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(54) Title: SYSTEMS AND METHODS FOR GENERATING A 3-D MODEL OF A VIRTUAL TRY-ON PRODUCT

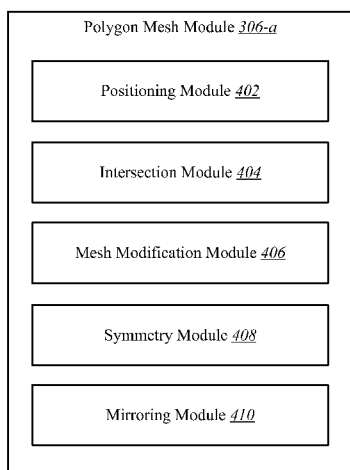


FIG. 4

(57) Abstract: A computer-implemented method for generating a three-dimensional (3-D) model of a virtual try-on product. At least a portion of an object is scanned. The object includes at least first and second surfaces. An aspect of the first surface is detected. An aspect of the second surface is detected, the aspect of the second surface being different from the aspect of the first surface. A polygon mesh of the first and second surfaces is generated from the scan of the object.



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## SYSTEMS AND METHODS FOR GENERATING A 3-D MODEL OF A VIRTUAL TRY-ON PRODUCT

### RELATED APPLICATIONS

5           **[0001]** This application claims priority to U.S. Provisional Application No. 61/650,983, entitled SYSTEMS AND METHODS TO VIRTUALLY TRY-ON PRODUCTS, filed on May 23, 2012; U.S. Provisional Application No. 61/735,951, entitled SYSTEMS AND METHODS TO VIRTUALLY TRY-ON PRODUCTS, filed on December 11, 2012; and U.S. Application No. 13/774,985, entitled SYSTEMS  
10 AND METHODS FOR GENERATING A 3-D MODEL OF A VIRTUAL TRY-ON PRODUCT, filed on February 22, 2013, all of which are incorporated herein in their entirety by this reference.

### BACKGROUND

15           **[0002]** The use of computer systems and computer-related technologies continues to increase at a rapid pace. This increased use of computer systems has influenced the advances made to computer-related technologies. Indeed, computer systems have increasingly become an integral part of the business world and the activities of individual consumers. Computers have opened up an entire industry of internet shopping. In many ways, online shopping has changed the way consumers  
20 purchase products. For example, a consumer may want to know what they will look like in and/or with a product. On the webpage of a certain product, a photograph of a model with the particular product may be shown. However, users may want to see more accurate depictions of themselves in relation to various products.

### DISCLOSURE OF THE INVENTION

25           **[0003]** According to at least one embodiment, a computer-implemented method for generating a virtual try-on product is described. At least a portion of an object may be scanned. The object may include at least first and second surfaces. An aspect of the first surface may be detected. An aspect of the second surface may be detected. The aspect of the first surface may be different from the aspect of the  
30 second surface. A polygon mesh of the first and second surfaces may be generated from the scan of the object

[0004] In one embodiment, the polygon mesh may be positioned in relation to a 3-D fitting object in a virtual 3-D space. The shape and size of the 3-D fitting object may be predetermined. At least one point of intersection may be determined between the polygon mesh and the 3-D fitting object.

5 [0005] In some configurations, the object may be scanned at a plurality of predetermined viewing angles. The polygon mesh may be rendered at the predetermined viewing angles. One or more vertices of the polygon mesh corresponding to the first surface may be modified to simulate the first surface. Modifying the one or more vertices of the polygon mesh of the first surface may include adding a plurality  
10 of vertices to at least a portion of the polygon mesh corresponding to the first surface. A decimation algorithm may be performed on at least a portion of the polygon mesh corresponding to the second surface.

[0006] In some embodiments, at least one symmetrical aspect of the object may be determined. Upon determining the symmetrical aspect of the object, a portion  
15 of the object may be scanned based on the determined symmetrical aspect. The result of scanning the object may be mirrored in order to generate a portion of the polygon mesh that corresponds to a portion of the object not scanned. A texture map may be generated from the scan of the object. The texture map may include a plurality of images depicting the first and second surfaces of the object. The texture map  
20 may map a two-dimensional (2-D) coordinate of one of the plurality of images depicting the first and second surfaces of the object to a 3-D coordinate of the generated polygon mesh of the object.

[0007] A computing device configured to generate a virtual try-on product is also described. The device may include a processor and memory in electronic  
25 communication with the processor. The memory may store instructions that are executable by the processor to scan at least a portion of an object, wherein the object includes at least first and second surfaces, detect an aspect of the first surface, and detect an aspect of the second surface. The second aspect may be different from the first aspect. The instructions may be executable by the processor to generate a poly-  
30 gon mesh of the first and second surfaces from the scan of the object.

[0008] A computer-program product to generate a virtual try-on product is also described. The computer-program product may include a non-transitory com-

puter-readable medium that stores instructions. The instructions may be executable by a processor to scan at least a portion of an object, wherein the object includes at least first and second surfaces, detect an aspect of the first surface, and detect an aspect of the second surface. The second aspect may be different from the first aspect.

5 The instructions may be executable by the processor to generate a polygon mesh of the first and second surfaces from the scan of the object.

[0009] Features from any of the above-mentioned embodiments may be used in combination with one another in accordance with the general principles described herein. These and other embodiments, features, and advantages will be more  
10 fully understood upon reading the following detailed description in conjunction with the accompanying drawings and claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings illustrate a number of exemplary embodiments and are a part of the specification. Together with the following description,  
15 these drawings demonstrate and explain various principles of the instant disclosure.

[0011] FIG. 1 is a block diagram illustrating one embodiment of an environment in which the present systems and methods may be implemented;

[0012] FIG. 2 is a block diagram illustrating another embodiment of an environment in which the present systems and methods may be implemented;  
20

[0013] FIG. 3 is a block diagram illustrating one example of a model generator;

[0014] FIG. 4 is a block diagram illustrating one example of a polygon mesh module;

25 [0015] FIG. 5 illustrates an example arrangement for scanning an object;

[0016] FIG. 6 illustrates an example arrangement of a virtual 3-D space;

[0017] FIG. 7 is a flow diagram illustrating one embodiment of a method for generating a 3-D model of an object;

[0018] FIG. 8 is a flow diagram illustrating one embodiment of a method  
30 for rendering a polygon mesh;

[0019] FIG. 9 is a flow diagram illustrating one embodiment of a method for scanning an object based on a detected symmetry of the object; and

[0020] FIG. 10 depicts a block diagram of a computer system suitable for implementing the present systems and methods.

5 [0021] While the embodiments described herein are susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. However, the exemplary embodiments described herein are not intended to be limited to the particular forms disclosed. Rather, the instant disclosure covers all modifications, equivalents, and alternatives falling within the scope of the appended claims.

#### **BEST MODE(S) FOR CARRYING OUT THE INVENTION**

[0022] The systems and methods described herein relate to the virtually trying-on of products. Three-dimensional (3-D) computer graphics are graphics that use a 3-D representation of geometric data that is stored in the computer for the purposes of performing calculations and rendering two-dimensional (2-D) images. Such images may be stored for viewing later or displayed in real-time. A 3-D space may include a mathematical representation of a 3-D surface of an object. A 3-D model may be contained within a graphical data file. A 3-D model may represent a 3-D object using a collection of points in 3-D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3-D models may be created by hand, algorithmically (procedural modeling), or scanned such as with a laser scanner. A 3-D model may be displayed visually as a two-dimensional image through rendering, or used in non-graphical computer simulations and calculations. In some cases, the 3-D model may be physically created using a 3-D printing device.

[0023] A device may capture an image of the user and generate a 3-D model of the user from the image. A 3-D polygon mesh of an object may be placed in relation to the 3-D model of the user to create a 3-D virtual depiction of the user wearing the object (e.g., a pair of glasses, a hat, a shirt, a belt, etc.). This 3-D scene may then be rendered into a 2-D image to provide the user a virtual depiction of the user in relation to the object. Although some of the examples used herein describe

articles of clothing, specifically a virtual try-on pair of glasses, it is understood that the systems and methods described herein may be used to virtually try-on a wide variety of products. Examples of such products may include glasses, clothing, footwear, jewelry, accessories, hair styles, etc.

5           **[0024]**   **FIG. 1** is a block diagram illustrating one embodiment of an environment 100 in which the present systems and methods may be implemented. In some embodiments, the systems and methods described herein may be performed on a single device (*e.g.*, device 102). For example, a model generator 104 may be located on the device 102. Examples of devices 102 include mobile devices, smart  
10 phones, personal computing devices, computers, servers, etc.

**[0025]**   In some configurations, a device 102 may include a model generator 104, a camera 106, and a display 108. In one example, the device 102 may be coupled to a database 110. In one embodiment, the database 110 may be internal to the device 102. In another embodiment, the database 110 may be external to the device  
15 102. In some configurations, the database 110 may include polygon model data 112 and texture map data 114.

**[0026]**   In one embodiment, the model generator 104 may initiate a process to generate a 3-D model of an object. As described above, the object may be a pair of glasses, an article of clothing, footwear, jewelry, an accessory, or a hair style. In  
20 some configurations, the model generator 104 may obtain multiple images of the object. For example, the model generator 104 may capture multiple images of an object via the camera 106. For instance, the model generator 104 may capture a video (*e.g.*, a 5 second video) via the camera 106. In some configurations, the model generator 104 may use polygon model data 112 and texture map data 114 to generate a  
25 3-D representation of the scanned object. For example, the polygon model data 112 may include vertex coordinates of a polygon model of a pair of glasses. In some embodiments, the model generator 104 may use color information from the pixels of multiple images of the object to create a texture map of the object. In some embodiments, the polygon model data 112 may include a polygon model of an object. In  
30 some configurations, the texture map data 114 may define a visual aspect of the 3-D model of the object such as color, texture, shadow, and/or transparency.

[0027] In some configurations, the model generator 104 may generate a virtual try-on image by rendering a virtual 3-D space that contains a 3-D model of a user in relation to the 3-D model of the object. In one example, the virtual try-on image may illustrate the user with a rendered version of the product. In some configurations, the model generator 104 may output the virtual try-on image to the display 108 to be displayed to a user.

[0028] FIG. 2 is a block diagram illustrating another embodiment of an environment 200 in which the present systems and methods may be implemented. In some embodiments, a device 102-a may communicate with a server 206 via a network 204. Example of networks 204 include, local area networks (LAN), wide area networks (WAN), virtual private networks (VPN), wireless local area networks (WLAN), cellular networks (using 3G and/or LTE, for example), etc. In some configurations, the network 204 may include the internet. In some configurations, the device 102-a may be one example of the device 102 illustrated in FIG. 1. For example, the device 102-a may include the camera 106, the display 108, and an application 202. It is noted that in some embodiments, the device 102-a may not include a model generator 104. In some embodiments, both a device 102-a and a server 206 may include a model generator 104 where at least a portion of the functions of the model generator 104 are performed separately and/or concurrently on both the device 102-a and the server 206.

[0029] In some embodiments, the server 206 may include the model generator 104 and may be coupled to the database 110. For example, the model generator 104 may access the polygon model data 112 and the texture map data 114 in the database 110 via the server 206. The database 110 may be internal or external to the server 206.

[0030] In some configurations, the application 202 may capture multiple images via the camera 106. For example, the application 202 may use the camera 106 to capture a video. Upon capturing the multiple images, the application 202 may process the multiple images to generate result data. In some embodiments, the application 202 may transmit the multiple images to the server 206. Additionally or alternatively, the application 202 may transmit to the server 206 the result data or at least one file associated with the result data.



[0031] In some configurations, the model generator 104 may process multiple images of an object to generate a 3-D model of the object. The model generator 104 may render a 3-D space that includes the 3-D model of a user and the 3-D polygon model of the object to render a virtual try-on 2-D image of the object and the user. The application 202 may output a display of the user to the display 108 while the camera 106 captures an image of the user.

[0032] FIG. 3 is a block diagram illustrating one example of a model generator 104-a. The model generator 104-a may be one example of the model generator 104 depicted in FIGS. 1 and/or 2. As depicted, the model generator 104-a may include a scanning module 302, a surface detection module 304, a polygon mesh module 306, a texture mapping module 308, and a rendering module 310.

[0033] In some configurations, the scanning module 302 may obtain a plurality of images of an object. In some embodiments, the scanning module 302 may activate the camera 106 to capture at least one image of the object. Additionally, or alternatively, the scanning module 302 may capture a video of the object. In one embodiment, the scanning module 302 may include a laser to scan the object. In some configurations, the scanning module 302 may use structured light to scan the object. The scanning module 302 may scan at least a portion of the object. The object may include two or more distinguishable surfaces. In some embodiments, the scanning module 302 may scan the object at a plurality of predetermined viewing angles.

[0034] In one embodiment, the surface detection module 304 may detect one or more surfaces on the object being scanned. One or more surfaces on the object may have certain characteristics. For example, the object may have a surface that is glossy or shiny, a surface that is transparent, and/or a surface that is matte. For instance, from a scan of a pair of glasses the surface detection module 304 may detect a surface on the glasses corresponding to a lens, and detect a surface on the glasses corresponding to a portion of the frame. Thus, the surface detection module 304 may detect characteristics, or aspects, of two or more surfaces on the object where each characteristic is different from one or more characteristics of other surfaces.

[0035] In some configurations, from the scan of the object, the polygon mesh module 306 may generate a polygon mesh of each detected surface of the object. The texture mapping module 308 may be configured to generate a texture map from the scan of the object. The texture map may include a plurality of images depicting the first and second surfaces of the object. The texture map may correlate a two-dimensional (2-D) coordinate of one of the plurality of images depicting the first and second surfaces of the object to a 3-D coordinate of the generated polygon mesh of the object. Thus, in some configurations, the texture mapping module 308 may generate texture coordinate information associated with the determined 3-D structure of the object, where the texture coordinate information may relate a 2-D coordinate (e.g., UV coordinates) of an image of the object to a 3-D coordinate (e.g., XYZ coordinates) of the 3-D model of the object. In one configuration, the rendering module 310 may apply the texture map to the polygon mesh and render the polygon mesh at the predetermined viewing angles in relation to a plurality of images of a user.

[0036] FIG. 4 is a block diagram illustrating one example of an polygon mesh module 306-a. The polygon mesh module 306-a may be one example of the image processor 304 illustrated in FIG. 3. As depicted, the polygon mesh module 306-a may include a positioning module 402, an intersection module 404, a mesh modification module 406, a symmetry module 408, and a mirroring module 410.

[0037] In one configuration, the positioning module 402 may position the polygon mesh in relation to a 3-D fitting object in a virtual 3-D space. The 3-D fitting object may include a predetermined shape and size. An example of the 3-D fitting object may include a universal 3-D model of a human head. For instance, a polygon mesh of a pair of glasses may be positioned in relation to a universal 3-D model of a human head in order to determine how to position the glasses on a realistic, scaled 3-D model of a user's head. In one embodiment, the intersection module 404 may determine at least one point of intersection between the polygon mesh and the 3-D fitting object.

[0038] In some configurations, the mesh modification module 406 may modify one or more vertices of the polygon mesh corresponding to one or more surfaces of the object in order to simulate a characteristic detected in a surface. For ex-

ample, the surface corresponding to the lenses on a scanned pair of glasses may have a characteristic of being reflective, shiny, and/or transparent. The mesh modification module 406 may modify one or more 3-D points of data corresponding to the lenses in the polygon mesh of the glasses in order to better simulate the detected characteristics of reflectivity, shininess, and/or transparency detected from the scan  
5 of the glasses. In some configurations, the mesh modification module 406 may add one or more vertices to at least a portion of the polygon mesh corresponding to one of the surfaces of the scanned object. For example, the mesh modification module 406 may add one or more edge-loops to a region of the polygon mesh corresponding to a surface of the object in order to improve the visual simulation of that surface.  
10 In some configurations, the mesh modification module 406 may perform a decimation algorithm on at least a portion of the polygon mesh corresponding to one or more surfaces of the object. For example, because certain surfaces of an object when rendered may still appear realistic even when the number of vertices per given area are reduced, the mesh modification module 406 may reduce the number of vertices corresponding to one or more surfaces of the object. For instance, the mesh modification module 406 may reduce the number of vertices of a polygon mesh corresponding to at least a portion of the frames of a scanned pair of glasses.

[0039] In some embodiments, the symmetry module 408 may determine at least one symmetrical aspect of the object. For example, the symmetry module 408  
20 may determine the left side of a pair of glasses is more or less symmetrical with the right side. Upon determining the symmetrical aspect of the object, the scanning module 302 may scan a portion of the object based on the determined symmetrical aspect. For example, the scanning module 302 may scan the left side of a pair of glasses, but not the right side. The polygon mesh module 306-a may generate a polygon mesh corresponding to the left side of the pair of glasses. In some configurations, the mirroring module 410 may mirror the result of scanning a symmetrical portion of the object in order to generate the portion of the polygon mesh that corresponds to a portion of the object not scanned. For example, the mirroring module  
25 410 may mirror the generated polygon mesh of the left side of the pair of glasses in order to generate the polygon mesh of the right side of the pair of glasses. The polygon mesh module 306-a may merge the polygon meshes of left and right sides of

the pair of glasses to generate a complete polygon mesh of the pair of glasses. Thus, the generated polygon mesh of an object may be positioned in relation to an image of a user in order to create a realistic rendered image of the user wearing and/or holding the object.

5           **[0040]**   **FIG. 5** illustrates an example arrangement 500 for scanning an object 504. In particular, the illustrated example arrangement 500 may include a scanner 502, an object 504, and a display stand 506.

**[0041]**   As depicted, the object 504 (e.g., a pair of glasses) may be placed on a display stand 506. In one embodiment, the scanner may scan the object in association with the scanning module 302. For instance, the scanner 502 may use a laser to perform a laser scan of the object. The polygon mesh module 302 may generate a  
10           polygon mesh of the object from the laser scan of the object. Additionally, or alternatively, the scanner 502 may use structured light to scan the object.

**[0042]**   **FIG. 6** illustrates an example arrangement 600 of a virtual 3-D  
15           space 602. As depicted, the 3-D space 602 of the example arrangement 600 may include a 3-D model of an object 604 (e.g., a pair of glasses). In some embodiments, the 3-D model of the object 604 may include a polygon mesh model of the object, which may be stored in the database 110 as polygon data 112. The polygon data 112 of the 3-D model of the object may include 3-D polygon mesh elements such as ver-  
20           tices, edges, faces, polygons, surfaces, and the like. As depicted, the 3-D model of the object 604 may include a first surface 606 and a second surface 608. For example, a 3-D model of a pair of glasses may include a portion of the polygon mesh corresponding to the lenses and a portion of the polygon mesh corresponding to the frames. Additionally, or alternatively, the 3-D model of the object 604 may include  
25           at least one texture map, which may be stored in the database 110 as texture map data 114.

**[0043]**   **FIG. 7** is a flow diagram illustrating one embodiment of a method 700 for generating a 3-D model of an object. In some configurations, the method 700 may be implemented by the model generator 104 illustrated in FIGS. 1, 2, and/or 3.  
30           In some configurations, the method 700 may be implemented by the application 202 illustrated in FIG. 2.

[0044] At block 702, at least a portion of an object may be scanned. In some embodiments, the object may include at least first and second surfaces. At block 704, a characteristic of the first surface may be detected. At block 706, a characteristic of the second surface may be detected. As explained above, the object  
5 may include surfaces that are shiny, dull, matte, transparent, translucent, iridescent, opaque, metallic, smooth, and/or textured, etc. In some embodiments, the characteristic of the first surface may be different from the characteristic of the second surface. At block 708, a polygon mesh of each surface of the object may be generated from the scan of the object.

10 [0045] FIG. 8 is a flow diagram illustrating one embodiment of a method 800 for rendering a polygon mesh. In some configurations, the method 800 may be implemented by the model generator 104 illustrated in FIGS. 1, 2, and/or 3. In some configurations, the method 800 may be implemented by the application 202 illustrated in FIG. 2.

15 [0046] At block 802, an object may be scanned at a plurality of predetermined viewing angles. At block 804, each surface of the object may be detected. In some configurations, each surface may have one or more different characteristics. At block 806, one or more vertices of the polygon mesh corresponding to at least one detected surface may be modified. The vertices may be modified to improve the  
20 simulation of a detected characteristic of one or more surfaces of the scanned object. In some embodiments, one or more vertices may be added to the polygon mesh corresponding to one or more surfaces detected on the object. For example, one or more edge-loops may be added to the polygon mesh. Additionally, or alternatively, one or more vertices may be removed from the polygon mesh. For example, a decimation algorithm may be performed on one or more surfaces of the polygon mesh.  
25

[0047] At block 808, the polygon mesh may be positioned in relation to a 3-D fitting object located in a virtual 3-D space. In some embodiments, the 3-D fitting object may include a predetermined shape and size. For example, a polygon mesh generated from scanning a pair of glasses may be positioned in relation to a 3-  
30 D model of a head in order to facilitate positioning and fitting the polygon mesh of the pair of glasses to a 3-D model of any user's head. At block 810, at least one

point of intersection may be determined between the polygon mesh and the 3-D fitting object

[0048] At block 812, a texture map generated from the scan of the object may be applied to the polygon mesh. In some embodiments, the texture map may include a plurality of images depicting the first and second surfaces of the object. The texture map may map a 2-D coordinate (e.g., UV coordinates) of one of the plurality of images depicting the first and second surfaces of the object to a 3-D coordinate (e.g., XYZ coordinates) of the generated polygon mesh of the object. At block 814, the polygon mesh may be rendered at the predetermined viewing angles. For example, a polygon mesh of a pair of glasses may be textured and rendered in relation to an image of a user in order to realistically simulate the user wearing the pair of glasses.

[0049] FIG. 9 is a flow diagram illustrating one embodiment of a method 900 for scanning an object based on a detected symmetry of the object. In some configurations, the method 900 may be implemented by the model generator 104 illustrated in FIGS. 1, 2, and/or 3. In some configurations, the method 900 may be implemented by the application 202 illustrated in FIG. 2.

[0050] At block 902, at least one symmetrical aspect of the object may be determined. Upon determining at least one symmetrical aspect of the object, at block 904, the portion of the object may be scanned based on the determined symmetrical aspect. At block 906, a result of the scan of the object may be mirrored in order to generate a portion of the polygon mesh that corresponds to a portion of the object not scanned.

[0051] FIG. 10 depicts a block diagram of a computer system 1000 suitable for implementing the present systems and methods. The depicted computer system 1000 may be one example of a server 206 depicted in FIG 2. Alternatively, the system 1000 may be one example of a device 102 depicted in FIGS. 1 and/or 2. Computer system 1000 includes a bus 1002 which interconnects major subsystems of computer system 1000, such as a central processor 1004, a system memory 1006 (typically RAM, but which may also include ROM, flash RAM, or the like), an input/output controller 1008, an external audio device, such as a speaker system 1010 via an audio output interface 1012, an external device, such as a display screen 1014

via display adapter 1016, serial ports 1018 and mouse 1046, a keyboard 1022 (interfaced with a keyboard controller 1024), multiple USB devices 1026 (interfaced with a USB controller 1028), a storage interface 1030, a host bus adapter (HBA) interface card 1036A operative to connect with a Fibre Channel network 1038, a host bus adapter (HBA) interface card 1036B operative to connect to a SCSI bus 1040, and an optical disk drive 1042 operative to receive an optical disk 1044. Also included are a mouse 1046 (or other point-and-click device, coupled to bus 1002 via serial port 1018), a modem 1048 (coupled to bus 1002 via serial port 1020), and a network interface 1050 (coupled directly to bus 1002).

[0052] Bus 1002 allows data communication between central processor 1004 and system memory 1006, which may include read-only memory (ROM) or flash memory, and/or random access memory (RAM), as previously noted. The RAM is generally the main memory into which the operating system and application programs are loaded. The ROM or flash memory can contain, among other code, the Basic Input-Output system (BIOS) which controls basic hardware operation such as the interaction with peripheral components or devices. For example, a model generator 104-b to implement the present systems and methods may be stored within the system memory 1006. The model generator 104-b may be one example of the model generator 104 depicted in FIGS. 1, 2, and/or 3. Applications resident with computer system 1000 are generally stored on and accessed via a non-transitory computer readable medium, such as a hard disk drive (*e.g.*, fixed disk 1052), an optical drive (*e.g.*, optical drive 1042), or other storage medium. Additionally, applications can be in the form of electronic signals modulated in accordance with the application and data communication technology when accessed via network modem 1048 or interface 1050.

[0053] Storage interface 1030, as with the other storage interfaces of computer system 1000, can connect to a standard computer readable medium for storage and/or retrieval of information, such as a fixed disk drive 1052. Fixed disk drive 1052 may be a part of computer system 1000 or may be separate and accessed through other interface systems. Modem 1048 may provide a direct connection to a remote server via a telephone link or to the Internet via an internet service provider (ISP). Network interface 1050 may provide a direct connection to a remote server

via a direct network link to the Internet via a POP (point of presence). Network interface 1050 may provide such connection using wireless techniques, including digital cellular telephone connection, Cellular Digital Packet Data (CDPD) connection, digital satellite data connection or the like.

5           **[0054]** Many other devices or subsystems may be connected in a similar manner (*e.g.*, document scanners, digital cameras and so on). For example, the scanner 502 may connect to the computer system 1000 through the USB controller 1028, I/O controller 1008, network interface 1050, and/or other similar connections. Conversely, all of the devices shown in FIG. 10 need not be present to practice the present systems and methods. The devices and subsystems can be interconnected in  
10 different ways from that shown in FIG. 10. The operation of at least some of the computer system 1000 such as that shown in FIG. 10 is readily known in the art and is not discussed in detail in this application. Code to implement the present disclosure can be stored in a non-transitory computer-readable medium such as one or  
15 more of system memory 1006, fixed disk 1052, or optical disk 1044. The operating system provided on computer system 1000 may be MS-DOS<sup>®</sup>, MS-WINDOWS<sup>®</sup>, OS/2<sup>®</sup>, UNIX<sup>®</sup>, Linux<sup>®</sup>, or another known operating system.

**[0055]** Moreover, regarding the signals described herein, those skilled in the art will recognize that a signal can be directly transmitted from a first block to a  
20 second block, or a signal can be modified (*e.g.*, amplified, attenuated, delayed, latched, buffered, inverted, filtered, or otherwise modified) between the blocks. Although the signals of the above described embodiment are characterized as transmitted from one block to the next, other embodiments of the present systems and methods may include modified signals in place of such directly transmitted signals  
25 as long as the informational and/or functional aspect of the signal is transmitted between blocks. To some extent, a signal input at a second block can be conceptualized as a second signal derived from a first signal output from a first block due to physical limitations of the circuitry involved (*e.g.*, there will inevitably be some attenuation and delay). Therefore, as used herein, a second signal derived from a first  
30 signal includes the first signal or any modifications to the first signal, whether due to circuit limitations or due to passage through other circuit elements which do not change the informational and/or final functional aspect of the first signal.



[0056] While the foregoing disclosure sets forth various embodiments using specific block diagrams, flowcharts, and examples, each block diagram component, flowchart step, operation, and/or component described and/or illustrated herein may be implemented, individually and/or collectively, using a wide range of hardware, software, or firmware (or any combination thereof) configurations. In addition, any disclosure of components contained within other components should be considered exemplary in nature since many other architectures can be implemented to achieve the same functionality.

[0057] The process parameters and sequence of steps described and/or illustrated herein are given by way of example only and can be varied as desired. For example, while the steps illustrated and/or described herein may be shown or discussed in a particular order, these steps may be performed in an order not illustrated or discussed. The various exemplary methods described and/or illustrated herein may also omit one or more of the steps described or illustrated herein or include additional steps in addition to those disclosed.

[0058] Furthermore, while various embodiments have been described and/or illustrated herein in the context of fully functional computing systems, one or more of these exemplary embodiments may be distributed as a program product in a variety of forms, regardless of the particular type of computer-readable media used to actually carry out the distribution. The embodiments disclosed herein may also be implemented using software modules that perform certain tasks. These software modules may include script, batch, or other executable files that may be stored on a computer-readable storage medium or in a computing system. In some embodiments, these software modules may configure a computing system to perform one or more of the exemplary embodiments disclosed herein.

[0059] The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the present systems and methods and their practical applications, to thereby enable others skilled in the art to best utilize the present systems

and methods and various embodiments with various modifications as may be suited to the particular use contemplated.

[0060] Unless otherwise noted, the terms “a” or “an,” as used in the specification and claims, are to be construed as meaning “at least one of.” In addition, for ease of use, the words “including” and “having,” as used in the specification and claims, are interchangeable with and have the same meaning as the word “comprising.” In addition, the term “based on” as used in the specification and the claims is to be construed as meaning “based at least upon.”

What is claimed is:

1. A computer-implemented method for generating a three-dimensional (3-D) model of an object, the method comprising:
  - 5 scanning at least a portion of an object, wherein the object includes at least first and second surfaces;
  - detecting an aspect of the first surface;
  - detecting an aspect of the second surface, the aspect of the second surface being different from the aspect of the first surface; and
  - 10 generating a polygon mesh of the first and second surfaces from the scan of the object.
2. The method of claim 1, further comprising:
  - 15 positioning the polygon mesh in relation to a 3-D fitting object in a virtual 3-D space, wherein the 3-D fitting object comprises a predetermined shape and size; and
  - determining at least one point of intersection between the polygon mesh and the 3-D fitting object.
- 20 3. The method of claim 1, further comprising:
  - modifying one or more vertices of the polygon mesh corresponding to the first surface to simulate the first surface.
4. The method of claim 3, wherein modifying one or more vertices of the polygon mesh corresponding to the first surface further comprises:
  - 25 adding a plurality of vertices to at least a portion of the polygon mesh corresponding to the first surface.
5. The method of claim 1, further comprising:
  - 30 performing a decimation algorithm on at least a portion of the polygon mesh corresponding to the second surface.

6. The method of claim 1, further comprising:

determining at least one symmetrical aspect of the object;  
upon determining the symmetrical aspect of the object, scanning the portion  
of the object based on the determined symmetrical aspect; and  
5 mirroring a result of the scan of the object in order to generate a portion of  
the polygon mesh that corresponds to a portion of the object not  
scanned.

7. The method of claim 1, further comprising:

10 applying a texture map generated from the scan of the object to the polygon  
mesh, wherein the texture map includes a plurality of images depicting  
the first and second surfaces of the object, and wherein the texture map  
maps a two-dimensional (2-D) coordinate of one of the plurality of im-  
ages depicting the first and second surfaces of the object to a 3-D co-  
15 ordinate of the generated polygon mesh of the object.

8. The method of claim 1, wherein scanning at least a portion of the object further  
comprises:

scanning the object at a plurality of predetermined viewing angles.

20

9. The method of claim 8, further comprising:

rendering the polygon mesh at the predetermined viewing angles.

10. A computing device configured to generate a three-dimensional (3-D) model of an object, comprising:

a processor;

memory in electronic communication with the processor;

5 instructions stored in the memory, the instructions being executable by the processor to:

scan at least a portion of an object, wherein the object includes at least first and second surfaces;

detect an aspect of the first surface;

10 detect an aspect of the second surface, the aspect of the second surface being different from the aspect of the first surface; and

generate a polygon mesh of the first and second surfaces from the scan of the object.

15

11. The computing device of claim 10, wherein the instructions are executable by the processor to:

position the polygon mesh in relation to a 3-D fitting object in a virtual 3-D space, wherein the 3-D fitting object comprises a predetermined shape and size; and

20

determine at least one point of intersection between the polygon mesh and the 3-D fitting object.

12. The computing device of claim 10, wherein the instructions are executable by the processor to:

25

modify one or more vertices of the polygon mesh corresponding to the first surface to simulate the first surface.

13. The computing device of claim 12, wherein the instructions are executable by the processor to:

30

add a plurality of vertices to at least a portion of the polygon mesh corresponding to the first surface.

14. The computing device of claim 10, wherein the instructions are executable by the processor to:

5 perform a decimation algorithm on at least a portion of the polygon mesh corresponding to the second surface.

15. The computing device of claim 10, wherein the instructions are executable by the processor to:

10 determine at least one symmetrical aspect of the object;  
upon determining the symmetrical aspect of the object, scan the portion of the object based on the determined symmetrical aspect; and  
mirror a result of the scan of the object in order to generate a portion of the polygon mesh that corresponds to a portion of the object not scanned.

15

16. The computing device of claim 10, wherein the instructions are executable by the processor to:

20 apply a texture map generated from the scan of the object to the polygon mesh, wherein the texture map includes a plurality of images depicting the first and second surfaces of the object, and wherein the texture map maps a two-dimensional (2-D) coordinate of one of the plurality of images depicting the first and second surfaces of the object to a 3-D coordinate of the generated polygon mesh of the object.

25

17. The computing device of claim 10, wherein the instructions are executable by the processor to:

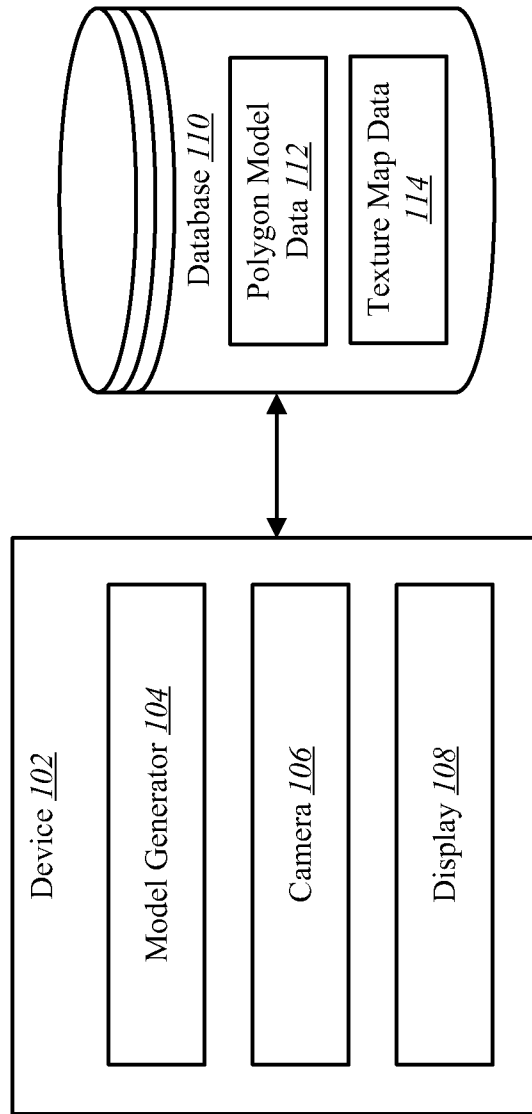
scan the object at a plurality of predetermined viewing angles.

30 18. The computing device of claim 17, wherein the instructions are executable by the processor to:

render the polygon mesh at the predetermined viewing angles.

19. A computer-program product for generating a three-dimensional (3-D) model of an object, the computer-program product comprising a non-transitory computer-readable medium storing instructions thereon, the instructions being executable by a processor to:
- 5 processor to:
- scan at least a portion of an object, wherein the object includes at least first and second surfaces;
  - detect an aspect of the first surface;
  - detect an aspect of the second surface, the aspect of the second surface  
10 being different from the aspect of the first surface; and
  - generate a polygon mesh of the first and second surfaces from the scan of the object.
20. The computer-program product of claim 19, wherein the instructions are executable by the processor to:
- 15 executable by the processor to:
- position the polygon mesh in relation to a 3-D fitting object in a virtual 3-D space, wherein the 3-D fitting object comprises a predetermined shape and size;
  - determine at least one point of intersection between the polygon mesh  
20 and the 3-D fitting object; and
  - render the polygon mesh at predetermined viewing angles.

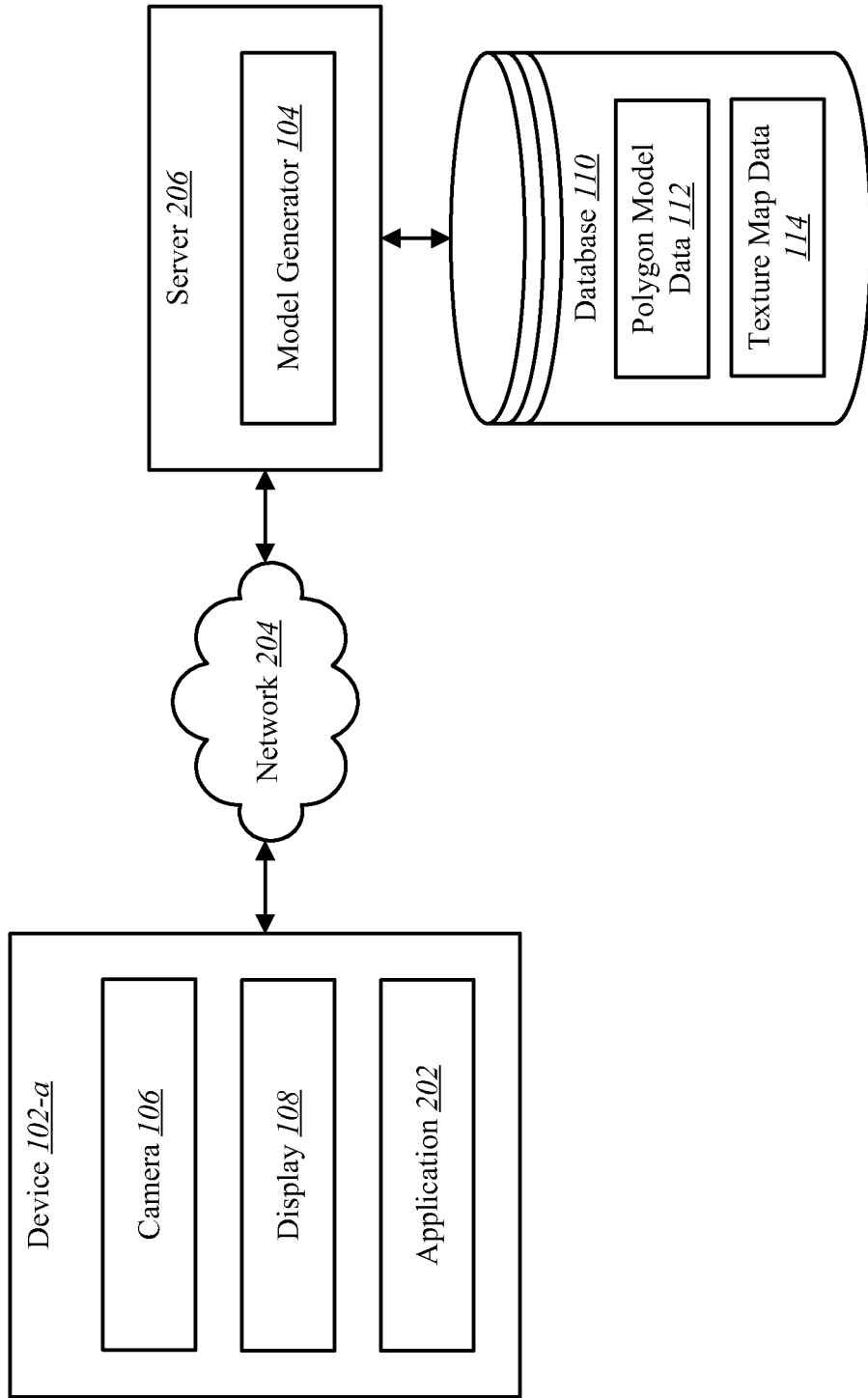
100 ↗



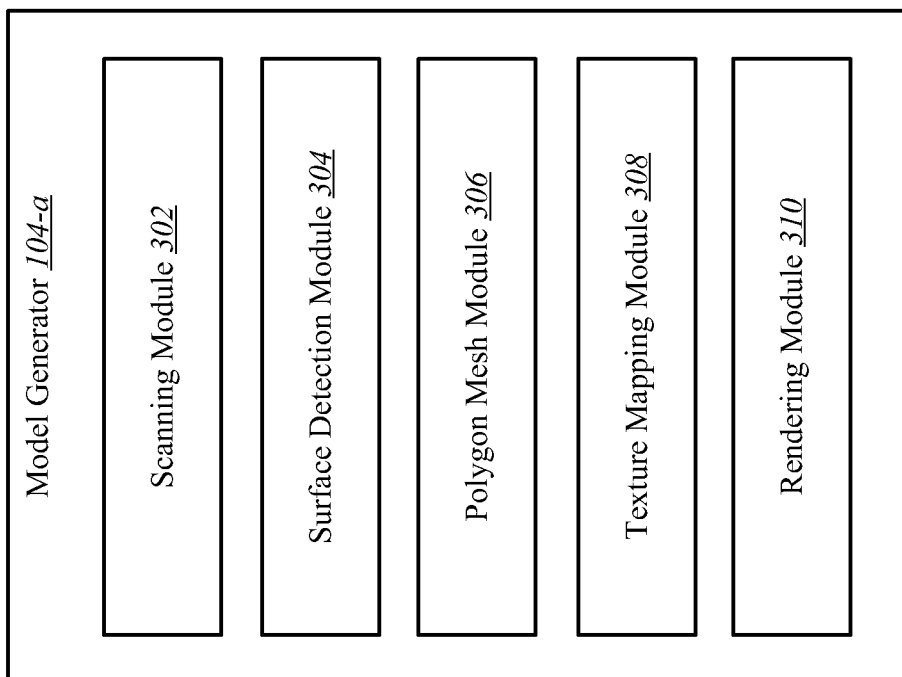
**FIG. 1**



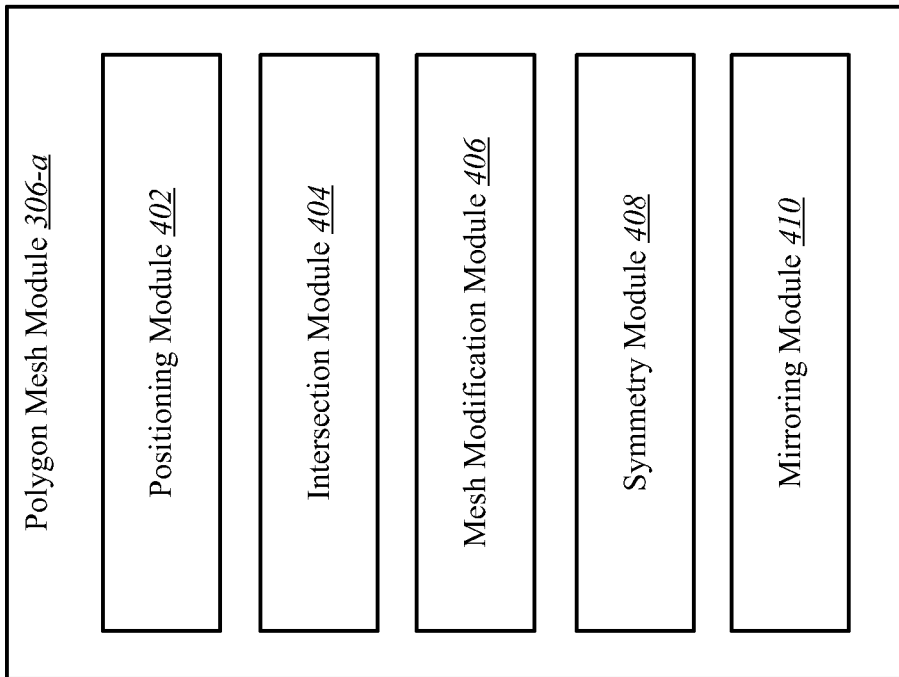
200 ↗



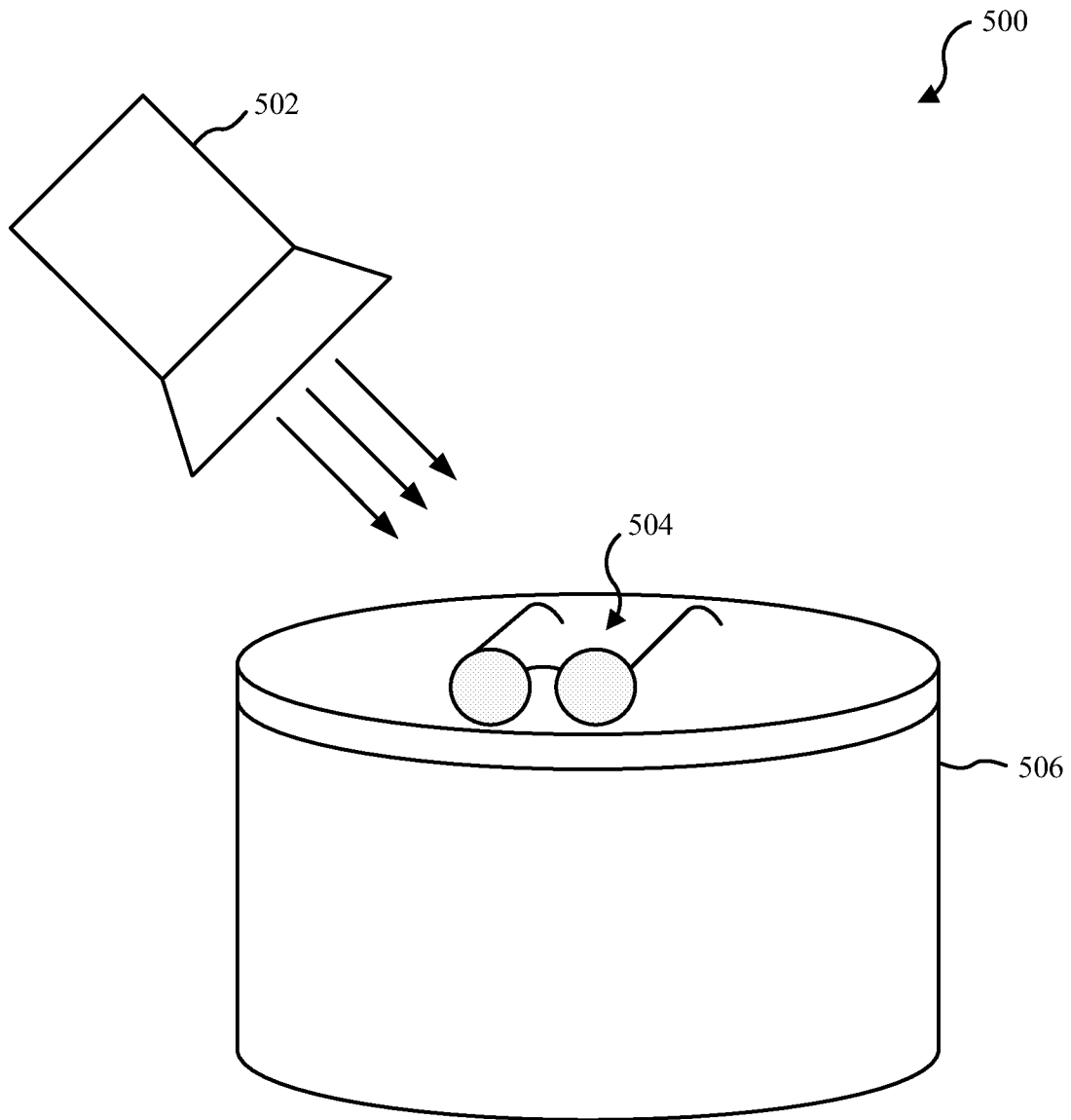
**FIG. 2**



**FIG. 3**

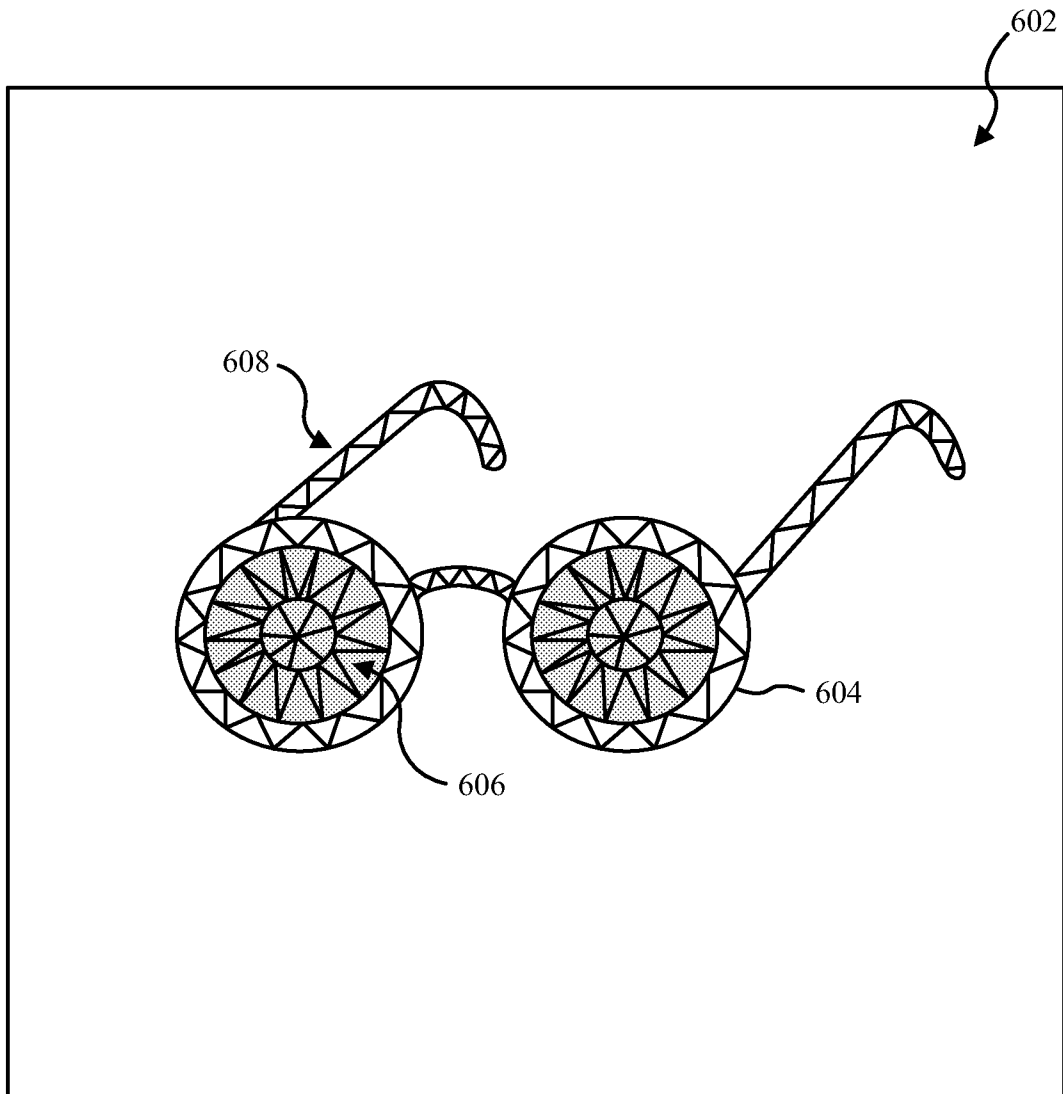


**FIG. 4**

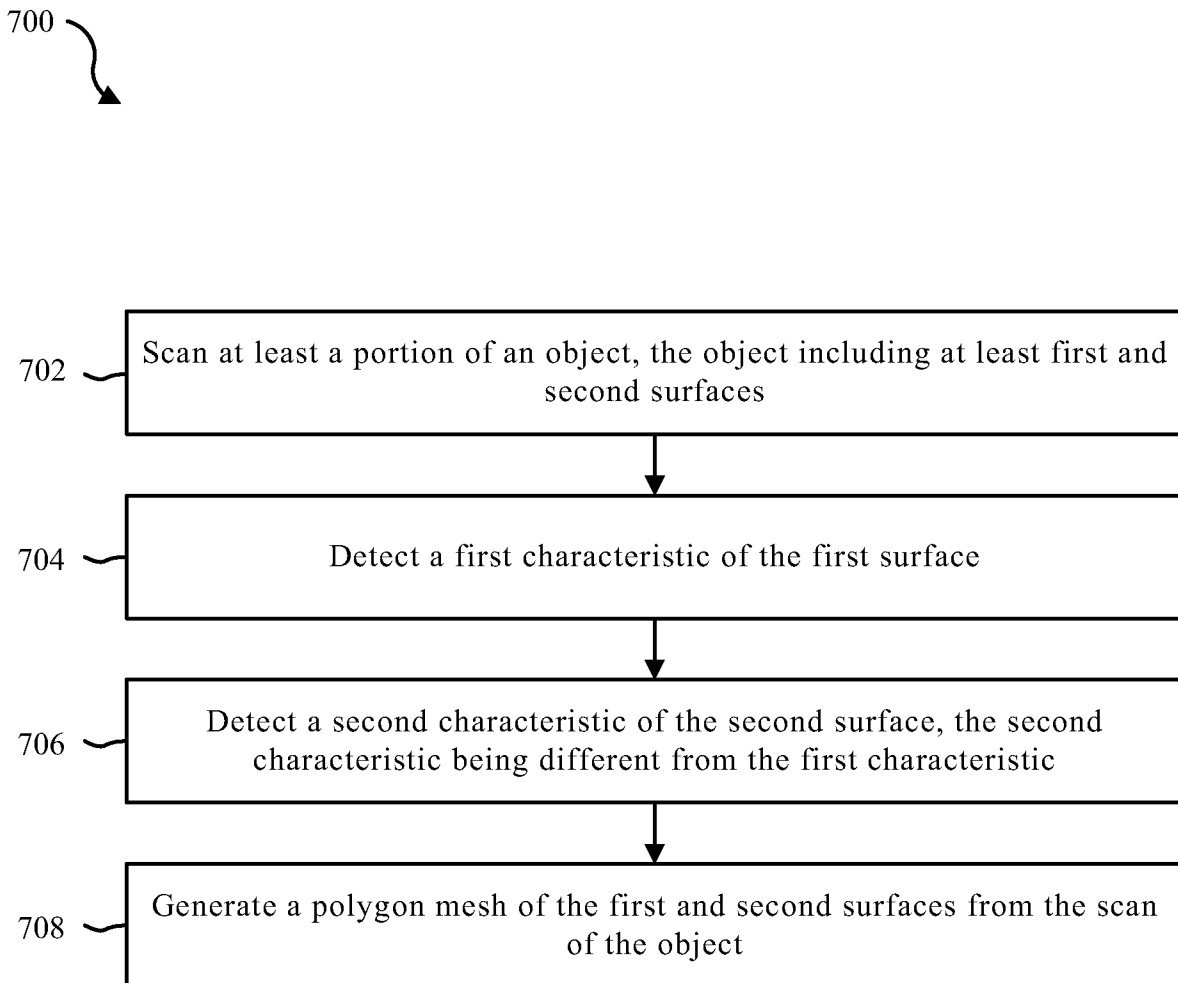


**FIG. 5**

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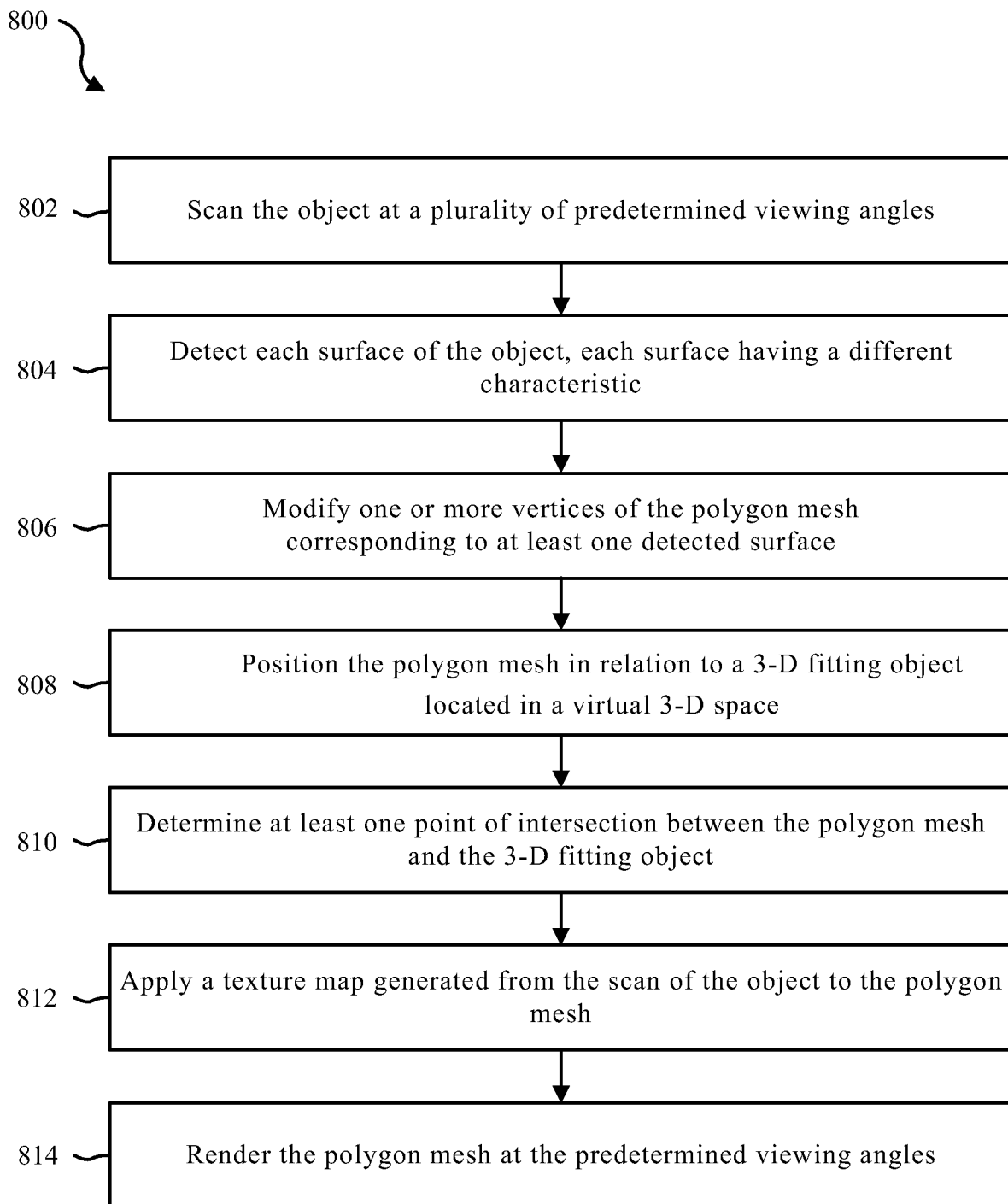


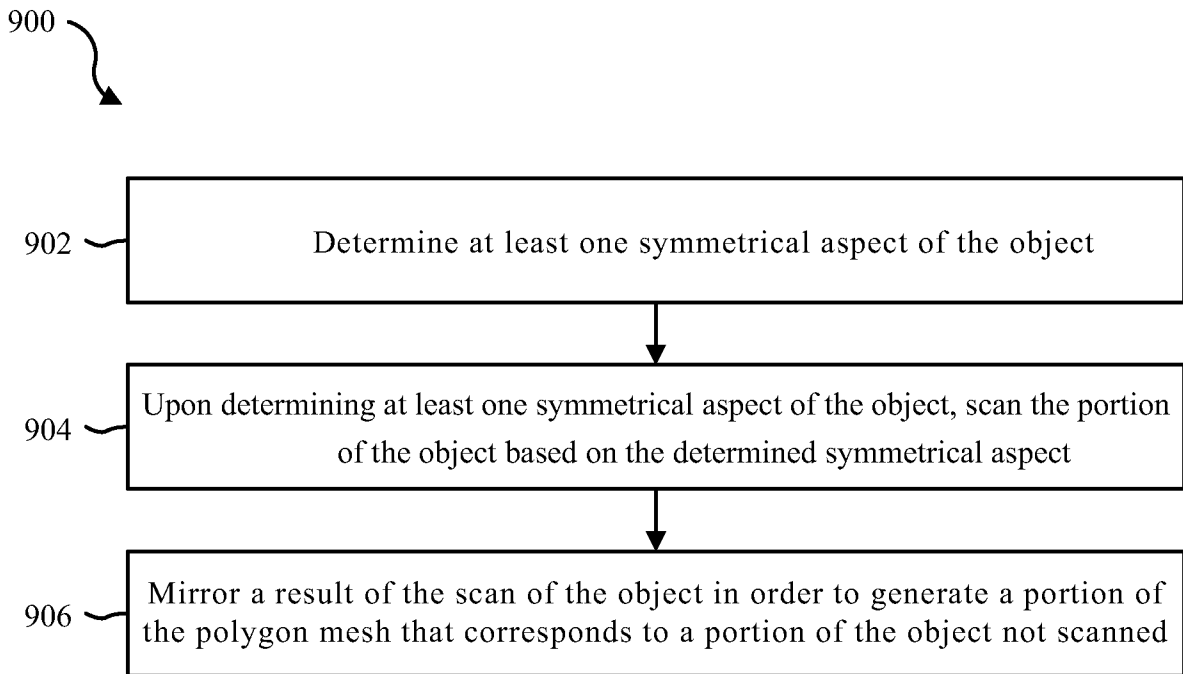
**FIG. 6**



**FIG. 7**

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**FIG. 8**



**FIG. 9**



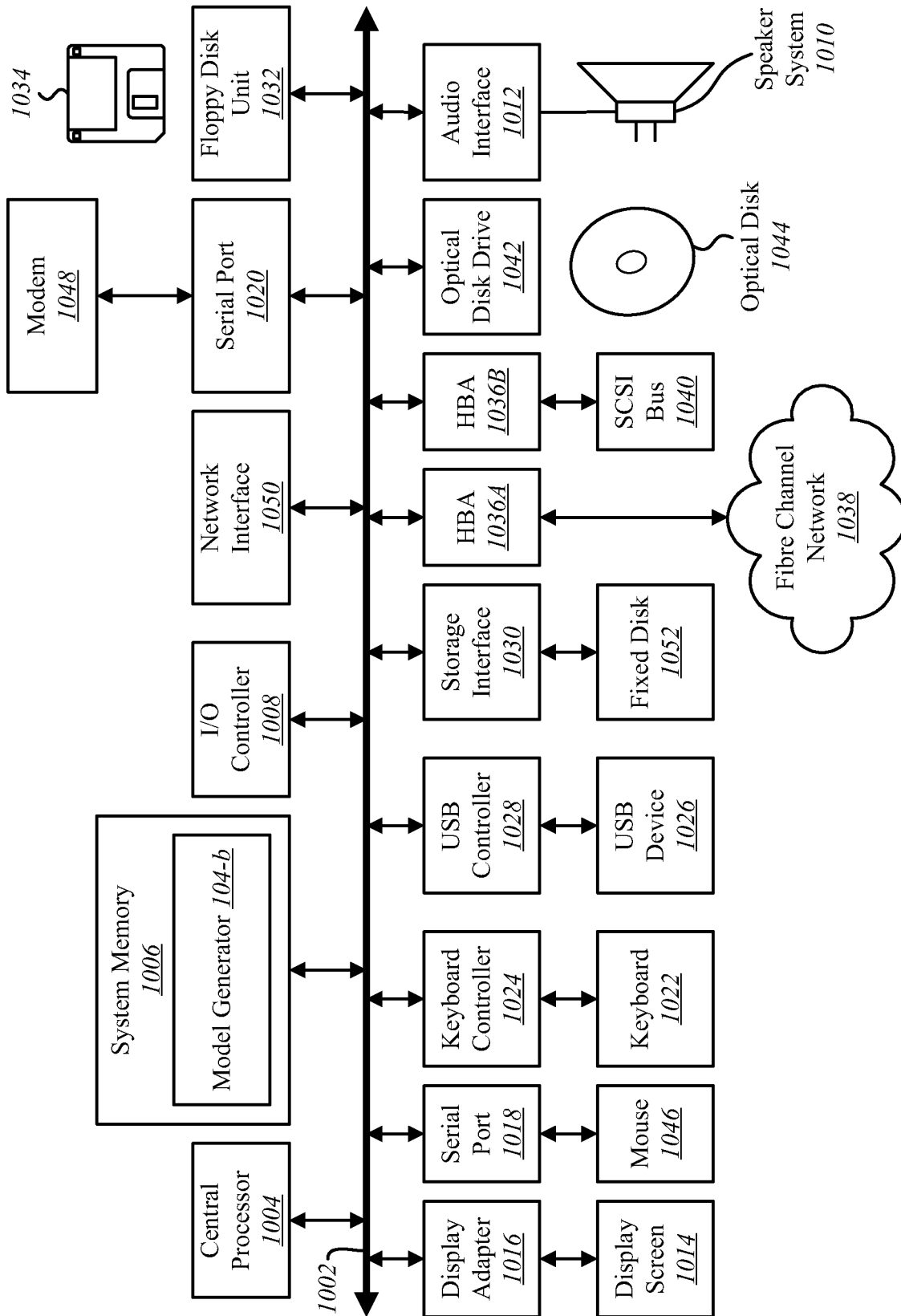


FIG. 10

**A. CLASSIFICATION OF SUBJECT MATTER****G06T 17/00(2006.01)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)

G06T 17/00; G06F 12/02; G06F 19/00; G06K 9/68; G06T 15/00; G06K 9/00

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) &amp; Keywords: three-dimension, surface, aspect, polygon, mesh

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6968075 B1 (KURT C. CHANG) 22 November 2005 See abstract; column 8, lines 31-67; column 9, lines 25-36; figures 1, 7-10; and claims 1, 3, 6.	1-20
Y	US 2010-0209005 A1 (LEONID I. RUDIN et al.) 19 August 2010 See abstract; paragraphs 6, 18, 42; figures 2-3, 5, 6; and claims 10-13.	1-20
A	US 2009-0154794 A1 (HO WON KIM et al.) 18 June 2009 See paragraphs 26-31; figures 1, 2; and claim 1.	1-20
A	US 2009-0316966 A1 (MICHAEL CRAIG MARSHALL et al.) 24 December 2009 See abstract; figures 1, 3, 4; and claim 1.	1-20
A	US 7310102 B2 (SEAN SPICER) 18 December 2007 See abstract; paragraphs 34, 35; figure 2; and claims 1, 2.	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

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"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

"&amp;" document member of the same patent family


Date of the actual completion of the international search

26 September 2013 (26.09.2013)

Date of mailing of the international search report

**27 September 2013 (27.09.2013)**

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## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/042520

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