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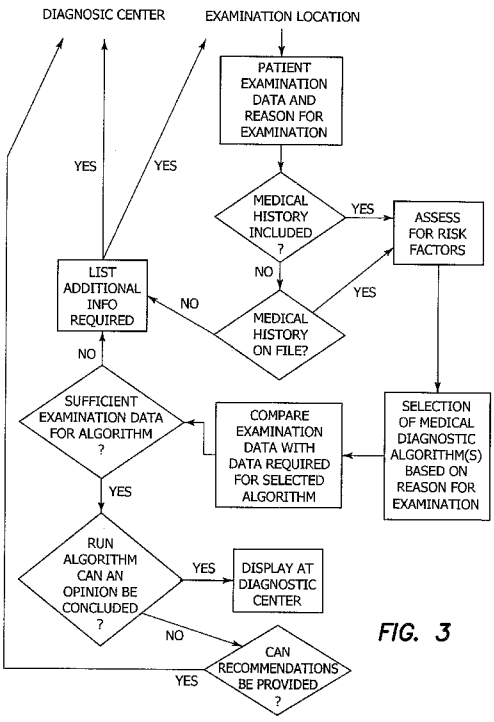

FIG. 3

(57) Abstract: The telemedicine method and system disclosed includes at least one wireless telecommunication device (WTD), preferably a general purpose WTD, a plurality of medical exanimation devices configured to acquire medical data from the patient and convey the data to the WTD, and wherein the WTD transmits the patient examination data to a remote diagnostic center, The diagnostic center, a central computing center, or a cloud network may maintain a database of patient records corresponding to the remotely collected examination data, and may perform diagnostic algorithms to assist a medical professional located in the diagnostic center to provide a professional opinion based on the examination data to the patient before the patient leaves the examination location.

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WIRELESS TELEMEDICINE SYSTEM

This application claims priority under 35 U.S.C. 119(e) to provisional patent application Serial No. 61/621857, filed April 9, 2012, which is hereby wholly incorporated by reference herein in its entirety.

Field and Description of the Invention

The present invention relates to the use of wireless data acquisition and transmission devices to conduct medical examinations, transfer patient examination information to a remote location, obtained an professional opinion regarding the patient's health using such information, and providing the patient with a real-time professional opinion based on such information. Certain aspects of the invention involve systems and methods for conducting a medical examination at a first location comprising the use of one or more medical examination devices (which devices may include one or more multifunctional device capable of performing multiple different tests) to convey patient medical data to a wireless telecommunication device (or be part of the device); the acquired patient examination data may then be transmitted to a diagnostic center at a second location at which a medical services professional can review the patient examination data and provide a professional opinion to the patient or medical professional, preferably in "real-time"; that is, for example, before the patient leaves the first location, or by e-mail, text or other telecommunication device.

With the acceleration of computerized communication and information gathering technology advances, opportunities for providing enhanced services traditionally requiring in-person contact between a service provider and client are increasingly possible. For example, in the medical field in medical care provider has traditionally required the physical presence of the patient in order to acquire data, medical history, and examination data concerning the patient in order to provide health care services to the patient. This is particularly true when immediate patient feedback is desirable or necessary. Furthermore, in remote areas, such as rural, underdeveloped, or inaccessible areas, medical care is increasingly difficult to obtain due, in part, to the significantly decreasing number of new physicians graduating from medical school who are interested in remote or rural medical practice. In some areas of the world, including in developed countries such as the United States, patients may need to travel a hundred miles or sometimes much more to visit the nearest medical practitioner. The inconvenience of making such a journey, both for patient and for the medical care provider, results in the neglect of basic preventative or routine medical care. Thus, when and if such a patient actually requires medical care he or she may be more acutely ill, or require substantially greater medical resources than would have been the case if such preventative or routine medical care have been available at or near the patient's home.

Telecommunication and wireless technology has been available since the late 19th and early 20th century, respectively. Thus, medical advice and consultation between medical care providers and patients may take place by telephone, by shortwave radio, by citizens band radio systems or more recently by satellite telephone, facsimile, or over the Internet. However, it is not been until the last 20 years or so that wireless technology has become sufficiently ubiquitous, convenient, comprehensive, and rapid to reach even the most remote regions of the world. Thus, for example, in Afghanistan many of its rural citizens had never even seen a telephone in 2001 when NATO forces entered the country in the wake of the World Trade Center disaster. By 2007, over 150,000 Afghan citizens had monthly cell phone subscriptions, with more than 12% of its population of 15 million people possessing cell phones. Similar trends are seen the world over, with almost 80% of the world's population of over 7 billion people estimated to have a mobile phone in 2011.

Wireless technology has also become far more sophisticated than was originally the case. By "wireless" is meant any available means for transmitting and/or receiving data (e.g., digital or analog data) without an electrical connection, such as a cable or wire. The term thus, without limitation, includes devices having a transmitter and/or a receiver capable, respectively, of transmitting or receiving data by employing one or more wavelength or ranges of

wavelengths of the electromagnetic spectrum, such as infrared, visible light, ultraviolet, microwave, and radio waves, magnetic flux, laser or focused beams, etc. Other methods may include, without limitation, acoustic detection, optical and radioactive methods, and sound. Thus, basic cellular phones have rapidly given way to portable computing/telecommunications devices including "smartphones", such as Apple's iPhone® smartphone, Google's Android® smartphone and Research in Motion's BlackBerry® smartphone, each of which combine digital telecommunications, text, internet, and e-mail capabilities within a single, hand-held device. The iPhone®, in particular, has revolutionized the smartphone field, permitting the acquisition and sharing of photographs (including "scanned" images), video, Internet webpage images, and the like; virtually every wireless telephone maker has subsequently entered the field with devices that are based upon, or improve upon, the capabilities of the iPhone®.

Another feature of the "iPhone® revolution" is the ability a user to download and utilize discrete cell phone-based software applications; other similar smartphones like the Android® also have this capability. These software applications are amazingly diverse, and include games, dictation software, calendaring software, business-oriented software, mobile banking software, shopping-oriented software, musical instrument-oriented software, and the like. Wireless (e.g., modem-based) communications using, for example, laptop

computers running self-contained software applications had already been available for a decade or so before the advent of the iPhone®; however these devices generally were of limited use without a relatively constant electrical supply, due to their considerable power requirements and limited rechargeable battery life.

Following the iPhone® in mass consumer acceptance were truly portable small computing devices such as tablet devices including Apple's iPad®, which combines many of the features of the smartphone and laptop computer into a hand-held portable touchscreen-based device. The iPad®, and its progeny typically do not contain a telephone, but communicate over digital telecommunications lines shared with access to the Internet. The iPad®, may contain a camera, such as a video camera, which permits face-to-face conversations between users over WiFi using the Internet. Additionally, the iPad®, uses smaller versions of certain personal computer software applications, such as word processing applications, web browsers, calendars, and the like, and, like the iPhone®, permits developers to fashion custom software. Because neither iPhone® or iPad®, devices (or competing devices having similar features) have hard drives, thus significantly reducing their power draw. This fact, and significant advances in battery design and engineering have permitted smartphones and tablet computing devices to operate for up to 10 hours without recharging.

In addition, other methods of reducing power draw from(and thus increasing the utility of) wireless mobile computing devices have been developed, although these are not in widespread use. As just one example, so-called "cloud" computing permits computationally intensive activities to occur at a server that may house the application, while permitting data entry and result reporting to occur at the user's workstation or device. AS another example, in a corporate setting a server or "server farm" may house the majority of the applications used by employees; in this case, relatively unsophisticated computing devices are required at each employees workstation, since most of what is required of such devices is to provided the input, and to retrieve computed results from the server or server farm.

The use of telecommunications in the medical field has created an array of various technologies, and systems, broadly termed "telemedicine". Telemedicine systems for performing vision testing and eye examination are described in U.S. Patent Nos. 4,761,071; 5,617,157; 5,694,199; 5,912,720; 5,943,116; 5,993,001; 6,003,991; 6,022,315; 6,027,217; and 6,033,076.

Additionally, United States Patent Publication No. 2001/0279718, to Borve, discloses systems, devices, and methods for communicating medical information using a mobile telephone with a digital camera. The Borve publication discloses digital images as a medium for diagnostics and

health care transmitted by a mobile telephone using the Multimedia Messaging Service (MMS) protocol.

Bates et al., United States Patent Publication No. 2009/0252306, discusses a telemedicine system including a "hub" in wireless communication with a medical sensor device, wherein the hub includes a data repository system and an interactive voice response (IVR) system, wherein the patient receives a set of instructions from the IVR by telephone which prompts the patient to self-administer a collection of a set of physiological data with the medical sensor device and requires the patient to confirm each of a plurality of steps in set of instructions with the user interface for the telephone.

United States Patent Publication No. 2006/0036134 (Tarassenko et al.) discusses a telemedicine system for monitoring chronic conditions such as asthma or diabetes. The system includes an electronic measurement device such as electronic peak expiratory flow meter or an electronic blood glucose meter connected to a cellular telephone. The cellular telephone automatically receives, formats, and transmits the data on acquisition by the medical device to a remote server. The server may acknowledge the data and make the data available to a clinician.

United States Patent No. 5,987,519 (Peifer et al.) is drawn to a packet-based telemedicine system for

communicating video, voice and medical data between a central monitoring station and a patient monitoring system, which is remotely located with respect to the central monitoring station. The patient monitoring station obtains digital video, voice and medical measurement data from the patient and encapsulates the data in packets, sending the packets over a network to the central monitoring station.

United States Patent Publication No. 2008/0146276 (Lee) discloses a mobile phone with a stethoscopic function. The stethoscope microphone may be either intricately built into the cellular phone, or an exterior stethoscopic microphone which is detachable from the body of the mobile phone.

United States Patent Publication No. 2009/0088607 (Muraca), is drawn to a remote disease management system, method, and computer-readable medium including a patient's cell phone acquiring medical data and automatically transmitting the acquired data to a server. The data may be acquired wirelessly or by manual input from remote sensors acquiring medical information about the patient. The patient's cell phone receives a text message from a physician workstation with medical questions and the patient's cell phone receives responses to medical questions from the patient and automatically transmits the responses to a server.

United States Patent No. 7,942,526 (Gearhart et al.)

discloses a macular health measurement and storage system comprising a plurality of macular-pigment measurement machines for measuring macular pigment density and humans, a plurality of computers each of which is associated with a corresponding one of such machines, and a central host. Each of the computers includes a second port for transferring patient data.

United States Patent Publication No. 2008/0259274 (Chinnock) discloses a handheld digital camera for obtaining images of a portion of a patient's body and having a handheld housing, of visible light source located within the housing for providing light, an image sensor that detects light returning from the patient's body along an imaging path that passes into the housing of the aperture, an output display carried by the housing, and the ability to electronically transmits stored images.

United States Patent No. 7, 232,220 and 7,520,611 (Franz & Weber) describe systems and methods including at least one remote exam module which in turn includes a plurality of optical devices configured to examine a patient's eye, and a controller for collecting and transmitting the examination data of the patient's eye. The information collected is transmitted via a communications link to a diagnostic center for analyzing the information collected at the remote exam module. The diagnostic center further maintains a database of patient records corresponding to the

remotely collected examination information and an exam console for enabling a diagnosis based on the collected information.

United States Patent Publication No. 2011/0153344 (Vesto) discloses methods and apparatus for medical case research and collaboration. In an example, the method includes receiving, by a processor, information from a person via a research tool related to one or more health issues of the person; generating a medical case based on the information received from the person; calculating one or more likelihoods associated with one or more potential causes of the health issues; determining whether the likelihoods indicate that the medical case is "complex"; and when the medical case is complex, granting the person access to collaboration module.

In the United States Patent Publication No. 2005/0124375 (Nowosielski), a multi functional mobile phone performs hearing and vision tests through a built-in or externally connected device monitor, measures and collects data of body and environmental temperature, heart beat, long respiration, cardiac and pulmonary house chelation, sugar level, blood pressure, etc., takes body photo images for the clinical assessment, displays and plays back instructions to conduct the diagnostic test and rehabilitation treatments, stores and updates programs for the tests and treatments and communicates with a remote medical specialist using a mobile phone network.

United States Patent Publication No. 2011/0015496 (Sherman et al.) is drawn to a portable medical device comprising sensors for connection to a smartphone, being configured to collect medical information relating to patient, and an interface coupled to the sensor and configured to communicate the collected medical data from the patient to the mobile communication device.

However, despite such advancements, there remains a need for improved, rapid, and practical systems of providing medical, vision, and/or dental services to patients in remote locations. Such systems may include an integrated, wireless-based telemedicine system, and associated methods of using such a system, that is able to convey data from at least a plurality of medical examination devices (either as separate devices or as one or more multifunctional device) to a wireless telecommunication device. In other embodiments the medical examination device or devices may be part of such a wireless telecommunications device, either as an integrated part (which may include a software program contained on such device) or as an attachment wherein the medical examination devices comprise at least one, and preferably a plurality of inexpensive attachments to such a wireless communication device. The system preferably enables a person to conduct a medical examination of a patient using a wireless telecommunication device at a remote examination site, and to transmit examination data to a central medical care site (diagnostic center) for analysis by a medical professional.

The system also preferably enables, a professional opinion to be transmitted back to the patient or to a medical professional at the medical examination site (or by a telecommunication device capable or receiving and displaying the opinion and associated data, such as e-mail, text messaging, photographic transmission, video transmission, or the like), preferably in "real-time". By "real time" is meant within a period of time, reasonable under the circumstances, within which the patient would be expected to be able to remain at or within close proximity to the medical examination site, the telecommunication device. Although in very remote locations, real-time may be within about 36 hours, or about 36 hours or less, in most cases it would helpful if the professional opinion were to be rendered and transmitted to the patient or medical professional within four hours or less, or within three hours or less, or within about two hours or less, or within about one hour or less; even more preferably, before the patient leaves the medical examination site.

Summary of the Invention

The present invention is related to improved methods and systems for providing medical diagnostic services. In particular, the invention is related to improved methods and systems for providing medical services to patients in remote locations through the use of wireless communication and/or computing devices. Such patients typically (although not invariably) lack convenient access to medical professionals

due to distance, age, infirmity, or lack of financial resources. In preferred aspects of the invention, the methods and systems of the present invention comprise the use of wireless telecommunications to provide sufficient patient examination data from a remote location to a medical professional in a diagnostic center to provide a professional opinion as to the patient's physical well-being, including the diagnosis of specific physical infirmities or conditions, preferably in real time. In certain embodiments the systems and methods of the present invention provide for the use of wireless telecommunications to communicate a professional opinion back to the patient before the patient has left the vicinity of the remote patient examination location.

A "medical professional" is defined herein to mean either a licensed medical professional, such as a physician, physician's assistant, registered nurse, nurse practitioner, or the like; or an unlicensed medical professional such as an optician or midwife.

A "diagnostic center" is defined as a location different (or "remote") from a patient examination location containing one or more digital communication device capable of receiving transmitted medical examination data, permitting a medical professional receiving such transmitted medical examination data to be capable of providing a professional opinion (such as, without limitation, a prescription or diagnosis) based thereupon. In certain embodiments a diagnostic center may comprise a different room from, or location within the same

building as, a patient examination location. However, in other embodiments a diagnostic location may exclude a different room or location within the same building from a patient examination location. In other embodiments the diagnostic location may comprise locations at least a distance of one mile or more from the examination location: for example, at least 5 miles, or at least 10 miles, or at least 25 miles, or at least 50 miles, or at least 70 miles, or at least 100 miles or more from the patient examination location.

Thus, with reference to a first location, a second location "remote" from the first location may comprise a different room from, or location within the same building as the first location. However, in other embodiments a remote location may be other than a different room or location within the same building from the first location. In other embodiments the remote location may be at least a distance of one mile or more from the first location: for example, at least 5 miles, or at least 10 miles, or at least 25 miles, or at least 50 miles, or at least 70 miles, or at least 100 miles or more from the first location.

In particularly valuable and preferred embodiments, the present invention involves the use of wireless data acquisition systems and/or wireless telecommunications systems, including diagnostic devices functionally linked to a wireless, portable, telecommunications device, to collect patient examination data in a first location and to transfer the patient information, either as raw data or as formatted

data, to a second location remote from the first location.

In a particularly useful advantage of preferred aspects, the present invention permits the collection of patient examination data from a patient located at an examination site and the wireless transmission of such data, either raw or processed (for example, compiled into a database, or otherwise manipulated using an algorithm), to a diagnostic center at a location remote from such patient examination site in a manner that is sufficiently inexpensive, fast and comprehensive to permit a medical professional at the remote location to provide a medically competent professional opinion, preferably in real time, and even more preferably before the patient leaves the patient examination site.

A "medical examination device" or "diagnostic device" may be capable of performing more than one medical test. For example, a single diagnostic device may comprise at least two of an autorefractor, a keratometer and a non-contact tomometer which are able to perform different tests. Unless indicated otherwise, in this patent application it will be understood that although a single diagnostic "device" may be used to provide more than one distinct test, each such test comprises a different diagnostic or medical examination device.

In some embodiments the system may include the direct or indirect wireless transmission of patient examination data to a database, or central computing site at a remote location

that employs algorithms and sophisticated software programs to automatically compare the patient examination data to a database of substantially similar data collected from a plurality of other patients, as well as to previous examination data from the same patient without the need for human analysis of the patient data. This latter comparison data may then be used by a medical professional to provide patient specific recommendations, information, and a professional opinion rapidly, preferably in real time, and often within the period of time before the patient leaves the remote examination location. In certain embodiments, the database or central computing center is part of a "cloud computing" network that receives input date wirelessly from a wireless, portable, telecommunications device and sends computational results wirelessly to the patient examination site, the diagnostic site, or both. It will be understood that in some embodiments a central computing center or cloud computing network may utilize more than one server or other processor, and may be located at more than one physical site remote from the patient examination site. Thus, in some circumstances the database or central computing site may be at a location remote from either the patient examination location or the diagnostic center. However, in other embodiments the database or central computing site, or a component thereof, may be located at the same location as the diagnostic center.

A "wireless telecommunications device" (or "WTD") means a device such as a wireless cellular or satellite telephone

capable of transmitting data (such as through a modem), or a wireless mobile computing device such as, without limitation, a smartphone, a laptop computer, a personal digital assistant (PDA), a tablet computing device (such as, for example, an iPad®-type device), or a visual display device (such as Google's Project Glass products) capable of transmitting data over the internet or a digital telephone network, such as a 3G or 4G network. In certain embodiments the wireless portable telecommunications device may have a minimum of microprocesssing ability itself, and will function mainly as a means for wirelessly transmitting the collected data to a central computing site or cloud network. The inventors specifically anticipate that WTDs and telecommunication systems will continue to evolve with the passage of time, and specifically include improved and/or different such devices having additional features useful for the purposes disclosed herein as part of the scope of the present invention.

In particularly preferred aspects of the invention, one or more medical data acquisition tool is comprised as part of a WTD. For example, such WTDs are configured and structured to operate software programs that are typically downloaded from the Internet, although they may be installed on the devices when they are purchased. These software programs, termed "apps", commonly comprise games, social networking interfaces, mobile banking or financial services applications, calendars, note pads, word processing applications, Internet web browsers, music players, and the like. Additionally, the WTDs

generally have operating system programs through which the other apps may work.

In some useful embodiments of the invention, the WTD is a general purpose wireless telecommunications device. By "general purpose" is meant that the basic WTD hardware and software is manufactured and sold to the general (non-medical professional) public and is not specially fabricated for use in a medical field. Examples may include common smartphones and tablet computing devices. Although the basic hardware and software of a general purpose WTD is not specialized, a general purpose WTD may optionally comprise downloadable apps, attachments, devices (such as diagnostic sensors or devices), and connectors; these may in certain cases be specialized to be used in concert with the WTD.

Preferably, the presently claimed invention employs WTDs having 1 or more, or 2 or more, or 3 or more medical examination sensor or device at least partially integrated therein. Thus, in this preferred embodiment the WTD itself comprises at least part of the device. By "at least partly integrated" is meant that the WTD (without hardware modifications) comprises at least an element of the 1 or more, or 2 or more, or 3 or more sensors or devices. This would be the case, for example, where a diagnostic device or sensor comprises a WTD's still or video camera function, pressure- or heat-sensitive screen function, eye location software function or the WTD comprises a diagnostic device software app.

Thus, WTD apps may be directed to medical uses. Also, a variety of smartphone and/or tablet apps have become available for use by medical students, patients, and medical professionals in order to provide, for example, record keeping, or reporting functions. General purpose WTDs such as the iPad® device and similar tablet deviceshave become popular for use by medical professionals in the clinical setting to take notes, perform calculations, maintain and display patient histories; display medications; and similar functions while the medical professional makes his or her rounds. The use of such tablet devices thus frees the medical professional from the desktop computer and provides greater flexibility, convenience, battery life, and portability than laptop computers or dedicated devices offer.

However, various more sophisticated apps have become available for both general purpose smartphone and tablet devices. For example, researchers at the University of California, Davis report a smartphone application which a blood sample may be placed on a slide, and photomicrographs taken by a smartphone camera bearing a microscope attachment. This application is reportedly able to reveal important medical information, such as the reduced number and increased variety of cells in iron deficiency anemia, and the elongated erythrocytes characteristic of sickle cell anemia. Similarly, the microscope attachment may be exchanged for a simple

spectrometer that analyzes light collected from the iPhone®'s camera. The attachment devices are reported to utilize materials that cost no more than the typical app itself; about $30 or less. Similar smartphone apps utilize attached devices to measure blood pressure, monitor blood sugar levels etc.

Various data and imaging applications are available for sharing data between mobile devices and a central computer center, computer network (such as a hospital network), or cloud network. For example, the Mobile MIMM™ application permits physicians to have mobile access via smartphone or tablet device to x-ray and ultrasound images, and to share the images with peers. Similarly, smartphone apps are available for physician remote monitoring of patient cardiology devices, vital sign monitoring, and OB/Gyn functions in real time. In 2009 the United States Patent and Trademark Office granted Apple an iPhone®-related patent that covers wireless remote monitoring of a patient's vital signs. These are, however, mainly remote display devices and involve routine monitoring rather than the collection or transmission of diagnostic examination data from or using the WTDs. By "diagnostic data" or "examination data" is meant data collected from a patient being tested for the presence or absence of one or more medical condition; such data may, and preferably does, exclude routine monitoring data; in other words, data resulting from the regular or frequent monitoring of basic vital signs over a period of time (for example, 4 hours, 12 hours, 24 hours, 48 hours, 72 hours or more) from a patient having a chronic

medical condition.

Currently, some doctors are skeptical of these devices, and even some of their advocates find the greatest value in such devices to be in promoting medical education rather than in providing the diagnostic data.

IPhone® related applications also been coupled with iPhone® attachments, some of them costing less than about $30 to produce, for conducting the diagnosis and analysis of potential refractive error in the lens of the eye. According to the world health organization, uncorrected refractive errors or the world's second-highest cause of blindness; all these people are potentially beneficiaries of such application. Furthermore, a group at Massachusetts Institute of Technology (MIT) has developed a slit lamp attachment and an inverse Shack-Hartmann wavefront sensor attachment for smartphones having a high-resolution image display capability.

Slit lamps are instruments consisting of a intense light source that can be focused to shine a thin sheet of light into the eye to examine features of the cornea, conjunctiva, lens, iris and sclera of the eye, and can detect and help form an attenuation map of the lens showing the presence of early onset cataracts; the inverse Shack-Hartmann wavefront sensor attachment involves a display set at very close range to the human eye. The laser which is usually shined into the eye of the patient is replaced by user interaction in which the

subject looks into a display and aligns patterns which pass through different visual regions, thus giving a measure of optical distortions and also myopia, hyperopia, and astigmatism. Both of these systems depend upon the use of smartphone apps that create the display, receive inputted patient instructions and data, and interpret the input data to facilitate the medical professional's ability to render a professional opinion on the patient's refractive eye health. The attachments reportedly cost about $4.00 to make.

The cost of the materials used for such devices as those listed in the preceding paragraph are also simple, and their low cost permits the development and large scale development of such devices for distribution to rural areas and less developed countries. Of course, similar software applications and attachments for general purpose mobile telecommunication devices other than the iPhone® or iPad® (such as the Android® smartphone, various laptop computers, and other tablet computing devices) may easily be adapted. Furthermore, smartphone attachments comprising two or more integrated diagnostic devices, or dedicated WTDs for medical use that include examination devices for conducting medical examinations may be available within the near future.

Brief Description of the Drawings

Fig. 1 provides an example of a wireless telecommunication system of the present invention in which a

patient's refractive error is tested at an examination location and the results wirelessly transmitted to a diagnostic center at a location remote from the examination location.

Fig. 2 provides an example of a wireless telecommunication system of the present invention in which a medical patient's data is collected at an examination location and then processed according to a software-based diagnostic algorithm at a central computing center. The prospective professional opinion is then provided to a medical professional located at a diagnostic center, permitting the professional to provide the opinion to the patient before the patient leaves the examination site.

Fig. 3 is a diagram showing an example of a basic algorithm of the type that may be used to process patient examination data for presentation to the medical professional and/or patient.

Detailed Description of the Invention

Thus, in a first aspect, the present invention is drawn to a mobile wireless telecommunication device (WTD), for example (but not limited to) a smartphone, laptop computer, "smart" eyewear (such as the "Google® glass" computing device), a "smart" vehicle (such as the Google® driverless

automobile, a wireless mobile laboratory, or the like), or tablet wireless personal computing device, in a system to acquire diagnostic patient examination data directly from a patient as part of an integrated wireless-based telemedicine system. Preferably the WTD is a general purpose WTD. In particular, an aspect of the present invention concerns a system for conducting a medical examination from a medical examination location, comprising:

a plurality of medical examination devices located at a first medical examination location;

a wireless telecommunication device located at said first medical examination location and configured to directly receive diagnostic patient examination data from two or more of the medical examination devices, said wireless telecommunication device configured to transmit the diagnostic data via a wireless communications link to a second location remote from said first medical examination location;

a diagnostic center situated in said second remote location and capable of receiving transmitted diagnostic data from said medical examination location to enable the diagnosis of a medical disorder or disease of the patient by a medical professional, thus permitting the medical professional to provide a professional opinion based on the patient's transmitted medical examination data to the patient before the patient leaves the examination location.

It will be understood that in certain embodiments a

medical examination device may be comprised (at least partially integrated) as part of the wireless telecommunication device. For example (and without limitation), in certain applications the still or video camera component of a WTD may be comprised in the medical examination device. In other applications, the medical examination device may comprise the touchscreen of, a software app of, or an attachment to the wireless telecommunication device. For example, the medical examination device may comprise a functional part or attachment to the wireless telecommunication device by operably plugging into a data port of the WTD, thereby routing the acquired data to the microprocessor of the WTD.

Less preferably, but still within the scope of the invention, the medical examination device may be distinct from, but functionally attached to, the WTD. For example, the medical examination device may comprise a data output port, which may be linked via a cable to the data input port of the WTD, thereby permitting the uploading of data to the microprocessor(s) of the WTD.

The medical examination may in some cases be any medical examination appropriate to the diagnosis of a medical condition (including the lack of a specific medical condition) or disease. As one example, a patient may be examined for the presence, absence, or progress of diabetes; this may be accomplished by, for example and without limitation, examining the patient using one or more of medical examination devices

selected from the group consisting of a blood glucose detection device, a blood pressure detecting device, a blood cholesterol detection device, a blood low density lipoprotein (LDL) detection device, a neural diagnosis device, a pupilometer, a scanning laser ophthalmoscope, blood high density lipoprotein (HDL) detection device, optical coherence tomographer (OCT) device, a blood triglyceride detection device, a visual fields testing device, a fundus camera, a retinal imaging device, a posterior segment imaging device; a urine glucose testing device, and the like. A medical professional may reasonably provide a competent professional opinion based on patient diagnostic data received from one or more such medical examination device. In certain embodiments the patient may be examined using two or more, or three or more or four or more such medical examination device.

In another embodiment the invention is directed to a system for conducting an eye examination from a remote location, comprising:

a plurality of eye examination devices located at an eye examination location;

a general purpose wireless telecommunication device (WTD) having one or more said eye examination devices at least partially integrated therein; said WTD being located at said eye examination location and configured to acquire diagnostic patient examination data from two or more of the eye examination devices, said diagnostic patient examination data being sufficient to

permit a medical professional to render a professional opinion, said WTD configured to transmit the patient examination data via a wireless communications link to a location remote from said eye examination location;

a diagnostic center situated in said remote location and capable of directly or indirectly receiving the diagnostic eye examination data from said eye examination location to enable a medical professional to render a professional opinion based thereupon, wherein said medical professional is located at the diagnostic center, thus permitting the eye care practitioner to provide a professional opinion based at least in part on the eye examination data, thus advising to the patient in real time,

and wherein said diagnostic eye examination data does not comprise routine monitoring data.

In certain embodiments of the invention, the system may comprise the system described immediately above wherein an eye examination device at least partially integrated in said general purpose WTD comprises a specialized software application loaded therein. In other embodiments the eye examination device comprises a camera integrated as part of said general purpose WTD.

In another embodiment the invention is directed to a system for conducting a diagnostic medical examination from a remote location, comprising:

a plurality of medical examination devices located at an

medical examination location, one or more said medical examination devices being at least partially integrated as part of

a general purpose wireless telecommunication device (WTD) located at said medical examination location and configured to receive patient examination data from two or more of the medical examination devices, said WTD configured to transmit patient examination data via a wireless communications link to a location remote from said examination location;

a diagnostic center situated in said remote location and capable of receiving the wireless transmitted patient examination data from said examination location to enable a medical professional located at the diagnostic center to provide a professional opinion, thus advising to the patient concerning the presence or absence of a medical disorder or disease based at least in part upon said patient examination data in real time,

and wherein said patient examination data does not comprise routine patient monitoring data.

In another embodiment the invention is directed to a system for conducting a medical examination from a remote location, comprising:

a plurality of medical examination devices located at a medical examination location, one or more said medical examination devices being at least partially integrated as part of

a general purpose wireless telecommunication device (WTD) located at said medical examination location and configured to receive patient examination data from two or more of the medical examination devices, said WTD configured to transmit patient examination data via a wireless communications link to a location remote from said examination location;

a diagnostic center situated in said remote location having a automated clinical decision support system (CDSS) comprising a algorithm which receives said patient examination data as input and calculates a preliminary diagnosis as output, said output being made available to a medical professional—to enable said medical professional to assess the preliminary diagnosis and return a professional opinion using a wireless communications link to said medical examination location, thus advising to the patient concerning the presence or absence of a medical disorder or disease based at least in part upon said patient examination data in real time.

In another embodiment the invention is directed to a telemedicine system for conducting an eye examination at a location remote from a diagnostic center at which a medical professional is located comprising:

a plurality of eye examination devices located at a first eye examination location;

a wireless telecommunication device located at said first eye examination location and configured to directly receive patient eye examination data from two or more of the eye

examination devices, said wireless telecommunication device configured to transmit the eye examination data via a wireless communications link to a second location remote from said first eye examination location;

a diagnostic center situated in said second remote location and capable of receiving transmitted diagnostic data from said eye examination location to enable the diagnosis of a eye disorder or disease of the patient by a medical professional, thus permitting the medical professional to provide a professional opinion based on the patient's transmitted eye examination data to the patient in real time, preferably before the patient leaves the eye examination location.

The eye examination may in some cases be any eye examination appropriate to the diagnosis of an eye condition (including the lack of a specific eye disorder) or disease related to the eye. As one example, a patient may be examined for the presence, absence, or progress of an adverse retinal condition; this may be accomplished by, for example and without limitation, examining the patient using one or more of eye examination devices selected from the group consisting of a blood glucose detection device, a blood pressure detecting device, a case history capture device, a lensometer, a tonometer, a visual fields tester, binocularity testing instruments; color vision testing devices; a fundus camera, retinal imaging device, a posterior segment imaging device, an automated refractor device, an optical coherence

tomographer (OCT) device, a neural diagnosis device, a pupilometer, a scanning laser ophthalmoscope, a biomicroscope and a corneal topographer, and the like. A medical professional, such as an eye care professional, may be able to reasonably provide a competent professional opinion as to the presence, absence, or progress of the adverse retinal condition based on patient eye examination data received from a plurality of such eye examination devices. In certain embodiments the patient may be examined using two or more, or three or more, or four or more such medical examination devices.

In another embodiment, the present invention is directed to a method of conducting a medical examination from a remote location, comprising using at least one medical diagnostic device at the medical examination location to provide patient examination data; wirelessly transmitting the medical examination data to a diagnostic center remote from the medical examination location to enable a medical professional located at the diagnostic center, to communicate a professional opinion based on the transmitted medical examination data to the examination location before the patient leaves the medical examination location; wherein the diagnostic center comprises no medical examination devices.

In another embodiment, the present invention is directed to a method of conducting an eye examination from a remote location, comprising conducting an eye examination of a patient at an eye examination location using at least one eye

examination device at the eye examination location to provide patient eye examination data; wirelessly transmitting the eye examination data to a diagnostic center remote from the eye examination location to enable a eye care professional located at the diagnostic center to communicate a professional opinion based on the transmitted eye examination data to the eye examination location in real time, preferably before the patient leaves the eye examination location; wherein the diagnostic center comprises no eye examination devices.

A "comprehensive eye examination" means an examination yielding patient data sufficient to reasonably support a professional opinion or professional recommendation by a medical professional for communication to the patient. In particular embodiments, a comprehensive eye examination may require patient data obtained from at least two medical diagnostic devices, or at least three medical examination devices, or at least four medical examination devices.

A "comprehensive medical examination" means an examination yielding patient data sufficient to reasonably support a professional opinion or professional recommendation by a medical professional for communication to the patient. In particular embodiments, a comprehensive eye examination may require patient data obtained from at least two medical examination devices, or at least three medical examination devices, or at least four medical examination devices.

Wireless Telecommunication Device

The wireless telecommunications device ("WTD") means a device such as a wireless cellular or satellite telephone capable of transmitting data (such as through a modem), or a wireless mobile computing device such as, without limitation, a smartphone, a laptop computer, a personal digital assistant (PDA), or a tablet computing device (such as, for example, an Ipad®-type device) capable of transmitting data over the internet or a digital telephone network, such as a 3G or 4G network. Preferably, the WTD is a general purpose WTD. In certain, less preferred, embodiments the wireless portable telecommunications device may have minimal microprocesssing ability itself, and is not capable of performing significant data processing; in such instances the WTD functions mainly as a means for wirelessly transmitting the collected data to a central computing site or cloud network. In other, more preferred, embodiments the WTD is capable of processing the collected data to at least some extent prior to transmitting the data wirelessly; in such instances, the WTD may run software applications that are complementary to or adapted to function with the collection of data by a medical examination device.

For example, software apps may be made to be run by an appropriate WTD to collect data from a medical examination device and permit additional patient/examination information

to be input (either from the examination device, from a WTD data input means, or from an alternative source) such as one or more of the following items: the patient's name, age, sex, and/or any current medication; the date of the examination, the time of day of the examination, and other relevant information. Alternatively, the WTD may contain and run a software application that collects patient examination data from a plurality of medical examination devices and may format the data for entry into a database. In some cases this application may comprise a database itself, which may, for example, contain previous examination data from the same patient and may calculate comparisons test results over time.

In such cases the formatted data or updated database may be wirelessly transmitted directly to the diagnostic center, or may first be wirelessly transmitted to a central computing center or cloud computing network for further processing, for example using algorithms accessing previous medical data from the same patient or a database of medical information collected from a plurality of patients, to calculate one or more probably professional opinion and transmit such data to the diagnostic site.

In certain embodiments the patient himself/herself may input data into a WTD device using a medical software application. As just one example, a patient who has diabetes (or is at risk of having diabetes) may input such data as blood glucose, temperature, medications, carbohydrates ingested, and the like into an application stored in a WTD,

which can then be transmitted to a remote location. In such a case, the medical examination devices may be the thermometer, blood glucose detecting means, and the patient herself.

Medical Examination Devices

In a preferred embodiment the medical examination devices used in the systems and methods of the present invention are at least partially integrated as part of the WTD wireless telecommunication device, or are directly connected to the wireless telecommunication device. By "directly connected" is meant that the medical examination devices are connected to the wireless telecommunication device either through a "wired" connection, such as a cable or port connection, or wirelessly, for example by use of Bluetooth® technology or other wireless transmission means.

Medical examination devices that may be connected to a wireless telecommunication device may comprise any device capable of converting the medical examination device data to digital form, and then relay the digital data to the wireless telecommunication device. Therefore, virtually any medical examination device including, for example and without limitation: a MRI device; a CT scan; a PET scan device; a mammography device; an echocardiogram device; an ultrasound device; an EMG device; a dual-emission X-ray absorptiometry device; X-ray devices; CRT devices; ultrasound devices; CAT scan devices; PET/CT scan devices; radiology devices; nuclear

medicine scan devices, thermometers; EKG detecting devices; EEG detecting devices; blood pressure cuffs; still and motion picture cameras (including microscope cameras); blood glucose monitors; blood chemistry monitors; binocularity testing instruments; color vision testing devices; ophthalmic ultrasound devices, optical coherence tomographer (OCT) devices; a neural diagnosis device, a pupilometer, a scanning laser ophthalmoscope, case history capture devices; lensometers; tonometers; visual fields testers; fundus cameras; retinal imaging systems; posterior segment imaging systems; automated refractors; biomicroscopes; corneal topographers; radiology equipment; CRT equipment; combinations of two or more such devices, and the like may be manufactured to have this capability. In particularly preferred embodiments, one or more of the medical examination devices are relatively simple and inexpensive, so as to permit their use in remote and sometimes undeveloped locations. The data connection between the WTD and the medical examination device may be wireless; may comprise a digital cable capable of connecting with the WTD, and/or may comprise the ability of the device itself to be comprised as part of the WTD, for example, mounted on to or within the WTD, wherein the medical examination device data is related through a mounting connection with the WTD.

Preferably, one or more medical examination device comprises a part of, attachment to, or extension of the WTD. Thus, in a preferred embodiment the medical examination device

may comprise a slit lamp attachment, blood glucose monitor attachment, microscope attachment, spectrometer attachment, cataract detector attachment (such as the CATRA™ system developed at MIT), an abberometer attachment (such as the NETRA™ system developed at MIT), and similar devices either at least partially integrated as part of the WTD or as attachments to the WTD used to examine a patient for one or more medical condition (including the lack of any abnormal condition), disorder, or disease.

Of course, patient examination data may be collected from more than one type of medical examination device; for example, patient medical examination data may be collected by a WTD from standalone medical examination devices such as a PET scan device and transmitted either wirelessly or via data cable to the WTD; while other information concerning the same patient may be collected from medical examination devices that are integral to the WTD, such as a microscope attachment thereto.

As indicated, the patient examination data collected by the medical examination devices is conveyed to and preferably stored by the WTD. The medical examination data from a plurality of patient examination devices may be stored within a spreadsheet or database type program run as an app on the WPP before transmission to the diagnostic center, central computer network, or cloud network. Alternatively, each item of patient examination data may be transmitted independently to a database in a remote location, either substantially as

acquired or as formattd by an app comprised in the WTD. In either case, in a preferred embodiment of the present invention the patient examination data is then wirelessly transmitted to a location remote from the patient examination location.

Wireless Telecommunication

In a preferred embodiment, the patient examination data is wirelessly transmitted using a cellular telecommunications system, such as, without limitation, a 3G or 4G cellular mobile communications system. However, it is anticipated that in certain underdeveloped or remote locations broadband access to wireless telecommunications may not be available; in such cases, the wireless transmission may occur by means of a modem which converts digital data from the WTD to an analog signal which may be transmitted over a telephone line. This analog signal may be transmitted using non-broadband wireless telecommunications systems, or even a wireless satellite telephone. Of course, certain satellite telephone systems permit the transmission of digital data as well; additionally satellite-based internet access systems are known and used.

In certain embodiments, the wireless telecommunication system may wholly or partially comprise a local network, such as a hospital network system, the corporate network system, or a home computer network system. Hospital or office-based network systems may comprise "Wi-Fi" transmitters that provide wireless telecommunications between the WTD and the internet

as a whole at broadband speed. In these embodiments, the remote location may comprise a room or office in the same building the as patient examination location, or may be located at a site further away from the medical examination location.

In some instances, the wireless telemedicine system of the present invention may comprise more than one patient examination location; for example a plurality of patient examination locations may each comprise medical examination devices and at least one WTD for transmission of patient examination data to a diagnostic center. In such cases, the patient examination data may be directly transmitted to the diagnostic center, or may be received at an intermediate location comprising, for example, a central computing center or cloud network in which the data may be stored and/or processed before being forwarded to the diagnostic center. The central computing center or cloud network may be located at a site different from both the examination site and the diagnostic center, or may be located within the diagnostic center. Additionally, the central computing center may be comprised in a cloud network, or may be a computing center unconnected to a cloud network, such as a hospital, office or business computing center.

It is desirable that the wireless communication network, and indeed all steps along the telecommunication link be suitable for the transmission of, for example, high resolution images, photographs, charts, test results and the like.

However, in certain embodiments, particularly when telecommunications takes place between a diagnostic center and a remote location in a undeveloped, underdeveloped or sparsely populated region, the wireless communications network and/or some of the intermediate steps may not support the transmission of high resolution images. For example, relatively low population density, topographical barriers such as mountains, and greater geographical distances have limited the extension, or the rate of such extension, of mobile broadband internet access as of 2012 to parts of the rural U.S., including relatively large areas of the mountainous Western United States. Mobile broadband access is even less common in regions of Africa, Greenland, South America, the Middle East and Mongolia. However, it is contemplated that even in such areas the use of, for example, modem- and/or satellite-based wireless telecommunication can permit the wireless telemedicine systems of the present invention to be used in such remote places, although the quantity (e.g., # of bytes) of data that can be practically transferred may be adversely affected thereby.

Database

The wireless telemedicine system of the present invention in most cases will comprise a database in which patient examination information is stored. However in certain embodiments, such as embodiments of the system of the present invention in which patient information is wirelessly transmitted directly to the diagnostic center, the patient

examination data may be transmitted to the diagnostic center without intermediate long-time storage in a database, cloud computing network, or central computer center. For example, using medical examination devices to determine the refractive error of the patient's eyes, the WTD may itself calculate the refractive error data, and then wirelessly transmit this data via a telecommunications system directly to an optometrist or optician, who can provide a professional opinion based upon the patient examination data to prescribe the proper corrective lenses suitable for use by the patient. In this case, the WTD itself may comprise a database, however, no database may be necessary between the patient examination site and the diagnostic center.

In cases in which a intermediate data storage or processing center is helpful or required, patient examination data that is wirelessly transmitted from the WTD is then received by a central computing center or cloud network; a database will generally be comprised as part of such a network. The database may save and maintain records corresponding to the collected patient medical examination data; the database may also add such information to previously existing data concerning the patient, and optionally format such data in a manner as a summary or report which can be sent or "pushed" to, or otherwise accessed by a medical professional at the diagnostic center. Additionally, the database may be designed to enable collection of data from multiple patients, creation of statistics using the data

contained therein and to analyze the data thereby allowing practitioner to search for and research population group trends, changes or expectations based on various criteria.

Furthermore, either or both the central computing center or cloud computing network and any data processing system at the diagnostic center may analyze the patient information according to one or more software-based medical algorithm. Medical algorithms have been long developed as means by which a medical professional may acquire and process patient examination data to make decisions as to the diagnosis, prognosis, and treatment of the patient. However, these algorithms have been used as decision-making tools for direct, manual use or memorization by medical professionals. That is, in the past, such algorithms have not been used as part of a wireless telemedicine system such as the one described in the present patent application, wherein a software program can automatically and simultaneously provide the patient examination data to the algorithm when called for to answer to questions posed by the algorithm at algorithm decision points in order to arrive at a professional opinion: that is, a diagnosis, prescription, professional recommendation or other professional opinion based on the data, or an indication of the need for more patient information, and the type of patient information, testing, or treatment required before a dependable professional opinion can be provided. As used in this specification, a "professional opinion" may include such an indication of the need for further patient information.

Diagnostic Center

The diagnostic center may be any location at which a medical professional is located, and where she may receive the patient examination data (either in a relatively raw format, or after analysis using a software-based medical algorithm), and respond to the medical examination site with a professional opinion rendered and transmitted in real time, preferably before the patient leaves the patient examination site. Hence, depending upon the circumstances, the diagnostic center may comprise, for example, a place of business, a physician's, nurse practitioner's, or midwife's home or office, a hospital or clinic, or any other location at which a medical professional is located can provide a professional opinion based upon the patient examination data and, optionally, any other available information or knowledge of the patient's prior medical history, including results of previous examinations, knowledge of medications taken by the patient, and the like. Generally, the diagnostic center comprises a computer system which saves the incoming patient examination information and/or analysis of such patient examination performed by any central computing center or cloud network. In certain circumstances the patient examination data may be displayed on an examination console for the medical professional so that she may formulate a professional opinion to be communicated back to the examination location; the examination console may optionally be comprised as part of a WTD to which the medical professional has access, such as

(without limitation) general purpose WTD such as a laptop computer, tablet computing device, or smartphone. In other cases the examination console may be a desktop computer or terminal module part of a hospital, clinic, or doctor's office computer network; in still other cases more than one examination console may be available, for example, as both a desktop computer and a tablet computing device.

In one embodiment, the examination console may permit videoconferencing between the patient examination site and the diagnostic center. For example, such videoconferencing may utilize cameras located on smartphones, tablet device or laptop computers running a software teleconferencing program, for example Skype™, FaceTime™, Go to Meeting™or another videoconferencing software program. As another alternative, a dedicated teleconferencing facility may be located and one or both the examination site or the diagnostic center.

Preferably the database, if present at any step in the telecommunications link, is able to recall and display (or even compare) the patient examination data with the patient's medical history. The patient's medical history may be entered during or attendant to the collection of the medical examination data, or may be preexisting data contained in the central computer center or the cloud network. In the latter case, the patient's medical history may include information based upon the patient's recollection (such as information gathered in a questionnaire during an initial visit to a new physician's office) and may include test results and patient

examination data based upon one or more previous examination employing medical examination devices. Thus, the patient's medical history may include charts, measurements, graphs, photographs, x-ray results, images from CAT scans or PET scans, as well as answers to questions posed in a medical questionnaire, such as previous illnesses, allergies, current medication, and the like. All these data may be compiled in a display or report for the medical professional and formatted using software running comprising one or more medically-based algorithm, to provide the necessary information, in a useful and informative format to the medical professional so that she may provide sound professional opinion based on the patient examination data and any available useful and/or necessary additional information.

The wireless telemedicine system of the present invention thus provides the ability for the medical professional to render a professional opinion based, at least in part, upon newly acquired patient examination data, and, in most cases, to provide a professional opinion via the wireless telecommunications network to the patient examination site, preferably before the patient leaves the examination site. Additionally, software associated with computers at the diagnostic center, or the central computing center, may be used to generate a printed report for the medical professional which includes a summary of the results of the patient examination; this report may be transmitted back to the patient or attending medical professional at the patient

examination location for delivery to the patient upon completion of the examination.

As is important for legal compliance in many countries, the medical examination data, medical history, written reports, professional opinion and other transmitted patient data may be encrypted before transmission. Encryption and decryption of all patient data from points of transmission and data receipt ensures that the operators of the system maintain control and confidentiality in all aspects of patient care and communication. The encryption may be applied to data before transmission through any of the communication links and/or before storage in the database; decryption may be performed by a software program residing on a computer or WTD at the point of data receipt, whether at the examination location, the diagnostic center, or at intermediate locations such as the central computer center or the cloud network.

Examples

Example 1

Referring now to Fig. 1, a patient at an examination location (101) presents with suspected myopia. The patient utilizes a general-purpose smartphone-based system for determining the refractive error in each eye (103). The smartphone-based system comprises the use of a smartphone attachment (104) which is designed to work in conjunction with

a software app comprised in the smartphone. By viewing a test screen through the smartphone attachment (104) the patient adjusts the display in the viewfinder using the manual controls of the smartphone. The software in the smartphone adjusts the viewfinder display in accordance with the patient's manipulation of these manual controls. The patient is instructed either by a medical professional at the examination location or by the smartphone software itself to manipulate the display in the viewfinder until an "end state" is reached; for example, until viewfinder display bars are arranged to be parallel or at right angles to each other. When the test screen is arranged as the patient is instructed to do, the smartphone calculates the refractive error for the eye used to view the display. When both eyes have been tested in this manner, the smartphone calculates the refractive error in the patient's left and right eyes.

These data are transmitted wirelessly (105) over a cellular telecommunications system (such as a 3G or 4G network) to a cell site (107), such as a cellular tower or other wireless telecommunications receiving location. The patient examination data is then transmitted (109) by the cell site to the diagnostic center (111). The cell site (107) may wirelessly relay the patient examination data to one or more additional cell site, or may relay the patient examination data via a cable, such as fiber optic cable, either directly to the diagnostic center (111) or to another cell site (not shown) which then wirelessly transmits the signal to a display

or terminal (113) at the diagnostic Center (111). The display or terminal (113) at the diagnostic center may comprise a simple viewing station, a desktop or laptop computer, or a WTD such as a tablet computing device. The display or terminal (113) display is the patient examination data, or the results of the software program contained in the smartphone (103), which may comprise the calculated refractive error for each of the patient's eyes. Preferably, the displayed patient examination data may also include ROM measurements upon which the calculated refractive error depends for its conclusion so that the medical professional in the diagnostic center may verify the accuracy of the software calculation, or may make it an independent calculation herself.

Once the medical professional (117) has satisfied himself/herself that he or she is able to provide a professional opinion based upon the patient examination data, he or she may telephone or teleconference with the patient and/or a medical professional at the examination location. In the situation as shown, the medical professional utilizes a telephone whose signal is transmitted (119) to a cellular tower (121) which then transmits the telephone call or teleconference data wirelessly (123) to the examination location. Additionally, the medical professional at the diagnostic center may order the preparation of glasses containing the necessary corrective lenses (125) based on the patient examination data, which then may be shipped (127) directly to the examination location or the patient's home.

Preferably, the time course of the example shown in Fig. 1 is sufficiently rapid to permit the medical professional at the diagnostic center to received the patient examination data, formulate a professional opinion, and communicate back to the remote examination location before the patient leaves the examination location. The medical professional may be, without limitation, an ophthalmologist, an optometrist, a nurse, or an optician or other medical professional.

Of course, those of ordinary skill in the art can easily in vision alterations or variations based upon the example given in Fig. 1. For example, rather than using a cellular telecommunications network, the examination location may use a satellite or dial-up modem-based system-particularly if the examination location is sufficiently remote, for example on board a ship or located in a rural or undeveloped area. Additionally, the test for refractive error may be done using a traditional refracting device (such as an autorefractor) system, rather than a smartphone-based system, in which the data obtained using the system is conveyed to a WTD device, which then transmits the patient examination data in a manner substantially similar to that shown in Fig. 1.

Example 2

In Fig. 2, another embodiment of the present invention is shown. In this example, a patient (203) at an examination location (201) is given two tests: an x-ray and blood pressure

determination. The x-ray machine produces an image (205) that is wirelessly transmitted (207) to a general purpose tablet WTD device (213) using, for example a Bluetooth wireless system. A blood pressure cuff (209) produces a reading which is transmitted to the tablet device (213) via a data cable (211). The tablet WTD (213) displays the blood pressure data, the x-ray image, and medical history of the patient that has been manually entered into the WTD software (215). The combined patient medical data is preferably encrypted and then transmitted wirelessly (217) to a cell site (219) which then relays (221) the patient medical data to a central computing center (223).

The central computing center (223) may comprise a library of medical algorithms for different medical conditions. Based upon the patient's medical history, and the other patient examination data which it is received, combined with any other information concerning this patient that may reside within the database in the central computing center, the central computing center (223) selects one or more medical algorithm with which it then tests the patient examination data. The selection and testing procedures may be automatic, or may be manually initiated, either at the central computing site, by the patient or a medical professional at the examination location, or by a medical professional at the diagnostic center. As explained further below, the algorithm(s) run by the central computing center (which may be a cloud computing network) may determine that there is insufficient data with

which to formulate a professional opinion; this presumptive opinion is then transmitted (225) to a medical professional at the diagnostic center (227) and/or the examination location (201) so that the indicated additional information may be provided to permit the diagnostic algorithm to formulate a presumptive professional opinion. If the patient examination data, combined with the patient's medical history, is sufficient to form a professional opinion concerning the patient's current medical status, the professional medical opinion and any additional information, such as recommendations for treatment, lifestyle changes, or further testing is also forwarded (225) to the diagnostic center (217).

The professional opinion and additional information, if any, is then displayed on a terminal or monitor at the diagnostic center (227). The terminal may be a terminal of a larger institutional computer network (such as a hospital, clinic, or medical office network) or may itself be a computer or WTD, such as a tablet computing device, such as an IPad® tablet, a laptop computer or a smartphone.

The algorithm or algorithms used to provide the prospective diagnosis or professional opinion in this example may comprise a nested set of algorithms, in which a 1st algorithm is used to search a library of diagnostic algorithms and select one or more such diagnostic algorithms to run based the upon the patient examination data and any additional information provided either at the examination location, the

diagnostic center, or elsewhere. The diagnostic algorithms may be contained in a larger software program, in which a single software program algorithm is used to access, diagnose, and report a prospective professional opinion to the diagnostic Center. Alternatively, particular diagnostic algorithms may be selected at the examination location or the diagnostic Center for use in processing the patient examination data, without the use of a larger multi functional diagnostic software program. By "multi functional" in this context is meant a larger software program capable of being used to diagnose a variety of different medical conditions.

In addition to optionally comprising diagnostic algorithms, the central computing center or cloud network may comprise a database containing additional information concerning the patient. For example, the central computing center may contain the patient medical history, results of previous examination tests, and in certain cases comprises a collection of patient data from a plurality of patients which may be used for the creation of statistics using the data contained therein and to analyze the data, thereby allowing medical professionals to search for and research patient population group trends, changes or expectations based on various criteria. The collection of patient data may be used to refine the diagnostic algorithms thereby providing professional opinions based upon patient examination dated with greater accuracy than might have been possible otherwise.

Additionally, or alternatively, the algorithm or

algorithms used to provide the prospective diagnosis may comprise a clinical decision support system (CDSS). A CDSS is an active knowledge system, which uses two or more items of patient data to generate case-specific advice. The methodology of using CDSS preferably forces the medical professional to interact with the CDSS utilizing both the medical professional's knowledge and the CDSS to make a better analysis of the patient's data than either human or CDSS could make on their own. While in certain embodiments the CDSS may make the diagnosis without human intervention, preferably the CDSS would make suggestions of outputs or a set of outputs for the medical professional to look through and the medical professional would pick useful information and remove erroneous CDSS suggestions.

CDSS's generally comprise three parts, the knowledge base, inference engine, and a mechanism to communicate. The knowledge base contains the rules and associations of compiled data which most often take the form of IF-THEN rules. For example, if the CDSS is used for determining drug interactions, then a rule might be that IF drug X is taken AND drug Y is taken THEN alert user. Using another interface, an advanced user could edit the knowledge base to keep it up to date with new drugs. The inference engine combines the rules from the knowledge base with the patient's data. The communication mechanism will allow the system to show or transmit the results to the user as well as have input into the system.

CDSS's that do not use a knowledge base use a form of artificial intelligence called machine learning, which allows computers to learn from past experiences and/or find patterns in clinical data. Two types of non-knowledge-based systems are artificial neural networks and genetic algorithms.

Artificial neural networks use nodes and weighted connections between them to analyze the patterns found in the patient data to derive the associations between the symptoms and a diagnosis. This eliminates the need for writing rules and for expert input. However, since the system cannot explain the reason it uses the data the way it does, such systems are less preferred for reliability and accountability reasons.

Genetic algorithms are based on simplified evolutionary processes using directed selection to achieve optimal CDSS results. The selection algorithms evaluate components of random sets of solutions to a problem. The solutions that come out on top are then recombined, "mutated", and run through the process again. This happens over and over till the proper solution is discovered. They are the same as neural networks in that they derive their knowledge from patient data. Non-knowledge-based networks often focus on a narrow list of symptoms like ones associated with a single disease as opposed to the knowledge based approach which cover many different diseases to diagnosis. See Wikipedia article entitled Clinical Decision Support System, http://en.wikipedia.org/wiki/Clinical_decision_support_system, (accessed February 6, 2013).

Example 3

Fig. 3 shows an example of a basic algorithm as an example of those which may be used in conjunction with the wireless telemedicine system of the present invention. As shown, patient examination data is transmitted wirelessly from the examination location along with an indication of the reason for the medical examination. This latter information may be provided separately or may be inherently indicated in, or from the nature of, the patient examination data. The algorithm may first inquire whether the patient's medical history is included with the patient examination data. If the patient medical history is not included with the patient examination data, then the algorithm may query whether the patient's medical history is on file within a database contained in the central computing center. If it is not, then the algorithm responds with a query, which may be sent to the diagnostic center and/or patient examination location in which, for example, a request for patient history information required to provide a prospective professional opinion according to the algorithm is listed. This query provides the medical professional at the examination location and/or the diagnostic location with an indication of what further patient history information should be provided before a prospective professional opinion may be rendered.

If the patient medical history is included with the patient examination data, or if the patient medical history is currently on file within a database in an accessible computer

center, then the medical history information is assessed for risk factors associated with the purpose for the current examination visit. If any such risk factors are present, they are readied for access by the medical diagnostic algorithm. Additionally (and not necessarily performed before the risk factor assessment is is made) a selection of one or more medical diagnostic algorithms pertinent to the medical reason for the patient's examination is selected. The medical diagnostic algorithm then compares the patient's examination data with the criteria requested by the selected algorithm or algorithms, as informed by the patient medical history. The algorithm or algorithms used for medical diagnosis assess the medical examination data to determine if there is sufficient examination data to formulate a professional opinion. If not, the necessary or desired additional examination data information may be listed and sent to the diagnostic center and/or the examination location for rectification, if possible, as indicated above for missing medical history information.

If there is sufficient examination data to run the diagnostic algorithm or algorithms, then the algorithm(s) is/are performed using the patient examination data to answer queries at key algorithm decision points. After the algorithm has processed this information, if an opinion can be provided by the algorithm according to its criteria, then the prospective professional opinion optionally combined with graphs, images, and other analysis, is displayed at the

terminal or monitor at the diagnostic center. On the other hand if, after running the algorithm, a professional opinion cannot be concluded based upon the criteria programmed into the algorithm software, then this fact, along with any recommendations such as treatment recommendations, lifestyle recommendations, further testing, and schedule for subsequent patient examinations may be listed and sent to the diagnostic center.

A medical professional at the diagnostic center receives output from the algorithm(s), including the prospective professional opinion, if any. The medical professional may optionally access the central computing center (or cloud network) computers to obtain further information if available or necessary in her opinion to help formulate a final professional opinion or recommendation.

Based on this information the medical professional then is able to telephone, teleconference with, and/or otherwise provide information back to a medical professional at the examination location or the patient, preferably before the patient leaves the examination location.

While this invention has been described in conjunction with the specific embodiments outlined above, it is evident that many alternatives, modifications and variations are apparent to those skilled in the art. Accordingly, the preferred embodiments of the invention as set forth above are

intended to be illustrative and not limiting. Additionally, elements of the various embodiments of the invention described herein may be exchanged, combined, or deleted, without departing from the spirit and scope of the invention. Additionally, each and every patent publication, patent, and non-patent publication (including internet-published publications) cited or mentioned in this patent application is hereby specifically and individually incorporated by reference as part of this disclosure in its entirety.

CLAIMS

What is claimed is:

1. A system for conducting an eye examination from a remote location, comprising:

a plurality of eye examination devices located at an eye examination location;

a general purpose wireless telecommunication device (WTD) having one or more said eye examination devices at least partially integrated therein; said WTD being located at said eye examination location and configured to acquire diagnostic patient examination data from two or more of the eye examination devices, said diagnostic patient examination data being sufficient to permit a medical professional to render a professional opinion, said WTD configured to transmit the patient examination data via a wireless communications link to a location remote from said eye examination location;

a diagnostic center situated in said remote location and capable of directly or indirectly receiving the diagnostic eye examination data from said eye examination location to enable a medical professional to render a professional opinion based thereupon, wherein said medical professional is located at the diagnostic center, thus permitting the eye care practitioner to provide a professional opinion based at least in part on the eye examination data, thus advising the patient in real time,

and wherein said diagnostic eye examination data does not comprise routine monitoring data.

2) The system of claim 1 wherein an eye examination device at least partially integrated in said WTD comprises a specialized software application loaded therein.

3) The system of claim 2 wherein said eye examination device comprises a camera comprised as part of said WTD.

4) The system of claim 1 wherein said plurality of eye examination devices comprises a device selected from the group consisting of a case history capture device, lensometer, tonometer, visual fields tester, fundus camera, an optical coherence tomographer (OCT) device, a retinal imaging system, a slit lamp, a pupilometer, a scanning laser ophthalmoscope, a posterior segment imaging system, an automated refractor, a biomicroscope, binocularity testing instrument, and a color vision test, ophthalmic ultrasound device, and a corneal topographer.

5. The system of claim 1 wherein said WTD is selected from the group consisting of a mobile telephone, a personal digital assistant, a tablet computing device and a personal computer.

6. The system of claim 1 wherein two or more said eye examination devices is at least partially integrated as part of the WTD.

7. The system of claim 1 wherein the wireless communications link is selected from a satellite telecommunications system and a

wireless telecommunications system.

8. The system of claim 1 wherein the eye examination location lacks access to an AC power source.

9. The system of claim 1 wherein patient examination data received from two or more eye examination devices is processed by a software application before it is viewed by a medical professional at the diagnostic center.

10. A system for conducting a diagnostic medical examination from a remote location, comprising:

a plurality of medical examination devices located at an medical examination location, one or more said medical examination devices being at least partially integrated as part of a general purpose wireless telecommunication device (WTD) located at said medical examination location and configured to receive patient examination data from two or more of the medical examination devices, said WTD configured to transmit patient examination data via a wireless communications link to a location remote from said examination location;

a diagnostic center situated in said remote location and capable of receiving the wireless transmitted patient examination data from said examination location to enable a medical professional located at the diagnostic center to provide a professional opinion, thus advising the patient concerning the presence or absence of a medical disorder or disease based at least in part upon said patient examination data in real time,

and wherein said patient examination data does not comprise routine patient monitoring data.

11. The system of claim 10 wherein the medical examination devices are selected from an EEG device, a blood pressure detector, a blood glucose detector, an X-ray device, a MRI device, a CT scan, a PET scan device, a mammography, an echocardiogram device, an ultrasound device, an EKG device, an EMG device, a dual-emission X-ray absorptiometry device, a case history capture device, a lensometer, a slit lamp, a pupilometer, a scanning laser ophthalmoscope, a tonometer, a visual fields tester, a fundus camera, retinal imaging system, a posterior segment imaging system, an optical coherence tomographer (OCT) device, an automated refractor, a biomicroscope and a corneal topographer.

12. The system of claim 10 wherein the diagnostic center comprises a second wireless digital transmission device.

13. The system of claim 12 wherein the second wireless digital transmission device comprises a device selected from the group consisting of: a smartphone, a tablet computing device; a PDA, a laptop computer, and a visual display device.

14. A wireless medical system, comprising:

a plurality of medical examination devices located at a medical examination location;

a first general purpose wireless digital transmission device (WTD) located at said medical examination location and configured

to receive diagnostic patient data from two or more of the medical examination devices, said first WTD configured to transmit the diagnostic data via a wireless communications link to a location remote from said medical examination location upon examining a patient;

a diagnostic center situated in said remote location and capable of receiving the wireless transmitted diagnostic data from said medical examination location to enable the diagnosis of an medical disorder or disease of the patient by a medical care practitioner located at the diagnostic center, thus permitting the medical care practitioner to provide a diagnosis and prescription based on the medical examination data to the patient before the patient leaves the examination location.

15. The medical system of claim 14 wherein the wireless medical data is transmitted from the wireless digital transmission device to a second WTD in the diagnostic center for observation by the medical care practitioner.

16. The system of claim 14 wherein diagnostic patient data received from two or more medical examination devices is processed by a software application in said first WTD before it is transmitted to the diagnostic center.

17. The system of claim 14 wherein the medical examination devices are selected from an EEG device, a blood pressure detector, a blood glucose detector, an X-ray device, a MRI device, a CT scan, a PET scan device, a mammography, an echocardiogram device, an ultrasound device, an EKG device , an

EMG device, a dual-emission X-ray absorptiometry device, a case history capture device, a lensometer, a tonometer, a visual fields tester, a fundus camera, retinal imaging system, a posterior segment imaging system, an automated refractor, an optical coherence tomographer (OCT) device, a biomicroscope and a corneal topographer.

18. A system for conducting a medical examination from a remote location, comprising:

a plurality of medical examination devices located at a medical examination location, one or more said medical examination devices being at least partially integrated as part of a general purpose wireless telecommunication device (WTD) located at said medical examination location and configured to receive patient examination data from two or more of the medical examination devices, said WTD configured to transmit patient examination data via a wireless communications link to a location remote from said examination location;

a diagnostic center situated in said remote location having a automated clinical decision support system (CDSS) comprising a algorithm which receives said patient examination data as input and calculates a preliminary diagnosis as output, said output being made available to a medical professional to enable said medical professional to assess the preliminary diagnosis and return a professional opinion using a wireless communications link to said medical examination location, thus advising the patient concerning the presence or absence of a medical disorder

or disease based at least in part upon said patient examination data in real time.

19. A method of conducting a medical examination from a remote location, comprising using at least one medical diagnostic device at the medical examination location to provide patient examination data; wirelessly transmitting the medical examination data directly or indirectly to a diagnostic center remote from the medical examination location to enable a medical professional located at the diagnostic center, to communicate a professional opinion based on the transmitted medical examination data to the examination location before the patient leaves the medical examination location; wherein the diagnostic center comprises no medical examination devices.

20. A method of conducting an eye examination from a remote location, comprising conducting an eye examination of a patient at an eye examination location using at least one eye examination device at the eye examination location to provide patient eye examination data; wirelessly transmitting the eye examination data to a diagnostic center remote from the eye examination location to enable a eye care professional located at the diagnostic center to communicate a professional opinion based on the transmitted eye examination data to the eye examination location before the patient leaves the eye examination location; wherein the diagnostic center comprises no eye examination devices.

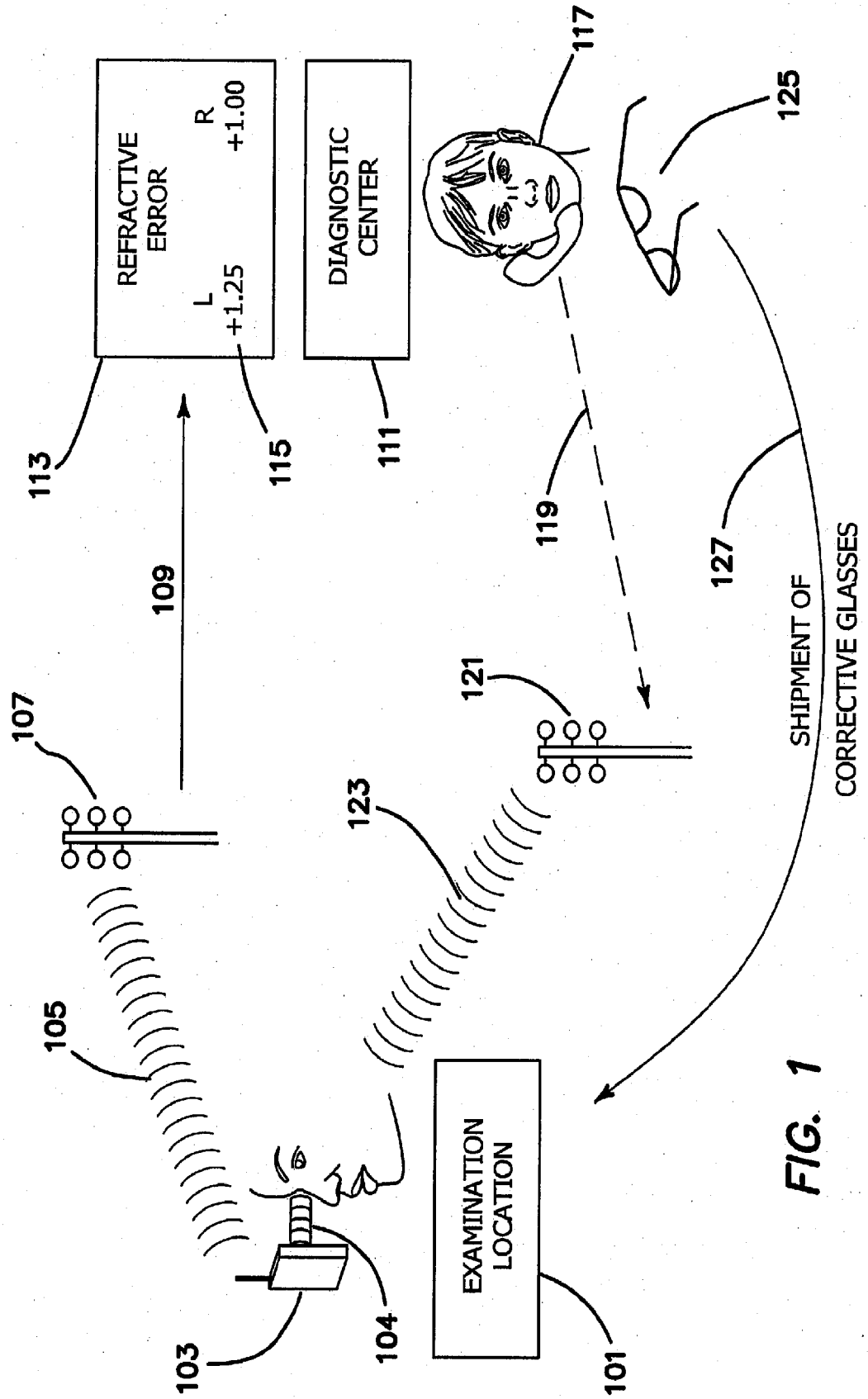
REFRACTIVE ERROR
R +1.00
L +1.25
DIAGNOSTIC CENTER
EXAMINATION LOCATION
SHIPMENT OF CORRECTIVE GLASSES
101
103
104
105
107
109
111
113
115
117
119
121
123
125
127

FIG. 1

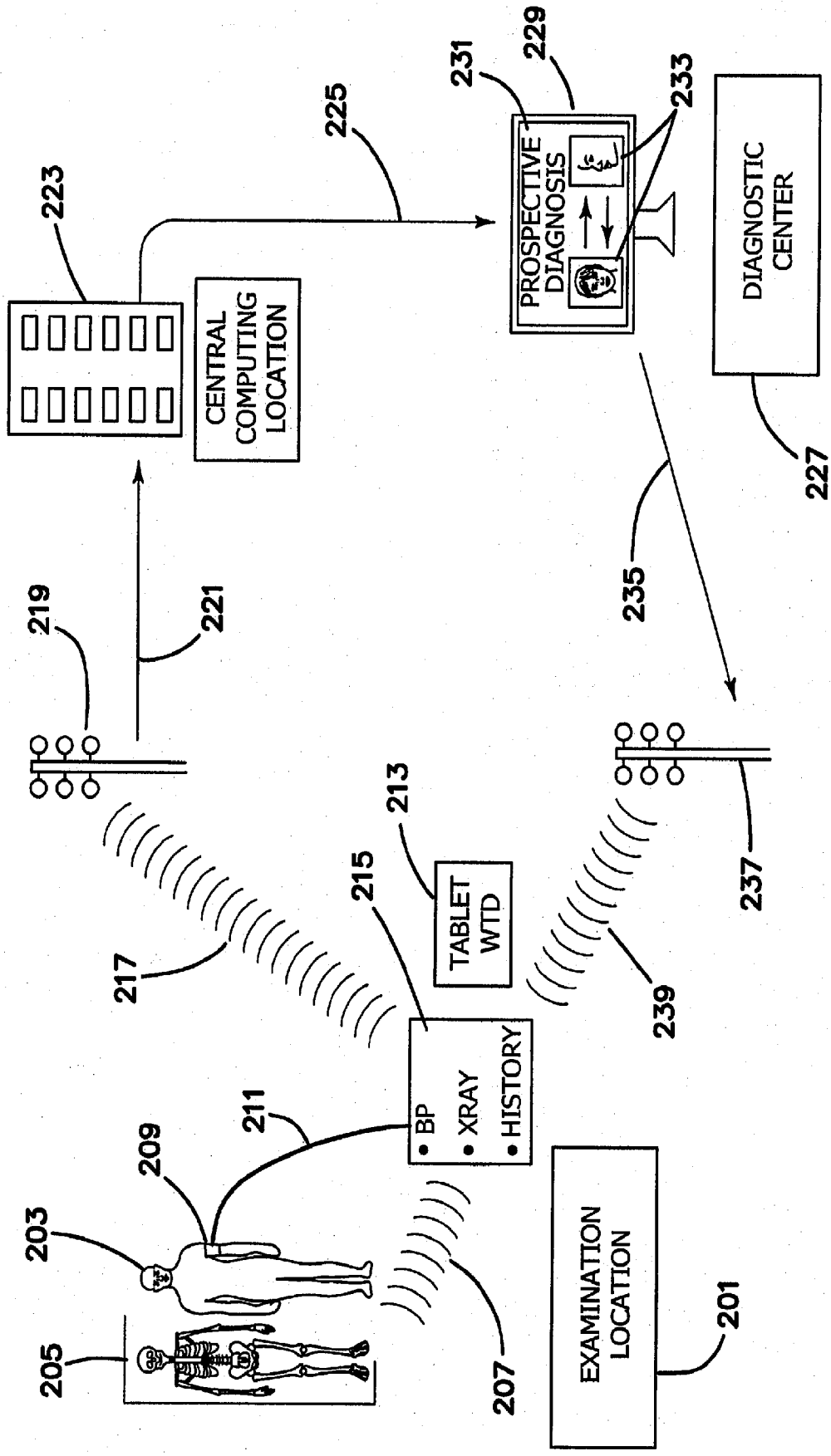
223
CENTRAL COMPUTING LOCATION
225
231
229
233
PROSPECTIVE DIAGNOSIS
DIAGNOSTIC CENTER
227
219
221
235
213
215
TABLET WTD
217
237
239
• BP
• XRAY
• HISTORY
211
209
203
205
207
EXAMINATION LOCATION
201

FIG. 2

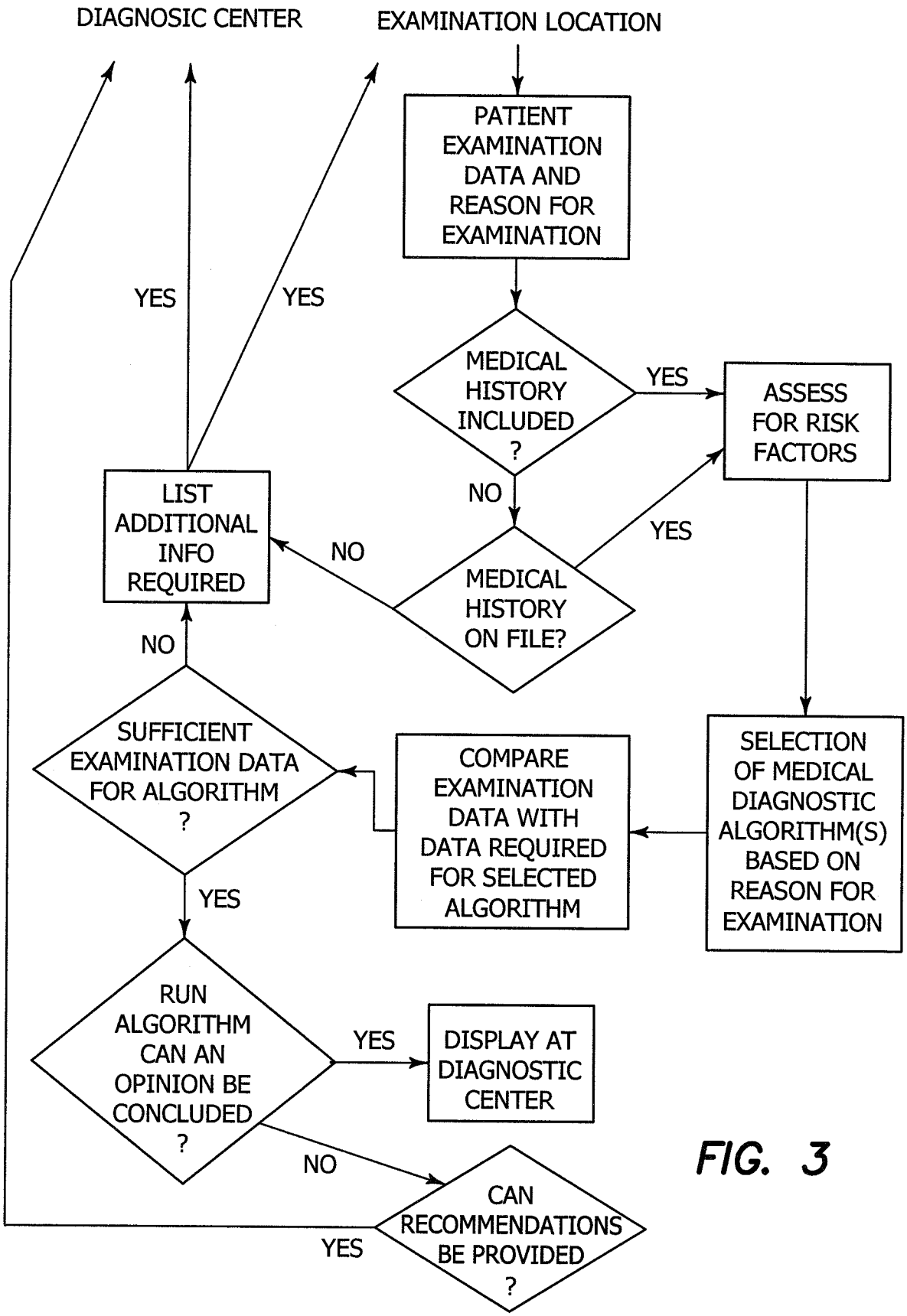
DIAGNOSIC CENTER
EXAMINATION LOCATION
PATIENT EXAMINATION DATA AND REASON FOR EXAMINATION
MEDICAL HISTORY INCLUDED ?
YES
ASSESS FOR RISK FACTORS
NO
YES
YES
YES
LIST ADDITIONAL INFO REQUIRED
NO
MEDICAL HISTORY ON FILE?
NO
SELECTION OF MEDICAL DIAGNOSTIC ALGORITHM(S) BASED ON REASON FOR EXAMINATION
COMPARE EXAMINATION DATA WITH DATA REQUIRED FOR SELECTED ALGORITHM
SUFFICIENT EXAMINATION DATA FOR ALGORITHM ?
YES
RUN ALGORITHM CAN AN OPINION BE CONCLUDED ?
YES
DISPLAY AT DIAGNOSTIC CENTER
NO
CAN RECOMMENDATIONS BE PROVIDED ?
YES

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/035644

A. CLASSIFICATION OF SUBJECT MATTER

G06Q 50/22(2012.01)i

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)
G06Q 50/22; A61B 3/02; A61B 3/10; A61B 3/032; A61B 7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: medical examination, eye, diagnosis center, remote location, telemedicine, wireless telecommunication device, real time

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007-0195267 A1 (FRANZ, RICHARD et al.) 23 August 2007 See abstract and claims 1, 11, 16.	1-20
Y	KR 10-2004-0017031 A (CHO, CHANG HO et al.) 26 February 2004 See abstract, page 2, lines 8-12, page 3, lines 17-19, page 4, line 12, claims 1-2, and figure 1.	1-20
Y	KR 10-2002-0038071 A (LEE, BYUNG HOON) 23 May 2002 See abstract and claim 1.	18
A	KR 10-2002-0031978 A (LEE, SEON BEOM) 03 May 2002 See abstract, claims 1-20 and figures 1, 3-4, 9-10.	1-20
A	US 2010-0292999 A1 (VERMA, DINESH) 18 November 2010 See abstract, paragraphs [0125]-[0132], claims 48-57, 71-76 and figure 5.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of 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
26 July 2013 (26.07.2013)	**26 July 2013 (26.07.2013)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/035644

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		WO 2008-020252 A2	21/02/2008
		WO 2008-020252 A3	26/06/2008