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(71) Applicant: CROSS MATCH TECHNOLOGIES, INC. [US/US]; 3960 RCA Boulevard, Suite 6001, Palm Beach Gardens, FL 33410 (US).

(72) Inventors: MCCLURG, George W.; 2166 N.E. Ocapi Court, Jensen Beach, FL 34957 (US). CARVER, John F.; 2648 S.W. Bear Paw Trail, Palm City, FL 34990 (US). CANNON, Greg L.; 9135 Indian River Run, Boynton Beach, FL 33437 (US). VOORHEES, Richard W.; 1260 S.W. 5th Court, Boca Raton, FL 33432 (US).

(74) Agents: MESSINGER, MICHAEL V. et al.; Sterne, Kessler, Goldstein & Fox, P.L.L.C., 1100 New York Avenue, Washington, DC 20005 (US).

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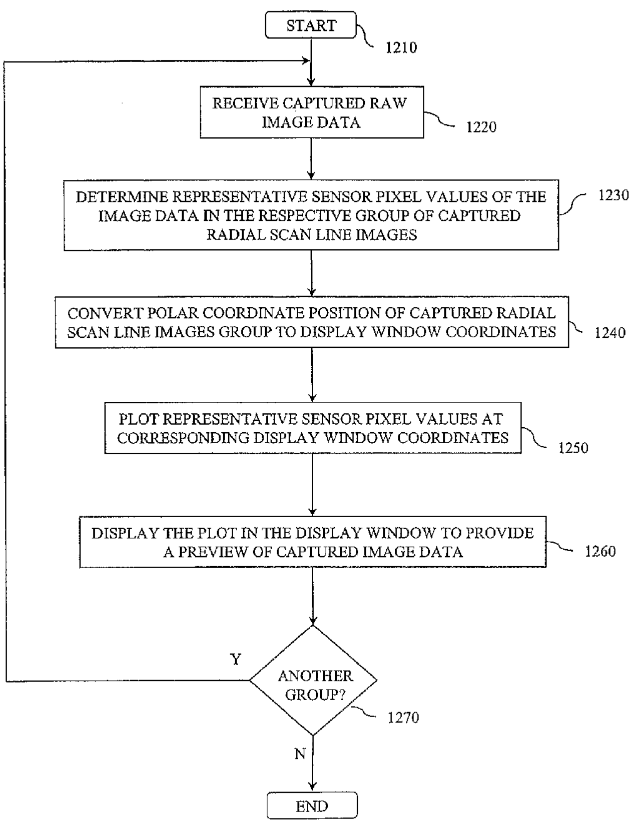
(54) Title: SYSTEMS AND METHODS FOR CAPTURING PRINT INFORMATION USING A COORDINATE CONVERSION METHOD AND FOR GENERATING A PREVIEW DISPLAY



(57) Abstract: A system and method is provided for converting image data (150) captured in a first coordinate system (254) into a second coordinate system (e.g., from polar to rectangular) and for generating a preview display of a captured image and a high resolution display of a selected area of the preview display (190). After receiving a group of captured radial scan lines the preview generation module determines the representative pixel values for pixels in the group, converts the position of the group to a position in the display window coordinates, and plots the pixel values at the corresponding display window coordinates.

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SYSTEMS AND METHODS FOR CAPTURING PRINT INFORMATION USING A COORDINATE CONVERSION METHOD AND FOR GENERATING A PREVIEW DISPLAY

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention pertains to biometric imaging technology, and in particular, to live scanning of prints.

Background

[0002] Law enforcement, banking, voting, and other industries are increasingly relying upon biometric data for security and identity recognition. This increased reliance has created a demand for highly reliable, efficient biometric imaging systems. In addition, in order to perform further processing operations on captured images, these groups require the captured image data to be in a particular format. In post-processing applications, this format is a rectangular coordinate system format.

[0003] Biometric imaging systems may include, but are not limited to, print imaging systems. Such print imaging systems are also referred to as scanners or live scanners. In conventional biometric imaging systems, an object such as a hand or finger is placed on the outer surface of a platen. The platen surface can be a surface of a prism or another surface in optical contact with an outside surface of a prism. For example, a platen surface can be a surface of an optical protective layer (e.g., silicon pad) placed on a prism. To produce raw image data representing the biometric print data, an illumination source illuminates the underside of the object. Raw image data representative of valleys, ridges, and other minutiae of a print is then captured.

[0004] Proper placement of the print pattern on the platen surface is also critical to capturing a high quality image suitable for biometric applications. Even a slight deviation in placement or in the pressure applied by the subject could result in captured image data that is undesirable or unusable by downstream applications. As a result, prior to forwarding the image data to downstream applications, a system operator typically evaluates the image to ensure that an adequate image data has been captured. This evaluation requires the system operator to wait until the scan is completed and the image displayed. Extensive waiting time however is inconvenient and wasteful for both the system operator and the subject.

[0005] Conventional live scanners capture raw image data in a rectangular coordinate system format. Thus, both conventional capture and post-processing applications have used the same rectangular coordinate system format appropriate for the planar surfaces of a conventional prism and camera.

BRIEF SUMMARY OF THE INVENTION

[0006] The present invention provides an image conversion system that can process raw image data captured in a first coordinate system format and convert the raw image data into a second coordinate system format acceptable by downstream processing systems. In an embodiment, the present invention can convert image data captured in a scan of a non-planar platen surface such as a curved conical prism surface to image data associated with an approximately planar surface of a camera.

[0007] The inventors recognized that the use of a single rectangular coordinate system for capture and in post-processing applications limits implementation options for prisms and capturing systems in the biometric imaging system. When a live scanner has a prism that is non-planar, use of a single rectangular coordinate system to capture the raw image data results in distorted or lost information. As a result, the captured raw image becomes less accurate and may introduce significant errors into post-processing operations.

[0008] The present invention is directed to a system and method for converting captured image data in a first coordinate system format to a second coordinate system format. In accordance with embodiments of the present invention, the image conversion system includes a receiving module, a coordinate conversion module, and a memory. The image conversion system can be implemented in a biometric imaging system or as a system external to a biometric imaging system.

[0009] In an embodiment of the invention, the coordinate conversion module calibrates the image conversion system by generating a conversion data array. The conversion data array maps each pixel in a second coordinate system output area to a position in the first coordinate system. After calibration, the receiving module of the image conversion system receives captured image data in a first coordinate system format from a biometric imaging system and stores the captured image data in memory. For each pixel in the second coordinate system output area, the coordinate conversion module retrieves an entry in the conversion data array and one or more samples from the captured raw image data. The coordinate conversion module then interpolates the retrieved samples using weighting based on the retrieved conversion data array entry to obtain the respective pixel value in the second coordinate system.

[0010] The inventors recognized that an extensive waiting time may be encountered for large platen areas and in particular for a non-planar surface such as a conical prism large enough to capture an image of one or two hands. The present invention is directed to a system and method for generating a preview display of a captured image of a print pattern placed on a non-planar surface. In accordance with embodiments of the present invention, the display processing system includes a preview generation module and a memory. The display processing system can be implemented in a live scanner or as a system external to a live scanner.

[0011] In an embodiment of the invention, the display processing system receives a group of captured radial scan line images from a scanning and capturing system. The preview generation module then determines the representative pixel values (e.g., representative pixel values) for pixels in the group of captured radial scan line images. Next, the polar coordinate system position of the respective group of captured radial scan line images is converted to a position in the display window coordinates. The representative pixel values are then plotted at the corresponding display window coordinates and displayed in the display window.

[0012] The present invention is also directed to a system and method for generating a high resolution display of an area of the preview display. This area can be an area within a preview display selected by the system operator. In accordance with embodiments of the present invention, the display processing system includes a preview generation module, a high resolution display processing module, and a memory. The display processing system is coupled to an image conversion system. The display processing system can be implemented in a biometric imaging system or as a system external to a biometric imaging system.

[0013] In an embodiment of the present invention, a system operator selects an area of the preview display and requests a high resolution display of that area. When the request is received, the high resolution display processing module invokes conversion processing in the image conversion system. For each pixel in the selected area, the image conversion system retrieves an entry in the conversion data array and one or more samples from the captured raw polar image data. The image conversion system then interpolates the retrieved samples using weighting based on the retrieved conversion data array entry to obtain the respective pixel value in the second coordinate system. After all pixels in the selected area have been processed, the image conversion system communicates the converted image data to the display processing module. The display processing module then displays the high resolution image in the display window.

[0014] Further embodiments, features, and advantages of the present inventions, as well as the structure and operation of the various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

[0015] The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate the present invention and, together with the description, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention.

[0016] FIG. 1 shows a system incorporating an image conversion system and a display processing module in accordance with an embodiment of the present invention.

[0017] FIG. 2 shows an image conversion system for converting image data captured in a first coordinate system format to a second coordinate system format in accordance with an embodiment of the present invention.

[0018] FIG. 3 shows a display processing module for generating a preview display and a high resolution display in accordance with an embodiment of the present invention.

[0019] FIG. 4 shows a portion of an output device in accordance with an embodiment of the present invention.

[0020] FIG. 5 shows a view of a non-planar prism in accordance with an embodiment of the present invention.

[0021] FIG. 6 shows a flowchart depicting a method for converting captured image data in a first coordinate system to an image data in a second coordinate system.

[0022] FIG. 7A illustrates how a subject places a hand on a non-planar prism in accordance with various embodiments of the present invention.

[0023] FIG. 7B shows a position for an illumination source in accordance with various embodiments of the present invention.

[0024] FIG. 7C is a diagram that illustrates radial scan line images captured along an arcuate scan path and stored in an array.

[0025] FIG. 8 shows a flowchart depicting a calibration method.

[0026] FIG. 8A-B are diagrams that illustrate a conversion data array and the relationships between coordinates in polar and rectangular coordinate systems.

[0027] FIG. 9 shows a flowchart depicting a method for converting captured image data in a first coordinate system to an image data in a second coordinate system using system calibration data.

[0028] FIG. 10 and 11 illustrate the relationship between points on a conical platen surface and corresponding points when the conical platen surface is lifted and flattened to a rectangular coordinate space.

[0029] FIG. 12 shows a flowchart depicting a method for generating a preview display image.

[0030] FIG. 13 illustrates an exemplary preview display image.

[0031] FIG. 14 shows a flowchart depicting a method for generating a high resolution image of a selected area of a preview display image.

[0032] FIG. 15 shows a system incorporating an image conversion system and a display processing module in accordance with an alternate embodiment of the present invention.

[0033] FIG. 16 shows a system incorporating an image conversion system and a display processing module in accordance with an alternate embodiment of the present invention.

[0034] The present invention will now be described with reference to the accompanying drawings. In the drawings, like reference numbers can indicate identical or functionally similar elements. Additionally, the left-most digit(s) of a reference number may identify the drawing in which the reference number first appears.

DETAILED DESCRIPTION OF THE INVENTION

1.0 Architectural Embodiments of the Present Invention

[0035] FIG. 1 shows a block diagram of a live scanner 100. Live scanner 100 includes a non-planar prism 120 optically coupled between an illumination source 115 and an electro-optical system 125 and an image conversion system 150 coupled to the electro-optical system. In an embodiment, live scanner 100 also includes a display processing module 180 coupled to the image conversion system 150 and/or the electro-optical system 125. An output device 190 is coupled to display processing module 180.

[0036] Live scanner 100 captures biometric data from objects interacting with non-planar prism 120 and communicates the captured raw image data to image conversion system 150.

1.1 Image Conversion System

[0037] FIG. 2 is a block diagram of an image conversion system 150 for converting the raw image data captured in a first coordinate system format into a second coordinate system format in accordance with an embodiment of the present invention. In an embodiment, image conversion system 150 is implemented in software. Persons skilled in the relevant art(s) will appreciate that functions of image conversion system 150 can be implemented in hardware, firmware, or a combination of software and hardware/firmware.

[0038] Image conversion system 150 includes a receiving module 252, a coordinate conversion module 254, and a memory 256. Receiving module 252 is configured to receive captured image data in a first coordinate system format from a live print scanner. The first coordinate system used in capturing the raw image data depends upon the geometry of a prism implemented in the live scanner. For example, in a live scanner having a conical prism, the first coordinate system is a polar coordinate system. The polar coordinate system describes a point in terms of its angle, θ, and distance (i.e., radius, r) from a fixed origin. Thus, the polar coordinate system is ideal for describing non-planar surfaces such as cones. In an embodiment, the polar coordinate system defines the conical platen surface associated with a conical prism.

[0039] Coordinate conversion module 254 is coupled to the receiving module 252 and to memory 256. Coordinate conversion module 254 contains logic to calibrate the image conversion system 150 and logic to convert captured first coordinate system image data to a second coordinate system format. The second coordinate system used in converting the captured data depends upon the format required by downstream processing systems. In an embodiment of the present invention, the second coordinate system is a rectangular coordinate system. In the case of a conical prism, coordinate conversion module 254 converts image data captured in a polar coordinate system format to a rectangular system format. This conversion is described in further detail with respect to FIGs. 4-8.

[0040] FIG. 2 depicts a separate memory 256 coupled to coordinate conversion module 254 and receiving module 252. In an alternative embodiment, memory 256 could be integrated in coordinate conversion module 254. However, the invention is not limited to these configurations. Other configurations for memory 256 are possible as would be appreciated by a person skilled in the relevant art(s).

1.2 Display Processing Module

[0041] FIG. 3 is a block diagram of a display processing module 180 in accordance with an embodiment of the present invention. Display processing module 180 is configured to communicate information concerning the status of the image scanning and capturing process to one or more output devices. For example, display processing module 180 may generate a preview display of the captured image data at or near real-time as radial scan lines are being captured. Display processing module 180 may also activate LEDs or audio devices in an output device to indicate a scan is in process or other status information.

[0042] As shown in FIG. 3, display processing system 180 includes a preview generation module 382 and a memory 386. In an embodiment, display processing system 180 may also include a high resolution display processing module 384. Preview generation module 382 has logic to generate a preview image of an object being scanned by the live scanner. High resolution display processing module 384 comprises logic to generate a high resolution display based on a request received from an output device. The display request includes the boundary points of the selected area of the preview display.

[0043] In an embodiment, display processing system 180 is implemented in software. Persons skilled in the relevant art(s) will appreciate that functions of display processing system 180 can be implemented in hardware, firmware, or a combination of software and hardware/firmware.

[0044] Display processing system 180 is coupled to output device 190. Output device 190 includes a user interface for providing outputs to users such as visual, audible, or tactile indications and for receiving inputs from a user such as control inputs for starting/stopping a scan and powering system 100 on and off. An example output device is described further below with respect to FIG. 4.

[0045] FIG. 4 shows a portion 491 of output device 190 in accordance with an embodiment of the present invention. Portion 491 includes a display window 492 for displaying the preview image. In an alternate embodiment, portion 491 also includes one or more visual indicators 494 (e.g., LEDs), and/or an audio device 496 for indicating status information about a scan. Portion 491 can also include input devices 498, such as a start/stop button and on/off button.

[0046] FIG. 5 depicts a cross-sectional view of an exemplary non-planar prism 520 in accordance with an embodiment of the present invention. Non-planar prism 520 has an opening 522 running along an axis of symmetry 524. Opening 522 is defined within an area 526 of non-planar prism 520 that has a non-planar first section 528 and a substantially planar second section 532. A first surface 536 of first section 528 is shaped so as to provide the non-planar aspect to prism 520. The non-planar shape is preferably approximately conical, but can also be curved, spherical, or the like. Preferably, a platen surface 534 provides total internal reflection of an incident beam so that a high quality image of a print pattern can be captured.

2.0 Image Conversion Method

[0047] FIG. 6 depicts a flowchart of a method 600 for converting image data captured in a first coordinate system format to a second coordinate system format in accordance with the present invention. The flowchart 600 will be described with continued reference to the example image conversion system 150 described in reference to FIGS. 1 and 2, above. However, the invention is not limited to that embodiment.

[0048] Method 600 includes a calibration (or pre-processing) process 610 and a run-time process 620. Calibration process 610 can be carried out anytime prior to run-time or on-the-fly before a scan. Calibration process 610 involves the calibration of arrays, tables, and parameters used by the image conversion system 150 for conversion processing (step 630). Step 630 is described in further detail below with respect to FIG. 5.

[0049] Run-time process 620 is initiated when the image conversion system 150 receives raw first coordinate system image data from a live scanner (step 640). In step 645, the raw first coordinate system image data are stored in memory 156.

[0050] Prior to the start of run-time process 620, a scan is initiated in a live scanner (step 625). The scan can begin automatically or manually (e.g., in response to a user selection at a user interface to initiate a scan). During the scan, electro-optical system 125 captures image data from a platen surface scanning area. The captured image data can include raw image data representative of a print pattern from which biometric data (such as finger minutiae, ridge data, and/or other finger and hand characteristic information) can be extracted. This image data is communicated to the image conversion system internally or via a data network.

[0051] FIGs 7A-C illustrate the scanning and capturing process in a live scanner having an exemplary conical platen surface in accordance with an embodiment of the present invention. FIG. 7A illustrates the placement of a subject's hand on a conical platen surface during the scan. FIG. 7B shows a cross-sectional view of a portion of the live scanner performing the scan. In this embodiment, illumination source 115 is positioned in opening 522 of non-planar prism 520. Based on the reflection angle of a beam from illumination source 115 off the surface 534, the electro-optical system 125 captures images.

Electro-optical system 125 can rotate about axis 524 (e.g., axis of rotation) to capture images of platen surface 536.

[0052] FIG. 7C illustrates a scan of a print pattern placed on the conical platen surface 536 depicted in FIGs. 7A and B. As shown in the example diagram in FIG. 7C, a linear camera 127 having a length between a radius $r_{initial}$ and r_{final} moves from an initial angular position $\theta_{initial}$ along an arcuate path y to a final angular position θ_{final}. In this way, the linear camera 127 sweeps out a path in polar space over an area between angular positions $\theta_{initial}$ and θ_{final} and radial positions $r_{initial}$ and r_{final}.

[0053] As the linear camera scans, radial scan lines of image data (referred to herein as polar space raw image data) are successively captured and communicated to the receiving module 252 of the image conversion system 150 (step 640). The received polar coordinate system raw image data is stored in memory 256 (step 645). The stored polar system raw image data is shown schematically as an array of radial scan line images 728 in FIG. 7C. In practice, because of the conical platen surface, image data is captured and stored at a higher resolution (e.g., a greater dpi) in the scanning area near the top of the conical platen surface that is, closer to radial position $r_{initial}$, compared to the scanning area near the base of the conical area, that is, closer to radial position r_{final}. The capture and storing of radial scan line image data proceeds until the linear camera has swept a desired scanning path.

[0054] Returning to FIG. 6, in step 650, the coordinate conversion module 254 converts the stored raw first coordinate image data to second coordinate image data using the conversion data generated in step 630. In an embodiment of the present invention, conversion step 650 is not initiated until the scan is completed and all the captured image data has been received by the image conversion system 150. In an alternate embodiment, conversion step 650 begins after sufficient captured image data to perform conversion has been received. In this embodiment, the conversion step occurs in parallel with the scan. Step 650 is described in further detail below with respect to FIG. 6.

[0055] After the conversion process is completed, the conversion coordinate module 254 stores the converted second coordinate system image data in memory 156 (step 660). Other optional image processing operations such as filtering can be performed on the converted second coordinate system image data prior to step 660 or after storage. Second coordinate system image data can then be output for display or further processing by downstream applications (step 670). Examples of further processing operations are extract and match, store and forward, or other print processing or image processing operations. Run-time process 620 is repeated for each scan performed in an associated biometric imaging system.

[0056] In an embodiment of the present invention, after step 670, the display processing module 180 generates a preview display of the converted image. In this embodiment, the display processing module 180 determines a representative pixel value for pixels in a group of (x,y) coordinates using a decimation technique. For example, the processing module may select every n^{th} pixel as the representative pixel value for that group. Alternatively, the processing module may select a pixel at random. The representative pixel values are then plotted at a corresponding output device and displayed in a display window. In this way, a preview display can be provided quickly. In an alternate embodiment, the representative pixel values can be generated prior to step 670, before or during the conversion process.

[0057] FIG. 8 depicts a flowchart of calibration (or pre-processing) process 610. In step 812, the conversion coordinate module 254 generates the conversion data. In an embodiment, the coordinate conversion module 254 generates one or more conversion data arrays in step 812. Each conversion data array contains data necessary for converting captured first coordinate system image data to a second coordinate system format. Generation step 812 includes creating an array entry for each pixel in the defined output area of the second coordinate system. The conversion data array maps each pixel to a position in the first coordinate system. Each conversion data array entry includes second coordinate system coordinates and second coordinate system offset values as described further below.

[0058] FIG. 8A and 8B illustrate the generation of a conversion data array in a system having a polar first coordinate system and a rectangular second coordinate system. FIG. 8A shows an illustrative graph 850 of a polar coordinate system. Graph 850 has multiple radii 852 and angles 854. Point A_{RECT} represents the mapping of a rectangular coordinate (x_A, y_A) into the polar coordinate system.

[0059] FIG. 8B illustrates a conversion data array 870 associated with the graph of FIG. 8A. Conversion data array 870 includes a plurality of rectangular coordinate system (x,y) entries 872. Each respective (x,y) entry has an associated polar coordinate (r, θ) 874 and associated polar offsets $(r_{offset}, \theta_{offset})$ 876 for example, point A_{RECT} having coordinates (x_A, y_A) in (x,y) coordinate space has an entry 878 that contains polar coordinates (r_i, θ_i) and polar offsets $(r_{offsetA}, \theta_{offsetA})$. As shown in graph 850, polar coordinates (r_i, θ_i) point to a point A_{POLAR} in polar space, which is at or near point A_{RECT}. The polar offsets $(r_{offsetA}, \theta_{offsetA})$ identify displacements between point A_{POLAR} in polar space and point A_{RECT} in rectangular coordinate space as shown in graph 850. The present invention is not intended to be limited to conversion data array 870. Other types of data structures and/or coordinate space conversions can be used, as would be apparent to a person skilled in the art given this description.

[0060] FIG. 11 depicts a mapping 1100 of a conical platen surface 1190 onto a rectangular area 1195. As can be seen in FIG. 11, portions of the rectangular area 1195 do not overlap with the conical platen surface 1190. For (x,y) coordinates located in these portions, no data exists for conversion. Therefore, coordinate conversion is not required for these (x,y) coordinates. To improve efficiency, during generation of a conversion data array, the coordinate conversion module 254 stores a flag or a data value in the entry for each non-overlapped (x,y) coordinate. During run-time process 620, the flag or value indicates to the coordinate conversion module 254 that no computation is necessary for this (x,y) coordinate. The coordinate conversion module 254 then proceeds to the next (x,y) coordinate to be processed. In this embodiment, when the image is displayed, the display device will paint non-overlapped (x,y) coordinates with a default value such as white.

[0061] Returning to FIG. 8, after the conversion data array is generated, the conversion coordinate module 254 stores the conversion data array in memory 256 (step 816). In addition to generating and storing a conversion data array, other calibration (e.g., camera calibration) or pre-processing operations can be carried out as would be apparent to a person skilled in the art given this description. Also, generating and storing a conversion data array are described with respect to calibration and pre-processing. In alternate embodiments of the invention, the steps of generating and storing the conversion data array are carried out in real-time during run-time processing.

[0062] FIG. 9 depicts a process loop 650 for converting first coordinate space image data to second coordinate system image data based on the stored conversion data. Process loop 650 is described in reference to a first polar coordinate system and a second rectangular coordinate system such as depicted in FIG. 8A and 8B. Persons skilled in the relevant art(s) will recognize that other first and second coordinate systems can be used without departing from the spirit or scope of the present invention.

[0063] Process loop 650 is performed for each pixel (x,y) in an output rectangular area. An output rectangular area can correspond to an area obtained when a conical platen surface is flattened as shown in the mappings of FIG. 10-11. In step 952, the coordinate conversion module 254 retrieves conversion data associated with the second coordinate system pixel being processed from the conversion data array. In the example array 870, the retrieval for a given pixel at coordinates (x,y) would obtain values for corresponding polar coordinates (r, θ) and polar offsets (r_{offset}, θ_{offset}). This retrieved conversion data identifies a region in polar space that corresponds to the particular pixel. For example, as shown in graph 850, in the case of a look up for a pixel at rectangular space coordinates (x_A, y_A), polar coordinate values (r_i, θ_i) are retrieved which correspond to a point in polar space near the pixel at point (x_A, y_A).

[0064] In step 954, one or more samples of the captured image data in first coordinate system format are retrieved from memory 256. The samples are selected based on the retrieved conversion data array entry. In particular, samples at or near polar coordinate values (r, θ) are selected. In step 956, the coordinate conversion module 254 interpolates the retrieved samples to obtain the pixel value for a respective pixel in rectangular image space. The coordinate conversion module 254 uses a weighting in the interpolation, which is based on the retrieved polar offsets (r_{offset}, θ_{offset}).

[0065] Any conventional sampling and interpolation techniques can be used in steps 954 and 956, including but not limited to, bi-linear interpolation, and cubic spline interpolation (e.g., a Catmull-Rom interpolation). In the example shown in graph 850, sixteen samples denoted by an "X" may be retrieved from the captured polar space image data at or near the looked up polar coordinate values (r_i, θ_i). Weighting coefficients for a Catmull-Rom interpolation are then determined based upon the looked up polar offsets (r_{offset}, θ_{offset}). In this way, a sampled and interpolated value is obtained from captured polar space image data that corresponds to a pixel value in rectangular image space. High resolution in the raw image data is maintained.

[0066] Method 600 describes the coordinate conversion module 254 calculating the weighting coefficients during run-time process step 650. In an alternate embodiment, a weighting coefficient table for each interpolation method supported could be generated and stored during or prior to calibration. In this embodiment, in step 956, the coordinate conversion module 254 accesses the appropriate weighting coefficient table to determine the weighting used during interpolation.

[0067] In an alternate embodiment of the present invention, method 600 also includes the ability for a user to configure various aspects related to the scan, conversion, and/or display. In this embodiment, a user may input criteria to be used during conversion and/or display processing. For example, a user may input a desired output resolution (e.g., 600 dpi, 1200 dpi, etc.), a desired output size, and/or a desired output location. If the coordinate conversion module supports input criteria, the coordinate conversion module 254 may generate multiple data arrays. For example, the coordinate conversion module may generate one array for use if 600 dpi is selected, a second array for use if 800 dpi is selected, a third array if 1200 dpi is selected, and so on. These multiple data arrays may be generated dynamically upon input by the user or may be generated during or prior to calibration.

[0068] In this embodiment, a user may also input goal criteria such as reducing aliasing, improving focus, and/or improving contrast. Based on these criteria, the coordinate conversion module 254 selects the appropriate parameters for meeting these goals. For example, the coordinate conversion module 254 may select the best interpolation method to be used during conversion to meet the user input criteria. In an alternate embodiment of the invention, the live scanner may automatically generate the criteria to be used for the scan.

[0069] In an alternate embodiment, the orientation of a print being displayed can also be adjusted. During conversion processing, the image conversion system 150 determines the center of the scanned image (e.g., the center of the handprint or the center of the fingerprint). For example, the image center can be represented by a coordinate point or by horizontal and/or vertical lines. The system 150 then assigns the image center as the root for display and conversion processing. By identifying the center, the coordinate conversion module 254 can rotate the orientation of the print image during conversion processing. In this way, the print image can be displayed in the correct orientation without requiring additional processing to correct the orientation. In an alternate embodiment, the orientation can be adjusted after conversion by the coordinate conversion module 254 or by the display processing module 180.

[0070] FIGS. 10 and 11 illustrate point-by-point how mapping between a polar coordinate system and a rectangular coordinate system can be performed for a conical prism using the above described methods and systems. FIG. 10 illustrates where polar coordinates and rectangular coordinates approximately overlap before conversion. FIG. 11 illustrates how a few polar coordinate system points on the conical platen surface correlate to rectangular coordinate system points.

3.0 Display Processing

3.1 Preview Generation Method

[0071] FIG. 12 depicts a flowchart of a method 1200 for generating a preview display of a print pattern placed on a non-planar platen surface in accordance with the present invention. Method 1200 will be described with continued reference to example display processing system 180 described in reference to FIGs. 1 and 3, above.

[0072] In an embodiment of the present invention, method 1200 is initiated by the system operator via a user-interface at the output device 190. Alternatively, method 1200 could be initiated automatically. For example, the system operator may have the option of selecting a *Preview Display* command on a user-interface screen. In an alternate embodiment, method 1200 is automatically initiated each time a scan is performed. Method 1200 is a process loop which is performed for each group of radial scan line images captured during a scan. A group of radial scan line images consists of one or more radial scan lines. In one example, a group of radial scan lines is made up of approximately 25 scan lines.

[0073] Prior to the start of method 1200, a scan is initiated in a live scanner as described above in reference to FIGs 7A-C. In step 1220, the display processing system 180 receives a group of captured radial scan line images from a scanning and capturing system. The captured radial scan line images are in a polar coordinate system format. After a group is received, the preview generation module 382 determines the representative pixel values for pixels in the group of captured radial scan line images (step 1230). Any representative pixel value can be used including but not limited to average sensor pixel values or decimated selected values. Next, the polar coordinate system position of the respective group of captured radial scan line images is converted to a position in the display window coordinates (step 1240) by the preview display module.

[0074] In step 1250, the representative pixel values (e.g., average sensor pixel values) are plotted at the corresponding display window coordinates and displayed in the display window of output device 190 (step 1260). In this way, a preview display can be provided quickly and, as groups of radial line scan images are processed, can sweep across an arcuate path in the display window to provide a visual image approximating the actual captured data. In step 1270, preview display processing module determines whether another group of radial scan line images remains to be processed. If another group exists, then method 1200 repeats. If no other group exists, method 1200 ends until re-initiated.

[0075] Using method 1200, a quick preview display can be output as image data is being captured across a large platen surface. Such a preview is even more helpful when more time consuming operations such as coordinate conversion are needed when processing the scanned image.

[0076] In an alternate embodiment of the present invention, preview generation module 382 stores the converted display window coordinates temporarily in memory 386 until all the groups of scan line images have been processed. After all the groups have been processed, the representative pixel values (such as average pixel values) are plotted and displayed. In this embodiment, step 1250 and 1260 are performed only once during generation of the preview image.

[0077] FIG. 13 illustrates an exemplary preview display of a hand print image. Upon viewing the preview display, a system operator may desire a more detailed view of a portion of the displayed image. For example, the system operator may wish to view a high resolution image of the print contained in area 1365. In an embodiment, the output device 190 provides a mechanism (such as a graphical user interface) for the system operator to select area 1365 and request the high resolution display. For example, the system operator may have the option of highlighting an area of interest with a mouse or cursor and selecting a *Convert Image* command on the user-interface screen.

3.2 High Resolution Display Method

[0078] FIG. 14 depicts a flowchart 1400 of a method for generating a high resolution display of a selected portion of the preview display. Method 1400 will be described with continued reference to FIGs. 1, 2, and 3, below.

[0079] Prior to the start of method 1400, a preview image is generated and displayed at an output device 190 according to method 1200 described above. After the preview image is displayed, method 1400 begins when a system operator identifies a selected area in the preview display window and requests a high resolution display of that area. Alternatively, system 100 can automatically select an area and initiate a high resolution display. In step 1420, the boundary points of the selected area are determined and communicated to the high resolution display processing module 184 in a request message. Upon receiving the request, the high resolution display processing module 184 invokes coordinate conversion processing in the image conversion system 150.

[0080] For each pixel in the selected preview display area, a conversion process (steps 1430-1460) is performed in the image conversion system to provide a high-resolution display of the image in the selected area. In step 1430, conversion data for the pixel being processed is retrieved by the coordinate conversion module 254 from the conversion data array stored in memory 256. The retrieved conversion data entry includes polar coordinates and offset data associated with the (x,y) pixel position. The coordinate conversion module 254 also retrieves one or more samples of the captured polar image data associated with the polar coordinate values from the conversion array entry (step 1440). In step 1450, the retrieved samples are interpolated with a weighting based on the polar offset data to obtain the respective pixel value in rectangular image space. In step 1460, a decision is made whether there are more pixels to process. If yes, method 1400 returns to step 1430. If no more pixels remain to process, the stored rectangular image data is communicated to the high resolution display processing module 184 and then output to the display window of output device 190.

[0081] In an embodiment of the present invention, after the conversion process is complete, the high resolution display processing module 384 may generate a preview image instead of a high resolution image. In this embodiment, the high resolution display processing module 384 determines a representative pixel value for pixels in a group using a decimation technique. For example, the processing module may select every n^{th} pixel as the representative pixel value for that group. Alternatively, the processing module may select a pixel at random.

[0082] Method 1400 provides an advantage to a user because a user can initiate a quick preview display early in a scan and then select an area of interest in which to display an even higher resolution image of a print pattern. This is especially helpful to ensure proper placement of the print pattern on the non-planar surface of a large area conical prism before such a large amount of image data is sent for further image processing. The ability of a user to select an area of interest with the preview display has many advantages such as providing an opportunity to engage a user especially during a long scan time and allowing a user to interactively examine different parts of a scanned image at a high resolution. Providing a preview display and a high resolution display of a selected area of interest is especially important in the case of a conical platen surface where a target's hands may slide or roll down the surface or where the user may not have the benefit of trained personnel nearby to assist during the capture.

[0083] In an alternate embodiment, the orientation of a print being displayed can also be adjusted. During method 1200 and method 1400, the display processing system 180 determines the center of the scanned image (e.g., the center of the handprint or the center of the fingerprint). For example, the image center can be represented by a coordinate point or by horizontal and/or vertical lines. The system 180 then assigns the image center as the root for display and conversion processing. By identifying the center, the display processing system 180 can rotate the orientation of the print image during processing. In this way, the print image can be displayed in the correct orientation without requiring additional processing to correct the orientation. In an alternate embodiment of high resolution display processing method 600, the coordinate conversion module can adjust the orientation during conversion processing.

4.0 Alternate Architectural Embodiments of the Present Invention

[0084] FIGs. 15-16 depict alternative embodiments of the image conversion system described above. FIG. 15 depicts a system 1500 having a live scanner 1510 coupled to an external image conversion system 1550 via a data network 1560. In an alternate embodiment, two or more live scanners are coupled to the external image conversion system 1550 via data network 1560. Live scanner 1510 and image conversion system 1550 may also be coupled to a display processing module 1580 which in turn is coupled to output device 1590. Electro-optical system 125 captures raw image data and communicates the raw data to external image conversion system 1550 via data network 1560. Network 1560 can be any type of network or combination of networks known in the art, such as a local area network (LAN), a wide area network (WAN), an intranet, or an Internet. In an embodiment of the present invention, network 1560 includes a data link between the live scanner 1510 and the external image conversion system1550.

[0085] FIG. 16 depicts a system 1600 incorporating a distributed architecture in accordance with an alternate embodiment of the present invention. System 1600 includes a live scanner 1610 having an internal image conversion system 1650A coupled to an external image conversion system 1650B via a data network 1660. Image conversion processing is distributed between image conversion systems 1650A and 1650B. For example, internal image conversion system 1650A may include the calibration logic and external image conversion system 1650B may include the conversion logic. Display processing is distributed between display processing system 1680A and display processing system 1680B. As will be appreciated by persons skilled in the relevant art(s), other architectures for distributing image conversion processing among multiple image conversion systems can be used without departing from the spirit or scope of the invention.

[0086] The terms "biometric imaging system," "scanner," "live scanner," "live print scanner," "fingerprint scanner," and "print scanner" are used interchangeably, and refer to any type of system which can obtain an image of all or part of one or more fingers, palms, toes, foot, hand, etc. in a live scan.

5.0 Conclusion

[0087] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

WHAT IS CLAIMED IS:

1. A system for processing image data representing biometric data, comprising:

a receiving module for receiving image data captured in a first coordinate system; and

a coordinate conversion module coupled to the receiving module for converting the image data captured in the first coordinate system to converted image data in a second coordinate system.

2. The system of claim 1 further comprising a memory coupled to the coordinate conversion module.

3. The system of claim 1 wherein the second coordinate system is a rectangular coordinate system.

4. The system of claim 2 wherein the first coordinate system is a polar coordinate system.

5. The system of claim 1 further comprising a scanning and capturing system coupled to the receiving module wherein the scanning and capturing system comprises:

a non-planar prism; and

a scanning imaging system optically coupled to the non-planar prism for capturing image data in a first coordinate system and for communicating the image data to the receiving module.

6. The system of claim 5 wherein the scanning and capturing system is coupled to the receiving module via a data network.

7. The system of claim 6 wherein the second coordinate system is a rectangular coordinate system.

8. The system of claim 7 wherein the first coordinate system is a polar coordinate system.

9. A system for processing image data representing biometric data, comprising:

a non-planar prism;

a scanning imaging system optically coupled to the non-planar prism for capturing the image data in a first coordinate system; and

an image conversion system coupled to the scanning imaging system for converting the image data captured in the first coordinate system to converted image data in a second coordinate system.

10. The system of claim 9 wherein the image conversion system includes:

a receiving module for receiving image data captured in a first coordinate system; and

a coordinate conversion module coupled to the receiving module for converting the image data captured in the first coordinate system to converted image data in a second coordinate system.

11. The system of claim 10 wherein the image conversion system further comprises a memory coupled to the coordinate conversion module.

12. The system of claim 11 wherein the second coordinate system is a rectangular coordinate system.

13. The system of claim 12 wherein the first coordinate system is a polar coordinate system.

14. The system of claim 11 wherein the non-planar prism is a conical prism.

15. A system for processing image data representing biometric data, comprising:

a biometric imaging system comprising:

a non-planar prism,

an scanning imaging system optically coupled to the non-planar prism for capturing the image data in a first coordinate system, and

a first image conversion system coupled to the scanning imaging system for generating and storing conversion data; and

a second image conversion system coupled to the biometric imaging system for converting the image data captured in the first coordinate system to converted image data in a second coordinate system.

16. The system of claim 15 wherein the first image conversion system includes:

a receiving module for receiving image data captured in a first coordinate system; and

a coordinate conversion module coupled to the receiving module for converting the image data captured in the first coordinate system to converted image data in a second coordinate system.

17. The system of claim 16 wherein the second image conversion system includes:

a receiving module for receiving image data captured in a first coordinate system; and

a coordinate conversion module coupled to the receiving module for converting the image data captured in the first coordinate system to converted image data in a second coordinate system.

18. The system of claim 15 wherein the second coordinate system is a rectangular coordinate system.

19. The system of claim 18 wherein the first coordinate system is a polar coordinate system.

20. A system for processing image data representing biometric data, comprising:

means for converting image data captured in a first coordinate system to converted image data in a second coordinate system.

21. The system of claim 20 wherein the second coordinate system is a rectangular coordinate system.

22. The system of claim 21 wherein the first coordinate system is a polar coordinate system.

23. A method for processing image data representing biometric data comprising:

receiving the image data captured in a first coordinate system and storing the captured image data; and

converting the captured image data in the first coordinate system to converted image data in a second coordinate system.

24. The method of claim 23, wherein the converting comprises using a rectangular coordinate system as the second coordinate system.

25. The method of claim 24, wherein the first coordinate system is a polar coordinate system.

26. The method of claim 23, further comprising:

generating and storing a conversion data array including coordinate and offset data.

27. The method of claim 23, further comprising:

prior to receiving captured image data, receiving criteria associated with specifications for processing the captured image data; and

generating and storing at least conversion data array corresponding to the received criteria.

28. The method of claim 27 further comprising generating and storing at least one conversion parameter corresponding to the received criteria.

29. The method of claim 27 wherein one of the at least one conversion parameter includes a parameter indicating the interpolation method.

30. The method of claim 27 wherein each of the at least one conversion data array is generated dynamically.

31. The method of claim 23, wherein said converting comprises:

for each pixel in an output rectangular area, the steps of:

performing a look up to obtain conversion data including the coordinate data and the offset data associated with respective pixel coordinates;

retrieving at least one sample of stored captured image data; and

interpolating each retrieved sample with weighting based on the looked up offset data to obtain a respective pixel value in the second coordinate system.

32. A method for processing image data representing biometric data in a system having a scanning and capturing system and an image conversion system, comprising:

generating and storing conversion data in the image conversion system;

capturing in the scanning and capturing system the image data in a first coordinate system;

communicating the captured first coordinate system image data to the image conversion system; and

converting the captured first coordinate system image data to converted image data in a second coordinate system.

33. The method of claim 32, wherein the capturing comprises using a polar coordinate system as the first coordinate system.

34. The method of claim 33, wherein the converting comprises using a rectangular coordinate system as the second coordinate system.

35. The method of claim 32, wherein said converting comprises:

for each pixel in an output rectangular area, the steps of:

performing a look up in a conversion data array to obtain conversion data including the coordinate data and the offset data associated with respective pixel coordinates;

retrieving at least one sample of stored captured image data; and

interpolating each retrieved sample with weighting based on the looked up offset data to obtain a respective pixel value in the second coordinate system.

36. The method of claim 35 wherein the step of interpolating each retrieved sample includes calculating the weighting.

37. The method of claim 35 wherein the step of interpolating each retrieved sample includes performing a look up to determine the weighting.

38. A method for processing image data representing biometric data comprising:

capturing the image data in a first coordinate system; and

converting the captured image data in the first coordinate system to converted image data in a second coordinate system.

39. The method of claim 38, wherein the capturing comprises using a polar coordinate system as the first coordinate system.

40. The method of claim 38, wherein the converting comprises using a rectangular coordinate system as the second coordinate system.

41. The method of claim 40, further comprising:

generating and storing conversion data including polar coordinate and polar offset data.

42. The method of claim 41, wherein said converting comprises:

for each pixel in an output rectangular area, the steps of:

performing a look up to obtain conversion data including the polar coordinate data and the offset data associated with respective pixel coordinates;

retrieving at least one sample of stored polar space image data; and

interpolating each retrieved sample with weighting based on the looked up polar offset data to obtain a respective pixel value in rectangular image space.

43. A method for generating a preview of a print pattern on a conical platen surface, an image of the print pattern being captured in a scan made up of a series of radial scan line images along an arcuate path, comprising:

for each group of radial scan line images, the steps of:

determining a representative sensor pixel value for pixels in a group of captured radial scan line images;

converting a polar coordinate position of the respective group of captured radial scan line images to a position in display window coordinates;

plotting the representative sensor pixel values determined in said determining step at corresponding display window coordinates; and

displaying the plot of the representative sensor pixel values in a display window as a preview of the captured print pattern image.

44. The method of claim 43 wherein determining a representative sensor pixel value includes determining an average sensor pixel value for pixels in the group of captured radial scan lines.

45. The method of claim 43 wherein the group of radial scan line images consists of approximately 25 radial scan lines.

46. The method of claim 43 further comprising the steps of:

receiving a request for a high resolution display of a selected area of the preview of the print pattern; and

converting the captured polar coordinate system image data contained in the portion of the preview of the print pattern to converted image data in a rectangular coordinate system.

47. The method of claim 46 wherein determining a representative sensor pixel value includes decimating the converted image data.

48. The method of claim 46, wherein said converting comprises:

for each pixel in the user selected area, the steps of:

performing a look up to obtain conversion data including the polar coordinate data and the polar offset data associated with respective pixel coordinates;

retrieving at least one sample of stored captured image data; and

interpolating each retrieved sample with weighting based on the looked up offset data to obtain a respective pixel value in rectangular coordinate system.

49. A system for generating a display of a print pattern on a conical platen surface, an image of the print pattern being captured in a scan made up of a series of radial scan line images along an arcuate path, comprising:

a prism having a conical platen surface;

a scanning imaging system optically coupled to the prism for capturing the image data in a polar coordinate system; and

a display processing system coupled to the scanning imaging system wherein the display processing system comprises a preview generation module for generating a preview display of the captured print image.

50. The system of claim 49 wherein the display processing system further comprises a high resolution display processing module for generating a high resolution display of an area of the preview display selected by a system user.

51. The system of claim 50 further comprising an image conversion system.

52. The system of claim 49 wherein the prism is a conical prism.

53. The system of claim 49 wherein the scanning and capturing system is coupled to the display processing system via a data network.

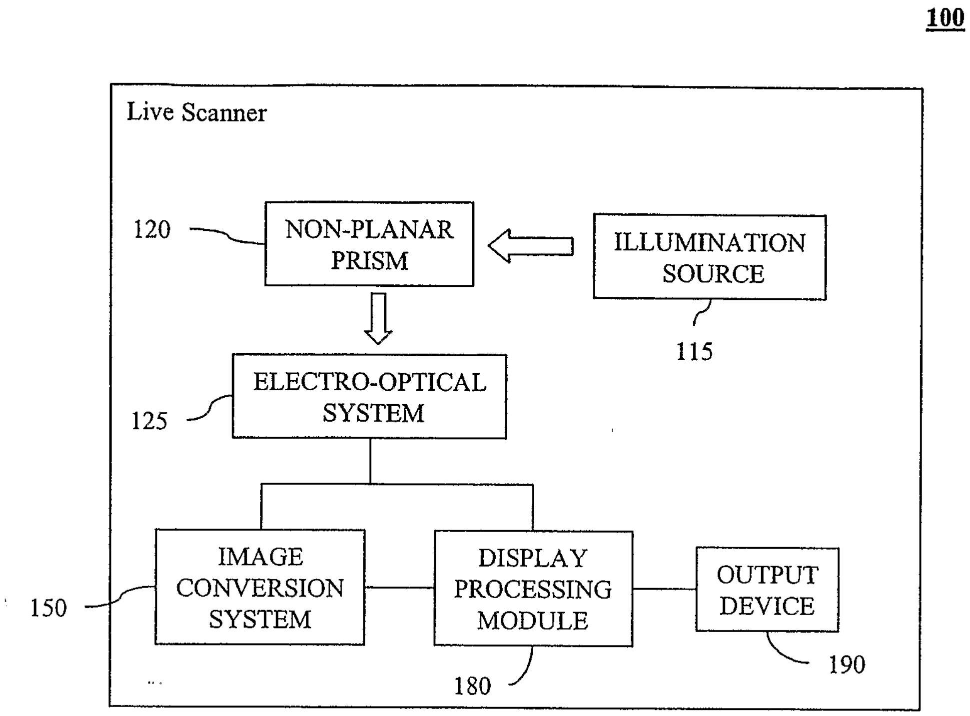

100
Live Scanner
120
NON-PLANAR PRISM
ILLUMINATION SOURCE
115
125
ELECTRO-OPTICAL SYSTEM
150
IMAGE CONVERSION SYSTEM
DISPLAY PROCESSING MODULE
OUTPUT DEVICE
180
190

FIG. 1

150

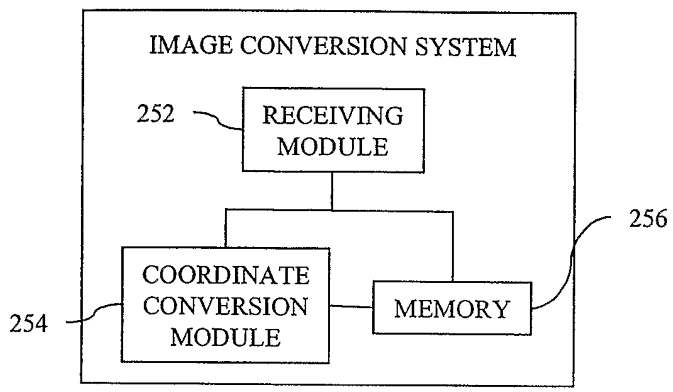


IMAGE CONVERSION SYSTEM
252
RECEIVING MODULE
256
COORDINATE CONVERSION MODULE
MEMORY
254

FIG. 2

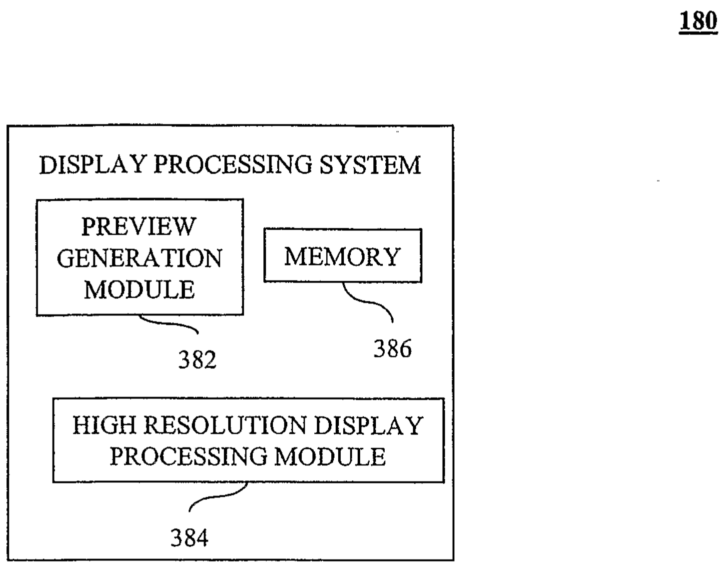

180
DISPLAY PROCESSING SYSTEM
PREVIEW GENERATION MODULE
MEMORY
382
386
HIGH RESOLUTION DISPLAY PROCESSING MODULE
384

FIG. 3

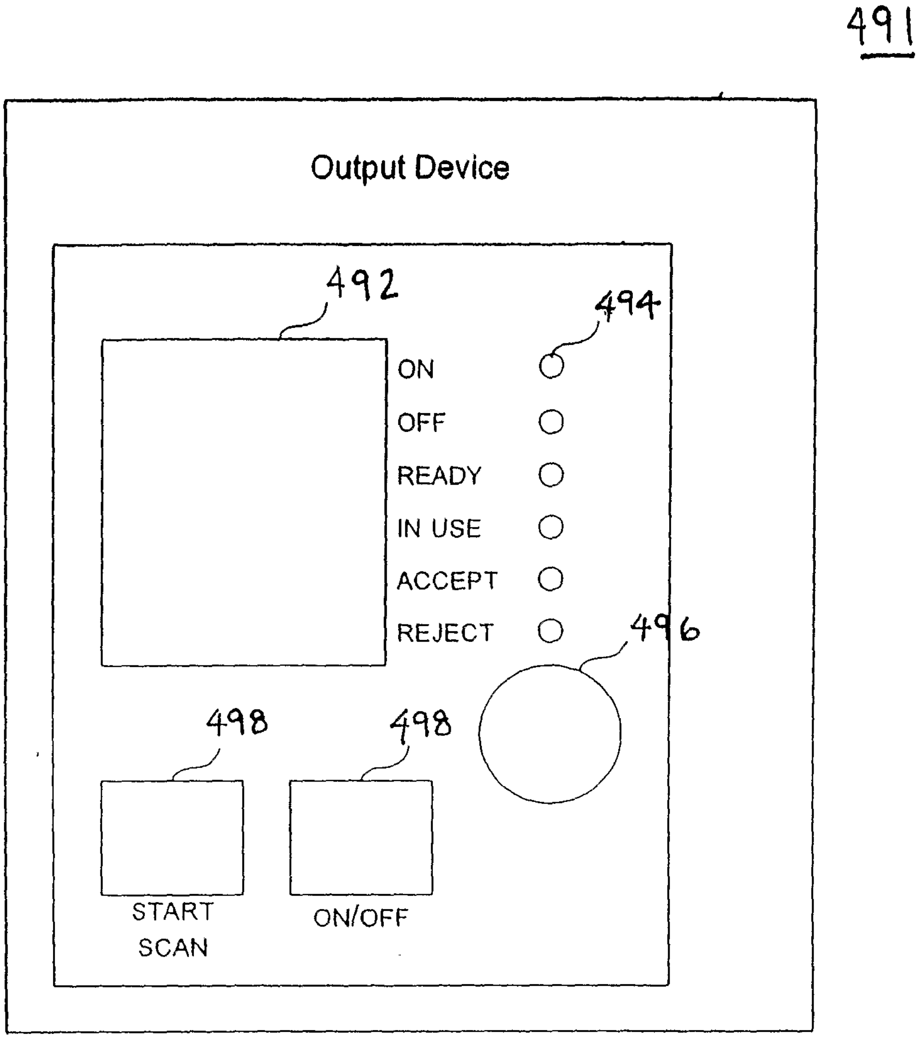
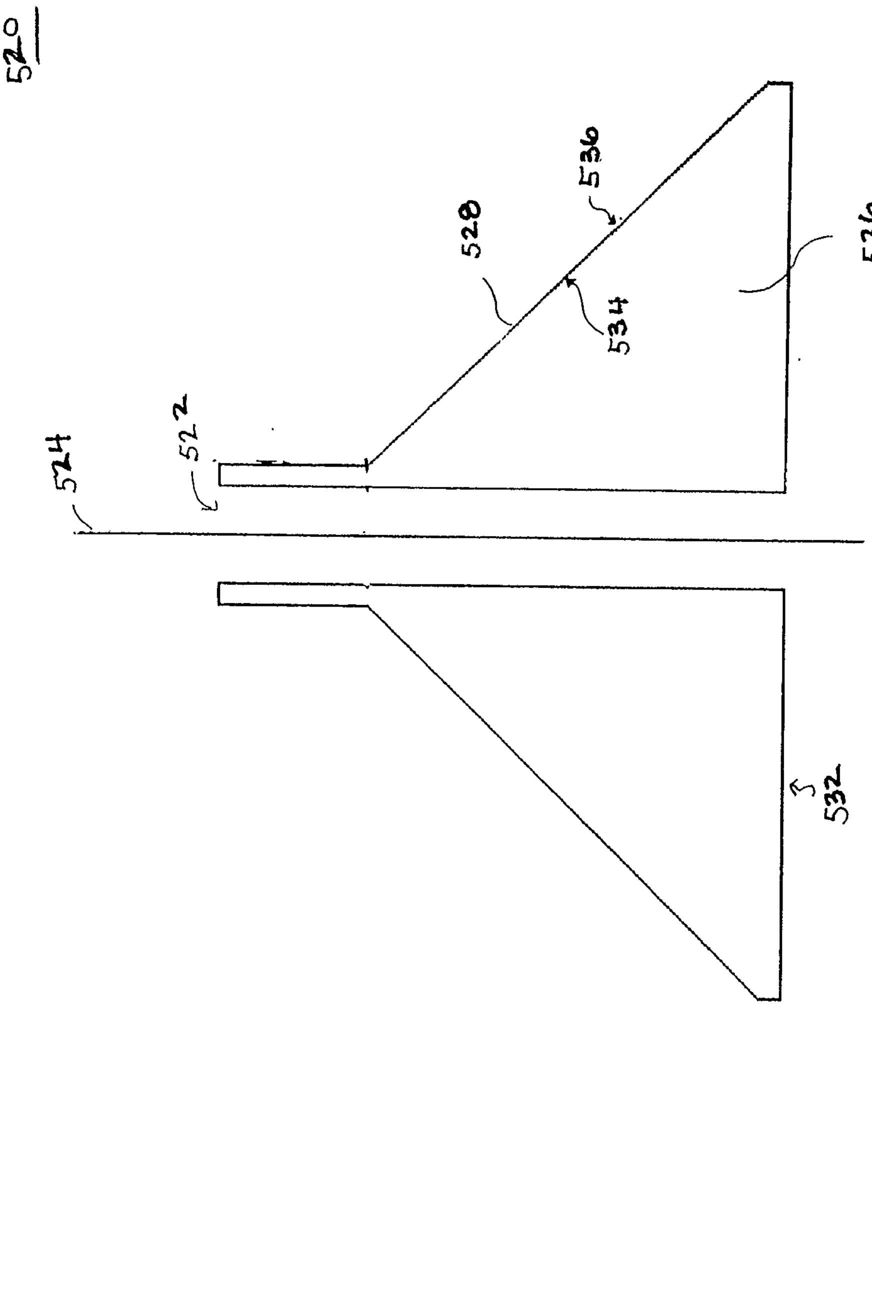

491
Output Device
492
494
ON
OFF
READY
IN USE
ACCEPT
REJECT
496
498
498
START
SCAN
ON/OFF

FIG. 4

FIG. 5



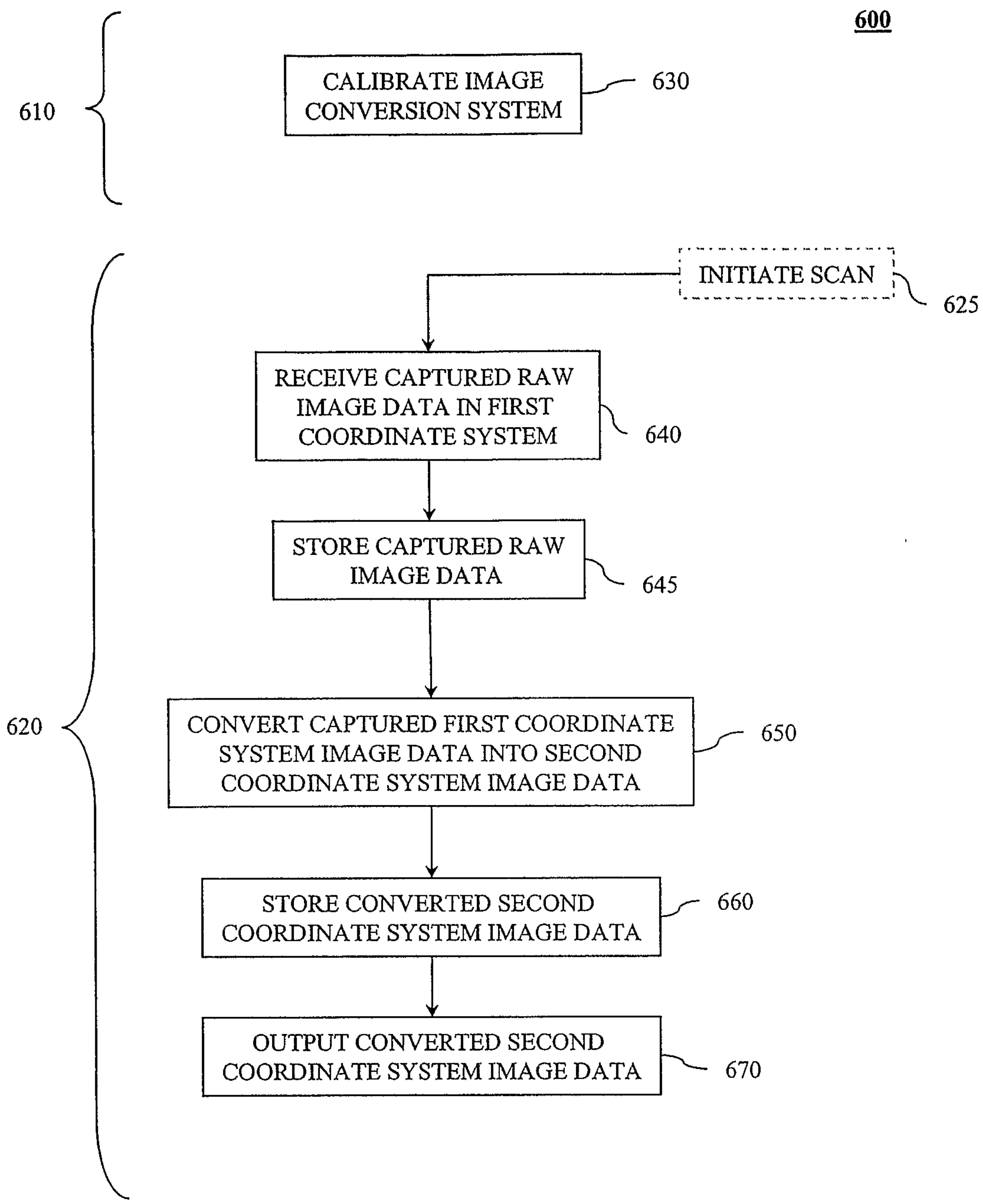

600
610
CALIBRATE IMAGE CONVERSION SYSTEM
630
620
INITIATE SCAN
625
RECEIVE CAPTURED RAW IMAGE DATA IN FIRST COORDINATE SYSTEM
640
STORE CAPTURED RAW IMAGE DATA
645
CONVERT CAPTURED FIRST COORDINATE SYSTEM IMAGE DATA INTO SECOND COORDINATE SYSTEM IMAGE DATA
650
STORE CONVERTED SECOND COORDINATE SYSTEM IMAGE DATA
660
OUTPUT CONVERTED SECOND COORDINATE SYSTEM IMAGE DATA
670

FIG. 6

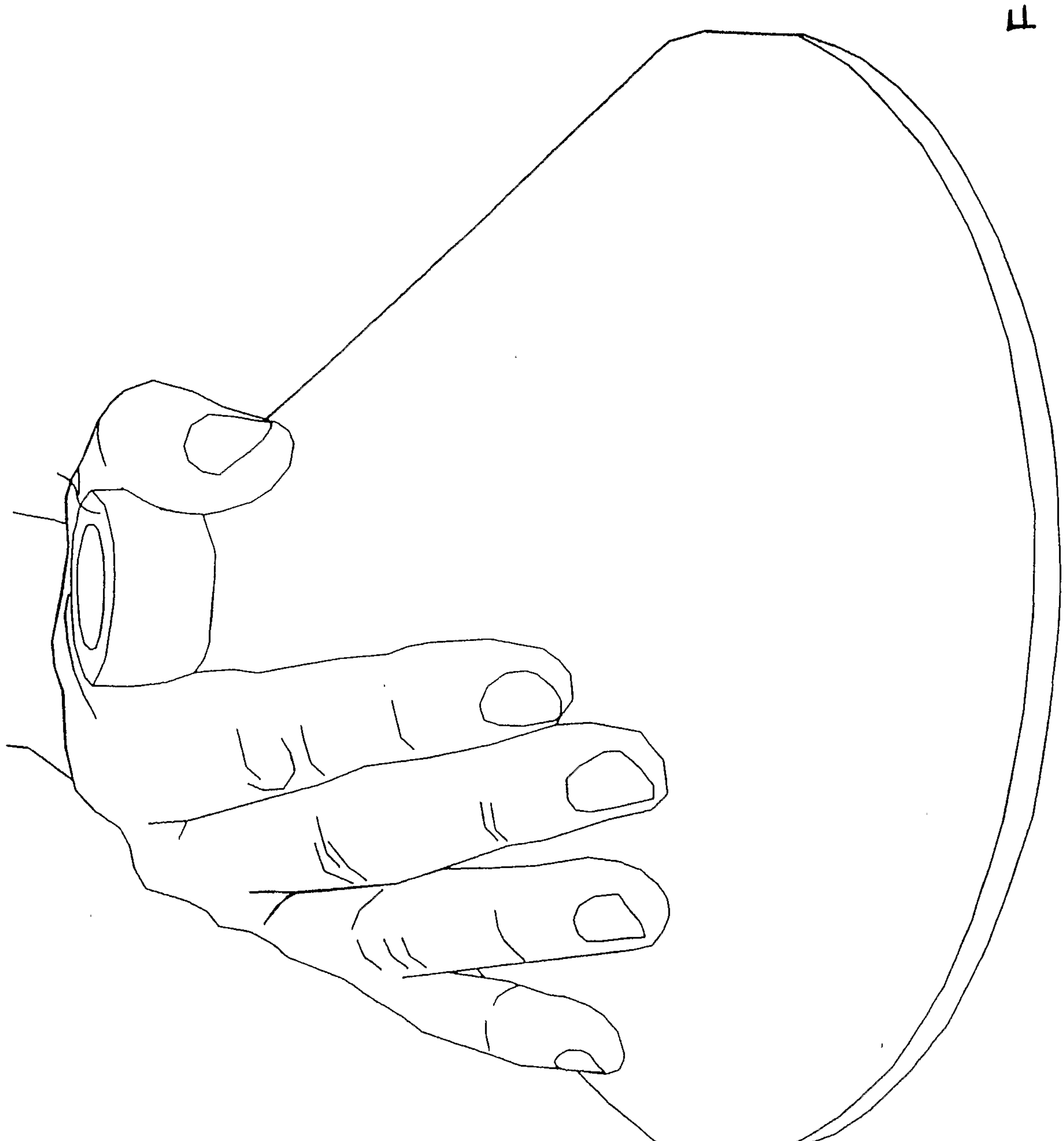


FIG. 7A

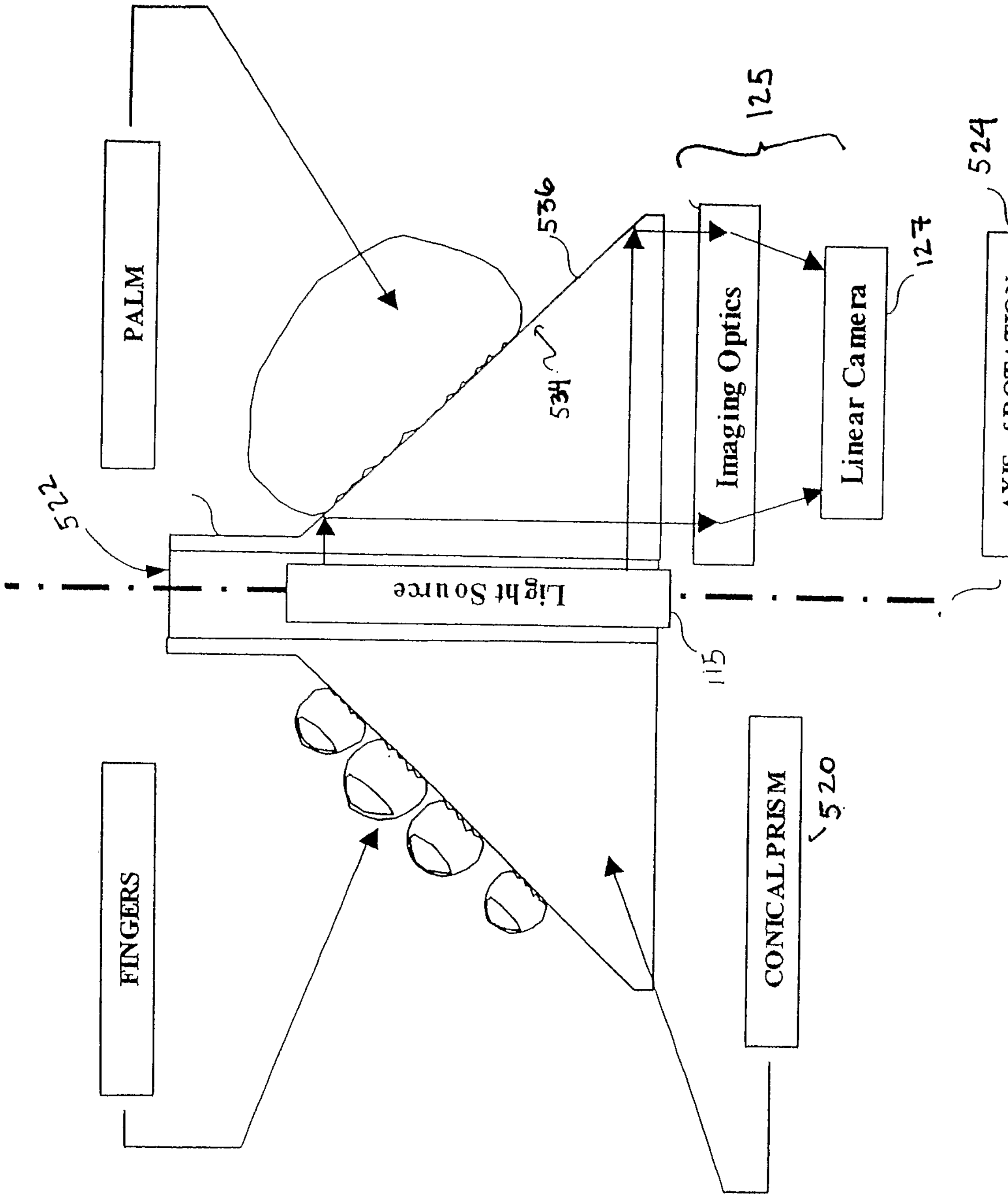
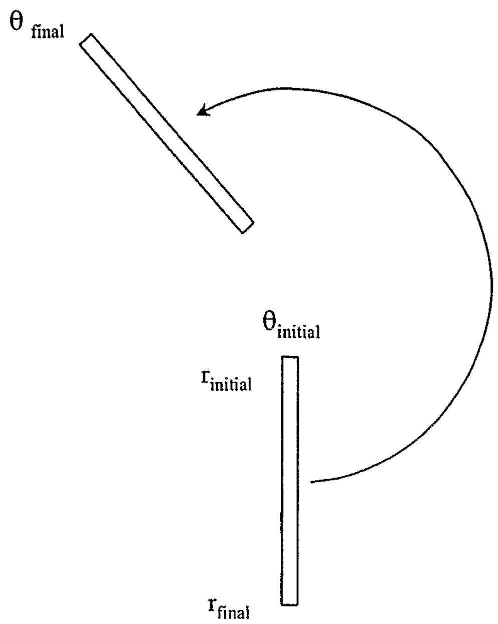
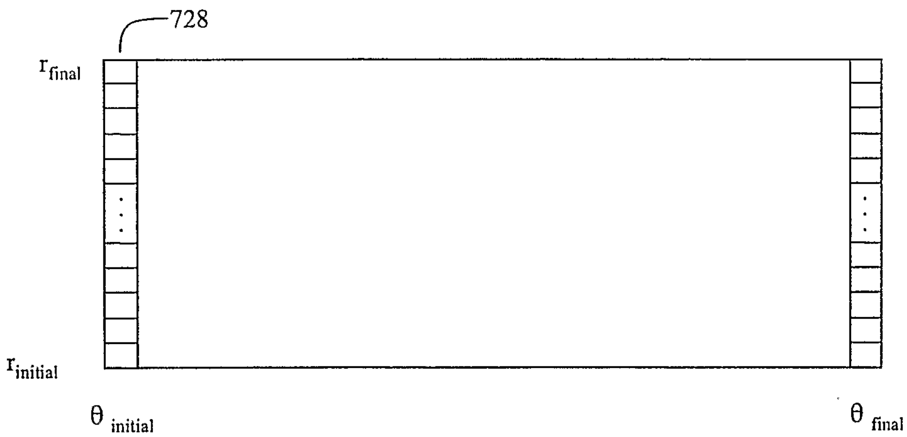

PALM
FINGERS
CONICAL PRISM
Imaging Optics
Linear Camera
AXIS of ROTATION
Light Source
522
536
534
125
127
524
115
520

FIG. 7B



θ final
θinitial
rinitial
rfinal



728
rfinal
rinitial
θ initial
θ final

FIG. 7C

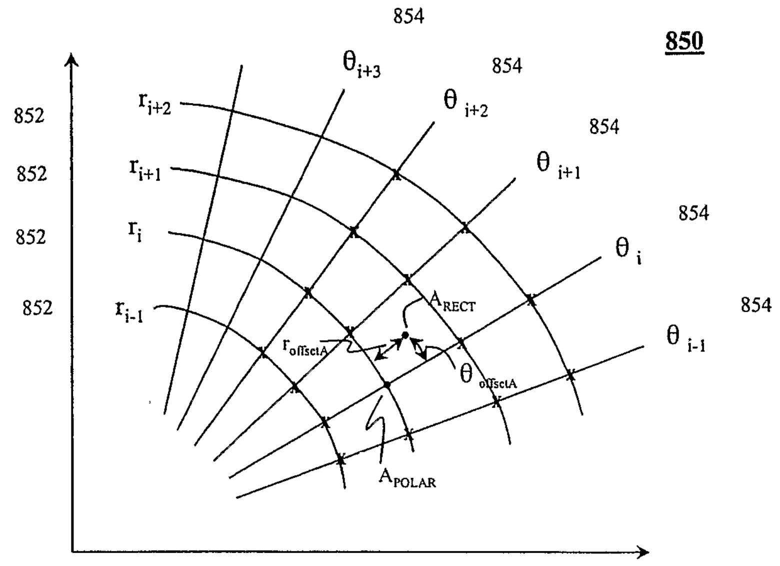


FIG. 8A

870

872 874 876 878

(x,y)	r	θ	r_{offset}	θ_{offset}
x_A, y_A	r_i	θ_i	$r_{offsetA}$	$\theta_{offsetA}$

FIG. 8B

610

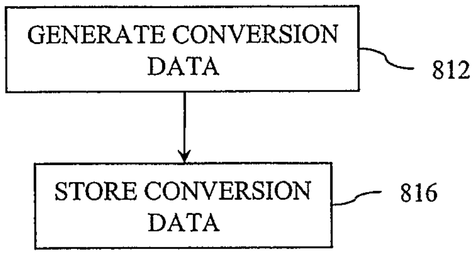


FIG. 8

650

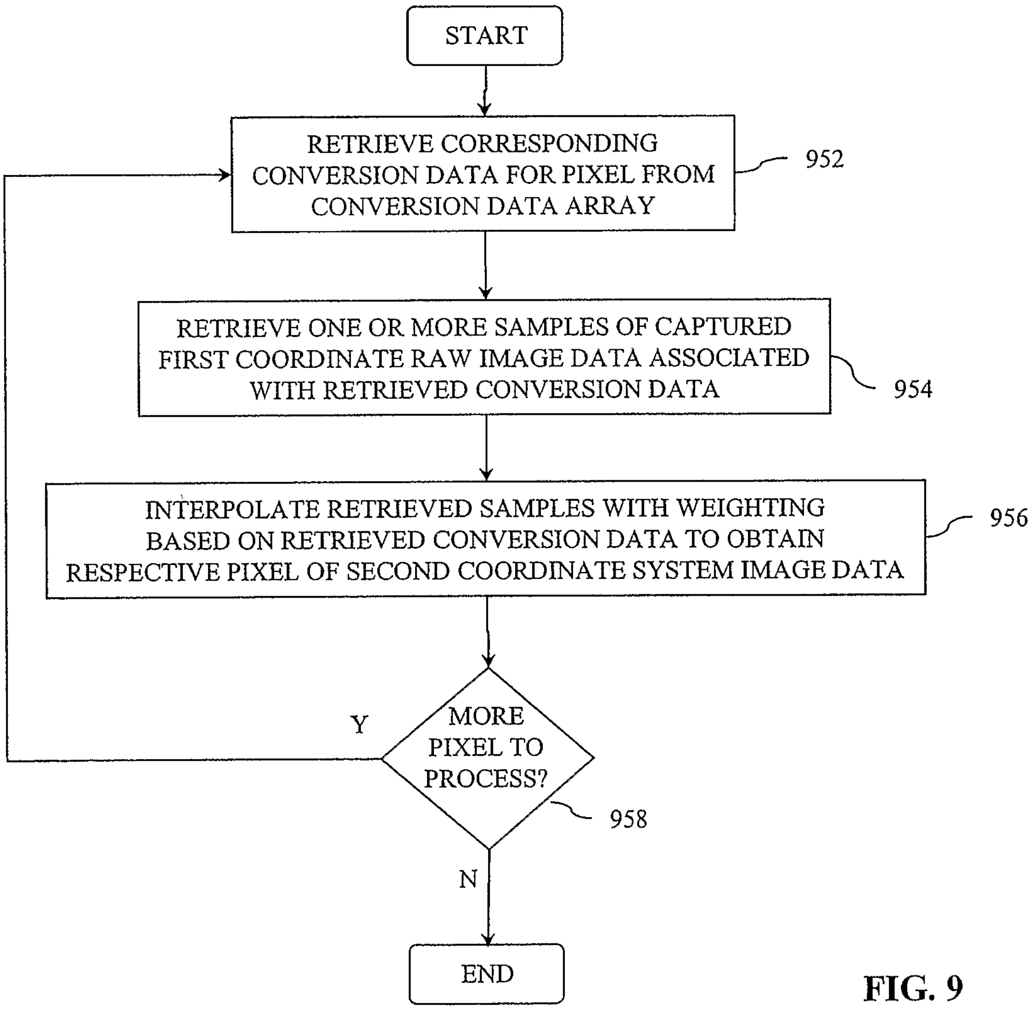


FIG. 9

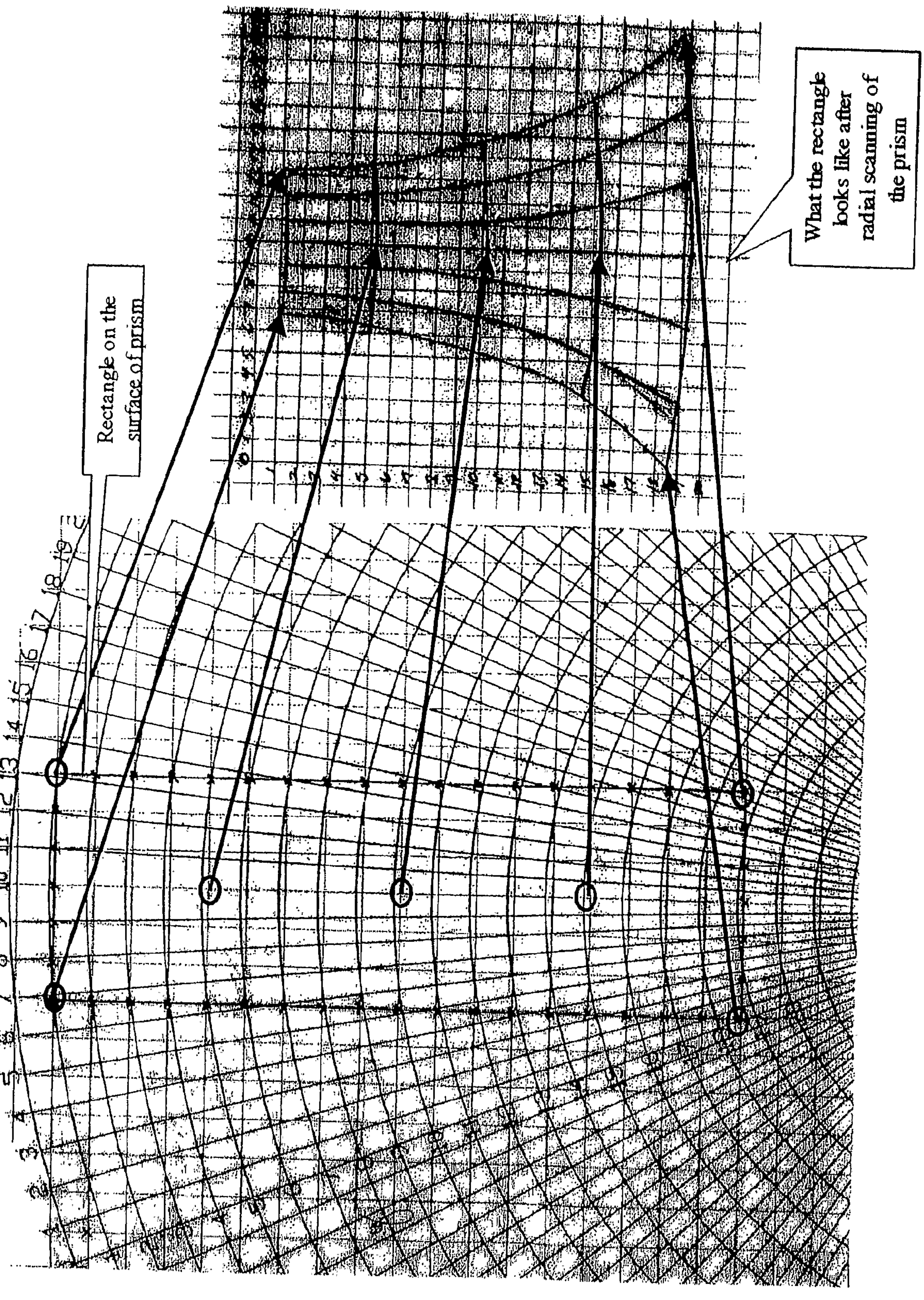

Rectangle on the surface of prism
What the rectangle looks like after radial scanning of the prism

FIG. 10

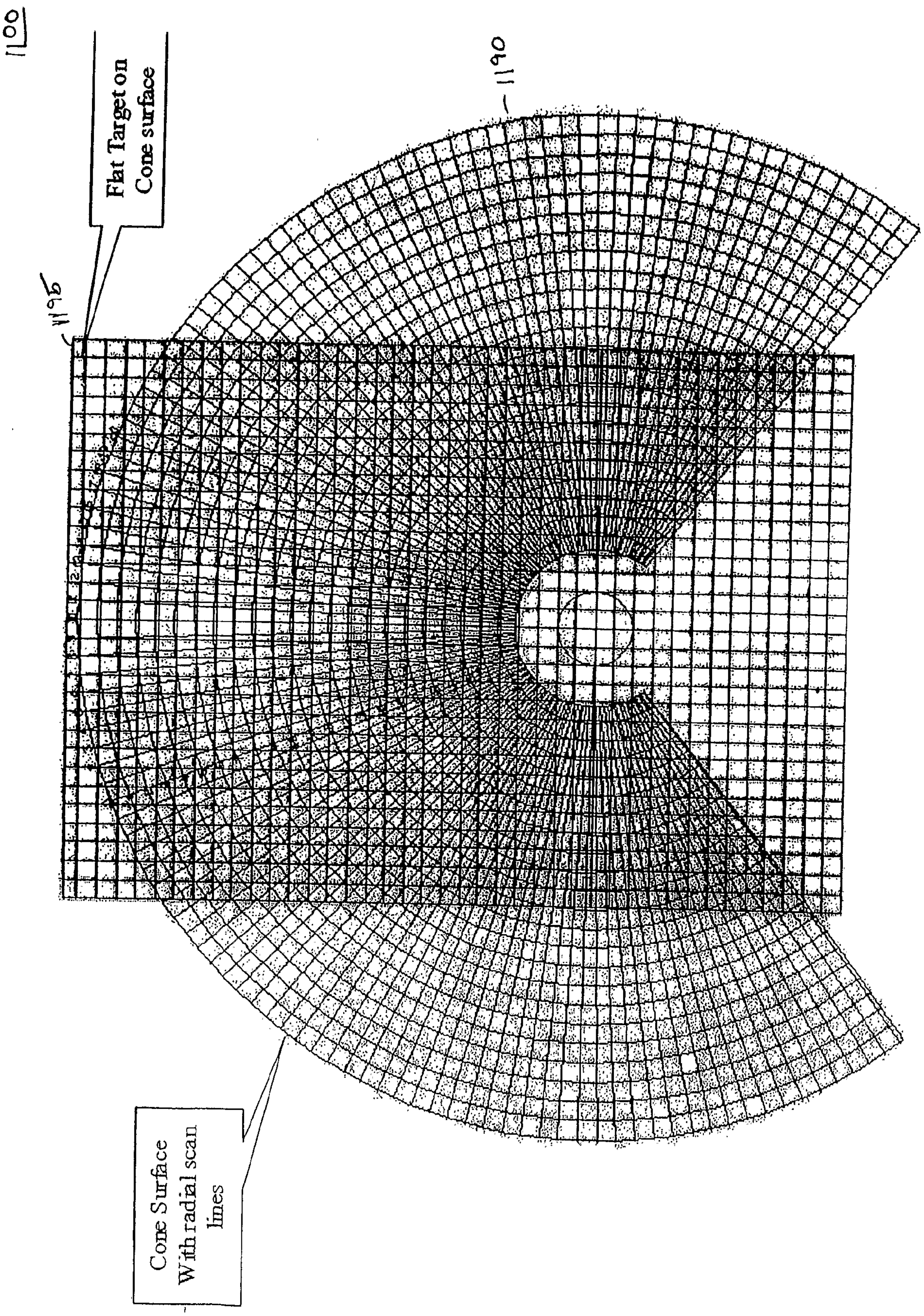

1100
Flat Target on Cone surface
1195
1190
Cone Surface With radial scan lines

FIG. 11

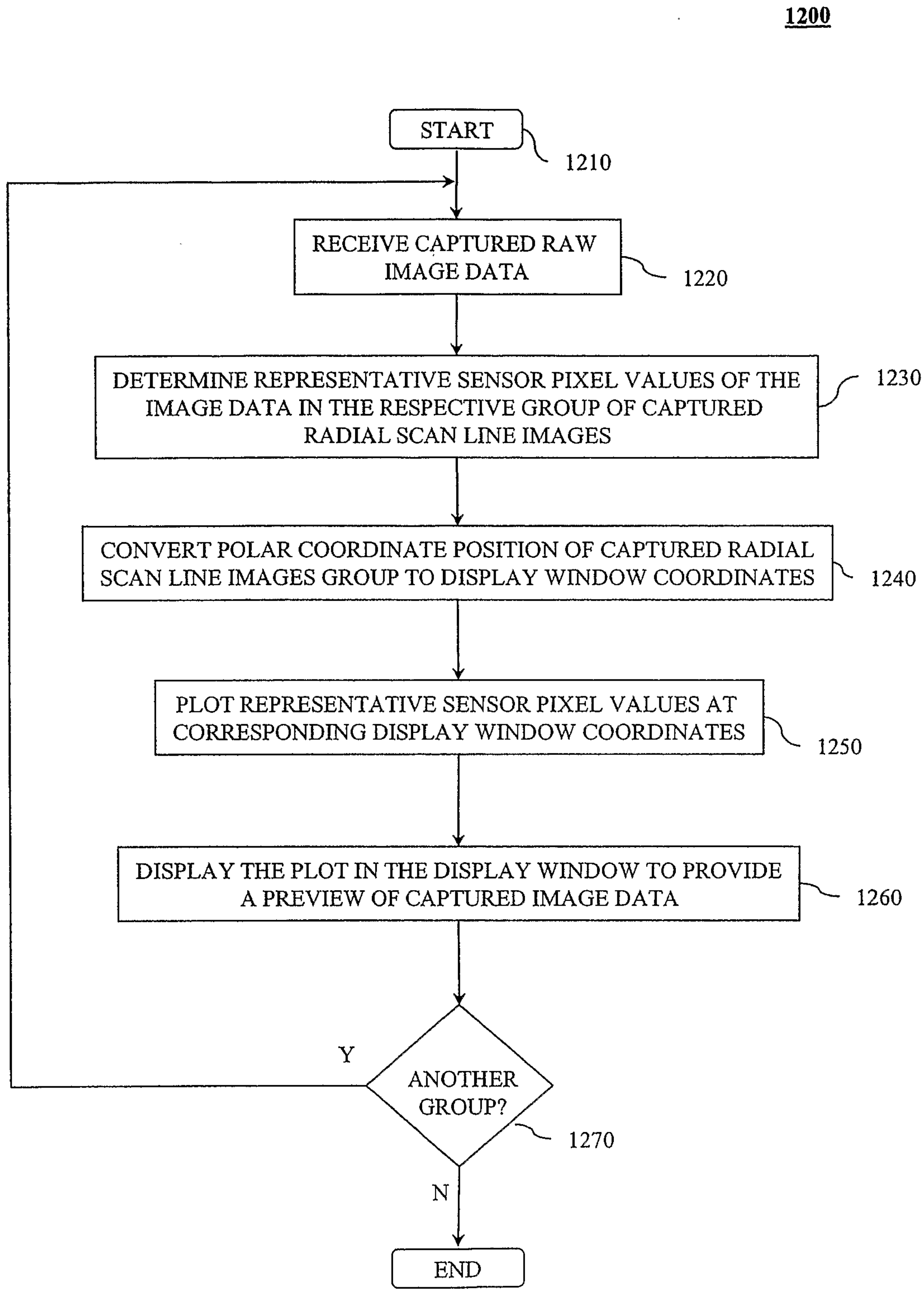

1200
START
1210
RECEIVE CAPTURED RAW IMAGE DATA
1220
DETERMINE REPRESENTATIVE SENSOR PIXEL VALUES OF THE IMAGE DATA IN THE RESPECTIVE GROUP OF CAPTURED RADIAL SCAN LINE IMAGES
1230
CONVERT POLAR COORDINATE POSITION OF CAPTURED RADIAL SCAN LINE IMAGES GROUP TO DISPLAY WINDOW COORDINATES
1240
PLOT REPRESENTATIVE SENSOR PIXEL VALUES AT CORRESPONDING DISPLAY WINDOW COORDINATES
1250
DISPLAY THE PLOT IN THE DISPLAY WINDOW TO PROVIDE A PREVIEW OF CAPTURED IMAGE DATA
1260
Y
ANOTHER GROUP?
1270
N
END

FIG. 12

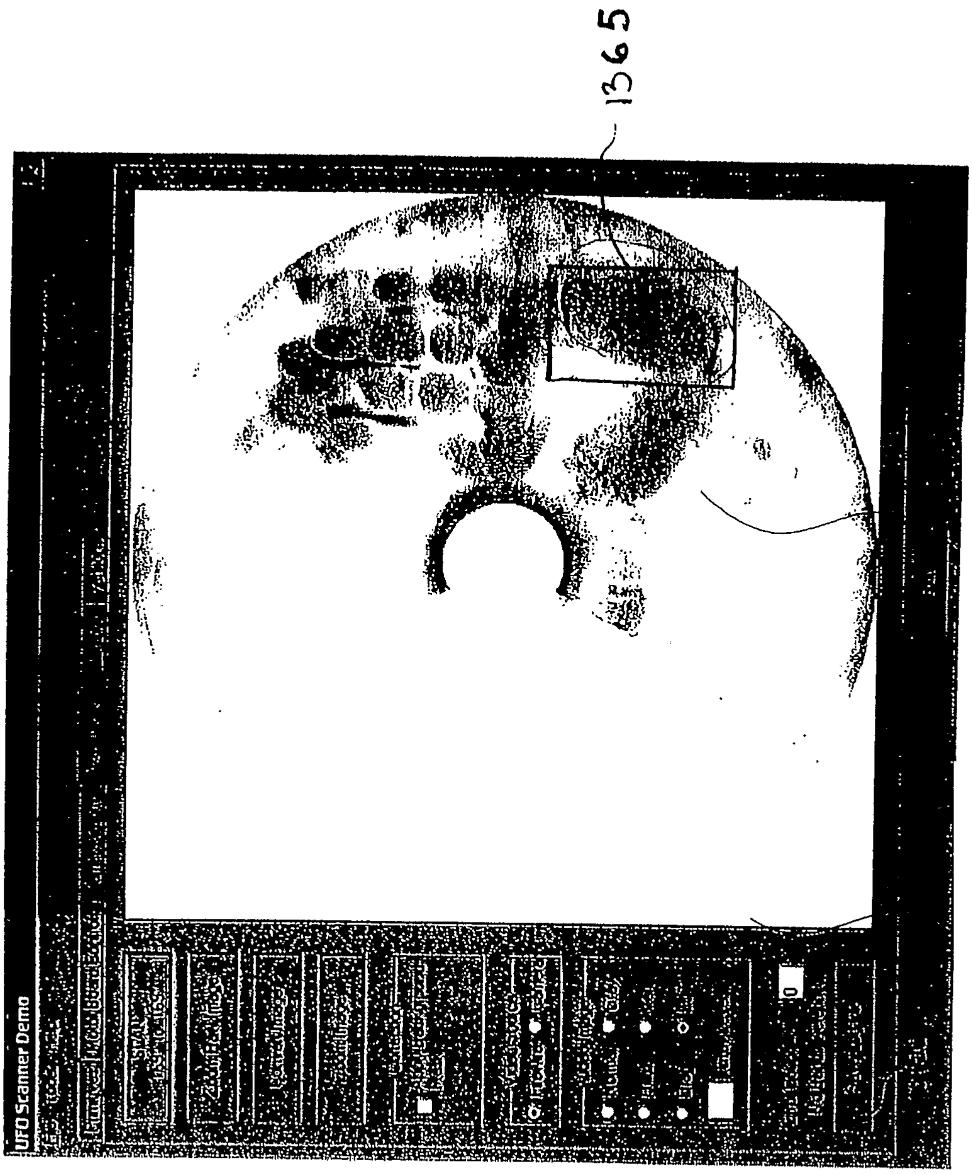


FIG. 13

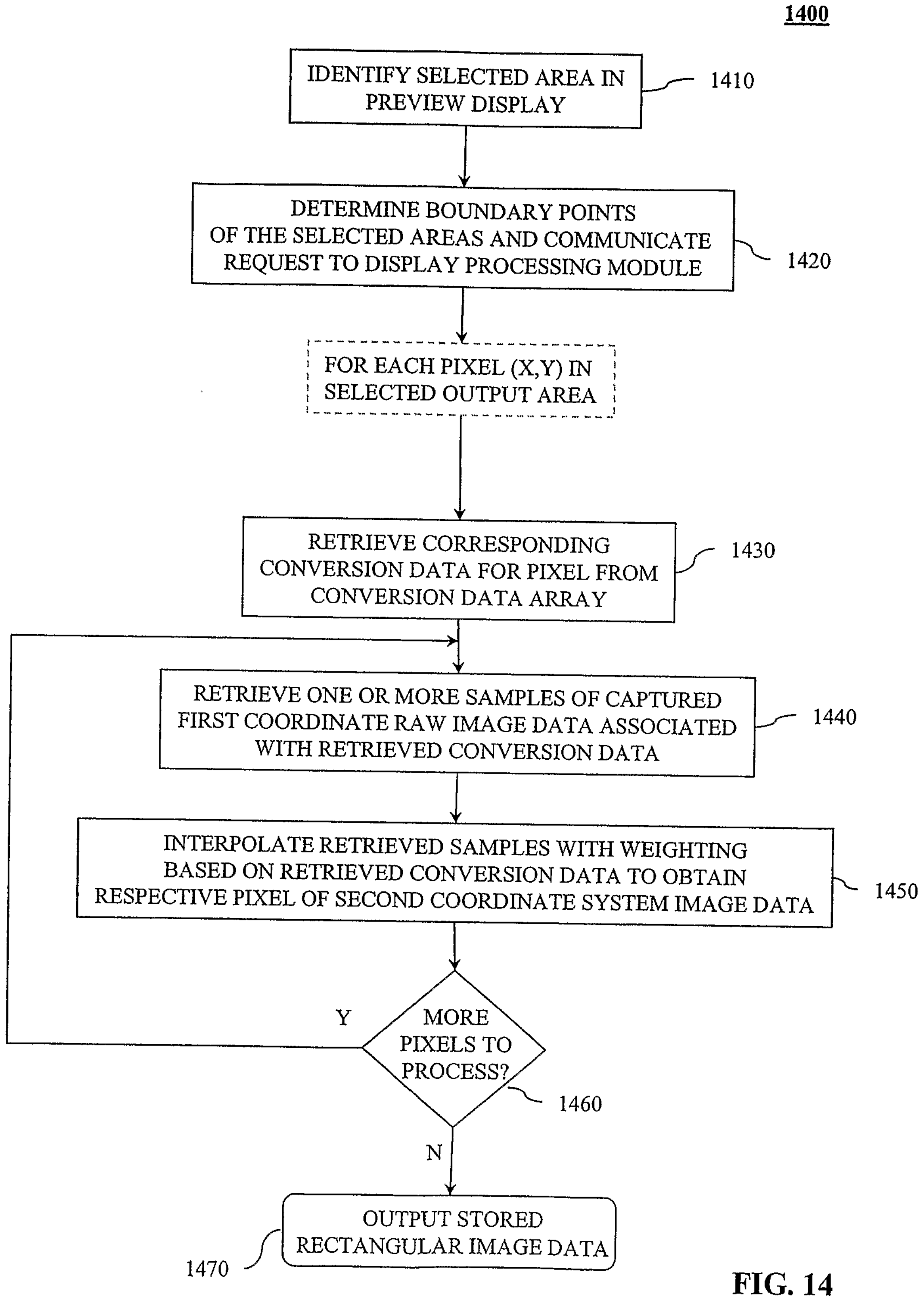

1400
IDENTIFY SELECTED AREA IN PREVIEW DISPLAY
1410
DETERMINE BOUNDARY POINTS OF THE SELECTED AREAS AND COMMUNICATE REQUEST TO DISPLAY PROCESSING MODULE
1420
FOR EACH PIXEL (X,Y) IN SELECTED OUTPUT AREA
RETRIEVE CORRESPONDING CONVERSION DATA FOR PIXEL FROM CONVERSION DATA ARRAY
1430
RETRIEVE ONE OR MORE SAMPLES OF CAPTURED FIRST COORDINATE RAW IMAGE DATA ASSOCIATED WITH RETRIEVED CONVERSION DATA
1440
INTERPOLATE RETRIEVED SAMPLES WITH WEIGHTING BASED ON RETRIEVED CONVERSION DATA TO OBTAIN RESPECTIVE PIXEL OF SECOND COORDINATE SYSTEM IMAGE DATA
1450
Y
MORE PIXELS TO PROCESS?
1460
N
OUTPUT STORED RECTANGULAR IMAGE DATA
1470

FIG. 14

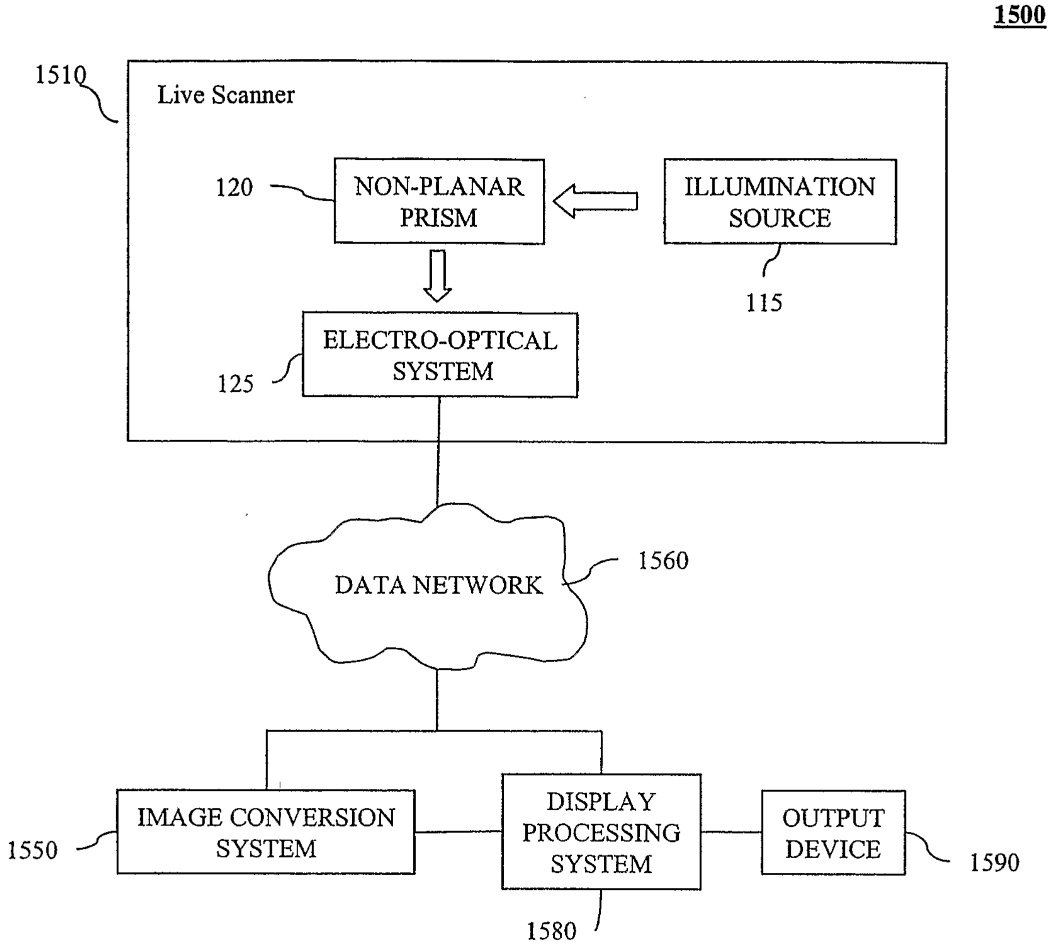

1500
1510
Live Scanner
120
NON-PLANAR PRISM
ILLUMINATION SOURCE
115
ELECTRO-OPTICAL SYSTEM
125
DATA NETWORK
1560
IMAGE CONVERSION SYSTEM
1550
DISPLAY PROCESSING SYSTEM
1580
OUTPUT DEVICE
1590

FIG. 15

1600

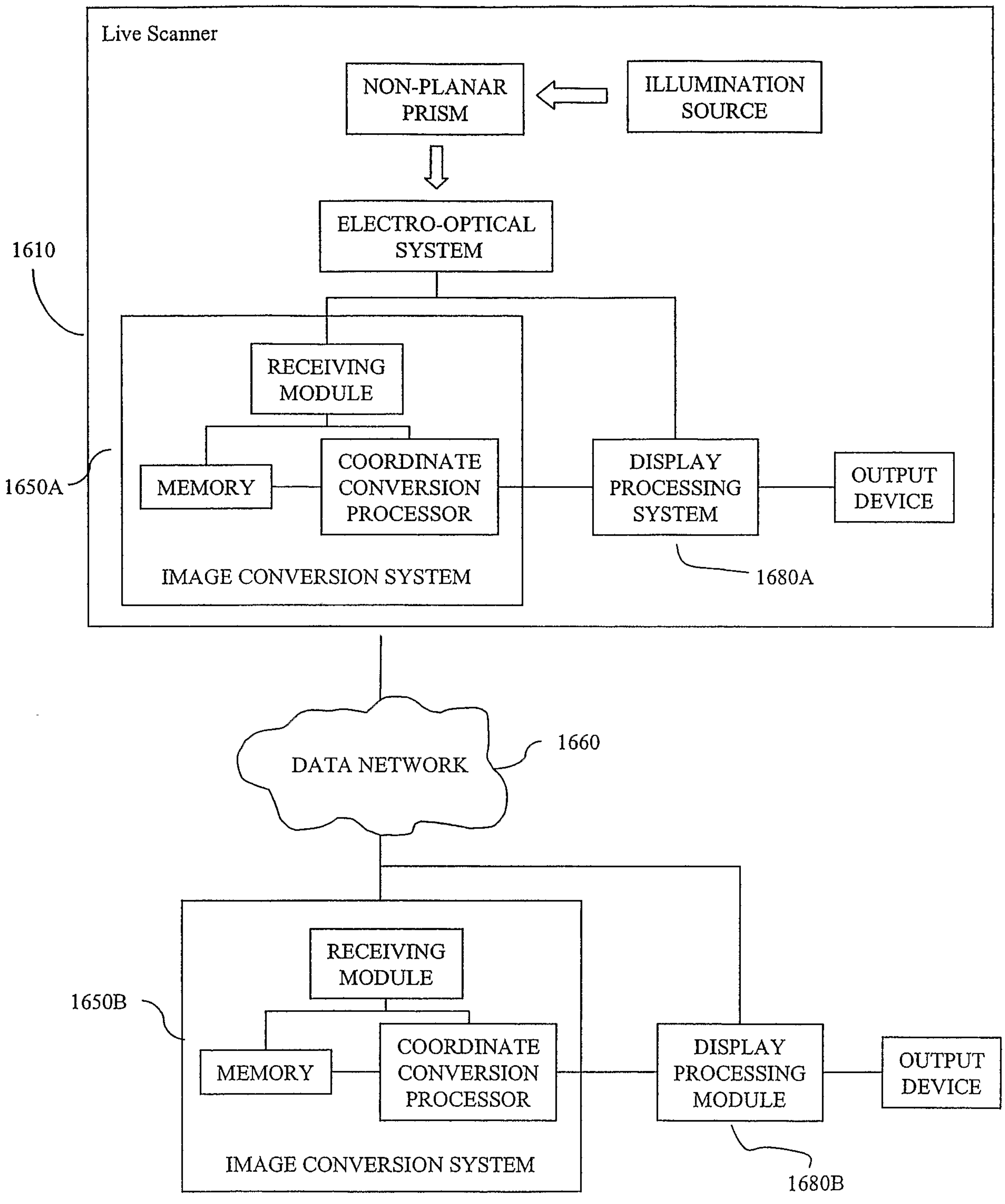

Live Scanner
NON-PLANAR PRISM
ILLUMINATION SOURCE
ELECTRO-OPTICAL SYSTEM
1610
RECEIVING MODULE
1650A
MEMORY
COORDINATE CONVERSION PROCESSOR
DISPLAY PROCESSING SYSTEM
OUTPUT DEVICE
IMAGE CONVERSION SYSTEM
1680A
DATA NETWORK
1660
RECEIVING MODULE
1650B
MEMORY
COORDINATE CONVERSION PROCESSOR
DISPLAY PROCESSING MODULE
OUTPUT DEVICE
IMAGE CONVERSION SYSTEM
1680B

FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/38644

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G 06 K 9/52; G 02 B 27/14; G 01 S 7/40

US CL : 382/293; 359/630; 342/185

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/293; 359/630; 342/185

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

East searched

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	U S 3,765,018 A (HEARD et al) 09 October 1973, column 8, lines 23-56	1-53
Y	U S 5,440,428 A (HEGG et al) 08 August 1995, column 7, lines 11-37	1-53
Y	U S 4,790,025 A (INOUE et al) 06 December 1988, column, lines 37-47	1-53
Y	U S 4,578,793 A (KANEE et al) 25 March 1986, column, lines 45-62	1-53

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 March 2004 (19.03.2004)	21 APR 2004
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Abolfazl Tabatabai Telephone No. (703) 306 5917