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(54) **HYBRID STEREOSCOPIC VIEWING DEVICE**

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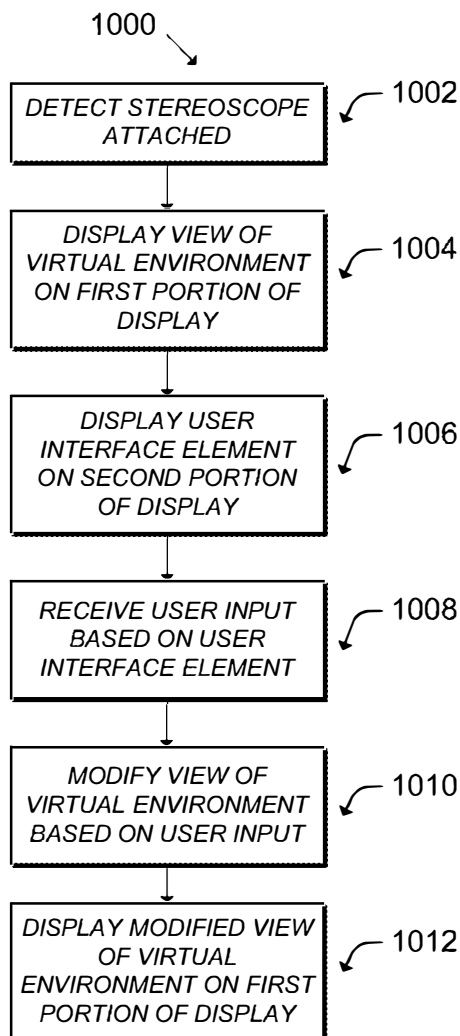
(57) **ABSTRACT**

A virtual reality hardware and software platform comprised of a stereoscope which attaches to a mobile touchscreen computer/tablet. The stereoscope, in which the user looks through, covers just the top portion of the tablet screen. This top portion displays the stereoscopic view of a virtual environment. The bottom portion displays the two-dimensional view. The user touches the view with his/her thumbs and/or fingers in order to interact with and travel through the virtual environment seen in the view.

1000

1002 — DETECT STEREOSCOPE ATTACHED

1004 — DISPLAY VIEW OF VIRTUAL ENVIRONMENT ON FIRST PORTION OF DISPLAY

1006 — DISPLAY USER INTERFACE ELEMENT ON SECOND PORTION OF DISPLAY

1008 — RECEIVE USER INPUT BASED ON USER INTERFACE ELEMENT

1010 — MODIFY VIEW OF VIRTUAL ENVIRONMENT BASED ON USER INPUT

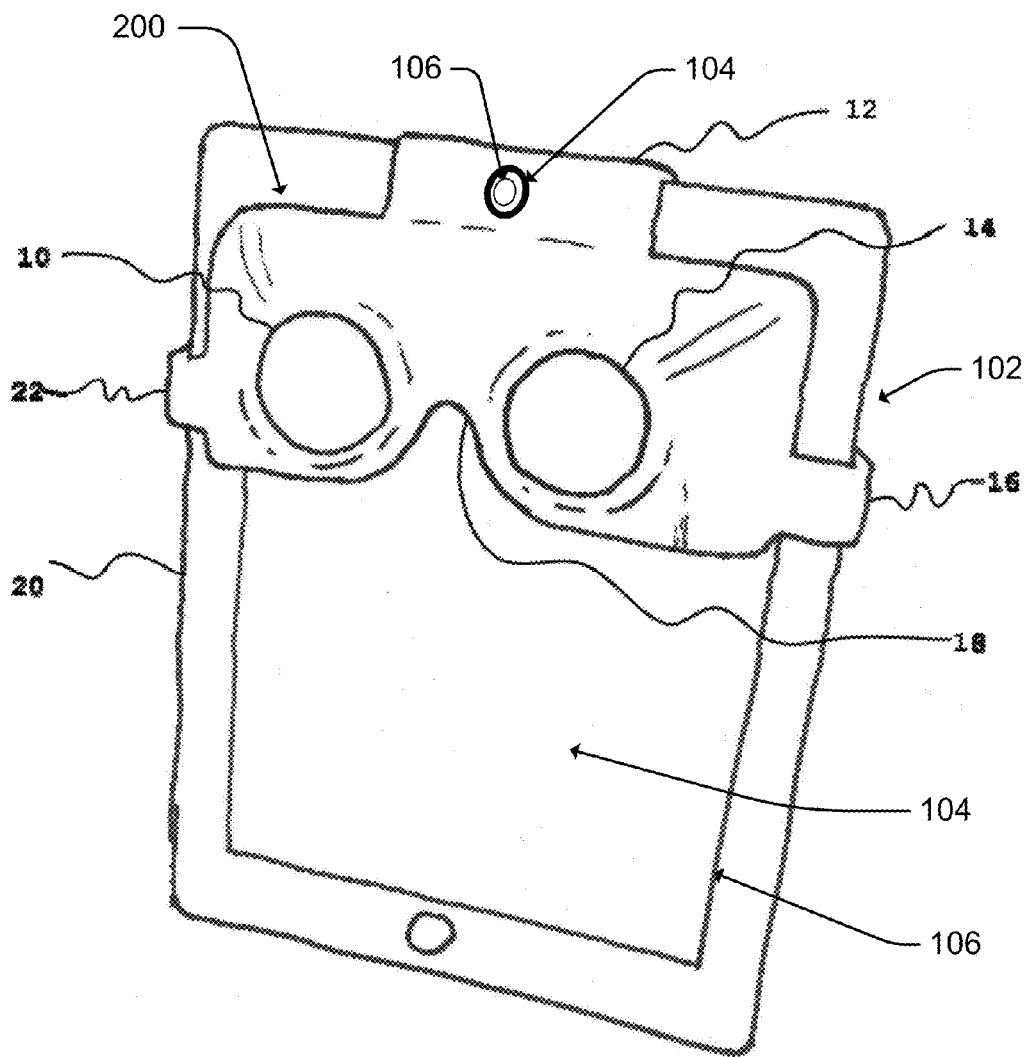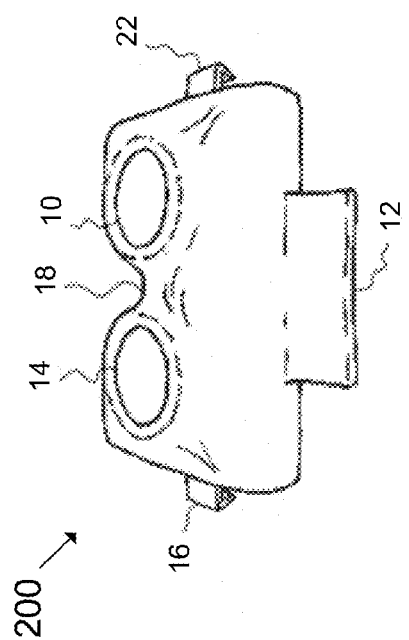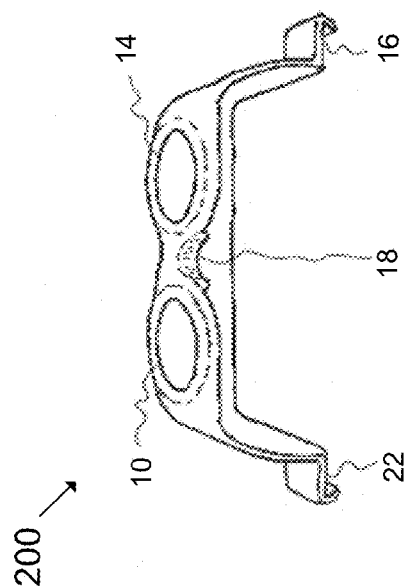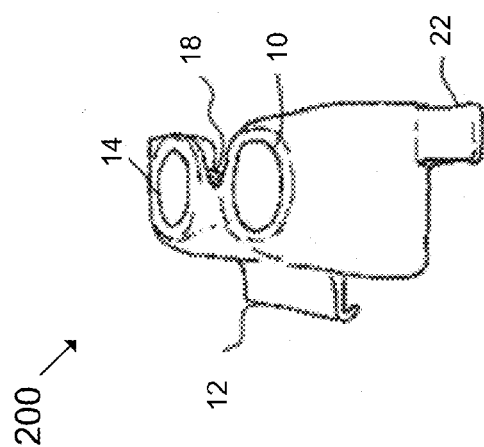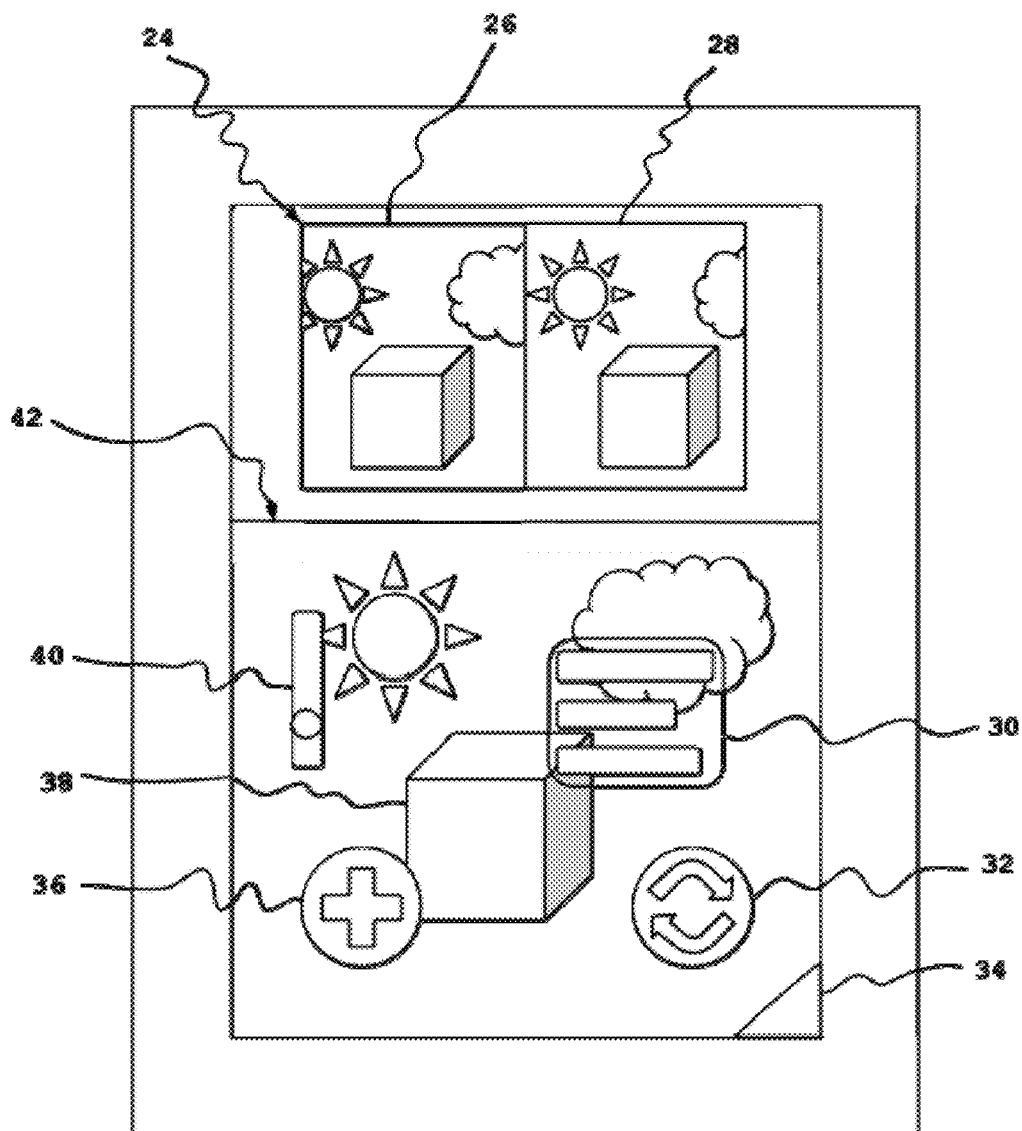1012 — DISPLAY MODIFIED VIEW OF VIRTUAL ENVIRONMENT ON FIRST PORTION OF DISPLAY
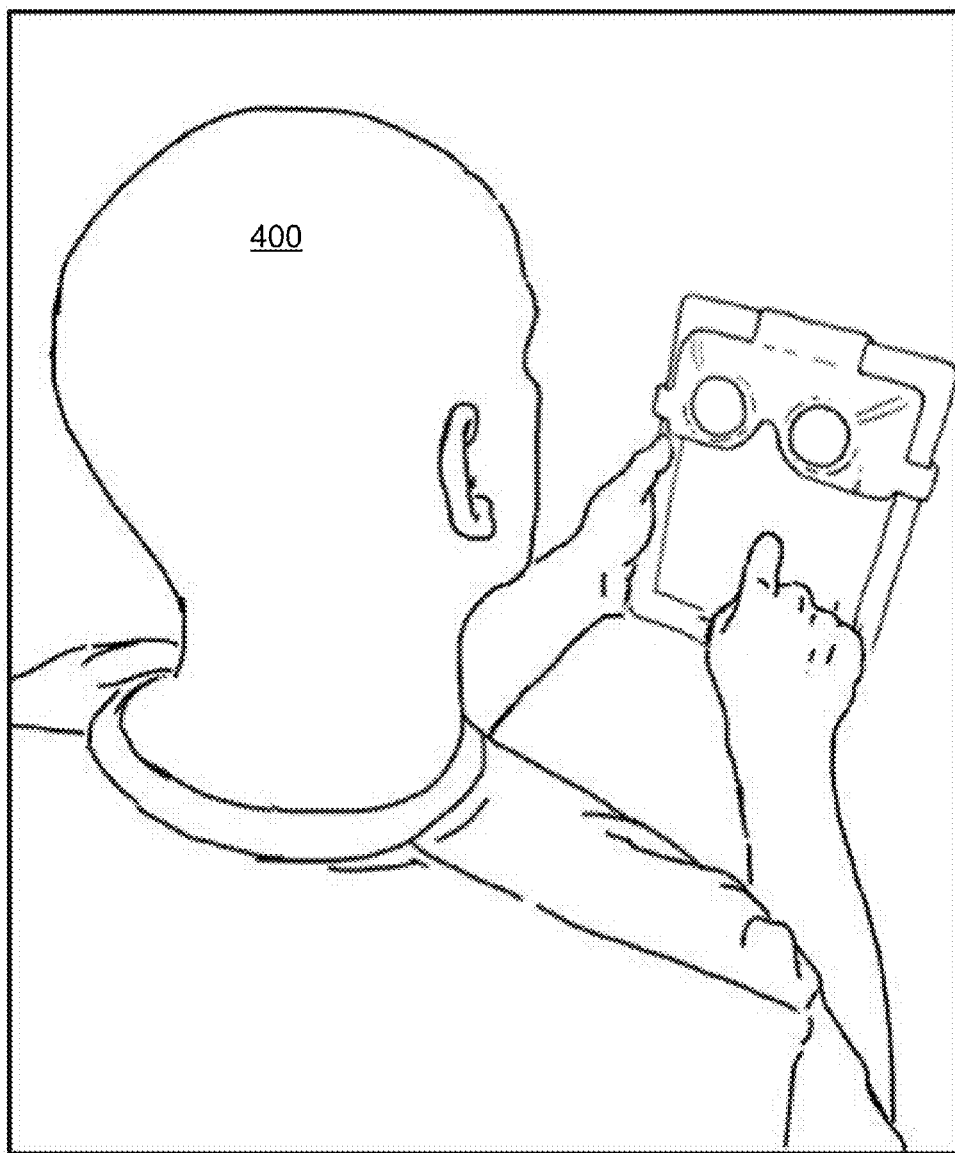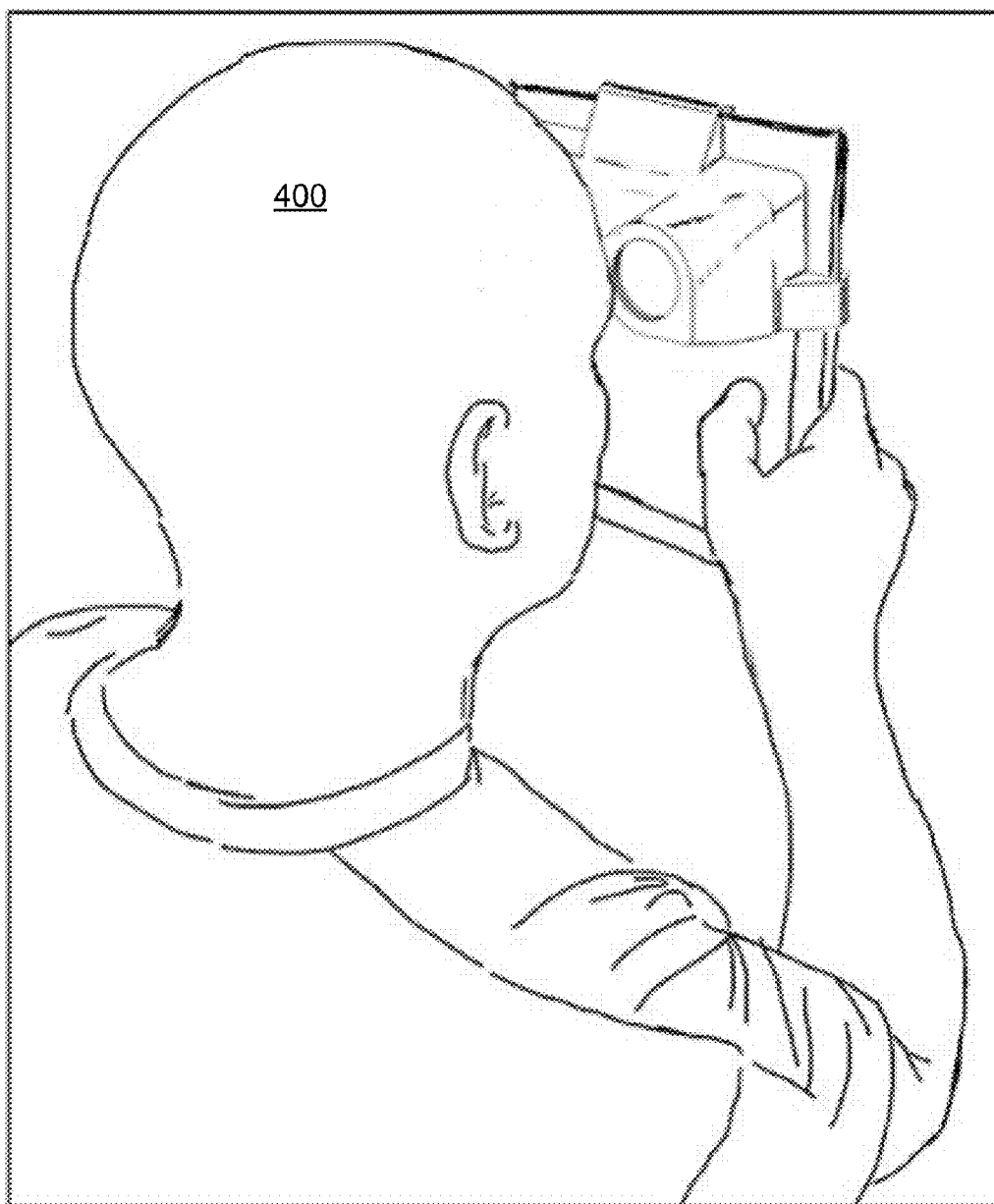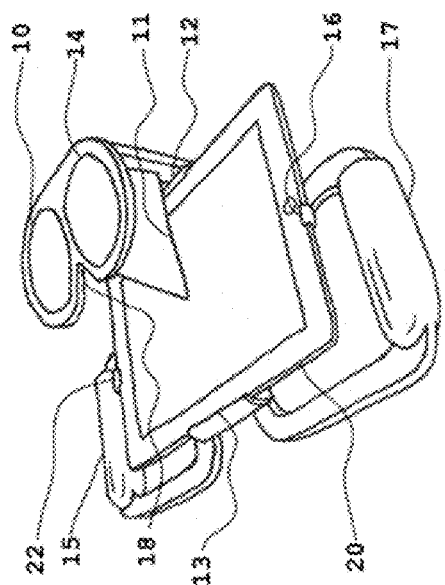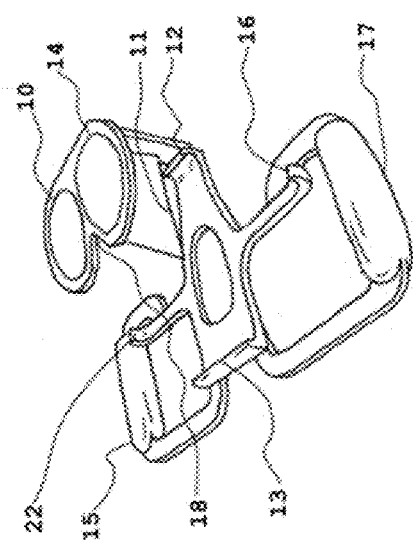
FIG. 1

FIG. 2B

FIG. 2C

FIG. 2A

FIG. 3

400

FIG. 4A

FIG. 4B

FIG. 5A

FIG. 5B

FIG. 5C

FIG. 6B

FIG. 6A

FIG. 7B

FIG. 7A

↙ 800

0.5316	0	0.005759	0
0	0.397	0	0
0	0	-1	-0.3
0	0	-1	0

FIG. 8A

↙ 850

0.5316	0	-0.005759	0
0	0.397	0	0
0	0	-1	-0.3
0	0	-1	0

FIG. 8B

FIG. 9

1000

1002 DETECT STEREOSCOPE ATTACHED

1004 DISPLAY VIEW OF VIRTUAL ENVIRONMENT ON FIRST PORTION OF DISPLAY

1006 DISPLAY USER INTERFACE ELEMENT ON SECOND PORTION OF DISPLAY

1008 RECEIVE USER INPUT BASED ON USER INTERFACE ELEMENT

1010 MODIFY VIEW OF VIRTUAL ENVIRONMENT BASED ON USER INPUT

1012 DISPLAY MODIFIED VIEW OF VIRTUAL ENVIRONMENT ON FIRST PORTION OF DISPLAY

FIG. 10A

1050

1052 MOVE STEREOSCOPE NEAR USER'S EYES SUCH THAT SECOND PORTION IS NOT VISIBLE TO USER

1054 VIEW A VIEW OF VIRTUAL ENVIRONMENT ON A FIRST PORTION OF DISPLAY THROUGH STEREOSCOPE

1056 MOVE STEREOSCOPE AWAY FROM USER'S EYES SUCH THAT SECOND PORTION IS VISIBLE TO USER

1058 INTERFACE WITH SECOND PORTION OF DISPLAY TO MANIPULATE VIEW OF VIRTUAL ENVIRONMENT WHEN SECOND PORTION IS VISIBLE TO USER

1060 VIEW MANIPULATED VIEW OF VIRTUAL ENVIRONMENT THROUGH STEREOSCOPE WHEN NEAR USER'S EYES

FIG. 10B

FIG. 11

HYBRID STEREOSCOPIC VIEWING DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims priority to U.S. provisional patent application 61/801,032, entitled "Inverse Immersive Tablet—Hybrid Stereoscopic Viewing Device," filed Mar. 15, 2013, attorney docket number 028080-0850, the entire content of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Technical Field

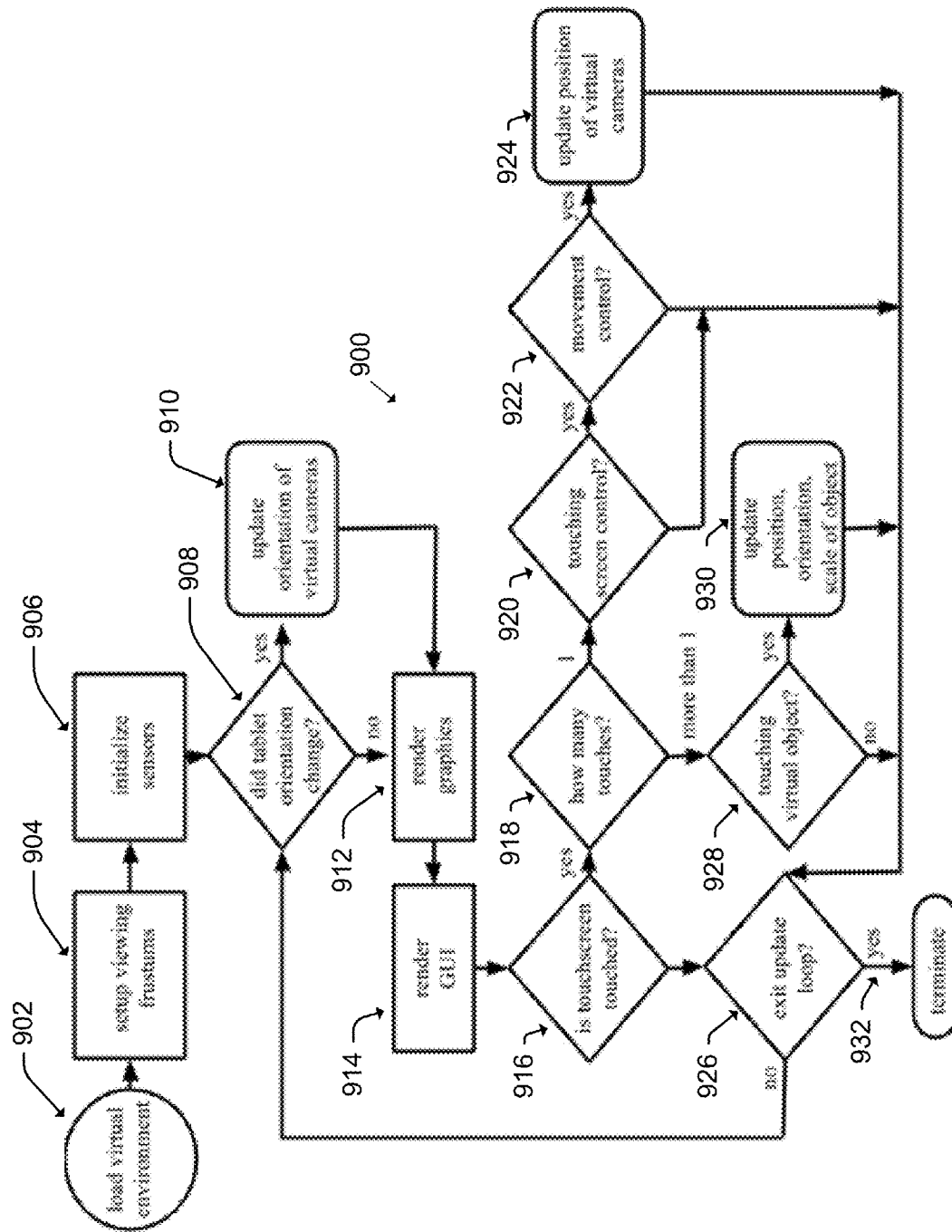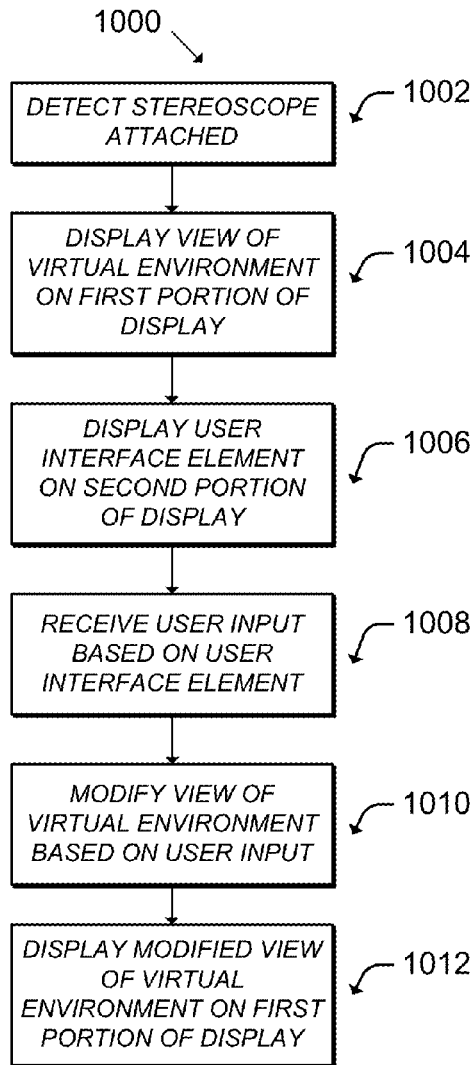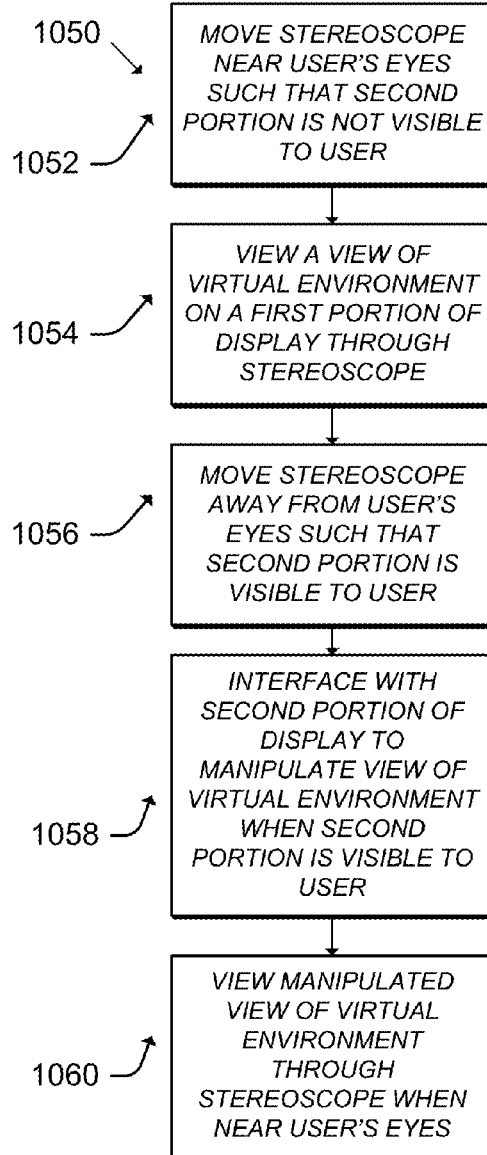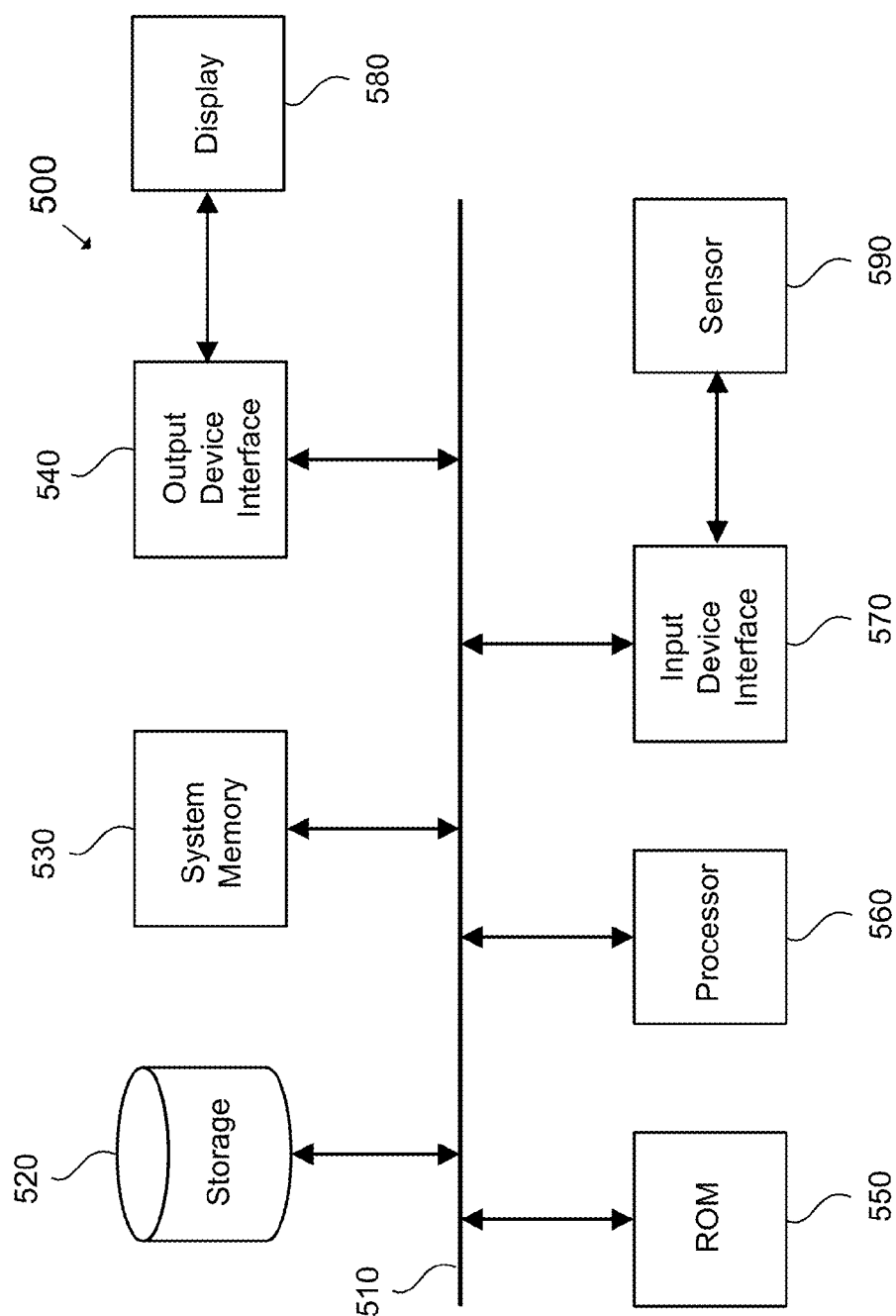[0003] This disclosure to 3D virtual reality (VR) experiences programmed on mobile touchscreen devices such as tablet computers.

[0004] 2. Description of Related Art

[0005] Stereoscopic 3D displays date back to the 1830s, when Charles Wheatstone built the first stereoscope, later improved by David Brewster and Oliver Wendell Holmes. The Holmes stereoscope was extremely popular in the second half of the 19th century, and could be said to be the virtual reality (VR) of its day. In **1939**, the View-Master was introduced, and became the most widely used stereoscope for most of the 20th century. The first stereoscopic head-mounted display (HMD) was built by Ivan Sutherland in 1965, but it wasn't until the 1980s that any handheld stereo VR display appeared. The BOOM™ by FakeSpace in 1991, U.S. Pat. No. 5,253,832, the entire content of which is incorporated herein by reference, was an early example of handheld (or head-coupled) VR displays.

[0006] Virtual Keyboards: Virtual keyboards, such as the on-screen keyboard on smartphones, have something in common with the idea we are describing, in that the lower part of the screen is used as input for the upper part of the screen.

[0007] Hasbro™ my3D™ (stereoscopic smartphone attachment): The my3D™ has thumb holes at the bottom which allow limited and fairly awkward interaction by tapping the touchscreen display.

[0008] The devices above used to consume stereoscopic VR experiences exhibit certain limitations:

[0009] (a) HMDs require a separate computer for rendering and displaying graphics.

[0010] (b) HMDs require separate means for tracking the user's head position and orientation, through the use of external mechanical, magnetic, or optical sensors.

[0011] (c) HMDs require external sources of input (such as keyboards, mice, and joysticks) in-order to control and interact with the immersive VR software.

[0012] (d) An HMD's limited field-of-view is a combination of optical magnification power and the distance between the user's eyes and the lenses.

[0013] (e) HMDs force users to attend exclusively to tasks in the VR environment, and inhibits the user from performing other real-world tasks.

[0014] (f) With HMDs, the user is immersed in a display that entirely fills his/her visual field, blocking out their actual physical surroundings and isolating them from the real world.

[0015] (g) HMDs attach to the user's head by means of a head band, which is difficult to customize for every head shape and hairstyle.

[0016] (h) Smartphones have the computational power to render and display sophisticated computer-generated graphics, but have limited screen space to do so.

[0017] (i) Smartphones with touchscreens can receive user input via finger touch, but fingers can obscure the user's view of the screen if attached is a stereoscope that envelopes the entire screen of the smartphone.

[0018] (j) Smartphones with attached stereoscopes are capable of receiving user input that does not interfere with the user's view of the screen, but only if an external source of input is used (such as a wireless keyboard).

[0019] (k) Stereoscopes for smartphones such as the Hasbro™ my3D™ envelop the entire smartphone, isolating the other useful features of the smartphone from the user.

[0020] (l) External sources of input occupy coordinate systems that are different from the coordinate systems of the display (the direction of "UP" on a joystick is different from what is "UP" inside an HMD or smartphone, which is disorienting for the user).

[0021] (m) All stereoscopes, whether they are HMDs or stereoscopes for smartphones, force the user's eyes to focus on the visual experience, which forces the user to rely on the sense of touch to find external controllers.

SUMMARY

[0022] This hybrid stereoscopic viewing device is a fully-contained and functionally complete virtual reality (VR) platform, which comprises of a detachable stereoscope and a mobile touchscreen tablet. No external controllers or peripherals are necessary since the VR software programmed onto the tablet gathers input directly from the user through the touchscreen itself. The software gathers further input via the tablet's available sensors (i.e. gyrometers, accelerometers, magnetometers, depth cameras, video cameras), obviating the need for external motion tracking systems which are commonly used in VR applications.

[0023] Accordingly, the present inventive concepts may include:

[0024] (a) to allow the user to view a computer-generated virtual reality (VR) environment and control his/her point-of-view within this virtual environment (VE) all on the same tablet;

[0025] (b) to unobstruct the user's stereoscopic view when he/she is touching the touchscreen interface of the tablet;

[0026] (c) to allow the user's eyes to be as close to the stereoscope's lenses in order for them to perceive the maximum field-of-view;

[0027] (d) to allow a broader audience to experience and interact with virtual environments;

[0028] (e) to leverage the tablet's built-in sensors (including gyrometers, accelerometers, magnetometers, depth cameras, video cameras) in order to track the user's position and rotation in the real world;

[0029] (f) to allow the user unencumbered access to all of the built-in functions of the tablet while he/she is using the stereoscope with tablet;

[0030] (g) to allow the user to transition fluidly between tasks in the VE and tasks normally performed on a touchscreen tablet by-itself;

[0031] (h) to allow the user to quickly switch between tasks in the VE and tasks in the real world;

[0032] (i) to allow the user to easily communicate his/her experience about the VE to other users in the same room;

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[0033] (j) to give the user an intuitive mapping of controls in the VE; and

[0034] (k) to allow the user to control their virtual experience without requiring them to look away from the stereoscope and the virtual experience it presents.

[0035] One implementation describes a method of interacting with a virtual environment using a stereoscope removably attached to a computing device having a display integrated with an input device, the display having a first portion and a second portion, the stereoscope covering the first portion and positioned to allow stereoscopic viewing of a view of the virtual environment The method comprises displaying, on the first portion, the view of the virtual environment, and displaying, on the second portion, a user interface element. The method further comprises receiving, from the input device, a user input based on the user interface element; modifying, based on the user input, the view of the virtual environment; and displaying, on the first portion, a modified view of the virtual environment.

[0036] Another implementation describes a method of interacting with a virtual environment using a stereoscope removably attached to a computing device having a display integrated with an input device, the display having a first portion and a second portion, the stereoscope covering the first portion and positioned to allow stereoscopic viewing of a view of the virtual environment. The method comprises moving the stereoscope near a user's eyes such that the second portion is not visible to the user. The method further comprises viewing, through the stereoscope, a view of the virtual environment on the first portion; moving the stereoscope away from the user's eyes such that second portion is visible to the user; interfacing with the second portion to manipulate the view of the virtual environment when the second portion is visible to the user; and viewing, through the stereoscope, a manipulated view of the virtual environment when the stereoscope is near the user's eyes.

[0037] In yet another implementation, a non-transitory, tangible, computer-readable storage medium contains a program of instructions that cause a computer system running the program of instructions to detect whether a stereoscope is attached to a first portion of a display of the computer system; display, on the first portion, a stereoscopic view of a virtual environment when the stereoscope is attached to the display; display, on a second portion of the display, a user interface element; receive, from an input device of the computer system, a user input based on the user interface element; modify, based on the user input, the stereoscopic view of the virtual environment; and display, on the first portion, the modified view of the virtual environment.

[0038] These, as well as other components, steps, features, objects, benefits, and advantages, will now become clear from a review of the following detailed description of illustrative embodiments, the accompanying drawings, and the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0039] The drawings are of illustrative embodiments. They do not illustrate all embodiments. Other embodiments may be used in addition or instead. Details that may be apparent or unnecessary may be omitted to save space or for more effective illustration. Some embodiments may be practiced with additional components or steps and/or without all of the components or steps that are illustrated. When the same numeral appears in different drawings, it refers to the same or like components or steps.

[0040] FIG. 1 illustrates the stereoscope attached to the mobile touchscreen tablet designed for a tablet held in portrait orientation according to example aspects of the present disclosure.

[0041] FIG. 2A illustrates the left-side of the unattached stereoscope according to example aspects of the present disclosure.

[0042] FIG. 2B illustrates the top of the unattached stereoscope according to example aspects of the present disclosure.

[0043] FIG. 2C illustrates the bottom of the unattached stereoscope according to example aspects of the present disclosure.

[0044] FIG. 3 illustrates the graphical user interface (GUI) of the tablet according to example aspects of the present disclosure.

[0045] FIG. 4A illustrates a user interacting with the tablet when not looking through the stereoscope according to example aspects of the present disclosure.

[0046] FIG. 4B illustrates the user interacting with the tablet when looking through the stereoscope according to example aspects of the present disclosure.

[0047] FIG. 5A illustrates a stereoscope designed for a tablet held in a landscape orientation according to example aspects of the present disclosure.

[0048] FIG. 5B illustrates the stereoscope of FIG. 5A attached to a tablet according to example aspects of the present disclosure.

[0049] FIG. 5C illustrates a user holding the stereoscope and tablet of FIG. 5B according to example aspects of the present disclosure.

[0050] FIG. 6A illustrates a metal knob connected to clock springs and suction cups according to example aspects of the present disclosure.

[0051] FIG. 6B illustrates the metal knob of FIG. 6A attached to the touchscreen by suction cups according to example aspects of the present disclosure.

[0052] FIG. 7A illustrates a plastic stencil with beveled-cutouts according to example aspects of the present disclosure.

[0053] FIG. 7B illustrates the plastic stencil of FIG. 7A attached to the tablet according to example aspects of the present disclosure.

[0054] FIG. 8A is a 4×4 perspective projection matrix for a viewing frustum according to example aspects of the present disclosure.

[0055] FIG. 8B is a 4×4 perspective projection matrix for another viewing frustum according to example aspects of the present disclosure.

[0056] FIG. 9 illustrates a flowchart of software operations according to example aspects of the present disclosure.

[0057] FIG. 10A illustrates a flowchart of according to example aspects of the present disclosure

[0058] FIG. 10B illustrates a flowchart of according to example aspects of the present disclosure.

[0059] FIG. 11 illustrates a conceptual diagram of a computer system according to example aspects of the present disclosure.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0060] Illustrative embodiments are now described. Other embodiments may be used in addition or instead. Details that may be apparent or unnecessary may be omitted to save space or for a more effective presentation. Some embodiments may

be practiced with additional components or steps and/or without all of the components or steps that are described.

[0061] One implementation of a hybrid stereoscopic display is illustrated in FIG. **1**. It comprises a detachable stereoscope **200**, as illustrated in FIG. **2A**, FIG. **2B**, and FIG. **2C**, as well as a mobile touchscreen tablet **20** which is programmed with the virtual reality (VR) software and graphical user interface (GUI). The stereoscope affixes itself to the front of the tablet with a clip **16** on the right side and a clip **22** on the left side. The top clip **12** keeps the stereoscope centered on top of the stereoscopic view **24** (FIG. **3**). Mounting means besides a clip can also be used such as hook and loop fasteners, threaded fasteners, adhesives, and so forth. The stereoscope **12** may include an opening **104** for exposing, for example, a camera **106** of the tablet **20**, or other feature of the tablet **20**. The stereoscope contains a pair of lenses, a right lens **14** and a left lens **10**. The lenses are typically 34 mm to 61 mm in diameter and are spaced anywhere between 61 mm to 68 mm apart. Their magnification power can be anywhere from 4× to 7×. These lenses can be spherical, aspherical, reflective, fresnel-based, or other magnifying optical approaches including combinations of the above. Lenses made from plastic may be used to reduce weight. The stereoscope itself can be made of a sturdy plastic such as acrylonitrile butadiene styrene (ABS). Thickness of the material may be anywhere between 2 mm to 5 mm, although other thicknesses may be used. The stereoscope may cover from approximately 25%-75% of the display, such as about 50%, or may cover more or less of the screen, although less than 100% to provide screen space for a GUI. The GUI screen may be arranged as a single continuous portion as described, or may be arranged as multiple portions that straddle or surround the stereoscope.

[0062] In one implementation, a user **400** holds the display up to his/her face, as shown in FIG. **4B**, and looks through the lenses **14** and **10** to see the stereoscopic view **24** of a virtual environment (VE). The saddle bridge **18** allows the user's nose to fit underneath the stereoscope. With the corners of the tablet **20** resting firmly in his/her hands, he/she can interact with the lower portion of the touchscreen using his/her thumbs. FIG. **4A** shows that the user may also pull the display away from his/her face in order to interact with the touchscreen using one or more fingers or to view the two-dimensional (2D) view **42** (FIG. **3**) of the VE. Other hand postures may be used as well.

[0063] FIG. **3** also illustrates one implementation of a GUI programmed for the tablet **20**. The user's fingers and/or thumbs may interact with any number of one-dimensional controls such as slider(s) **40** or radial dial(s) **32**; two-dimensional controls such as joystick zone(s) **36**; or button(s) **34** or pop-up menus **30** or with a view of the virtual environment **42** including but not limited to having the user "touch" object(s) **38** inside the VE.

[0064] Another implementation is shown in FIGS. **5A**, **5B**, and **5C**. FIG. **5A** shows the stereoscope unattached from the tablet. In addition to clips **12**, **16**, and **22**, a bottom clip **13** is used to secure the tablet in place. FIG. **5B** shows the tablet **20** attached to the stereoscope. FIG. **5C** shows the user holding the stereoscope (rather than the tablet) by gripping the left handle **15** and the right handle **17**. The lens **10** and **14** will be of a larger diameter and lesser magnification power (ie 60 mm and 4× respectively). An image divider **11** is used to prevent the user's left eye from seeing the right eye view and to prevent his/her right eye from seeing the left eye view.

[0065] FIGS. **6A** and **7A** are attachments that can be added the tablet in order to aid the user in finding touchscreen controls using just touch, specifically when the user's eyes are focused on the stereoscopic view. FIG. **6A** shows a knob **600** which is recognized by the tablet as a finger touch. The knob **600** may be metal or other hard material. The knob is connected to one or more plastic clock springs **602**, which in turn are attached to the touchscreen with suction cups **604**. As the metal knob is pushed with the thumb or finger in one direction, the plastic clock springs push the knob in the opposing direction. Logitech® and Ten One Design LLC have designed such attachments for tablets like the Apple® iPad® (tablet computer). FIG. **6B** shows how they would attach over the touchscreen.

[0066] FIG. **7A** shows a stencil which is a plastic sheet **700** with cutouts **19** and beveled edges **21**, also designed to assist the user in interacting with the touchscreen without requiring the user to look directly at the graphical user interface. The plastic sheet **700** may be made of hard plastic or other suitable hard material. It can be attached to the tablet separate from the stereoscope, as shown in FIG. **7B**, or the stereoscope and stencil can be one whole attachment. Beveled edges **21** provide tactile feedback to fingers that make direct contact with the touchscreen. Non beveled edges or other edge treatments may also be used.

[0067] Several features may be exhibited from example aspects of the present disclosure:

[0068] (a) Virtual reality (VR) software can be written for an abstracted set of tablet hardware since the software developer does not need to consider programming for the myriad of external controllers that is required for interactions within traditional VR environments.

[0069] (b) The stereoscope divides the touchscreen into two separate spaces, keeping the user's finger interactions from interfering with his/her stereoscopic view.

[0070] (c) The stereoscope's saddle bridge accommodates for a great variety of users' nose shapes, allowing each user to bring his/her eyes closer to the lenses, which grants them the maximum field-of-view.

[0071] (d) Users with any size and shape of head, along with any hairstyle, will be able to hold the hybrid display close to their faces, because the device is hand-held it enables users to freely position the device with respect to their face thus accommodating a wide range of user ergonomic preferences and body and facial features including skull geometry.

[0072] (e) The software does not need to interface with external tracking systems, since the software developer can access all tracking data directly from the tablet's built-in sensors.

[0073] (f) The stereoscope is easily and readily detachable, allowing the user to pause his/her VR experience and switch to a different task on the tablet, e.g. browsing the Internet, checking E-mail.

[0074] (g) The software can incorporate seamless transitions between immersive experiences and traditional touchscreen experiences (an example of this would be an e-reader style storybook which includes stereoscopic illustrations).

[0075] (h) Due to the portability of the hybrid display, the user can enjoy VR experiences in any real world setting (indoors and outdoors).

[0076] (i) If the user needs to attend to a task in the real world, he/she simply puts down the hybrid display and pull away from the VR experience.

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[0077] (j) The user can use the 2D view **42** to verbally communicate and share his/her current VR experience with other users nearby.

[0078] (k) Touchscreen controls on **42** share the same coordinate system as the view **24** on the tablet since they are all on the same device (the direction of "UP" on the touchscreen is the same as "UP" inside the view).

[0079] (l) Users are able to keep their sights trained on the immersive experience as they are able to control their experience by touching tablet attachments that provide tactile feedback.

[0080] Software Initialization

[0081] The hybrid display exists when the stereoscope is attached to a tablet which has been programmed with the virtual reality (VR) software. The user starts the VR software as they would any other software application on the tablet. FIG. **9** shows a flowchart **900** of one implementation.

[0082] The software starts by loading a virtual environment (**902**) and by setting up the position and orientation of virtual cameras in a virtual environment (VE) mapped to a three-dimensional cartesian coordinate system (**904**). At a minimum is one pair of stereo virtual cameras, consisting of one camera to render an image for the left-eye view **26** and another camera to render an image for the right-eye view **28**. Computer generated images are generated in real-time, and are updated in the software's update loop (which can refresh at a rate of 30 frames per second, or higher, to minimize the chances of motion sickness for the user). A standard 3D graphics rendering pipeline can be implemented to create the 2D raster representations (for views **26**, **28**, and optionally **42**) of the 3D VE. Each view **26** and **28** measures 42% of the display's width and 31.25% of the display's height.

[0083] The view dimensions defined above were designed to be magnified by 7× magnifying lenses. The 4×4 perspective projection matrix **800** shown in FIG. **8A** is used to setup the off-axis viewing frustum for the left virtual camera. The matrix **850** shown in FIG. **8B** is used to setup the frustum for the right virtual camera. However, the components of each matrix are arbitrary and depend largely on the dimensions of view **26** and **28**, and how each lens **10** and **14** is centered over each corresponding view. The values for the near and far clipping planes of each camera are also arbitrary, but the near clipping plane is usually set to 0.15 units and the far clipping plane is set to 1000 units. VEs typically adopt meters for measuring distance. Finally, the software also prepares to receive data from the tablet's built-in sensors.

[0084] Software Update Loop—Sensors

[0085] After the software has completed the initialization process, it initializes sensors (**906**) and it enters its update loop (**908**), executing rendering code and control code 30 times per second or more. This is where the position and orientation of the virtual cameras are updated (**910**, **924**), based on user input from the graphical user interface and the tablet's built-in sensors.

[0086] Orientation data received from the tablet's gyrometer and magnetometer can be mapped directly to the orientation of the virtual cameras. The software can also be programmed to use the tablet's video camera to recognize fiducial markers using computer vision algorithms. Based on the position or orientation of the marker perceived by the video camera, the virtual cameras can be positioned and oriented accordingly. Position data for the virtual cameras can also be obtained from the tablet's depth sensors. For example, the virtual cameras can be repositioned in virtual space based

on how far the user holding the tablet is standing from a solid wall indoors. Global position data received from a built-in GPS sensor, represented as latitude and longitude pairs, can also be used to reposition virtual cameras or instruct the tablet to switch between different VEs. Other sensors may also be used including but not limited to position, orientation, keyboards, switches, sliders, touch devices, acoustic, eye tracking, user tracking relative to the lenses and display and so forth. Such sensors may not be part of the tablet's available sensors and be incorporated into the system via Bluetooth, USB, or other such data communication mechanisms.

[0087] There are many other ways sensor data can update the position and orientation of the virtual camera, but the main goal is to establish a one-to-one relationship between the user's head orientation and the orientation of the virtual cameras inside the VE. For example, when the user holds the hybrid display device while looking through its stereoscope (FIG. **4B**), the tablet will always be oriented parallel with the user's face. So if the user is standing upright, and begins to bend at his/her hips to lean forward and look down, the orientation of the virtual cameras should also be updated to tilt downwards to present a downward view of the VE to the user's eyes. Similarly, as the user looks up in the real world, he/she looks up in the VE. In technical terms, the yaw, pitch, and roll of the device should be mapped directly to the yaw, pitch, roll of the virtual cameras.

[0088] Rendering

[0089] After the sensor data has been acquired and mapped, the 2D rasterization of the 3D VE takes place and images are drawn to views **26**, **28**, and optionally **42** (**912**). Alternatively, view **42** can display only solid color. Or it can display live video from the tablet's built-in camera(s).

[0090] Next, the graphical user interface (GUI) is drawn on top what was already rendered for view **42** (**914**). Depending on the application of the software, the GUI may consist of any combination of buttons **34**, menus **30**, sliders **40**, dials **32**, and zones **36**. It may also display textual information, 2D images, and pre-recorded video.

[0091] Because view **24** (comprised of **26** & **28**) and **42** can be programmed to display virtually anything, whatever it displays in general can be changed based on a combination of software states. For example, if the entire hybrid display is oriented flat on top of a table surface, view **42** can display a body of text similar to a book also laying flat on a table. Once the hybrid display is lifted off of the table and oriented towards the user's face, the software can switch back to an interactive GUI for view **42** and an immersive view for view **24**.

[0092] Input

[0093] At this stage, user input can be gathered from the touchscreen of the tablet and be used to trigger different events in the software (**916**). Most tablet touchscreens can detect multiple finger-touches, so at a given moment in time, the software must loop through and identify all of the fingers that are touching the screen. For example, for a control to be manipulated, the software must check how many fingers are touching the control (**918**). Some controls may be manipulated with one finger (**920**). Other controls may be manipulated with two fingers (**928**).

[0094] A control can be manipulated in one dimension, such as slider **40** which is similar to a fader on a sound mixing console; or a radial dial **32** which is similar to the volume

control of a car stereo. Alternatively, a control can be a circle-shaped joystick zone **36** on the screen which can be manipulated in two-dimensions.

[0095] Zone **36** can be used to control the virtual cameras position inside the VE (**922**). Its placement in view **42** is important because the control itself must be reachable by the user's thumb(s) when the hybrid viewer is held in the manner indicated by FIG. **4B**. Because this control occupies the same coordinate system as the stereoscopic view **24** it is easy for the user to understand how the position of his/her thumb inside zone **36** relates to the position of the virtual cameras (**924**). For example, when the user moves his/her thumb "up" inside zone **36** (in the direction towards the top of the tablet) this can be programmed to move the virtual cameras vertically upwards inside the VE. Alternatively, the controller can be programmed to move the virtual cameras forward in the direction the user is facing when the thumb moves up inside zone **36**.

[0096] Other controls, such as single-touch buttons **34**, can be used to change modes of interaction, such as changing the appearance of text, images, videos; or flipping pages of a book; or playing, pausing, or seeking through video; or advancing through a slide show; or toggling sounds or music; or activating and toggling menus. These buttons do not have to be visible and can take the appearance of text hyperlinks on a document or web page.

[0097] Any kind of control can be used to change the VE or make changes inside the VE, such as switching environments, creating or activating effects, or changing the volume of audio. They can also activate static text and images that helpfully explain the function of each control. The location and appearance of touchscreen controls are arbitrary and can change or transform at any time to suit the needs of the user and their immersive experience.

[0098] If multiple fingers are touching the screen, the software can interpret it as a grasping gesture to manipulate an interact-able object **38** (**928**). The software can then recognize when the fingers move up, down, or side-to-side; in order to correspondingly move object **38** up, down, and side-to-side in the VE (**930**). The touchscreen then gives the user the feeling of being able to reach into the VE to interact with objects within it. If the update loop exits (**926**), the process may terminate (**932**).

[0099] Thus the reader will see that the hybrid stereoscopic display combines two modes of operation in a single device. When held up to the face, the user has an immersive virtual reality (VR) viewer in which they can view and interact with stereoscopic imagery and virtual worlds; when lowered to a desktop or lap, the user has a touchscreen interface that can be used to view and interact with 2D content. This is a new kind of media platform supporting both multi-touch screen-based interactions, and fully immersive VR, combining both modes into a single hybrid device. With this new platform we are creating a new class of media experiences that will make a huge impact in education and entertainment.

[0100] The list of possible experiences are endless. A few examples of these applications are:

[0101] Imagine reading a story about a magical forest and then being able to peer into the viewer to find yourself surrounded by those very same enchanted woods. Picture reading a story about a wizard then glancing through your viewer to discover the sage standing in your room.

[0102] A real estate app, with a navigable map of the house location and a floor plan displayed on the lower portion of the screen, along with immersive 360 degree 3D panoramas of the exterior, and of the interior rooms of the house.

[0103] A math textbook, with examples and problems presented on the lower part of the screen, along with 3D views of geometric figures and formulas on the upper part.

[0104] A history of the Civil War, with interactive maps and historical documents displayed on the lower part of the screen, along with historic 3D photographs on the upper part.

[0105] An interactive strategy game combined with a first-person shooter VR experience.

[0106] A molecular modeling app, with data and controls on the lower part of the screen and stereoscopic views of molecular models on the upper part.

[0107] An online catalog of real merchandise or digital content in the lower part of the screen coupled with a stereoscopic preview of the merchandise or digital content in the upper part.

[0108] A "fish tank"-style VR experience which gives the user a perspective-correct view of a virtual environment in the lower part based on the user's body relative to the surface of the screen, as detected by the tablet's front facing camera or other sensors.

[0109] Although the description above contains many specificities, these should not be construed as limiting the scope of the disclosure but as merely providing illustrations of some implementations. For example:

[0110] The stereoscope can attach to the tablet with elastic straps that go around the back of the tablet.

[0111] The stereoscope can be built into a carrying case which typically protects the surface of the tablet.

[0112] The stereoscope can be made of a flexible material allowing it to collapse into a compact form, and stretching out to normal operating dimensions.

[0113] The front surface of the stereoscope containing the lenses does not need to be flat, but can be curved or molded around the natural curvature of the human face.

[0114] The lenses can have other shapes, such as oval, rectangular, triangular, cylindrical, etc.

[0115] The saddle bridge can be cushioned with soft padding to create more comfort for the user's nose.

[0116] The stereoscope can have built-in flaps that cover the lenses to protect against scratches.

[0117] The stereoscope can contain hinging mechanisms to allow it to swing onto and away from the surface of the tablet like a screen door.

[0118] The stereoscope can be painted in any color.

[0119] The layout of the GUI is completely arbitrary and depends on the purpose of the VR application.

[0120] The layout of cutouts with beveled grooves in the stencil is completely arbitrary and depends on the layout of the GUI beneath it.

[0121] FIG. **10A** presents a flowchart **1000** of a process according to one implementation. At **1002**, whether a stereoscope is attached is detected, as in FIG. **1** or **5C**. At **1004**, a view **24** of the virtual environment is displayed on a first portion **102** of the display **106**. At **1006**, a user interface element (**32, 34, 40**) is displayed on a second portion **104** of the display **106**. At **1008**, a user input based on the user interface element is received, as in FIG. **4A**. At **1010**, the view

of the virtual environment is modified based on the user input. At **1012**, the modified view of the virtual environment is displayed on the first portion of the display.

[0122] FIG. **10B** presents a flowchart **1050** of a process according to one implementation. At **1052** the stereoscope **200** is moved near the user's **400** eyes such that the second portion **104** is not visible to the user, as in FIG. **4B**. At **1054**, the view **24** of the virtual environment is viewed on the first portion **102** of the display **106** through the stereoscope. At **1056** the stereoscope is moved away from the user's eyes such that the second portion is visible to the user. At **1058** the user may interface with the second portion of the display to manipulate the view of the virtual environment when the second portion is visible to the user. At **1060** the manipulated view of the virtual environment is viewed through the stereoscope when the stereoscope is near the user's eyes.

[0123] FIG. **11** conceptually illustrates an example computer system or electronic system with which some implementations of the subject technology can be implemented. Electronic system **500** can be a computer, phone, PDA, tablet or any other sort of electronic device. The electronic system **500** may be integrated with a head mounted display or head-coupled display, may be partially integrated with the head mounted display, or may be external to and in communication with the head mounted display. Such an electronic system includes various types of computer readable media and interfaces for various other types of computer readable media. Electronic system **500** includes a bus **510**, processing unit(s) **560**, a system memory **530**, a read-only memory (ROM) **550**, a permanent storage device **520**, an input device interface **570**, an output device interface **540**, a display **580**, and a sensor **590**.

[0124] The bus **510** collectively represents all system, peripheral, and chipset buses that communicatively connect the numerous internal devices of electronic system **500**. For instance, the bus **510** communicatively connects the processing unit(s) **560** with the ROM **550**, system memory **530**, and permanent storage device **520**. Portions of the bus **510** may be wireless.

[0125] From these various memory units, the processing unit(s) **560** retrieves instructions to execute and data to process in order to execute the processes of the present disclosure. The processing unit(s) **560** can be a single processor or a multi-core processor in different implementations.

[0126] The ROM **550** stores static data and instructions that are needed by the processing unit(s) **560** and other modules of the electronic system. The permanent storage device **520**, on the other hand, is a read-and-write memory device. This device is a non-volatile memory unit that stores instructions and data even when electronic system **500** is off. Some implementations of the subject disclosure use a mass-storage device (for example, a magnetic or optical disk and its corresponding disk drive) as the permanent storage device **520**.

[0127] Other implementations use a removable storage device (for example, a floppy disk, flash drive, and its corresponding disk drive) as the permanent storage device **520**. Like the permanent storage device **520**, the system memory **530** is a read-and-write memory device. However, unlike the storage device **520**, the system memory **530** is a volatile read-and-write memory, such as a random access memory. The system memory **530** stores some of the instructions and data that the processing unit(s) **560** needs at runtime. In some implementations, the processes of the present disclosure are stored in the system memory **530**, the permanent storage

device **520**, or the ROM **550**. For example, the various memory units include instructions for receiving user activity data and updating dimensions in accordance with some implementations. From these various memory units, the processing unit(s) **560** retrieves instructions to execute and data to process in order to execute the processes of some implementations.

[0128] The bus **510** also connects to input device interface **570** and output device interface **540**. The input device interface **570** enables the user to communicate information and select commands to the electronic system. Input devices used with input device interface **570** include, for example, alphanumeric keyboards and pointing devices (also called "cursor control devices"). The sensor **590**, which may correspond to the sensor **115**, may be one or more sensors configured to detect a user state, such as physiological and other parameters as described above, and may be further configured as trackers for a head mounted display. The output device interface **540** enables, for example, the display of images generated by the electronic system **500**. Output devices used with the output device interface **540** include, for example, printers and display devices, for example, cathode ray tubes (CRT) or liquid crystal displays (LCD), which may be used as a display for the head mounted display. Some implementations include devices, for example, a touchscreen that functions as both input and output devices.

[0129] Finally, the bus **510** also couples the electronic system **500** to a wired or wireless network (not shown). In this manner, the computer can be a part of a network of computers (for example, a local area network (LAN), a wide area network (WAN), or an Intranet, or a network of networks, for example, the Internet. Any or all components of electronic system **500** can be used in conjunction with the present disclosure.

[0130] Unless otherwise indicated, the devices and processes that have been discussed herein are implemented with a computer system configured to perform the functions that have been described herein for the component. Each computer system includes one or more processors, tangible memories (e.g., random access memories (RAMs), read-only memories (ROMs), and/or programmable read only memories (PROMS)), tangible storage devices (e.g., hard disk drives, CD/DVD drives, and/or flash memories), system buses, video processing components, network communication components, input/output ports, and/or user interface devices (e.g., keyboards, pointing devices, displays, microphones, sound reproduction systems, and/or touch screens).

[0131] Each computer system may include software (e.g., one or more operating systems, device drivers, application programs, and/or communication programs). When software is included, the software includes programming instructions and may include associated data and libraries. When included, the programming instructions are configured to implement one or more algorithms that implement one or more of the functions of the computer system, as recited herein. The description of each function that is performed by each computer system also constitutes a description of the algorithm(s) that performs that function.

[0132] The software may be stored on or in one or more non-transitory, tangible storage devices, such as one or more hard disk drives, CDs, DVDs, and/or flash memories. The software may be in source code and/or object code format. Associated data may be stored in any type of volatile and/or

non-volatile memory. The software may be loaded into a non-transitory memory and executed by one or more processors.

[0133] The components, steps, features, objects, benefits, and advantages that have been discussed are merely illustrative. None of them, nor the discussions relating to them, are intended to limit the scope of protection in any way. Numerous other embodiments are also contemplated. These include embodiments that have fewer, additional, and/or different components, steps, features, objects, benefits, and advantages. These also include embodiments in which the components and/or steps are arranged and/or ordered differently.

[0134] Unless otherwise stated, all measurements, values, ratings, positions, magnitudes, sizes, and other specifications that are set forth in this specification, including in the claims that follow, are approximate, not exact. They are intended to have a reasonable range that is consistent with the functions to which they relate and with what is customary in the art to which they pertain.

[0135] All articles, patents, patent applications, and other publications that have been cited in this disclosure are incorporated herein by reference.

[0136] The scope of protection is limited solely by the claims that now follow. That scope is intended and should be interpreted to be as broad as is consistent with the ordinary meaning of the language that is used in the claims when interpreted in light of this specification and the prosecution history that follows, except where specific meanings have been set forth, and to encompass all structural and functional equivalents.

[0137] Relational terms such as "first" and "second" and the like may be used solely to distinguish one entity or action from another, without necessarily requiring or implying any actual relationship or order between them. The terms "comprises," "comprising," and any other variation thereof when used in connection with a list of elements in the specification or claims are intended to indicate that the list is not exclusive and that other elements may be included. Similarly, an element preceded by an "a" or an "an" does not, without further constraints, preclude the existence of additional elements of the identical type.

[0138] None of the claims are intended to embrace subject matter that fails to satisfy the requirement of Sections 101, 102, or 103 of the Patent Act, nor should they be interpreted in such a way. Any unintended coverage of such subject matter is hereby disclaimed. Except as just stated in this paragraph, nothing that has been stated or illustrated is intended or should be interpreted to cause a dedication of any component, step, feature, object, benefit, advantage, or equivalent to the public, regardless of whether it is or is not recited in the claims.

[0139] The abstract is provided to help the reader quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, various features in the foregoing detailed description are grouped together in various implementations to streamline the disclosure. This method of disclosure should not be interpreted as requiring claimed implementations to require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed implementation. Thus, the following claims are hereby incorporated into the detailed description, with each claim standing on its own as separately claimed subject matter.

The invention claimed is:

1. A method of interacting with a virtual environment using a stereoscope removably attached to a computing device having a display integrated with an input device, the display having a first portion and a second portion, the stereoscope covering the first portion and positioned to allow stereoscopic viewing of a view of the virtual environment, the method comprising:

displaying, on the first portion, a rendering of the virtual environment;

displaying, on the second portion, a user interface element;

receiving, from the input device, a user input based on the user interface element;

modifying, based on the user input, the virtual environment or the view of the virtual environment; and

displaying, on the first portion, a modified rendering of the virtual environment.

2. The method of claim 1, further comprising:

displaying, on the second portion, a 2D rendering of the virtual environment.

3. The method of claim 2, wherein displaying the user interface element further comprises overlaying the user interface element over the 2D rendering of the virtual environment.

4. The method of claim 2, wherein the 2D rendering includes a virtual object in the virtual environment.

5. The method of claim 1, further comprising:

producing a sound, from a speaker of the computing device, based on the modified rendering of the virtual environment.

6. The method of claim 1, further comprising:

modifying, based on the modified rendering of the virtual environment, the user interface element; and

displaying, on the second portion, the modified user interface element.

7. The method of claim 1, further comprising:

receiving, from a sensor of the computing device, a sensor data; and

modifying, based on the sensor data, the rendering of the virtual environment.

8. The method of claim 1, further comprising:

receiving, from an accelerometer of the computing device, a GPS sensor of the computing device, or a gyrometer of the computing device, an acceleration data, a geospatial data, or an orientation data; and

modifying, based on the acceleration data, the geospatial data, or the orientation data, the rendering of the virtual environment.

9. The method of claim 1, further comprising:

receiving, from a camera of the computing device, a video data; and

displaying, on the first portion, the video data and the rendering of the virtual environment.

10. The method of claim 1, further comprising:

receiving, from a microphone of the computing device, a sound data;

modifying, based on the sound data, the rendering of the virtual environment.

11. The method of claim 1, wherein the second portion comprises at least 50% of a viewable area of the display.

12. A method of interacting with a virtual environment using a stereoscope removably attached to a computing device having a display integrated with an input device, the display having a first portion and a second portion, the stereoscope covering the first portion and positioned to allow stereoscopic viewing of a view of the virtual environment, the method comprising:

  moving the stereoscope near a user's eyes such that the second portion is not visible to the user;

  viewing, through the stereoscope, a view of the virtual environment on the first portion;

  moving the stereoscope away from the user's eyes such that the second portion is visible to the user;

  interfacing with the second portion to manipulate the view of the virtual environment when the second portion is visible to the user; and

  viewing, through the stereoscope, a manipulated view of the virtual environment when the stereoscope is near the user's eyes.

13. The method of claim **12**, wherein the view of the virtual environment includes a virtual object.

14. The method of claim **13**, further comprising:

  interfacing with the second portion to manipulate the virtual object; and

  viewing, through the stereoscope, the manipulated virtual object.

15. The method of claim **14**, wherein interfacing with the second portion to manipulate the virtual object includes viewing, through the stereoscope, a user interface element on the first portion.

16. The method of claim **12**, further comprising:

  viewing, on the display, a 2D view of the virtual environment;

  interacting with the computing device to modify the 2D view of the virtual environment; and

viewing, on the display, a modified 2D view of the virtual environment.

17. The method of claim **12**, further comprising:

  interfacing with the second portion to manipulate the view of the virtual environment when the stereoscope near the user's eyes.

18. The method of claim **12**, wherein the first portion displays the view of the virtual environment on the first portion based on whether the stereoscope is attached to the computing device.

19. A non-transitory, tangible, computer-readable storage medium containing a program of instructions that cause a computer system running the program of instructions to:

  detect whether a stereoscope is attached to a first portion of a display of the computer system;

  display, on the first portion, a stereoscopic view of a virtual environment when the stereoscope is attached to the display;

  display, on a second portion of the display, a user interface element;

  receive, from an input device of the computer system, a user input based on the user interface element;

  modify, based on the user input, the stereoscopic view of the virtual environment; and

  display, on the first portion, the modified view of the virtual environment.

20. The non-transitory, tangible, computer-readable storage medium of claim **19**, wherein the program of instructions further causes the computer system to:

  detect when the stereoscope is moved away from a user's head; and

  display, on the second portion, a 2D view of the virtual environment when the stereoscope is moved away from the user's head.

* * * * *