



(51) International Patent Classification:

G09B 23/28 (2006.01) G06T 7/00 (2017.01)
G01B 11/25 (2006.01) A61B 5/00 (2006.01)

(21) International Application Number:

PCT/EP2017/058277

(22) International Filing Date:

6 April 2017 (06.04.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

16163994.3 6 April 2016 (06.04.2016) EP

(71) Applicant: **KONINKLIJKE PHILIPS N.V.** [NL/NL];
High Tech Campus 5, 5656 AE Eindhoven (NL).

(72) Inventors: **DE HAAN, Gerard**; High Tech Campus 5,
5656 AE Eindhoven (NL). **KIRENKO, Ihor, Olehovych**;
High Tech Campus 5, 5656 AE Eindhoven (NL).

(74) Agents: **LEDEBOER, Johannes, Albertus** et al.; High
Tech Campus 5, 5656 AE Eindhoven (NL).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD, DEVICE AND SYSTEM FOR ENABLING TO ANALYZE A PROPERTY OF A VITAL SIGN DETECTOR

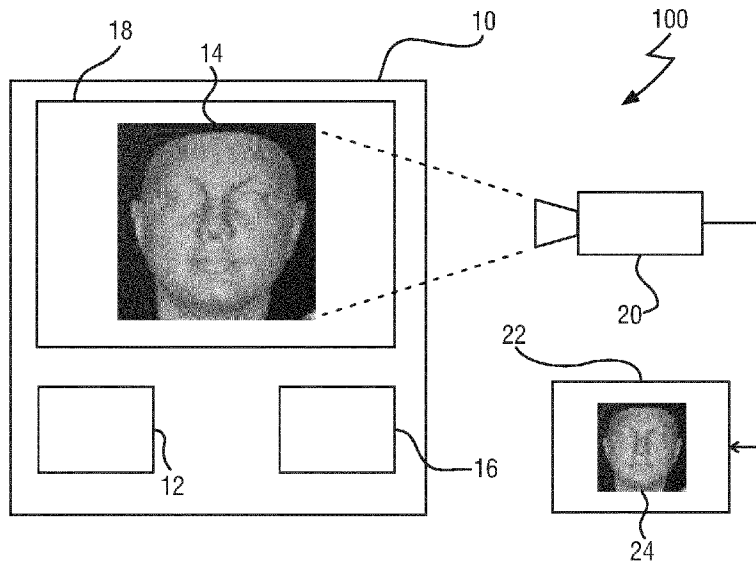


FIG. 1

(57) Abstract: The present invention relates to a method and a device for enabling to analyze a property of a vital sign detector (20). The proposed method comprises the steps of providing a virtual phantom (14) of a living being, rendering an artificial vital sign on the displayed virtual phantom (14), and outputting the virtual phantom (14) with the rendered artificial vital sign to the vital sign detector (20).



Method, device and system for enabling to analyze a property of a vital sign detector

FIELD OF THE INVENTION

The present invention relates to a method, a device and a system for enabling to analyze a property of a vital sign detector. In particular, the present invention relates to calibrating or testing vital signs cameras for monitoring various vital signs such as pulse, oxygenation level, respiration, etc.

BACKGROUND OF THE INVENTION

Health monitoring is traditionally present in the hospital, particularly the ICU and includes the monitoring of vital signs like EEG, ECG, pulse-rate, respiratory rate, blood-oxygenation level, blood pressure, etc. Also sleep laboratories acquire information about sleeping subjects using actigraphy and electromyography, additionally to some of the other vital signs.

These application areas often involve multiple sensors attached to the body of the patient, some of which may be wireless and others wired, restricting the freedom to move or the quality of sleep of the patient, in addition to causing discomfort and possible skin-damage.

Video Health Monitoring is recently emerging as a promising unobtrusive alternative for an increasing number of the above health indicators, not the least driven by the strong wish to reduce the burden caused by current techniques to (pre-term) neonates and patients with extensive skin damage, e.g. due to burns.

Clearly, Video Health Monitoring, due to its unobtrusive character, adds to patient comfort even in cases where no real damage is done by the current technology. However, also new application fields emerge in the consumer domain, as simpler derived methods may run on consumer platforms like laptops, tablets and mobile phones, or on embedded platforms inside equipment used for exercise in the gym.

Video Health Monitoring is also emerging for use in analyzing the human skin, in particular with relevance for cosmetic industry (e.g. moisturizers advice) and dermatology (e.g. melanoma detection). Various diseases may be diagnosed from motion in video sequences, like Periodic Leg Movements, Delirium, while video analysis may reveal

information about body posture with relevance in baby monitors to prevent Sudden Infant Death. Such motions that can be analyzed in order to extract the health condition of a patient are also understood as vital signs.

Consequently, there is a very broad application domain for Video Health Monitoring ranging from beauty product, the gym, consumer home-healthcare including baby-monitoring, sleep-center, the General Ward, the Intensive Care Unit, to the highly specialized Neonatal Intensive Care Unit and burn-center.

US 2015/0105670 A1 discloses a system for determining a vital sign of a subject, the system comprising an imaging unit for obtaining video data of the subject, a marker directly or indirectly attached to a body of the subject, wherein the marker comprises a graphical pattern, an image processing unit for detecting said marker in said video data, and an analysis unit adapted to extract a vital sign parameter related to the vital sign of the subject from said video data and to determine the vital sign from said vital sign parameter.

There is an increasing need to verify the calibration of these vital signs detectors, in particular cameras, once they are used widely in hospitals. Also, prior to admitting new detectors to the market, these detectors may need to be tested for the sake of adequate performance. Since the vital signs should be highly reliable to safely monitor the patient's health in high-risk (hospital) environments, correct calibration is crucial.

Wieringa et al. "CONTACTLESS MULTIPLE WAVELENGTH PHOTOPLETHYSMOGRAPHIC Imaging: A FIRST STEP TOWARD "SpO₂ Camera" Technology", Annals of Biomedical Engineering, Vol. 33, No. 8, August 2005, discloses a route toward contactless imaging of arterial oxygen saturation (SpO₂) distribution within tissue, based upon detection of a two-dimensional matrix of spatially resolved optical plethysmographic signals at different wavelength.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method, a device and a system for enabling to analyze a property of a vital sign detector such that the vital signs can be detected with improved accuracy.

In a first aspect of the present invention a method for enabling to analyze a property of a vital sign detector is provided that comprises the steps of providing a virtual phantom of a living being, rendering one or more artificial vital signs on the virtual phantom, and outputting the virtual phantom with the rendered one or more artificial vital signs to the vital sign detector.

In a further aspect of the present invention, a device for enabling to analyze a property of a vital sign detector is provided that comprises a virtual phantom providing unit for providing a virtual phantom of a living being, a vital sign rendering unit for rendering one or more artificial vital signs on the virtual phantom, and an output unit for outputting the virtual phantom with the rendered one or more artificial vital signs to the vital sign detector.

In yet further aspects of the present invention, there are provided a computer program which comprises program code means for causing a computer to perform the steps of the method disclosed herein when the computer program is carried out on a computer as well as a non-transitory computer-readable recording medium that stores therein a computer program product, which, when executed by a device, causes the method disclosed herein to be performed.

Preferred embodiments of the invention are defined in the dependent claims. It shall be understood that the claimed device, computer program and computer-readable recording medium have similar and/or identical preferred embodiments as the claimed method, as defined in the dependent claims and as disclosed herein.

The present invention achieves an improved detection of vital signs with higher accuracy by enabling to more reliably analyze properties of the vital sign detector. The property may be related to a calibration procedure or a test procedure defined by the steps of the method claimed herein. Alternatively, the analyzed property may be evaluation of motion robustness or other properties of the vital sign detector. Further, the virtual phantom may be used to prove or at least determine the likelihood of a vital sign detector using a particular algorithm (e.g. for robust pulse-rate extraction, or SpO₂-computation).

A virtual phantom is a specially designed object that is scanned or imaged in the field of medical imaging to evaluate, analyze, and tune the performance of various imaging devices. The virtual phantom may contain the form of a face or a full body of a living being such as human, preferably a neonate. The phantom may be an image of a natural human face or body, or an image of a mannequin.

The virtual phantom may be generated by the device which carries out the claimed method, preferably a computer carrying out a corresponding software program.

Alternatively, the virtual phantom may be generated by an external entity and subsequently transferred to the device to carry out the claimed method, e.g. via a communication interface or via wireless communication. The virtual phantom may be displayed on a display unit such as a RGB monitor.

The artificial vital signs may be associated with a pulse activity such as blood pressure, blood concentration (e.g. oxygen, glucose, bilirubin, CO, CO₂,...), pulse rate (e.g. in the range 40-240 beats per minute (bpm)), oxygen saturation (SpO₂), and photoplethysmography (PPG) amplitude (e.g. a defined set of decreasing SpO₂ values starting at a saturation level of 100% down to 60%). The artificial vital signs may be alternatively associated with a respiratory activity such as respiratory rate (e.g. in the range 70-100 bpm) and vital capacity. In addition, the artificial vital signs may be associated with a motion such as one that is typical for chest breathing or abdominal breathing, or one that is typical for entering or leaving a bed, or one that is typical for various sleep stages such as body stretching or muscle contraction. The artificial vital signs may also be associated with a body temperature or any other physiological parameter.

The term "artificial" indicates that the vital signs do not actually originate from the virtual phantom itself. In particular, the artificial vital signs may be generated by using previously obtained results of vital sign measurements performed on a natural living being or natural tissues. Alternatively or additionally, the artificial vital signs may be, in contrast to natural vital signs of a natural living being or tissue, generated using computer simulation involving a mathematical model.

The artificial vital signs may be rendered using one or more phantom parameters for characterizing the provided virtual phantom. For instance, illumination of a human face or a scene background of the human face may be used as phantom parameters, so that a certain level of illumination and a certain scene background can be mimicked.

The artificial vital sign(s) may be rendered on the virtual phantom by means of a user interface, on which a parameter such as a numeral value or a text string, e.g. color, type of motion or activity level, may be selected.

The vital sign detector may be a vital sign camera, in particular a remote PPG camera or a sleep-actigraphy camera. It can also be a pulse oximeter or any other detector suitable for detecting a physiological parameter of a living being. Remote PPG is generally known in the art and described in many documents, e.g. in Verkruyssen et al., "Remote plethysmographic imaging using ambient light", *Optics Express*, 16(26), 22 December 2008, pp. 21434-21445.

By outputting the virtual phantom, on which the artificial vital sign is rendered, to a vital sign detector, the present invention enables to analyze a property, e.g. to determine a setting related to calibration or testing of the vital sign detector. Virtual phantoms are made easily available and also configurable according to the actual need of the

user. For instance, there can be a set of virtual phantoms each corresponding to a specific body part or a body part during a specific stage of an illness or treatment. Also, since the artificial vital sign is rendered independently from the vital sign detector, the reliability of the determination of the setting is increased. The present invention is particularly advantageous when a large number of vital sign detectors need to be calibrated or tested.

It is noted that providing a virtual phantom may mean creating or generating a new virtual phantom, or alternatively transferring or copying an existing virtual phantom. Further, it is also noted that outputting a virtual phantom may mean displaying a virtual phantom, or alternatively transferring a virtual phantom.

Preferably, at least one of the rendered artificial vital signs is temporally varying. For instance, when a value, e.g. amplitude, is assigned to the artificial vital sign, the artificial vital sign may vary temporally in its value. When the artificial vital sign refers to a motion of a living being that is to be identified by a vital sign detector, e.g. entering or leaving a bed, the artificial vital sign may vary temporally during various stages of the respective motion. In this way, dynamic vital signs can be rendered on the virtual phantom, so that the calibration or testing of the vital sign detector can take a variety of health conditions/states of a living being, in particular a patient or neonate, into account. This advantageously increases the reliability of the calibrated or tested vital sign detector. The rendered artificial vital sign may also be assigned a selection of parameters such as color, type of motion or activity level. Preferably, a static signal for a first artificial vital sign (e.g. SpO₂) may be rendered based on a time-varying signal for a second artificial vital sign (e.g. the pulse).

In particular, the rendered artificial vital sign may comprise a periodic variation of a shape, a volume, a position, an orientation and/or a color of the provided virtual phantom. Since a plurality of vital signs including pulse signals, respiratory signals and SpO₂ signals show periodic behaviors, the present invention enables to mimic natural human body parts or tissues with high accuracy using the virtual phantom. The color of the provided virtual phantom may be a pseudo-color which indicates the case where the "color" variations are rendered in the near-infrared (NIR) spectral range, so that the variations are not visible in contrast to color variations in the visible spectral range.

For instance, for the case that the virtual phantom contains the form of a human face, the artificial vital sign may comprise the skin color that varies periodically, thereby mimicking a periodic change in skin color of a natural human face due to the varying blood volume in the skin during the cardiac cycles or due to respiration. In this case, the

artificial vital sign may be the pulse or pulse-rate or respiratory rate that can be output to the vital sign detector.

Alternatively, the rendered artificial vital sign may comprise a non-periodic variation of a shape, a volume, a position, an orientation and/or a color of the provided virtual phantom. For instance, the virtual phantom may contain a whole human body, wherein the artificial vital sign may comprise the body orientation that varies in a non-periodic manner, thereby mimicking a change in the body orientation of a person during sleep or when entering or leaving the bed. In this case, the artificial vital sign may be the (average) frequency of turning the body during sleep, or a discrimination between the various sleep stages (shallow/deep sleep, REM-sleep, etc.).

Preferably, the step of providing and/or rendering comprises projecting, emitting and/or absorbing a plurality of images of the living being each for a corresponding wavelength. This enables to more easily generate a virtual phantom with the rendered artificial vital signs by using one or more projectors while maintaining the accuracy of the artificial vital signs.

In particular, the projected plurality of images each for a corresponding wavelength may be overlaid over each other. The overlaying may comprise an optical overlay, a spatial mixing (e.g. Bayer-pattern) or a temporal mixing (e.g. color-sequential). This allows the use of a light modulator, a micro-mirror device or a liquid crystal display (LCD) with a separate near-infrared (NIR) filter for a light source of the projector(s).

Preferably, the step of rendering is achieved by modulating a light signal to be emitted/absorbed from/by the provided virtual phantom, and/or by using a time sequential emission or absorption of a light signal to be emitted or reflected from the provided virtual phantom. The accuracy of the rendered vital signs is further improved. An Organic Light Emitting Diode (OLED) that provides a curved surface may be used to enable a 3D light-emitting phantom.

Preferably, the step of rendering comprises varying an absorption of a light signal by the provided virtual phantom. This may be achieved in combination with using a display for displaying the virtual phantom with the rendered artificial vital signs. In this way, the display is a passive display which does not emit light but rather locally varies its absorption of light. In particular, a surface of the display may be configured to modulate the absorption. If this surface is illuminated, the artificial vital sign can be measured from the varying reflected light. This resembles the skin more than a light-emitting phantom. The modulation of absorption may be achieved by using an LCD. In particular, the reflecting

surface behind the LCD-modulator provides a reflective display. The surface can be further curved in order to resemble natural skin under real illumination conditions even more. The phantom may take the form of a doll. The display may be flat or curved.

Preferably, the step of rendering comprises emitting, reflecting, spatially
5 and/or temporally varying an irradiation in one or more wavelength intervals from a range between 200 nm and 1200 nm.

Preferably, the rendered artificial vital sign comprises skin-tone variations over time reflecting the effects of pulse and respiratory signals as typically detectable with (remote) PPG-cameras on a natural person, i.e. with the detected relative amplitude being a
10 function of wavelength.

Preferably, the output unit comprises a color monitor, a light modulator, a micro-mirror element, a projection display and/or a liquid crystal display (LCD) element. These examples of the output unit, e.g. display unit, enables to output or display the virtual phantom with the rendered artificial vital signs more reliably to the vital sign detector, e.g.
15 vital sign camera, for the purpose of calibration or testing.

Preferably, the output unit is configured to operate in a non-visible, in particular near-infrared (NIR) spectral range and/or the LCD element comprises a NIR filter. This enables to mimic a natural body part showing natural vital sign(s) that can be detected in an environment with low illumination such as at night.
20

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter. In the following drawings

Fig. 1 shows a schematic block diagram of a first embodiment of a device
25 according to the present invention;

Fig. 2 shows a schematic block diagram of a method according to the present invention; and

Fig. 3 shows illustratively an example of a user interface for configuring a virtual phantom and a plurality of artificial vital signs to be rendered on the virtual phantom.
30

DETAILED DESCRIPTION OF THE INVENTION

Vital signs such as blood volume pulse which induces a periodic change in the color of human skin can be detected using contact (PPG) sensors, and more recently using video cameras (rPPG). In this way, various vital signs (pulse, oxygenation level, respiration,

etc.) can be monitored. Similarly, such sensors, in particular cameras, are utilized to monitor patient movements for sleep actigraphy and/or respiratory movement detection.

There is an increasing need to verify the calibration of these vital sign detectors e.g. vital sign cameras, once they have been introduced widely in hospitals. Also, prior to admitting new detectors to the market, the detectors may need to be tested for the sake of adequate performance.

To this end, the current invention proposes to use a virtual phantom, e.g. containing the form of a human body part (e.g. face) or a full-body, in an environment rendered at a monitor where the rendered skin mimics a natural body part/full-body showing one or more vital signs associated with the body part or full-body.

Such vital sign(s) may be "generated" on the virtual phantom, thereby leading to artificial vital signs rendered on the virtual phantom. For instance, for the case of the virtual phantom having the form of a human face, the artificial vital sign may comprise periodic variations of the skin color. Such a behavior of skin color can usually be observed on a natural human face due to pulse and/or respiration. Therefore, the rendered artificial vital signs enable to mimic a natural human face whose skin color changes periodically due to pulse and/or respiration.

The rendering of artificial vital signs involves the application of a mathematical model, in particular associated with parameters such as the shape, orientation, and color of the head, or full body. The parameters can be easily changed in order to mimic specific pulse-rates, respiratory signals and/or SpO₂ values that can be detected using vital signs cameras registering the virtual phantom. The virtual phantom, in particular together with the rendered artificial vital sign(s), may be provided by means of a software being run on a general purpose computer. Alternatively, the virtual phantom may be provided by means of a standalone device including the rendered artificial vital sign(s) to be registered by the vital signs camera under test.

Fig. 1 shows a schematic block diagram of a first embodiment of a device for enabling to determine a setting of a vital sign detector 20. The device 10 comprises a virtual phantom providing unit 12 for providing a virtual phantom 14 of a living being. The living being may be a human and the virtual phantom 14 may accordingly have the form of a human face, as shown in Fig. 1.

Preferably, the human face is computed from a mathematical model run on the computer and exhibits temporal, in particular periodic variations in the skin color of the displayed face, e.g. one period or cycle per second. Such computed variations in the skin

color mimic a periodic change caused by a pulse and/or a respiratory activity of a human being. Under illumination using visible light, the temporal variations in the skin color due to respiration and/or pulse are strongest in the green portion and weakest in red portion of the visible spectrum. This can be mimicked by displaying a computed human face which exhibits
5 computed temporal variations in the skin color.

Further preferably, the display of the output unit 18 is capable of emitting or reflecting variable visible light, e.g. red (600-700nm), green (500-600nm) and blue (440-500nm). Alternatively or additionally, the display of the output unit 18 is capable of emitting
10 of reflecting variable NIR radiation of a plurality of different wavelength intervals, e.g. a first band around a center wavelength of 660nm, a second band around a center wavelength of 800nm and a third band around a center wavelength of 900nm.

The virtual phantom providing unit 12 may comprise a communication interface or a wireless connection for transferring a prepared virtual phantom from an external entity, e.g. a storage medium or a communication network. The virtual phantom
15 providing unit 12 may alternatively or additionally be configured to generate the virtual phantom 14 on its own, e.g. by means of computer simulation or by selecting from a plurality of optional virtual phantoms.

The device 10 further comprises a vital sign rendering unit 16 for rendering an artificial vital sign on the virtual phantom 14. The artificial vital sign may be rendered by
20 using previously obtained results of vital sign measurements performed on a natural living being or natural tissues. Alternatively or additionally, the artificial vital sign may be, in contrast to natural vital signs of a natural living being or tissue, rendered using computer simulation involving a mathematical model. Preferably, the vital sign rendering unit 16 is configured to use a computer program to compute the artificial vital sign based on the
25 mathematical model. In particular, artificial vital signs are added to the provided phantom using a mathematical model, or are based on a pre-recorded data-set that may have been recorded from a living being (e.g. human).

The device 10 further comprises an output unit 18 for outputting the virtual phantom 14 together with the rendered artificial vital sign to the vital sign detector 20. The
30 output unit 18 is preferably, but not restricted to, a display unit for displaying the virtual phantom 14, in particular a monitor, e.g. an RGB color monitor. Alternatively, the output unit 18 may comprise a communication interface, a data interface and/or a storage unit. The virtual phantom 14 may comprise a synthetic video that can be displayed on an LCD monitor of the output unit 18.

Further preferably, the vital sign detector 20 may be a vital sign camera, e.g. an RGB camera, or a video health monitor. The vital sign detector 20 is connected to or contains itself a detector display unit 22, e.g. an RGB camera display, for displaying a detected vital sign signal. The detected vital sign signal comprises preferably a detected virtual phantom 24 received from the output unit 18 as shown in Fig. 1, further preferably together with one or more rendered artificial vital signs. In another embodiment, a contact sensor can be attached to the output unit 18, preferably the monitor, to be calibrated. In this case, the virtual phantom 14 may take the form of a piece of skin and/or a finger of a living being.

Based on the detected vital sign signal, a setting of the vital sign detector 20 can be determined. Preferably, the vital sign detector 20 can be calibrated or tested based on the received virtual phantom 24. For instance, the artificial vital sign rendered on the virtual phantom 14, 24 is preferably associated with a predetermined parameter such as a numeral value or a text description of a physiological state or category. Since the parameter is predetermined, the detected vital sign signal is associated with a known parameter, e.g. a known numeral value or a known physiological state or category. Based on the known parameter, the calibrated or tested vital sign detector 20 can be operated in order to detect a vital sign.

The temporal variations in the aforementioned example can be detected by the vital sign detector 20. In particular, the vital sign detector 20 may be configured to determine the vital sign as pulse and/or respiration with a predetermined pulse rate or respiratory rate by detecting a maximum in the color variation of the green portion of the visible spectrum while detecting a minimum in the color variation of the red portion of the visible spectrum.

The vital sign detector 20 may comprise a video health monitor operating in the near-infrared (NIR) spectrum range. In particular, the video health monitor may be operated under NIR illumination by the device 10, e.g. by a display of the output unit 18.

The display may comprise a projection display, onto which a plurality of images, each using light with a different wavelength, can be projected from one or more projectors, in order to provide the virtual phantom and/or to render the artificial vital sign. Preferably, the plurality of images are overlaid on top of each other in order to achieve optical superposition. This allows the use of an existing light-modulator, e.g. a micro-mirror device, or an LCD with a separate NIR-filter for the light-source used in each of the individual projectors. Further options for the display may include an array of light-emitters, and an array of light-modulators. Also a single modulated light-source (e.g. for a

predetermined wavelength) can be used in combination with a scanning mechanism.
(O)LED-arrays may be used that can operate in the NIR spectrum range.

The display of the output unit 18 may comprise a display using time-sequential emission of various wavelengths. In this case the, possibly time-varying,
5 intensities per wavelength are multiplexed in time. The multiplexing of the intensities should be fast enough to guarantee that they are seen as simultaneously by the vital sign detector under test. This mode of operation is known from color sequential slide-projectors (beamers) that multiplex the red, green and blue color channels fast enough for them to be perceived by the human observer as being simultaneously available. Just like the human observer, the vital
10 sign detection means typically have an integration time, which should be long compared to the cycle length of the color sequential multiplexing. Alternatively or additionally, the virtual phantom providing unit 12 may be configured to use time-sequential emission of various wavelengths.

The display of the output unit 18 may be a passive display, i.e. the virtual
15 phantom and/or the artificial vital sign is not achieved based on light emitted from the display itself but rather based on locally varying the absorption level of light.

Preferably, the artificial vital sign such as pulse-rate and/or the respiratory rate may be rendered on the virtual phantom so that it varies over time. This can be achieved by simulating a temporally varying skin color of a human face using a mathematical model. For
20 instance, the temporal or periodic variations of the skin color may be simulated to correspond to a pulse rate within a range, e.g. 30-240 beats per minute (bpm). In this way, irregular respiratory (apnea) and pulse (arrhythmia) signals may be modeled. Further, the relative pulsilities in different (e.g. NIR) wavelengths may be varied to mimic different SpO₂ values of a patient. For a subject with a near 100% arterial oxygenation, the pulsatility around
25 650nm is very low compared to the relative pulsatility around other wavelengths (e.g. 800nm). If the oxygenation level decreases in an unhealthy subject, the pulsatility around 650nm increases relative to the strength at other wavelengths. The phantom could be configured to slowly cycle through the complete range of SpO₂-values (e.g. 60% up to 100%) by varying the relative pulsatility in a band between 620nm and 770nm compared to
30 the pulsatility at 800nm (or another wavelength that has been selected). For any emulated SpO₂-value the accuracy of the detector can consequently be established.

In yet other embodiments, instead of a face, a whole body of a patient is provided as the virtual phantom. Preferably, artificial vital signs comprising one or more motions are rendered on the patient body, e.g. motions that are typical for chest and/or

abdominal breathing. Further preferably, such motions can be rendered as visualization of blanket movements due to motion of a person during sleep.

Further foreseen are embodiments where a person is rendered entering/leaving a bed to provide testing tools for camera-based bed-leave/entrance/falling detection. Again the rendering may be based on a mathematical model, or a visualization may be rendered from pre-recorded subjects performing the action under different conditions that could contain challenges for the detector under test.

Finally, the rendered person may exhibit movements typical for various sleep stages in order to test validate sleep-staging devices.

Fig. 2 shows a schematic block diagram of a method for enabling to analyze a property of a vital sign detector 20. The method comprises the steps 201-203. In step 201, a virtual phantom 14 of a living being is provided. In step 202, an artificial vital sign is rendered on the virtual phantom 14. In step 203, the virtual phantom 14 is output to the vital sign detector 20 together with the rendered artificial vital sign.

Fig. 3 shows illustratively an example of a user interface 30 for configuring a virtual phantom and a plurality of artificial vital signs to be rendered on the virtual phantom.

The user interface 30 comprises a plurality of function buttons 32a-32f each for configuring an artificial vital sign. For instance, the function buttons 32a-32f may be used to configure the artificial vital signs "PPG Amplitude", "Pulse Rate" and "Motion", respectively. Further, function buttons for configuring phantom parameters, preferably "Ethnicity", "Illumination" and "Scene Background", may also be provided for configuring artificial vital signs related to the phantom parameters. Further examples for phantom parameters are strength and/or orientation of the light source and (possibly flickering) backgrounds that can be provided as additional challenges for the device under test, or to be calibrated. Preferably, the phantom parameter and/or artificial vital sign appear as a text string on the respective function button 32a-32f.

Under each of the function buttons 32a-32f, one or more selection fields are provided. For instance, under the function button 32a for configuring "Ethnicity", a number of selection bars 34b are listed (e.g. indicating skin-tones with different values on the Fitzpatrick scale) together with a selection activation circle 34a. After selecting the function button 32a which highlights the latter, the user can use a mouse or another pointing element to effect a selection among the selection bars 34b by clicking the corresponding selection activation circle 34a, which highlights the latter. The selection bars 34b under "Ethnicity"

may represent "Pale White", "White", "Cream White", "Moderate Brown", "Dark Brown" and "Dark", or any value in the range of Fitzpatrick's scale of skin-tones.

The highlighting may appear as filling the clicked selection activation circle 34a. Alternatively, as shown under the function button 32b for configuring "Illumination" in Fig. 3, a square may be used instead of a circle for selecting from the selection bars 36, which exemplarily could represent "Intensity", "Position (az, el)" and "Source Color (RGB)".

Another way of selection under a chosen function button 32a-32f is shown under the function button 32c for configuring "PPG Amplitude". A level bar 38a is provided for selecting a level being high, middle or low, which can be done by clicking on a downward arrow 38b adjacent to the level bar 38a. Similarly, the selection under the function button 32d "Pulse Rate" can be done by choosing a value for pulse rate shown in a level bar 40a by clicking a downward arrow 40b adjacent to the level bar 40a.

Under the function button 32e for configuring "Motion", the user can activate a first selection bar 41b representing "Motion Rate" by clicking a corresponding activation field 41a. The same can be done with a second selection bar 41c. A maximum bar 42a is subordinated to the first selection bar 41b for choosing a maximum motion rate by clicking a rightward arrow 42b. Analogously, a minimum motion rate can be chosen by clicking a leftward arrow, as shown in Fig. 3. A plurality of selection fields 43a representing different types of motions, preferably "Translation", "Rotation", "Scaling" and "Mixed", are subordinated to the second selection bar 41c.

The function button 32f for configuring "Scene Background" has a plurality of selection bars 44, preferably representing "Light Frequency", "Color (RGB)" and "Intensity". These selection bars 44 can be activated analogously to the selection bars 34b and 36.

By using the function buttons 32a-32f in combination with their corresponding subordinated selection fields, the user can configure a virtual phantom and render one or more artificial vital signs on the virtual phantom. In a display element 46, the configured virtual phantom 47 can be displayed, which takes the selected phantom parameter(s) and/or rendered artificial vital sign(s) into account.

A diagram display element 48, 50 may be provided to display a value of an artificial vital sign, preferably a temporal and/or periodic evolution or variation of the artificial vital sign. Such a temporal and/or periodic evolution or variation may be configured using one or more of the function buttons/selection fields provided on the user interface 30.

On the left lower corner of the user interface 30, an image selection field 52 may be provided for displaying the virtual phantom 47 as a static image, while a video

selection field 54 is provided for displaying the virtual phantom 47 as a video clip. A clear button 56 may be available provided for clearing one or more selection previously made, and possibly return to a default setting.

5 The user interface 30 may be displayed on the output unit 18, the detector display unit 22 or another (external) entity. Further, the user interface 30 may be used to calibrate or test a camera-based, or contact-based motion-robust pulse-rate detector.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments.

10 Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single element or other
15 unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A method for enabling to analyze a property of a vital sign detector (20), comprising the steps of:
 - providing a virtual phantom (14) of a living being;
 - rendering one or more artificial vital signs on the virtual phantom (14); and
 - 5 - outputting the virtual phantom (14) with the rendered one or more artificial vital signs to the vital sign detector (20).
2. The method according to claim 1, wherein at least one of the rendered one or more artificial vital signs is temporally varying.
- 10 3. The method according to claim 2, wherein the rendered one or more artificial vital signs comprise a periodic variation of a shape, a volume, a position, an orientation and/or a color of the provided virtual phantom (14).
- 15 4. The method according to claim 1, wherein the rendered one or more artificial vital signs are associated with a pulse activity, a respiratory activity, a concentration of a blood-component, a blood-pressure and/or a motion of the living being.
- 20 5. The method according to claim 1, wherein the step of rendering comprises projecting a plurality of images of the living being each for a corresponding wavelength.
6. The method according to claim 5, wherein the step of rendering further comprises overlaying the projected plurality of images over each other.
- 25 7. The method according to claim 1, wherein the step of rendering comprises modulating a light signal to be emitted from the provided virtual phantom (14).

8. The method according to claim 1, wherein the step of rendering comprises using a time sequential emission or absorption of a light signal to be emitted or reflected from the provided virtual phantom (14).

5 9. The method according to claim 1, wherein the step of rendering comprises varying an absorption of a light signal by the provided virtual phantom (14).

10. The method according to claim 1, further comprising assigning a value to at least one of the rendered one or more artificial vital signs and/or identifying a motion
10 associated with at least one of the rendered one or more artificial vital signs.

11. Device (10) for enabling to analyze a property of a vital sign detector (20), comprising:

- a virtual phantom providing unit (12) for providing a virtual phantom (14) of a
15 living being;
- a vital sign rendering unit (16) for rendering one or more artificial vital signs on the virtual phantom (14); and
- an output unit (18) for outputting the virtual phantom (14) with the rendered one or more artificial vital signs to the vital sign detector (20).

20

12. The device (10) according to claim 11, wherein the output unit (18) comprises a color monitor, a light modulator, a micro-mirror element, a projection display and/or a liquid crystal display (LCD) element.

25 13. The device (10) according to claim 12, wherein the output unit (18) is configured to operate in a near-infrared (NIR) spectral range and/or the LCD element comprises a NIR filter.

14. System (100) for enabling to analyze a property of a vital sign detector (20),
30 comprising:

- a device (10) according to one of the claims 11 to 13;
- a vital sign detector (20) for detecting an artificial vital sign output by the device (10).

15. Computer program comprising program code means for causing a computer to carry out the steps of the method as claimed in claim 1 when said computer program is carried out on the computer.

1/2

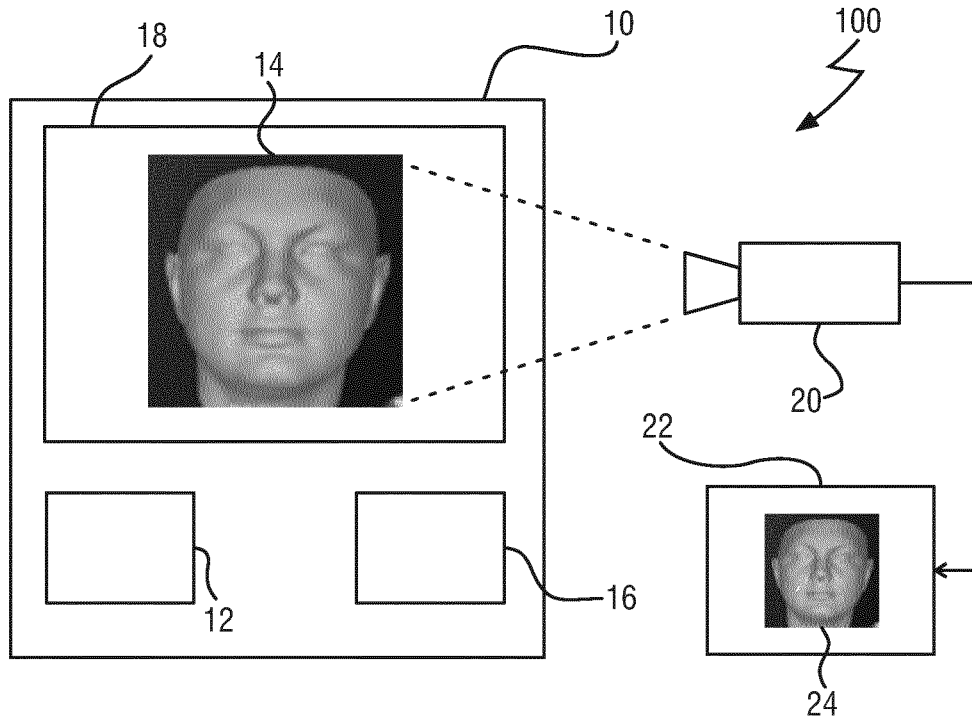


FIG. 1

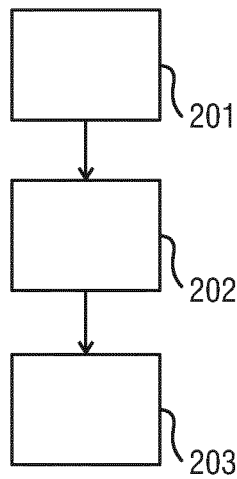


FIG. 2

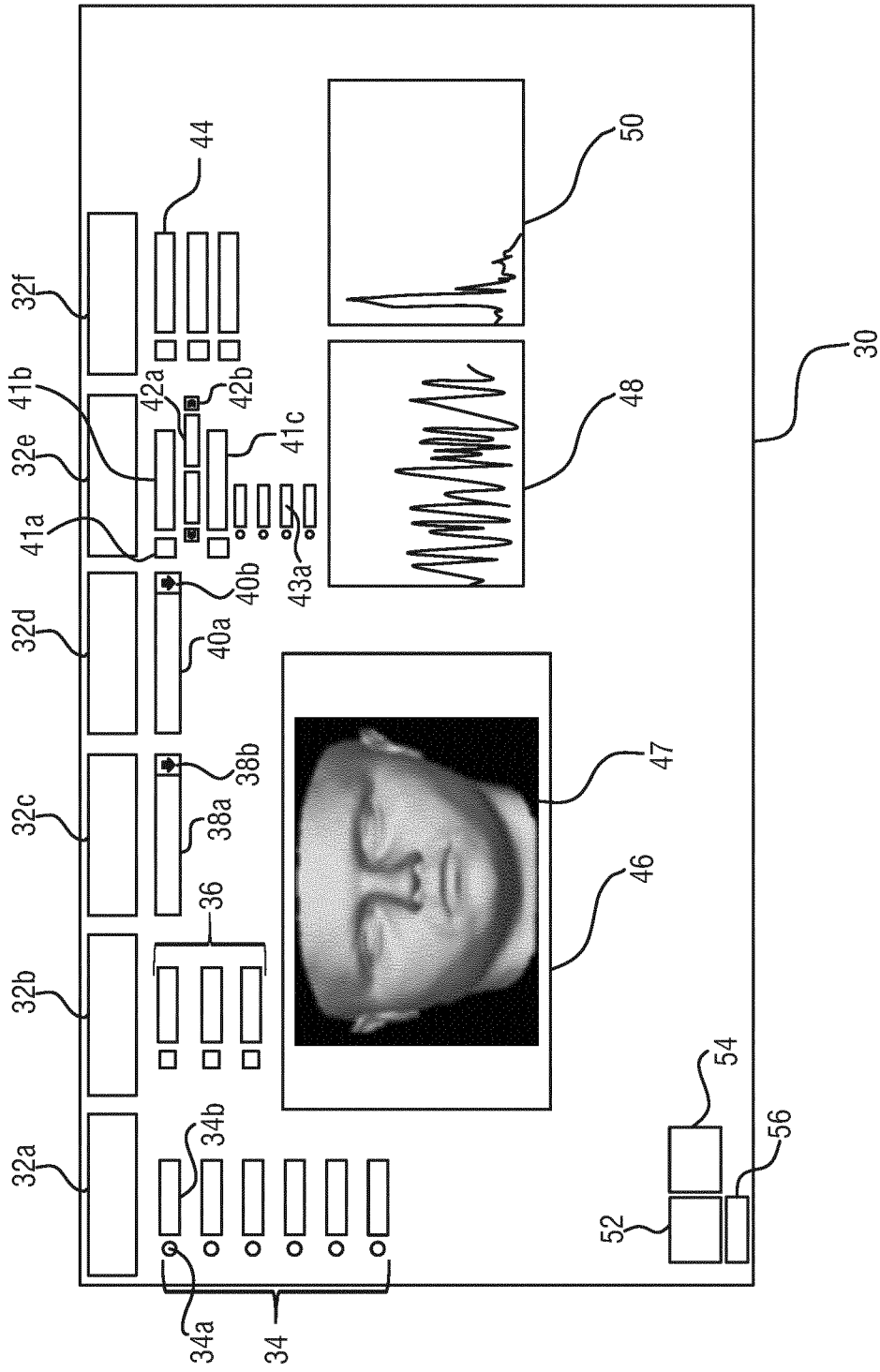


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/058277

A. CLASSIFICATION OF SUBJECT MATTER
INV. G09B23/28 G01B11/25 G06T7/00 A61B5/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
G09B G01B G06T A61B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
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	WIERINGA F P ET AL: "Contactless Multiple Wavelength Photoplethysmographic Imaging: A First Step Toward SpO2 Camera Technology", ANNALS OF BIOMEDICAL ENGINEERING, KLUWER ACADEMIC PUBLISHERS-PLENUM PUBLISHERS, NE, vol. 33, no. 8, 1 August 2005 (2005-08-01), pages 1034-1041, XP019272995, ISSN: 1573-9686 figure 5 Item "DISCUSSION" on pages 1038-1039 -----	1-15
X	US 8 811 692 B2 (PROKOSKI FRANCINE J [US]) 19 August 2014 (2014-08-19) figures 14-31 column 11, line 60 - column 12, line 14 column 37, lines 28-34 ----- -/--	1-15

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search 27 June 2017	Date of mailing of the international search report 04/07/2017
--	---

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Dhervé, Gwenaëlle
--	--

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/058277

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/086500 A1 (KALEAL III ROBERT LOUIS [US]) 24 March 2016 (2016-03-24) figures 14-15 paragraphs [0265] - [0268], [0277] -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/058277

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8811692	B2	19-08-2014	
		US 2010172567 A1	08-07-2010
		US 2010189313 A1	29-07-2010
		US 2010191124 A1	29-07-2010
		US 2010191541 A1	29-07-2010
		WO 2008130903 A1	30-10-2008
		WO 2008130905 A2	30-10-2008
		WO 2008130906 A1	30-10-2008
		WO 2008130907 A1	30-10-2008

US 2016086500	A1	24-03-2016	NONE

专利名称(译)	用于能够分析生命体征检测器的特性的方法，设备和系统		
公开(公告)号	EP3440660A1	公开(公告)日	2019-02-13
申请号	EP2017715746	申请日	2017-04-06
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	DE HAAN GERARD KIRENKO IHOR OLEHOVYCH		
发明人	DE HAAN, GERARD KIRENKO, IHOR, OLEHOVYCH		
IPC分类号	G09B23/28 G01B11/25 G06T7/00 A61B5/00		
CPC分类号	A61B5/744 A61B2560/0223 G09B23/28 A61B5/0077 A61B5/0205 A61B5/021 A61B5/02433 A61B5/0816 A61B5/1128 A61B5/1455 A61B2560/0233 G06T7/80 G06T2207/10024 G06T2207/10048 G06T2207/10152		
优先权	2016163994 2016-04-06 EP		
外部链接	Espacenet		

摘要(译)

本发明涉及一种能够分析生命体征检测器 (20) 的特性的方法和设备。所提出的方法包括以下步骤：提供生物的虚拟体模 (14) ，在所显示的虚拟体模 (14) 上呈现人造生命体征，以及将具有所呈现的人工生命体征的虚拟体模 (14) 输出到生命体征符号检测器 (20) 。