [wherein the instructions relate to] adjusting the composite image [is performed in order to] [compensate] *compensates* for a determined amount of [the one of] compression [and] *or* stretching along [said] *or* dimension.

55. [A] *The* storage medium [according to] *of* claim **35** wherein [the data relates to instructions for performing the step of] determining an amount and distribution of [one of] compression [and] *or* stretching along the dimension of the composite image and [wherein the instructions relate to] adjusting the composite image [in order to compensate] *compensates* for a determined amount [and distribution of the one] of *the* compression [and] *or* stretching along [said] *or* dimension.

56. A swipe contact imager comprising:

means for sensing a biometric surface and for providing image data relating to portions thereof; and

means for forming a composite image from the image data and adjusting the composite image along a dimension thereof to expand or decrease the composite image size along said dimension by removing composite image elements along a line perpendicular to said dimension within the composite image or adding image elements along a line perpendicular to said dimension within the composite image to result in a second composite image with a different number of parallel lines of composite image elements perpendicular to the dimension.

57. The swipe contact imager of claim 34, further comprising a force measurer configured to measure an amount of force applied to the platen when the biometric surface passes the platen.

58. The swipe contact imager of claim 57 wherein the processor is configured to adjust the composite image based on the measured amount of force.

59. The swipe contact imager of claim 57 wherein the force measurer is configured to measure an amount of force applied to the platen in at least two regions, and wherein the processor is configured to adjust the composite image according to the amount of force applied in the at least two regions.

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