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(71) Applicant *(for all designated States except US)*: **HONEYWELL INTERNATIONAL, INC.** [US/US]; 101 Columbia Road, P.O. Box 2245, Morristown, New Jersey 07962 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **JELINEK, Jan** [US/US]; 10325 40th Avenue North, Plymouth, Minnesota 55441 (US). **PHINNEY, Thomas** [US/US]; 5012 W. Torrey Pines Circle, Glendale, Arizona 85308 (US).

(74) Agents: **HONEYWELL INTERNATIONAL, INC.** et al; Patent Services, 101 Columbia Road, AB-2B, P.O. Box 2245, Morristown, New Jersey 07962 (US).

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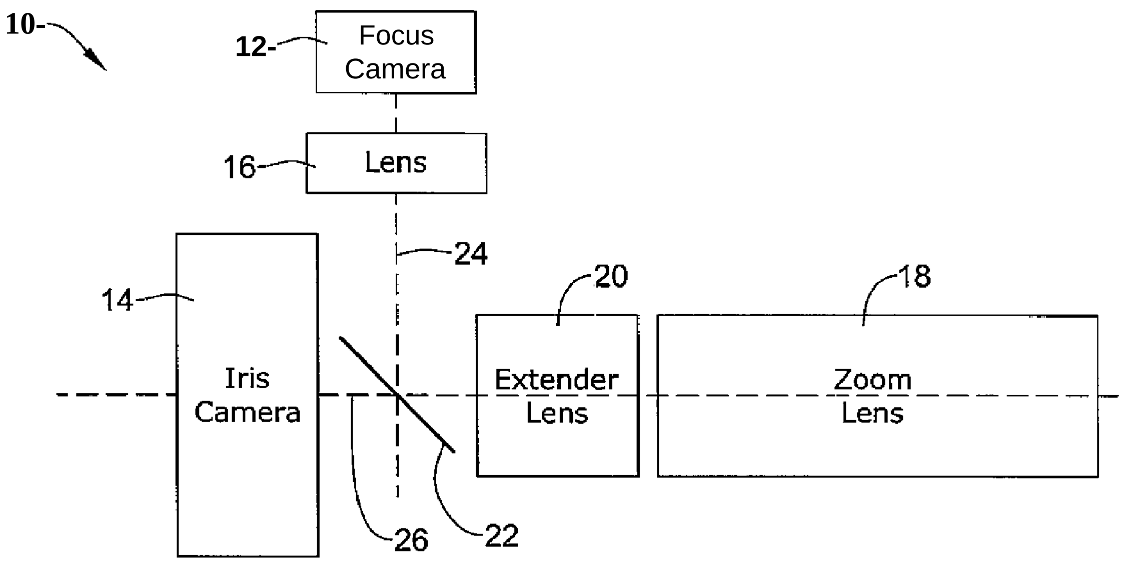
(54) Title: SINGLE LENS SPLITTER CAMERA



(57) Abstract: A camera system may be used to capture iris images of targeted people who may be unaware of being targeted and hence their movement may not be constrained in any way. Iris images may be used for identification and/or tracking of people. In one illustrative embodiment, a camera system may include a focus camera and an iris camera, where the focus camera is sensitive to ambient light or some spectrum thereof, and the iris camera is sensitive to infrared or some other wavelength light. The focus camera and the iris camera may share an optical lens, and the focus camera may be used to auto-focus the lens on a focus target. A beam splitter or other optical element may be used to direct light of some wavelengths to the focus camera for auto-focusing the lens, and other wavelengths to the iris camera for image capture of the iris images.

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SINGLE LENS SPLITTER CAMERA

This application claims the benefit of U.S. Provisional Application No. 60/778,770, filed March 3, 2006, and U.S. Provisional Application No. 60/807,046, filed July 11, 2006. This application is also a continuation-in-part of U.S. Patent Application No. 11/382,373, filed May 9, 2006. Each of these applications is hereby incorporated by reference.

The government may have rights in the invention.

Related Applications

This Application is related to U.S. Patent Application No. 10/979,129, filed November 3, 2004, U.S. Patent Application No. 10/655,124, filed September 5, 2003, now U.S. Patent No. 7,183,895, U.S. Patent Application No. 11/275,703, filed January 25, 2006, U.S. Provisional Application No. 60/647,270, filed January 26, 2005, U.S. Patent Application No. 11/043,366, filed January 26, 2005, U.S. Patent Application No. 11/372,854, filed March 10, 2006, U.S. Patent Application No. 11/672,108, filed February 7, 2007, and U.S. Patent Application No. 11/675,424, filed February 15, 2007, all of which are hereby incorporated by reference.

Technical Field

The invention pertains generally to cameras and relates more particularly to cameras and camera systems that are configured to find and track facial features.

Background

In some applications, it may be desirable to identify individuals from a distance, perhaps with the individual unaware that they are being watched or identified. In some cases, the individual may be standing still, or they may be moving. One way of identifying people is by imaging their eyes, or at least the iris portion of their eyes. There is a need for a camera system that is capable of obtaining high quality iris images.

Summary

The present invention relates generally to structure and methods that provide high quality iris images that may be used for identification and/or tracking or people.

In some instances, a camera system may include a focus camera and an iris camera. In some cases, the focus camera may be sensitive to ambient light or some spectrum thereof, while the iris camera may be sensitive to infrared or other spectrum of light. The focus camera and the iris camera may share an optical path that includes one or more lens that capture light, as well as a beam splitter or other optical element that directs light of some wavelengths to the focus camera and allows other wavelengths to reach the iris camera.

Brief Description of the Figures

The above summary of the present invention is not intended to describe each disclosed embodiment or every implementation of the present invention. The Figures, Detailed Description and Examples which follow more particularly exemplify these embodiments.

Figure 1 is a schematic illustration of an exemplary camera system in accordance with an example of the present invention;

Figure 2 is a schematic illustration of how particular elements of the camera system of Figure 1 support an iris camera;

Figure 3 is a schematic illustration showing how subject movement may be monitored;

Figure 4 is a schematic illustration showing how digital tilt and pan may be used to find and track an individual's irises;

Figure 5 is a flow diagram showing a method that may be carried out using the camera system of Figure 1;

Figure 6 is a flow diagram showing a method that may be carried out using the camera system of Figure 1; and

Figure 7 is a flow diagram showing a method that may be carried out using the camera system of Figure 1.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

Detailed Description

The following description should be read with reference to the drawings, in which like elements in different drawings are numbered in like fashion. The drawings, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of the invention. Although examples of construction, dimensions, and materials are illustrated for the various elements, those skilled in the art will recognize that many of the examples provided have suitable alternatives that may be utilized.

Figure 1 provides an illustrative but non-limiting example of a camera system 10. Camera system 10 may include a focus camera 12 and an iris camera 14. hi some instances, focus camera 12 may have a considerably lower resolution than iris camera 14, but this is not required. A lens 16 may be used to provide focus camera 12 with a field of view that is similar to a field of view of iris camera 14. hi some cases, lens 16 may be excluded, depending on the particular specification and/or configuration of the focus camera 12 and/or the iris camera 14.

In some cases, focus camera 12 may be sensitive to ambient light or some spectrum thereof. Focus camera 12 may be any suitable camera that has a sufficiently high frame rate and sensitivity to perform an auto-focusing function, such as, for example a PixeLink PL-A741 camera. It will be recognized that having a relatively high frame rate may mean that focus camera 12 may have a relatively lower resolution, but this is not always the case. In some cases, focus camera 12 may have a frame rate of at least about 100 frames per second, or a frame every 10 milliseconds.

It is contemplated that iris camera 14 may be any suitable camera that is capable of acquiring an iris image in a desired light spectrum and with a desired quality, such as, for example, a REDLAKE ESIl 000® or a ES16000 digital camera. The light spectra used may include, but are not limited to, visible and infrared wavelengths. The desired image quality may depend on an intended security application. For example, higher security level applications typically require higher image quality. The image quality is typically dependent on the entire optical path including both the camera and its optics. For some applications, the minimum iris image quality for various security levels is defined in ANSI standard INCITS M1/03-0590.

Camera system 10 may include a lens 18 and optionally an extender lens 20. While a single lens 18 and a single extender lens 20 are illustrated, it will be recognized that in some applications, depending for example on a distance between camera system 10 and a possible subject, or perhaps depending at least in part on the particular optics of lens 18 and/or extender lens 20, two or more lens 18 and/or two or more extender lens 20 may be deployed, as desired. Lens 18 and/or extender lens 20 may be configured to provide any desired degree of magnification.

A beam splitter 22 or other optical element may be deployed downstream of lens 18 and extender lens 20. Beam splitter 22 may be a glass beam splitter, for example, and may be configured to permit some wavelengths of light to pass straight through while other wavelengths of light are deflected at an angle as shown. In some instances, beam splitter 22 may be configured to permit infrared light such as near infrared light (about 700 to about 900 nanometers) to pass through beam splitter 22 towards iris camera 14 while deflecting visible light (about 400 to about 700 nanometers) or some spectrum thereof towards focus camera 12.

As a result, focus camera 12 and iris camera 14 may see the same image, albeit in different wavelengths, and may be considered as sharing an optical path, i.e., through lens 18 and/or extender lens 20. Focus camera 12 may be considered as having an optical axis 24 while iris camera 14 may be considered as having an optical axis 26. In some cases, optical axis 24 is perpendicular or at least substantially perpendicular to optical axis 26, but this is not required. Rather, this may be a feature of the optical properties of beam splitter 22. In some instances, zoom lens 18 and extender 20 may be considered as being disposed along optical axis 26. In some cases, beam splitter 22 may be disposed at or near an intersection of optical axis 24 and optical axis 26, but this is not required.

Focus camera 12 may be used to move focus a lens that is part of lens 18 and that is used to focus it. Since focus camera 12 and iris camera 14 see the same image, by virtue of their common optical path, it will be recognized that focusing lens 18 via focus camera 12 may provide an initial focusing for iris camera 14, under ambient lighting conditions. In some cases, focus camera 12 may move the focus lens within lens 18 using one or more servo motors under the control of any suitable auto-focusing algorithm, as is known in the art. In some cases, a controller (not shown in Figure 1) may orchestrate the auto-focusing operation.

Because light of differing wavelengths are refracted differently as they pass through particular materials (glass lenses and the like, for example), focusing lens 18 via one wavelength of light may not provide a precise focus for iris camera 14 at another wavelength of light. In some cases, it may be useful to calculate or otherwise determine a correction factor that may be used to correct the focus of lens 18 after lens 18 has been auto-focused using the focus camera 12, but before the iris camera 14 captures an image. Details regarding one such a correction can be found in, for example, Patent Application Serial No. 11/68 1,25 1, filed March 2, 2007, entitled CAMERA WITH AUTO FOCUS. This application is incorporated by reference in its entirety.

Figure 2 is another schematic illustration of camera system 10, showing some of the functions and interactions of the individual components of camera system 10. Focus camera 12 may perform several tasks, including for example, finding a focus target point (generally indicated at reference number 28) and auto focusing (generally indicated at reference number 30).

Once camera system 12 is pointed at a face, the focus camera 12 (or a separate controller or the like) is tasked with finding a focus target within an image seen or sensed by focus camera 12. In some cases, the focus target may be a predefined point on the focus target, such as a predefined specific point on a face such as an eye pupil or the nose bridge. Once the focus target is located at functionality 28 and focus camera 12 is precisely autofocused on it via functionality 30, it may be necessary to provide a focus correction pertaining to the difference in focal length between the ambient light or some spectrum thereof used to auto-focus the lens, and the wavelength(s) to be captured by the iris camera, as indicated at 30. If/when the subject moves, such as by walking, bending, turning their head, and the like, focus camera 12 may be tasked to focus lens 18 in an ongoing process. Once focus has been achieved, camera system 10 may provide an in-focus flag 32 to initiate iris camera shutter control 34, and in some case, a flash controller.

In some cases, camera system 10 may be deployed in a position that permits detection and identification of people who are standing or walking in a particular location such as a hallway, airport concourse, and the like. Figure 3 is a diagram showing how camera system 10 may track a moving individual. In this drawing, an individual is walking or otherwise moving along walking path 36, in a direction from upper right to lower left. Camera system 10 locks onto the individual at point 38 and is able to track the individual until they reach point 40. Camera system 10 may be configured to be able to lock onto and obtain sufficient iris images in the time between point 38 and point 40 to be able to identify the individual.

This illustration makes several assumptions. For example, a steering angle of plus or minus 22.5 degrees (or a total path width of about 45 degrees) has been assumed. It is assumed, for purposes of this illustration, that the individual is unaware of being identified and hence is being uncooperative. As a result, the individual happens to walk in a manner that increases the relative angle between the camera and the individual. The person is detected at a distance of about 2 to about 5 meters in this example.

Figure 4 defines digital tilt and pan within a field of view of iris camera 14. In this example, iris camera 14 is capable of providing an image having about 11 megapixels. At a particular distance, iris camera 14 has a field of view that is indicated by box 42. Box 42 is in scale to an individual 44. A smaller box 46 shows the relative field of view necessary to view the individual's irises. It can be seen that unless the individual 44 moves excessively, iris camera 14 may digitally tilt and/or pan the image to track box 46 within larger box 42 without any need to mechanically adjust its physical pan and tilt. The specific numbers of Figure 4 pertain to a particular system design parameter set that, according to the ANSI standard referenced above, is suitable for a lower security application.

It will be recognized that digital tilt and pan permit a camera to remain pointed at a face without requiring mechanical re-positioning as long as a desired portion of the image, such as a face or a portion of a face, remain within the viewable image. Because focus camera 12 and iris camera 14 have about the same field of view, they have about the same digital tilt and pan. A focus target algorithm finds the focus target (such as an eye pupil or nose bridge) within the focus camera image and then precisely focuses on it.

Figure 5 is a flow diagram showing an illustrative but non-limiting method that may be carried out using camera system 10 (Figure 1). At block 48, the lens is focused, often under ambient light or some spectrum thereof. In some instances, lens 18 (Figure 1) may be focused via an iterative auto-focus algorithm using focus camera 12 (Figure 1), sometimes under ambient lighting or some selected spectrum thereof. Control passes to block 50, where an iris image is captured. In some instances, an iris image may be captured using iris camera 14, which is timed with a flash that produces infrared light or any other light having a desired spectrum.

Figure 6 is a flow diagram showing an illustrative but non-limiting method that may be carried out using camera system 10 (Figure 1). At block 47, a focus target is located within a focus image. At block 48, the lens is focused at it. In some instances, lens 18 (Figure 1) maybe auto-focused via an iterative auto-focus algorithm using focus camera 12 (Figure 1) under ambient lighting or some selected spectra thereof. Control is then passed to block 52, where the lens is adjusted. In some cases, the focus of lens 18 may be adjusted to correct for the differences between, for example, ambient and infrared light. Then, at block 50, an iris image is captured. In some instances, an iris image may be captured using iris camera 14, which is timed with a flash that produces infrared or any other desired light.

Figure 7 is a flow diagram showing an illustrative but non-limiting method that may be carried out using camera system 10 (Figure 1). At block 54, light that maybe entering camera system 10 is split into an ambient light or some spectrum thereof and an infrared light portion. Control passes to block 56, where the ambient light portion is directed into or towards focus camera 12 (Figure 1), and the infrared light portion is directed into or towards iris camera 14 (Figure 1). In some cases, these steps may be achieved by beam splitter 22 (Figure 1).

At block 58, a focus target is found within the focus camera image. Image data from a small area surrounding the focus target are extracted from the focus camera image at block 60, and the extracted data is used to precisely auto focus the focus camera 12. Control passes to block 62, where the focus setting is corrected, if necessary, for any differences between the light spectrum used for focusing and the light spectrum used for image acquisition by iris camera 14. Control passes to block 64, where an iris image is captured using, for example, infrared light sometimes aided by a flash discharge.

The invention should not be considered limited to the particular examples described above, but rather should be understood to cover all aspects of the invention as set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the invention can be applicable will be readily apparent to those of skill in the art upon review of the instant specification.

WE CLAIM:

1. A camera system comprising:

an iris camera having an optical axis;

a focus camera having an optical axis, wherein the optical axis of the focus camera is angularly offset from the optical axis of the iris camera;

a lens; and

a beam splitter arranged downstream of the lens, the beam splitter directing a first wavelength or range of wavelengths of incoming light to the focus camera and a second wavelength or range of wavelengths of incoming light to the iris camera.

2. The camera system of claim 1, wherein the optical axis of the focus camera is arranged at least substantially perpendicular to the optical axis of the iris camera.

3. The camera system of claim 1, wherein the beam splitter is configured to permit the second wavelength or range of wavelengths of incoming light to pass straight through the beam splitter.

4. The camera system of claim 1, wherein the first wavelength or range of wavelengths of light includes ambient light.

5. The camera system of claim 1, wherein the first wavelength or range of wavelengths of light includes visible light.

6. The camera system of claim 1, wherein the second wavelength or range of wavelengths of light includes flash illumination light.

7. The camera system of claim 1, wherein the second wavelength or range of wavelengths of light includes infrared light.

8. The camera system of claim 1, wherein the focus camera is sensitive to visible light or some sub spectra thereof.

9. The camera system of claim 1, wherein the iris camera is sensitive to infrared light.

10. The camera system of claim 1, wherein an output of the focus camera is used to locate a given focus target.

11. The camera system of claim 10, wherein an output of the focus camera is used to auto-focus the lens on the focus target.

12. The camera system of claim 1, further comprising a near infrared flash that is used in conjunction with the iris camera.

13. An camera system comprising:

a first camera that is sensitive to ambient light;

a second camera that is sensitive to light from a flash discharge;

a lens; and

a beam splitter disposed downstream of the lens, the beam splitter splitting the light passing through the lens into an ambient light image that is directed to the first camera, and a flash light image that is directed to the second camera.

14. The camera system of claim 13, wherein an output of the first camera is used to auto-focus the lens.

15. The camera system of claim 13, wherein the second camera is configured to capture an infrared image of an iris of a target subject.

16. A method of capturing an iris image using a camera system comprising a focus camera, an iris camera and a lens disposed upstream of and shared by the focus camera and the iris camera, the method comprising the steps of:

finding a focus target in a focus camera image;

focusing the lens on the focus target using the focus camera; and
capturing the iris image using the iris camera.

17. The method of claim 16, wherein the focus camera focuses the lens using ambient light or some spectra thereof.

18. The method of claim 16, further comprising a step of correcting the lens focus after the lens is focused by the focus camera, but prior to capturing the iris image.

19. The method of claim 16, further comprising a step of finding a focus target within an image seen or sensed by the focus camera.

20. The method of claim 19, further comprising a step of extracting image data and using the image data to precisely auto focus the focus camera.

21. The method of claim 16, further comprising the step of splitting the light that passes through the shared lens into an ambient light based image and an infrared light based image, wherein the ambient light based image is directed to the focus camera and the infrared light based image is directed to the iris camera.

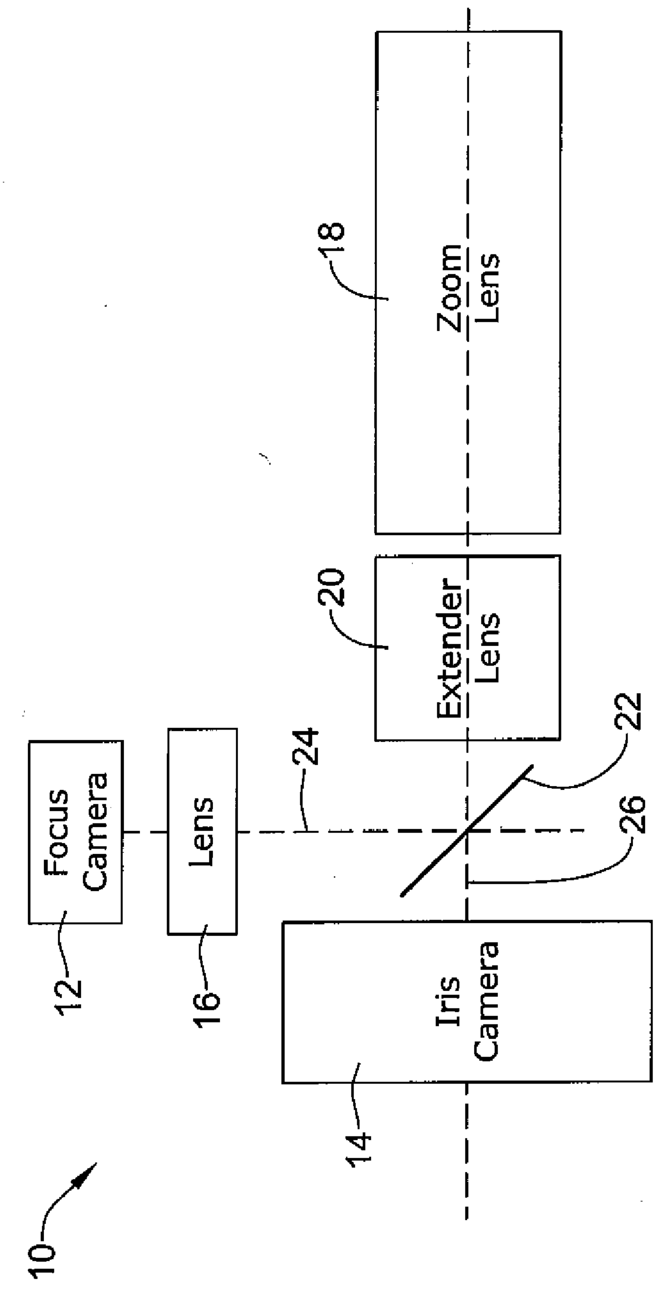
Focus Camera
Lens
Iris Camera
Extender Lens
Zoom Lens
10
12
14
16
18
20
22
24
26

Figure 1

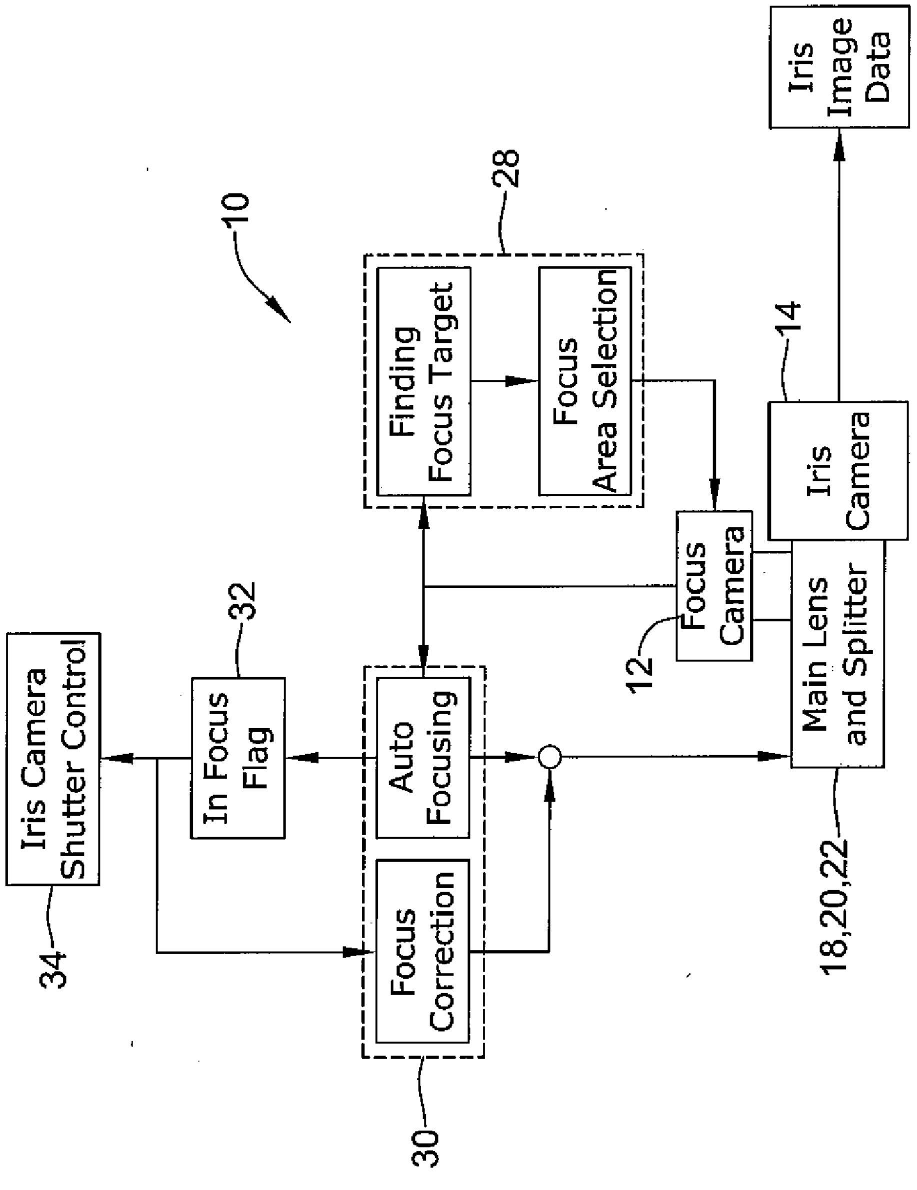
10
28
Finding Focus Target
Focus Area Selection
Iris Image Data
14
Iris Camera
Focus Camera
12
Main Lens and Splitter
18,20,22
Auto Focusing
Focus Correction
30
In Focus Flag
32
Iris Camera Shutter Control
34

Figure 2

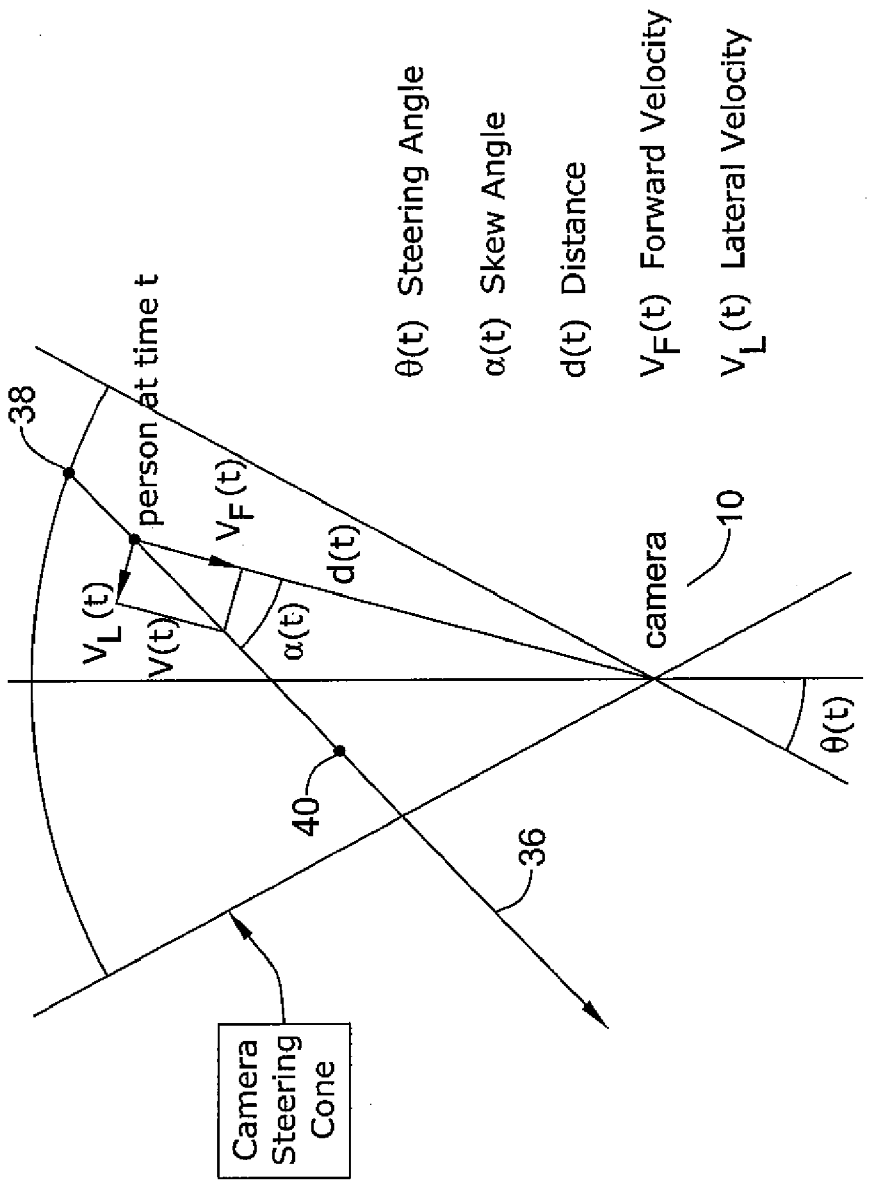
θ(t) Steering Angle
α(t) Skew Angle
d(t) Distance
V_F(t) Forward Velocity
V_L(t) Lateral Velocity
38
person at time t
V_F(t)
d(t)
V_L(t)
V(t)
α(t)
camera
10
θ(t)
40
36
Camera Steering Cone

Figure 3

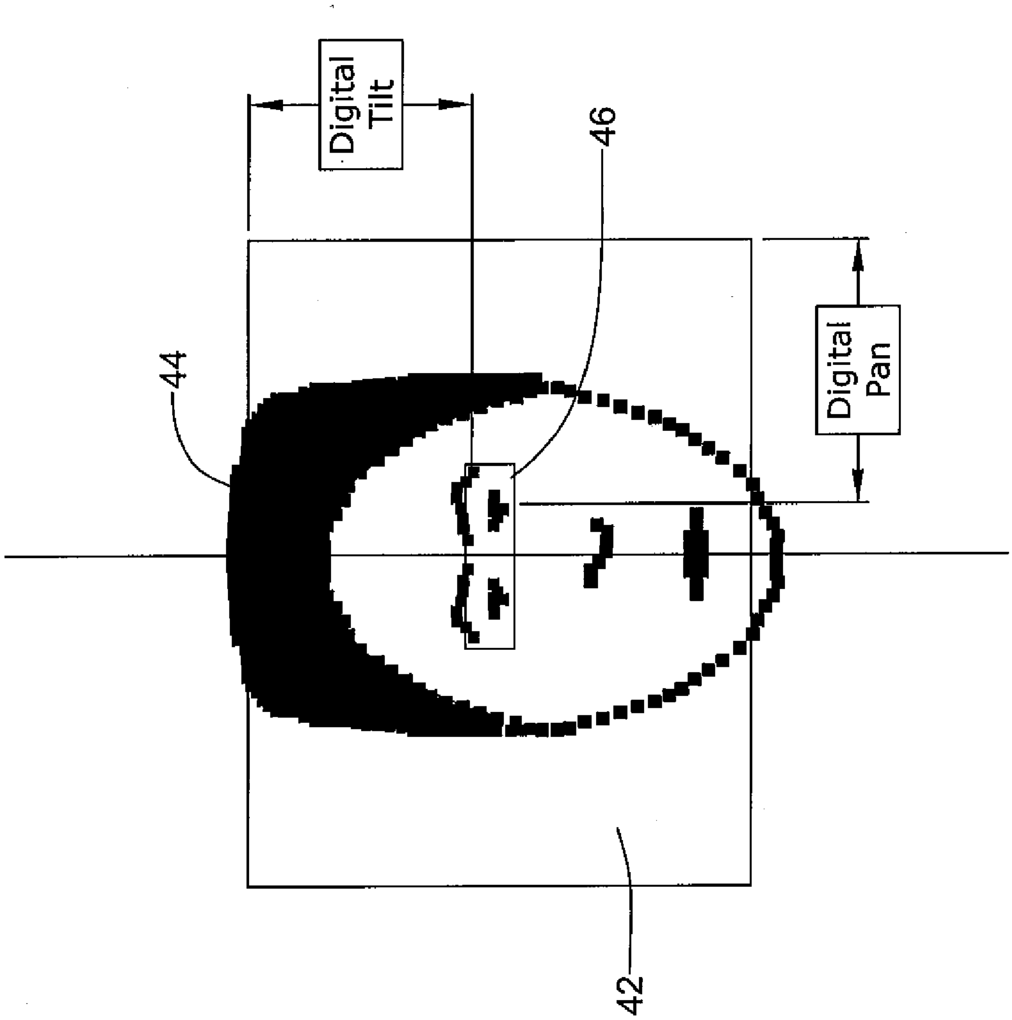

Figure 4

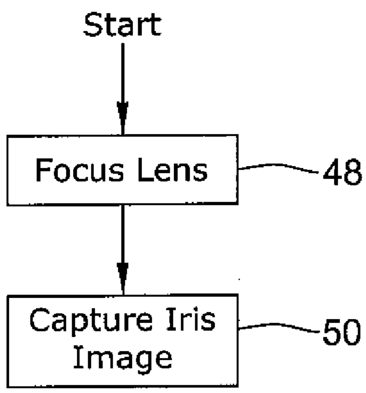

Figure 5

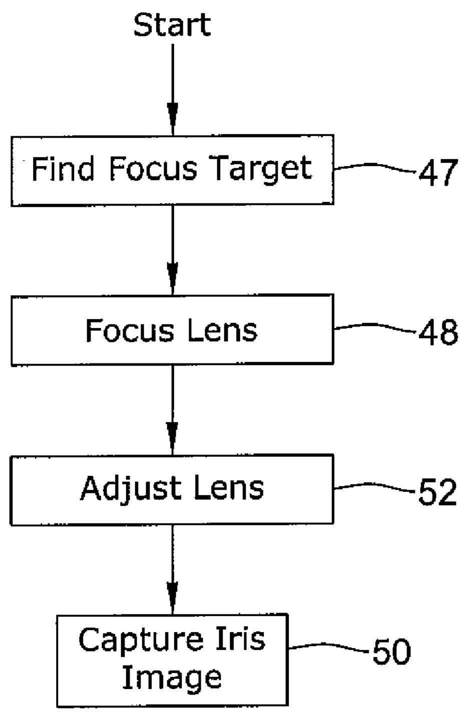
Start
Find Focus Target
47
Focus Lens
48
Adjust Lens
52
Capture Iris Image
50

Figure 6

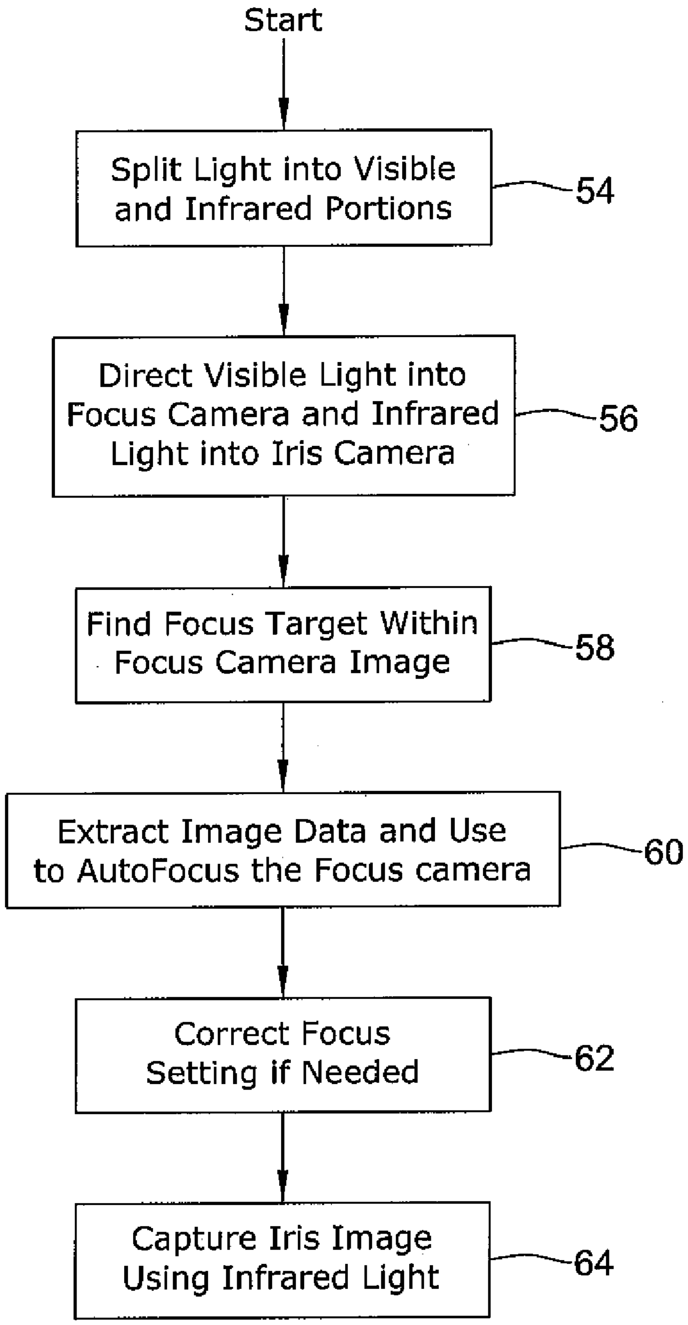
Start
Split Light into Visible and Infrared Portions
54
Direct Visible Light into Focus Camera and Infrared Light into Iris Camera
56
Find Focus Target Within Focus Camera Image
58
Extract Image Data and Use to AutoFocus the Focus camera
60
Correct Focus Setting if Needed
62
Capture Iris Image Using Infrared Light
64

Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/063205

A. CLASSIFICATION^ SUBJECT MATTER
INV. G06K9/00
ADD. H04N5/33

According to international Patent Classification (IPC) orto both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06K A61B H04N

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 practical, search terms used)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02/19030 Al (RECON OPTICAL INC [US]) 7 March 2002 (2002-03-07) page 19, line 8 - line 25; figure 4a	1-21
A	WO 01/28476 Al (TECHNOLAS GMBH OPHTHALMOLOGISC [DE]; HOHLA KRISTIAN [DE]; NEUHANN THOM) 26 April 2001 (2001-04-26) page 26, line 13 - page 30, last line ; figure 12	1-21
A	GB 2 375 913 A (HEWLETT PACKARD CO [US]) 27 November 2002 (2002-11-27) page 12, line 8 - page 16, line 8 ; figures 1-3	1-21

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the International search report
20 June 2007	27/06/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL- 2280 HV RiJSWiJk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schinnerl , Arnol d

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/063205

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2005/008567 A (UNIV YONSEI SEOUL [KR]; KIM JAI-HIE [KR]; PARK KANG-RYOUNG [KR]; BAE K) 27 January 2005 (2005-01-27) abstract; figures 1,19,20	1-21
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/063205

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