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(54) **Titre : SYSTEMES ET PROCEDES DE MESURE DE CARACTERISTIQUES FACIALES**
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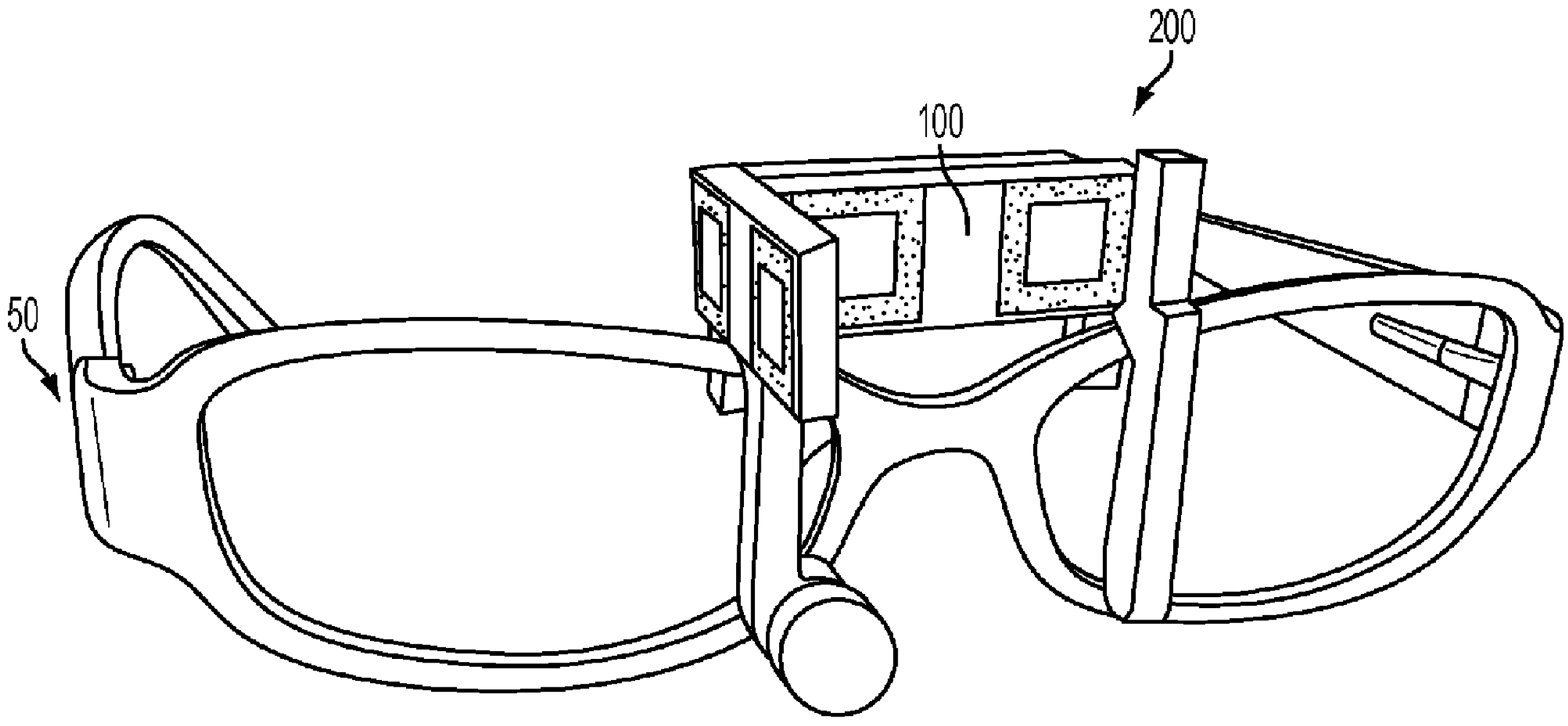

FIG. 1

(57) **Abrégé/Abstract:**
Systems and methods for measuring facial characteristics of patients. In various embodiments, the system uses a geometric pattern to determine a reference scale for an image that includes the geometric pattern and at least a portion of the patient's face.

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(57) **Abrégé(suite)/Abstract(continued):**
The system may determine the reference scale based at least in part on a known measurement within the geometric pattern. The known measurement may include a distance between two geometric attributes of the geometric pattern. The system may be further configured to correct for errors caused by an orientation of the geometric pattern within the image and/or distortion of the geometric pattern within the image. The geometric pattern may be disposed on a reference device that may be configured to enable a user to attach the reference device to the head of the patient or a pair of eyewear worn by the patient.

Abstract

Systems and methods for measuring facial characteristics of patients. In various embodiments, the system uses a geometric pattern to determine a reference scale for an image that includes the geometric pattern and at least a portion of the patient's face. The system may determine the reference scale based at least in part on a known measurement within the geometric pattern. The known measurement may include a distance between two geometric attributes of the geometric pattern. The system may be further configured to correct for errors caused by an orientation of the geometric pattern within the image and/or distortion of the geometric pattern within the image. The geometric pattern may be disposed on a reference device that may be configured to enable a user to attach the reference device to the head of the patient or a pair of eyewear worn by the patient.

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SYSTEMS AND METHODS OF MEASURING FACIAL CHARACTERISTICS

BACKGROUND

When fitting eyewear for a user, it may be necessary to take measurements of various facial characteristics of the user. Accordingly, there is a need for improved methods and techniques for taking such measurements.

SUMMARY

A reference device for facilitating measurement of one or more facial characteristics of a user, according to various embodiments, comprises a geometric pattern and an attachment mechanism operatively coupled to the geometric pattern. In a particular embodiment, the geometric pattern comprises a first geometric attribute and a second geometric attribute spaced a first distance apart from the first geometric attribute. In some embodiments, the attachment mechanism is configured to removably attach the geometric pattern to an object selected from a group consisting of: (i) an eyewear frame; and (ii) the user's head.

A computer system for measuring facial characteristics of a person wearing eyewear, according to various embodiments, comprises at least one processor. In particular embodiments, the computer system is configured for receiving a first image that comprises a reference device and at least a portion of the face of a wearer of eyewear that includes at least the wearer's first and second eye. In various embodiments, the reference device has a geometric pattern and is attached to the pair of eyewear worn by the wearer, and the geometric pattern includes a first geometric attribute and a second geometric attribute spaced a known distance apart from the first attribute. In various embodiments, the system is further configured to determine a distance between the first geometric attribute and the second geometric attribute from the image; calculate, based at least in part on the known distance and the determined distance, a reference scale for the first image; determine a measurement of a facial characteristic from the first image; and using the reference scale and the measurement of the facial characteristic, calculate an actual measurement of the facial characteristic of the wearer in the first image.

A method of measuring a facial characteristic of a patient, in various embodiments, comprises providing a reference device, where the reference device comprises a geometric pattern having a first geometric attribute and a second geometric attribute spaced apart from the from the first geometric attribute. The reference device also comprises an attachment mechanism

operatively coupled to the geometric pattern and configured to enable a user to selectively attach the reference device to eyewear. In particular embodiments, the method further includes: (1) attaching the reference device to eyewear; (2) placing the pair of eyewear and the reference device on a patient; (3)receiving, by at least one processor, an image comprising the reference device and at least a portion of the patient's face; (4) determining, by at least one processor, a measurement of a second distance between the first geometric attribute and the second geometric attribute from the received image; (5) calculating, by at least one processor, a reference scale for the image based at least in part on the first distance and the second distance; and (6) using, by at least one processor, the reference scale to convert measurements of facial characteristics of the patient taken from the image into actual measurements of the patient's facial characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of a system and method for measuring facial characteristics of a user are described below. In the course of this description, reference will be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a perspective view of a reference device according to a particular embodiment of the present system and methods;

Figure 2 is a detail view of a geometric pattern according to a particular embodiment;

Figure 3A is a front perspective view of the reference device of Figure 1;

Figure 3B is a rear perspective view of the reference device of Figure 1;

Figure 3C is an exploded view of the reference device of Figure 1;

Figure 4 is a block diagram of a facial characteristic measuring system in accordance with an embodiment of the present system;

Figure 5 is a schematic diagram of a computer, such as a mobile measuring device that may be suitable for use in various embodiments;

Figure 6 depicts a flow chart that generally illustrates steps performed by a facial characteristic measuring module.

DETAILED DESCRIPTION

Various embodiments now will be described more fully hereinafter with reference to the accompanying drawings. It should be understood that the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Reference Device

Referring to Figure 1, a reference device for measuring various facial characteristics, in various embodiments, comprises a geometric pattern **100** and a geometric pattern mounting device **200**. The geometric pattern mounting device **200** removably couples the geometric pattern **100** to a pair of eyewear **50** according to a particular embodiment. These and other components of a reference device for measuring various facial characteristics are discussed more fully below.

Geometric Pattern

Figure 2 shows an exemplary geometric pattern **100** for use with a reference device for measuring various facial characteristics. In the embodiment shown in this figure, the geometric pattern **100** is substantially symmetrical (e.g., symmetrical) and comprises a first geometric attribute **110** and a second geometric attribute **120**. In this embodiment, the first and second geometric attributes **110**, **120** each comprise a substantially rectangular (e.g., substantially square) polygon that are spaced a first distance apart from one another. In the embodiment shown in this figure, the square geometric attributes **110**, **120** are substantially the same size, are coplanar, and oriented so that a side of each rectangular polygon is substantially parallel to one another. In particular embodiments, the first and second geometric attributes **110**, **120** are substantially identical. In various embodiments, the first distance is a distance **114** between the centers of the substantially square geometric attributes **110**, **120**.

In various embodiments, each side of the two square geometric attributes **110**, **120** has a length of between about 3 millimeters and about 15 millimeters. In a particular embodiment, each side of the two square geometric attributes **110**, **120** has a length of about 5 millimeters. In yet another particular embodiment, each side of the two square geometric attributes **110**, **120** has a length of about 10 millimeters. In various embodiments, the first distance is between about 10 millimeters and about 25 millimeters. In a particular embodiment, the first distance is about 16 millimeters.

In the embodiment shown in Figure 2, the first and second geometric attributes **110**, **120** have a perimeter edge **118**, **128** formed in a first color and a corresponding interior surface **112**, **122** at least partially bounded (e.g., fully bounded) by the perimeter edge **118**, **128** in a second color. In particular embodiments, the interior surface **112**, **122** may be partially bounded by the perimeter edge **118**, **128** (e.g., the interior surface **112**, **122** may not be fully bounded by the perimeter edge **118**, **128**). In various embodiments, the first and second colors are sufficiently contrasting to enable an imaging device to at least substantially distinguish between the perimeter edge and the interior surface (e.g., transition from the first color to the second color). In the embodiment shown in this figure, the perimeter edge is a dark color (e.g., black) and the interior portion is a lighter color (e.g., white). In other embodiments, the perimeter edge and interior portions may comprise any suitable color combination that is sufficiently contrasting (e.g., black and orange, black and yellow, red and green, etc.). Moreover, particular finishes on the geometric pattern can enhance or decrease the system's ability to distinguish between the perimeter edge area and the interior surface area. For example, in various embodiments, a matt finish on the geometric pattern may increase the system's ability to detect a transition from the perimeter edge to the interior area in various lighting conditions.

In various embodiments, the perimeter edge **118**, **128** is sufficiently thick to enable an imaging device to detect a transition from the perimeter edge **118**, **128** to the interior surface **112**, **122**. For example, in a particular embodiment, the perimeter edge **118**, **128** is sufficiently thick such that an image of the geometric pattern **100** taken by an imaging device from a reasonable distance (e.g., such as a distance from which an image would be taken of a patient by a person desiring to take a measurement of a facial characteristic of the patient) would include the perimeter edge **118**, **128**, and the perimeter edge **118**, **128** would have a thickness of two or more pixels within the image. In some embodiments, the thickness of the perimeter edge **118**, **128** is between about 1 mm and about 4 mm thick. In a particular embodiment, the thickness of the perimeter edge **118**, **128** is about 2 mm.

In other embodiments, the first and second geometric attributes **110**, **120** may include any other suitable geometric attribute. For example, in a particular embodiment, the first and second geometric attributes **110**, **120** may include any suitable portions of a geometric pattern **100**. For example, a geometric pattern comprising a single substantially rectangular polygon may include first and second geometric attributes **110**, **120** in the form of opposing edges of the substantially

rectangular polygon. In other embodiments the first and second geometric attributes **110**, **120** may have any other suitable shape than rectangular such as circular or polygonal (e.g., triangular, pentagonal, hexagonal, heptagonal, octagonal, or any other suitable polygon).

In various embodiments, the first and second geometric attributes may comprise any suitable portion of a geometric pattern that enables an imaging device to measure a distance between the first and second geometric attributes from a digital image that contains the first and the second geometric attributes. The geometric attributes may comprise, for example any suitable portion of a geometric shape that makes up part of the geometric pattern (e.g., an edge, a center, etc.). In various embodiments, the geometric pattern may include any suitable combination of shapes having defined angles (e.g., such as any suitable combination of polygons). It should be understood that geometric patterns that contain known angles are preferred over geometric shapes without angles. Thus, geometric patterns containing 90 degree inside angles enhances detection of the geometric pattern while reducing the incidence of false detection of unintended patters in the image.

Geometric Pattern Mounting Device

Figures 3A-3C show an exemplary geometric pattern mounting device **200**. As may be understood from Figures 3A-3C and from Figure 1, the geometric pattern mounting device **200**, in various embodiments, is configured to enable a user to selectively attach the geometric pattern **100** to a pair of eyewear **50**. In the embodiment shown in Figures 3A-3C, the geometric pattern mounting device **200** comprises a clip body **210**, a clip horizontal slider **250**, and a vertex reference mount **290**. These features are discussed more fully below.

Clip Body

Referring particularly to Figures 3A and 3B, in the embodiment shown the clip body **210** is substantially rectangular (e.g., rectangular); extends between a first end side wall **287** and a second end side wall **288**; and has a substantially flat (e.g., flat) front surface **281**, a rear surface **282**, a top surface **285** and a bottom surface **286**. As may be understood from Figure 3B, the clip body **210** defines a substantially rectangular first opening **289** that is formed through the second end side wall **288**, extends at least partially between the second end side wall **288** and the first end side wall **287**, and opens into a substantially rectangular chamber within the clip body **210** defined by the front surface **281**, rear surface **282**, top surface **285** and bottom surface **286**. The

clip body **210** further defines a substantially rectangular rear cutaway **283** on the clip body's rear surface **282** that opens into the rectangular chamber. The clip body **210**, in particular embodiments, further defines a first threaded opening **216** formed in top surface 285 of the clip body **210**. In various embodiments, the clip body **210** defines a vertex reference mount support notch **217** (Figure 3C) formed through the clip body's top surface **285** adjacent the first end side wall **288**.

In particular embodiments, the clip body **210** comprises a first frame support **212** that extends substantially perpendicularly from the clip body bottom surface **286** and a second frame support **214** (Figure 3B) that extends from the clip body rear surface **282**. The second frame support has a first proximate portion **215** that is disposed at an angle with respect to the first frame support 212, and a second distal portion **217** that is substantially parallel to the first frame support **212**. In various embodiments, the first and second frame supports **212**, **214** are configured to cooperate to maintain the geometric pattern mounting device **200** adjacent a pair of eyewear (e.g., adjacent a top surface of the eyewear frame such that the geometric pattern **100** is positioned substantially above the eyewear when the eyewear is being worn by a user). In a particular embodiment, the first and second frame supports **212**, **214** form a cradle **270** that is configured to receive at least a portion of the frame of the eyewear (e.g., the top of the frame). In other embodiments, the geometric pattern mounting device **200** may include any other suitable mechanism for attaching the geometric pattern mounting device **200** to a pair of eyewear (e.g., such as a clip, sticker, magnet, etc.).

In the embodiment shown in Figures 3A-3B, the clip body's first frame support **212** contains a second threaded opening **222** that is sized to receive a threaded screw **220**. As may be understood from these figures and from Figure 1, the threaded screw **220** is configured to adjust a pitch of the front surface **281** of the clip body **210** relative to the eyewear **50** when the geometric pattern mounting device **200** is attached to the eyewear **50**. In this embodiment, the threaded screw is configured to enable a user to move the threaded screw **220** relative to the second threaded opening **222** in order to adjust the pitch of the front surface **281** of the clip body **210.** Said another way, as the length of the threaded screw **220** increases in length through the back side of the first frame support **212**, it engages a front surface of a lens in the frame thereby causing the mounting device to rotate rearward thereby changing the pitch angle of the front surface **281** of the clip body front face **281**.

In other embodiments, the geometric pattern mounting device **200** may include any other suitable mechanism for adjusting the pitch of the front surface **281** of the clip body **210** relative to the eyewear **50** when the geometric pattern mounting device **200** is attached to the eyewear **50**. For example, the front surface **281** may be defined on a second portion (not shown) of the clip body **210** that is adjustably coupled to the clip body (e.g., via a swivel, hinge, or other mechanism suitable for adjusting a pitch of the front surface **281** relative to the clip body **210**).

As shown in Figure 3A, the front surface **281** of the clip body **210** is substantially flat and is configured to receive the geometric pattern **100** thereon (e.g., such as in the embodiment shown in Figure 1). As may be understood from Figure 1, the substantially flat front surface**281** is defined such that when the geometric pattern mounting device **200** is attached to the eyewear **50**, the substantially flat front surface **281** is positioned facing substantially away from the wearer of the eyewear (e.g., in a position such that the geometric pattern **100** would be substantially facing an imaging device taking an image of a wearer's face while the wearer was wearing eyewear with the geometric pattern attached).

Clip Horizontal Slider

As shown in Figure 3C, the clip horizontal slider **250** comprises a substantially rectangular (e.g., rectangular) sliding portion **255**, a first frame support **252** that extends from an end of sliding portion **255**, and is substantially perpendicularly to the sliding portion **255**. A second frame support **254** has a first proximate portion **257** (Figure 3A) that is disposed at an angle from the first frame support **252,** and a second distal portion **259** (Figure 3A) that is substantially parallel to the first frame support **252**. As may be understood from these figures, the first and second frame supports **252**, **254** generally form an end portion of the sliding portion **255.** In various embodiments, the sliding portion **255** is configured to slide within the chamber formed in the clip body **210** through the clip body's first opening **289** to enable a user to adjust a length of the geometric pattern mounting device **200** to accommodate for different size frames. As may be understood from Figure 3B, when the sliding portion **255** is at least partially inserted into the clip body **210**, the clip body **210** and the clip horizontal slider **250** form a substantially rigid structure.

In particular embodiments, the clip horizontal slider **250** is configured to utilize a locking screw **218** that generally corresponds in size to the first threaded opening **216**. The interaction of the locking screw **218** and the sliding portion **255** enables a user to tighten the locking screw **218**

against the sliding portion **255** to at least substantially lock a position of the clip horizontal slider **250** relative to the clip body **210**. As shown in Figure 3C, the sliding portion **255** defines a substantially circular third threaded opening **256** that is configured to receive a second locking screw **258** that is configured to enable a user to tighten the second locking screw **258** against an inside wall of the clip body to at least substantially prevent the clip horizontal slider **250** from moving relative to the clip body **210**.

In other embodiments, the geometric pattern mounting device **200** may include any other suitable mechanism for adjusting a size of the geometric pattern mounting device **200** (e.g., a length of the geometric pattern mounting device **200**). For example, the clip body **210** may define one or more circular recesses along a surface defining the cavity, and the sliding portion **255** may comprise a spring loaded ball detent that is configured to cooperate with any one of the plurality of recesses to maintain a position of the clip horizontal slider relative to the clip body, while enabling a user to substantially easily adjust the position by applying sufficient force to the clip horizontal slider to force the ball up against the spring allowing the ball to move from one recess to an adjacent recess.

In another example, the clip body **210** may comprise a first portion and a second portion that are configured to enable a user to selectively couple the first portion to the second portion. In this example, the geometric pattern mounting device **200** may further comprise one or more spacers that are configured to enable a user to adjust a size of the geometric pattern mounting device **200** by for example: (1) decoupling the clip body first portion from the clip body second portion; (2) coupling one or more spacers to the clip body first portion; and (3) coupling the clip body second portion to the one or more spacers coupled to the clip body first portion. As may be understood from this example, coupling the first and second portions via the one or more spacers may increase the overall length of the geometric pattern mounting device **200** by the length of the one or more spacers. The spacers may include spacers in any size suitable for increasing the length of the geometric pattern mounting device **200** by any suitable increment.

In various embodiments, the mechanism for adjusting the size of the geometric pattern mounting device **200** may enable a user to adjust the geometric pattern mounting device **200** in order to use the geometric pattern mounting device **200** in combination with eyewear of substantially any size or shape (e.g., enable the user to selectively mount the geometric pattern mounting device **200** to substantially any pair of eyewear).

Vertex Reference Mount

Referring to Figure 3C, in various embodiments, the vertex reference mount **290** is substantially rectangular (e.g., rectangular); extends between a first end side wall **295** and a second end side wall **296**; and has a substantially flat (e.g., flat) front surface **291**, a rear surface **297** (Figure 3B), a top surface **293** and a bottom surface **294**. In various embodiments, the vertex reference mount **290** comprises a mounting arm **292** that extends substantially perpendicularly from the rear surface **297** and is sized to substantially correspond to the vertex reference mount support notch **217** defined in the clip body **210**. As may be understood from the figures, the vertex reference mount **290** is configured to selectively attach to the clip body **210** by at least partially inserting the mounting arm **292** into the support notch **217**. In this embodiment, when the vertex reference mount **290** is attached to the clip body **210**, the front surface **291** is substantially perpendicular to the clip body's front surface **281**. As shown in these figures, the front surface **291** may, for example, comprise a second geometric pattern **100**. In various embodiments the vertex reference mount **290** may provide a geometric pattern in a plane perpendicular to a primary geometric plane, and the vertex reference mount **290** may enable measurement of particular geometric features of a user's face (e.g., such as vertex distance or pantoscopic tilt).

Overview of a System for Measuring Facial Characteristics

In various embodiments, a system for measuring facial characteristics is configured to measure pupillary distance (e.g., a distance between a person's pupils), vertex distance (e.g., a distance between a back surface of a corrective lens and the front of a cornea of a wearer of the corrective lens), or any other suitable characteristic of a person's face. In particular embodiments, the system is configured to determine these various facial measurements by: (1) receiving an image containing the person's face and one or more of the geometric pattern's described above; (2) determining a reference scale for the image based at least in part on the geometric pattern as measured in the image and compared to the known size and shape of the geometric pattern; and (3) determining the facial measurement based at least in part on the reference scale.

Exemplary Technical Platforms

As will be appreciated by one skilled in the relevant field, the present invention may be, for example, embodied as a computer system, a method, or a computer program product. Accordingly, various embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment, or an embodiment combining software and hardware aspects. Furthermore, particular embodiments may take the form of a computer program product stored on a computer-readable storage medium having computer-readable instructions (e.g., software) embodied in the storage medium. Various embodiments may take the form of web-implemented computer software. Any suitable computer-readable storage medium may be utilized including, for example, hard disks, compact disks, DVDs, optical storage devices, and/or magnetic storage devices.

Various embodiments are described below with reference to block diagrams and flowchart illustrations of methods, apparatuses (e.g., systems) and computer program products. It should be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by a computer executing computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus to create means for implementing the functions specified in the flowchart block or blocks.

These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner such that the instructions stored in the computer-readable memory produce an article of manufacture that is configured for implementing the function specified in the flowchart block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

Accordingly, blocks of the block diagrams and flowchart illustrations support combinations of mechanisms for performing the specified functions, combinations of steps for

performing the specified functions, and program instructions for performing the specified functions. It should also be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, can be implemented by special purpose hardware-based computer systems that perform the specified functions or steps, or combinations of special purpose hardware and other hardware executing appropriate computer instructions.

Example System Architecture

An overview of the digital measurement system for optical applications according to an illustrative embodiment is described with reference to Figure 4. As illustrated in Figure 4, the system **410** includes at least one mobile measurement device **452** (e.g., such as a smart phone, a tablet computer, a wearable computing device, a laptop computer, etc.) configured to receive or collect data of, or from, at least one user, which may be a patient or an eye care professional (ECP) (e.g., an optometrist, an optician, an assistant, or other eye care technician). The mobile measurement device **452** includes an optical system and image acquisition technology. The optical system and image acquisition technology may be one or more digital cameras or digital video recorders capable of collecting one or more images, videos, or taking one or more photographs.

In an illustrative embodiment, the mobile measurement device **452** communicates with, accesses, receives data from, and transmits data to a Facial Characteristic Measurement Server **400** via one or more networks **415**. In general, the Facial Characteristic Measurement Server **400** provides computing/processing resources, software, data access, and storage resources without requiring the user or client to be familiar with the location and other details of the Facial Characteristic Measurement Server **400**. The Facial Characteristic Measurement Server **400** includes one or more modules accessible by the mobile measurement device **452**, including a facial characteristic measuring module **600** (described in more detail below) and one or more associated databases **440**. In an illustrative embodiment, the mobile measurement device **452** may communicate with one or more ophthalmic laboratories **412** via the one or more networks **415** to submit orders to the one or more ophthalmic laboratories **412** for frames and/or lenses.

In an illustrative embodiment, the mobile measurement device **452** accesses the facial characteristic measuring module **600** allowing accurate position of wear measurements of a patient to be obtained based on one or more images of the patient. The mobile measurement

device **452** can be used to obtain, for example, monocular pupillary distance (PD), binocular PD, monocular near PD, binocular near PD, vertex distance, and other measurements of the type. These measurements may then be sent to and used, for example, by one or more ophthalmic laboratories to produce customized lenses for the patient.

System **410** may also include a desktop computer **454** that is operatively coupled to the database **440** and facial characteristic measurement server **400** via the one or more networks **415**. Desktop computer **454** may be used to run practice management software where additional information or facial characteristic measurements may be received and stored. In various embodiments, the facial characteristic measurements, image of the patient, etc. may be used by the desktop computer **454** to display the data or allow the ECP to illustrate how various eyewear frames would look on the patient.

The one or more computer networks **415** may include any of a variety of types of wired or wireless computer networks such as the Internet, a private intranet, a mesh network, a public switch telephone network (PSTN), or any other type of network (e.g., a network that uses Bluetooth or near field communications to facilitate communication between computers). The communication link between Facial Characteristic Measurement Server **400** and Database **440** may be, for example, implemented via a Local Area Network (LAN) or via the Internet.

Figure 5 illustrates a diagrammatic representation of a computer architecture **520** that can be used within the System **410**, for example, as one of mobile measurement device **452,** desktop computer **454** , or as Facial Characteristic Measurement Server **400**, as shown in Figure 4.

In particular embodiments, the computer **520** may be connected (e.g., networked) to other computers in a LAN, an intranet, an extranet, and/or the Internet. As noted above, the computer **520** may operate in the capacity of a server or a client computer in a client-server network environment, or as a peer computer in a peer-to-peer (or distributed) network environment. Further, while only a single computer is illustrated, the term "computer," "processor" or "server" shall also be taken to include any collection of computers that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

An exemplary computer **520** includes a processing device **502**, a main memory **504** (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as

synchronous DRAM (SDRAM) or Rambus DRAM (RDRAM), etc.), a static memory **506** (e.g., flash memory, static random access memory (SRAM), etc.), and a data storage device **518**, which communicate with each other via a bus **532**.

The processor **502** represents one or more general-purpose processing devices such as a microprocessor, a central processing unit, or the like. More particularly, the processor **502** may be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, or processor implementing other instruction sets, or processors implementing a combination of instruction sets. The processor **502** may also be one or more special-purpose processing devices such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), network processor, or the like. The processor **502** may be configured to execute processing logic **526** for performing various operations and steps discussed herein (e.g., facial characteristic measuring module **600**).

The computer **520** may further include a network interface device **508**. The computer **520** also may include a video display unit **510** (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)), an alphanumeric input device **512** (e.g., a keyboard), a cursor control device **514** (e.g., a mouse), and a signal generation device **516** (e.g., a speaker).

The data storage device **518** may include a non-transitory computer-accessible storage medium **530** (also known as a non-transitory computer-readable storage medium or a non-transitory computer-readable medium) on which is stored one or more sets of instructions (e.g., software **522** in the form of facial characteristic measuring module **600**) embodying any one or more of the methodologies or functions described herein. The software **522** may also reside, completely or at least partially, within the main memory **504** and/or within the processor **502** during execution thereof by the computer **520** – the main memory **504** and the processor **502** also constituting computer-accessible storage media. The software **522** may further be transmitted or received over the network **415** via a network interface device **508**.

While the computer-accessible storage medium **530** is shown in an exemplary embodiment to be a single medium, the term "computer-accessible storage medium" should be understood to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "computer-accessible storage medium" should also be understood to include any

medium that is capable of storing, encoding or carrying a set of instructions for execution by the computer and that cause the computer to perform any one or more of the methodologies of the present invention. The term "computer-accessible storage medium" should accordingly be understood to include, but not be limited to, solid-state memories, optical and magnetic media, etc.

Exemplary Methods for Measuring Facial Characteristics

Various embodiments of a method for measuring facial characteristics may be implemented in any suitable manner. For example, various aspects of the system's functionality may be executed by certain system modules, including a Facial Characteristic Measuring Module **600**. This module is discussed in greater detail below with reference to Figure 6. It should be understood by reference to this disclosure that the method associated with the module **600** describes an exemplary embodiment of the methods steps carried out by the present system, and that other exemplary embodiments may be created by adding other steps, by removing one or more of the method steps described in Figure 6, or by performing one or more of the method steps described in Figure 6 in an order other than the order in which they are presented. .

Overview

A method of using the mobile measurement device **452** according to an illustrative embodiment is described. An ECP accesses the facial characteristic measurement module **600** via the mobile measurement device **452**. In an illustrative embodiment, the mobile measurement device **452** is configured to capture an image of the patient when the patient is wearing eyewear frames having the geometric pattern **100** removably attached to the eyewear frames using the geometric pattern mounting device **200** described above.

The ECP positions a patient wearing a selected frame or an object, having the geometric pattern **100** mounted thereon using the geometric pattern mounting device **200** in the field of view of the digital camera in the mobile measurement device **452**. The ECP then captures one or more images of the patient or object on the mobile measurement device **452**, for example, on a screen or display on the client measurement device **452**. The captured image may be stored, for example, in a memory of the mobile measurement device **452** and/or in the one or more databases **440**. In an illustrative embodiment, the ECP presses or touches a button on the mobile

measurement device **452** to activate the digital camera contained therein and captures the image(s) of the patient or object.

Facial Characteristic Measuring Module

Figure 6 is a flow chart of operations performed by an exemplary Facial Characteristic Measuring Module **600**. In particular embodiments, the Facial Characteristic Measuring Module **600** may facilitate the measurement of a facial characteristic of a user (e.g., such as a patient being fitted for glasses).

When executing the Facial Characteristic Measuring Module **600**, the system begins, at Step **610** by receiving a first image comprising a geometric pattern. In various embodiments, the geometric pattern may be any suitable geometric pattern, such as any geometric pattern **100** described in this disclosure. In particular embodiments, the first image comprises at least a portion of a user's face (e.g., at least a portion of the user's face that includes a characteristic of the user's face that the user or another desires to measure). In particular embodiments, the geometric pattern in the first image is disposed on a mounting device (e.g., geometric pattern mounting device **200**), which may, for example, be attached to eyewear worn by the user. In particular embodiments, the system may receive the first image from any suitable image capturing device (e.g., a desktop computer or any suitable mobile computing device).

In particular embodiments, the system may be configured to substantially automatically detect the geometric pattern within the first image. That is, the system **410** analyzes the captured image and locates the geometric pattern **100** within the captured image. That is, the system **410** locates a center of each of the first and second geometric attributes within the captured image, using known image processing technology and/or algorithms. In an illustrative embodiment, the system **410** locates the center of each of the first and the second geometric attributes by filtering and analyzing the captured image. The filtering process involves a combination of Gaussian blur, custom color channel manipulation, intensity thresholding, and a Suzuki85 algorithm for connected component labeling. The filtering process produces a set of points defining possible locations of the geometric pattern **100**. The set of points or shapes is analyzed according to several criteria, such as, but not limited to, shape area, dimensions of the geometric attributes, and the existence of a similar shape within a certain threshold distance from the shape. If the aforementioned shapes meet the above criteria, the shapes are considered to be successful matches.

For example, in various embodiments, the system **410** may use multiple pattern detection methods. For example, in various embodiments, a first group of methods for pattern detection may be used that (1) isolate search areas for a pattern, (2) increase edge definition with minimal distortion, (3) obtains contour in RGB color space, (4) filter the inner most contour, (5) add the contour to the contour list, and (6) repeats the process for additional contours. Once all suspected contours have been processed, the contours and/or contour pairs are filtered out from the contour list if (1) their polygonal angles do not match the expected angles in the geometric pattern, (2) the area of the contour is outside the expected area geometric pattern, (3) the height/width ratio is outside the expected height/width ratio of the geometric pattern, (4) the contour pairs are not within a specified distance of each other's center points, (5) the area ratio between contour pairs is outside a specified ratio of the geometric pattern, and (6) horizontal angle between contour pairs is outside a specified horizontal angle of the geometric pattern.

In these embodiments, if the captured image contains both bad lighting and bad focus and the first group of pattern detection methods fail, the system may be configured to use a second group of methods for pattern detection that (1) isolates search areas for the geometric pattern, (2) adjusts the image contrast to enable the system to better detect the geometric pattern, (3) gets contours in gray scale, (4) adds the contours to the contour list, and then (5) applies the filtering process described above with regard to the first group of pattern detection methods.

Finally, if the system cannot detect the geometric pattern using the first and second groups of pattern detection methods, the system may be configured to apply a third group of pattern detection methods that (1) isolates search areas for the geometric pattern, (2) gets hue saturation value channel process and applies thresholds, (3) gets contours in gray scale, (4) adds the contours to the contour list, and then (5) applies the filtering process described above with regard to the first group of pattern detection methods.

Once the pattern is detected, the system **410** then determines the distance between the first geometric attribute and the second geometric attribute within the captured image. In an illustrative embodiment, the distance between the first geometric attribute and the second geometric attribute created by the geometric pattern **100** within the captured image is determined in terms of pixels. As described above with respect to Figure 2, the centers of the first and second geometric attributes within the captured image should be equal to the distance **114** (Figure 2), for example approximately sixteen millimeters apart from one another.

The system continues, at Step **620** by determining a reference scale for the first image based at least in part on the geometric pattern. In various embodiments, a determination of the reference scale may be based in part on known characteristics of the geometric pattern. For example, the system may determine a reference scale based at least in part on a known distance between two geometric attributes of the geometric pattern. The geometric attributes may include any suitable portion of the geometric pattern, such as, for example, a distance between the centers of the two substantially square geometric attributes **110**, **120** of the geometric pattern shown in Figure 2. In other embodiments, the known distance may include any suitable distance between any suitable reference points within the geometric pattern. These reference points may include any suitable portion of geometric attributes that the geometric pattern comprises (e.g., a distance between edges of one or more geometric attributes, a distance between inner border portions of one or more geometric attributes, or any other suitable distance). Continuing the example above, the first distance **114** is compared to the measured distance in pixels between the centers of the first and second attributes. Thus, the system **410** determines a scaling factor for the captured image.

In various embodiments, determining the reference scale further comprises adjusting the reference scale to correct for errors that arise from misalignment of the geometric reference pattern with respect to a plane of the image sensor in the mobile measurement device **452**. For example, the system **410** may account for pitch errors (e.g., when the plane of the geometric pattern is rotated about a horizontal axis with respect to the plane of the image sensor), yaw errors (e.g., when the plane of the geometric pattern **100** is rotated about a vertical axis with respect to the plane of the image sensor , and roll errors (e.g., where the plane of the geometric pattern is rotated about an axis that is normal to the face of the geometric pattern with respect to the plane of the sensor). In other embodiments, the system may be configured to also correct the measured reference scale at least in part by correcting for errors caused by changes in one or more of the pitch, roll and yaw angle of the plane of the image sensor used to capture the image with respect to the plane of the geometric pattern. In still other embodiments, the system is configured to correct for changes in origination of both the geometric pattern plane and the image sensor plane.

In particular embodiments, the system is further configured to correct for errors caused by a distance between the geometric pattern and the user's eye. As may be understood from this

disclosure, when wearing eyewear on which a reference device containing a geometric pattern is mounted, the geometric pattern will be spaced a distance apart from the wearer's eye. Thus, an error due to this distance depends on the distance from the image sensor to the lens plane and the distance from the lens plane to the wearer's eyes. The system may be configured to utilize any suitable algorithm to compensate for this offset when determining a reference scale, which may for example, be determined based at least in part on an average offset, a distance between the image capturing device and the user when the image is captured, or any other suitable factor.

Returning to Step **630**, the system uses the reference scale to measure at least one facial characteristic of the user. The at least one facial characteristic may include pupillary distance (e.g., a distance between a user's pupils), vertex distance (e.g., a distance between a back surface of a corrective lens and the front of a cornea of the user), pantoscopic tilt (panto) measurements of a patient, or any other suitable characteristic of a user's face from one or more captured images. The system may use the reference scale to measure the at least one facial characteristic by measuring the characteristic from the first image (e.g., by determining a measurement as a number of pixels within the first image) and converting the measurement to a distance based on the reference scale (e.g., converting the measured number of pixels to a distance in inches, millimeters or other suitable measurement unit) where the converted measurement at least generally corresponds to an actual measurement of the at least one facial characteristic (e.g., a real-world distance between two points on the user's face).

As an illustrative example, in order to obtain or calculate the monocular PD, which is the distance from each of the patient's pupils (e.g., using light reflected from the cornea) to the center of the patient's nose (e.g., where the center of the frame bridge rests), and the binocular PD, which is the distance between the patient's pupils, the patient should be facing the mobile measurement device **452**. The ECB then positions the patient wearing the selected frame, with the patient facing the mobile measurement device **452** in the field of view of the digital camera.

Once the mobile measurement device **452** captures the first image of the patient, the system **410** analyzes the first image, for example using facial recognition and 3-D rendering technology, and determines the size and dimensions of the patient. The system **410** then analyzes the image and determines or calculates the monocular PD and the binocular PD measurements of the patient.

In order to obtain or calculate the vertex distance, which is the distance between the back surface of a lens and the front of the cornea of the patient, and the pantoscopic tilt, which is the angle between the plane of the lens and frame front and the frontal plane of the face, the patient should be facing about ninety degrees away from the mobile measurement device **452**. The ECB positions the patient wearing the selected frame, with the patient facing about ninety degrees away from the mobile measurement device **452**, in the field of view of the mobile measurement device **452** and captures a second image of the patient. The system **410** analyzes the second image, for example, using facial recognition and 3-D rendering technology, and determines the size and dimensions of the patient's head. The system **410** then analyzes the image and determines or calculates the vertex distance and pantoscopic tilt measurements of the patient wearing the selected frames.

The pantoscopic tilt is determined by determining an angle between a plane of the lens and frame front and a frontal plane of the patient's face. For example, the frontal plane of the patient's face may be vertical, and the plane of the lens and frame front may be slightly tilted, for example, creating a hypotenuse of a right triangle with a height of the right triangle or an adjacent side (Adj.) of the right triangle being the frontal plane of the patient's face. A horizontal distance from the frontal plane of the patient's face to the plane of the lens and frame front creates an opposite side of the right triangle. Thus, the lengths of the hypotenuse and the adjacent side are the respective distances from the opposite side of the right triangle to a point where the frontal plane of the patient's face and the plane of the lens and frame front intersect. The system **410** can determine the length in pixels of each of the sides of the right triangle and then convert these distances to sufficient units (e.g., inches, mm, etc.) using the reference scale.

Once the system calculates the various facial characteristics of interest, the system **410** may be configured to store the measurements in the one or more databases **440** for later retrieval and use. In various embodiments, the measurements may be stored in conjunction with the patient's information.

Conclusion

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. For example, as will be understood by one skilled in the relevant field in light of this disclosure, the invention may take form in a

variety of different mechanical and operational configurations. For example, the eyewear described in this embodiment may include any other suitable eyewear, such as, for example, ski or swim goggles, sunglasses, safety goggles or glasses, etc. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that the modifications and other embodiments are intended to be included within the scope of the appended exemplary concepts. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for the purposes of limitation.

Claims

What is claimed is:

1. A reference device for facilitating measurement of one or more facial characteristics of a user compriscs:

   a. a geometric pattern comprising:

      i. a first geometric attribute; and

      ii. a second geometric attribute spaced a first distance apart from said first geometric attribute; and

   b. an attachment mechanism operatively coupled to said geometric pattern,

      whercin said attachment mechanism is configurcd to rcmoveably attach said geometric pattern to an object selected from a group consisting of:

      i. an eyewear frame; and

      ii. said user's head.

2. The reference device of Claim 1, wherein said pattern is configured to allow an imaging machine to calculate a reference scale for an image captured by the imaging machine based at least in part on said first distance

3. The reference device of Claim 2, wherein:

   a. said first geometric attribute is a first border of said geometric pattern; and

   b. said second geometric attribute is a second border of said geometric pattern that is spaccd apart from said first bordcr by said first distancc.

4. The reference device of Claim 2, wherein said geometric pattern comprises a first geometric pattern and a second geometric pattern, wherein:

   a. said first geometric pattern comprises said first geometric attribute;

   b. said second geometric pattern comprises said second geometric attribute.

5. The reference device of Claim 4, wherein said first and second geometric patterns are substantially rectangular.

6. The reference device of Claim 4, wherein:
   a. said first geometric pattern comprises a first perimeter edge formed in a first color and a first interior surface in a second color and at least partially bounded by said first perimeter edge; and
   b. said second geometric pattern comprises a second perimeter edge formed in said first color and a second interior surface in said second color and at least partially bounded by said second perimeter edge.

7. The reference device of Claim 6, wherein said first and second colors are sufficiently contrasting to enable an imaging device to detect a transition from said first color to said second color.

8. The reference device of Claim 4, wherein said first and second geometric patterns have substantially the same shape.

9 The reference device of Claim 8, wherein said first and second geometric patterns have a shape selected from the group consisting of:
   a. substantially circular; and
   b. substantially polygonal.

10. The reference device of Claim 1, wherein said attachment mechanism comprises a clip body comprising a first frame support and a second frame support, wherein said first and second frame supports are configured to cooperate to maintain said reference device adjacent said eyewear frame when said reference device is attached to said eyewear frame.

11. The reference device of Claim 10, wherein said attachment mechanism further comprises a clip horizontal slider comprising a third frame support and a fourth frame support, wherein said clip horizontal slider is configured to enable a user to:
   a. slideably attach said clip horizontal slider to said clip body, and

b. slide relative to said clip body such said clip body and said clip horizontal slider is adjustable between a first length and a second length.

12. The reference device of Claim 10, wherein said first frame support comprises a pitch adjustment mechanism configured to adjust a pitch of a portion of said reference device relative to said eyewear frame when said reference device is attached to said eyewear frame.

13. The reference device of Claim 12 wherein said pitch adjustment mechanism comprises:

a. a threaded opening in said first frame support; and

b. a threaded screw that substantially corresponds in diameter to said threaded opening,

wherein said screw is configured to enable a user to adjust said pitch of said portion of said reference device by rotating said threaded screw within said threaded opening.

14. The reference device of Claim 12, wherein said portion of said reference device is a substantially planar surface that is configured to removeably receive said geometric pattern in an orientation that is substantially parallel to a front surface of lenses postioned in the eyewear.

15. The reference device of Claim 10, wherein:

a. said clip body defines a substantially flat surface; and

b. said geometric pattern is disposed at least partially on said substantially flat surface,

wherein the flat surface is substantially parallel to a surface of a lens retained in the eyewear frame.

16. The reference device of Claim 1, further comprising a mobile measurement device comprising at least one processor configured to:

a. capture an image of a user wearing the frames having said geometric pattern removeably coupled to the frames;

b. determine a second distance between the first and second geometric attributes in said geometric pattern from the captured image;

c. calculate a scale factor at least partially based on the determined second distance and the first distance;

d. determine a measurement of a facial characteristic from the captured image;
e. calculate an actual measurement of the facial characteristic at least partially based on the measurement of the facial characteristic from the captured image and the calculated scale factor.

17. A computer system for measuring facial characteristics of a person wearing eyewear, said computer system comprising at least one processor, wherein said computer system is configured to:
a. receive a first image comprising
i. a reference device having a geometric pattern attached thereon, wherein the reference device is attached to a pair of eyewear that is worn by a wearer, said geometric pattern comprising:
a first geometric attribute; and
a second geometric attribute that is spaced a known distance apart from said first geometric attribute; and
ii. at least a portion of a face of the wearer, said at least a portion of the face of the wearer comprising a first eye and a second eye of the wearer;
b. determine a distance between said first geometric attribute and said second geometric attribute from said image;
c. calculate, based at least in part on said known distance and said determined distance, a reference scale for said first image;
d. determine a measurement of a facial characteristic from said first image; and
e. using said reference scale and said measurement of said facial characteristic, calculate an actual measurement of said facial characteristic of the wearer in the first image.

18. The computer system of Claim 17, wherein said facial characteristic is selected from a group consisting of:
a. a pupillary distance of the wearer in said first image; and
b. a vertex distance of the wearer in said first image.

19. The computer system of Claim 17, wherein calculating said reference scale further comprises adjusting said reference scale to correct for errors that arise at least in part on an orientation of said geometric pattern with respect to an image sensor used to capture said first image.

20. The computer system of Claim 18, wherein said calculating said reference scale further comprises adjusting said reference scale to correct for errors arise at least in part on distortion of said geometric pattern within said first image.

21. A method of measuring a facial characteristic of a patient comprises:

a. providing a reference device comprising:

i. a geometric pattern comprising:

a first geometric attribute; and

a second geometric attribute spaced a first distance apart from said first geometric attribute; and

ii. an attachment mechanism operatively coupled to said geometric pattern and configured to enable a user to selectively attach the reference device to eyewear;

b. attaching said reference device to eyewear;

c. placing said pair of eyewear and said reference device on a patient;

d. receiving, by at least one processor, an image comprising said reference device and at least a portion of said patient's face;

e. determining, by at least one processor, a measurement of a second distance between said first geometric attribute and said second geometric attribute from the received image;

f. calculating, by at least one processor, a reference scale for said image based at least in part on said first distance and said second distance;

g. using, by at least one processor, said reference scale to convert measurements of facial characteristics of the patient taken from said image into actual measurements of the patient's facial characteristics.

22. The method of Claim 21, wherein said facial characteristic is selected from a group consisting of:

a. a pupillary distance of said patient; and

b. a vertex distance of said patient.

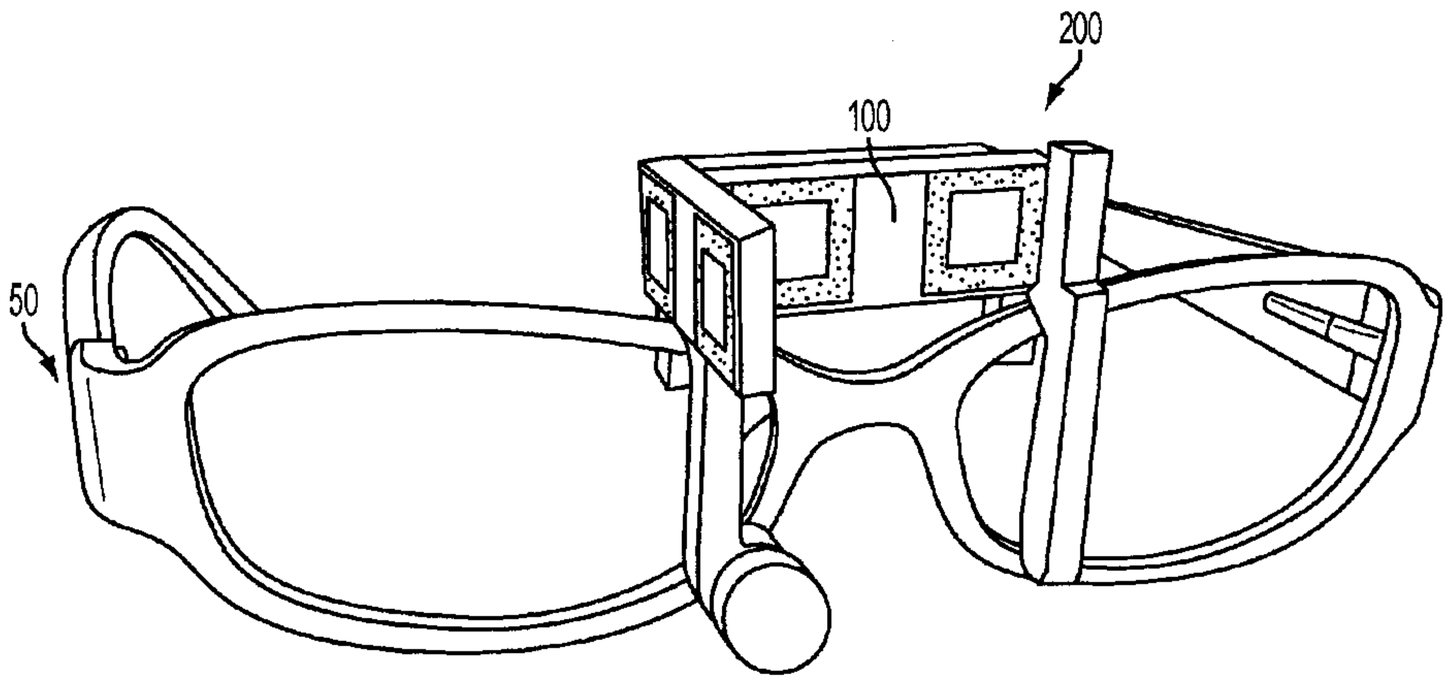


FIG. 1

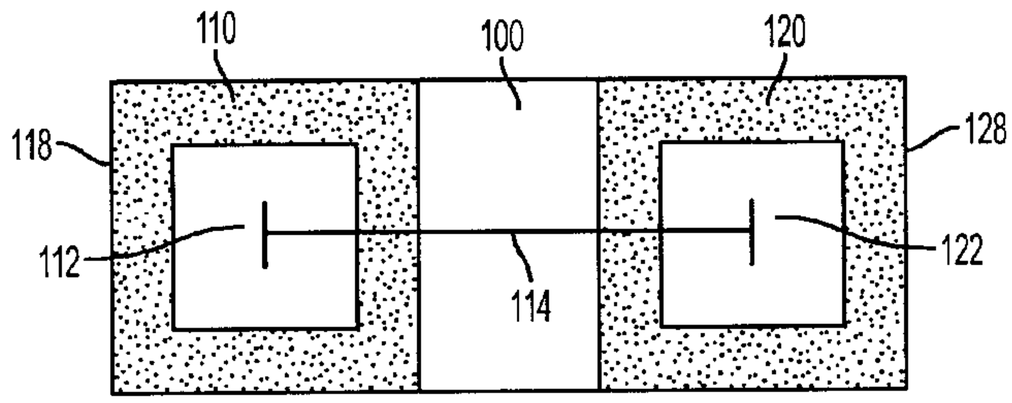
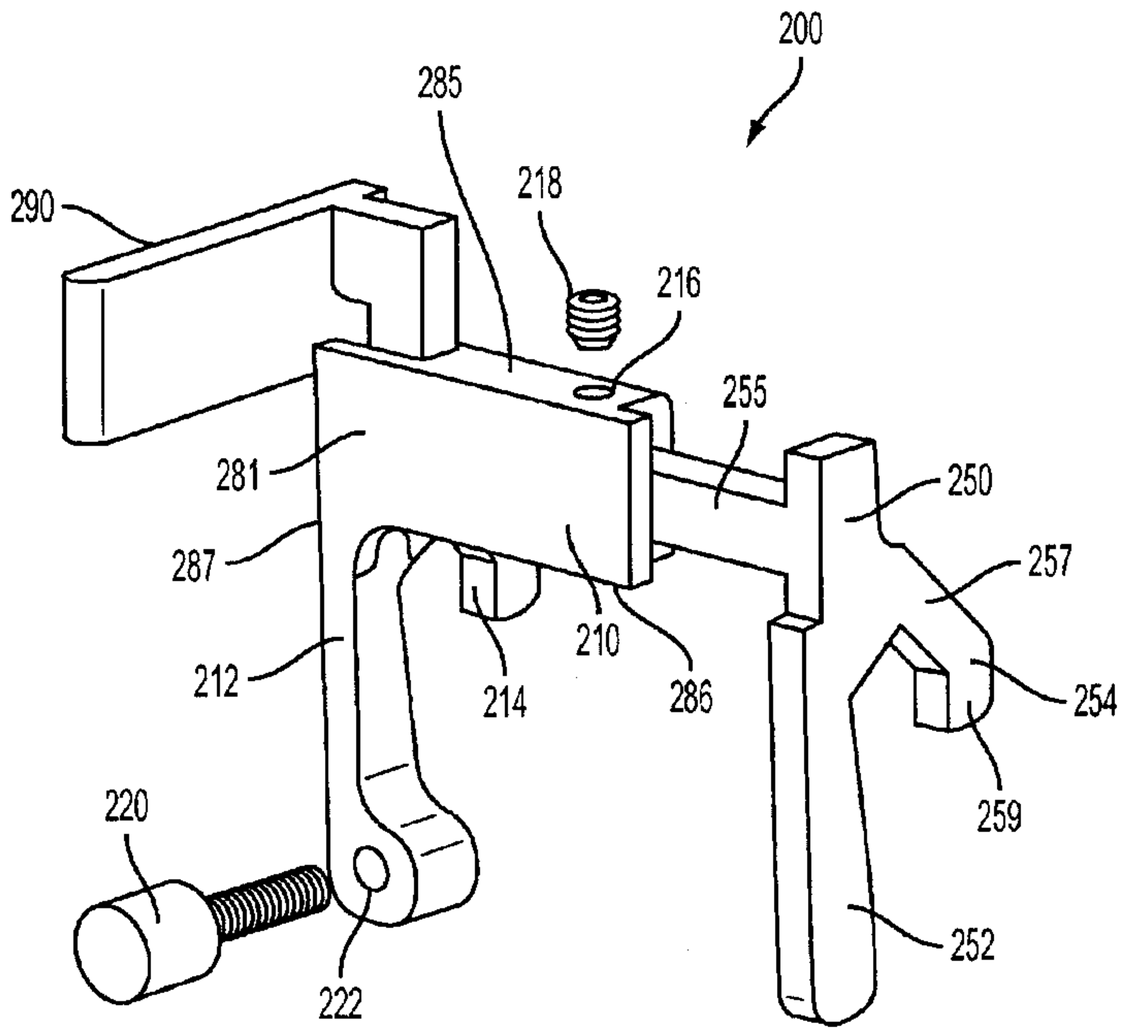


FIG. 2


200
285
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290
216
255
281
250
287
257
210
212
214
286
254
259
220
252
222

FIG. 3A

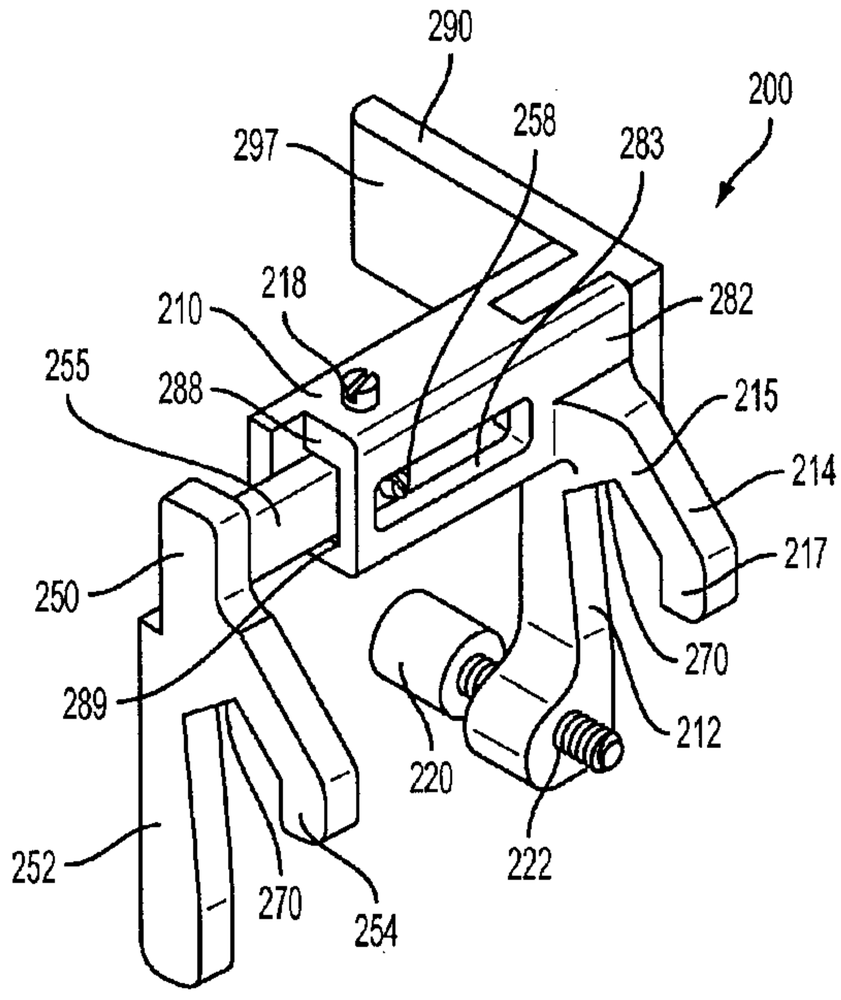
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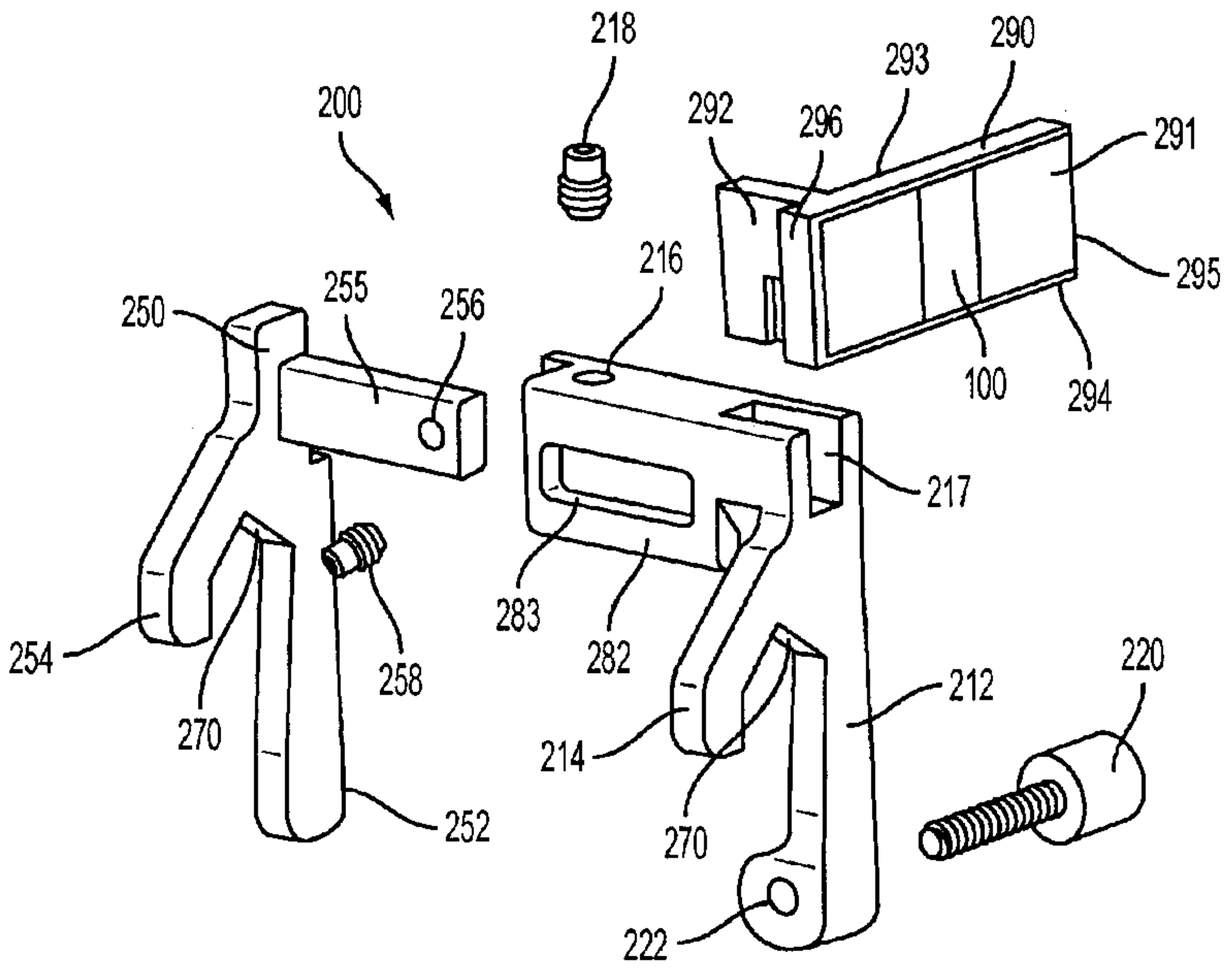
FIG. 3B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214
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270
222

FIG. 3C

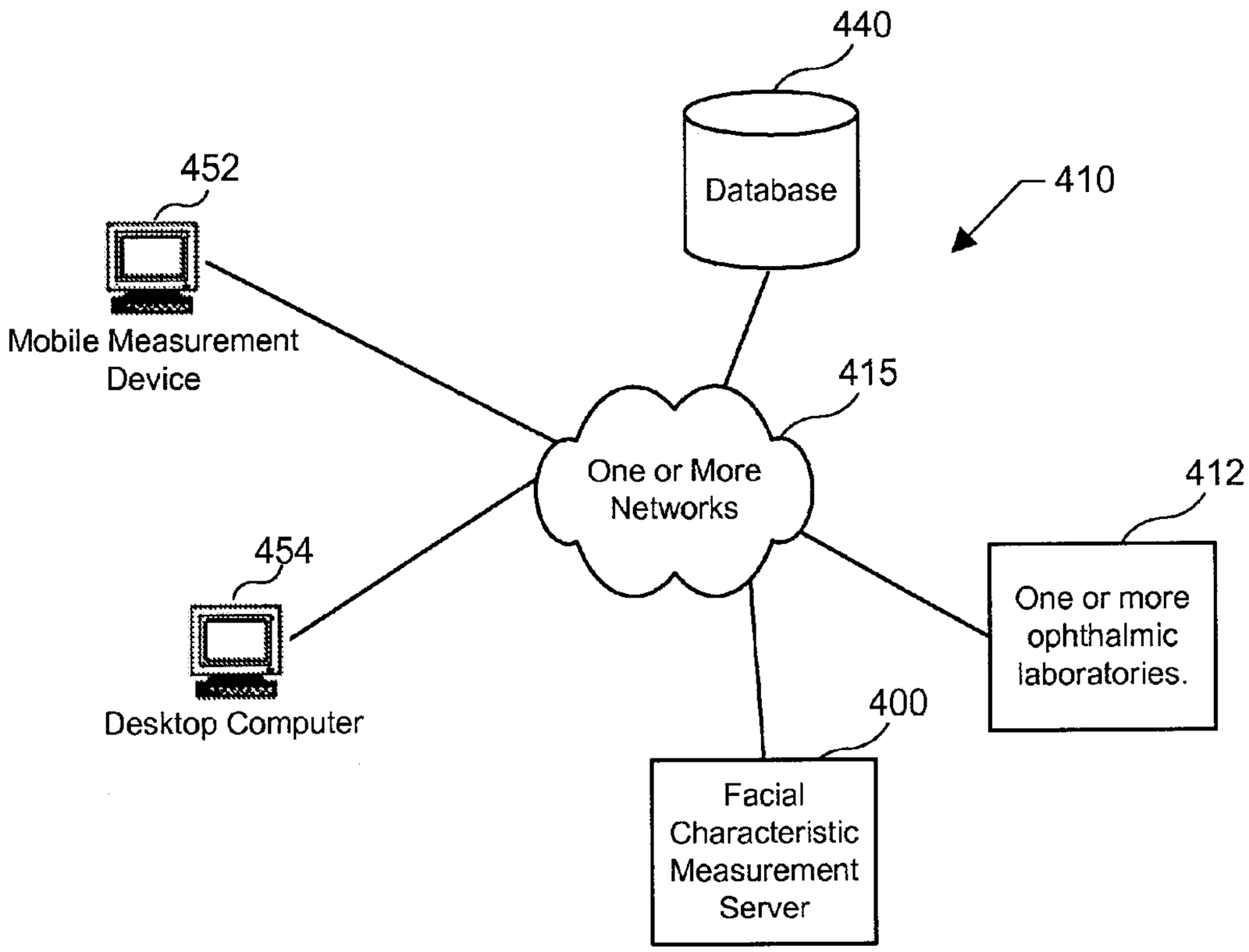
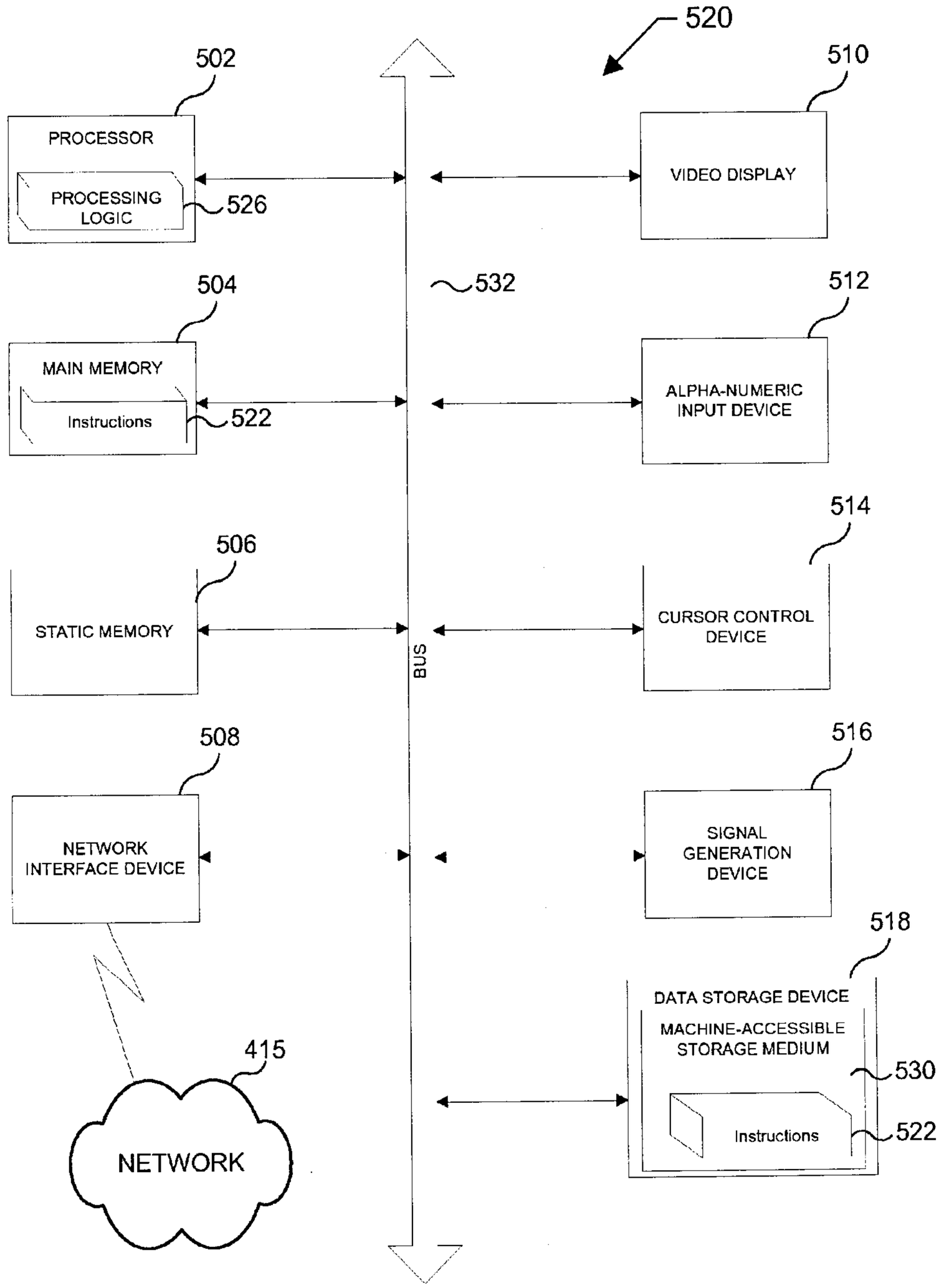

440
Database
410
452
Mobile Measurement Device
415
One or More Networks
412
One or more ophthalmic laboratories.
454
Desktop Computer
400
Facial Characteristic Measurement Server

FIG. 4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PROCESSOR
PROCESSING LOGIC
526
510
VIDEO DISPLAY
504
MAIN MEMORY
Instructions
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532
512
ALPHA-NUMERIC INPUT DEVICE
506
STATIC MEMORY
514
CURSOR CONTROL DEVICE
BUS
508
NETWORK INTERFACE DEVICE
516
SIGNAL GENERATION DEVICE
518
DATA STORAGE DEVICE
MACHINE-ACCESSIBLE STORAGE MEDIUM
530
Instructions
522
415
NETWORK

FIG. 5

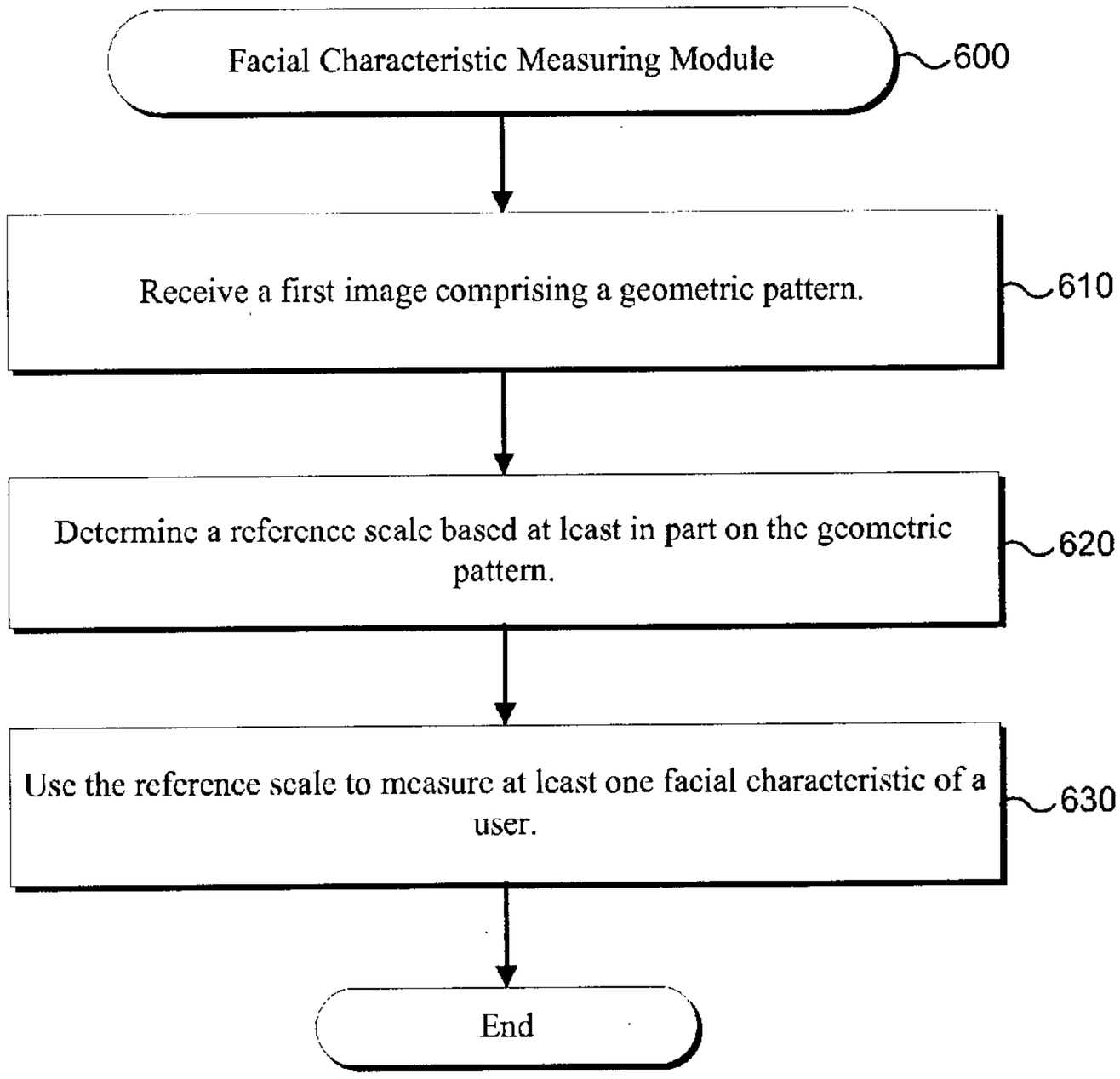
Facial Characteristic Measuring Module
600
Receive a first image comprising a geometric pattern.
610
Determine a reference scale based at least in part on the geometric pattern.
620
Use the reference scale to measure at least one facial characteristic of a user.
630
End

FIG. 6

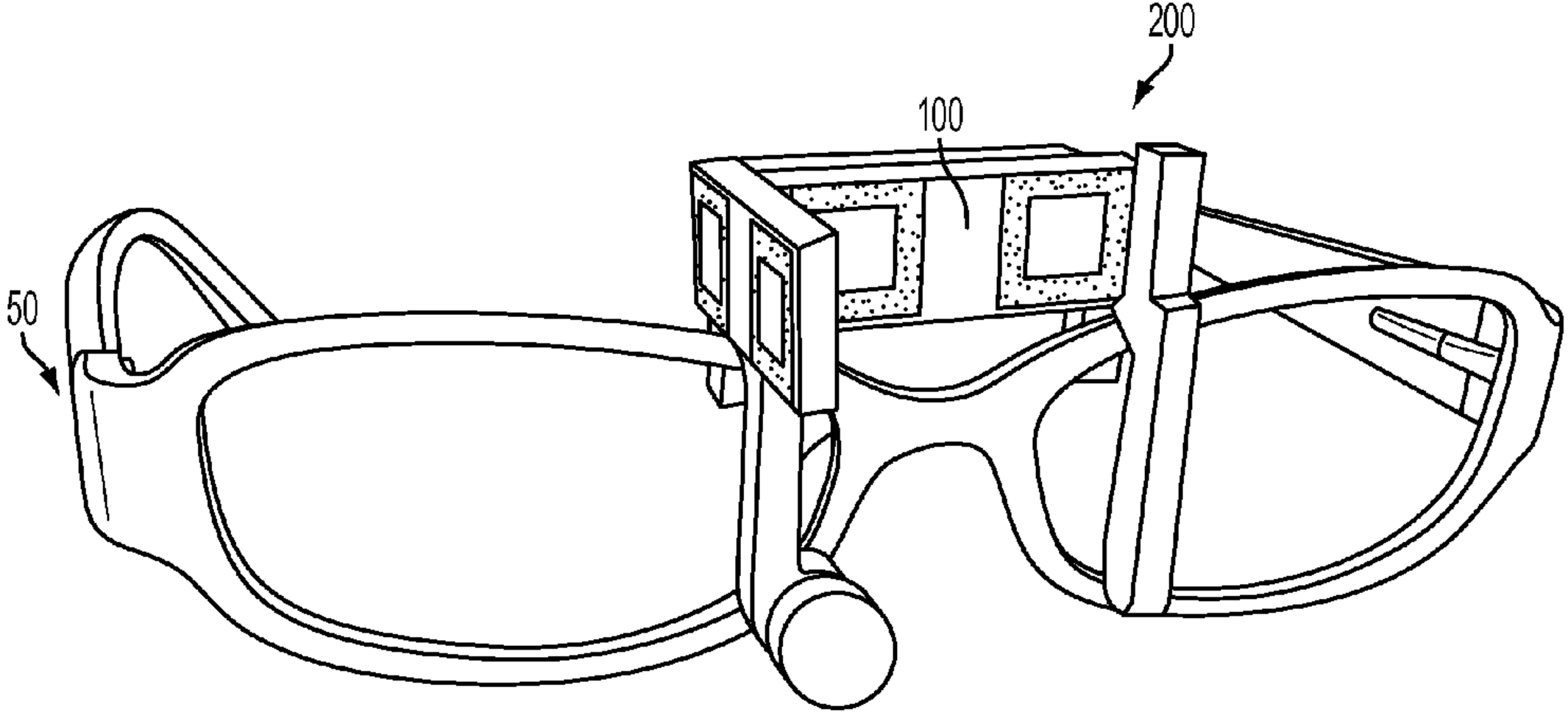

FIG. 1