(12) STANDARD PATENT (11) Application No. **AU 2007284299 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
A system for iris detection, tracking and recognition at a distance

(51) International Patent Classification(s)
G06K 9/00 (2006.01)

(21) Application No: **2007284299** (22) Date of Filing: **2007.03.01**

(87) WIPO No: **WO08/021584**

(30) Priority Data

(31) Number	(32) Date	(33) Country
11/382,373	**2006.05.09**	**US**
60/778,770	**2006.03.03**	**US**

(43) Publication Date: **2008.02.21**
(44) Accepted Journal Date: **2011.07.07**

(71) Applicant(s)
Honeywell International Inc.

(72) Inventor(s)
Bazakos, Michael E.;Kilgore, George A.;Au, Kwong Wing

(74) Agent / Attorney
Davies Collison Cave, 1 Nicholson Street, Melbourne, VIC, 3000

(56) Related Art
WO 1997/021188
DAUGMAN, J. G., 'High Confidence Visual Recognition of Persons by a Test of Statistical Independence', IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 15, No. 11, November 1993
US 5751836
US 6714665
SCOTT STILLMAN, "A System for Tracking and Recognizing Multiple People with Multiple Cameras", GEORGIA INSTITUTE OF TECHNOLOGY, TECHNICAL REPORT, 25 August 1998 ,XP009097239
US 6005704

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 February 2008 (21.02.2008)

PCT

(10) International Publication Number
WO 2008/021584 A3

(51) International Patent Classification:
G06K 9/00 (2006.01)

(21) International Application Number:
PCT/US2007/063016

(22) International Filing Date: 1 March 2007 (01.03.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/778,770 3 March 2006 (03.03.2006) US
11/382,373 9 May 2006 (09.05.2006) US

(71) Applicant *(for all designated States except US)*: **HONEYWELL INTERNATIONAL INC.** [US/US]; Law Department AB/2B, 101 Columbia Road, Morristown, NJ 07962 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BAZAKOS, Michael E.** [US/US]; 11133 Xylon Avenue South, Bloomington, Minnesota 55438 (US). **AU, Kwong Wing** [US/US]; 4908 West 93rd Street, Bloomington, Minnesota 55437 (US). **KILGORE, George A.** [US/US]; 6801 Dovre Drive, Edina, Minnesota 55436 (US).

(74) Agent: **CHESS, Deborah**; Honeywell International Inc., Law Departmetn AB/2B, 101 Columbia Road, Morristown, New Jersey 07962 (US).

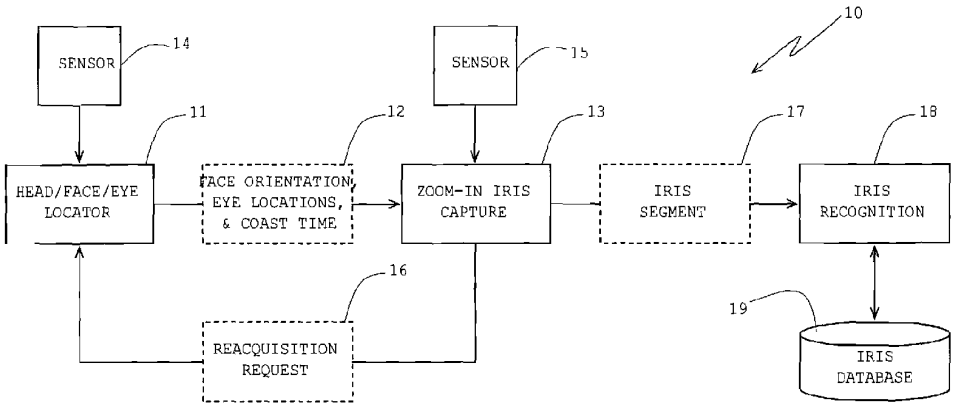
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report:
15 May 2008

(54) Title: A SYSTEM FOR IRIS DETECTION, TRACKING AND RECOGNITION AT A DISTANCE



(57) Abstract: A stand-off range or at-a-distance iris detection and tracking for iris recognition having a head/face/eye locator, a zoom-in iris capture mechanism and an iris recognition module. The system may obtain iris information of a subject with or without his or her knowledge or cooperation. This information may be sufficient for identification of the subject, verification of identity and/or storage in a database.

WO 2008/021584 A3

A SYSTEM FOR IRIS DETECTION, TRACKING AND RECOGNITION AT A DISTANCE

This application claims the benefit of U.S. Provisional Application No. 60/778,770, filed March 3, 2006.

Background

The present invention pertains to recognition systems and particularly to biometric recognition systems. More particularly, the invention pertains to iris recognition systems.

U.S. Provisional Application No. 60/778,770, filed March 3, 2006, is hereby incorporated by reference. U.S. Application No. 11/043,366, filed January 26, 2005, is hereby incorporated by reference. U.S. Application No. 11/275,703, filed January 25, 2006, is hereby incorporated by reference. U.S. Application No. 10/446,521, filed May 27, 2003, is hereby incorporated by reference. U.S. Patent No. 6,718,049, issued April 6, 2004, is hereby incorporated by reference.

Summary

According to the present invention there is provided a system for iris detection at a distance of non-cooperative or cooperative subjects, comprising:

a multi-band imaging camera for detecting skin of a subject, the multi-band imaging camera including a visible band and at least one infrared band;

a first mechanism for determining with specific algorithms whether the skin is of a region containing at least a part of a face of the subject containing at least one eye, by locating several facial features such as eyes, eyebrows, nose or mouth and their positions relative to each other;

an adjustable zoom camera, connected to a processor, for obtaining initial close-up high resolution images of the region that contains at least one eye, the eye not necessarily looking directly at the camera; and

a second mechanism, connected to the camera, for determining, with eye tracking algorithms, whether the initial images contain a best iris position; and

wherein:

the best iris position is when the iris has the best orientation towards the zoom camera, and is determined with the algorithms by maximizing a function that depends on key features of the iris to provide a point of maximization;

wherein the processor is configured to send a reacquisition request to the zoom camera to obtain additional close-up high resolution images of the region that contains at least one eye if the initial images do not contain a best iris position;

wherein if the initial images do contain a best iris position, the zoom camera takes several secondary close-up images of each iris region at the point of maximization; and

wherein the secondary images are passed on to be processed by an iris recognition device.

The present invention also provides a system for iris detection, tracking and recognition of a non-cooperative or cooperative subject at a distance, comprising:

an acquisition module comprising:

a multi-band imaging camera for skin detection of a subject, the multi-band imaging camera including a visible band and at least one infrared band;

a face detection and tracking system for determining if detected skin is part of a face of the subject by locating several facial features, such as eyes, and extracting the facial features; and

2007284299 15 Jun 2011

wherein:

from one or more facial features, information containing face orientation with respect to line of sight and eye location is sent to a juncture for determining whether the information provides a sufficiently good view; and

metrics for a good view comprise face symmetry and orientation toward the camera based on the facial features;

wherein the acquisition module includes metrics that signals the face detection and tracking system to re-initiate the facial features extraction if there is not a good view, the acquisition module repeating the facial feature extraction until a good view is achieved;

when there is a good view, the information containing face orientation and eye location is sent to a zoom-in iris capture mechanism;

the zoom-in iris capture mechanism comprises:

a zoom-in and framing mechanism for zooming in and framing an eye region containing an iris;

an iris segmentation mechanism connected to the zoom-in and framing mechanism; and

wherein the iris segmentation mechanism is for extracting features of the iris by approximating inner and outer borders of the iris by ellipses and performing one-dimensional segmentation of the iris in a polar domain.

The present invention also provides a method for detecting an iris at a distance of a non-cooperative or cooperative subject, comprising:

providing a system for iris detection, the system including an acquisition module, a processor, and at least one multi-band camera having a visible band and at least one infrared band, the method including using the system to perform the following steps:

scanning for a subject;

2007284299 15 Jun 2011

detecting skin of the subject using the multi-band camera;

determining whether the skin is of a region containing a face of the subject by locating one or more facial features such as eyes;

obtaining a plurality of detailed images of the region containing the face and having at least one eye;

determining if one of the plurality of images includes an image of an iris of the at least one eye that shows a best position or view of the iris based on maximizing a function that depends on features of the iris, wherein the best position of view of the iris is when the iris has a best orientation towards the camera;

if no image shows a best position or view of the iris, the system sends a reacquisition signal to the acquisition module and the method steps are repeated until a successful image of the iris showing a best position of the view of the iris is achieved; and

when a successful image of the iris is achieved, extracting features of the iris by determining the inner and outer borders of the iris and doing a one dimensional segmentation of the iris in a polar domain.

Brief Description of the Drawing

Figure 1 is an overall diagram of the distant iris detection, tracking and recognition system;

Figure 2 is a diagram of a head, face and eye region locator of the system in Figure 1; and

Figure 3 is a diagram of a zoom-in and iris capture stage of the system in Figure 1.

Description

The present system may involve remote iris detection and tracking, remote iris recognition, remote biometrics, non-cooperative iris ID, non-invasive iris recognition and face detection from a stand off range. The invention may have application to identity management, access control, identification, verification, security, surveillance, medical imaging, and so forth.

Current iris recognition (biometrics) technology and devices are limited in their application use because they require actual cooperation by the subject. They also require that the subject places his or her eye or eyes for a few seconds in line with the device scanning window and look inside the device at the imaging source, or at best from a short distance away. This may be sufficient for some access control applications. However, there are applications (e.g., non-cooperative identification, surveillance, and fast access control), which require

that iris identification be accomplished from a relatively long distance away.

Various properties and characteristics make iris recognition technology a potentially reliable personal identification tool. This technology may provide uniqueness and genetic independence in identification. The iris of the eye has an extraordinary structure that is unique to each human being. Unlike other well known biometric technologies, such as face-prints and fingerprints, irises are unique to each person and even among genetically identical individuals (i.e., twins). Although the striking visual similarity of identical twins reveals the genetic penetrance of facial appearance, a comparison of genetically identical irises reveals just the opposite for iris patterns. Biomedical literature suggests that iris features are as distinct for each human as fingerprints or patterns of retinal blood vessels. An iris has a data-rich physical structure with sufficient texture to provide adequate discrimination between human subjects. There is no aging effect, that is, there is stability over life of the iris features. Iris recognition technology provides non-invasiveness. The iris is regarded an internal and unique organ, yet is externally visible and can be measured from a distance, using this technique.

From a technical point of view, biometric accuracy may rely significantly on how best the iris is resolved, focused, segmented and extracted. When acquiring iris images, the number of "on-iris" pixels, iris exposure, dynamic range and focus must all be sufficiently precise to produce a high quality image that captures the intricacy of the iris tissue structure. When analyzing iris images of cooperative subjects, the segmentation approach may be a relatively straightforward process of edge detection and circular fitting. However, this is often not the case for stand-off range eye detection and tracking or iris-at-a-distance systems, which often do not receive the cooperation of the subject. In many cases of stand-off range and at-a-distance systems, merely a portion of the iris may be captured due to, for example, closure effect and/or eyelash and eyelid occlusions. Furthermore, given that the subject is not typically asked to cooperate, a tilted head or a rotated iris typically needs also be considered. The present system may extract accurate segments of the iris borders, among other things, in a stand-off range and at-a-distance environment. Computing iris features may use a good-quality segmentation process that focuses on the subject's iris and properly extracts its borders.

The system may detect the head and/or the face from a distance, track the head/face from a distance, track

the head/face, locate the eyes in the face when they are presented in a direction of the camera intentionally or unintentionally, and track them. Then a high quality zoom camera may obtain close-ups of the eye, and a smart algorithm may determine when the iris has the best orientation towards the zoom camera, at which point several high quality sequential pictures of the eye/iris may be taken, to perform the iris recognition task.

The system may be based on the following approach operating from a distance. One may include a Tri-Band Imaging™ (TBI) (Honeywell International Inc) camera skin detector. Then specific algorithms may be used to determine if the detected skin is part of the face. This may be accomplished by locating several facial features (eyes, eye brows, nose, mouth, and so forth) and their positions relevant to each other. For skin and features determinations, one may use a commercially available (COTS) face detection and tracking system.

A high quality zoom camera may be used to obtain close-up high resolution images of a rectangular region that contains both eyes. Eye tracking algorithms may be used for iris location within the eye and to determine the "best iris position" with respect to the camera. The "best iris position" may be determined via algorithms by maximizing a function that depends on the key features of the iris and/or the face. At this point of maximization,

the zoom camera may take several close-up images of each eye/iris region and pass it on to be processed by commercially available iris recognition algorithms or devices.

Figure 1 is a block diagram of a stand-off range or at-a-distance iris detection system 10. A head/face/eye region locator or acquisition module 11 may seek out eye locations, face orientation and coast time of an individual that is a subject of inquiry. The eye locations, face orientation and coast time information, as shown by block 12, may go to a zoom-in iris capture module 13. The head/face/eye locator 11 may perform its operations with one or two sensors or cameras. There may be a cueing sensor 14 and a zoom sensor 15 collocated, or located at different places. The sensors may be physically one integrated multi-function sensor. If iris capture is not successful, then there may be a reacquisition request signal 16 that goes back to the head/face/eye locator module 11 so that the module may again seek out eye locations, face orientation, and coast time, of the subject individual to be forwarded to the zoom-in-iris capture module 13 for another capture of the individual's iris. If the capture is successful, then the resultant capture of the iris may be an iris segment 17 that may go on to an iris recognition module 18. The iris recognition module 18 may match the iris segment 17

with an iris segment in an iris database 19. The matching may a one-to-one verification of an identity of the subject individual, or it may be a one-to-many search to possibly identify the individual with a match in the database 19. Or the iris recognition module 18 may enter the iris segment 17 as information about the subject individual into the iris database 19 for reasons of cataloging for later use in cases of identification or verification of the individual.

Figure 2 reveals more detail of the head/face/eye region locator or acquisition module 11. The module may start with head/face detection 21. The head/face detection may be performed with a present or future acquisition system, such as the Honeywell Tri-Band Imaging™ (TBI) camera. Other off-the-shelf (COTS) camera or sensor systems using a video and/or an infrared (IR) camera or other imaging techniques may be implemented. With the detected head/face information, face feature extraction 22 may be performed. From this feature or features, information 23 containing face orientation with respect to a camera line-of-sight (LOS) and eye location, may be sent to diamond shaped juncture 24 that asks the question whether the information 23 provides a sufficiently good view. The metrics for determining a good view may include face symmetry and face orientation based on facial features. If the answer to the good view

question is no, then a signal may go to a head/face tracking module 25 which re-initiates the face feature extraction 22. The head/face tracking module 25 also may provide the time to coast in the "zoom-in iris capture" continuous mode, before the tracking is reinitiated. If the answer to the good view question is no, then one may get the face orientation, eye location, and estimate coast time information 12 which is provided on to the zoom-in iris capture module 13.

Figure 3 shows some detail of the zoom-in and iris capture section or module 13. After receipt of the face orientation, eye location, and estimate coast time information 12, there may be a mechanism for providing zoom-in and a localizing (i.e., framing) of the eye region in module 26. From this information, an iris segmentation 27 may be performed. The activities for mechanisms or modules 26 and 27 may be accomplished with COTS technologies. The iris segmentation 27 may be reviewed at a diamond shaped juncture 28 to consider the question as to whether there is good iris fitness. If the answer is no, then a question at a diamond shaped juncture 29 is whether the coast time has expired. If the answer is yes, then a reacquisition request 16 may be initiated back to the head/face/eye locator module 11 in Figure 1. There, the approach may be repeated in accordance with Figure 1, as described herein. If the

answer is no at juncture 29, then the action of zoom-in and localize the eye region module 26 may be reinstituted and its results forwarded on to the iris segmentation module 27 and to juncture 28 for determining whether there is a good iris fitness of a segment. If the answer at juncture 28 is yes, then the iris segment 17 may be provided to the iris recognition module 18 for the one-to-one verification of a person or the one-to-many identification of a person in conjunction with the database 19 of information. Or the iris segment 17 may be part of an acquisition of a non-cooperative (or cooperative) subject individual into the database 19.

The iris segmentation algorithms can be of any type which faithfully outlines the imaged iris presented to them. One such algorithm is one developed by Honeywell operating in the polar domain and is described herein.

Conducting the segmentation in the polar domain may lead to a more efficient and faster process to execute not only the segmentation, but also calibration, and noise removal, all in one step to generate a feature map for the encoding step.

The system may provide reliable calibration and an efficient segmentation (i.e., localization) of the stand-off range or at-a-distance iris detection, resulting in better extraction of the iris features that may eventually be converted into a numeric code. Conversion

of an iris annular image into a numeric code that can be easily manipulated may be essential to iris recognition. The iris codes may be compared with previously generated iris codes for verification and identification purposes.

The orientation of head and eyes may result into different perspective of views of the iris circular shape. The captured shapes of the iris are usually apart from being circles or ellipses due to the orientation, tilt and slant angles.

In an illustrative example, the iris biometric approach may include using a POSE™ (i.e., Honeywell International Inc.--polar segmentation) technique to move virtually immediately the analysis to a polar domain and execute a 1-D segmentation of the iris borders, using one or more symmetry properties to detect one or more non-occluded areas of the iris--non-symmetric regions can correspond to areas partially covered by eyelashes, eyelids, and so forth (thus asymmetric). In some cases, one may limit the analysis to those segments where the iris and the sclera are detected relative to their symmetry. The sclera may be regarded as a tough white fibrous outer envelope of tissue covering the entire eyeball except the cornea. Once an orientation is detected, nominal angles with the least likelihood of distortions (i.e., occluded or deformed due to orientation) may be identified by, for example,

estimating the ellipse parameters from nominal angles, and computing a calibration factor. A rotated ellipse detection technique that uses overlapping variable circles to detect the iris borders modeled as elliptic or irregular shapes rather than circles, and/or a least square fitting may be used to estimate the elliptic parameters and orientation. Mixture modeling may be used to handle variation in the iris textures.

The iris inner and outer boundaries of iris may be approximated by ellipses than circles of irregular shapes using snake delineation. However, the two ellipses are usually not concentric. One may characterize the shape and texture of the structure of the iris having a large number of interlacing blocks such as freckles, coronas, furrows, crypts, and stripes. The outer boundaries of the iris may be captured with irregular edges due to presence of eyelids and eyelashes. Taken in tandem, these observations suggest that iris localization may be sensitive to a wide range of edge contrasts.

The present system is well suited for high-security access control involving stand-off range and at-a-distance biometrics applications where less control is exercised on subject positioning and/or orientations. Such operations may include, for example, subjects captured at various ranges from the acquisition device, and/or may not have the subjects eye(s) directly aligned

with the imaging equipment. Usually, for such applications, it is difficult to implement the level of control required by most of the existing art to enable reliable iris recognition. The system may help cope with asymmetry in acquired iris images, and may further help under uncontrolled environments as long as some of the iris annular is visible. The system may solve the asymmetry problem associated with image acquisition without the collaboration of the subjects and operate under uncontrolled operations as long as some of the iris annular is visible.

In the present specification, some of the matter may be of a hypothetical or prophetic nature although stated in another manner or tense.

Although the invention has been described with respect to at least one illustrative example, many variations and modifications will become apparent to those skilled in the art upon reading the present specification. It is therefore the intention that the appended claims be interpreted as broadly as possible in view of the prior art to include all such variations and modifications.

2007284299 19 Nov 2010

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A system for iris detection at a distance of non-cooperative or cooperative subjects, comprising:

a multi-band imaging camera for detecting skin of a subject, the multi-band imaging camera including a visible band and at least one infrared band;

a first mechanism for determining with specific algorithms whether the skin is of a region containing at least a part of a face of the subject containing at least one eye, by locating several facial features such as eyes, eyebrows, nose or mouth and their positions relative to each other;

an adjustable zoom camera, connected to a processor, for obtaining initial close-up high resolution images of the region that contains at least one eye, the eye not necessarily looking directly at the camera; and

a second mechanism, connected to the camera, for determining, with eye tracking algorithms, whether the initial images contain a best iris position; and

wherein:

the best iris position is when the iris has the best orientation towards the zoom camera, and is determined with the algorithms by maximizing a function that depends on key features of the iris to provide a point of maximization;

wherein the processor is configured to send a reacquisition request to the zoom camera to obtain additional close-up high resolution images of the region that contains at least one eye if the initial images do not contain a best iris position;

wherein if the initial images do contain a best iris position, the zoom camera takes several secondary close-up images of each iris region at the point of maximization; and

wherein the secondary images are passed on to be processed by an iris recognition device.

2. The system of claim 1, wherein the first mechanism is a face detection and tracking system.

3. The system of claim 1, wherein the iris recognition device is for identifying the subject upon recognition of an iris in the images of iris regions of the subject.

4. The system of claim 1, wherein the eye is not necessarily looking directly at the camera since the eye may be of a non-cooperative subject.

5. A system for iris detection, tracking and recognition of a non-cooperative or cooperative subject at a distance, comprising:

an acquisition module comprising:

a multi-band imaging camera for skin detection of a subject, the multi-band imaging camera including a visible band and at least one infrared band;

a face detection and tracking system for determining if detected skin is part of a face of the subject by locating several facial features, such as eyes, and extracting the facial features; and

wherein:

from one or more facial features, information containing face orientation with respect to line of sight and eye location is sent to a juncture for determining whether the information provides a sufficiently good view; and

metrics for a good view comprise face symmetry and orientation toward the camera based on the facial features;

wherein the acquisition module includes metrics that signals the face detection and tracking system to re-initiate the facial features extraction if there is not a good view, the acquisition module repeating the facial feature extraction until a good view is achieved;

when there is a good view, the information containing face orientation and eye location is sent to a zoom-in iris capture mechanism;

the zoom-in iris capture mechanism comprises:

a zoom-in and framing mechanism for zooming in and framing an eye region containing an iris;

an iris segmentation mechanism connected to the zoom-in and framing mechanism; and

wherein the iris segmentation mechanism is for extracting features of the iris by approximating inner and outer borders of the iris by ellipses and performing one-dimensional segmentation of the iris in a polar domain.

6. The system of claim 5, further comprising a mechanism for converting features of the iris into an iris numeric code.

7. The system of claim 6, further comprising a mechanism for comparing the iris numeric code with previously generated iris numeric codes for verification and identification of the iris numeric code.

8. The system of claim 5, wherein the segmentation mechanism is further for characterizing shape and texture of a structure of the iris having interlacing blocks of freckles, coronas, furrows, crypts and stripes.

9. The system of claim 8, wherein mixture modeling is used to handle variation in the texture of the structure of the iris.

10. The system of claim 5, wherein the inner and outer borders of the iris are approximated by ellipses using snake delineation.

11. The system of claim 5, wherein the outer border of the iris is instead approximated with irregular edges due to eyelids and eyelashes.

12. A method for detecting an iris at a distance of a non-cooperative or cooperative subject, comprising:

providing a system for iris detection, the system including an acquisition module, a processor, and at least one multi-band camera having a visible band and at least one infrared band, the method including using the system to perform the following steps:

scanning for a subject;

detecting skin of the subject using the multi-band camera;

determining whether the skin is of a region containing a face of the subject by locating one or more facial features such as eyes;

obtaining a plurality of detailed images of the region containing the face and having at least one eye;

determining if one of the plurality of images includes an image of an iris of the at least one eye that shows a best position or view of the iris based on maximizing a function that depends on features of the iris, wherein the best position of view of the iris is when the iris has a best orientation towards the camera;

if no image shows a best position or view of the iris, the system sends a reacquisition signal to the acquisition module and the method steps are repeated until a successful image of

the iris showing a best position of the view of the iris is achieved; and

when a successful image of the iris is achieved, extracting features of the iris by determining the inner and outer borders of the iris and doing a one dimensional segmentation of the iris in a polar domain.

13. The method of claim 12, further comprising converting the features of the iris into an iris numeric code.

14. The method of claim 13, further comprising comparing the iris numeric code with previously generated iris numeric codes for verification and identification of the iris numeric code or for entry of the iris numeric code into a database.

15. The method of claim 12, wherein the inner and outer borders of the iris are approximated with ellipses.

16. The method of claim 15, wherein least squares modeling is used to estimate elliptic parameters and orientation.

17. The method of claim 15, wherein the ellipses are not necessarily concentric.

18. The method of claim 12, wherein the outer border of the iris is approximated with irregular edges due to eyelids and eyelashes.

19. A system for iris detection at a distance of non-cooperative or cooperative subjects substantially as hereinbefore described, with reference to the accompanying drawings.

15 Jun 2011

2007284299

20. A system for iris detection substantially as hereinbefore described, with reference to the accompanying drawings.

21. A method for detecting an iris substantially as hereinbefore described, with reference to the accompanying drawings.

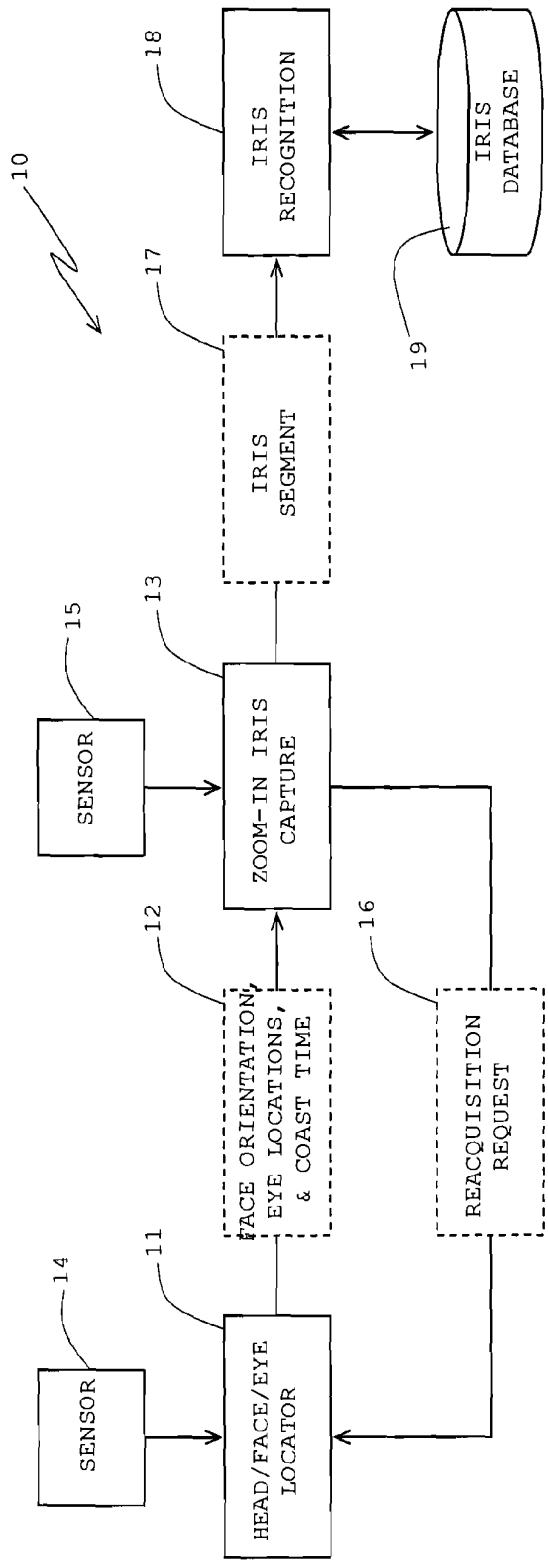

10
11
12
13
14
15
16
17
18
19
HEAD/FACE/EYE LOCATOR
SENSOR
FACE ORIENTATION, EYE LOCATIONS, & COAST TIME
ZOOM-IN IRIS CAPTURE
SENSOR
REACQUISITION REQUEST
IRIS SEGMENT
IRIS RECOGNITION
IRIS DATABASE

FIGURE 1

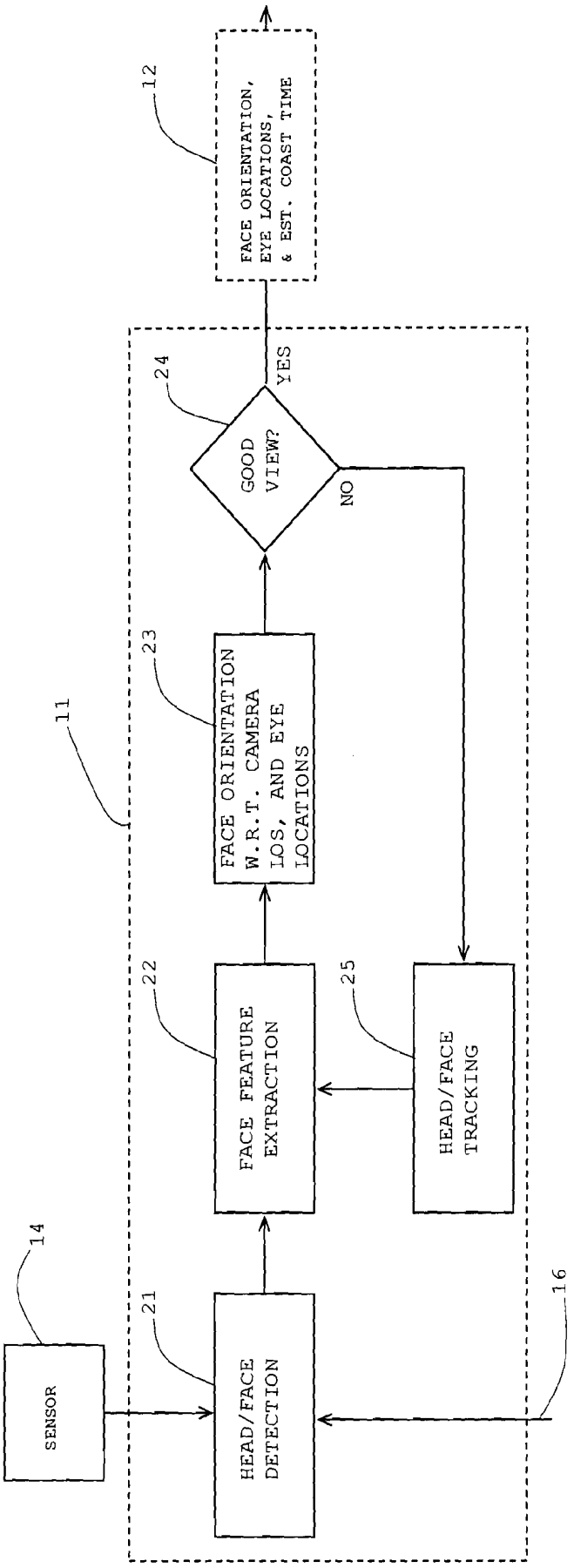

12
FACE ORIENTATION, EYE LOCATIONS, & EST. COAST TIME
24
GOOD VIEW?
YES
NO
11
23
FACE ORIENTATION W.R.T. CAMERA LOS, AND EYE LOCATIONS
22
FACE FEATURE EXTRACTION
25
HEAD/FACE TRACKING
14
SENSOR
21
HEAD/FACE DETECTION
16

FIGURE 2

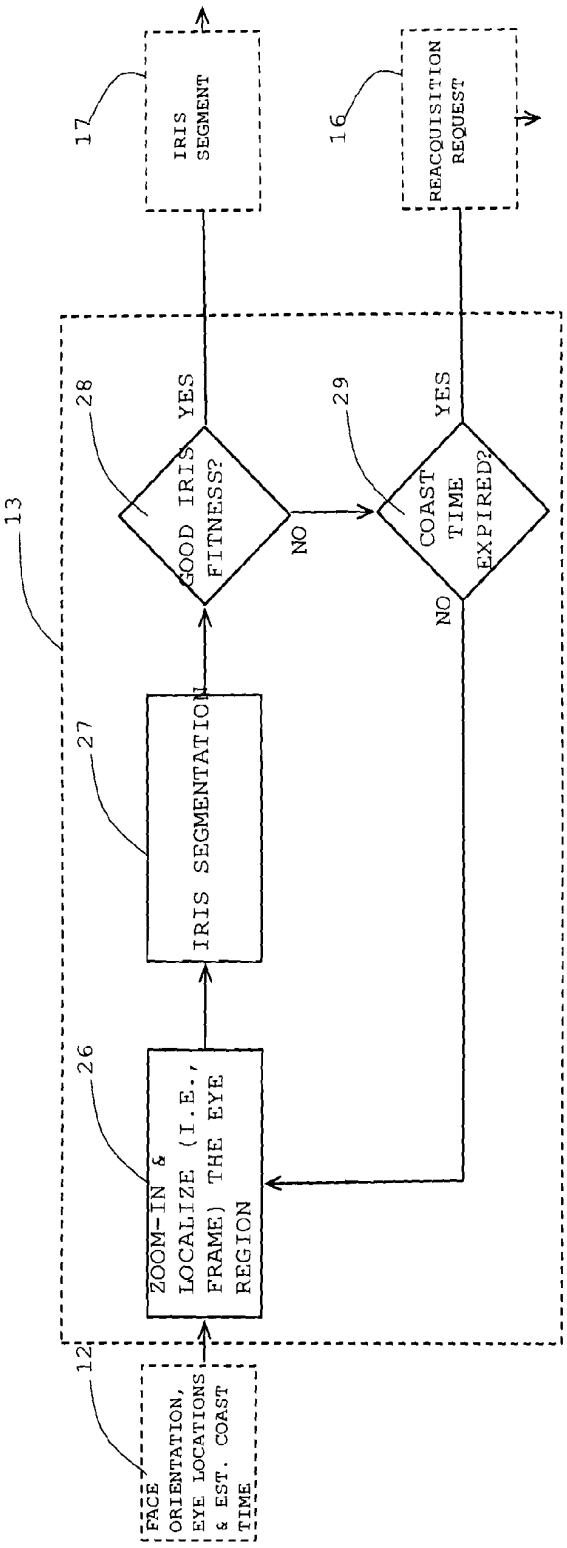

12
FACE ORIENTATION, EYE LOCATIONS & EST. COAST TIME
13
26
ZOOM-IN & LOCALIZE (I.E., FRAME) THE EYE REGION
27
IRIS SEGMENTATION
28
GOOD IRIS FITNESS?
YES
NO
29
COAST TIME EXPIRED?
YES
NO
16
REACQUISITION REQUEST
17
IRIS SEGMENT

FIGURE 3