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(54) **SYSTEMS AND METHODS FOR NON-CONTACT BIOMETRIC SENSING**

SYSTEME UND VERFAHREN FÜR KONTAKTFREIE BIOMETRISCHE MESSUNG

SYSTÈMES ET PROCÉDÉS POUR UNE DÉTECTION BIOMÉTRIQUE SANS CONTACT

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- **UMBERTO MORBIDUCCI ET AL: "Optical Vibrocardiography: A Novel Tool for the Optical Monitoring of Cardiac Activity", ANNALS OF BIOMEDICAL ENGINEERING, KLUWER ACADEMIC PUBLISHERS-PLENUM PUBLISHERS, NE, vol. 35, no. 1, 3 November 2006 (2006-11-03), pages 45-58, XP019446488, ISSN: 1573-9686, DOI: DOI:10.1007/S10439-006-9202-9**
- **BURGOON J K ET AL: "Potential noncontact tools for rapid credibility assessment from physiological and behavioral cues", SECURITY TECHNOLOGY, 2008. ICCST 2008. 42ND ANNUAL IEEE INTERNATIONAL CARNAHAN CONFERENCE ON, IEEE, PISCATAWAY, NJ, USA, 13 October 2008 (2008-10-13), pages 150-157, XP031407035, ISBN: 978-1-4244-1816-9**

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Description

BACKGROUND

[0001] The field of the disclosure relates generally to emergency response situations and more specifically, to methods and systems for non-contact biometric sensing.

[0002] In emergency response to disasters of various kinds, first responders are hampered by being unable to reach victims, or are encased in protective equipment that prevents sufficient contact with victims to do standard medical triage. No solution currently exists which permits non-contact standoff measurement of human vital signs. Existing solutions require contact with the victim, for example, palpating the neck or wrist of victim to measure pulse rate or respiration and/or listening for a heart beat with an ear pressed against a chest. As can be seen from the preceding description, existing triage techniques require contact. As a result triage cannot be done when contact is prevented by lack of access or when intervening materials (e.g., biohazards) hamper contact.

[0003] ZHU ET AL: "Integration of Laser Vibrometry with Infrared Video for Multimedia Surveillance Display", AFRL/HECB GRANT FINAL PERFORMANCE REPORT,, The City College of New York, December 2004, relates to a long-range, clandestine, multimedia surveillance system using a laser Doppler vibrometer (LDV) as a non-contact, remote and high-resolution voice detector and an infrared imaging camera to detect targets for LDV audio surveillance. US-A1-2004/089812 relates to a structural defect-detection system using ultrasonic excitation to generate heat in a structure and a thermal imaging camera to detect the presence of cracks from images taken during heating of the structure. A Doppler laser vibrometer is used to measure the acoustic chaos generated in the structure by the ultrasonic energy.

[0004] MORBIDUCCI ET AL: "Optical Vibrocardiography : A Novel Tool for the Optical Monitoring of Cardiac Activity" ANNALS OF BIOMEDICAL ENGINEERING, vol. 35, no. 1, 3 January 2007 relates to a non-contact method for heart beat monitoring based on the optical recording of movements of the chest wall by means of laser Doppler vibrometry.

[0005] US-A1-2008/045847 relates to a non-contact, passive method for measurement of arterial pulse from areas such as the major superficial arteries of the body through analysis of thermal IR images acquired by passive thermal IR imaging sensors and through the modelling of the pulsatile nature of the blood flow and arterial pulse propagation in the circulatory system.

[0006] US-A1-2008/077019 relates to human health evaluation by scanning body areas of a patient using an infrared camera, detecting abnormalities in the body of the patient, analyzing abnormalities of the patient against information stored in a database, and reporting results to the patient in a pre-determined format.

[0007] Burgoon JK et al, "Potential noncontact tools for rapid credibility assesment from physiological and behavioral cues", Security Technology, 2008, ICC ST 2008. 42nd Annual IEEE International Carnahan Conference on, IEEE, Piscataway, NJ, USA, 13 October 2008 pp 150-157 Showss a noncontact biometric sensing device in accordance with the pre-characterizing part of claim 1.

BRIEF DESCRIPTION

[0008] In one aspect, a non-contact biometric sensing device is provided, in accordance with claim 1.

[0009] In another aspect, a method for sensing biometric parameters associated with an object, without contacting the object, is provided. The method is set out in claim 5.

[0010] The features, functions, and advantages that have been discussed can be achieved independently in various embodiments or may be combined in yet other embodiments further details of which can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Figure 1 is a depiction of a person using one embodiment of a remote biometric measuring device to measure vital signs of another person.

Figure 2 is a block diagram of a non-contact biometric sensing device.

Figure 3 is a top isometric view of the non-contact biometric sensing device of Figure 2.

Figure 4 is bottom isometric view of the non-contact biometric sensing device of Figure 2.

Figure 5 is a top isometric view of an assembled non-contact biometric sensing device within a chassis.

Figure 6 is a block diagram of a pointing stabilization system.

Figure 7 is a flow diagram describing operation of the non-contact biometric sensing device of Figure 2.

Figure 8 is a flow diagram of a data pre-processing stage for a pulse algorithm.

Figure 9 is a flow diagram of a model calibration stage for a pulse algorithm.

Figure 10 is a flow diagram of an initial detection/quantification stage for a pulse algorithm.

Figure 11 is a flow diagram of a post-detection processing stage for a pulse algorithm.

DETAILED DESCRIPTION

[0012] The described embodiments include a handheld emergency response triage device, for example, to assist in the on-scene assessment of victim status, via standoff assessment of key physiological parameters, the device usable by personnel wearing PPE. In embodiments, the device combine a laser Doppler vibrometry sensor with an infrared imaging device, to measure human biometric signals without contact, and with a standoff distance between the user and the person whose biometric signals are being measured. As further described, other embodiments include other non-contact physiological measuring methods and devices. Figure 1 depicts such a device in one contemplated use. More specifically, Figure 1 depicts a first responder 10 to an emergency situation. The circumstances and types of such emergency situations are nearly unlimited, therefore, for purposes of this disclosure, the description utilizes the example of a chemical spill or leak. Embodiments of the described device allow for the evaluation of the physical condition of accident victims remotely, safely, and accurately, minimizing the risk to first responders.

[0013] In such situations, the first responder will generally be wearing some type of personal protection equipment (PPE) that prevents him from physically contacting a person 20 that has been compromised by the emergency situation. The emergency situation may be of a nature where physical contact between the first responder 10 and the person is hazardous to the first responder 10. To address the triage needs of person 20, the first responder 10 is equipped with a non-contact biometric sensing device 50.

[0014] Non-contact biometric sensing device 50, in various embodiments, allows the first responder 10 to measure the physiological parameters of person 20. The measured physiological parameters provide the first responder 10 with indicators of physical condition of person 20, for example, by measuring mechanical motion with a laser and thermal distributions with an infrared camera. In such embodiments, the laser is able to measure mechanical motion at the surface of the skin of person 20, due to respiration and heart beat. As shown in Figure 1, some embodiments of non-contact biometric sensing device 50 are handheld devices. Other portable configurations are contemplated.

[0015] Figure 2 is a block diagram of one embodiment of non-contact biometric sensing device 50. Device 50 combines an infrared camera 52, a visible camera 54 and a laser doppler vibrometer sensor 60. In order to operate in a handheld mode, the non-contact biometric sensing device 50 includes a processing device 70 which includes programming that operates to remove the motion of the user (first responder 10). In order to operate over a number of ranges, the non-contact biometric sensing device 50 includes autofocus methods programmed into the processing device 70 for the optical sensors. In the illustrated embodiment, there is an autofocus device 80 associated with the infrared camera 52, an autofocus device 82 associated with the visible camera 54, and an autofocus device 84 associated with the laser doppler vibrometer sensor 60. In addition to the autofocus device 84, laser doppler vibrometer sensor 60 includes a waveform generator 100, a solenoid drive 102, a tuning fork/solenoid 104, a laser driver 106, a laser 108 and associated fiber optics 110. A two-axis fine steering mirror 112 is included in embodiments of non-contact biometric sensing device 50 to stabilize laser beams emanating from and received by laser doppler vibrometer sensor 60.

[0016] In alternative embodiments, additional sensors are integrated into non-contact biometric sensing device 50 including ranging lasers 120, gyroscopes 130, and a detector amplifier/ADC 140 (analog-to-digital converter). Fine steering mirror 112 may also be utilized to stabilize laser beams emanating from and received by ranging lasers 120. Ranging lasers 120 provide visible laser guide beams which provide an indication for the user of where the sensors of device 50 are pointed. For example, if the visible laser beams are impinging person 20 (shown in Figure 1) the user 10 knows that the other sensors (e.g., visible camera 54, IR camera 52, and laser doppler vibrometer sensor 60 are also directed to person 20. In certain embodiments, gyroscopes 130 are MEMS gyroscopes.

[0017] According to the invention, visible camera 54 is utilized for platform motion detection and processing device 70 (along with an algorithm running thereon) uses the information from visible camera 54 to remove the effects of motion of user 10 from the readings received from the other sensors. Similarly, gyroscope 130 is utilized to remove the hand motion associated with a user 10. In embodiments, and as described within the following paragraphs, functions included within non-contact biometric sensing device 50 include a linear motion detector, display, control buttons, an embedded computer, a field programmable gate array and associated firmware implementation of motion estimation algorithms, mirror controls, and sensor interfaces.

[0018] Non-contact biometric sensing device 50 further includes a battery/power subsystem 150, a user interface 160 and a user display 170. The battery/power subsystem 150 provides power to the other components of the device 50. The user interface 160 is communicatively coupled to the processing device 70 such that the programming stored therein can react to user input. The user display 170 is communicatively coupled to the processing device 70 such that information from the sensors described herein may be presented to the first responder 10.

[0019] As further described herein, device 50 enables standoff use, and also allows use by personnel wearing personal protective equipment, which hampers triage by direct contact methods. Device 50 measures mechanical motion, and measures temperature distribution, without contact at ranges of about five feet to about forty feet.

Signals from the various sensors are processed by the processing device 70 to extract pulse rate, measure a breathing rate, and generate a map of temperature distribution on the human skin. These measurements indicate physical condition as calibrated with the measurements of physical condition by other contact methods such as strain belts, EKG and temperature probes.

[0020] Turning now to Figure 3, a top isometric view of non-contact biometric sensing device 50 is provided. Components that were described with respect to Figure 2 are shown in Figure 3 using the same reference numerals. Additionally, Figure 3 illustrates two visible laser drivers 200 and 202 that are associated with the ranging lasers 120. An optical splitter 210 allows the wavelength of light associated with the laser doppler vibrometer sensor 60, from auto focus 84 to pass through to fine steering mirror 112. In the illustrated embodiment, the lenses 220 and 222 associated with autofocus devices 80 (not shown in Figure 3), 82, and 84 respectively include a linear translator 224, 226 which moves the respective lens 220, 222 to accomplish the focusing function.

[0021] Figure 4 is a bottom isometric view of non-contact biometric sensing device 50 which illustrates the above described IR camera 52, battery/power subsystem 150 and printed circuit boards 250 which house the processing device 70 (not shown in Figure 4 as well as supporting circuits for user interface 160 and display 170. In embodiments, an autofocus function is added to the IR camera 52, as shown in Figure 2. For clarity, the autofocus function is not shown in Figure 4 though in practice such a function is similar to 82 and 84 shown in Figure 3 and in embodiments utilizes a linear translator.

[0022] Figure 5 is a top isometric view of an assembled non-contact biometric sensing device 50 which includes a chassis 300 further including a plurality of shock and vibration isolating bumpers 310 mounted on corners of chassis 300. Also shown in Figure 5 are the display 170 and buttons 320 and 322 on handles 330 and 332 of chassis. Buttons 320 and 322 make up at least a portion of user interface 160. Windows 340 and 342 for the ranging lasers 120 are shown as well as windows 350 and 360 for the infrared camera 52 and the visible camera 54.

[0023] As mentioned above, the above described system is operable for standoff measurement of biometric signals and is contemplated to function, at least in part, as a standoff triage device for civilian first responders and military first responders. To provide such functionality, the visible light from the ranging lasers 120 is utilized by the visible camera 54 to provide data that can be utilized by the processing device 70 to calculate an auto focus value for operation of the infrared camera 52 and the laser doppler vibrometer sensor 60. Specifically, the visible camera 54 sees the two laser beams from ranging lasers 120, measures how far apart the beams are at an impact point (e.g., on person 20 (shown in Figure 1). The distance between the beams at the impact is utilized by the processing device 70 to determine a distance to the impact point and therefore control the autofocus function associated with the infrared camera 52, the visible camera 54, and the laser doppler vibrometer sensor 60.

[0024] In regard to operation of the laser doppler vibrometer sensor 60, it operates through the detection of reflected signals as sensed by detector/amplifier/ADC 140. which passes the detected signals onto the processing device 70 which is programmed to convert the received signals into velocities which is then passed to a triage algorithm. In embodiments, the laser doppler vibrometer sensor 60 has a data rate of about 800 Hz, a frequency resolution of 16 bits (~1 Hz in 100 kHz), a signal to noise resolution of 14bits (10 in 10^6), a mirror size of about one inch (2.54 cm) in diameter, a mirror quality of lambda/4, and is gold coated. The focus stage resolution of the laser doppler vibrometer sensor 60, in one embodiment, is 3.4 microns in 3 mm (.2 Rayleigh range) and the ranging resolution is 0.04 in (0.1016 cm) at 5 ft (1.524 m) and two inches (5.08 cm) at 40 ft (12.192 m) (.1 Rayleigh range).

[0025] As is understood by those skilled in the art, non-contact biometric sensing device 50 is programmed with several operating modes, which are activated via the user interface 160 and executed by the processing device 70, which either accesses or includes a memory for storing the instructions utilized in operation of non-contact biometric sensing device 50. In embodiments, a sleep mode is included which operates to conserve battery power by turning the display 170 off, turning the various lasers off, and putting the processing device 70 into a low power mode. In a search mode, the display 170 is on, the lasers are on, a display of the long-wavelength infrared (LWIR) image provided by IR camera 52 is provided on display 170, and the beam stabilization afforded by the gyroscopes 130 and visible camera 54 for the laser doppler vibrometer sensor 60 is inactive and fixed in a neutral position.

[0026] Beam stability for one embodiment of the laser doppler vibrometer sensor 60 is about one centimeter. At 40 feet, this stability translates to about 0.047 degrees or about 820 micro radians. User hand jitter is stabilized up to about 20 Hz which implies a control loop bandwidth of about 2x, or 40 Hz, and a controller update rate of 10x or 400 Hz. Beam pointing accuracy of the laser doppler vibrometer sensor 60 is about 1 to 1.5 centimeters.

[0027] Figure 6 is a block diagram 400 of a pointing stabilization system and algorithm for device 50. Gyroscopes 130 provide sensing of two-axis angular rates that are associated with the user handling of the device 50. Rate filters 402 and integrator 404 within processing device 70 convert sensed rates to estimates of high-frequency platform angular pointing errors. In parallel, a sensed image 406 from visible camera 54 and a stored reference image 408 are subjected to an image sensor processing algorithm 410 to determine pointing errors due to low-frequency angular platform motion and two-DOF (depth of field) platform translations. A position control algorithm 412 determines steering mirror angles to compensate, and cancel out, such motion. Outputs of the rate filtering 402 and integrator 404 algorithms are combined with the outputs of the position control algorithm 412 and provided as data to the steering mirror control function 420 which continually adjusts positioning of the mirror 430 associated with laser doppler vibrometer sensor 60 to provide a stabilized laser beam. The gyroscopes 130 sense and outputs therefrom are utilized to cancel-out higher-frequency platform rotations. Concurrently, the camera-based motion-estimation algorithm compensates for DC-to-mid-frequency platform rotation and platform translation. The unstabilized guide beams from ranging lasers 120 aid the operator in keeping the steering mirror within range limits.

[0028] To further describe operation of non-contact biometric sensing device 50, Figure 7 is a flow diagram 450 describing operation of the non-contact biometric sensing device 50 for the sensing of biometric parameters associated with an object. Initially, the user directs 452 a plurality of visible laser beams, emanating from sensing device 50, onto the object to provide an aiming function. Through user input or programming, a signal is caused 454 to be output from the laser doppler vibrometer sensor 60. The signal emanating from the laser doppler vibrometer sensor 60 from sensing device 50 thus impinges the object in the vicinity of the visible laser beams. Infrared data is received 456 from the object at the infrared camera 52 associated with the sensing device 50, where the infrared data is also in the vicinity of the visible laser beams. Mechanical motion data associated with the object as sensed by the laser doppler vibrometer sensor and thermal distribution data as sensed by the infrared camera is utilized 458 to calculate biometric data associated with the object.

[0029] In use, the user 10 aims the device 50 at person 20 using the guide beams from the visible ranging lasers 120, which are the dual, un-stabilized guide beams, and the measurement location for the infrared camera 54 and the laser doppler vibrometer sensor 60 is centered between guide beams. In one embodiment, the user 10 presses a "lock" button when guide beams are in the vicinity of the desired measurement location. An initial lock location could be several inches (centimeters) away from desired location, and the user 10 may utilize fine-adjust controls to move lock-location from initial to desired location. Alternatively, the user 10 presses a lock button repeatedly until initial lock is close enough to the desired measurement location. The user 10 holds the un-stabilized guide beams in the vicinity of the area being measured during measurement for a period of time due to limited range on the fast steering mirror 112.

[0030] In an autofocus mode, a range to the target is measured, based on the beams provided by the visible ranging lasers 120, focus is set, beam stabilization for the laser doppler vibrometer sensor 60 is active, and a final LWIR image is acquired. In addition, a patient identifier is incremented. In a first acquire mode, the signal from laser doppler vibrometer sensor 60 is acquired and displayed, acquisition of the signal is the first attempt to detect a pulse or other signs of life of person 20. In a second acquire mode, acquisition and display of the laser doppler vibrometer sensor 60 signal is continued, and an attempt to detect respiration as well as the processing and display of a pulse rate is begun. In a third acquire mode, acquisition and display of the laser doppler vibrometer sensor 60 signal is continued, and an attempt to process and display respiration rate is made. In an analyze mode, beam stabilization for the laser doppler vibrometer sensor 60 signal is inactive, while the processing device continues to analyze collected data to present a diagnosis. A diagnostic mode is used to capture and store raw data for troubleshooting. One or more of the buttons 320 and 322 are used as an on/off switch and as a switch to change between the above described operations modes or to select a body part which is being analyzed (e.g., carotid, chest, other). In embodiments, LEDs may be incorporated to provide an indication of which mode the device 50 is operating in.

[0031] As described herein, the device 50 is utilized to perform a triage function, typically to be used by first responders at the scene of an incident or accident. The triage function can be broken down to establish a timeline hierarchy of analysis. Specifically, the first 3-5 seconds is utilized to detect primitive signs of life, including, displaying of mechanical motion against time, displaying the image as provided by IR camera 52 as a colorized map of absolute temperature, and detecting a pulse, as well as including an indication of confidence and/or signal quality. At 10-20 seconds, respiration mechanical motion is detected while the pulse rate is processed and displayed, including an indication of confidence and/or signal quality. At 30-60 seconds respiration rate is processed and displayed, pulse quality is evaluated, and if possible, a diagnosis is presented and/or a quantitative measure of patient health (i.e. 0=dead...100=healthy) is provided, also including an indication of confidence and/or signal quality.

[0032] Figure 8 is a flow diagram 500 of a data preprocessing stage for a pulse algorithm. A velocity signal is read 502 by the laser doppler vibrometer sensor 60 which is sampled 504 by the processing device 70, through detector/amplifier 140, and despeckled to create 506 new output channels including a heart sound channel 510, a maximum velocity peak detection channel 512, a landmark detection/measurement channel 514, an artifact auto-detection channel 516 and a respiration channel 518. These channels are passed through various filters and other processing and the results are written 520 to a file.

[0033] Figure 9 is a flow diagram 550 of a model calibration stage for a pulse algorithm. In one embodiment, 15 seconds of data from a pre-processed file (see Figure 8) is read 552 and maximum likelihood heartbeats are identified 554 using, for example, generic models from which individualized models are created 556. The models include, in one embodiment, a heart sounds model 560, a maximum velocity peak detection model 562, a landmark detection/measurement model 564, and an artifact auto-detection model 566. In regard to the landmark detection/measurement model 564, if the correlation between a current higher frequency measurement model and the model from the previous 15 second input exceeds 570 a criterion, consecutive models are averaged 572 and stored. If the criterion is not exceeded 570, another 15 seconds of data is read 552 and the process continues.

[0034] Figure 10 is a flow diagram 600 of an initial detection/quantification stage for a pulse algorithm. Initially, 25 seconds of data is read 602 in from a pre-processed signal file (see Figure 8), in one embodiment, with a three second overlap with the preceding epoch. "Candidate" beats are identified 604 using cross-correlation between heart sounds input channel and heart sounds model, for example, when both are down-sampled to 20Hz. Appropriate maximum velocity peaks and extract epochs are identified 606 if an amplitude of a maximum velocity peak lies within expected values. Next, extracted epochs are labeled 608 as "detected beats" if correlation with the maximum velocity detection model exceeds a criterion. Lower and higher frequency landmark detection epochs are extracted 610 and single beat landmarks (in higher and lower frequency signals) are detected 612 and quantified. Models are dynamically updated 614, and epoch points exceeding low and high frequency "noise" criteria are identified 616. If the end of the input file been reached 618, write 620 all detections and measurements to and output file. Otherwise read 602 another 25 seconds of data.

[0035] Figure 11 is a flow diagram 650 of a post-detection processing stage for a pulse algorithm. Initially, an Inter-Beat-Interval (IBI) distribution is computed 652 and incorrect detections (IBIs too short) and misses (IBIs too long) are modeled 654. Successive epochs containing incorrect detections are extracted 656, and correlations with higher frequency measurement model are used to remove incorrect beats. Epochs with missed beats are iteratively extracted 658 and cross-correlations with higher frequency measurement models are used to add missing beats. Discontinue if either no new beats are found, or if the number of iterations exceeds a maximum iteration criterion. An average response across all detections and measure landmarks is computed 660 and ensemble averaged responses (ensemble size = 3, lag = 1) are computed 662. Landmarks are measured and an output file is updated 664.

[0036] The description of the different advantageous embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different advantageous embodiments may provide different advantages as compared to other advantageous embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

[0037] This written description uses examples to disclose various embodiments, which include the best mode, to enable any person skilled in the art to practice those embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope is defined by the claims.

Claims

1. A non-contact biometric sensing device (50) configured to calculate biometric data of a target, the device comprising:

   a processing device (70);
   a user interface (160) communicatively coupled to said processing device (70);
   a display (170) communicatively coupled to said processing device (70);
   a laser doppler vibrometer sensor (60) communicatively coupled to said processing device (70);
   an infrared camera (52) communicatively coupled to said processing device (70), said processing device programmed to utilize mechanical motion data received from said laser doppler vibrometer sensor (60) to calculate biometric data comprising at least one of a pulse rate of the target and a breathing rate of the target, and thermal distribution data from said infrared camera (52) to calculate biometric data comprising a map of temperature distribution of the target, when signals originating from said laser doppler vibrometer sensor (60) are reflected back towards said device from the target, and when thermal distribution data is received at said device from the target; **characterized by**:

      a plurality of ranging lasers (120) each configured to emanate a visible beam for use as an aiming device for said sensing device (50); and
      a visible camera (54) communicatively coupled to said processing device (70), **characterized in that** said processing device is programmed to utilize data received from said visible camera (54), including the tracking of beams from said ranging lasers (120), to remove the motion associated with a user of said sensing device from the data received from said laser doppler vibrometer sensor (60) and said infrared camera (52).

2. The non-contact biometric sensing device (50) ac-

cording to Claim 1 further comprising at least one gyroscope (130) communicatively coupled to said processing device (70), said processing device programmed to utilize data received from said gyroscope (130) to remove the hand motion associated with a user of said sensing device from the data received from said laser doppler vibrometer sensor (60) and said infrared camera (52).

3. The non-contact biometric sensing device (50) according to Claim 2 wherein said at least one gyroscope (130) is configured to output a pitch rate and a yaw rate that is associated with user handling of said sensing device, said processing device (70) programmed with an algorithm which uses sensed angular rate data to estimate higher-frequency angular pointing errors and said processing device (70) is programmed to continually adjust positioning of mirrors associated with said laser doppler vibrometer sensor (60), to remove the hand motion associated with a user of said sensing device.

4. The non-contact biometric sensing device (50) according to Claim 1, the visible camera (54) communicatively coupled to said processing device (70), said laser doppler vibrometer sensor (60), said infrared camera (52), and said visible camera (54) comprising lenses associated with an autofocus function, said processing device (70) programmed with the autofocus function, the autofocus function based on a range to a target as measured using the visible beams from said ranging lasers (120).

5. A method for sensing biometric parameters associated with an object without contacting the object, said method comprising
directing a plurality of visible laser beams, emanating from a sensing device, onto the object to provide an aiming function;
causing a signal from a laser doppler vibrometer sensor (60), the signal emanating from the sensing device, to impinge the object in the vicinity of the visible laser beams;
receiving infrared data from the object at an infrared camera (52) associated with the sensing device, the infrared data emanating from the vicinity of the visible laser beams;
utilizing mechanical motion data associated with the object as sensed by the laser doppler vibrometer sensor (60) to calculate biometric data comprising at least one of a pulse rate of the object and a breathing rate of the object and thermal distribution data as sensed by the infrared camera (52), to calculate biometric data comprising a map of temperature distribution of the object; and **characterized in that** it further comprises utilizing data from a visible camera to remove the motion associated with a user of said sensing device from the data received by the laser doppler vibrometer sensor (60) and the infrared camera (52).

6. The method according to Claim 5 further comprising:

determining a first distance between the visible laser beams at the object; and
using the determined first distance to determine a second distance between the object and the sensing device.

7. The method according to Claim 6 further comprising using the determined second distance from the object to focus the laser doppler vibrometer sensor (60), the infrared camera (52), and a visible light camera.

8. The method according to Claim 5 further comprising using a fine steering mirror to stabilize laser beams emanating from and received by at least one of the laser doppler vibrometer sensor (60) and a ranging laser that is the source of the visible laser beams.

9. The method according to Claim 5 further comprising utilizing data from a gyroscope (130) within the sensing device to remove higher frequency rotations of the sensing device from the mechanical motion data and the thermal distribution data.

Patentansprüche

1. Kontaktfreie biometrische Messvorrichtung (50), die dazu eingerichtet ist, biometrische Daten eines Zielobjekts zu berechnen, wobei die Vorrichtung umfasst:

eine Verarbeitungsvorrichtung (70),
eine Benutzer-Schnittstelle (160), die kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist,
eine Anzeige (170), die kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist,
einen Laser-Doppler-Vibrometersensor (60), der kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist,
eine Infrarot-Camera (52), die kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist, wobei die Verarbeitungsvorrichtung dazu programmiert ist, von dem Laser-Doppler-Vibrometersensor (60) empfangene Daten von mechanischen Bewegungen zu verwenden, um biometrische Daten zu berechnen, die eine Pulsfrequenz des Zielobjekts und/oder eine Atemfrequenz des Zielobjekts umfassen, und Wärmeverteilungs-Daten von der Infrarot-Camera (52) dazu zu verwenden, um biometrische Daten zu berechnen, die eine Abbildung der Tem-

peraturverteilung des Zielobjekts umfassen, wenn Signale, die von dem Laser-Doppler-Vibrometersensor (60) stammen, von dem Zielobjekt zu der Vorrichtung zurück reflektiert werden, und wenn Wärmeverteilungs-Daten von dem Zielobjekt bei der Vorrichtung empfangen werden,

gekennzeichnet durch

mehrere Ortungslaser (120), die jeweils dazu eingerichtet sind, einen sichtbaren Strahl auszustrahlen, der als Anvisierungsvorrichtung für die Messvorrichtung (50) dient, und

eine Camera (54) für sichtbares Licht, die kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist,

dadurch gekennzeichnet, dass

die Verarbeitungsvorrichtung dazu programmiert ist, von der Camera (54) für sichtbares Licht empfangene Daten einschließlich des Trackings von Strahlen von den Ortungslasern (120) zu verwenden, um die mit einem Benutzer der Messvorrichtung verbundene Bewegung von den Daten zu entfernen, die von dem Laser-Doppler-Vibrometersensor (60) und der Infrarot-Camera (52) empfangen werden.

2. Kontaktfreie biometrische Messvorrichtung (50) nach Anspruch 1, die ferner mindestens ein Gyroskop (130) aufweist, das kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist, wobei die Verarbeitungsvorrichtung dazu programmiert ist, von dem Gyroskop (130) empfangene Daten zu verwenden, um die mit einem Benutzer der Messvorrichtung verbundene Hand-Bewegung von den Daten zu entfernen, die von dem Laser-Doppler-Vibrometersensor (60) und der Infrarot-Camera (52) empfangen werden.

3. Kontaktfreie biometrische Messvorrichtung (50) nach Anspruch 2, bei der das mindestens eine Gyroskop (130) dazu eingerichtet ist, eine Drehgeschwindigkeit um die Querachse und eine Giergeschwindigkeit auszugeben, die mit der Handhabung der Messvorrichtung durch den Benutzer verbunden ist, wobei die Verarbeitungsvorrichtung (70) mit einem Algorithmus programmiert ist, der erfasste Daten der Winkelgeschwindigkeit verwendet, um höherfrequente Winkel-Richtfehler zu schätzen, und die Verarbeitungsvorrichtung (70) dazu programmiert ist, die Positionierung von dem Laser-Doppler-Vibrometersensor (60) zugeordneten Spiegeln kontinuierlich einzustellen, um die mit einem Benutzer der Messvorrichtung verbundene Hand-Bewegung zu entfernen.

4. Kontaktfreie biometrische Messvorrichtung (50) nach Anspruch 1, wobei die Camera (54) für sichtbares Licht kommunikativ mit der Verarbeitungsvorrichtung (70) verbunden ist, der Laser-Doppler-Vibrometersensor (60), die Infrarot-Camera (52) und die Camera (54) für sichtbares Licht Linsen aufweisen, die mit einer Autofokus-Funktion verbunden sind, die Verarbeitungsvorrichtung (70) mit der Autofokus-Funktion programmiert ist und die Autofokus-Funktion auf einer Entfernung zu einem Zielobjekt beruht, die unter Verwendung der sichtbaren Strahlen von den Ortungslasern (120) gemessen wird.

5. Verfahren zur Messung von biometrischen Parametern, die mit einem Objekt verbunden sind, ohne Kontakt mit dem Objekt, wobei das Verfahren umfasst:

Richten von mehreren sichtbaren Laserstrahlen, die von einer Messvorrichtung ausgestrahlt werden, auf das Objekt zur Erzielung einer Anvisierungs-Funktion;

Veranlassen, dass ein Signal von einem Laser-Doppler-Vibrometersensor (60), das von der Messvorrichtung ausgestrahlt wird, in der Nähe der sichtbaren Laserstrahlen auf das Objekt fällt;

Empfangen von Infrarot-Daten von dem Objekt bei einer Infrarot-Camera (52), die mit der Messvorrichtung verbunden ist, wobei die Infrarot-Daten von der Nachbarschaft der sichtbaren Laserstrahlen ausgehen;

Verwenden von mit dem Objekt verbundenen Daten der mechanischen Bewegung, die mit dem Laser-Doppler-Vibrometersensor (60) gemessen werden, zum Berechnen von biometrischen Daten, die eine Pulsfrequenz des Objekts und/oder eine Atemfrequenz des Objekts umfassen, und Verwenden von Wärmeverteilungs-Daten, die durch die Infrarot-Camera (52) gemessen werden, zum Berechnen von biometrischen Daten, die eine Abbildung der Temperaturverteilung des Objekts umfassen, und

dadurch gekennzeichnet, dass es ferner umfasst:

Verwenden von Daten von einer Camera für sichtbares Licht, um die mit einem Benutzer der Messvorrichtung verbundene Bewegung von den Daten zu entfernen, die durch den Laser-Doppler-Vibrometersensor (60) und die Infrarot-Camera (52) empfangen werden.

6. Verfahren nach Anspruch 5, das ferner umfasst:

Ermitteln eines ersten Anstands zwischen den sichtbaren Laserstrahlen bei dem Objekt und Verwenden des ermittelten ersten Abstands zur Ermittlung eines zweiten Abstands zwischen dem Objekt und der Messvorrichtung.

7. Verfahren nach Anspruch 6, das ferner umfasst:

Verwenden des ermittelten zweiten Abstands von dem Objekt zum Fokussieren des Laser-Doppler-Vibrometersensors (60), der Infrarot-Camera (52) und einer Camera für sichtbares Licht.

8. Verfahren nach Anspruch 5, das ferner umfasst:

Verwenden eines fein steuerbaren Spiegels zur Stabilisierung von Laserstrahlen, die von dem Laser-Doppler-Vibrometersensor (60) und/oder einem Ortungslaser, der die Quelle der sichtbaren Laserstrahlen ist, ausgehen und durch den Laser-Doppler-Vibrometersensor (60) und/oder einen Ortungslaser, der die Quelle der sichtbaren Laserstrahlen ist, empfangen werden.

9. Verfahren nach Anspruch 5, das ferner umfasst:

Verwenden von Daten von einem Gyroskop (130) in der Messvorrichtung zum Entfernen von höherfrequenten Drehungen der Messvorrichtung von den Daten der mechanischen Bewegung und den Daten der Wärmeverteilung.

Revendications

1. Dispositif de détection biométrique sans contact (50) configuré de manière à calculer les données biométriques d'une cible, le dispositif comprenant :

un dispositif de traitement (70) ;
une interface utilisateur (160) couplée en communication audit dispositif de traitement (70) ;
un écran d'affichage (170) couplé en communication audit dispositif de traitement (70) ;
un capteur vibrométrique à effet Doppler laser (60) couplé en communication audit dispositif de traitement (70);
une caméra infrarouge (52) couplée en communication audit dispositif de traitement (70), ledit dispositif de traitement étant programmé de manière à utiliser des données de mouvement mécanique reçues en provenance dudit capteur vibrométrique à effet Doppler laser (60), en vue de calculer des données biométriques comprenant au moins une fréquence parmi une fréquence de pouls de la cible et une fréquence de respiration de la cible, et des données de distribution thermique en provenance de ladite caméra infrarouge (52) en vue de calculer des données biométriques comprenant une carte de distribution de température de la cible, lorsque des signaux en provenance dudit capteur vibrométrique à effet Doppler laser (60) sont réfléchis vers ledit dispositif par la cible, et lorsque des données de distribution thermique sont reçues niveau dudit dispositif en provenance de la cible; **caractérisé par** :

une pluralité de lasers de télémétrie (120) lesquels sont chacun configurés de manière à émettre un faisceau visible destiné à être utilisé en tant qu'un dispositif de visée pour ledit dispositif de détection (50) ; et
une caméra à lumière visible (54) couplée en communication audit dispositif de traitement (70), **caractérisé en ce que** ledit dispositif de traitement est programmé de manière à utiliser des données reçues en provenance de ladite caméra à lumière visible (54), notamment le suivi de faisceaux provenant desdits lasers de télémétrie (120), en vue de supprimer le mouvement associé à un utilisateur dudit dispositif de détection des données reçues en provenance dudit capteur vibrométrique à effet Doppler laser (60) et de ladite caméra infrarouge (52).

2. Dispositif de détection biométrique sans contact (50) selon la revendication 1, comprenant en outre au moins un gyroscope (130) couplé en communication audit dispositif de traitement (70), ledit dispositif de traitement étant programmé de manière à utiliser des données reçues en provenance dudit gyroscope (130) afin de supprimer le mouvement de main associé à un utilisateur dudit dispositif de détection des données reçues en provenance dudit capteur vibrométrique à effet Doppler laser (60) et de ladite caméra infrarouge (52).

3. Dispositif de détection biométrique sans contact (50) selon la revendication 2, dans lequel ledit au moins un gyroscope (130) est configuré de manière à fournir en sortie une vitesse angulaire de tangage et une vitesse de lacet qui est associée à la manipulation, par l'utilisateur, dudit dispositif de détection, ledit dispositif de traitement (70) étant programmé avec un algorithme qui utilise des données de vitesse angulaire détectée pour estimer des erreurs de pointage angulaire de fréquence supérieure, et ledit dispositif de traitement (70) étant programmé de manière à ajuster continuellement un positionnement de miroirs associés audit capteur vibrométrique à effet Doppler laser (60), afin de supprimer le mouvement de main associé à un utilisateur dudit dispositif de détection.

4. Dispositif de détection biométrique sans contact (50) selon la revendication 1, dans lequel la caméra à lumière visible (54) couplée en communication audit dispositif de traitement (70), ledit capteur vibrométrique à effet Doppler laser (60), ladite caméra infrarouge (52), et ladite caméra à lumière visible (54) comprennent des lentilles associées à une fonction de mise au point automatique, ledit dispositif de traitement (70) étant programmé avec la fonction de mise au point automatique, la fonction de mise au point automatique étant basée sur une distance jusqu'à une cible telle que mesurée en utilisant les faisceaux visibles provenant desdits lasers de télémétrie (120).

5. Procédé de détection de paramètres biométriques associés à un objet, sans entrer en contact avec l'objet, ledit procédé comprenant les étapes ci-dessous consistant à :

diriger une pluralité de faisceaux laser visibles, émanant d'un dispositif de détection, sur l'objet, en vue de fournir une fonction de visée ;
amener un signal provenant d'un capteur vibrométrique à effet Doppler laser (60), le signal émanant du dispositif de détection, à heurter l'objet à proximité des faisceaux laser visibles ;
recevoir des données infrarouges provenant de l'objet, au niveau d'une caméra infrarouge (52) associée au dispositif de détection, les données infrarouges émanant du voisinage des faisceaux laser visibles ;
utiliser des données de mouvement mécanique associées à l'objet telles que détectées par le capteur vibrométrique à effet Doppler laser (60), en vue de calculer des données biométriques comprenant au moins une fréquence parmi une fréquence de pouls de l'objet et une fréquence de respiration de l'objet, et des données de distribution thermique telles que détectées par la caméra infrarouge (52), en vue de calculer des données biométriques comprenant une carte de distribution de température de l'objet ; et
caractérisé en ce qu'il comprend en outre l'étape consistant à utiliser des données provenant d'une caméra à lumière visible pour supprimer le mouvement associé à un utilisateur dudit dispositif de détection des données reçues par le capteur vibrométrique à effet Doppler laser (60) et la caméra infrarouge (52).

6. Procédé selon la revendication 5, comprenant en outre les étapes ci-dessous consistant à :

déterminer une première distance entre les faisceaux laser visibles au niveau de l'objet ; et
utiliser la première distance déterminée en vue de déterminer une seconde distance entre l'objet et le dispositif de détection.

7. Procédé selon la revendication 6, comprenant en outre l'étape consistant à utiliser la seconde distance déterminée par rapport à l'objet en vue de mettre au point le capteur vibrométrique à effet Doppler laser (60), la caméra infrarouge (52), et une caméra à lumière visible.

8. Procédé selon la revendication 5, comprenant en outre l'étape consistant à utiliser un miroir d'orientation fine en vue de stabiliser des faisceaux laser émanant d'au moins l'un, et reçus par au moins l'un, parmi le capteur vibrométrique à effet Doppler laser (60) et un laser de télémétrie qui correspond à la source des faisceaux laser visibles.

9. Procédé selon la revendication 5, comprenant en outre l'étape consistant à utiliser des données provenant d'un gyroscope (130) au sein du dispositif de détection en vue d'éliminer des rotations à fréquence supérieure du dispositif de détection des données de mouvement mécanique et des données de distribution thermique.

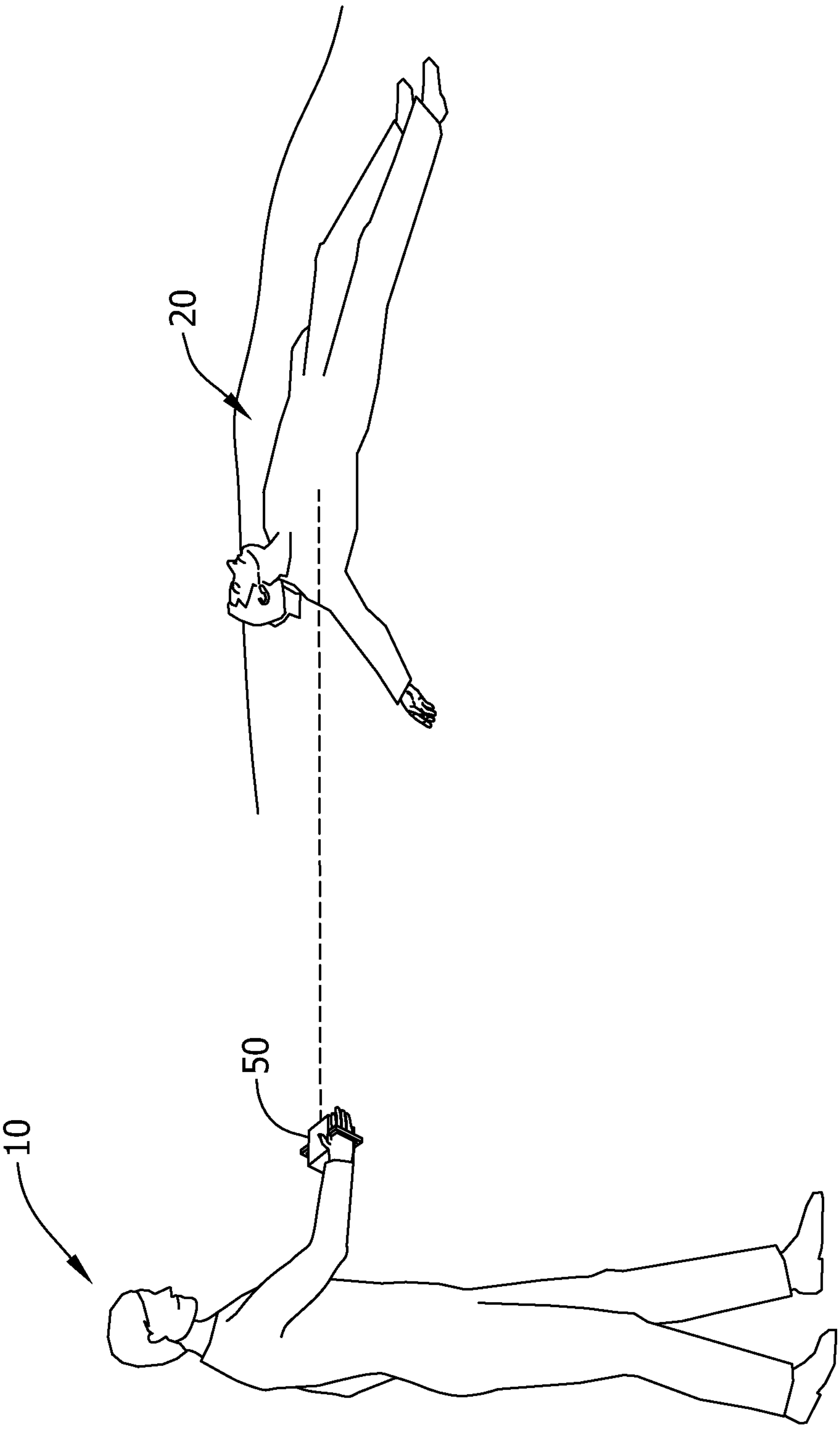


FIG. 1

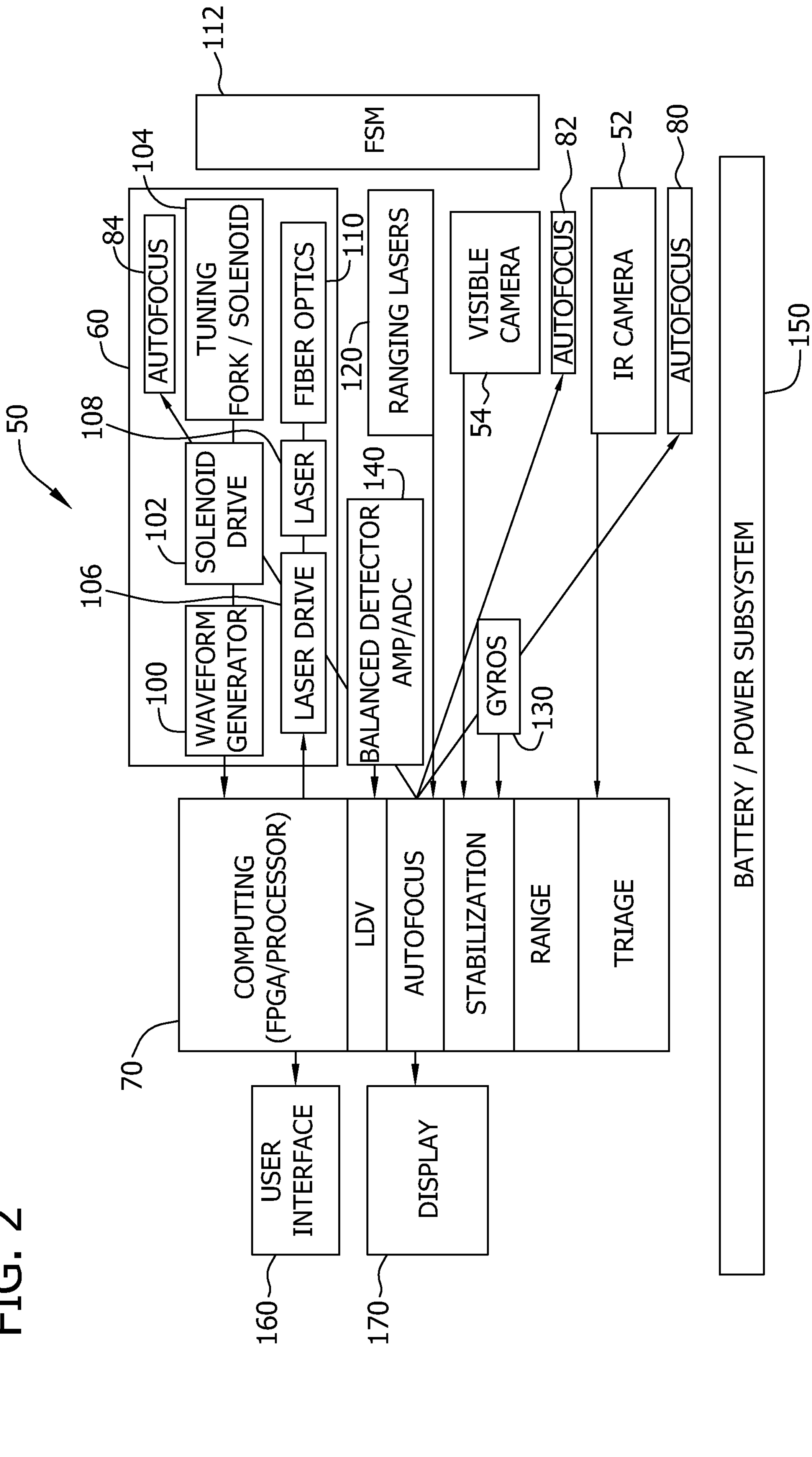

50
60
AUTOFOCUS
84
TUNING FORK / SOLENOID
104
FIBER OPTICS
110
FSM
112
RANGING LASERS
120
VISIBLE CAMERA
54
AUTOFOCUS
82
IR CAMERA
52
AUTOFOCUS
80
SOLENOID DRIVE
102
108
LASER
140
WAVEFORM GENERATOR
100
106
LASER DRIVE
BALANCED DETECTOR AMP/ADC
GYROS
130
COMPUTING (FPGA/PROCESSOR)
LDV
AUTOFOCUS
STABILIZATION
RANGE
TRIAGE
70
USER INTERFACE
160
DISPLAY
170
BATTERY / POWER SUBSYSTEM
150

FIG. 2

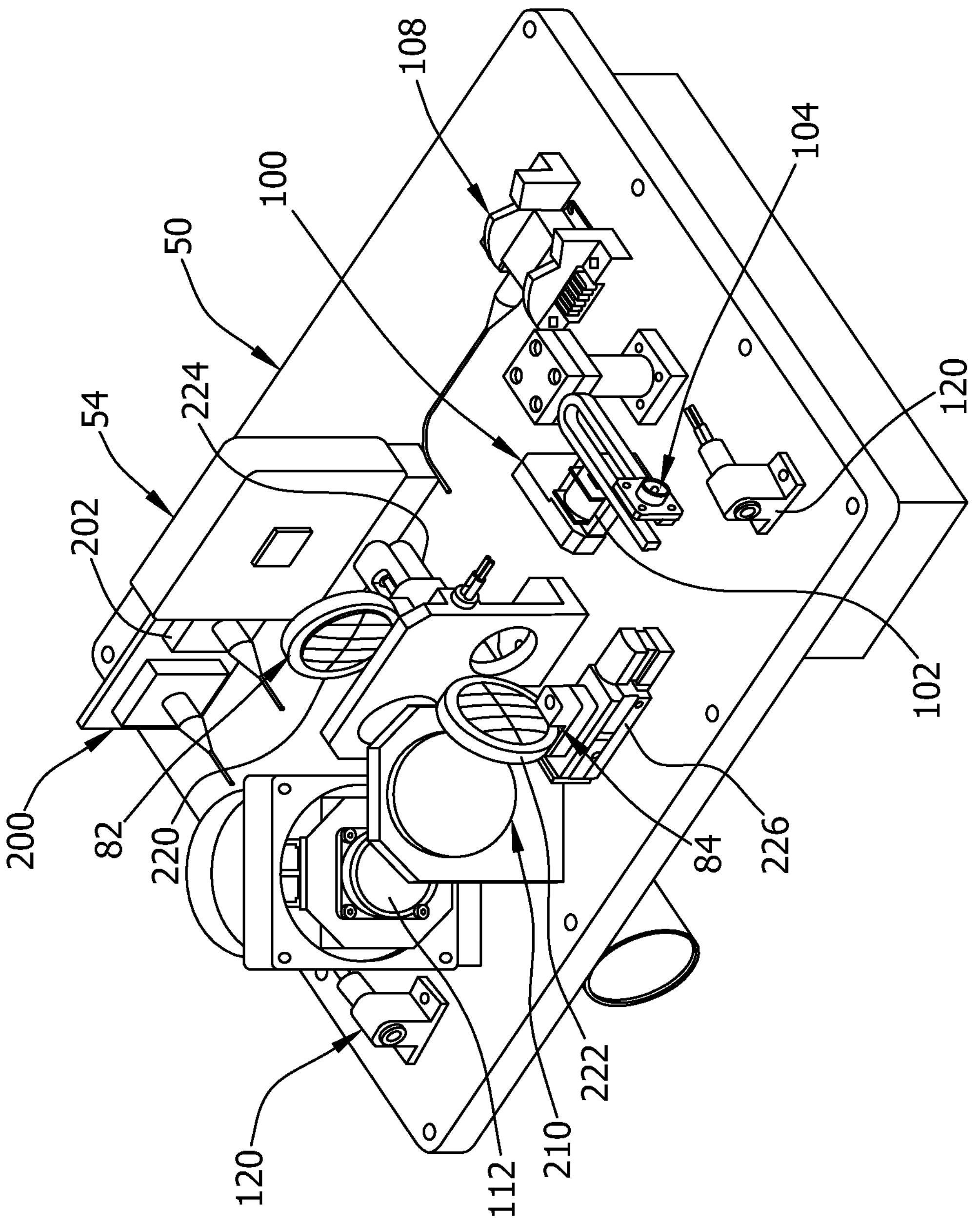

108
100
50
104
54
224
202
120
102
200
82
220
84
226
222
210
112
120

FIG. 3

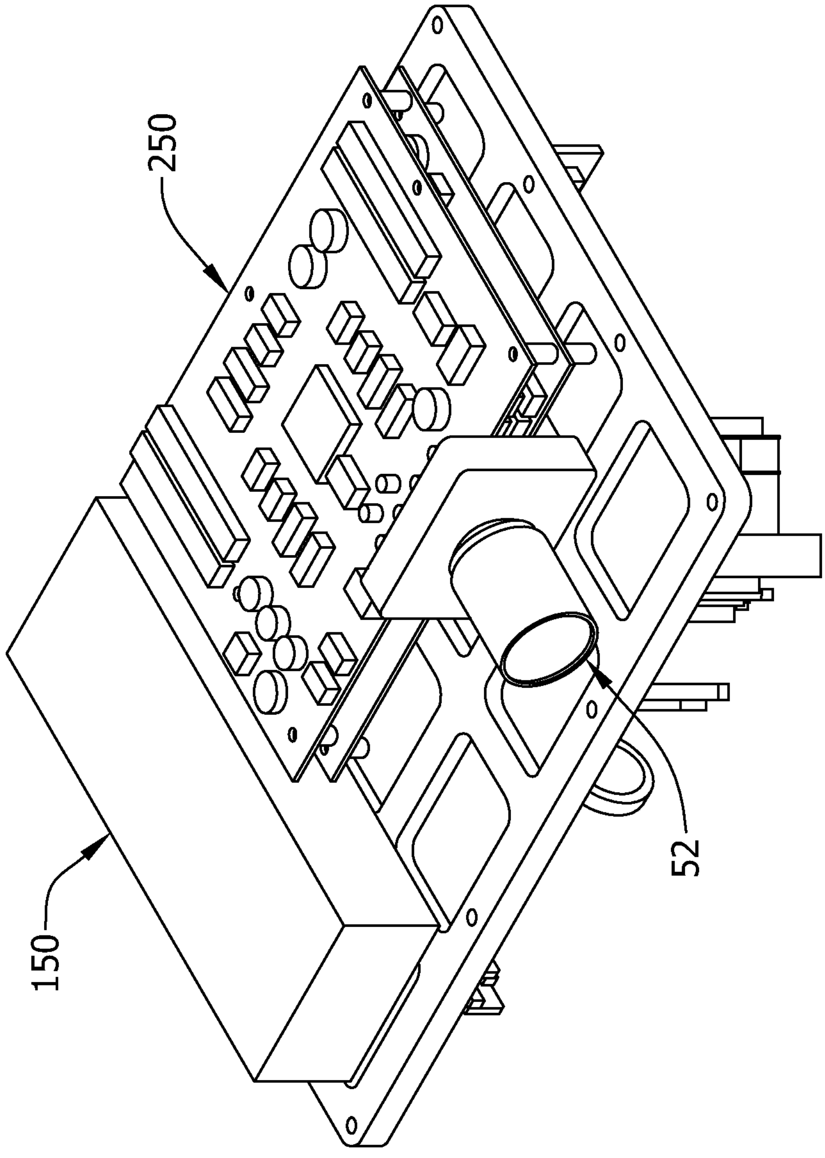


FIG. 4

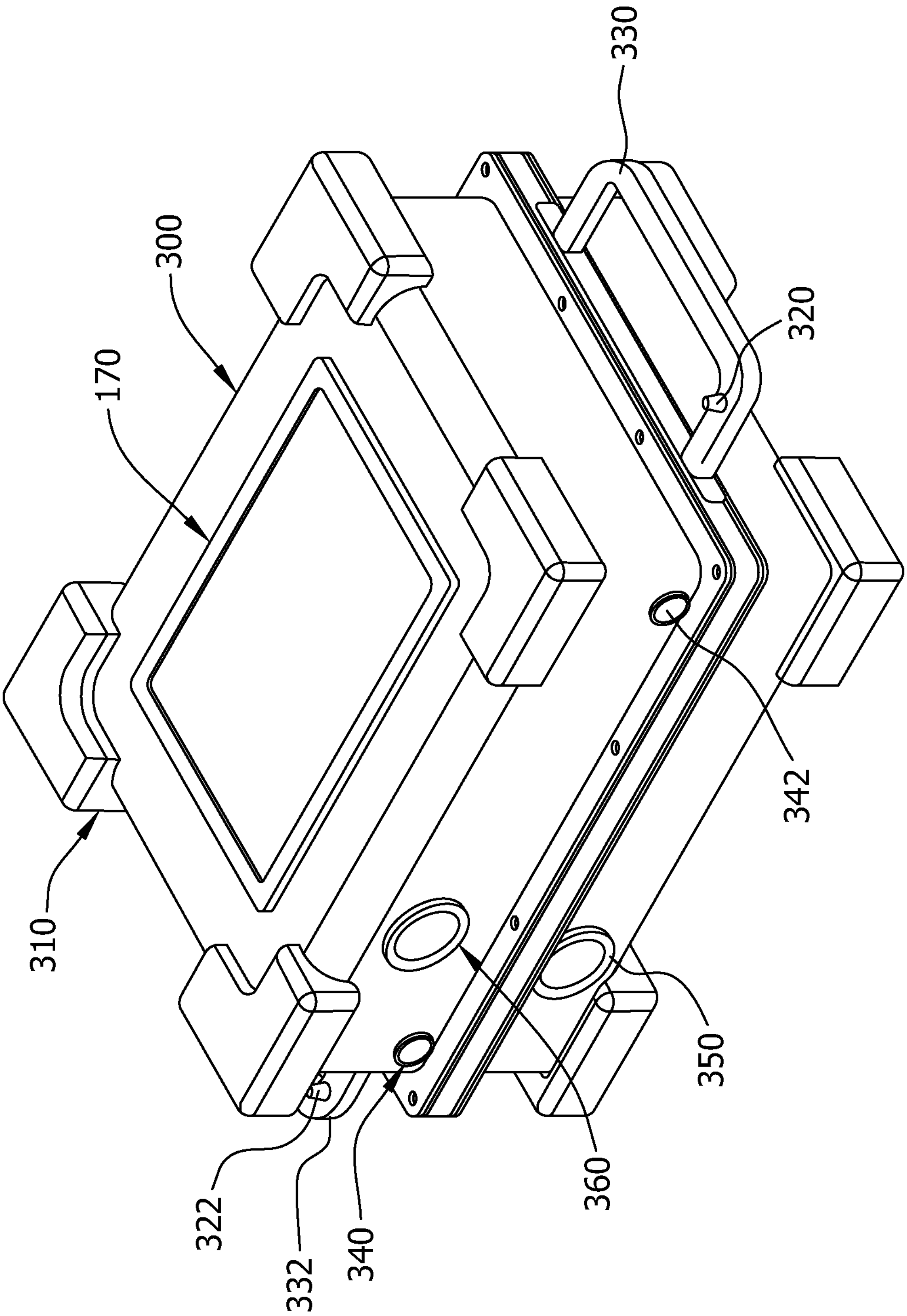


FIG. 5

FIG. 6

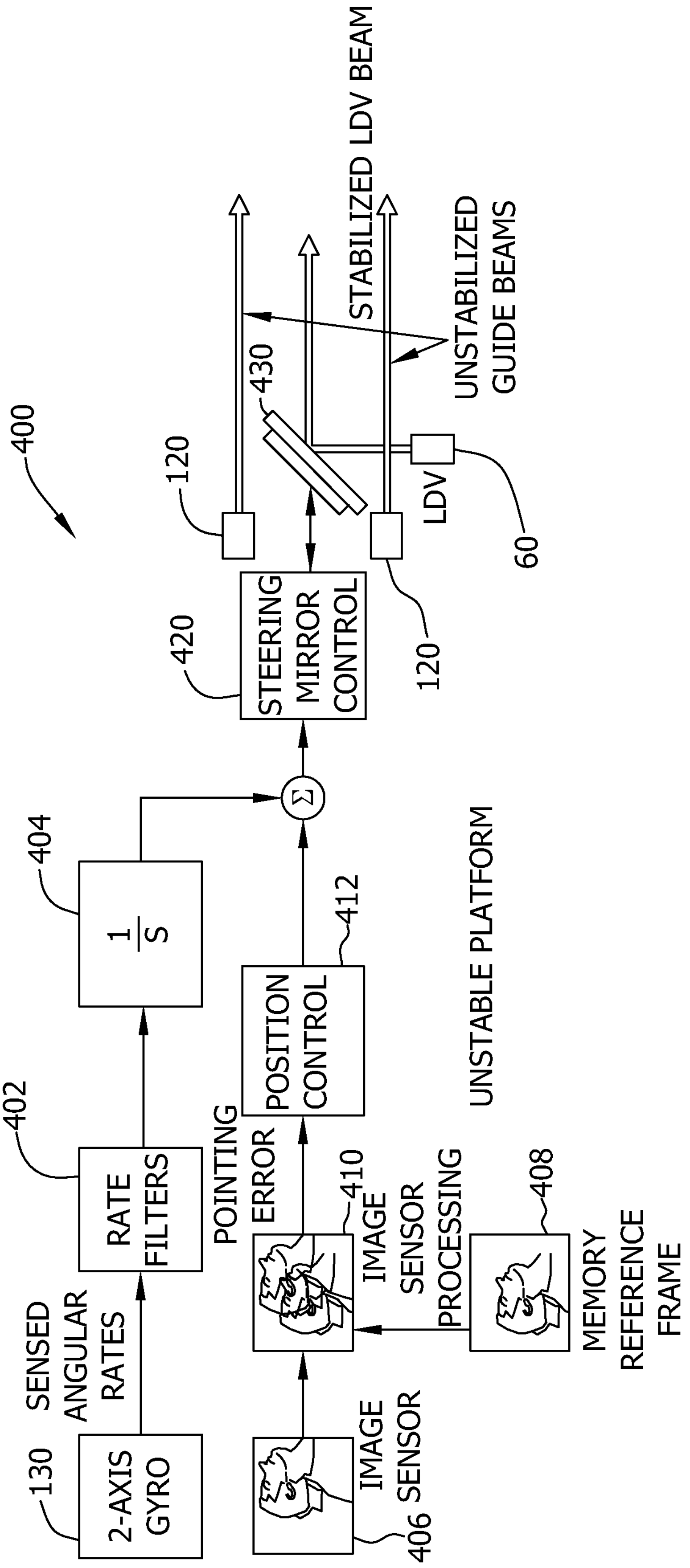

400
130
2-AXIS GYRO
SENSED ANGULAR RATES
402
RATE FILTERS
404
1/S
Σ
420
STEERING MIRROR CONTROL
120
430
120
LDV
60
STABILIZED LDV BEAM
UNSTABILIZED GUIDE BEAMS
406
IMAGE SENSOR
410
IMAGE SENSOR PROCESSING
POINTING ERROR
412
POSITION CONTROL
408
MEMORY REFERENCE FRAME
UNSTABLE PLATFORM

FIG. 7

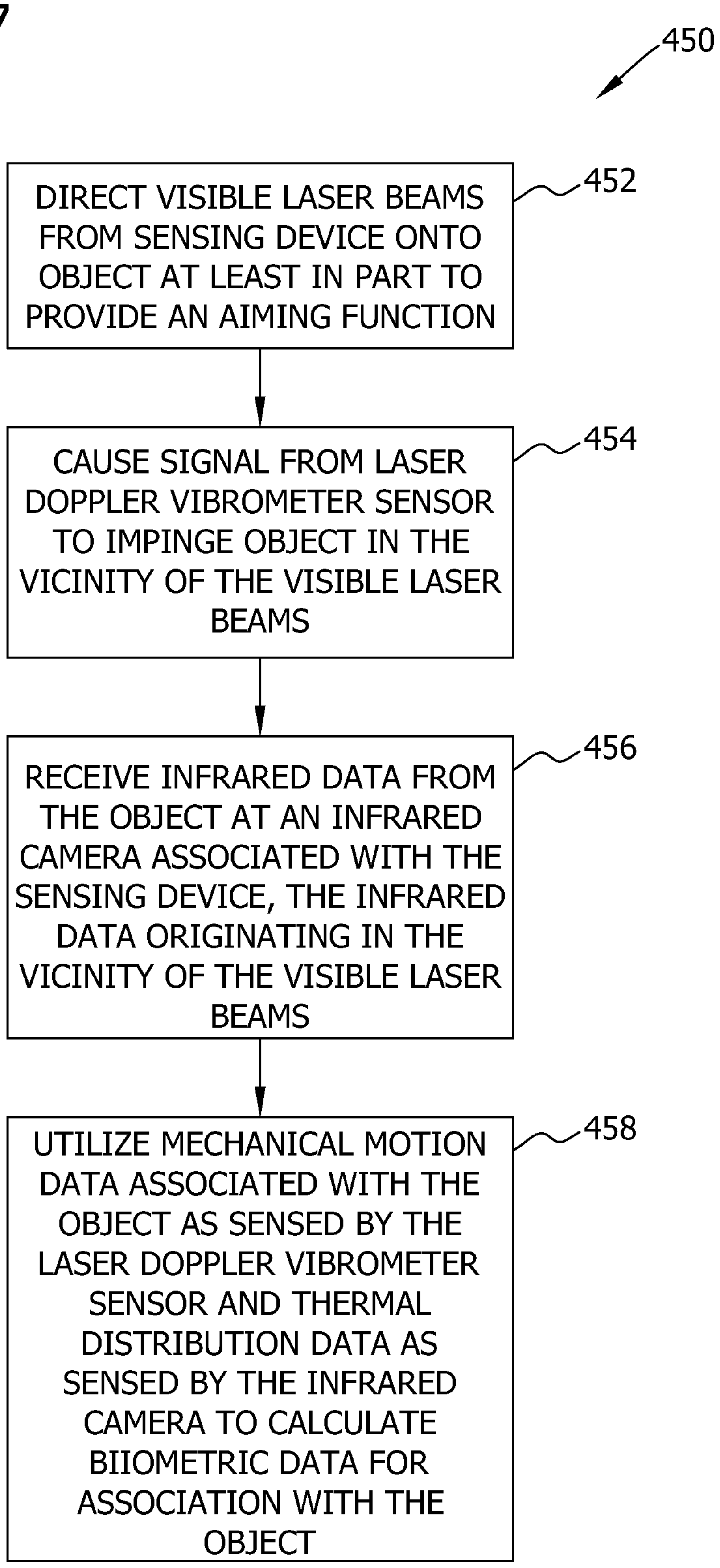

450
DIRECT VISIBLE LASER BEAMS FROM SENSING DEVICE ONTO OBJECT AT LEAST IN PART TO PROVIDE AN AIMING FUNCTION
452
CAUSE SIGNAL FROM LASER DOPPLER VIBROMETER SENSOR TO IMPINGE OBJECT IN THE VICINITY OF THE VISIBLE LASER BEAMS
454
RECEIVE INFRARED DATA FROM THE OBJECT AT AN INFRARED CAMERA ASSOCIATED WITH THE SENSING DEVICE, THE INFRARED DATA ORIGINATING IN THE VICINITY OF THE VISIBLE LASER BEAMS
456
UTILIZE MECHANICAL MOTION DATA ASSOCIATED WITH THE OBJECT AS SENSED BY THE LASER DOPPLER VIBROMETER SENSOR AND THERMAL DISTRIBUTION DATA AS SENSED BY THE INFRARED CAMERA TO CALCULATE BIIOMETRIC DATA FOR ASSOCIATION WITH THE OBJECT
458

FIG. 8

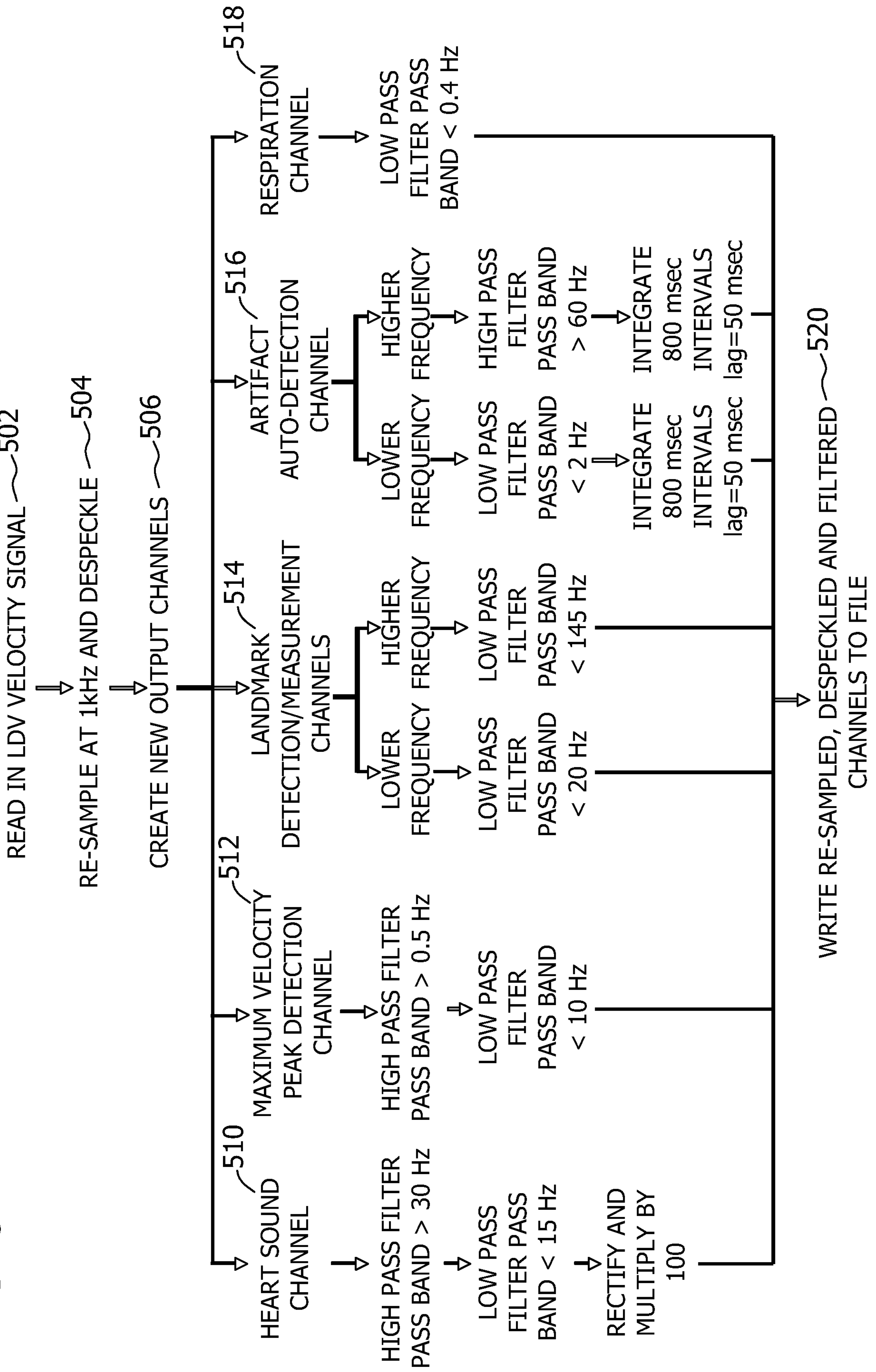

READ IN LDV VELOCITY SIGNAL 502
RE-SAMPLE AT 1kHz AND DESPECKLE 504
CREATE NEW OUTPUT CHANNELS 506
HEART SOUND CHANNEL 510
HIGH PASS FILTER PASS BAND > 30 Hz
LOW PASS FILTER PASS BAND < 15 Hz
RECTIFY AND MULTIPLY BY 100
MAXIMUM VELOCITY PEAK DETECTION CHANNEL 512
HIGH PASS FILTER PASS BAND > 0.5 Hz
LOW PASS FILTER PASS BAND < 10 Hz
LANDMARK DETECTION/MEASUREMENT CHANNELS 514
LOWER FREQUENCY
LOW PASS FILTER PASS BAND < 20 Hz
HIGHER FREQUENCY
LOW PASS FILTER PASS BAND < 145 Hz
ARTIFACT AUTO-DETECTION CHANNEL 516
LOWER FREQUENCY
LOW PASS FILTER PASS BAND < 2 Hz
INTEGRATE 800 msec INTERVALS lag=50 msec
HIGHER FREQUENCY
HIGH PASS FILTER PASS BAND > 60 Hz
INTEGRATE 800 msec INTERVALS lag=50 msec
RESPIRATION CHANNEL 518
LOW PASS FILTER PASS BAND < 0.4 Hz
WRITE RE-SAMPLED, DESPECKLED AND FILTERED CHANNELS TO FILE 520

FIG. 9

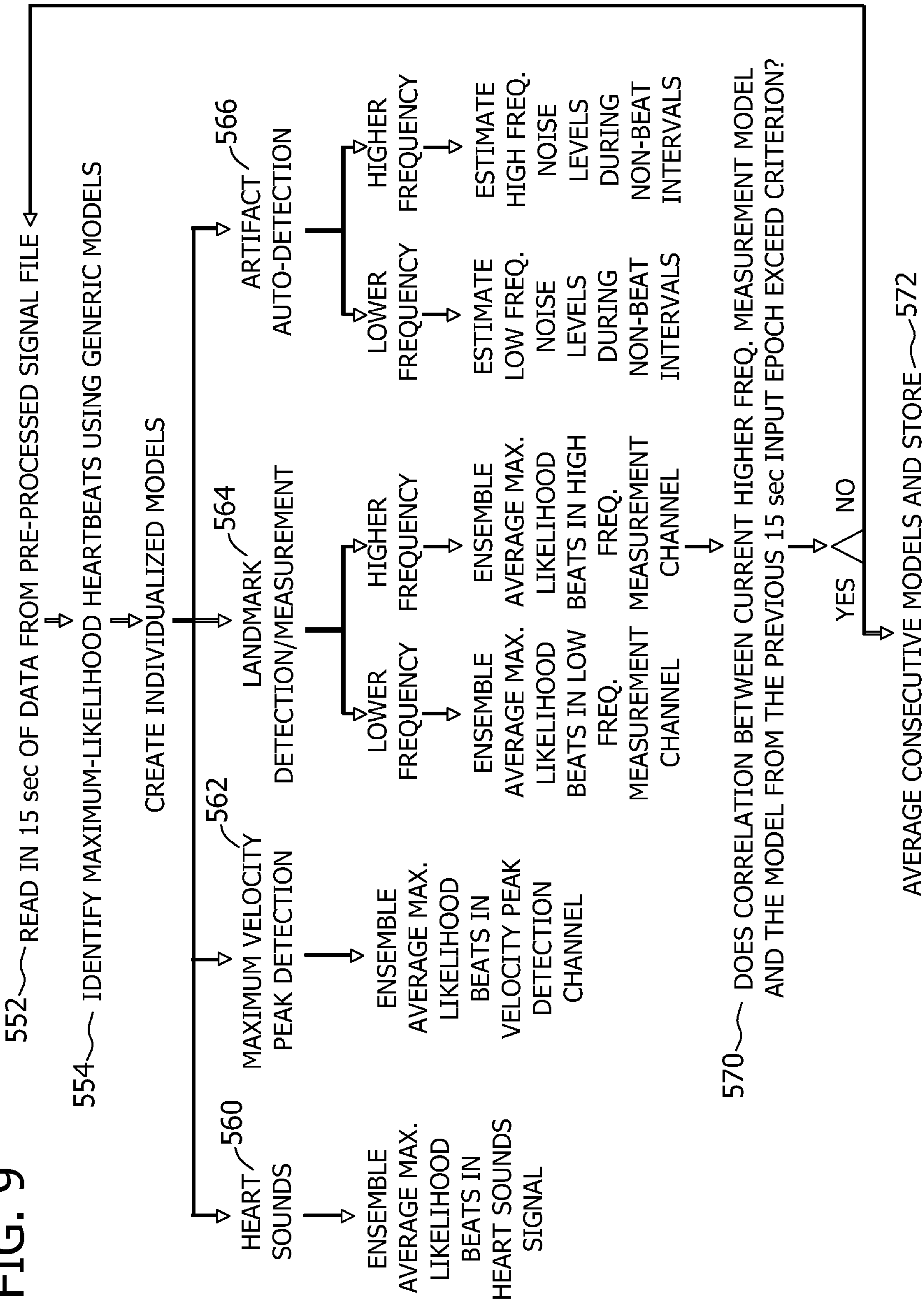

552
READ IN 15 sec OF DATA FROM PRE-PROCESSED SIGNAL FILE
554
IDENTIFY MAXIMUM-LIKELIHOOD HEARTBEATS USING GENERIC MODELS
CREATE INDIVIDUALIZED MODELS
560
HEART SOUNDS
ENSEMBLE AVERAGE MAX. LIKELIHOOD BEATS IN HEART SOUNDS SIGNAL
562
MAXIMUM VELOCITY PEAK DETECTION
ENSEMBLE AVERAGE MAX. LIKELIHOOD BEATS IN VELOCITY PEAK DETECTION CHANNEL
564
LANDMARK DETECTION/MEASUREMENT
LOWER FREQUENCY
ENSEMBLE AVERAGE MAX. LIKELIHOOD BEATS IN LOW FREQ. MEASUREMENT CHANNEL
HIGHER FREQUENCY
ENSEMBLE AVERAGE MAX. LIKELIHOOD BEATS IN HIGH FREQ. MEASUREMENT CHANNEL
566
ARTIFACT AUTO-DETECTION
LOWER FREQUENCY
ESTIMATE LOW FREQ. NOISE LEVELS DURING NON-BEAT INTERVALS
HIGHER FREQUENCY
ESTIMATE HIGH FREQ. NOISE LEVELS DURING NON-BEAT INTERVALS
570
DOES CORRELATION BETWEEN CURRENT HIGHER FREQ. MEASUREMENT MODEL AND THE MODEL FROM THE PREVIOUS 15 sec INPUT EPOCH EXCEED CRITERION?
YES
NO
AVERAGE CONSECUTIVE MODELS AND STORE
572

FIG. 10

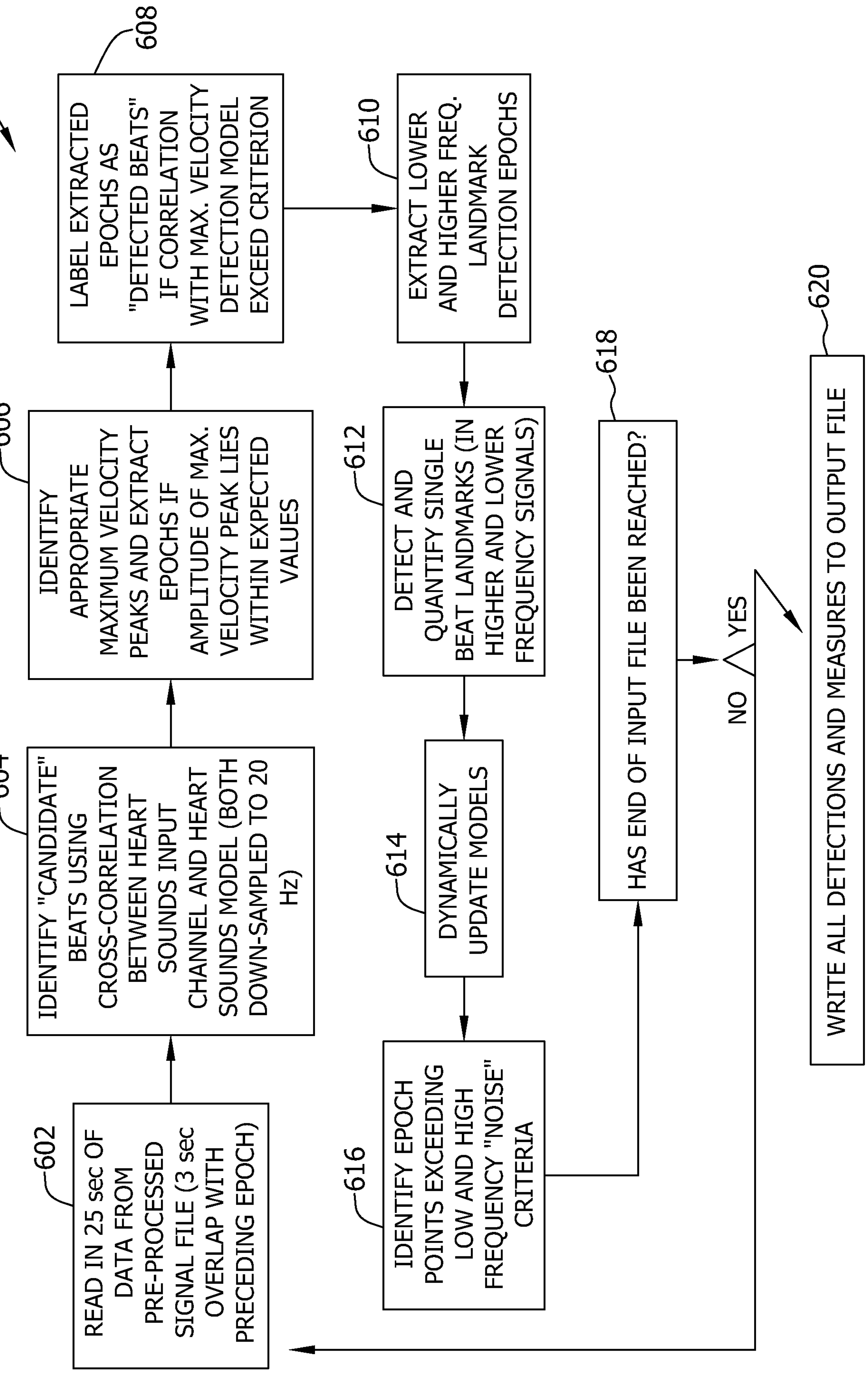
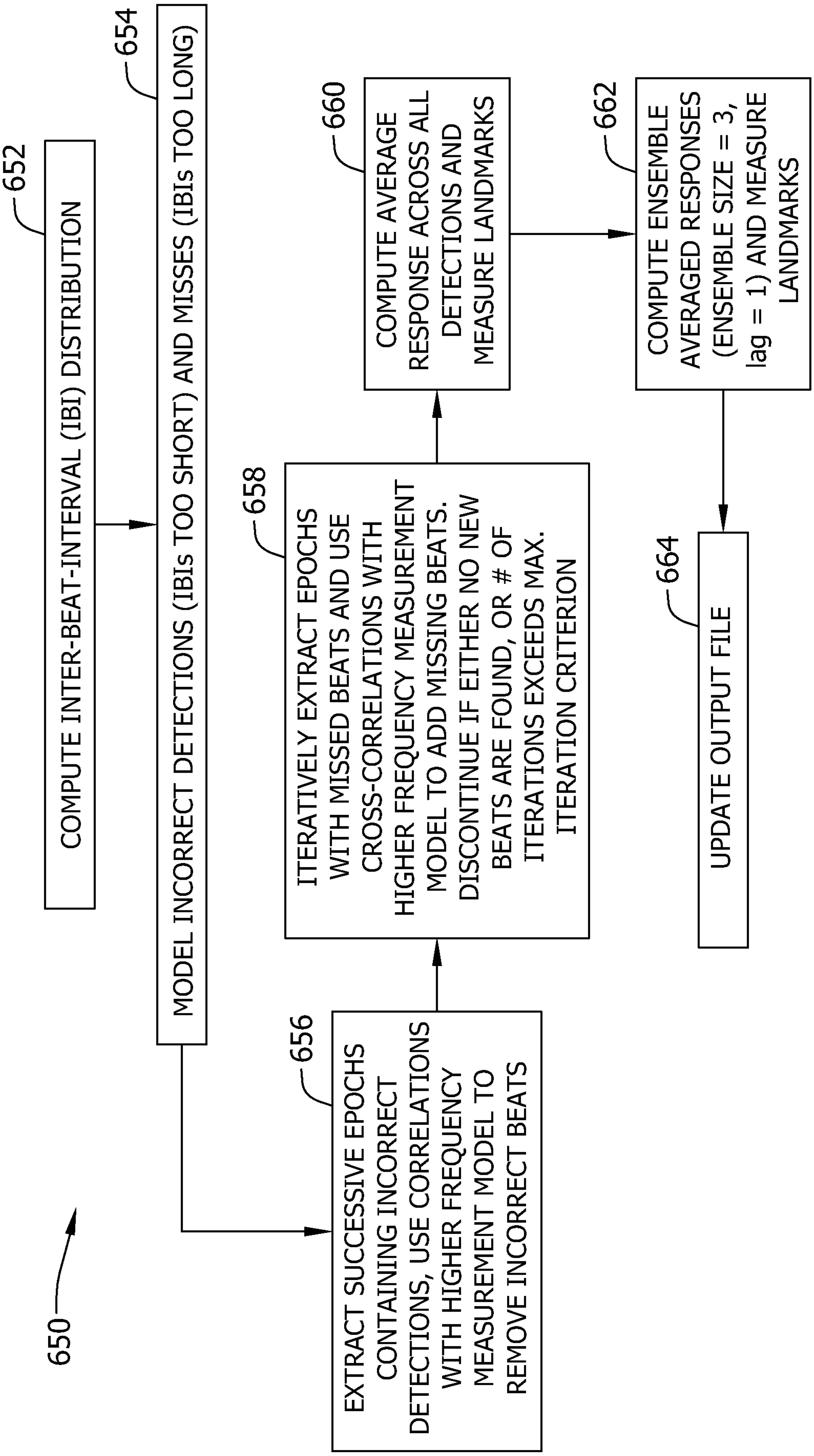

600
602
READ IN 25 sec OF DATA FROM PRE-PROCESSED SIGNAL FILE (3 sec OVERLAP WITH PRECEDING EPOCH)
604
IDENTIFY "CANDIDATE" BEATS USING CROSS-CORRELATION BETWEEN HEART SOUNDS INPUT CHANNEL AND HEART SOUNDS MODEL (BOTH DOWN-SAMPLED TO 20 Hz)
606
IDENTIFY APPROPRIATE MAXIMUM VELOCITY PEAKS AND EXTRACT EPOCHS IF AMPLITUDE OF MAX. VELOCITY PEAK LIES WITHIN EXPECTED VALUES
608
LABEL EXTRACTED EPOCHS AS "DETECTED BEATS" IF CORRELATION WITH MAX. VELOCITY DETECTION MODEL EXCEED CRITERION
610
EXTRACT LOWER AND HIGHER FREQ. LANDMARK DETECTION EPOCHS
612
DETECT AND QUANTIFY SINGLE BEAT LANDMARKS (IN HIGHER AND LOWER FREQUENCY SIGNALS)
614
DYNAMICALLY UPDATE MODELS
616
IDENTIFY EPOCH POINTS EXCEEDING LOW AND HIGH FREQUENCY "NOISE" CRITERIA
618
HAS END OF INPUT FILE BEEN REACHED?
NO
YES
620
WRITE ALL DETECTIONS AND MEASURES TO OUTPUT FILE

FIG. 11


650
652
COMPUTE INTER-BEAT-INTERVAL (IBI) DISTRIBUTION
654
MODEL INCORRECT DETECTIONS (IBIs TOO SHORT) AND MISSES (IBIs TOO LONG)
656
EXTRACT SUCCESSIVE EPOCHS CONTAINING INCORRECT DETECTIONS, USE CORRELATIONS WITH HIGHER FREQUENCY MEASUREMENT MODEL TO REMOVE INCORRECT BEATS
658
ITERATIVELY EXTRACT EPOCHS WITH MISSED BEATS AND USE CROSS-CORRELATIONS WITH HIGHER FREQUENCY MEASUREMENT MODEL TO ADD MISSING BEATS. DISCONTINUE IF EITHER NO NEW BEATS ARE FOUND, OR # OF ITERATIONS EXCEEDS MAX. ITERATION CRITERION
660
COMPUTE AVERAGE RESPONSE ACROSS ALL DETECTIONS AND MEASURE LANDMARKS
662
COMPUTE ENSEMBLE AVERAGED RESPONSES (ENSEMBLE SIZE = 3, lag = 1) AND MEASURE LANDMARKS
664
UPDATE OUTPUT FILE

REFERENCES CITED IN THE DESCRIPTION

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- **MORBIDUCCI et al.** Optical Vibrocardiography : A Novel Tool for the Optical Monitoring of Cardiac Activity. *ANNALS OF BIOMEDICAL ENGINEERING,* 03 January 2007, vol. 35 (1 **[0004]**
- Potential noncontact tools for rapid credibility assesment from physiological and behavioral cues. **BURGOON JK et al.** Security Technology, 2008, ICC ST 2008. 42nd Annual IEEE International Carnahan Conference on. IEEE, 13 October 2008, 150-157 **[0007]**

专利名称(译)	用于非接触式生物识别传感的系统和方法		
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[标]申请(专利权)人(译)	波音公司		
申请(专利权)人(译)	波音公司		
当前申请(专利权)人(译)	波音公司		
[标]发明人	SAINT CLAIR JONATHAN MARTIN HIGGINS ROBERT P SOREIDE DAVID C RAY GARY A ANDERSON TYLER M SPURGEON DONALD ALLEN VOTH MITCHELL D SJOHOLM PAUL F		
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摘要(译)

描述了一种非接触式生物识别传感装置。该设备包括处理设备，通信地耦合到处理设备的用户界面，通信地耦合到处理设备的显示器，通信地耦合到处理设备的激光多普勒振动计传感器，以及通信地耦合到处理设备的红外摄像机。处理装置被编程为利用从激光多普勒振动计传感器接收的机械运动数据和来自红外摄像机的热分布数据来计算生物识别数据，此时来自激光多普勒振动计传感器和红外摄像机的信号被反射回来自设备。目标。

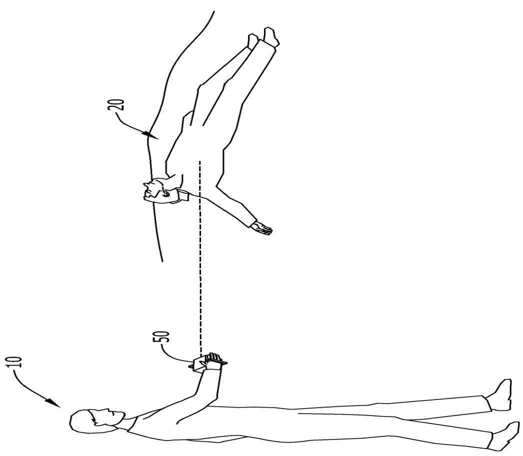

FIG. 1