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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 February 2013 (21.02.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/025809 A1

(51) International Patent Classification:
*A61B 5/05* (2006.01) *G03G 17/00* (2006.01)

(21) International Application Number:
PCT/US2012/050956

(22) International Filing Date:
15 August 2012 (15.08.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/523,746 15 August 2011 (15.08.2011) US

(71) Applicant *(for all designated States except US)*: **EPIC RESEARCH AND DIAGNOSTICS, INC.** [US/US]; 8501 East Princess Drive, Suite 100, Scottsdale, Arizona 85255 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **RIZZO, Nancy R.** [US/US]; 27913 North 154th Place, Scottsdale, Arizona 85262 (US).

(74) Agents: **ARORA, Suneel** et al.; Schwegman, Lundberg & Woessner, P.A., P.O. Box 2938, Minneapolis, Minnesota 55402 (US).

(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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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, 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, ML, MR, NE, SN, TD, TG).

**Published**:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: LOCALIZED PHYSIOLOGIC STATUS FROM LUMINOSITY AROUND FINGERTIP OR TOE

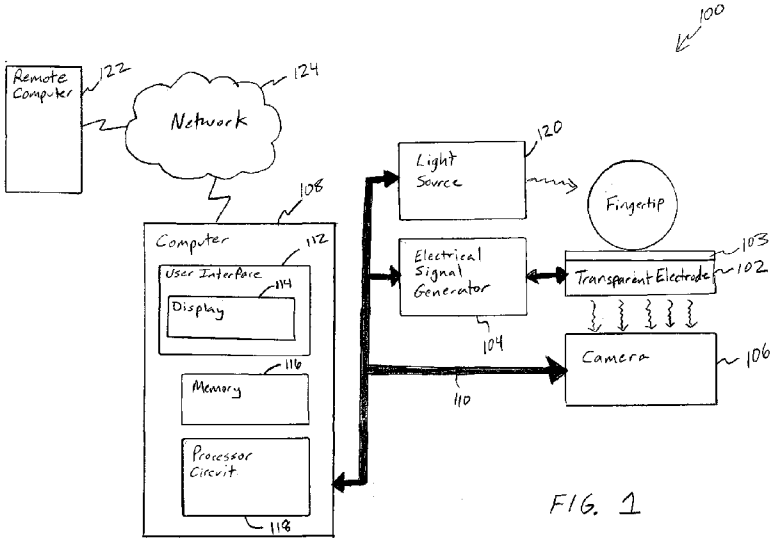



FIG. 1

(57) **Abstract**: Spatial light response around a fingertip or toe of a subject in response to electrical stimulation can be associated to a specified remote particular body anatomy, location, component, or system such as for providing a particularized physiological status indicator or other particularized response indication that is particular to the specified particular body anatomy, location, component, or system.

WO 2013/025809 A1

# LOCALIZED PHYSIOLOGIC STATUS FROM LUMINOSITY AROUND FINGERTIP OR TOE

## BACKGROUND

U.S. Patent Application Publication No. 2005/0014998, entitled METHOD OF DIAGNOSIS OF HUMAN ORGANISM, discusses a human diagnostic method that involves applying an electromagnetic field to fingers contacting an electrode, obtaining visual images of resulting "gas discharge streamers," dividing the visual images into sectors corresponding to various human organs or systems, projecting the sectors onto a single image formed along the contour of the silhouette of the human body. (See U.S. Patent Application Publication No. 2005/0014998 ¶0010.) The resulting single image can be compared to a reference image, such as to give a diagnosis or evaluate an effect of a therapy. (See id. at ¶0029.)

U.S. Patent Application Publication No. 2006/0084845, entitled METHOD FOR DETERMINING THE ANXIETY LEVEL OF A HUMAN BEING, discusses determining a gas discharge luminosity around a finger in response to an applied electromagnetic field via a glass plate electrode—(1) directly, and (2) in the presence of an intervening polymer film. A level of anxiety of the human being is determined using information from these two different measurements.

U.S. Patent No. 7,156,866, entitled HOLISTIC METHOD OF TREATING INJURED OR PATHOLOGIC TISSUE WITH A LASER, discusses body energy paths of Eastern medicine, referred to as meridian pathways and Jin Shin Jyutsu energy pathways. (See U.S. Patent No. 7,156,866 at col. 1, lines 23-26.) It explains that in acupuncture a localized tissue problem area is treated by needling trigger points consisting of nerve endings known to be interconnected along an energy flow path to the localized problem area. (See id. at col. 1, lines 26-29.) It instead uses laser treatment along an energy path to normalize energy flow in a problematic area. (See id. at col. 1, lines 54-62.)

## OVERVIEW

This document describes, among other things, systems, devices, and methods that can include a medical device that can be used as a galvanic skin response (GSR) measurement system, such as to acquire skin conductance measurements through a body part, such as the fingertips or toes (for brevity, this document emphasizes operation with respect to one or more fingertips, but it is to be understood that like apparatuses and methods can be additionally or alternatively used with one or more of the subject's toes). The device can measure electromagnetic (field) ("electrical") resistance of the skin. A subject's fingertip can be placed in contact with a transparent electrode, which can be grounded through a power cord. A series of electrical impulses can be applied to the electrode. This can generate a localized electromagnetic field around the finger. Under the influence of this electromagnetic field, and depending on the resistance of the skin of the fingertip, a very small current can be created within the air molecules. This can result in a two-dimensional (2D) spatial response to the electrical field, e.g., in the form of a surrounding small burst of visible or other light, such as in the visible through the ultraviolet range. The light can be captured by a static or dynamic camera image. The captured 2D light spatial response can be assessed for its level of intensity and other analytical criteria that can vary, such as in accordance with the resistance at the fingertip/electrode junction at the time of measurement. For example, the 2D spatial response can be classified, such as either a low, normal, or high response.

Galvanic skin response measurements correlate to the body's electrophysiology. It is believed that the electromagnetic (field) resistance of the human body is not homogenous and that electromagnetic (field) signaling occurs at the cellular level throughout the body. It is believed that the electro-magnetic (field) signaling is produced via the mitochondrial cell membrane polarity as it produces energy for the body in the form of adenosine triphosphate (ATP). The ATP process is believed to produce biophotons, packets of electromagnetic energy that that can be transferred through the biological system. In particular, nerve fibers throughout the body are believed to produce a higher level of biophotons than other tissue. The fingers and toes are believed to have the highest concentration of tactile nerve fibers in the human body. The hands are believed to have the highest biophotonic production across the body's surface.

The relationship of biophotonic signaling at the fingertips or toes to the organs and structures of the body is believed to exist through the neural network of the body. This document includes results from a clinical study that demonstrate a strong correlation from luminosity measurements at the fingertips back to specified organs, systems, or structures elsewhere in the body.

It is also believed that electrical pathways exist over the body. Such electrical pathways can be referred to as meridians. It is believed that the meridians are linked to corresponding particular organs. Imbalances in various organs are believed to manifest themselves as electrophysiological disturbances in the associated meridians. A su-jok method of relating sections of the fingers to their associated meridians can provide an example of a registration system from the major organ systems and structures throughout the body. A capacitive barrier can be used to localize or exclude anxiety response from the overall physiological measurement. Such anxiety can produce perspiration at the fingertips or toes.

The su-jok method of relating sections of the fingers to their associated meridians is mentioned as an example of a registration system from the fingers to the major organ systems and structures throughout the body. The particular registration system that is used can provide a direct measure of the state of the associated organ/system electrophysiology. If the meridian or other electrophysiological pathway associated with a particular body anatomy, location, component, or system, has an electrophysiological imbalance, e.g., a loss of conductive ability, then the portion of the fingertip image for that particular body anatomy, location, component, or system may be dim to non-existent. On the other hand, for excessive conductivity, the portion of the fingertip image may be very bright and potentially very large. The electrophysiology can vary due to many health issues, such as dehydration or loss of electrolytes. It is believed that the fingertip response will change depending on the conductive ability of the metabolic state of the cellular mitrochondria along the nerve fibers. A metabolic state of dehydration or loss of electrolytes, for example, can result in a dim and diffuse image pattern not only for the cardiovascular system, but for all organs/systems. The degree of dehydration as measured as explained herein can help a user understand the degree to which the metabolic processes are disturbed, such as to assess the best

direction for treatment. The clinical study results presented later in this document are believed to demonstrate the potential for recognizing various different localized abnormal physiological states or disease patterns, providing a meaningful score that a physician can review.

The present systems, devices, and methods can offer a unique measure of electrophysiology characteristics on a systemic level. By analyzing the meridian impedance data, the present systems, devices, and methods can help analyze and evaluate the electrophysiology of the meridians. The reports can provide the user with unprecedented information that can help in the understanding of disease processes while affording the user a more efficient method to assess a subject from a systemic point of view.

The present systems, devices, or methods can be used to validate, correlate, and translate such measurements into an automated report. The results in the report are believed to correlate with physiological abnormalities associated with the disruption of electrophysiological pathways in the body, such as can involve response information into a physiological status indicator that is particular to a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system. For example, an association with a specified particular body anatomy, location, component, or system that is remote from the finger or toe can involve a particular one of a: cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system. The report can assist a user in triaging subjects for evaluation and testing.

An example can include subject matter (such as an apparatus, a method, a means for performing acts, or a device-readable medium including instructions that, when performed by the device, cause the device to perform acts) that can include obtaining at least two-dimensional (2D) spatial response information of visible or other light around a finger or toe of a subject. The spatial response information obtained at a light detector can be capable of providing spatial information (e.g., about at least first and second spatial dimensions that are orthogonal to each other) or other spatiotemporal information. The light can be obtained in response to electrical stimulation of the finger or toe, which can be sufficient to produce the light at the light detector around the finger or toe.

The spatial response information can be associated to a specified particular body anatomy, location, component, or system that is remote from the finger or toe at which the image information was obtained. The associating can include using information about an electrophysiological pathway for translating the spatial response information into a particularized response indication that is particular to the specified particular body anatomy, location, component, or system. The associating can include radially sectorizing the 2D spatial response information. A plurality of parameters can be computed, including using the radially sectorized 2D spatial response information to compute at least one of the parameters. At least one of the parameters can be adjusted or compared using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject. The at least one adjusted parameter can be used for translating the spatial response information into a particularized response indication that is particular to the specified particular body anatomy, location, component, or system.

This overview is intended to provide an overview of subject matter of the present patent application. It is not intended to provide an exclusive or exhaustive explanation of the invention. The detailed description is included to provide further information about the present patent application.

## BRIEF DESCRIPTION OF THE DRAWINGS

The patent or application file may include at least one drawing executed in color. Copies of this patent or patent application publication with color drawing(s) will be provided by the Office upon request and payment of the necessary fee.

In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The drawings illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

FIG. 1 is a block diagram showing an illustrative example of portions of a system and portions of an environment in which it can be used.

FIG. 2 is a diagram illustrating generally an example of portions of the present technique that can be used to obtain a physiological status indicator that

is particular to a specified particular body anatomy location, which can be remote from the fingertip.

FIG. 3 shows an illustrative example of portions of an image-analysis technique.

FIG. 4 shows an illustrative example of portions of an image-analysis technique.

FIG. 5 shows an illustrative example of a report that can be presented to a user.

FIG. 6 shows an illustrative example of a report that can be presented to a user.

FIG. 7 shows another illustrative example of a report that can be presented to a user, such as can be referred to as a Biofield graphical presentation.

FIG. 8 shows an illustrative example of a user-interface display that can be associated with calibration.

FIG. 9A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal cardiovascular condition,

FIG. 9B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal cardiovascular condition, with the shaded area representing a 95% confidence interval.

FIG. 9C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal cardiovascular condition,

FIG. 9D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal cardiovascular condition, with the shaded area representing a 95% confidence interval.

FIG. 10A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal gastrointestinal condition,

FIG. 10B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal gastrointestinal condition, with the shaded area representing a 95% confidence interval.

FIG. 10C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal gastrointestinal condition,

FIG. 10D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal gastrointestinal condition, with the shaded area representing a 95% confidence interval.

FIG. 11A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal renal condition,

FIG. 11B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal renal condition, with the shaded area representing a 95% confidence interval.

FIG. 11C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal renal condition,

FIG. 11D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal renal condition, with the shaded area representing a 95% confidence interval.

FIG. 12A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal hepatic condition,

FIG. 12B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal hepatic condition, with the shaded area representing a 95% confidence interval.

FIG. 12C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal hepatic condition,

FIG. 12D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal hepatic condition, with the shaded area representing a 95% confidence interval.

FIG. 13A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal respiratory condition,

FIG. 13B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal respiratory condition, with the shaded area representing a 95% confidence interval.

FIG. 13C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal respiratory condition,

FIG. 13D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal respiratory condition, with the shaded area representing a 95% confidence interval.

## DETAILED DESCRIPTION

This document describes, among other things, techniques that can include systems or methods of obtaining and processing image or other at least two-dimensional (2D) spatial information about light emitted around a fingertip or toe of a subject, such as in response to electromagnetic (field) ("electrical") stimulation of the subject (for brevity, this document emphasizes operation with respect to one or more fingertips, but it is to be understood that like apparatuses and methods can be additionally or alternatively used with one or more of the subject's toes). Such processing can include mapping the image or other 2D spatial response information to a specified particular body anatomy location, component, or system that is remote from the fingertip at which the image

information was obtained (for brevity, this document emphasizes operation with using at least 2D spatial information, but it is to be understood that like apparatuses and methods can additionally or alternatively be used with other at least 2D spatiotemporal information, such as can include a trend over time of at least 2D spatial information, or frequency content of at least 2D spatial information). Such mapping can include using an Eastern medicine meridian mapping or other registration system for associating a luminosity response at the fingertips to a specified particular body anatomy, location, component, or system, such as, for example, associating to a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system. Such processing, registration, or mapping can be used to generate a physiological status indication that is particular to a specified particular body anatomy, location, component, or system. The physiological status indicator can then be provided to a user or an automated process, such as in a textual or pictorial graphic report, or otherwise.

By way of overview, the present techniques can include measuring galvanic skin response (GSR). A subject's fingertip can be placed in contact with a transparent electrode, such as a glass electrode. Electrical or other electromagnetic impulses can be applied to the glass electrode, such as for generating a localized electromagnetic field around the fingertip. Under the influence of this electromagnetic field, and depending on the fingertip skin resistance, ionization can create a very small current within nearby air molecules. This can result in a small burst of visible or other (e.g., ultraviolet) light in a region surrounding the fingertip. An image of this light can be captured, such as by an automated charge-coupled device (CCD) digital camera or other camera or imaging device. The light image (or at least 2D spatial or spatiotemporal response information obtained therefrom) can be image-processed, such as to assess its intensity level or one or more other analytical criteria. The light intensity, for example, can be a function of the resistance at the junction between the fingertip and the electrode at the time of the measurement. The light intensity can be registered, for example, as a low, normal, or high response. As explained in detail below, the light image or other at least 2D spatial or spatiotemporal information can be processed to generate a physiological status indication that is particular to a specified particular body

anatomy location, component, or system that is remote from the fingertip. The physiological status indicator can then be provided to a user or an automated process, such as in the form of a textual or pictorial graphical report, or otherwise.

System Overview Example

FIG. 1 is a block diagram showing an example of portions of a system 100 and portions of an environment in which it can be used. In an example, the system 100 can include a transparent electrode 102, which can be configured for receiving a fingertip of a subject, such as on a top surface thereof. An optional removable transparent dielectric barrier 103 can be placed between the fingertip and the electrode 102 during certain measurements, and can be removed or omitted during other measurements.

An electromagnetic (e.g., electrical) signal generator 104 can be electrically coupled to the electrode 102, such as for delivering a suitable electrical (or other electromagnetic) stimulation signal to the fingertip for generating visible or other light (e.g., light in the visible through UV portions of the electromagnetic spectrum) about the fingertip, in response to the electrical stimulation. A camera 106 can provide a light detector to detect an at least 2D spatial response such as an image (or a spatiotemporal response, such as multiple images taken at different times) of the light generated about the fingertip in response to the electrical stimulation of the fingertip. The image information can be communicated to a computer 108, such as via a bus 110.

The computer 108 can include a user or other input/output interface 112, which can allow input from the user or an apparatus or output to the user or an apparatus. The user interface 112 can include a display 114. The computer 108 can include a memory circuit 116, such as for providing a tangible nontransitory medium for storing instructions that can be performed by a signal processor circuit such as processor circuit 118, which can include the memory circuit 116 or can be separate therefrom. The memory circuit 116 can also store image information obtained from the camera, or other 2D spatial or spatiotemporal response information, such as can be derived from such image information. The processor circuit 118 can be configured to provide image processing of the image information obtained from the camera 106. The processor 118 can provide, include, or be coupled to a microcontroller circuit, such as to control or

coordinate operation of the electrical signal generator 104, the camera 106, and an optional light-emitting diode (LED) or other light source 120.

The light source 120 can be used to illuminate the subject's fingertip, such as to help align or orient the fingertip as desired on the electrode 102, such as before electrical stimulation and responsive light imaging of the fingertip are performed. The computer 108 can also be configured to communicate with a server or other remote computer 122, such as over a wired or wireless communications or computer network 124, such as a local area network (LAN) or a wide area network (WAN).

Electrical Stimulation and Electrode Example

One approach to GSR would be to measure the relatively slow ~ 8-10 microampere current flow response of the skin, during a time period that is on the order of 10 to 100 seconds, to a small (approximately + 2 volt) DC voltage applied to the skin. The current flow can be translated to a 0-100 scale with 50 indicating a normal, healthy person response, less than 50 indicating a weak condition, and more than 50 indicating an irritated situation. An "indicator drop" (I.D.) of the conductance number, after slowly rising to its maximum value, can also be determined. For a normal response (~ 50), the I.D. occurs within ~ 1-3 seconds and the electrical resistance then maintains a constant value until the full measurement time elapsed (~ 10-20 sec). When there is an abnormal response (above or below 50), the I.D. can be much longer (~ 20-60 seconds), depending upon how far away from 50 the maximum conductance reading occurred.

Unlike the above approach, the present techniques need not pass any direct current through the subject's body. Instead, the present techniques can involve measuring light emitted around the finger in response to a small high-frequency alternating current (AC) excitation applied to the subject, such as to the subject's fingertip. The emitted visible or other light can be observed around the entire circumference of the circular or oval contact area of a fingertip, such as for each of the subject's ten fingertips or toes. The intensity of the light emitted around the finger contact area in response to the applied AC electrostimulation can vary according to the skin resistance of the subject.

The AC electrostimulation can be applied to the subject's fingertip by applying the AC electrostimulation potential to the electrode 102, on which the

fingertip can rest either directly, or separated therefrom by the dielectric 103. In an example, the electrode 102 can include a transparent glass dielectric portion, upon which the fingertip can be placed, and a transparent conductive portion, such as an indium tin oxide (ITO) coating, to which the AC electrostimulation signal can be applied by the electrical signal generator 104.

When a fingertip is placed on the dielectric glass portion of the electrode 102, two dielectrics (skin and glass) are situated in non-parallel geometry. When an AC electrostimulation voltage is applied to the fingertip skin, breakdown ionization can occur in the air surrounding the fingertip, because of the energy transfer between the charges in the stratum corneum of the fingertip and the dielectric glass portion of the electrode 102. The fingertip can act as a leaky dielectric, and some time may pass before ionizing breakdown of air occurs and light is emitted around the fingertip. The light emitted can vary according to one or more factors, which can include the electrolyte or water content of the fingertip.

In human tissue, the dielectric response is a function of the electric permeability of the skin and the frequency applied to the voltage used when making a measurement. The dielectric properties of the skin decrease with increasing frequency due to the time required for charges to form and migrate across the interfaces and interact with the opposing electrode.

At low frequencies, corresponding to a period on the order of 10-100 seconds, conduction current exists, allowing charge to be transferred across the stratum corneum. When the applied voltage is AC at approximately 1000 Hz, the impedance slowly increases with time, but to a smaller degree than when DC voltage is applied over a period of time. Without being bound by theory, this effect can be attributed to the selective permeability nature of the cell membranes (which pass positive ions more easily than negative ions) and the short-circuit channels between the cells. At an approximately 1000 Hz repetition rate, with a positive going square wave voltage pulse of 10 microseconds applied, there is time for the charge to build-up to breakdown. Then, with the ~ 1 millisecond that exists between the voltage pulses, there is almost sufficient time for the charges to decay before the next pulse arrives. Thus, variations of finger conductance in the high frequency region can be detectable.

The skin, due to its layered structure, can be likened to a capacitor. Each cell in the stratum corneum can have an electrical double layer $10^{-6}$ to $10^{-7}$ cm thick at each cell wall, and these can polarize to give rise to capacitance under the influence of an electric field. For ~100 layers of cell membrane in parallel that make up the stratum corneum, with a dielectric constant of approximately 50, a capacitance on the order of 0.045 $\mu F/cm^2$ can arise, which is within the range observed for skin. This capacitance can vary, such as according to the amount of electrolyte, water, or protein in the skin. The major barrier to the absorption or diffusion of water or electrolytes through the skin is in the outside layers of the epidermis. The overall range of skin permeability is approximately between 0.004 - 600 µcm/min) and, with age, this permeability decreases. Absorption is most likely along the "spot welds" or desmosomes, which occur at short intervals, creating channels down through the cell membrane layers. These channels act to decrease the leakage resistance between the cell membranes and thus decrease the capacitance of the cell membranes. Diffusion through the desmosomes yields a diffusion coefficient for water of D = 2 µcm2/sec which is 10 - 20 % of the epidermis bulk value.

A cellular membrane includes fixed charge sites, which may be predominantly positively or negatively charged, depending upon the pH of the tissue fluid relative to the iso-electric point (IEP) of the cells. The IEP represents the pH of the solution needed to neutralize the charge state of the surface of the cell. In the instance where the membrane surface is electro-positively charged, H+ ions will be absorbed by the membrane surface. It will be selectively permeable to negative (anions) only. When the membrane becomes electro-negatively charged it is permeable to positive (cations) only. The iso-electric point of a membrane will shift depending on the degree and type of proteins and carbohydrates imbedded in the cell surface. Skin is generally found to be electronegatively charged and is therefore primarily permeable to positive (cations) ions. This selective permeability nature of the skin is similar in effect to the function of a diode in a circuit.

In an example, the electrical signal generator applies a sinusoidal AC electrical signal at a frequency of approximately 1000Hz, a repetition rate of between about 33 Hz and 1000 Hz, and a duty cycle of between about 5 and 15 microseconds, for a total fingertip electrostimulation exposure duration of

between 0.5 second and 32 seconds. The camera 106 can capture light emitted around the fingertip, such as during the entire electrostimulation exposure or a portion thereof, such as in one or a series of images.

Registration, Orientation, and Radial Sector Mapping or Association Example

FIG. 2 is a diagram illustrating generally an example of portions of the present techniques that can be used to obtain a particularized response indication (such as a physiological status indicator) that is particular to the specified particular body anatomy, location, component, or system, which can be remote from the fingertip.

At 202, electrostimulation, such as the AC electrostimulation described above, can be applied by the electrical signal generator 104 to the fingertip, such as to generate visible or other light around the fingertip in response thereto.

At 204, at least two-dimensional (2D) spatial response capture, such as image capture, can be performed. This can include using a light detector such as the camera 106 to acquire the light image obtained in response to the AC electrostimulation. The light image obtained in response to the AC electrostimulation can be referred to as the "energized image." A corresponding light image obtained without such AC electrostimulation, which can be referred to as the "live image" can also optionally then be obtained, such as under illumination by the light source 120 (without accompanying AC electrostimulation). The live image can later be used to orient the later-obtained energized image, if desired.

At 206, a baseline determination can be made, such as to determine a level of background noise that is present in the light image. First, a centroid of the image can be determined and deemed to correspond to the center of the fingertip. Then, the background noise can be determined, such as by using the processor circuit 118 to perform image-processing of the image pixels from the camera 106 to locate the highest gradient in light intensity in the image. This highest gradient in light intensity will occur at the inner edge of the image where the outer perimeter of the fingertip meets the electrode 102 (or the dielectric 103) upon which the fingertip is placed. Within such perimeter, any light detected in the image can be deemed noise, since insufficient air is present there to generate an ionizing light response to the AC electrostimulation. All lower intensity pixels within such perimeter can be removed from the image, such as

by iteratively processing the image from the center of the fingertip outward. Such lower intensity pixel removal can continue iteratively until a consistent radius from the center of the fingertip to the highest gradient in light intensity is obtained. The magnitude of this radius can then be calculated, such as can be expressed as the number of pixels from the center of the fingertip image to the inner edge radius of the image.

At 208, the at least two-dimensional (2D) spatial response, such as the image, can be registered to the body, such as for mapping the light intensity information of particular radial sectors of the image (e.g., referenced to a center of the image located at the centroid of the fingertip) to a respective corresponding particular body anatomy, location, component, or system, which can be remote from the fingertip. The "live image" described above can be used to automatically (e.g., without requiring user intervention) orient (e.g., at least one of rotationally or translationally) an oval onto the "energized image," described above. The oval can be used to establish the coordinates on the energized image so that a radial sectoring system can be placed on the energized image in the correct orientation.

According to an example of the radial sectoring system, the fingers can be numbered, starting with the thumb, which can be designated finger number one, the forefinger (index finger) can be designated finger number two, and so forth. Table 1 illustrates: (1) individual fingers; (2) examples of radial sectors of the various individual fingers; (3) examples of angles defining such radial sectors; and (4) particular body anatomy location, component, or system corresponding to the respective radial sectors. In Table 1, the angles describe angular locations of radial rays extending radially outward from the center of the fingertip image, with 0° corresponding to a vertically upward extending ray (e.g., 12 o'clock), with the angle value increasing proceeding in a clockwise direction therefrom.

**Table 1: Example of Radial Sectoring System and Association or Mapping to Body Anatomy**

| Finger & Sector Number | Finger | Angles (degrees) | Body Anatomy |
|---|---|---|---|
| 1L1 | ThumbLeft | 280 - 315 | Right Eye |
| 1L2 | ThumbLeft | 260 - 280 | Right Ear, Nose |

| | | | |
|---|---|---|---|
| | | | Maxillary Sinus |
| 1L3 | ThumbLeft | 225 - 260 | Jaw, Teeth Right Side |
| 1L4 | ThumbLeft | 135 - 225 | Throat, Larynx, Trachea, Thyroid |
| 1L5 | ThumbLeft | 100 - 135 | Jaw, Teeth Left Side |
| 1L6 | ThumbLeft | 80 - 100 | Left Ear, Nose, Maxillary Sinus |
| 1L7 | ThumbLeft | 45 - 80 | Left Eye |
| 1L8 | ThumbLeft | 315 - 45 | Cerebral Zone (Cortex) |
| | | | |
| 1R1 | ThumbRight | 280- 315 | Right Eye |
| 1R2 | ThumbRight | 260 - 280 | Right Ear, Nose Maxillary Sinus |
| 1R3 | ThumbRight | 225 - 260 | Jaw, Teeth Right Side |
| 1R4 | ThumbRight | 135 - 225 | Throat, Larynx, Trachea, Thyroid |
| 1R5 | ThumbRight | 100 - 135 | Jaw, Teeth Left Side |
| 1R6 | ThumbRight | 80 - 100 | Left Ear, Nose, Maxillary Sinus |
| 1R7 | ThumbRight | 45 - 80 | Left Eye |
| 1R8 | ThumbRight | 315 - 45 | Cerebral Zone (Cortex) |
| | | | |
| 2L1 | ForefingerLeft | 260 - 280 | Descending Colon |
| 2L2 | ForefingerLeft | 220 - 260 | Sigmoid Colon |
| 2L3 | ForefingerLeft | 190 - 220 | Rectum |
| 2L4 | ForefingerLeft | 170 - 190 | Coccyx, Pelvis Minor |
| 2L5 | ForefingerLeft | 140 - 170 | Sacrum |
| 2L6 | ForefingerLeft | 100 - 140 | Lumbar Zone |
| 2L7 | ForefingerLeft | 85 - 100 | Thorax |
| 2L8 | ForefingerLeft | 45 - 80 | Cervical |
| 2L9 | ForefingerLeft | 280 - 45 | Transverse Colon |
| | | | |
| 2R1 | ForefingerRight | 280 - 315 | Cervical |
| 2R2 | ForefingerRight | 260 - 280 | Thorax |
| 2R3 | ForefingerRight | 220 - 260 | Lumbar |
| 2R4 | ForefingerRight | 190 - 220 | Sacrum |
| 2R5 | ForefingerRight | 170 - 190 | Coccyx Pelvis |
| 2R6 | ForefingerRight | 130 - 170 | Bling Gut |
| 2R7 | ForefingerRight | 100 - 130 | Appendix |
| 2R8 | ForefingerRight | 80 - 100 | Ascending Colon |
| 2R9 | ForefingerRight | 315 - 80 | Transverse Colon |
| | | | |

| | | | |
|---|---|---|---|
| 3R1 | MiddleLeft | 210 - 330 | Cardiovascular System |
| 3R2 | MiddleLeft | 180 - 210 | Kidney |
| 3R3 | MiddleLeft | 150 - 180 | Liver |
| 3R4 | MiddleLeft | 100 - 150 | Abdominal Area |
| 3R5 | MiddleLeft | 80 - 100 | Immune system |
| 3R6 | MiddleLeft | 30 - 80 | Thorax & Respiratory |
| 3R7 | MiddleLeft | 330 - 30 | Cerebral Vessels |
| | | | |
| 3R1 | MiddleRight | 280 - 330 | Thorax & Respiratory |
| 3R2 | MiddleRight | 260 - 280 | Immune System |
| 3R3 | MiddleRight | 210 - 260 | Gall-Bladder |
| 3R4 | MiddleRight | 180 - 210 | Liver |
| 3R5 | MiddleRight | 150 - 180 | Kidney |
| 3R6 | MiddleRight | 30 - 150 | Cardiovascular System |
| 3R7 | MiddleRight | 330 - 30 | Cerebral Vessels |
| | | | |
| 4L1 | RingLeft | 280 - 315 | Hypothalamus |
| 4L2 | RingLeft | 260 - 280 | Nervous System |
| 4L3 | RingLeft | 225 - 260 | Spleen |
| 4L4 | RingLeft | 150 - 225 | Uro-Genital |
| 4L5 | RingLeft | 130 - 150 | Adrenal |
| 4L6 | RingLeft | 110 - 130 | Pancreas |
| 4L7 | RingLeft | 80 - 110 | Thyroid |
| 4L8 | RingLeft | 45 - 80 | Hypophysis - Pituitary |
| 4L9 | RingLeft | 315 - 45 | Epiphysis - Pineal |
| | | | |
| 4R1 | RingRight | 280 - 315 | Pituitary |
| 4R2 | RingRight | 250 - 280 | Thyroid |
| 4R3 | RingRight | 230 - 250 | Pancreas |
| 4R4 | RingRight | 210 - 230 | Adrenal |
| 4R5 | RingRight | 135 - 210 | Uro-Genital |
| 4R6 | RingRight | 100 - 135 | Spleen |
| 4R7 | RingRight | 80 - 100 | Nervous System |
| 4R8 | RingRight | 45 - 80 | Hypothalamus |
| 4R9 | RingRight | 315 - 45 | Pineal |
| | | | |
| 5L1 | LittleLeft | 270 - 315 | Left Heart |
| 5L2 | LittleLeft | 225 - 270 | Left Uro-Kidney |
| 5L3 | LittleLeft | 135 - 225 | Left Breast/Respiratory System |
| 5L4 | LittleLeft | 90 - 135 | Jejunum |
| 5L5 | LittleLeft | 45 - 90 | Right heart |
| 5L6 | LittleLeft | 315 - 45 | Coronary Vessels |

| | | | |
|---|---|---|---|
| 5R1 | LittleRight | 270 - 315 | Duodenum |
| 5R2 | LittleRight | 225 - 270 | Ileum |
| 5R3 | LittleRight | 135 - 225 | Right Breast, Respiratory System |
| 5R4 | LittleRight | 90 - 135 | Right Uro-Kidney |
| 5R5 | LittleRight | 45 - 90 | Heart |
| 5R6 | LittleRight | 315 - 45 | Coronary Vessels |

At 208, the energized image can be rotationally or translationally oriented, such as automatically, without requiring user intervention. This can be accomplished via signal processing by placing an oval over the live image at a center, which can be calculated as the centroid obtained from the pixels of the live image. The live image center can be deemed to correspond exactly to the center of the energized image, and these two centers can be overlaid. In an example, the live image can allow the user (or an automated process) to visualize the finger, including how it projects out of the image plane. This can permit the user (or an automated process) to visualize the orientation of the finger in the live image. The user or automated process can use such orientation information from the live image to properly orient the energized image, such as rotationally to within a few degrees.

In an example, the processor circuit 118 can be configured to perform image processing that can take the live image of a fingertip and calculate parallel lines along the edges of the live image of the finger as it projects out of the image plane. Such parallel lines can then be aligned to a vertical (longitudinal) center line of the oval. This can allow the live image to be oriented with respect to the oval using such parallel lines and the longitudinal center line of the oval. When the external edges of the live image of the finger are not clear, or if the finger is very large and therefore there is little of the outward-projecting portion of the finger to be seen in the live image, an automated process may not be able to achieve the correct orientation. In such a case, the user can use information displayed on the display to verify for correct orientation, such as by visually comparing the live image to the energized image and visually assessing the orientation correlation therebetween.

At 210, the properly oriented energized image of a fingertip can by analyzed, such as by using automated image processing that can be provided by the processor circuit 118, such as described further below.

Image Analysis Example: Parameter Determination

FIG. 3 shows an example of such an image-analysis technique. At 302, for image analysis, the energized image can be broken down into a pixel matrix, for an illustrative (non-limiting) example, such as a x=320 by y=240 pixel matrix representing the respective x and y positions of pixels in the image. Each pixel can include data representing light intensity observed at that pixel location. From the pixel information, in an example, various analysis parameters can be determined, such as by automated image processing of the energized image using the processor circuit 118. In an example, such analysis parameters can include Area, Intensity, Form, Form 2, Entropy, Fractal, NS, and Break coefficients, such as described further below.

At 303, a Center Point location parameter of the energized image can be obtained or determined. In an example, the Center Point can be determined by first determining contour points of the fingertip boundaries. The contour points can be determined by (e.g., working out from the true center of the image) selecting pixels having an intensity exceeding a specified intensity threshold value. An ellipse can then be fitted to such contour points, such as by using a least-squares analysis to perform the fitting. The ellipse fitting can be iteratively repeated, if desired. At each iteration, one or more outliers among the contour points can be removed. The midpoint of the ellipse can be determined and deemed to be the Center Point of the energized image.

At 304, a Minimum Radius parameter of the fingertip energized image can be determined, such as by automated image processing using the processor circuit 118. The Minimum Radius parameter of the image can be determined as the smaller principal axis of the ellipse fitted as described above.

At 306, a Maximum Radius of the fingertip energized image can be determined, such as by automated image processing using the processor circuit 118. The Maximum Radius of the image can be determined as the larger principal axis of the ellipse fitted as described above.

At 308, an Image Angle parameter can be determined, such as by automated image processing using the processor circuit 118. The Image Angle

can be given by the angle between the major axis and the vertical (longitudinal) center line pointing from the centerpoint upward (in the 12 o'clock direction) on the energized image. If the ellipse is close to a circle (which is the case when the ratio of the major axis to the minor axis is at or near 1.0), then the Image Angle can be declared to be zero.

At 310, a Background Noise Level parameter can be determined, such as by determining a threshold intensity level at which only a specified amount (e.g., 0.002% of the pixels in the center region of the image) exceed the threshold intensity level. In an example, this Background Noise Level can be determined in the center region of the image, which can be taken as the interior of the ellipse (e.g., within the Minimum Radius), with the ellipse fitted such as described above with respect to 303). This threshold intensity level can be declared to be the Background Noise Level. The center region of the image can be used because this should be an area completely devoid of light and therefore representative of what the background of the image should look like.

In an example, to calculate the Background Noise Level, intensities can be determined for all "lit" pixels within the center region area that is defined by the ellipse fitted as described above with respect to 303. An iterative calculation can be used to iteratively remove portions of the lit pixels within the center region. In an example, percentages of the lit pixels can removed, such as based on their intensities, until only a specified target amount (e.g. 0.002%) of the originally-present lit pixels in that center region remain. So, in an illustrative example, if there are 100 lit pixels to start with, of varying intensities, in a first pass through, all lit pixels with intensities less than a threshold value (e.g., threshold value = 20) can be cleared. Those lit pixels that remain, if greater than the specified target amount of 0.002% of the original number of lit pixels that were present in the center region, can be processed in another pass, in which all lit pixels having an intensity value of less than a higher threshold value (e.g., threshold value = 30) can be removed. If greater than the specified target amount of 0.002% of the original number of lit pixels in the center region are still present in the center region, then another pass can be made. This iterative process can continue until the specified target amount of only 0.002% of the original number of lit pixels within the center region remain. The corresponding

intensity level can be declared to be the Background Noise Level. In an example, the Background Noise level can be between 30 and 45, in most cases.

An Inner Radius can be determined, as explained above, such as after the Background Noise has been subtracted from the image. The remaining image has an Inner Radius that is described by the distance from the center point to the first pixel, in the radial direction from the center, that exceeds the background noise level. This Inner Radius dimension will be variable along the inner edge of the image due to the size and shape of the finger that created the image. For each calculation, the inner radial distance can be calculated.

At 312 of FIG. 3, a Sector Area parameter of a particular radial sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. A radial sector can be given by an area between rays, such as adjacent rays, emanating radially outward from the Center Point of the 2D energized image. The Sector Area of a particular sector can be determined as the number of pixels within a particular sector and within the fitted ellipse, having an intensity exceeding a specified value, such as exceeding a specified value of the Background Noise Level.

At 314, a Normalized Sector Area parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. In an example, the Normalized Sector Area can be given by the following relationship:

Normalized Sector Area = Sector Area * ((360 ÷ (Number of Sectors)) ÷ Radial Angle of the Sector between End Rays)

At 316, an Average Intensity parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. In an example, the Average Intensity of a particular sector can be determined by dividing the sum of intensities of all pixels in a particular sector by the number of pixels given by the Sector Area for that sector.

At 318, an Entropy parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. This

can include computing a Shannon Entropy along a profile. The profile can be created by traversing the image radially with a sweep ray extending from the Center Point of the fitted ellipse, and sweeping the ray clockwise with respect to the Center Point of the fitted ellipse, which can serve as a fixed reference. The clockwise sweep of the sweep ray can be performed in steps, such as of ¼ of an angular degree, in an illustrative example, and the profile (and corresponding Shannon Entropy) can be determined along the sweep ray at each such step.

For each of the resulting (e.g., 360 x 4 = 1440) angles, an image profile can be computed, such as by selecting the pixels exceeding the Background Noise Level (e.g., as explained above with respect to FIG. 4) that intersect with the sweep ray at one of the 1440 (or other number of) angles and centered at the ellipse midpoint. Thus, a particular image profile can include an angle, a set of pixels extending radially along the profile at that angle, and the intensities associated with the profile pixels.

An Entropy for a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as by first computing an Entropy for each individual profile within that particular sector, and then averaging or otherwise determining a central tendency of each individual profiles to obtain a composite profile for that particular sector. For various pixel positions $i$ along the radial profile (where the integer $i = 1, 2, \ldots n$, and $n$ is the total number of pixels in the radial profile), the Entropy can be expressed as a radial vector $E$ given by the following relationship:

$$E = -\sum i \mu i \log 10 \mu i,$$

where $\mu i = \Delta Ii / \sum i \, \Delta Ii$, and

$\Delta Ii$ is pixel intensity above the Background Noise Level.

At 320, a Form parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. The particular image profiles determined at the various (e.g., 1440 angles) angular positions, as explained above, can be used in determining the Form parameter. The active area of the fingertip image can be divided into adjacent concentric regions (e.g., annular regions or, in the center, a disk) that are separated from each other by concentric circular rings (of different radii), which can be commonly coaxially centered at the Center Point of the ellipse. In an example,

three such concentric rings can be used, with corresponding progressively increasing radii of R1, R2, and R3 to define boundaries of three concentric regions having respective areas A1 (area of a disk bounded by R1), A2 (area of a ring between R1 and R2), and A3 (area of a ring between R2 and R3). In an example, the Form parameter of a particular sector can be expressed using multiple coefficients, such as Form 1.1, Form 1.2, Form 1.3, and Form 1.4.

In an example, Form 1.1, Form 1.2, and Form 1.3 can represent derivative coefficients, respectively providing an indication of the amount of change in pixel intensity along each radial image profile within a given concentric region A1, A2, or A3. Form 1.1, Form 1.2, and Form 1.3 can be determined by computing the maximum value of the derivative along the image profile within a particular concentric region, A1, A2, and A3 as indicated above. In an example, the Form parameter for a particular sector can be expressed as follows:

Form = $4\pi L/S(1)$, calculated for concentric region having respective areas A1, A2, and A3 where $S(1) = \Delta Ii/\sum i\ \Delta Imax$,

where $\Delta Ii$ is the pixel intensity above the Background Noise Level,

and L is the length as given in pixels of intensity described by S(1).

At 322, Form 2 can be calculated using a similar calculation; however it can be carried out for only the concentric region that is greater than that associated with A3, namely the concentric region associated with A4 and greater radial distances.

At 324, a Fractal dimension parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. The Fractal parameter can be determined by computing a mathematical fractal dimension, such as using a box-counting method for a two-dimensional area. The Fractal parameter can be represented by:

Fractal = $2\pi L/Rav$,

where $2\pi L$ is perimeter length (in pixel count) of the radial image sector, and where $Rav=(1/n)*\sum_i^n Ri$, and Ri is the Inner Radius, such as described above with respect to FIG. 4, and the integer $i = 1, 2, \ldots n$ denotes the particular radial profile of the $n$ such radial profiles within that particular radial image sector.

At 326, a NS parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. NS can provide a comparison measure between a subject's image sector and a corresponding sector of a subject-specific calibration image (e.g., a calibration image that has been taken on the same day as the subject images). The NS comparison can be determined both with and without the dielectric 103 in place. In an example, the NS parameter can be determined for a particular sector using the following relationship:

NS = [(Iav (subject image sector) ÷ Iav(calibration image sector)) - 0.5] ÷ [(log (number of active pixels of subject image sector) ÷ (number of total pixels of subject image sector + epsilon)) ÷ (log (number of active pixels of calibration image sector) ÷ (number of total pixels of calibration image sector + epsilon))]

where Iav = average intensity of the pixels in the radial sector of the image, and epsilon can be set to a value (e.g., epsilon = $10^{-4}$) to help ensure stability, and the value 0.5 can be subtracted for normalization.

At 328, an NS' parameter of a particular sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors) can be computed, such as for one or more radial sectors of the energized image. The NS' parameter can also provide a comparison measure between a subject's image sector and a corresponding sector of a "perfect" subject image (such as has been previously stored and retrieved from a database). The NS' comparison can be determined both with and without the dielectric 103 in place, just as described above for NS, except that the determination of NS' can differ by substituting a population-composite healthy person image for the subject-specific calibration image used in the NS computation. The population-composite healthy person image can be determined by generating a composite image from a sample (e.g., of tens of thousands) of human fingertip images from known or presumed healthy subjects.

At 330, a Break Coefficient can be determined. The Break Coefficient, can represent a gap coefficient, providing an indication of whether there is a gap in the inner ring bounding a particular concentric region. A gap can be declared to exist when one or more pixels along such inner ring has an intensity that falls

below a threshold value, such as the Background Noise Level. The value of the Break Coefficient can correspond to the size (e.g., the circumferential length along the inner ring) of such gap, if any. If a gap exists, the Break Coefficient can be assigned a specified value, such as a value between 0 and 10.

Image Analysis Example: Analysis Process & Rules

By way of overview, in an example, each of the coefficients/parameters described above with respect to FIG. 3 (e.g., Center Point, Inner Radius, Fractal, Entropy, etc., which can be denoted ($x_1$, $x_2$, . . ., $x_n$)) can be calculated from the energized image, assessed for normality within the dataset (e.g., using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject), and statistical outliers can be discarded (or otherwise adjusted).

After such processing, if any, the coefficients/parameters described above can be combined, for a particular radial sector, into a sector composite parameter for that radial sector, such as by a weighted linear combination (e.g., $y = a \cdot z_1 + b \cdot z_2 + c \cdot z_3 + \ldots + y \cdot z_n$, where a, b, c, etc. are scaling coefficients, and $z_1$ . . . $z_n$ are the normal distribution z-scores associated with the various coefficients/parameters such as described above with respect to FIG. 3.) The normal distribution z-scores can be determined using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject.

The sector composite parameter then can be scaled, such as to fit within a defined scale (e.g., a scale between 0 and 5, or a scale between 0 and 25, which can be defined by a population to which the subject is being compared (e.g., using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject), or by other sector composite parameters associated with the same subject). An example is explained in more detail below with respect to FIG. 4. The acts described with respect to FIG. 4 can be applied after each of the parameters/coefficients described above with respect to FIG. 3 has been calculated for each of the radial sectors.

At 402, for each parameter/coefficient ($x_1$, $x_2$, . . ., $x_n$) described above with respect to FIG. 3, a corresponding average value ($\mu_1$, $\mu_2$, . . ., $\mu_n$) or other

central tendency of that parameter/coefficient can be computed across all radial sectors in the energized image.

At 404, for each parameter/coefficient ($x_1$, $x_2$, . . ., $x_n$) described above with respect to FIG. 3, a corresponding standard deviation value (($\sigma_1$, $\sigma_2$, . . ., $\sigma_n$) or variance, or other measure of dispersion or variability) of that parameter/coefficient can be computed across all radial sectors in the energized image. Then, a first variability range (e.g., of +/- one standard deviation) of that parameter/coefficient across all the radial sectors in the energized image can be calculated. Then, a second variability range (e.g., of +/- three standard deviations) of that parameter/coefficient across all the radial sectors in the energized image can be calculated.

At 406, for each radial sector, any parameters/coefficients that fall within the second variability range (e.g., fall within +/- three standard deviations) can be excluded from the next average and standard deviation calculation. From those parameters/coefficients that have not been so excluded, and a second average and a second standard deviation can be computed across non-excluded radial sectors.

At 408, a normal distribution z-value (also called a z-score, where $z_1 = (x_1 - \mu_1)/\sigma_1$) can be calculated for all parameter/coefficients ($x_1$, $x_2$, . . ., $x_n$), for all sectors, including those that were excluded from the previous average and standard deviation calculation, of the energized image—but using the applied second average and the applied second standard deviation determined at 406, instead of the average and standard deviation determined at 402 and 404.

At 410, for each radial sector, the z-scores described above at 408 can be combined into a sector composite parameter, such as by a weighted linear combination (e.g., $y = a \cdot z_1 + b \cdot z_2 + c \cdot z_3 + \ldots + x \cdot z_n$, where y is the sector composite parameter, and where a, b, c, etc. are scaling weights, and $z_1 \ldots z_n$ are the various unscaled z-scores such as described above at 408). In an example, the scaling weights associated with the corresponding unscaled z-scores of the various coefficients/parameters can be as follows: Area weight =0.5, Intensity weight = 25, Entropy weight = 1500, Form weight = 300, Form2 weight = 300, NS weight = 3000, Fractal weight = 225, Break weight = 5000. The Break weight can be applied as an on/off rule; it can be applied if a break is

present, and not applied if the break is not present. The Break weight can be scaled by a specified value, such as value that can be between 0 and 10.

At 414-424, one or more rules can then be applied to the sector composite parameter, based upon the z-scores of the parameters/coefficients associated with that radial sector.

At 414A, if any radial sector meets one or more specified criteria, such as a z-score greater than or equal to a specified value (e.g., 0.9) for both Area and Intensity, then at 414B the sector composite parameter for that radial sector can be adjusted, such as by adding an additional amount (e.g., 5000) can be added to the sector composite parameter for that radial sector of the energized image.

At 416A, if any radial sector meets one or more specified criteria, such as a z-score greater than or equal to 0.9 for Fractal, then at 416B the sector composite parameter for that radial sector can be adjusted, such as by adding an additional amount (e.g., 10,000) to the sector composite parameter for that radial sector of the energized image.

At 418A, if any radial sector meets one or more specified criteria, such as a z-score greater than or equal to 0.9 for each of Form1, Form2, and Entropy, then at 418B the sector composite parameter for that radial sector can be adjusted, such as by adding an additional amount (e.g., 7000) to the sector composite parameter for that radial sector of the energized image.

At 420A, if any radial sector meets one or more specified criteria, such as a z-score greater than or equal to 0.9 for each of Form1 and Form2, then at 420B the sector composite parameter for that radial sector can be adjusted, such as by adding an additional amount (e.g., 5000) to the sector composite parameter for that radial sector of the energized image.

At 422A, if any radial sector meets one or more specified criteria, such as a z-score greater than or equal to 0.9 for each of Form1 and Entropy, then at 422B the sector composite parameter for that radial sector can be adjusted, such as by adding an additional amount (e.g., 7000) to the sector composite parameter for that radial sector of the energized image.

At 424A, if any radial sector meets one or more specified criteria, such as a z-score greater than or equal to 0.9 for each of Form2 and Entropy, then at 424B the sector composite parameter for that radial sector can be adjusted, such

as by adding an additional amount (e.g., 10,000) to the sector composite parameter for that radial sector of the energized image.

At 414-424, the one or more rules can be evaluated (in the priority listed and shown in FIG. 4) such that only one of these rules is actually applied and given effect, such that there is no duplicative effect to the sector composite parameter from more than one of the rules of 414-424.

At 430, for those body anatomy organs or systems in Table 1 that correspond to both a radial sector of the left hand and a radial sector of the right hand, a left-right differential sector composite parameter ("delta") between the respective sector composite parameters for such left-hand and right-hand radial sectors can be computed. If the delta exceeds 50% of the value of either of the respective sector composite parameters for such left-hand and right-hand radial sectors corresponding to the same body anatomy organ or system, then an additional amount (e.g., 20,000) can be added to the respective sector composite parameters for such left-hand and right-hand radial sectors corresponding to the same body anatomy organ or system.

At 432, the sector composite parameter for each radial sector of the energized image, after adjusting as described above with respect to 414 – 430, can be scaled, such as by multiplying or dividing the value of the sector composite parameter by a specified normalizing amount (e.g., dividing by 100).

At 434, the resulting normalized sector composite parameter can be compared to a within-subject curve (e.g., a normal distribution curve compiled from all of the sector composite parameters of the same subject) and also fit to a population-based curve (e.g., a normal distribution curve for the same sector composite parameter from a comparable population or subpopulation of subjects, such as using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject). The population-based curve can be based on a comparable subpopulation of patients, such as based upon one or more factors such as medical history, gender, race, or age). The location of the sector composite parameter within the within-subject curve can be scaled and reported to the user. The location of the sector composite parameter within the population-based curve can also be scaled and separately reported to the user.

At 436, in an example, two statistical modeling analysis methods can be employed to associate and optimize sector relationship to the particularized response indication that is particular to the specified particular body anatomy, location, component, or system, wherein the particularized response indication can be indicative of disease etiology, progression, or pattern as well as severity of 'issue' or abnormality that is particular to the specified particular body anatomy, location, component, or system.

A first statistical approach can include Naïve-Bayes analysis, which can produce one or more probabilities and multiplicative factors for each sector and coefficient combination. These factors can be applied to the 78 sectors. A resultant physiology-specific composite score that can provide a physiological status indicator that is specific to a particular body anatomy location, component, or system can be produced, such as on a scale of 0-5 or 0-25 (e.g., such as for one of five major organ systems, such as Cardiovascular system, 0-5 or 0-25, Renal system 0-5 or 0-25, Respiratory system 0-5 or 0-25, Gastrointestinal system, 0-5 or 0-25, or Hepatic system, 0-5 or 0-25). The higher the physiology-specific score for a particular body anatomy location, component, or system, the greater the probabilistic prediction that there is an issue or abnormality with that particular body anatomy location, component, or system.

A second statistical approach that can be employed can include Logistic Regression, such as using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject. In an example, one or more multiplicative factors can be calculated for each sector and coefficient combination. Using these probabilistic outcomes for each sector, a ranking can be created for each sector.

In an example, using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject, such as across a population of several thousand data points these probabilities have been normalized and translated into a scoring system from 0-25. A score of 25 can indicate the highest probability that there is an issue or abnormality with a particular body anatomy, location, component, or system for the particular individual whose image is being analyzed.

Within a patient-specific or population-based range, such as the 0-25 range example, subranges can defined, such as can respectively represent a normal response (e.g., 0-10), a chronic response (e.g., 11-16), and an emergent or acute response (e.g., 17-25). These subranges can be scaled to correspond to a specified cutoff value in a patient-specific or population-based distribution of such physiology-specific composite scores. For example, the 0-10 subrange can correspond to values within a 68% cutoff value (inclusive) on the patient-specific or population-based distribution, the subrange 11-16 can be scaled to correspond to values between a 69% cutoff value and a 95% cutoff value (inclusive), and the subrange 17-25 can be scaled to correspond to values that are greater than the 95% cutoff value. Although the above example is described using a scale from 0-25, another scale (e.g., 0-5) can be selected and used.

Trending over time (e.g., over a time period of days, weeks, months, or years) can be carried out, such as on the physiology-specific composite score, on one or more of its underlying coefficients/parameters, or on the image or other at least 2D spatial or spatiotemporal response information. In an example, one or more such trends can be analyzed, such as to provide a trend-based physiological status indication or other particularized response indication that is particular to the specified particular body anatomy, location, component, or system.

Report Generation and Presentation Examples

In an example, the information generated as discussed above (e.g., one or more of the coefficients/parameters, the physiology-specific composite scores, or the trends) can be presented to a diagnostician, caregiver, or other user. This can be in the form of one or more textual or pictorial reports, charts, or images that can be displayed or printed or otherwise provided to the user or to an automated process.

FIG. 5 shows an illustrative example of a report that can be presented to a user. In the example of FIG. 5, the physiology-specific composite scores can be presented to a user, such as in association with various particular body anatomy locations, components, or systems (which can be annotated "L" or "R" if separate physiologic-specific composite scores are generated from the left and right hands for that particular physiology-specific composite score). Thus, in the illustrative example of FIG. 5, the scores are presented in visual correspondence with their respective particular body anatomy location, component, or system

(e.g., one or any combination of Eye (L), Eye (R), Ear/Nose/Sinus (L), Ear/Nose/Sinus (R), Jaw/Teeth (L), Jaw/Teeth (R), Cervical Spine, Thoracic Spine, Lumbar Spine, Scarum, Coccyx/Pelvis, Nervous System, Hypothalamus, Pituitary, Pineal, Cerebral Cortex, Cerebral Vessels, Immune System, Spleen, etc.), which, in turn can be organized into more generic systems (e.g., "Sensory & Skeletal Systems," "Nervous & Immune Systems", etc.).

In an example, the physiologic specific composite scores that are presented in the user can include both "Physical" and "Autonomic" composite scores. The Physical composite scores can be determined, such as described above, from energized images that can be acquired with the dielectric barrier 103 in place. The Autonomic composite scores can be obtained, such as described above, from the energized images that can be acquired without the dielectric barrier in place. The Autonomic composite scores can include a component arising from stress or anxiety of the subject. The Physical composite scores can attenuate such a component arising from stress or anxiety of the subject.

In the example of FIG. 5, both the Physical and Autonomic composite scores can be presented in such a manner so that the user can easily tell whether they fall within a Normal range, or whether they fall outside the Normal range. Likewise, the Physical and Autonomic composite scores can be presented in such a manner so that the user can easily tell whether they were obtained using Left-hand images (L) or right-hand images (R). In the example of FIG. 5, this can be accomplished by presenting the composite scores in separate columns that can help make such distinctions, such as: Normal Physical (L), Normal Physical (R), Out of Range Physical (L), Out of Range Physical (R), Out of Range Autonomic (L), Out of Range Autonomic (R), Normal Autonomic (L), and Normal Autonomic (R). The particular composite score can be placed within the appropriate column. In the example of FIG. 5, the user's attention can be drawn toward the center-most columns to view or compare Out of Range Physical and Autonomic values.

In an example using a 0-25 scale, physiologic-specific composite score values in the range between 0 and 10 inclusive can be considered normal, and can be displayed without any special color, values in the range between 11 and 16 inclusive can be considered representative of chronic electrophysiology conditions or patterns, and can be displayed in a particular color (e.g., red), and

values in the range between 17 and 25 inclusive can be considered representative of more emergent or acute electrophysiology conditions or patterns, and can be displayed in a particular color (e.g., red) and otherwise highlighted (e.g., with yellow highlighting background). Although the above example is described using a scale from 0-25, another scale (e.g., 0-5) can be selected and used.

In an example, a first ("Self-Scale") report such as illustrated in the example of FIG. 5 can be provided in which "Normal" and "Out of Range" can be determined with respect to a distribution or baseline of data previously obtained from the same subject, and a second ("Population Comparison") report such as illustrated in the example of FIG. 5 can be provided in which "Normal" and "Out of Range" can be determined using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject, such as with respect to a distribution or baseline of data previously obtained from a population or subpopulation of subjects. In an example, both such Self-Scale and Population Comparison reports can be combined in a textual or pictorial report that can be displayed or otherwise presented to the user or an automated process. In an example, the user can select whether to display one or both of the individual reports or the combined report.

FIG. 6 shows another illustrative example of a report that can be presented to a user. In the example of FIG. 6, the physiology-specific composite scores can be presented in a table, such as shown. The table can be sorted, such as by organ system, by side (Left-Hand, Right-Hand) for both the Physical System measurements (e.g., determined using energized images obtained without the capacitive barrier) and the Autonomic System measurements (e.g., determined using energized images obtained with the capacitive barrier). In an example, the table presented can be user-filtered, such as by one or more organs, by Autonomic or Physical, or by or one or more other user-specified display filter characteristics (e.g., such as low-to-high or high-to-low physiology-specific composite score).

In the examples shown in FIGS 5-6, or other examples, textual or other explanatory content can also be provided, such as can help the user understand relationships between organ system results, between Physical and Autonomic results, between Left-Hand and Right-Hand results, or to assist user-

interpretation in any other way. For example, it is believed that the physiology-specific composite scores of certain particular body anatomy locations, components, or systems interact with other physiology-specific composite scores. In another example, it is also believed that a greater difference between Left-Hand and Right-Hand physiologic-specific composite scores for a particular body anatomy location, component, or system, (or set of such physiology-specific composite scores) can correlate to a greater likelihood of the presence of a corresponding pathological physiological status.

In an example, the information displayed or otherwise presented to the user need not focus on the physiologic-specific composite scores, but can additionally or alternatively include information about one or more parameters/coefficients, which can optionally be presented together with information about one or more corresponding particular body anatomy locations, components, or systems, or any helpful explanatory test. In an illustrative example, this can include information about the NS or NS' parameters described above, or differences between the NS or NS' parameters, or one or more trends in any of these, such as together with an interpretive explanation of how such information can be influenced by nervous system issues of the subject.

FIG. 7 shows another illustrative example of a report that can be presented to a user, such as can be referred to as a Biofield graphical presentation. In a Biofield graphical presentation, such as shown in the example of FIG. 7, the user can select a particular body anatomy location, component, or system (e.g., Skeletal System, Cardiovascular System, Small Intestine, Large Intestine, Renal & Reproductive System, Head & Upper Back, Lower Back, Immune System, Respiratory System, Nervous System, etc.) A rendered 2D or 3D anatomical representation of the user-selected system can be displayed, such as from various viewpoints (e.g., anterior, posterior, dorsal, ventral, left lateral, right lateral, etc.). The Biofield graphical representation can be superimposed on the one or more anatomical representations. Drill-down data corresponding to the user-selected anatomical system can also be displayed, such as by using a computer mouse or other user-input tool for selecting the "Item Data" tab on the display.

In the Biofield graphical representation, the intensity of the energized image sectors can be mapped to the corresponding anatomical locations

associated with such sectors. In the illustrative example of FIG. 7, the user has selected the respiratory system for display, and 2D rendered images of the respiratory system are displayed. In an example, the 2D rendered images are standard reference images of the particular user-selected anatomy, and need not display actual imaging data of the particular subject, although user-specific imaging data (e.g., MR data, CT data, or other imaging data) can be used and displayed. In the illustrative example of FIG. 7, the respiratory system is associated with radial sectors from fingers 5L, 5R, 3L, and 3R, the intensity data of each of which is mapped to and displayed in association with the corresponding anatomical regions on the display, such as using the mapping described and explained above.

Calibration Examples

In an example, the system described herein can be calibrated for acquiring the energized images as described above. In an example, this calibration can be carried out as explained below, such as on the same day on which the actual energized images are to be acquired from the subject.

First, a series of ten energized finger images can be acquired, using a specified manufacture of calibration probe rather than a human finger and then matrix analysis can be performed. Each image can be represented by an intensity matrix having two spatial dimensions (e.g., x=320 pixels by y=240 pixels) and an intensity dimension.

Then, the image data can be processed, such as to determine a variability in intensity and geographical location (finger position). Each of the ten images can be centered with respect to a calibration template image, and then compared against the calibration template image. A respective measure of the difference between the intensity and geographical location of the image and the calibration image can be determined.

In an example, the calibration template image can be a calculated composite matrix that can be determined based on calibration images gathered over time from several different cameras and assessed for variability, such as across hundreds of images. In an example, the calibration template image can be established by generating a representative radial profile of 5 degrees from the various calibration images gathered over time, and the representative radial

profile can be copied 72 times at 5 degree increments to form a 360 degree calibration template image.

In an example, the calibration template image can be a calculated composite matrix that can be determined based on one or more calibration images gathered using a calibration probe of a specified manufacture, such as a specified size, shape, or material (e.g., a tungsten-composite solid cylindrical metal probe). The calibration probe can be placed directly onto the glass electrode, and one or more images can be obtained. In an example, 5 images can be captured, but not recorded, and the following 10 images are captured and recorded. The 10 recorded images of the calibration probe can be analyzed as follows.

First, the background noise can be determined, such as by finding the highest intensity gradient in the calibration probe image (e.g., the inner edge of the calibration probe image). Then, the lower intensity pixels can be removed until the radius is consistent to the inner edge (highest intensity gradient). This radius can be calculated as the number of pixels from the center of the image to the inner edge of the calibration probe, as represented by the highest intensity gradient.

Next, from the center of the calibration probe image, rings generated using specified multiples of the inner edge radius can be calculated (e.g., 1.2·radius, 1.4·radius, 1.8·radius, etc.). Such rings can be equally-spaced, such as shown in the example of FIG. 8. Within each such ring, the area and average intensity can be calculated, such as described above with respect to coefficient/parameter calculation. The consistency of the area and average intensity for each ring can be analyzed across all 10 recorded calibration probe images, and a range of +/- one standard deviation can be calculated. If the standard deviation falls within a specified range, then an acceptable level of calibration can be declared to exist, and acquisition and processing of actual energized fingertip images can commence. Otherwise, an unacceptable level of calibration can be declared to exist, and either (1) acquisition and processing of actual energized fingertip images can be inhibited, prevented, or qualified, or (2) one or more data acquisition or signal processing parameters can be adjusted and used.

Dynamic Imaging Examples

The apparatuses and methods described herein can include using not only static image capture and analysis (or other static at least 2D spatial response capture or analysis), but can additionally or alternatively include using dynamic image capture and analysis, such as at least two (spatial) dimensional spatiotemporal response capture or analysis). In an illustrative example, a static image capture process can include capturing images for an exposure period of 0.5 seconds, during which 10 frames per second can be captured, thereby capturing 5 static image frames during the 0.5 second exposure period, after an initial specified ramp-up delay, such as can be established by hardware, software, or firmware. In an illustrative example, a dynamic image capture process can include capturing images for an exposure period that can be between 0.5 seconds and 30 seconds, such as using a 10 frame per second image capture rate, after an initial 200 millisecond delay, such as can be established by hardware, software, or firmware. This can result in capturing close to 300 image frames during a 30 second exposure period.

In an example, dynamic image or spatiotemporal response analysis can include computing the parameters/coefficients (such as described above) for each image frame in the dynamic imaging set of images, and optionally performing Fourier or harmonic analysis to assess the frequency response of one or more such coefficients/parameters. Such frequency domain information can be used in the determination of the physiological status indication or other particularized response indication that is particular to the specified particular body anatomy, location, component, or system, such as by statistical comparison to the within-patient distribution or to the population-based distribution. It is believed that such frequency domain information may further improve the sensitivity or specificity of the physiological status indication or other particularized response indication that is particular to the specified particular body anatomy, location, component, or system.

It is believed that each coefficient can provide a unique frequency measure that can be calculated, specific to each person and each organ system for this person, a composite profile of which may be able yield profile information of individuals, such as for later recognition or identification of the subject using the system. The frequency measure of individual

parameters/coefficients, or of the composite profile, can be used to provide a baseline measure, to which comparison can be made to determine a physiological status of the subject.

Experimental Results

A clinical trial was carried out with n=353 subjects, with subjects enrolled in each of the following groups:

(1) a cardiovascular group, comprising 195 subjects with an active medical diagnosis of at least one of coronary artery disease, left sided congestive heart failure with ejection fraction less than 50 percent, valvular heart disease, atrial fibrillation, or hypertension;

(2) a gastrointestinal/endocrine group, comprising 144 subjects with an active medical diagnosis of at least one of inflammatory bowel disease (including Crohn's disease, ulcerative colitis, or diverticulitis), peptic ulcer disease, IBS, cholecystitis, pancreatitis, malabsorption disorders (includin Celiac Sprue), or diabetest (Type I or Type II);

(3) a respiratory group, comprising 117 subjects with an active medical diagnosis of at least one of asthma, chronic obstructive pulmonary disease (COPD), bronchitis, emphysema, or pneumonia;

(4) a renal group, comprising 63 subjects with an active medical diagnosis of at least one of pyelonephristis, acute renal failure, or chronic renal failure stages II-V;

(5) a hepatic group, comprising 36 subjects with an active medical diagnosis of at least one of viral hepatitis, alcoholic hepatitis, steatohepatitis, or cirrhosis;

(6) a control group, comprising 64 subjects without any active medical diagnosis listed above with respect to groups (1), (2), (3), (4), and (5).

Each subject was measured using the ClearView system from Epic Research and Diagnostics, which implements devices and methods such as described in this document. Measurement sessions with the ClearView device took approximately fifteen (15) minutes. During measurement sessions, subjects were asked to place each of their ten fingertips on the ClearView device glass plate, and an image was captured, using the ClearView software. All ten (10) fingers were measured twice: once with a capacitive dielectric barrier between the fingertip and the light detector, and once without the capacitive barrier, for a

total of twenty (20) images. The capacitive barrier is configured to separate physical and psychological factors of the images. If the ClearView device operator deemed that an image is of poor quality (for example, if the subject rolled his or her finger, ambient light has entered the image, etc.), the image of that finger was retaken. To assess the reproducibility and variability of the measurements, a second measurement session was done 3-5 minutes after the first one was completed. Thus, each subject had a total of four Epic ClearView measurements, two with and two without capacitive barriers, each fingertip measurement was about 0.5 seconds in duration. The first set of measurements was used for the primary endpoint analysis for the clinical trial study.

The images were analyzed using the ClearView software, and assigned a response scale value between 0 and 5 for providing a particularized response indication of each of (1) a cardiovascular condition, (2) a gastrointestinal/endocrine condition, (3) a respiratory condition, (4) a renal condition, (5) a hepatic condition, or (6) none of the above conditions, wherein the conditions are more particularly described above with respect to the corresponding patient groups.

The primary effectiveness endpoint was the association of increasing values of the Epic ClearView response scale (0-5) with the system or organ(s) involved in an active diagnosis, as identified by a medical physician. The association was quantified using odds ratios (OR) from a logistic regression model, assessed for each of the five diagnostic groups individually. For each of the five diagnosis groups, the OR and 95% Wald confidence interval (CI) were calculated, along with the corresponding p-value. An OR that is statistically significantly different from the null value of 1.0 is evidence that the EPIC ClearView Response Scale is able to detect an association in the organ or systems involved in a known medical diagnosis.

As an example, if a subject scored a 1 (on the 0-5 scale) for the cardiovascular system (odds ratio = 4.031) at a first time measurement, and then on a subsequent visit was scanned again and scored a 2, the odds of that subject having a cardiovascular system issue increase by a factor of 4.031. If the subject had scored a 3 on the subsequent visit, the odds of that subject having a cardiovascular system issue increase by a factor of 16.25 (4.031*4.031).

Another example would be if subject A scored a 2 on the cardio scale and subject B scored a 4, the odds of subject B having a cardiovascular system issue are 16.25 times greater than subject A.

The clinical trial study results are summarized in Table. 2, below:

**Table 2. Primary Endpoint: Odds Ratio by Diagnosis Group**

| | With Capacitive Barrier | | | Without Capacitive Barrier | | |
|---|---|---|---|---|---|---|
| Diagnosis Group[1] | Odds Ratio[2] (95% Wald CI) | Raw *p*-value | Hommel Adjusted *p*-value | Odds Ratio[2] (95% Wald CI) | Raw *p*-value | Hommel Adjusted *p*-value |
| Cardiovascular (n=195)[3] | 4.031 (2.708, 5.999) | <0.0001 | <0.0001 | 2.843 (1.976, 4.089) | <0.0001 | <0.0001 |
| Gastrointestinal/ Endocrine (n=144) | 7.802 (3.909, 15.974) | <0.0001 | <0.0001 | 2.834 (1.598, 5.030) | 0.0004 | 0.0007 |
| Respiratory (n=117) | 14.156 (6.229, 32.171) | <0.0001 | <0.0001 | 7.558 (3.534, 16.164) | <0.0001 | <0.0001 |
| Renal (n=63) | 55.221 (13.500, 225.888) | <0.0001 | <0.0001 | 8.705 (3.362, 22.542) | <0.0001 | <0.0001 |
| Hepatic (n=36) | 159.923 (15.697, 1629.321) | <0.0001 | <0.0001 | 4.447 (0.313, 63.120) | 0.2703 | 0.2703 |

[1]Subjects may be included in more than 1 diagnosis group. Each analysis included 1 diagnosis group and the control group.
[2]Logistic model: Presence of disease (any qualifying diagnosis) = ClearView Response Scale result.
[3] For the control group, n=64.

As shown in Table 2, the odds ratios, confidence intervals, and p-values were calculated for each diagnosis group (including subjects in the relevant diagnosis and control groups), for measurements conducted both with and without the capacitive barrier.

The odds ratios corresponding to each of the five non-control diagnosis groups for measurements conducted with the capacitive barrier were all statistically significant. All five of the Hommel-adjusted p-values were less than 0.001.

For measurements conducted without the capacitive barrier, the odds ratios met statistical significance for four of the five diagnosis groups (Hommel-adjusted p-values less than 0.001). The odds ratio corresponding to the hepatic

diagnosis group had a corresponding p-value of 0.270 for measurements conducted without the capacitive barrier. However, this may be a reflection of the relatively small sample size of the hepatic group (n=36) and the odds ratio was greater than 1.0.

The odds ratios indicate that the ClearView response scale is able to detect an abnormal condition of a particular organ, system, etc. or a trend in the status of that abnormal condition.

Another way to help understand the strength of the ClearView analytics is to look at the sensitivity and specificity plots, Receiver Operating Characteristic (ROC) and Area Under Curve (AUC) plots, and predicted probability plots. An ROC curve can be used to evaluate and compare the performance of diagnostic tests or to evaluate model fit. An ROC curve can be expressed as a plot of the proportion of true positives (actual events predicted to be events) versus the proportion of false positives (nonevents predicted to be events) for various cut-offs on the diagnostic tool scale. The ROC curve can be expressed as a plot of sensitivity against specificity for different cut-points of the ClearView response scale (0-5).

The area under the ROC curve (AUC) is an overall measure of device performance (or accuracy in classifying patients as diseased or not). An AUC value of 1.0 means the test can perfectly predict the presence or absence of the disease or other abnormal condition. An AUC value of 0.5 means that one may as well just flip a coin as perform the test. Therefore, AUC values closer to 1 are best.

Logistic regression can give the predicted probability of having the disease or other abnormal condition for a specific ClearView response scale result. The interpretation is: if you have a ClearView result of X, then your predicted probability of having disease is Y. On such a plot, one can read up the X-axis for a result and then over to the Y-axis to get the probability of disease. A 95% confidence interval for the probability can be presented.

FIG. 9A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal cardiovascular condition,

FIG. 9B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described

herein (including using the dielectric barrier 103), for an abnormal cardiovascular condition, with the shaded area representing a 95% confidence interval.

FIG. 9C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal cardiovascular condition,

FIG. 9D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal cardiovascular condition, with the shaded area representing a 95% confidence interval.

FIG. 10A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal gastrointestinal condition,

FIG. 10B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal gastrointestinal condition, with the shaded area representing a 95% confidence interval.

FIG. 10C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal gastrointestinal condition,

FIG. 10D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal gastrointestinal condition, with the shaded area representing a 95% confidence interval.

FIG. 11A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal renal condition,

FIG. 11B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal renal condition, with the shaded area representing a 95% confidence interval.

FIG. 11C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal renal condition,

FIG. 11D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal renal condition, with the shaded area representing a 95% confidence interval.

FIG. 12A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal hepatic condition,

FIG. 12B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal hepatic condition, with the shaded area representing a 95% confidence interval.

FIG. 12C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal hepatic condition,

FIG. 12D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal hepatic condition, with the shaded area representing a 95% confidence interval.

FIG. 13A is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal respiratory condition,

FIG. 13B shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (including using the dielectric barrier 103), for an abnormal respiratory condition, with the shaded area representing a 95% confidence interval.

FIG. 13C is an ROC plot of Sensitivity vs. Specificity of the clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal respiratory condition,

FIG. 13D shows predicted probability vs. ClearView response scale score (on a 0-5 scale) of clinical trial data obtained, using the techniques described herein (without using the dielectric barrier 103), for an abnormal

respiratory condition, with the shaded area representing a 95% confidence interval.

FIGS. 9A-9D, 10A-10D, 11A-11D, 12A-12D, and 13A-13D indicate that ClearView apparatus and methods, as described herein, is able to detect an abnormal condition for providing a particularized response indication that is particular to the specified particular body anatomy location, component, or system comprising a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system.

Additional Notes & Examples

Example 1 can include subject matter (such as an apparatus, a method, a means for performing acts, or a storage device or other tangible nontransitory device-readable medium including instructions that, when performed by the device, cause the device to perform acts) that can include or use obtaining at least two (spatial) dimensional (2D) spatial or spatiotemporal response information (such as an image, a time-series of images, or frequency domain or time-frequency information derived from images or other response information) of visible or other light (e.g., in the electromagnetic spectrum between the visible spectrum and UV spectrum, inclusive) associated with a body part, such as around a finger or toe of a subject. The spatial response information can be obtained at a light detector capable of providing information about at least first and second spatial dimensions that are orthogonal to each other, and can optionally include a temporal or frequency dimension. The light can be obtained in response to electromagnetic field (e.g., electrical) stimulation of the finger or toe sufficient to produce the light at the light detector around the finger or toe.

The spatial response information can be mapped, registered, or otherwise associated to a specified particular body anatomy, location, component, or system (e.g., that is particular to a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system) that is remote from the finger or toe at which the image information was obtained. The associating can include radially sectorizing the at least 2D spatial response information—which can be included in at least two spatial dimensional spatiotemporal response information, such as a time series of images, for example. A plurality of coefficients or parameters can be

computed (e.g., Center Point, Minimum Radius, Maxim Radius, Image Angle, Background Noise Level, Inner Radius, Area, Intensity, Form, Form 2, Entropy, Fractal, NS, or Break). Computing coefficients or parameters can include using the radially sectorized 2D spatial response information to compute at least one of the parameters (e.g., Area, Intensity, Form, Form 2, Entropy, Fractal, NS, or Break), which can be computed for a particular radial sector (or a specified subset of the radial sectors that is smaller than the set of all radial sectors).

At least one of the parameters can be adjusted (e.g., scaled, normalized, discarded) or compared (e.g., to a corresponding threshold value, or to a population or subpopulation distribution of values) using information from a clinical knowledge base (e.g., stored in a memory circuit, a database, or obtained) representative of a population of patients including using at least some patients other than the subject (e.g., in addition or as an alternative to information obtained from the same subject).

The at least one adjusted parameter can be used for using the spatial response information for providing a particularized response indication (e.g., a odds ratio or other form of physiological status indicator) that is particular to the specified particular body anatomy, location, component, or system.

Example 2 can include or use, or can optionally be combined with the subject matter of Example 1 to optionally include or use, the particularized response indication indicating a relative risk (e.g., using an odds ratio or other indication) of an abnormal physiological state of the specified particular body anatomy, location, component, or system relative to at least one of (1) at least one other particular body anatomy, location, component, or system or (2) a normal physiological state of the specified particular body anatomy, location, component, or system.

Example 3 can include or use, or can optionally be combined with the subject matter of any of Examples 1 or 2 to optionally include or use, the at least 2D spatial response information being pre-processed, e.g., before computing the plurality of parameters, such as to attenuate or ignore one or more spatial response artifacts within at least one designated area of the at least 2D spatial response information (e.g., within an ellipse or other area corresponding to the outline of the fingertip).

Example 4 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 3 to optionally include or use, the signal processor circuit being configured such that the at least 2D spatial response information can be pre-processed, e.g., before computing the plurality of parameters, such as to automatically orient the at least 2D spatial response information at least one of rotationally or translationally. This can include using the live image to orient the energized image to within a few degrees, as explained above.

Example 5 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 4 to optionally include or use, the at least 2D spatial response information being pre-processed, e.g., before computing the plurality of parameters, such as to calibrate the at least 2D spatial response information. Such calibration can include using calibration at least 2D spatial response information obtained using a specified manufacture (e.g., size, shape, material) of calibration probe (e.g., a solid cylindrical tungsten or other metal calibration probed) in place of the finger or toe of the subject.

Example 6 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 5 to optionally include or use, the calibration at least 2D spatial response information to normalize the at least 2D spatial response information across different light detectors. This can help reduce or eliminate variability between measurements made with different apparatuses such as described herein.

Example 7 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 6 to optionally include or use, the calibration at least 2D spatial response information to adjust at least one of the parameters.

Example 8 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 6 to optionally include or use, the calibration at least 2D spatial response information for qualifying whether the at least 2D spatial response information is suitable for use for computing at least one of the parameters.

Example 9 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 7 to optionally include or use, the particularized response indication being exclusive to the specified particular

body anatomy, location, component, or system, and being exclusive of other particular body anatomy, locations, components, or systems.

Example 10 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 9 to optionally include or use, the associating including computing the particularized response indication using both at least 2D spatial light intensity aggregate and density information.

Example 11 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 10 to optionally include or use, an electrode that can be configured to provide the electromagnetic field or electrical stimulation to the finger or toe of the subject. The stimulation can include AC electrical stimulation. The electrode can be transparent enough to pass at least a portion of the visible or other light around the finger or toe of a subject. The light detector can be included in the apparatus. The light detector can be configured to receive from the electrode the passed at least a portion of the visible or other light around the finger or toe of a subject. The light detector can be configured to provide to the signal processor circuit at least two-dimensional (2D) spatial response information of visible or other light around a finger or toe of a subject. A dielectric barrier can be provided, such as between (1) the finger or toe of the subject and (2) the electrode or the light detector. The dielectric barrier can be configured to be transparent enough to pass at least a portion of the visible or other light around the finger or toe of the subject. The particularized response indication can be exclusive to the specified particular body anatomy, location, component, or system, and can be exclusive of other particular body anatomy, locations, components, or systems. The associating can include computing the particularized response indication using both at least 2D spatial light intensity aggregate and density information. The spatial response information can include at least 2D first spatial response information and at least 2D second spatial response information. The associating can include computing the particularized response information using differential or other relative information that can be determined between (1) the at least 2D first spatial response information, obtained with the presence of a dielectric barrier between the finger or toe and the light detector, and (2) the at least 2D second spatial response information, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

Example 12 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 11 to optionally include or use, the spatial response information including at least 2D first spatial response information and at least 2D second spatial response information. The associating can include computing the particularized response information using differential or other relative information determined between (1) the at least 2D first spatial response information, obtained with the presence of a dielectric barrier between the finger or toe and the light detector, and (2) the at least 2D second spatial response information, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

Example 13 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 12 to optionally include or use the associating including computing the particularized response indication using a trending over time of each of the spatial light intensity aggregate information and the spatial light intensity density information.

Example 14 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 13 to optionally include or use the associating including computing the particularized response indication using a polynomial relationship of an area and an average intensity of the spatial light intensity information.

Example 15 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 14 to optionally include or use, determining a physiological status indicator (e.g., an odds ratio indicating a relative likelihood of an abnormal physiological state) using the particularized response information. The physiological status indicator can be provided to a user or automated process.

Example 16 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 15 to optionally include or use the spatial response information for providing a particularized response indication that is particular to the specified particular body anatomy location, component, or system comprising a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system.

Example 17 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 16 to optionally include or use, the spatial response information for providing a particularized response indication including determining an Entropy parameter of the spatial response information.

Example 18 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 17 to optionally include or use, the spatial response information for providing a particularized response indication including determining a Form parameter of the spatial response information that is within a specified centered first annulus region between an inner first radius of the annulus and an outer second radius of the annulus.

Example 19 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 18 to optionally include or use, the spatial response information for providing the particularized response indication including also determining a Form 2 parameter of the spatial response information that is within a specified centered second annulus region between the inner first radius of the annulus and an outer third radius of the annulus, wherein the third radius exceeds the second radius.

Example 20 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 19 to optionally include or use, the spatial response information for providing the particularized response indication includes determining a Fractal parameter of the spatial response information using (1) a perimeter of spatial response pixels exceeding a specified threshold value and (2) a spatial variation in the perimeter of spatial response pixels exceeding the specified threshold value.

Example 21 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 20 to optionally include or use, the spatial response information including an at least 2D first spatial response information and an at least 2D second spatial response information, and wherein the translating the spatial response information into a particularized response indication includes using first differential information determined between (1) the first spatial response, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the second image, obtained without the presence of the dielectric barrier between the finger or toe and the light detector; and

wherein the spatial response includes an at least 2D third spatial response and an at least 2D fourth spatial response, and wherein the translating the spatial response information into a particularized response indication includes using second differential information determined between (1) the third spatial response, obtained as a calibration spatial response with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the fourth spatial response, obtained as a calibration image without the presence of the dielectric barrier between the finger or toe and the light detector.

Example 22 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 21 to optionally include or use, the second spatial response, the third spatial response, and the fourth spatial response being obtained from the same subject and same day calibration spatial response.

Example 23 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 22 to optionally include or use, the first spatial response and the second spatial response being obtained from the same subject, and wherein the third spatial response and the fourth spatial response are obtained by composite information from different subjects.

Example 24 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 23 to optionally include or use, the spatial response including a first spatial response and a second spatial response, and wherein the translating the spatial response information into a particularized response indication includes computing the particularized response indication using an NS parameter determined from (1) a composite intensity and (2) a spatial extent of active pixels, as determined for each of (1) the first spatial response, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the second spatial response, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

Example 25 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 19 to optionally include or use, the spatial response information for providing a particularized response indication includes computing the physiological status indicator using an NS parameter

determined from (1) a composite intensity and (2) a spatial extent of active pixels.

Example 26 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 25 to optionally include or use, sampling the spatial response information repeatedly over sampling period of interest at a sampling rate exceeding twice a frequency bandwidth of a parameter of interest; determining a frequency characteristic of the parameter of interest; and determining the physiological status indication using the frequency characteristic of the parameter of interest.

Example 27 can include or use, or can optionally be combined with the subject matter of any of Examples 1 through 26 to optionally include or use, displaying a visual illustration of the subject; and labeling the specified particular body anatomy, location, component, or system with information about the particularized response indicator that is particular to the specified particular body anatomy, location, component, or system.

These non-limiting examples can be combined in any permutation or combination.

The above detailed description includes references to the accompanying drawings, which form a part of the detailed description. The drawings show, by way of illustration, specific embodiments in which the invention can be practiced. These embodiments are also referred to herein as "examples." Such examples can include elements in addition to those shown or described. However, the present inventors also contemplate examples in which only those elements shown or described are provided. Moreover, the present inventors also contemplate examples using any combination or permutation of those elements shown or described (or one or more aspects thereof), either with respect to a particular example (or one or more aspects thereof), or with respect to other examples (or one or more aspects thereof) shown or described herein.

In the event of inconsistent usages between this document and any documents incorporated by reference, the usage in this document controls.

In this document, the terms "a" or "an" are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of "at least one" or "one or more." In this document, the term "or" is used to refer to a nonexclusive or, such that "A or B" includes "A but not B," "B

but not A," and "A and B," unless otherwise indicated. In this document, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Also, in the following claims, the terms "including" and "comprising" are open-ended, that is, a system, device, article, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

Method examples described herein can be machine or computer-implemented at least in part. Some examples can include a computer-readable medium or machine-readable medium encoded with instructions operable to configure an electronic device to perform methods as described in the above examples. An implementation of such methods can include code, such as microcode, assembly language code, a higher-level language code, or the like. Such code can include computer readable instructions for performing various methods. The code may form portions of computer program products. Further, in an example, the code can be tangibly stored on one or more volatile, non-transitory, or non-volatile tangible computer-readable media, such as during execution or at other times. Examples of these tangible computer-readable media can include, but are not limited to, hard disks, removable magnetic disks, removable optical disks (e.g., compact disks and digital video disks), magnetic cassettes, memory cards or sticks, random access memories (RAMs), read only memories (ROMs), and the like.

The above description is intended to be illustrative, and not restrictive. For example, the above-described examples (or one or more aspects thereof) may be used in combination with each other. Other embodiments can be used, such as by one of ordinary skill in the art upon reviewing the above description. The Abstract is provided to comply with 37 C.F.R. §1.72(b), to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. Also, in the above Detailed Description, various features may be grouped together to streamline the disclosure. This should not be interpreted as intending that an unclaimed disclosed feature is essential to any

claim. Rather, inventive subject matter may lie in less than all features of a particular disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment, and it is contemplated that such embodiments can be combined with each other in various combinations or permutations. The scope of the invention should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

THE CLAIMED INVENTION IS:

1. An apparatus comprising:

a signal processor circuit, configured to:

obtain at least two-dimensional (2D) spatial response information of visible or other light around a finger or toe of a subject, the spatial response information obtained at a light detector configured to be capable of providing information regarding at least first and second spatial dimensions that are orthogonal to each other, the light obtained in response to electrical stimulation of the finger or toe sufficient to produce the light around the finger or toe; and

associate the spatial response information to a specified particular body anatomy, location, component, or system that is remote from the finger or toe at which the spatial response information was obtained, the associating including :

radially sectorizing the at least 2D spatial response information;

computing a plurality of parameters, including using the radially sectorized at least 2D spatial response information to compute at least one of the parameters;

adjusting or comparing at least one of the parameters using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject; and

using the at least one adjusted parameter for using the spatial response information for providing a particularized response indication that is particular to the specified particular body anatomy, location, component, or system.

2. The apparatus of claim 1, wherein the signal processor circuit is configured such that the particularized response indication indicates a relative risk of an abnormal physiological state of the specified particular body anatomy, location, component, or system relative to at least one of (1) at least one other particular body anatomy, location, component, or system or (2) a normal

physiological state of the specified particular body anatomy, location, component, or system.

3. The apparatus of at least one of claims 1 or 2, wherein the signal processor circuit is configured such that the at least 2D spatial response information is pre-processed, before computing the plurality of parameters, to attenuate or ignore one or more spatial response artifacts within at least one designated area of the at least 2D spatial response information.

4. The apparatus of at least one of claims 1 through 3, wherein the signal processor circuit is configured such that the at least 2D spatial response information is pre-processed, before computing the plurality of parameters, to automatically orient the at least 2D spatial response information at least one of rotationally or translationally.

5. The apparatus of at least one of claims 1 through 4, wherein the signal processor circuit is configured such that the at least 2D spatial response information is pre-processed, before computing the plurality of parameters, to calibrate the at least 2D spatial response information using calibration at least 2D spatial response information obtained using a specified manufacture of calibration probe in place of the finger or toe of the subject.

6. The apparatus of claim 5, wherein the signal processor circuit is configured to use the calibration at least 2D spatial response information to normalize the at least 2D spatial response information across different light detectors.

7. The apparatus of at least one of claims 5 or 6, wherein the signal processor circuit is configured to use the calibration at least 2D spatial response information to adjust at least one of the parameters.

8. The apparatus of at least one of claims 5 through 7, wherein the signal processor circuit is configured to use the calibration at least 2D spatial response information to qualify whether the at least 2D spatial response information is suitable for use for computing at least one of the parameters.

9. The apparatus of at least one of claims 1 through 8, comprising:

an electrode, configured to provide the electrical stimulation to the finger or toe of the subject, wherein the electrical stimulation includes AC electrical stimulation, the electrode transparent enough to pass at least a portion of the visible or other light around the finger or toe of a subject;

the light detector, configured to receive from the electrode the passed at least a portion of the visible or other light around the finger or toe of a subject, the light detector configured to provide to the signal processor circuit at least two-dimensional (2D) spatial response information of visible or other light around a finger or toe of a subject;

a dielectric barrier, between (1) the finger or toe of the subject and (2) the electrode or the light detector, wherein the dielectric barrier is configured to be transparent enough to pass at least a portion of the visible or other light around the finger or toe of the subject;

wherein the particularized response indication is exclusive to the specified particular body anatomy, location, component, or system, and is exclusive of other particular body anatomy, locations, components, or systems;

wherein the associating includes computing the particularized response indication using both at least 2D spatial light intensity aggregate and density information; and

wherein the spatial response information includes at least 2D first spatial response information and at least 2D second spatial response information, and wherein the associating includes computing the particularized response information using differential or other relative information determined between (1) the at least 2D first spatial response information, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the at least 2D second spatial response information, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

10. The apparatus of any one of claims 1 or 2, wherein the signal processor circuit is configured to determine the particularized response indication including trending over time both at least 2D spatial light intensity aggregate and density information.

11. The apparatus of any one of claims 1 through 10, wherein the signal processor circuit is configured to determine the particularized response indication using a polynomial relationship of an area and an average intensity of spatial light intensity information.

12. The apparatus of any one of claims 1 through 11, wherein the signal processor circuit is configured to:

determine a physiological status indicator using the particularized response information; and

provide the physiological status indicator to a user or automated process.

13. The apparatus of any one of claims 1 through 12, wherein the signal processor circuit is configured to use the spatial response information for providing a particularized response indication that is particular to a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system.

14. The apparatus of any one of claims 1 through 13, wherein the signal processor circuit is configured to use the spatial response information for providing a physiological status indicator that is particular to a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system.

15. The apparatus of any one of claims 1 through 14, wherein the signal processor circuit is configured to use the spatial response information for providing a particularized response indication including using a determining of an Entropy parameter of the spatial response information.

16. The apparatus of any one of claims 1 through 15, wherein the signal processor circuit is configured to use the spatial response information for providing a particularized response indication including using a determining a Form parameter of the spatial response information that is within a specified centered first annulus region between an inner first radius of the annulus and an outer second radius of the annulus.

17. The apparatus of claim 16, wherein the signal processor circuit is configured to use the spatial response information for providing the particularized response indication including also determining a Form 2 parameter of the spatial response information that is within a specified centered second annulus region between the inner first radius of the annulus and an outer third radius of the annulus, wherein the third radius exceeds the second radius.

18. The apparatus of any one of claims 1 through 17, wherein the signal processor circuit is configured to use the spatial response information for providing the particularized response indication including determining a Fractal parameter of the spatial response information using (1) a perimeter of spatial response pixels exceeding a specified threshold value and (2) a spatial variation in the perimeter of spatial response pixels exceeding the specified threshold value.

19. The apparatus of any one of claims 1 through 18, wherein the spatial response information includes an at least 2D first spatial response information and an at least 2D second spatial response information, and wherein the signal processor circuit is configured to use the spatial response information for providing a particularized response indication including using first differential information determined between (1) the first spatial response, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the second image, obtained without the presence of the dielectric barrier between the finger or toe and the light detector; and

wherein the spatial response includes an at least 2D third spatial response and an at least 2D fourth spatial response, and wherein the signal processor circuit is configured to use the spatial response information for providing a

particularized response indication including using second differential information determined between (1) the third spatial response, obtained as a calibration spatial response with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the fourth spatial response, obtained as a calibration image without the presence of the dielectric barrier between the finger or toe and the light detector.

20. The apparatus of claim 19, wherein the first spatial response, the second spatial response, the third spatial response, and the fourth spatial response are obtained from the same subject and same day calibration spatial response.

21. The apparatus of claim 19, wherein the first spatial response and the second spatial response are obtained from the same subject, and wherein the third spatial response and the fourth spatial response are obtained by composite information from different subjects.

22. The apparatus of any one of claims 1 through 21, wherein the spatial response includes a first spatial response and a second spatial response, and wherein the signal processor circuit is configured to use the spatial response information for providing a particularized response indication including computing the particularized response indication using an NS parameter determined from (1) a composite intensity and (2) a spatial extent of active pixels, as determined for each of (1) the first spatial response, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the second spatial response, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

23. The apparatus of any one of claims 1 through 22, wherein the signal processor circuit is configured to use the spatial response information for providing a particularized response indication including computing the physiological status indicator using an NS parameter determined from (1) a composite intensity and (2) a spatial extent of active pixels.

24. The apparatus of any one of claims 1 through 23, wherein the signal processor circuit is configured to:

sample the spatial response information repeatedly over sampling period of interest at a sampling rate exceeding twice a frequency bandwidth of a parameter of interest;

determine a frequency characteristic of the parameter of interest; and

determine a physiological status indication using the frequency characteristic of the parameter of interest.

25. The apparatus of any one of claims 1 through 24, comprising:

a display, configured to display a visual illustration of the subject; and

wherein the display is configured to label a displayed indication of the specified particular body anatomy, location, component, or system with information about the particularized response indicator that is particular to the specified particular body anatomy, location, component, or system.

26. A method comprising:

obtaining at least two-dimensional (2D) spatial response information of visible or other light around a finger or toe of a subject, the spatial response information obtained at a light detector capable of providing information about at least first and second spatial dimensions that are orthogonal to each other, the light obtained in response to electrical stimulation of the finger or toe sufficient to produce the light at the light detector around the finger or toe; and

associating the spatial response information to a specified particular body anatomy, location, component, or system that is remote from the finger or toe at which the image information was obtained, the associating including:

radially sectorizing the at least 2D spatial response information;

computing a plurality of parameters, including using the radially sectorized at least 2D spatial response information to compute at least one of the parameters;

adjusting or comparing at least one of the parameters using information from a clinical knowledge base representative of a population of patients including using at least some patients other than the subject; and

using the at least one adjusted parameter for using the spatial response information for providing a particularized response indication that is particular to the specified particular body anatomy, location, component, or system.

27. The method of claim 26, wherein the particularized response indication indicates a relative risk of an abnormal physiological state of the specified particular body anatomy, location, component, or system relative to at least one of (1) at least one other particular body anatomy, location, component, or system or (2) a normal physiological state of the specified particular body anatomy, location, component, or system.

28. The method of at least one of claims 26 or 27, wherein the at least 2D spatial response information is pre-processed, before computing the plurality of parameters, to attenuate or ignore one or more spatial response artifacts within at least one designated area of the at least 2D spatial response information.

29. The method of at least one of claims 26 through 28, wherein the signal processor circuit is configured such that the at least 2D spatial response information is pre-processed, before computing the plurality of parameters, to automatically orient the at least 2D spatial response information at least one of rotationally or translationally.

30. The method of at least one of claims 26 through 29, wherein the at least 2D spatial response information is pre-processed, before computing the plurality of parameters, to calibrate the at least 2D spatial response information using calibration at least 2D spatial response information obtained using a specified manufacture of calibration probe in place of the finger or toe of the subject.

31. The method of claim 30, comprising using the calibration at least 2D spatial response information to normalize the at least 2D spatial response information across different light detectors.

32. The method of at least one of claims 30 or 31, comprising using the calibration at least 2D spatial response information to adjust at least one of the parameters.

33. The method of at least one of claims 30 through 32, comprising using the calibration at least 2D spatial response information for qualifying whether the at least 2D spatial response information is suitable for use for computing at least one of the parameters.

34. The method of any one of claims 26-33, wherein the particularized response indication is exclusive to the specified particular body anatomy, location, component, or system, and is exclusive of other particular body anatomy, locations, components, or systems.

35. The method of any one of claims 26 through 34, wherein the associating includes computing the particularized response indication using both at least 2D spatial light intensity aggregate and density information.

36. The method of any one of claims 26 through 35, wherein the spatial response information includes at least 2D first spatial response information and at least 2D second spatial response information, and wherein the associating includes computing the particularized response information using differential or other relative information determined between (1) the at least 2D first spatial response information, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the at least 2D second spatial response information, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

37. The method of any one of claims 26 through 36, wherein the associating includes computing the particularized response indication using a trending over time of each of the spatial light intensity aggregate information and the spatial light intensity density information.

38. The method of any one of claims 26 through 37, wherein the associating includes computing the particularized response indication using a polynomial relationship of an area and an average intensity of the spatial light intensity information.

39. The method of any one of claims 26 through 38, comprising:

determining a physiological status indicator using the particularized response information; and

providing the physiological status indicator to a user or automated process.

40. The method of any one of claims 26 through 39, comprising using the spatial response information for providing a particularized response indication that is particular to the specified particular body anatomy location, component, or system comprising a selected particular one of: a cardiovascular system, a gastrointestinal/endocrine system, a respiratory system, a renal system, or a hepatic system.

41. The method of any one of claims 26 through 40, wherein using the spatial response information for providing a particularized response indication includes determining an Entropy parameter of the spatial response information.

42. The method of any one of claims 26 through 41, wherein using the spatial response information for providing a particularized response indication includes determining a Form parameter of the spatial response information that is within a specified centered first annulus region between an inner first radius of the annulus and an outer second radius of the annulus.

43. The method of claim 42, wherein using spatial response information for providing the particularized response indication includes also determining a Form 2 parameter of the spatial response information that is within a specified centered second annulus region between the inner first radius of the annulus and an outer third radius of the annulus, wherein the third radius exceeds the second radius.

44. The method of any one of claims 26 through 43, wherein using spatial response information for providing the particularized response indication includes determining a Fractal parameter of the spatial response information using (1) a perimeter of spatial response pixels exceeding a specified threshold value and (2) a spatial variation in the perimeter of spatial response pixels exceeding the specified threshold value.

45. The method of any one of claims 26 through 44, wherein the spatial response information includes an at least 2D first spatial response information and an at least 2D second spatial response information, and wherein the using the spatial response information for providing a particularized response indication includes using first differential information determined between (1) the first spatial response, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the second image, obtained without the presence of the dielectric barrier between the finger or toe and the light detector; and

wherein the spatial response includes an at least 2D third spatial response and an at least 2D fourth spatial response, and wherein using the spatial response information for providing a particularized response indication includes using second differential information determined between (1) the third spatial response, obtained as a calibration spatial response with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the fourth spatial response, obtained as a calibration image without the presence of the dielectric barrier between the finger or toe and the light detector.

46. The method of claim 45, wherein the first spatial response, the second spatial response, the third spatial response, and the fourth spatial response are obtained from the same subject and same day calibration spatial response.

47. The method of claim 45, wherein the first spatial response and the second spatial response are obtained from the same subject, and wherein the third spatial response and the fourth spatial response are obtained by composite information from different subjects.

48. The method of any one of claims 26 through 47, wherein the spatial response includes a first spatial response and a second spatial response, and wherein the using the spatial response information for providing a particularized response indication includes computing the particularized response indication using an NS parameter determined from (1) a composite intensity and (2) a spatial extent of active pixels, as determined for each of (1) the first spatial response, obtained with the presence of a dielectric barrier between the finger or toe and the light detector; and (2) the second spatial response, obtained without the presence of the dielectric barrier between the finger or toe and the light detector.

49. The method of any one of claims 26 through 48, wherein using the spatial response information for providing a particularized response indication includes computing the physiological status indicator using an NS parameter determined from (1) a composite intensity and (2) a spatial extent of active pixels.

50. The method of any one of claims 26 through 49, comprising:

sampling the spatial response information repeatedly over sampling period of interest at a sampling rate exceeding twice a frequency bandwidth of a parameter of interest;

determining a frequency characteristic of the parameter of interest; and

determining the physiological status indication using the frequency characteristic of the parameter of interest.

51. The method of any one of claims 26 through 50, comprising:

displaying a visual illustration of the subject; and

labeling the specified particular body anatomy, location, component, or system with information about the particularized response indicator that is particular to the specified particular body anatomy, location, component, or system.

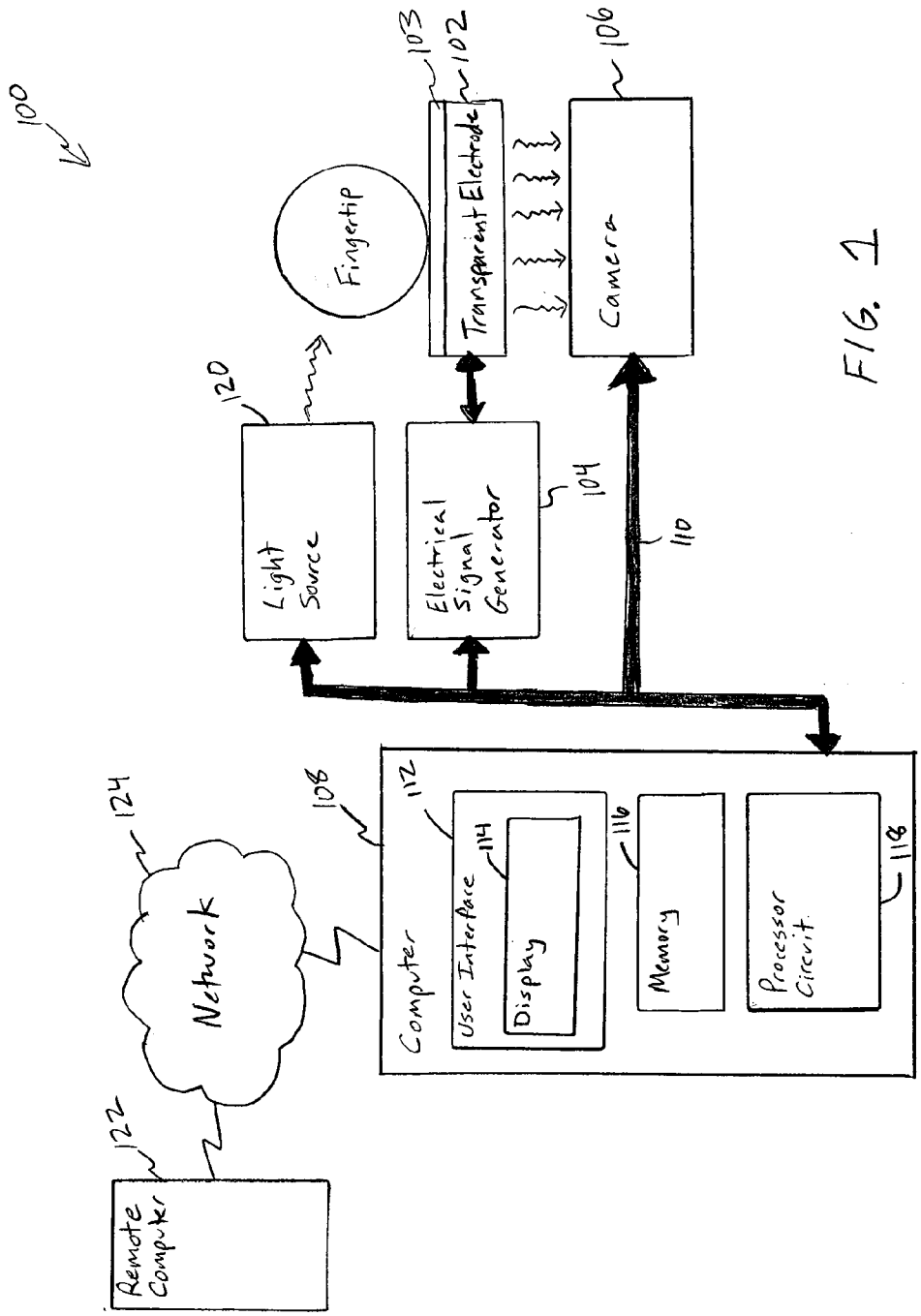

100
Fingertip
103
102
Transparent Electrode
106
Camera
120
Light Source
Electrical Signal Generator
104
110
108
Computer
112
User Interface
114
Display
116
Memory
118
Processor Circuit
124
Network
122
Remote Computer

FIG. 1

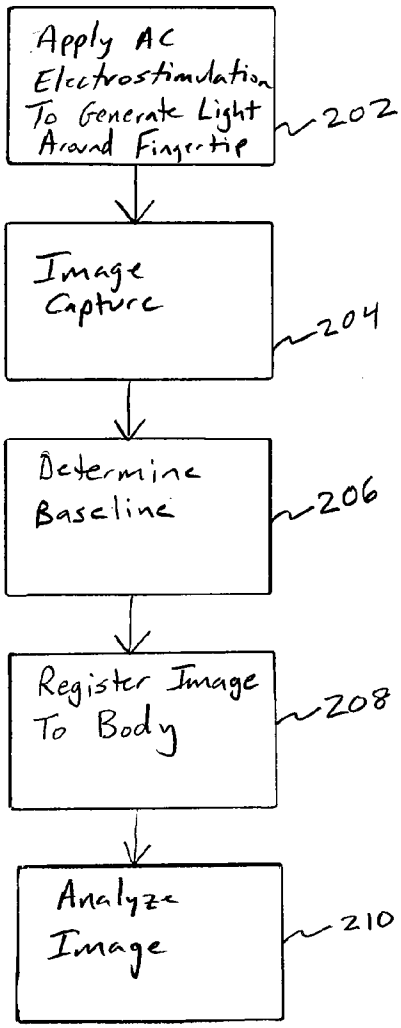

Apply AC Electrostimulation To Generate Light Around Fingertip
202
Image Capture
204
Determine Baseline
206
Register Image To Body
208
Analyze Image
210

FIG. 2

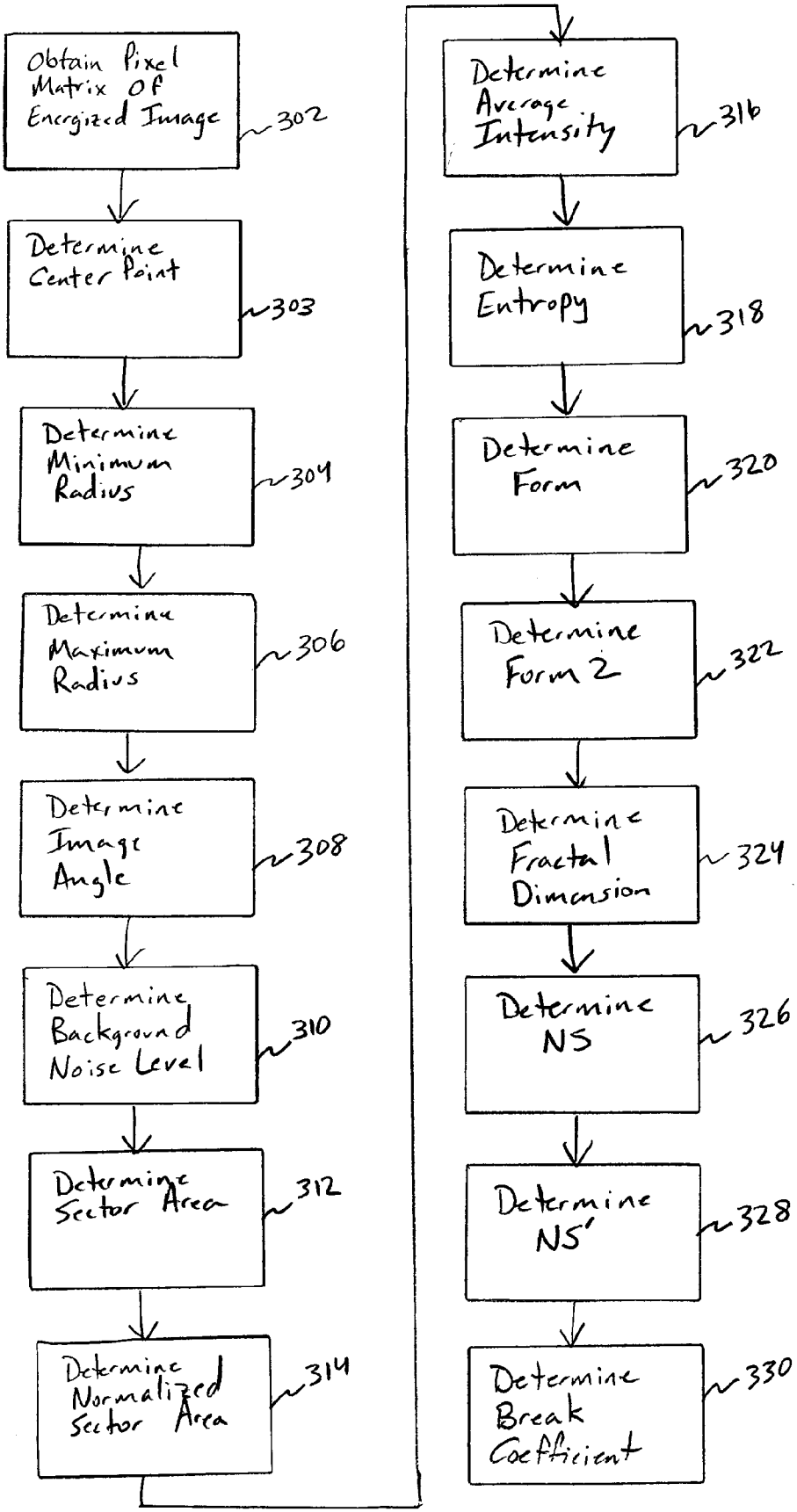

Obtain Pixel Matrix Of Energized Image
302
Determine Center Point
303
Determine Minimum Radius
304
Determine Maximum Radius
306
Determine Image Angle
308
Determine Background Noise Level
310
Determine Sector Area
312
Determine Normalized Sector Area
314
Determine Average Intensity
316
Determine Entropy
318
Determine Form
320
Determine Form 2
322
Determine Fractal Dimension
324
Determine NS
326
Determine NS'
328
Determine Break Coefficient
330

FIG. 3

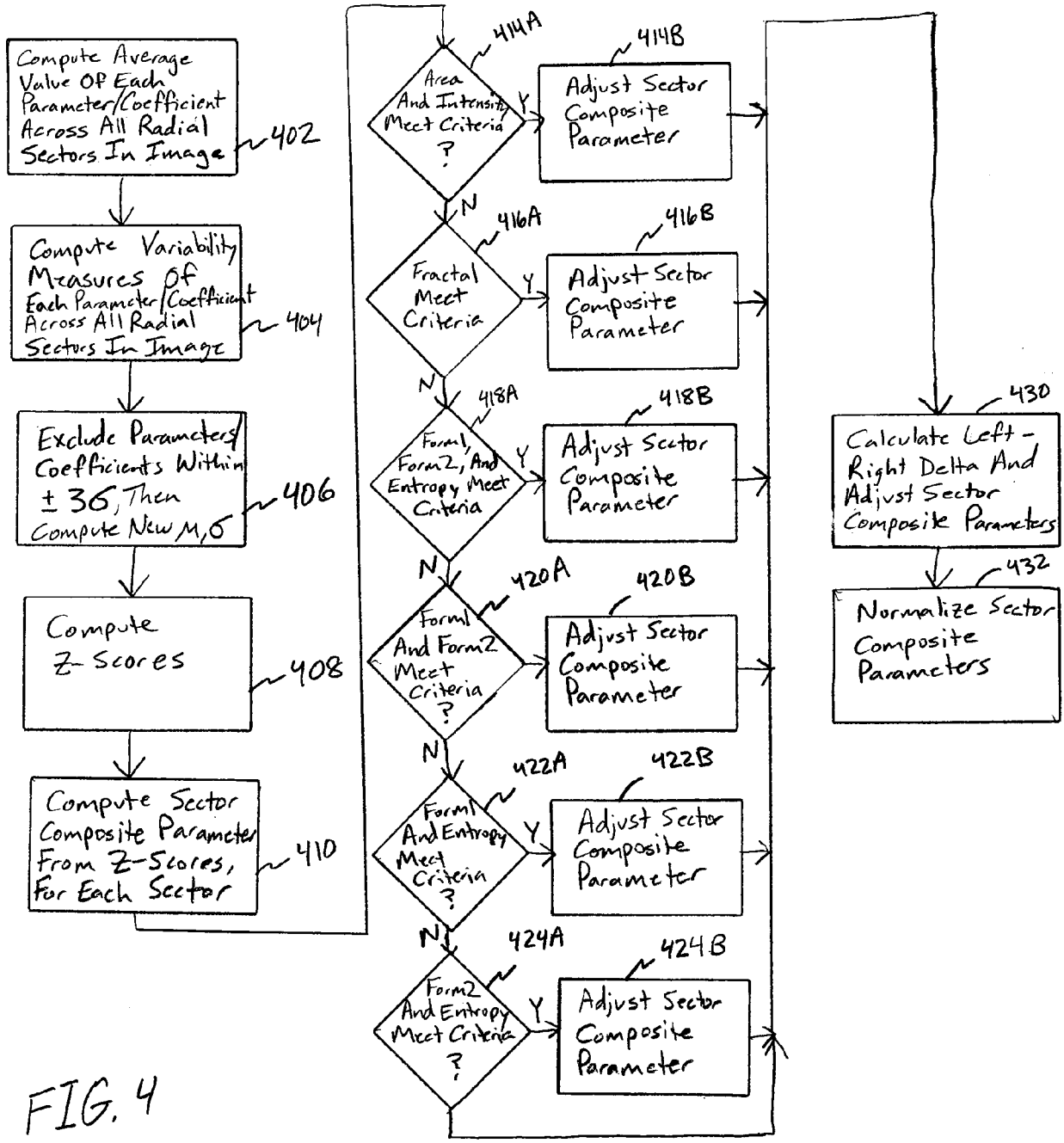
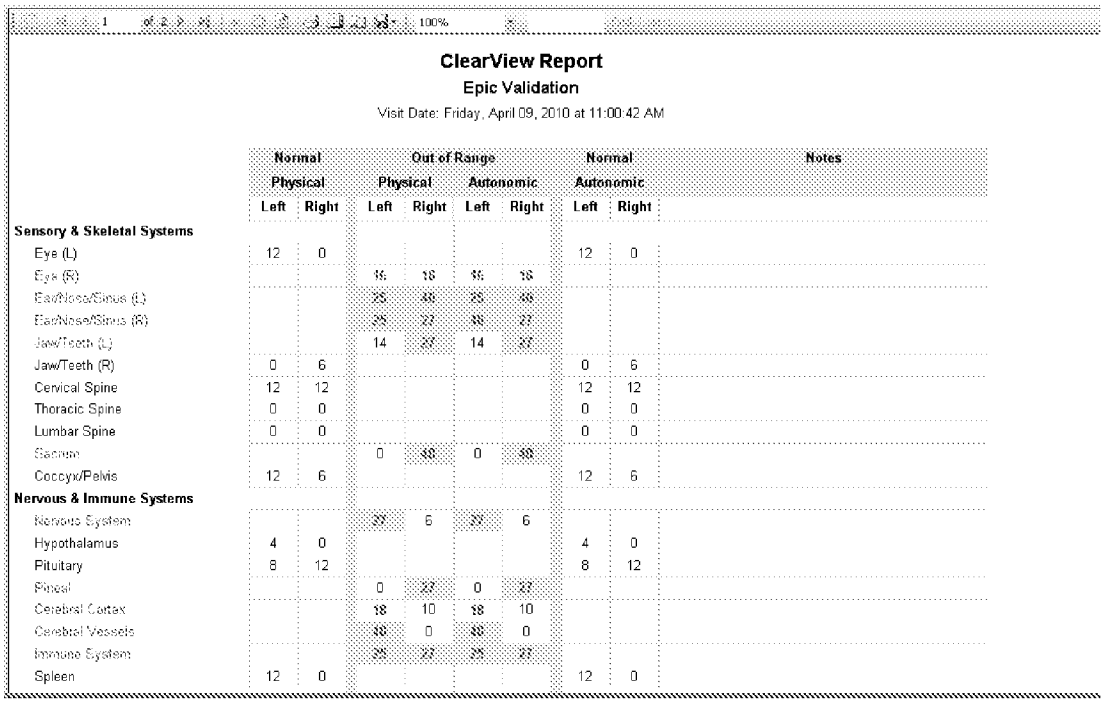

Compute Average Value Of Each Parameter/Coefficient Across All Radial Sectors In Image
402
Compute Variability Measures Of Each Parameter/Coefficient Across All Radial Sectors In Image
404
Exclude Parameters/Coefficients Within ± 3σ, Then Compute New μ, σ
406
Compute Z-Scores
408
Compute Sector Composite Parameter From Z-Scores, For Each Sector
410
414A
Area And Intensity Meet Criteria ?
Y
414B
Adjust Sector Composite Parameter
N
416A
Fractal Meet Criteria
Y
416B
Adjust Sector Composite Parameter
N
418A
Form1, Form2, And Entropy Meet Criteria
Y
418B
Adjust Sector Composite Parameter
N
420A
Form1 And Form2 Meet Criteria ?
420B
Adjust Sector Composite Parameter
N
422A
Form1 And Entropy Meet Criteria ?
Y
422B
Adjust Sector Composite Parameter
N
424A
Form2 And Entropy Meet Criteria ?
Y
424B
Adjust Sector Composite Parameter
430
Calculate Left-Right Delta And Adjust Sector Composite Parameters
432
Normalize Sector Composite Parameters

FIG. 4



**ClearView Report**

**Epic Validation**

Visit Date: Friday, April 09, 2010 at 11:00:42 AM

| | Normal Physical | | Out of Range Physical | | Out of Range Autonomic | | Normal Autonomic | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | Left | Right | Left | Right | Left | Right | Left | Right | |
| **Sensory & Skeletal Systems** | | | | | | | | | |
| Eye (L) | 12 | 0 | | | | | 12 | 0 | |
| Eye (R) | | | 18 | 18 | 18 | 18 | | | |
| Ear/Nose/Sinus (L) | | | 28 | 28 | 28 | 28 | | | |
| Ear/Nose/Sinus (R) | | | 28 | 28 | 28 | 28 | | | |
| Jaw/Teeth (L) | | | 14 | 28 | 14 | 28 | | | |
| Jaw/Teeth (R) | 0 | 6 | | | | | 0 | 6 | |
| Cervical Spine | 12 | 12 | | | | | 12 | 12 | |
| Thoracic Spine | 0 | 0 | | | | | 0 | 0 | |
| Lumbar Spine | 0 | 0 | | | | | 0 | 0 | |
| Sacrum | | | 0 | 48 | 0 | 48 | | | |
| Coccyx/Pelvis | 12 | 6 | | | | | 12 | 6 | |
| **Nervous & Immune Systems** | | | | | | | | | |
| Nervous System | | | 28 | 6 | 28 | 6 | | | |
| Hypothalamus | 4 | 0 | | | | | 4 | 0 | |
| Pituitary | 8 | 12 | | | | | 8 | 12 | |
| Pineal | | | 0 | 28 | 0 | 28 | | | |
| Cerebral Cortex | | | 18 | 10 | 18 | 10 | | | |
| Cerebral Vessels | | | 48 | 0 | 48 | 0 | | | |
| Immune System | | | 28 | 28 | 28 | 28 | | | |
| Spleen | 12 | 0 | | | | | 12 | 0 | |

FIG. 5

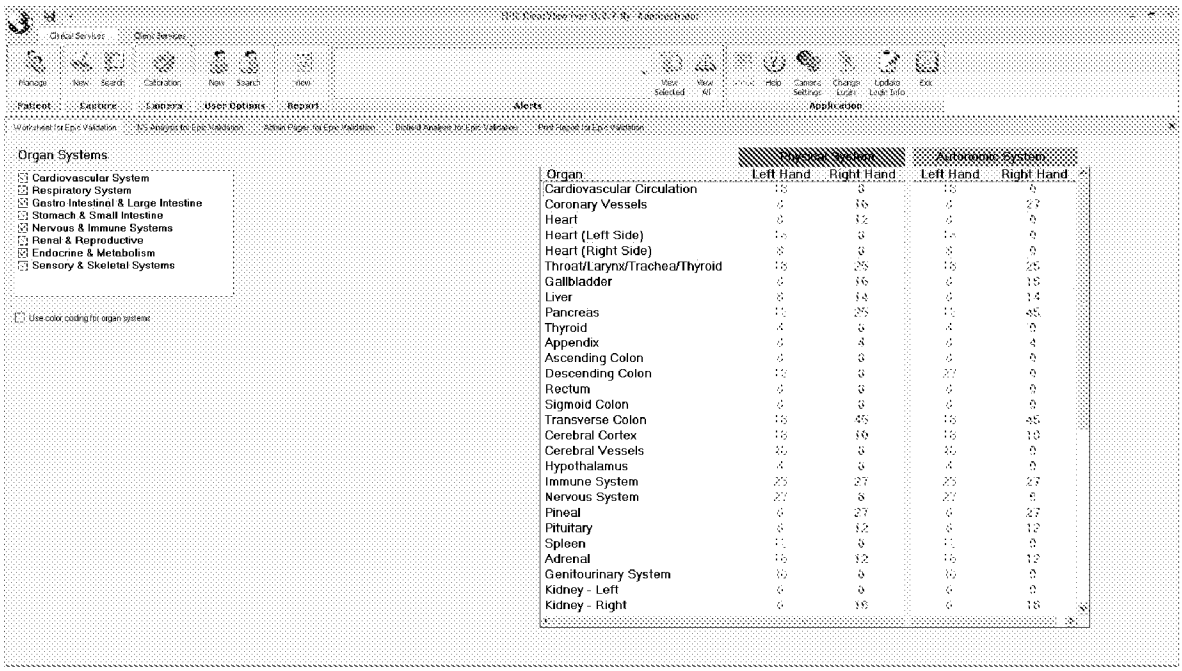



FIG. 6

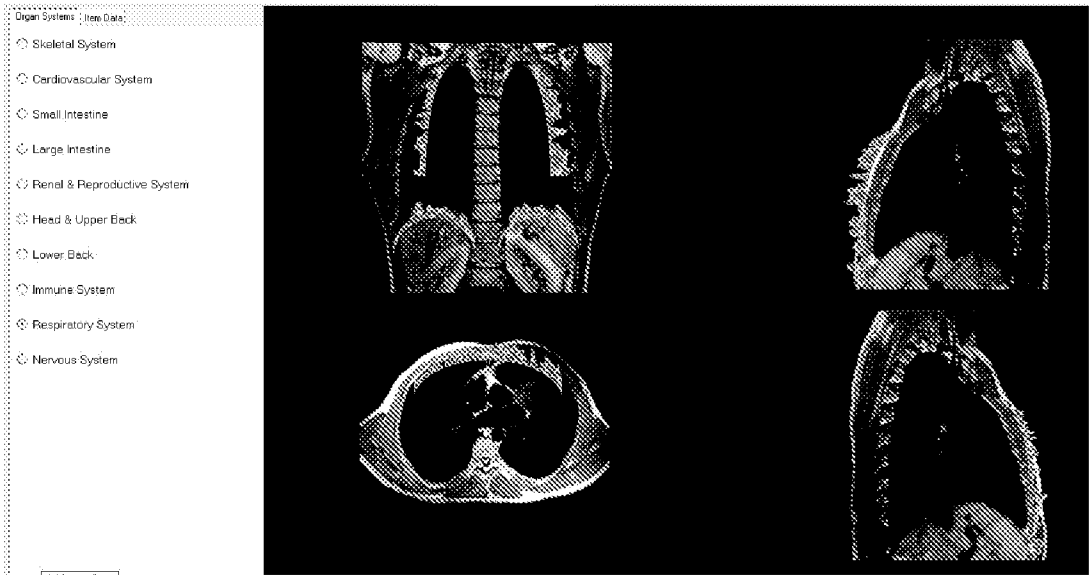

Organ Systems
Item Data:
Skeletal System
Cardiovascular System
Small Intestine
Large Intestine
Renal & Reproductive System
Head & Upper Back
Lower Back
Immune System
Respiratory System
Nervous System

FIG. 7

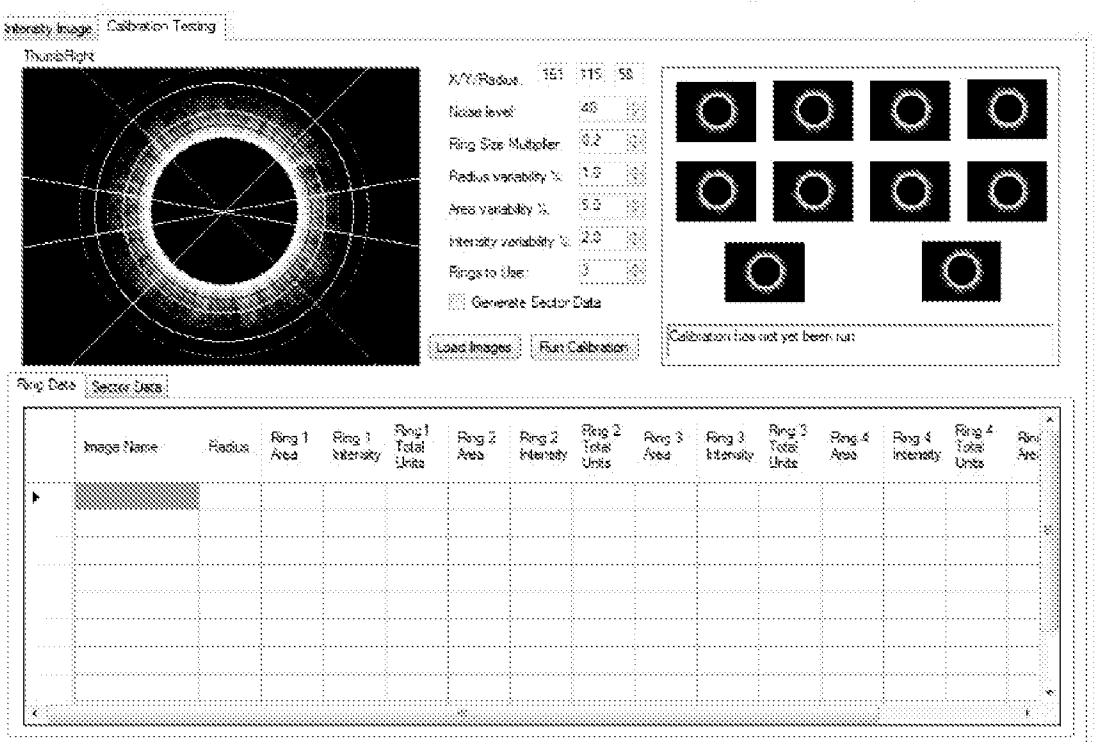

Intensity Image
Calibration Testing
Thumb Right
X/Y/Radius
Noise level
Ring Size Multiplier
Radius variability %
Area variability %
Intensity variability %
Rings to Use
Generate Sector Data
Load Images
Run Calibration
Calibration has not yet been run
Ring Data
Sector Data
Image Name
Radius
Ring 1 Area
Ring 1 Intensity
Ring 1 Total Units
Ring 2 Area
Ring 2 Intensity
Ring 2 Total Units
Ring 3 Area
Ring 3 Intensity
Ring 3 Total Units
Ring 4 Area
Ring 4 Intensity
Ring 4 Total Units

FIG. 8

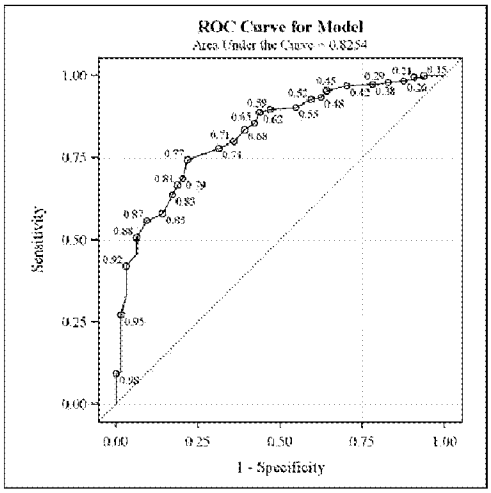



FIG. 9A

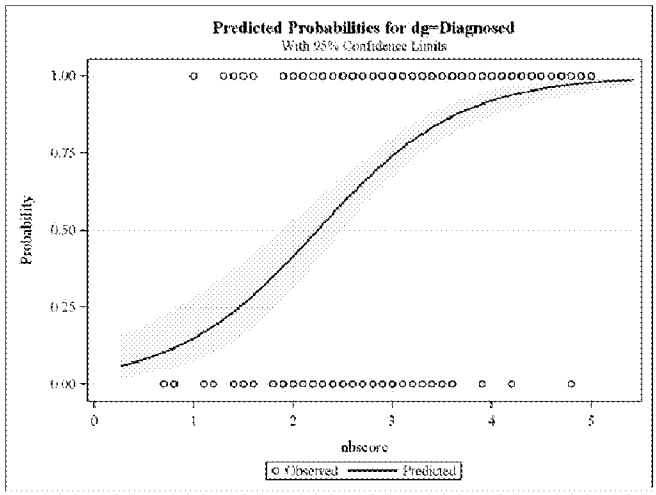



FIG. 9B

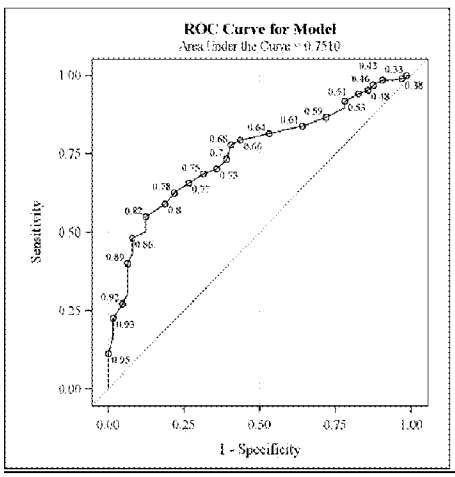



FIG. 9C

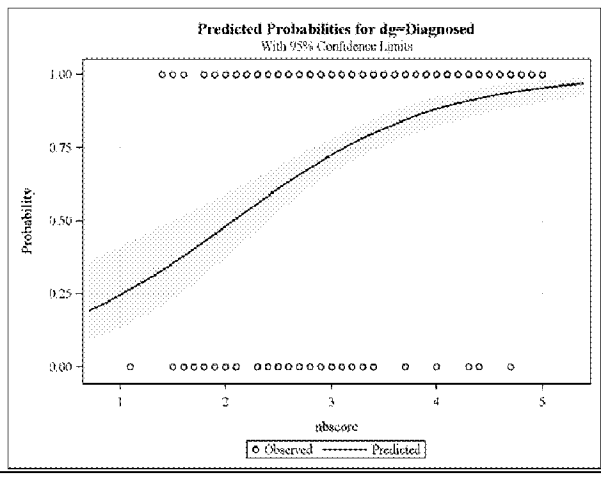



FIG. 9D

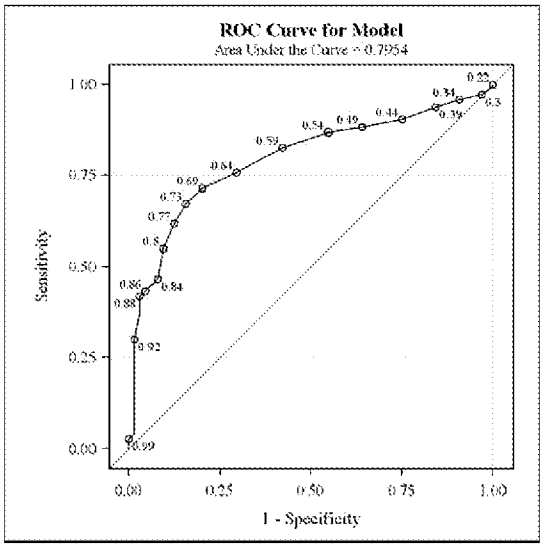



FIG. 10A

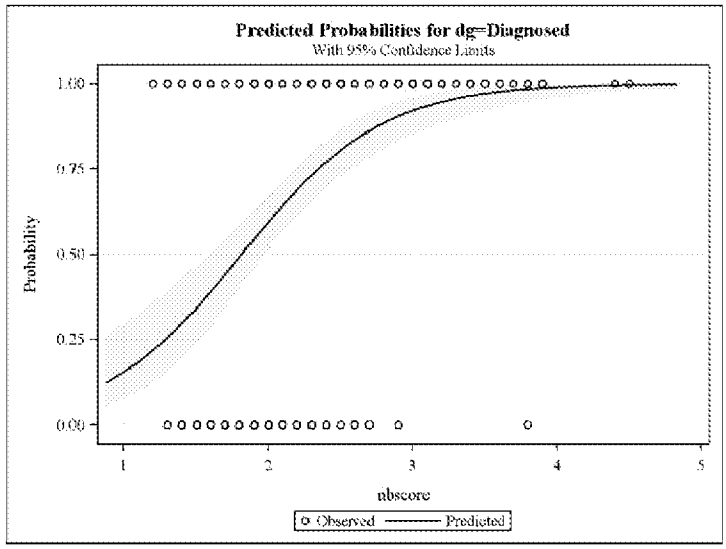



FIG. 10B

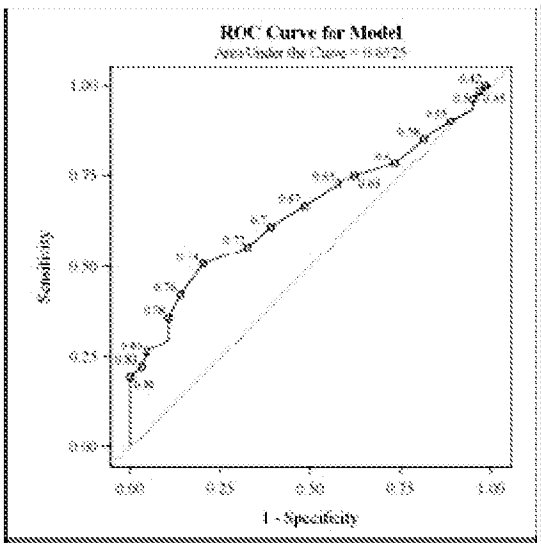



FIG. 10C

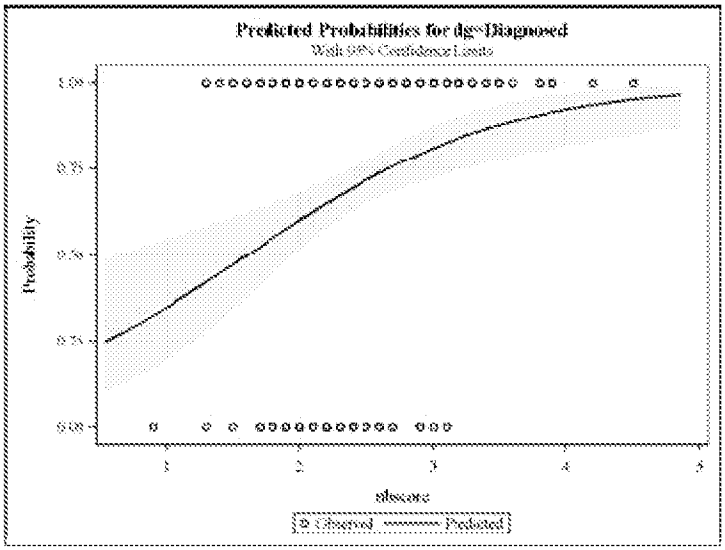



FIG. 10D

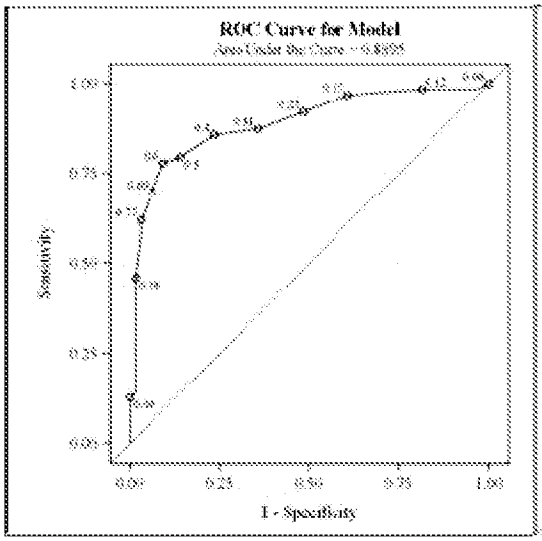



FIG. 11A

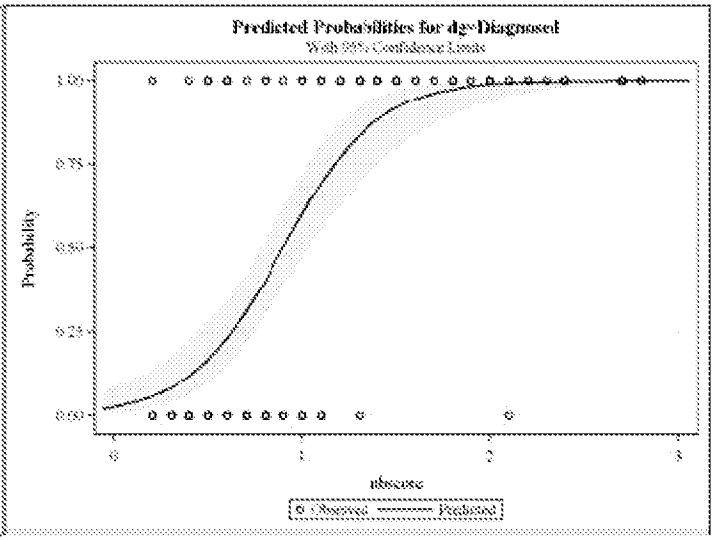



FIG. 11B

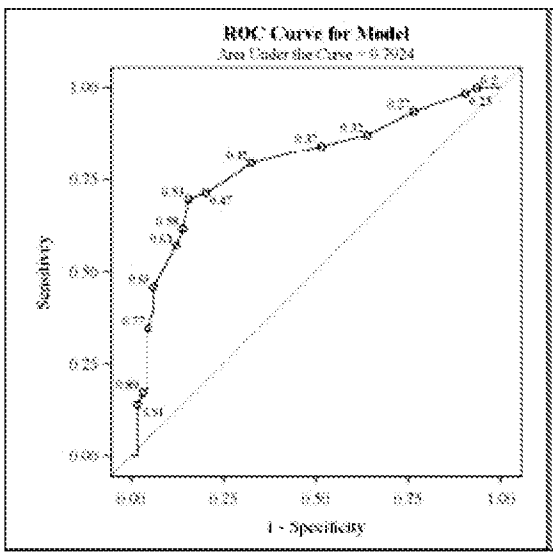



FIG. 11C

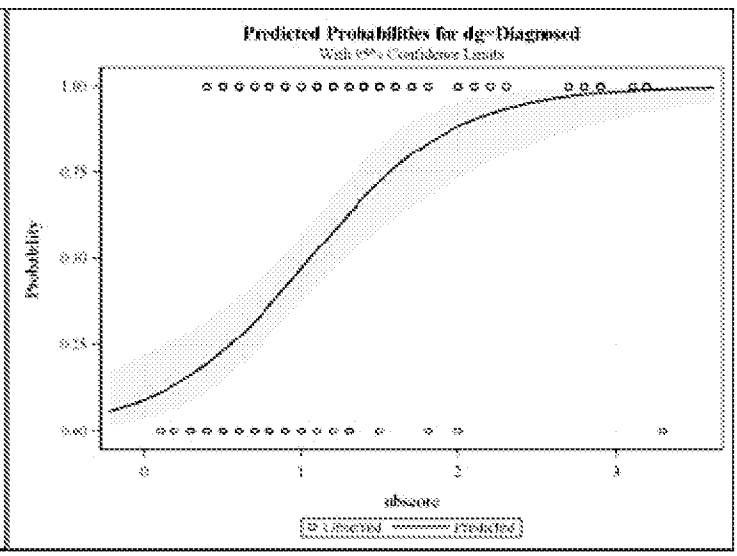



FIG. 11D

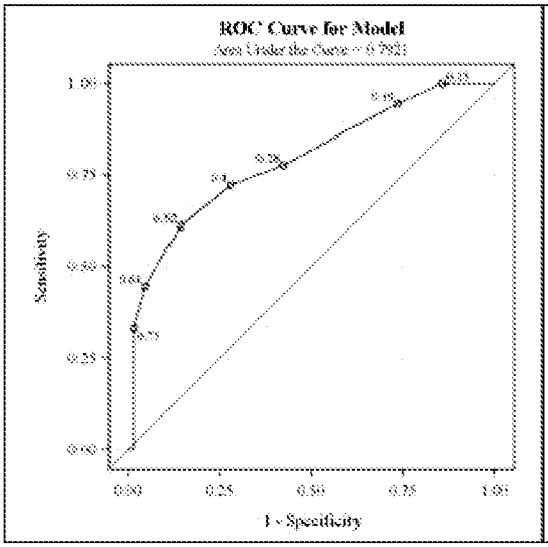



FIG. 12A

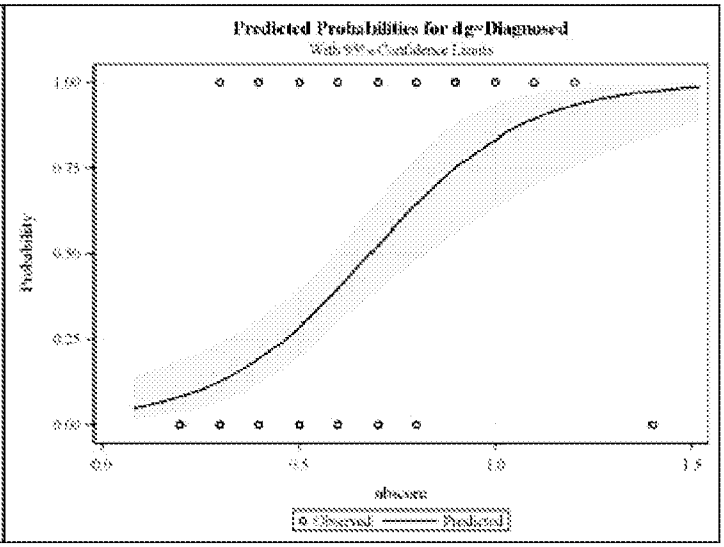



FIG. 12B

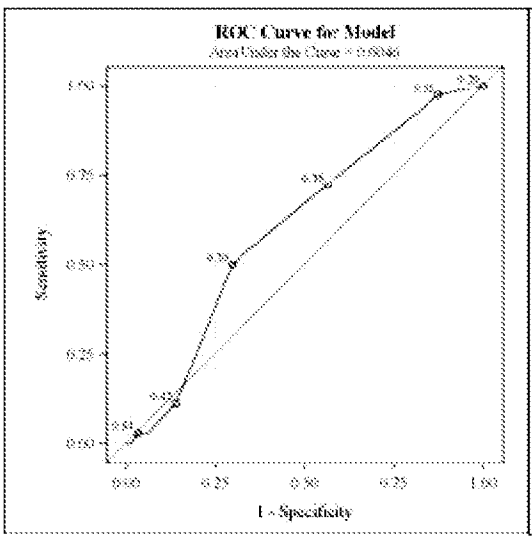



FIG. 12C

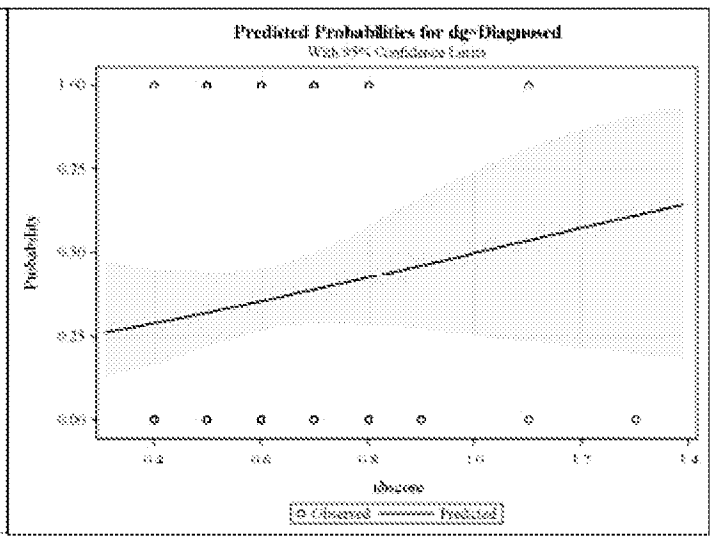



FIG. 12D

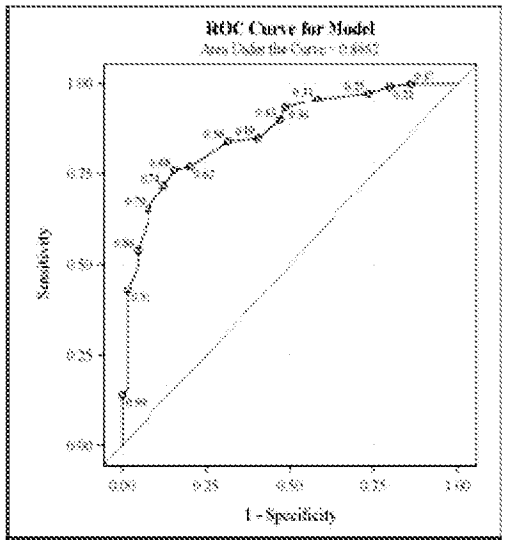



FIG. 13A

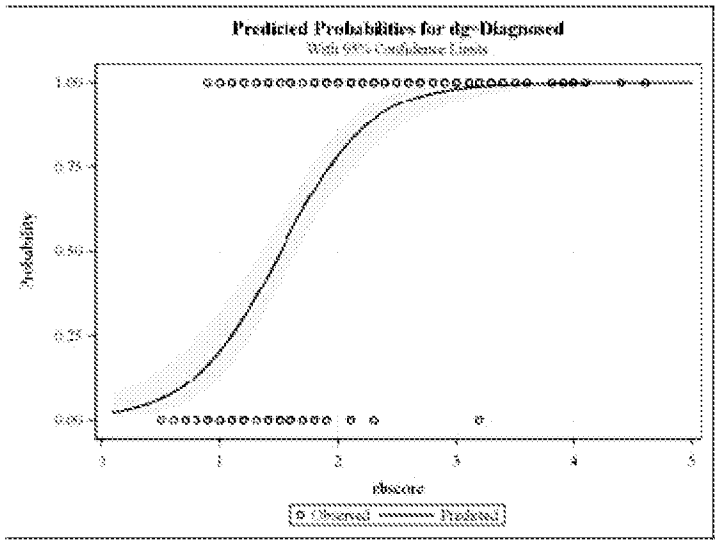



FIG. 13B

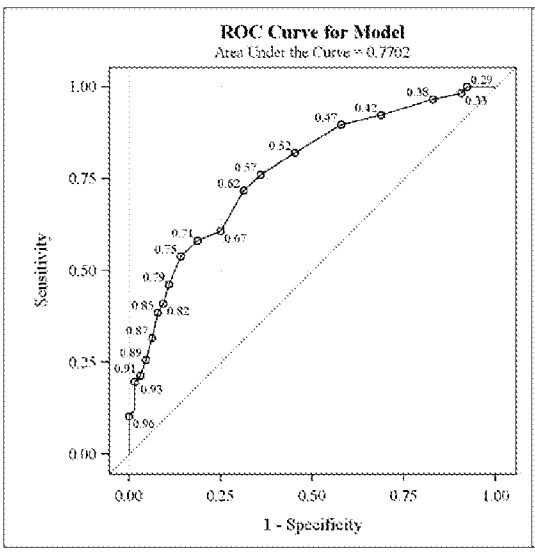



FIG. 13C

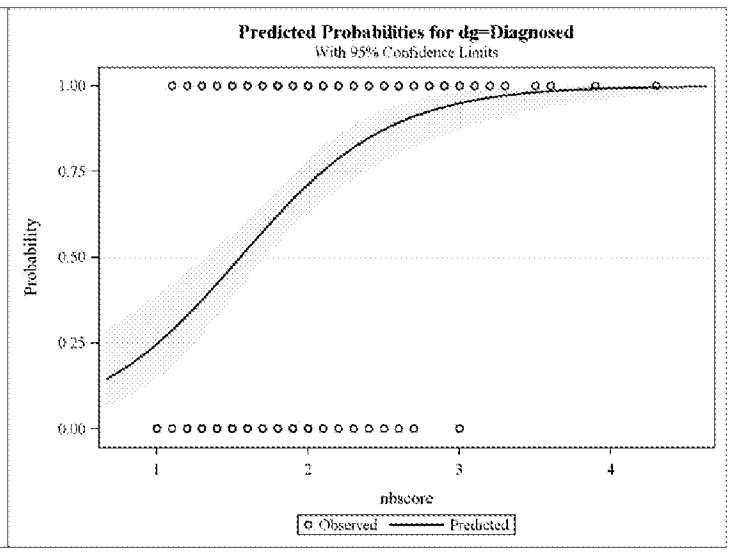



FIG. 13D

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/050956

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/05 G03G17/00
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)
G03G 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 | EP 1 495 717 A1 (KOROTKOV KONSTANTIN GEORGIEVIC [RU]) 12 January 2005 (2005-01-12) cited in the application | 1-8, 25-34,51 |
| A | column 3, lines 51-57<br>column 4, lines 24-29,47-50<br>paragraphs [0009], [0010], [0017], [0018]<br>figure 1 | 9,19-24, 36,45-50 |
| | ----- | |
| X | US 2006/266371 A1 (VAINSHELBOIM ALEX [US] ET AL) 30 November 2006 (2006-11-30)<br><br>paragraphs [0035], [0036], [0040], [0044], [0047], [0068], [0069] | 1,10-18, 26,35, 37-44 |
| | ----- | |
| | -/-- | |

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

[X] 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 | Date of mailing of the international search report |
|---|---|
| 4 December 2012 | 14/12/2012 |

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

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/050956

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 2003/095316 A1 (HERBEPIN PASCAL [FR] ET AL) 22 May 2003 (2003-05-22)<br>paragraphs [0042] - [0050], [0059]<br>figures 1,4<br>----- | 1,10,11,<br>26,37,38 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/050956

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 1495717 A1 | 12-01-2005 | AU 2002366776 A1 | 09-07-2003 |
| | | EP 1495717 A1 | 12-01-2005 |
| | | RU 2217047 C2 | 27-11-2003 |
| | | US 2005014998 A1 | 20-01-2005 |
| | | WO 03053240 A1 | 03-07-2003 |
| US 2006266371 A1 | 30-11-2006 | EP 1861002 A2 | 05-12-2007 |
| | | JP 2008528122 A | 31-07-2008 |
| | | KR 20070104585 A | 26-10-2007 |
| | | US 2006266371 A1 | 30-11-2006 |
| | | WO 2006079038 A2 | 27-07-2006 |
| US 2003095316 A1 | 22-05-2003 | AT 275739 T | 15-09-2004 |
| | | AU 774963 B2 | 15-07-2004 |
| | | AU 3185301 A | 24-07-2001 |
| | | BR 0107482 A | 03-09-2002 |
| | | CA 2397098 A1 | 19-07-2001 |
| | | CN 1394299 A | 29-01-2003 |
| | | DE 60105388 D1 | 14-10-2004 |
| | | DE 60105388 T2 | 15-09-2005 |
| | | EP 1247144 A1 | 09-10-2002 |
| | | ES 2227120 T3 | 01-04-2005 |
| | | FR 2803661 A1 | 13-07-2001 |
| | | PT 1247144 E | 31-01-2005 |
| | | US 2003095316 A1 | 22-05-2003 |
| | | WO 0151998 A1 | 19-07-2001 |