

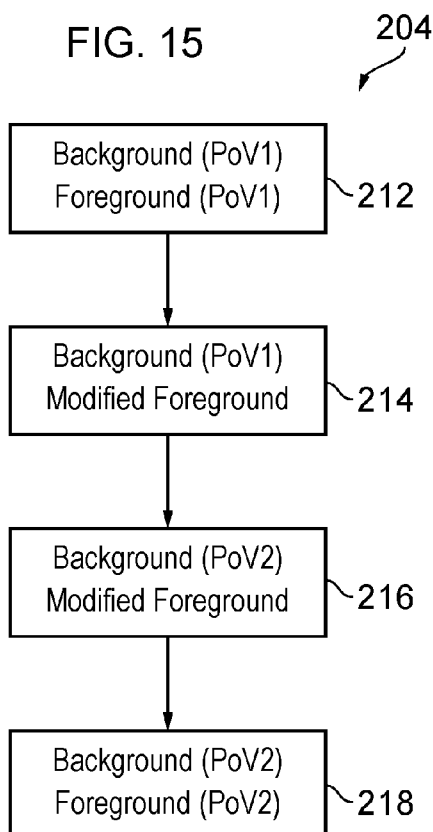


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(54) Title: MEDIATED REALITY

FIG. 15



(57) Abstract: A method comprising: displaying a background of a scene from a first point of view and a foreground of the scene from the first point of view; displaying a background of the scene from the first point of view and a modified foreground of the scene from the first point of view; displaying a background of a scene from a second point of view and a modified foreground; and displaying a background of a scene from the second point of view and a foreground of the scene from the second point of view.



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TITLE

Mediated reality

TECHNOLOGICAL FIELD

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Embodiments of the present invention relate to mediated reality for example augmented reality or virtual reality.

BACKGROUND

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Mediated reality in this document refers to a user experiencing a fully or partially artificial environment.

Augmented reality is a form of mediated reality in which a user experiences a partially artificial, partially real environment. Virtual reality is a form of mediated reality in which

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a user experiences a fully artificial environment.

BRIEF SUMMARY

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According to various, but not necessarily all, embodiments of the invention there is provided a method comprising: displaying a background of a scene from a first point of view and a foreground of the scene from the first point of view; displaying a background of the scene from the first point of view and a modified foreground; displaying a background of a scene from a second point of view and a modified foreground; and displaying a background of a scene from the second point of view

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and a foreground of the scene from the second point of view.

According to various, but not necessarily all, embodiments of the invention there is provided examples as claimed in the appended claims.

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BRIEF DESCRIPTION

For a better understanding of various examples that are useful for understanding the brief description, reference will now be made by way of example only to the accompanying drawings in which:

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Figs 1A-1C and 2A-2C illustrate examples of mediated reality in which Figs 1A, 1B, 1C illustrate the same virtual space and different points of view and Figs 2A, 2B, 2C illustrate a virtual scene from the perspective of the respective points of view;

5 Fig 3A illustrates an example of a real space and Fig 3B illustrates an example of a real scene that partially corresponds with the virtual scene of Fig 2A;

Fig 4 illustrates an example of an apparatus that is operable to enable mediated reality and/or augmented reality and/or virtual reality;

Fig 5A illustrates an example of a method for enabling mediated reality and/or augmented reality and/or virtual reality;

10 Fig 5B illustrates an example of a method for updating a model of the virtual space for augmented reality;

Figs 6A and 6B illustrate examples of apparatus that enable display of at least parts of the virtual scene to a user;

15 Fig 7 illustrates an example of a gesture in a real space and Fig 8 illustrates a corresponding representation of the gesture rendered in the virtual scene;

Figs 9A and 9B illustrate a simplified example of a virtual space at times t1 and t2, with a fixed point of view;

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Figs 10A and 10B illustrate the simplified example of the virtual space at times t1 and t2, with a variable point of view;

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Figs 11A, 11B, 11C, 11D illustrate the simplified example of the virtual space between times t1 and t2, with a variable point of view and modification of foreground;

Figs 12A, 12B, 12C, 12D illustrate virtual scenes corresponding to the points of view and scene content of Figs 11A, 11B, 11C, 11D;

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Figs 13A, 13B, 13C, 13D illustrate the simplified example of the virtual space at points in time between times t1 and t2, with a variable point of view and modification of foreground;

Figs 14A, 14B, 14C, 14D illustrate virtual scenes corresponding to the points of view and scene content of Figs 13A, 13B, 13C, 13D.

Fig 15 illustrates an example of a method.

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DEFINITIONS

“virtual space” refers to fully or partially artificial environment, which may be three dimensional.

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“virtual scene” refers to a representation of the virtual space viewed from a particular point of view within the virtual space.

“real space” refers to a real environment, which may be three dimensional.

“real scene” refers to a representation of the real space viewed from a particular point of view within the real space.

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“mediated reality” in this document refers to a user visually experiencing a fully or partially artificial environment (a virtual space) as a virtual scene at least partially displayed by a computer to a user. The virtual scene is determined by a point of view within the virtual space and a field of view. Displaying the virtual scene means providing it in a form that can be seen by the user.

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“augmented reality” in this document refers to a form of mediated reality in which a user visually experiences a partially artificial environment (a virtual space) as a virtual scene comprising a real scene of a physical real world environment (real space) supplemented by one or more visual elements displayed by an apparatus to a user;

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“virtual reality” in this document refers to a form of mediated reality in which a user visually experiences a fully artificial environment (a virtual space) as a virtual scene displayed by an apparatus to a user;

“perspective-mediated” as applied to mediated reality, augmented reality or virtual reality means that user actions determine the point of view within the virtual space, changing the virtual scene;

“first person perspective-mediated” as applied to mediated reality, augmented reality or virtual reality means perspective mediated with the additional constraint that the user’s real point of view determines the point of view within the virtual space;

5 “user interactive-mediated” as applied to mediated reality, augmented reality or virtual reality means that user actions at least partially determine what happens within the virtual space;

“displaying” means providing in a form that is perceived visually by the user .

DESCRIPTION

10 Figs 1A-1C and 2A-2C illustrate examples of mediated reality. The mediated reality may be augmented reality or virtual reality.

Figs 1A, 1B, 1C illustrate the same virtual space 20 comprising the same virtual objects 21, however, each Fig illustrates a different point of view 24. The position and direction of a point of view 24 can change independently. The direction but not the position of the point of view changes from Fig 1A to Fig 1B. The direction and the position of the point of view 24 changes from Fig 1B to Fig 1C.

Figs 2A, 2B, 2C illustrate a virtual scene 22 from the perspective of the different points of view 24 of respective Figs 1A, 1B, 1C. The virtual scene 22 is determined by the point of view 24 within the virtual space 20 and a field of view 26. The virtual scene 22 is at least partially displayed to a user.

20 The virtual scenes 22 illustrated may be mediated reality scenes, virtual reality scenes or augmented reality scenes. A virtual reality scene displays a fully artificial virtual space 20. An augmented reality scene displays a partially artificial, partially real virtual space 20.

25 The mediated reality, augmented reality or virtual reality may be user interactive-mediated. In this case, user actions at least partially determine what happens within the virtual space 20. This may enable interaction with a virtual object 21 such as a visual element 28 within the virtual space 20.

30 The mediated reality, augmented reality or virtual reality may be perspective-mediated. In this case, user actions determine the point of view 24 within the virtual space 20, changing the virtual scene 22. For example, as illustrated in Figs 1A, 1B, 1C a position

23 of the point of view 24 within the virtual space 20 may be changed and/or a direction or orientation 25 of the point of view 24 within the virtual space 20 may be changed. If the virtual space 20 is three-dimensional, the position 23 of the point of view 24 has three degrees of freedom e.g. up/down, forward/back, left/right and the direction 25 of the point of view 24 within the virtual space 20 has three degrees of freedom e.g. roll, pitch, yaw. The point of view 24 may be continuously variable in position 23 and/or direction 25 and user action then changes the position 23 and/or direction 25 of the point of view 24 continuously. Alternatively, the point of view 24 may have discrete quantised positions 23 and/or discrete quantised directions 25 and user action switches by discretely jumping between the allowed positions 23 and/or directions 25 of the point of view 24.

Fig 3A illustrates a real space 10 comprising real objects 11 that partially corresponds with the virtual space 20 of Fig 1A. In this example, each real object 11 in the real space 10 has a corresponding virtual object 21 in the virtual space 20, however, each virtual object 21 in the virtual space 20 does not have a corresponding real object 11 in the real space 10. In this example, one of the virtual objects 21, the computer-generated visual element 28, is an artificial virtual object 21 that does not have a corresponding real object 11 in the real space 10.

A linear mapping exists between the real space 10 and the virtual space 20 and the same mapping exists between each real object 11 in the real space 10 and its corresponding virtual object 21. The relative relationship of the real objects 11 in the real space 10 is therefore the same as the relative relationship between the corresponding virtual objects 21 in the virtual space 20.

Fig 3B illustrates a real scene 12 that partially corresponds with the virtual scene 22 of Fig 2A, it includes real objects 11 but not artificial virtual objects. The real scene 12 is from a perspective corresponding to the point of view 24 in the virtual space 20 of Fig 1A. The real scene 12 content is determined by that corresponding point of view 24 and the field of view 26.

Fig 2A may be an illustration of an augmented reality version of the real scene 10 illustrated in Fig 3B. The virtual scene 22 comprises the real scene 12 of the real space 10 supplemented by one or more visual elements 28 displayed by an apparatus to a user. The visual elements 28 may be a computer-generated visual element. In a see-through arrangement, the virtual scene 22 comprises the actual real scene 12 which

is seen through a display of the supplemental visual element(s) 28. In a see-video arrangement, the virtual scene 22 comprises a displayed real scene 12 and displayed supplemental visual element(s) 28. The displayed real scene 12 may be based on an image from a single point of view or on multiple images from different points of view at the same time, processed to generate an image from a single point of view.

Fig 4 illustrates an example of an apparatus 30 that is operable to enable mediated reality and/or augmented reality and/or virtual reality.

The apparatus 30 comprises a display 32 for providing at least parts of the virtual scene 22 to a user in a form that is perceived visually by the user. The display 32 may be a visual display that provides light that displays at least parts of the virtual scene 22 to a user. Examples of visual displays include liquid crystal displays, organic light emitting displays, emissive, reflective and transfective displays, direct retina projection display, near eye displays etc.

The display 32 is controlled in this example but not necessarily all examples by a controller 42

Implementation of a controller 42 may be as controller circuitry. The controller 42 may be implemented in hardware alone, have certain aspects in software including firmware alone or can be a combination of hardware and software (including firmware).

As illustrated in Fig 4 the controller 42 may be implemented using instructions that enable hardware functionality, for example, by using executable computer program instructions 48 in a general-purpose or special-purpose processor 40 that may be stored on a computer readable storage medium (disk, memory etc) to be executed by such a processor 40.

The processor 40 is configured to read from and write to the memory 46. The processor 40 may also comprise an output interface via which data and/or commands are output by the processor 40 and an input interface via which data and/or commands are input to the processor 40.

The memory 46 stores a computer program 48 comprising computer program instructions (computer program code) that controls the operation of the apparatus 30 when loaded into the processor 40. The computer program instructions, of the

computer program 48, provide the logic and routines that enables the apparatus to perform the methods illustrated in Figs 5A & 5B. The processor 40 by reading the memory 46 is able to load and execute the computer program 48.

- 5 The computer program 48 may arrive at the apparatus 30 via any suitable delivery mechanism. The delivery mechanism may be, for example, a non-transitory computer-readable storage medium, a computer program product, a memory device, a record medium such as a compact disc read-only memory (CD-ROM) or digital versatile disc (DVD), an article of manufacture that tangibly embodies the computer program 48. The
- 10 delivery mechanism may be a signal, such as a modulated electromagnetic wave or digitally encoded electrical signal., configured to reliably transfer the computer program 48. The apparatus 30 may propagate or transmit the computer program 48 as a computer data signal.
- 15 Although the memory 46 is illustrated as a single component/circuitry it may be implemented as one or more separate components/circuitry some or all of which may be integrated/removable and/or may provide permanent/semi-permanent/dynamic/cached storage.
- 20 Although the processor 40 is illustrated as a single component/circuitry it may be implemented as one or more separate components/circuitry some or all of which may be integrated/removable. The processor 40 may be a single core or multi-core processor.
- 25 References to 'computer-readable storage medium', 'computer program product', 'tangibly embodied computer program' etc. or a 'controller', 'computer', 'processor' etc. should be understood to encompass not only computers having different architectures such as single /multi- processor architectures and sequential (Von Neumann)/parallel architectures but also specialized circuits such as field-programmable gate arrays
- 30 (FPGA), application specific circuits (ASIC), signal processing devices and other processing circuitry. References to computer program, instructions, code etc. should be understood to encompass software for a programmable processor or firmware such as, for example, the programmable content of a hardware device whether instructions for a processor, or configuration settings for a fixed-function device, gate array or
- 35 programmable logic device etc.

As used in this application, the term 'circuitry' refers to all of the following:

(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and

5 (b) to combinations of circuits and software (and/or firmware), such as (as applicable):

(i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

10 (c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

This definition of 'circuitry' applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry"

15 would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or
20 other network device.

The blocks illustrated in the Figs 5A & 5B may represent steps in a method and/or sections of code in the computer program 48. The illustration of a particular order to the blocks does not necessarily imply that there is a required or preferred order for the
25 blocks and the order and arrangement of the block may be varied. Furthermore, it may be possible for some blocks to be omitted.

The apparatus 30 may enable mediated reality and/or augmented reality and/or virtual reality, for example using the process illustrated in Fig 5A or a similar process. The
30 controller 42 stores and maintains a model 50 of the virtual space 20. The model may be provided to the controller 42 or determined by the controller 42. For example, sensors in input circuitry 44 may be used to create overlapping depth maps of the virtual space 20 from different points of view and a three dimensional model may then be produced.

At block 62 it is determined whether or not the model of the virtual space 20 has changed. If the model of the virtual space 20 has changed the method moves to block 66. If the model of the virtual space 20 has not changed the method moves to block 64.

- 5 At block 64 it is determined whether or not the point of view 24 in the virtual space 20 has changed. If the point of view 24 has changed the method moves to block 66. If the point of view 24 has not changed the method returns to block 62.

At block 66, a two-dimensional projection of the three-dimensional virtual space 20 is taken from the location 23 and in the direction 25 defined by the current point of view
10 24. The projection is then limited by the field of view 26 to produce the virtual scene 22. The method then returns to block 62.

Where the apparatus 30 enables augmented reality, the virtual space 20 comprises objects 11 from the real space 10 and also visual elements 28 not present in the real space 10. The combination of such visual elements 28 may be referred to as the
15 artificial virtual space. Fig 5B illustrates a method 70 for updating a model of the virtual space 20 for augmented reality.

At block 72 it is determined whether or not the real space 10 has changed. If the real space 10 has changed the method moves to block 76. If the real space 10 has not changed the method moves to block 74. Detecting a change in the real space 10 may
20 be achieved at a pixel level using differentiating and may be achieved at an object level using computer vision to track objects as they move.

At block 74 it is determined whether or not the artificial virtual space has changed. If the artificial virtual space has changed the method moves to block 76. If the artificial virtual space has not changed the method returns to block 72. As the artificial virtual
25 space is generated by the controller 42 changes to the visual elements 28 are easily detected.

At block 76, the model of the virtual space 20 is updated.

The apparatus 30 may enable user-interactive mediation for mediated reality and/or augmented reality and/or virtual reality. The user input circuitry 44 detects user actions
30 using user input 43. These user actions are used by the controller 42 to determine what happens within the virtual space 20. This may enable interaction with a visual element 28 within the virtual space 20.

The apparatus 30 may enable perspective mediation for mediated reality and/or augmented reality and/or virtual reality. The user input circuitry 44 detects user actions. These user actions are used by the controller 42 to determine the point of view 24 within the virtual space 20, changing the virtual scene 22. The point of view 24 may be continuously variable in position 23 and/or direction 25 and user action changes the position 23 and/or direction 25 of the point of view 24. Alternatively, the point of view 24 may have discrete quantised positions 23 and/or discrete quantised directions 25 and user action switches by jumping to the next position and/or direction of the point of view 24.

The apparatus 30 may enable first person perspective for mediated reality, augmented reality or virtual reality. The user input circuitry 44 detects the user's real point of view 14 using user point of view sensor 45. The user's real point of view 14 is used by the controller 42 to determine the point of view 24 within the virtual space 20, changing the virtual scene 22. Referring back to Fig 3A, a user 18 has a real point of view 14. The real point of view may be changed by the user 18. For example, a real location 13 of the real point of view 14 is the location of the user 18 and can be changed by changing the physical location 13 of the user 18. For example, a real direction 15 of the real point of view 14 is the direction in which the user 18 is looking and can be changed by changing the real direction of the user 18. The real direction 15 may, for example, be changed by a user 18 changing an orientation of their head or view point and/or a user changing a direction of their gaze. A head-mounted apparatus 30 may be used to enable first-person perspective mediation.

The apparatus 30 may comprise as part of the input circuitry 44 point of view sensors 45 for determining changes in the real point of view 14.

For example, positioning technology such as GPS, triangulation (trilateration) by transmitting to multiple receivers and/or receiving from multiple transmitters, acceleration detection and integration may be used to determine a new physical location 13 of the user 18 and real point of view 14.

For example, accelerometers, electronic gyroscopes or electronic compasses may be used to determine a change in an orientation of a user's head or view point and a consequential change in the real direction 15 of the real point of view 14.

For example, pupil tracking technology, based for example on computer vision, may be used to track movement of a user's eye or eyes and therefore determine a direction

of a user's gaze and consequential changes in the real direction 15 of the real point of view 14.

The apparatus 30 may comprise as part of the input circuitry 44 image sensors 47 for imaging the real space 10.

- 5 An example of an image sensor 47 is a digital image sensor that is configured to operate as a camera. Such a camera may be operated to record static images and/or video images. In some, but not necessarily all embodiments, cameras may be configured in a stereoscopic or other spatially distributed arrangement so that the real space 10 is viewed from different perspectives. This may enable the creation of a three-dimensional image and/or processing to establish depth, for example, via the parallax effect.

- 15 In some, but not necessarily all embodiments, the input circuitry 44 comprises depth sensors 49. A depth sensor 49 may comprise a transmitter and a receiver. The transmitter transmits a signal (for example, a signal a human cannot sense such as ultrasound or infrared light) and the receiver receives the reflected signal. Using a single transmitter and a single receiver some depth information may be achieved via measuring the time of flight from transmission to reception. Better resolution may be achieved by using more transmitters and/or more receivers (spatial diversity). In one example, the transmitter is configured to 'paint' the real space 10 with light, preferably invisible light such as infrared light, with a spatially dependent pattern. Detection of a certain pattern by the receiver allows the real space 10 to be spatially resolved. The distance to the spatially resolved portion of the real space 10 may be determined by time of flight and/or stereoscopy (if the receiver is in a stereoscopic position relative to the transmitter).

- 25 In some but not necessarily all embodiments, the input circuitry 44 may comprise communication circuitry 41 in addition to or as an alternative to one or more of the image sensors 47 and the depth sensors 49. Such communication circuitry 41 may communicate with one or more remote image sensors 47 in the real space 10 and/or with remote depth sensors 49 in the real space 10.

- 30 Figs 6A and 6B illustrate examples of apparatus 30 that enable display of at least parts of the virtual scene 22 to a user. Other examples of apparatus 30 that enable display of at least parts of the virtual scene 22 to a user may be used.

Fig 6A illustrates a handheld apparatus 31 comprising a display screen as display 32 that displays images to a user and is used for displaying the virtual scene 22 to the user. The apparatus 30 may be moved deliberately in the hands of a user in one or more of the previously mentioned six degrees of freedom.

- 5 The handheld apparatus 31 may be or may be operated as a see-video arrangement for augmented reality that enables a live or recorded video of a real scene 12 to be displayed on the display 32 for viewing by the user while one or more visual elements 28 are simultaneously displayed on the display 32 for viewing by the user. The combination of the displayed real scene 12 and displayed one or more visual elements
10 28 provides the virtual scene 22 to the user.

If the handheld apparatus 30 has a camera mounted on a face opposite the display 32, it may be operated as a see-video arrangement that enables a live real scene 12 to be viewed while one or more visual elements 28 are displayed to the user to provide in combination the virtual scene 22.

- 15 Fig 6B illustrates a head-mounted apparatus 33 comprising a display 32 that displays images to a user. The apparatus 33 may be moved automatically when a head of the user moves.

- The head-mounted apparatus 33 may be a see-through arrangement for augmented reality that enables a live real scene 12 to be viewed while one or more visual elements
20 28 are displayed by the display 32 to the user to provide in combination the virtual scene 22. In this case a visor 34, if present, is transparent or semi-transparent so that the live real scene 12 can be viewed through the visor 34.

- The head-mounted apparatus 33 may be operated as a see-video arrangement for augmented reality that enables a live or recorded video of a real scene 12 to be
25 displayed by the display 32 for viewing by the user while one or more visual elements 28 are simultaneously displayed by the display 32 for viewing by the user. The combination of the displayed real scene 12 and displayed one or more visual elements 28 provides the virtual scene 22 to the user. In this case a visor 34 is opaque and may be used as display 32.

- 30 Referring back to Fig 4, an apparatus 30 may enable user-interactive mediation for mediated reality and/or augmented reality and/or virtual reality. The user input circuitry 44 detects user actions using user input 43. These user actions are used by the

controller 42 to determine what happens within the virtual space 20. This may enable interaction with a visual element 28 within the virtual space 20.

5 The detected user actions may, for example, be gestures performed in the real space 10. Gestures may be detected in a number of ways. For example, depth sensors 49 may be used to detect movement of parts of a user 18 and/or or image sensors 47 may be used to detect movement of parts of a user 18 and/or positional/movement sensors attached to a limb of a user 18 may be used to detect movement of the limb.

10 Object tracking may be used to determine when an object or user changes. For example, tracking the object on a large macro-scale allows one to create a frame of reference that moves with the object. That frame of reference can then be used to track time-evolving changes of shape of the object, by using temporal differencing with respect to the object. This can be used to detect small scale human motion such as gestures, hand movement, facial movement. These are scene independent user (only) movements relative to the user.

15 The apparatus 30 may track a plurality of objects and/or points in relation to a person's body, for example one or more joints of the person's body. In some examples, the apparatus 30 may perform full body skeletal tracking of a person's body.

The tracking of one or more objects and/or points in relation to a person's body may be used by the apparatus 30 in gesture recognition.

20 Referring to Fig 7, a particular gesture 80 in the real space 10 is a gesture user input used as a 'user control' event by the controller 42 to determine what happens within the virtual space 20. A gesture user input is a gesture 80 that has meaning to the apparatus 30 as a user input.

25 Referring to Fig 8, in some but not necessarily all examples, a corresponding representation of the gesture 80 in real space is rendered in the virtual scene 22. The representation involves one or more visual elements 28 moving 82 to replicate or indicate the gesture 80 in the virtual scene 22.

30 A gesture 80 may be static or moving. A moving gesture may comprise a movement or a movement pattern comprising a series of movements. For example it could be making a circling motion or a side to side or up and down motion or the tracing of a sign in space. A moving gesture may, for example, be an apparatus-independent gesture or an apparatus-dependent gesture. A moving gesture may involve movement

of a user input object e.g. a user body part or parts, or a further apparatus, relative to the sensors. The body part may comprise the user's hand or part of the user's hand such as one or more fingers and thumbs. In other examples, the user input object may comprise a different part of the body of the user such as their head or arm. Three-dimensional movement may comprise motion of the user input object in any of six degrees of freedom. The motion may comprise the user input object moving towards or away from the sensors as well as moving in a plane parallel to the sensors or any combination of such motion.

A gesture 80 may be a non-contact gesture. A non-contact gesture does not contact the sensors at any time during the gesture.

A gesture 80 may be an absolute gesture that is defined in terms of an absolute displacement from the sensors. Such a gesture may be tethered, in that it is performed at a precise location in the real space 10. Alternatively a gesture 80 may be a relative gesture that is defined in terms of relative displacement during the gesture. Such a gesture may be un-tethered, in that it need not be performed at a precise location relative in the real space 10 and may be performed at a large number of arbitrary locations.

A gesture 80 may be defined as evolution of displacement, of a tracked point relative to an origin, with time. It may, for example, be defined in terms of motion using time variable parameters such as displacement, velocity or using other kinematic parameters. An un-tethered gesture may be defined as evolution of relative displacement Δd with relative time Δt .

A gesture 80 may be performed in one spatial dimension (1D gesture), two spatial dimensions (2D gesture) or three spatial dimensions (3D gesture).

Figs 9A, 9B, 10A, 10B, 11A-11D, 13A-13D illustrate a simplified example of a virtual space 20, as previously described, for the purposes of illustrating how a transition between a first point of view and a second point of view can be achieved when the first and second points of view relate to different times and/or different directions. In these examples, the point of view 24 used to define a virtual scene 22 has a fixed position and the point of view 24 changes its direction in only an azimuthal direction (yaw), there is no change in pitch or roll.

The virtual space 20 is for the purposes of this illustration illustrated as a circle with the position of the point of view 24 at the center of the circle. The circumference of the circle represents a background 102 of the virtual space 20 in 360 degrees. The area between the circumference and the center represents a foreground 104 of the virtual space 20. In this examples, background 102 comprises distinctive content 106, in the form of compass bearing markings, however, this content is only for the purposes of illustration, so that relative rotation between the point of view 24 and the background 102 can be easily visualized in the virtual space 20 and the virtual scene 22. Other content is possible.

A virtual object 21, which may be a real object 11 or a visual element 28, is located at a first position within the foreground 104 at a time t1 and is located at a second, different, position within the foreground 104 at a different time t2.

As illustrated in Figs 9A and 9B, if the direction 25 of the point of view 24 remains fixed between times t1 and t2, then at the time t2 the virtual scene 22 does not comprise the virtual object 21.

As illustrated in Figs 10A and 10B, if the direction 25 of the point of view 24 changes between times t1 and t2, then at the time t2 the virtual scene 22 can comprise the virtual object 21. However, this can be disorienting for a user, when skipping between time t1 to time t2, as it may appear that the foreground object 21 is stationary in front of a rapidly changing background 102.

This problem is addressed by the method 200 illustrated in figs 11A-11D and 12A-12D. The figs 11A to 11D progress through time between time t1 to time t2. The time determines the location of the object 21 within the virtual space 20.

Although figs 11A-11D and 12A-12D will be described in the sequence A to D, that is in terms of a skip forward in time from time t1 to time t2, it should be understood that the method 200 may also occur in the opposite sense in the sequence D to A, that is in terms of a skip backward in time from time t2 to time t1.

Each of the figures 11A-11D illustrates a virtual space 20 and point of view 24 and has a corresponding fig 12A-12D illustrating a virtual scene 22 defined by the direction 25 of the point of view 24.

- 5 Each of figs 11A-11D illustrates the relative direction 25 of the point of view 24 with respect to the background 102 of the virtual space 20 and how this changes over time.

Each of figs 11A-11D illustrates a display state of the virtual object 21 described previously with reference to Figs 9A-9B and 10A-10B. A solid outline to the virtual
10 object 21 indicates that the virtual object 21 is displayed in the corresponding virtual scene 22 in an unmodified state and is clearly visible. A dotted outline to the virtual object 21 indicates that the virtual object 21 is displayed in the corresponding virtual scene 22 in a modified state and is not clearly visible.

- 15 In some but not necessarily all examples, only the virtual object 21 in the foreground 104 is modified when displayed. In other examples, a whole of the foreground 104 is modified when displayed. Both of these are examples of displaying a modified foreground 104

- 20 As illustrated in Figs 11A,, 12A, at time t_1 , the method 200 causes display of a background 102_1 of a scene 22_1 from a first point of view 24_1 in a first direction 25_1 and display of a foreground 104_1 of the scene 22_1 from the first point of view 24_1 . The background 102_1 and the foreground 104_1 displayed in the scene 22_1 are both unmodified and from the same point of view 24_1 .

- 25 Next, as illustrated in Figs 11B, 12B, at or after time t_1 , the method 200 causes display of the background 102_1 of the scene 22_1 from the first point of view 24_1 in the first direction 25_1 and display of a modified foreground $104'$. The background 102_1 and the modified foreground $104'$ displayed in the scene 22_1 may be from the same point of
30 view 24_1 , however, the background 102_1 is unmodified and the modified foreground $104'$ is modified.

- In some but not necessarily all examples, the modified foreground $104'$, as illustrated in Fig 12B, may be a modified version of the foreground 104_1 determined by the first
35 point of view 24_1 illustrated in Fig 11B. In these examples, the background 102_1 and

the modified foreground 104' displayed in the scene 22₁ are from the same point of view 24₁ and in these examples the modified foreground 104' is labeled 104₁'

Next, as illustrated in Figs 11C, 12C, at or just before time t₂, the method 200 causes display of a background 102₂ of a scene 22₂ from a second point of view 24₂ in a second direction 25₂ and a modified foreground 104'. The background 102₂ and the modified foreground 104' displayed in the scene 22₂ may be from the same point of view 24₂, however, the background 102₂ is unmodified and the modified foreground 104' is modified.

In some but not necessarily all examples, the modified foreground 104', as illustrated in Fig 12C, may be a modified version of the foreground 104₂ determined by the second point of view 24₂ illustrated in Fig 11C. In these examples, the background 102₂ and the modified foreground 104' displayed in the scene 22₂ are from the same point of view 24₂ and in these examples the modified foreground 104' is labeled 104₂'

Next, as illustrated in Figs 11D, 12D, at time t₂, the method 200 causes display of a background 102₂ of a scene 22₂ from the second point of view 24₂ in the second direction 25₂ and a foreground 104₂ of the scene 22₂ from the second point of view 24₂. The background 102₂ and the foreground 104₂ displayed in the scene 22₂ are both unmodified and from the same point of view 24₂.

In some examples, the modified foreground 104₁' of the scene 22₁ from the first point of view 24₁ (Figs 11B, 12B) and the modified foreground 104₂' of the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C) refers to a modification of a whole of the foreground.

In other examples, the modified foreground 104₁' of the scene 22₁ from the first point of view 24₁ (Figs 11B, 12B) and the modified foreground 104₂' of the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C) refers to a modification of only one or more objects 21 in the foreground. For example, an object 21 that is common to the foreground 104₁ of the scene 22₁ from the first point of view 24₁ (Fig 11B) and to the foreground 104₂ of the scene 22₂ from the second point of view 24₂ (Fig 11C), despite having different perspective views, is a 'common object'. The term 'modified foreground' may refer to a modification of a common object or objects 21. The modified

foreground 104₁' of the scene 22₁ from the first point of view 24₁ may therefore refer to modification of only common object(s) 21 that is/are in the foreground 104₁ of the scene 22₁ from the first point of view 24₁ (Figs 11B, 12B). The modified foreground 104₂' of the scene 22₂ from the second point of view 24₂ may therefore refer to
5 modification of only common object(s) 21 that is/are in the foreground 104₂ of the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C).

In this example, but not necessarily all examples, the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C) depends upon a selected time t₂ or a selected time skip
10 t₂-t₁. The selection may be performed by a user. The time skip defines a difference in time (t₂-t₁) between the displayed scene 22₁ from the first point of view 24₁, when the time skip is defined by user selection, and the displayed scene 22₂ from the second point of view 24₂.

15 In some but not necessarily all examples, the scene 22₁ from the first point of view 24₁ (Figs 11B, 12B) and the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C) may have in common at least one object and the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C) is determined by tracking the at least one object 21 that is present in the scene 22₁ from the first point of view 24₁ (Figs 11A, 12A). The tracked
20 object 21 may, or may not be a modified object 21 in the foreground 104.

The object 21 that is tracked may be selected by a user or, alternatively, it may be selected by the apparatus 30 using computer vision techniques. In some examples, the apparatus 30 using computer vision techniques may highlight objects 21 suitable
25 for selection.

In some but not necessarily all examples, the scene 22₂ from the second point of view 24₂ (Figs 11C, 12C) is pre-determined by the time t₂. For example, each point in time may be associated with a particular point of view 24 and corresponding scene 22. This
30 may be the case where the mediated reality is 'directed', for example, as in a movie.

Computer vision techniques may be used to differentiate foreground objects 21 from background 102. For example feature analysis and/or object segmentation may be used to identify objects, and to determine whether they are foreground or background
35 objects. In some cases, depth data may be provided from a stereoscopic camera or

an alternative depth sensing device, and analysis of the depth information be used for differentiating foreground objects from the background objects.

5 The features defining the object 21 move relative to a background of features if there is movement between an imaging camera 47 and the object 21. This may be achieved by changing a position or orientation of the camera 47, for example or by using a stereoscopic camera or a 360 degree camera.

10 The modification of the foreground 104 or one or more objects 21 in the foreground 104 may comprise fade-out of the image of the foreground or one or more objects 21 so that it is less clear and more indistinct. For example, the image may be made semi-transparent.

15 Figs 13A-13D are similar to Figs 11A-11D and illustrate the virtual space 20 and changing points of view 24 between time t1 and t2. Fig 13A is similar to Fig 11B and Fig 13D is similar to Fig 11C.

20 Figs 14A-14D are similar to Figs 12A-12D and illustrate the virtual scene 22 for changing points of view 24 between time t1 and t2. Fig 14A is similar to Fig 12B and Fig 14D is similar to Fig 12C.

25 Before displaying the background 102₂ of the scene 22₂ from the second point of view 24₂ and the modified foreground 104', the method 202 causes display, in series, of backgrounds 102_A, 102_B of intermediate scenes 22_A, 22_B from intermediate points of view 24_A, 24_B between the first point of view 24₁ and the second point of view 24₂ and display of modified foreground 104'. The intermediate points of view 24_A, 24_B have different directions 25_A, 25_B.

30 In some but not necessarily all examples, the intermediate scenes 22_A, 22_B defined by the intermediate points of view 24_A, 24_B are selected to have in common a particular foreground object 21.

In some but not necessarily all examples, the modified foreground 104' is fixed. The modified foreground 104' displayed while displaying the backgrounds 102_A, 102_B of

intermediate scenes 22_A, 22_B from intermediate points of view 24_A, 24_B may be the modified foreground 104₁' of the scene from the first point of view 24₁.

5 In some but not necessarily all examples, the modified foreground 104' varies. In some of these examples, for each one of multiple intermediate points of view 24_A, 24_B between the first point of view 24₁ and the second point of view 24₂, the method 202 causes display of a background 102_A, 102_B of an intermediate scene 22_A, 22_B from the respective intermediate point of view 24_A, 24_B and a modified foreground 104_A', 104_B' of the intermediate scene 22_A, 22_B from the intermediate point of view 24_A, 24_B.

10

In some but not necessarily all examples, the modified foreground 104' may comprise or consist of a modified foreground object 21' that is common to each one of multiple intermediate scenes 22_A, 22_B defined by intermediate points of view 24_A, 24_B between the first point of view 24₁ and the second point of view 24₂. The method 202 causes display of a background 102_A, 102_B of an intermediate scene 22_A, 22_B from the respective intermediate point of view 24_A, 24_B and at least a modification of the common foreground object 21 from the intermediate scene 22_A, 22_B displayed from the intermediate point of view 24_A, 24_B.

15

20 Fig 15, illustrates a method 204 comprising:
 at block, 212, causing display of a background of a scene from a first point of view and a foreground of the scene from the first point of view;
 at block, 214, causing display of a background of the scene from the first point of view and a modified foreground of the scene from the first point of view;
 25 at block, 216, causing display of a background of a scene from a second point of view and a modified foreground; and
 at block, 218, causing display of a background of a scene from the second point of view and a foreground of the scene from the second point of view.

30 The apparatus 30, as previously described may comprise means for performing the methods described with reference to Figs 9-15.

The computer program 48, may when loaded into a processor perform the methods described with reference to Figs 9-15.

35

The apparatus 30 therefore comprises: at least one processor 40; and at least one memory 46 including computer program code 48 the at least one memory 46 and the computer program code 48 configured to, with the at least one processor 40, cause the apparatus 30 at least to perform: causing display of a background of a scene from a first point of view and a foreground of the scene from the first point of view;
5 causing display of a background of the scene from the first point of view and a modified foreground of the scene from the first point of view; causing display of a background of a scene from a second point of view and a modified foreground; and causing display of a background of a scene from the second point of view and a
10 foreground of the scene from the second point of view.

Where a structural feature has been described, it may be replaced by means for performing one or more of the functions of the structural feature whether that function or those functions are explicitly or implicitly described.

15 As used here 'module' refers to a unit or apparatus that excludes certain parts/components that would be added by an end manufacturer or a user. The controller 42 may, for example be a module. The apparatus 20 may be a module. The input circuitry may be a module or comprise modules. The display 32 may be a module.

20 The term 'comprise' is used in this document with an inclusive not an exclusive meaning. That is any reference to X comprising Y indicates that X may comprise only one Y or may comprise more than one Y. If it is intended to use 'comprise' with an exclusive meaning then it will be made clear in the context by referring to "comprising only one.." or by using "consisting".
25

In this brief description, reference has been made to various examples. The description of features or functions in relation to an example indicates that those features or functions are present in that example. The use of the term 'example' or 'for example'
30 or 'may' in the text denotes, whether explicitly stated or not, that such features or functions are present in at least the described example, whether described as an example or not, and that they can be, but are not necessarily, present in some of or all other examples. Thus 'example', 'for example' or 'may' refers to a particular instance in a class of examples. A property of the instance can be a property of only that
35 instance or a property of the class or a property of a sub-class of the class that includes

some but not all of the instances in the class. It is therefore implicitly disclosed that a features described with reference to one example but not with reference to another example, can where possible be used in that other example but does not necessarily have to be used in that other example.

5

Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the invention as claimed.

10

Features described in the preceding description may be used in combinations other than the combinations explicitly described.

Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

15

Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

Whilst endeavoring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

25

I/we claim:

30

CLAIMS

1. A method comprising:

displaying a background of a virtual scene from a first point of view and a foreground
5 of the virtual scene from the first point of view;

displaying a background of the virtual scene from the first point of view and a modified
foreground;

displaying a background of a virtual scene from a second point of view and a modified
foreground; and

10 displaying a background of a virtual scene from the second point of view and a
foreground of the virtual scene from the second point of view.

2. A method as claimed in claim 1, wherein a content of the virtual scene from the
second point of view depends upon a selected time or time skip.

15

3. A method as claimed in claim 1 or 2, comprising:

before displaying the background of the virtual scene from the second point of view
and the modified foreground, displaying one or more backgrounds of one or more
intermediate virtual scenes from one or more intermediate points of view between the
20 first point of view and the second point of view and displaying modified foreground .

4. A method as claimed in claim 3, wherein the one or more intermediate virtual scenes
from intermediate points of view is/are selected to have in common one or more
foreground objects with the foreground of the virtual scene from the first point of view.

25

5. A method as claimed in any preceding claim, wherein the modified foreground
displayed while displaying the background of the virtual scene from the second point
of view is the modified foreground of the virtual scene from the first point of view.

30 6. A method as claimed in any preceding claim, wherein, for each one of multiple
intermediate points of view between the first point of view and the second point of view,
displaying a background of an intermediate virtual scene from the respective
intermediate point of view and a modified foreground of the intermediate virtual scene
from the intermediate point of view.

35

7. A method as claimed in any preceding claim, wherein, for each one of multiple intermediate virtual scenes comprising a common foreground object defined by intermediate points of view between the first point of view and the second point of view, displaying a background of the intermediate virtual scene from the intermediate point of view and at least a modification of the common foreground object from the intermediate virtual scene from the intermediate point of view.

8. A method as claimed in any preceding claim, wherein the second point of view is determined by tracking at least one tracked object.

10

9. A method as claimed in claim 8, wherein the tracked object is user determined.

10. A method as claimed in claim 8 or 9, wherein the tracked object is determined using computer vision.

15

11. A method as claimed in any preceding claim, wherein the second point of view is pre-defined by a skip time.

12. A method as claimed in any preceding claim, wherein modification comprises fade-out of image content.

20

13. A method as claimed in any preceding claim, wherein modification of an object comprises making the object, when displayed, semi-transparent.

14. A method as claimed in any preceding claim, wherein the modified foreground is a modified version of a foreground from the same point of view as the displayed background.

25

15. An apparatus comprising means for performing any of claims 1 to 13 or a computer program, which when loaded into a processor perform the methods of any of claims 1 to 13.

30

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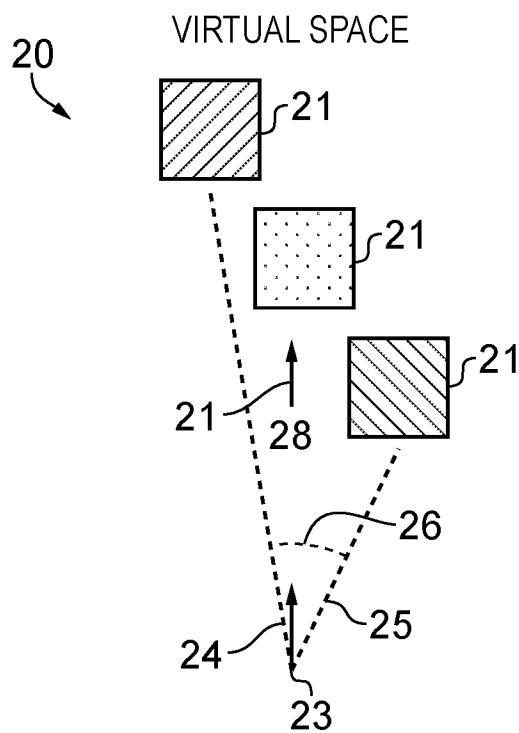


FIG. 1A

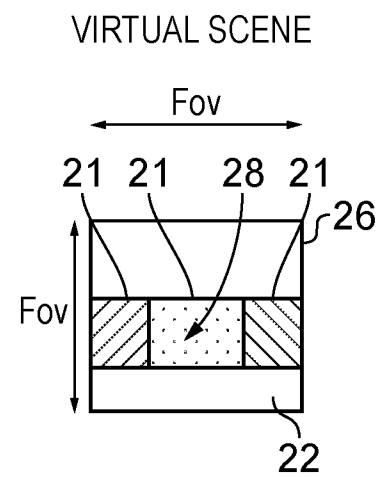


FIG. 2A

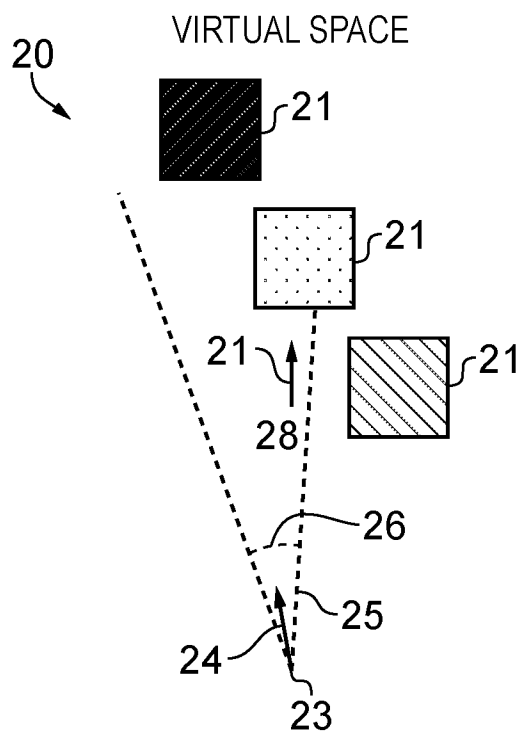


FIG. 1B

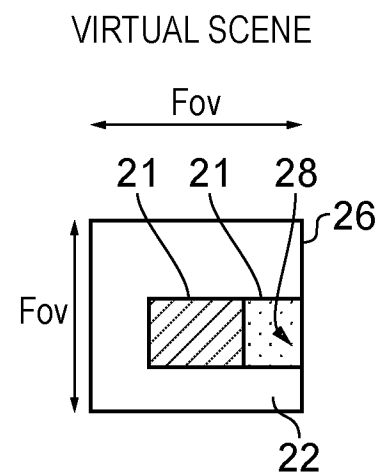


FIG. 2B

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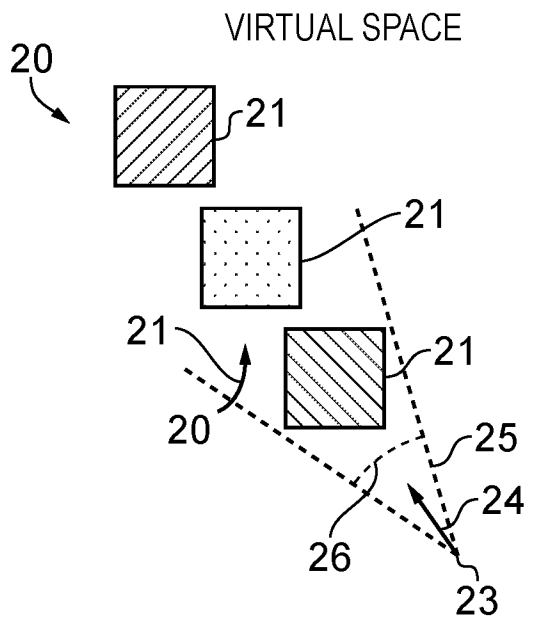


FIG. 1C

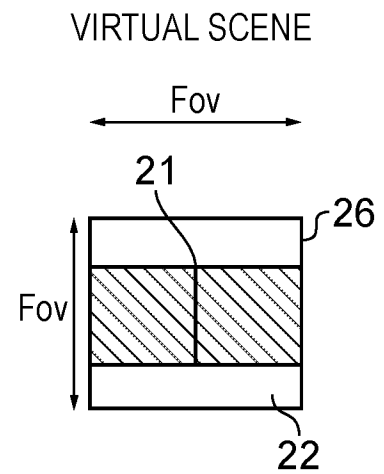


FIG. 2C

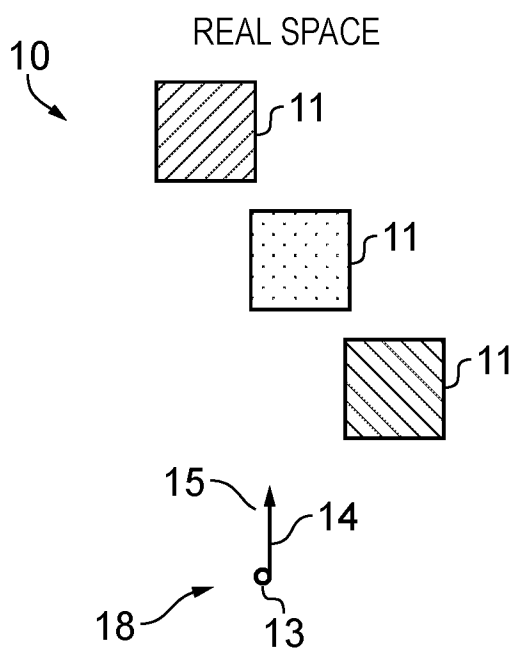


FIG. 3A

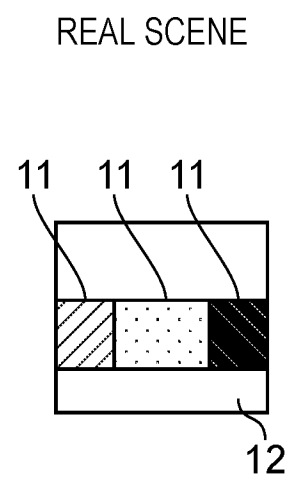


FIG. 3B

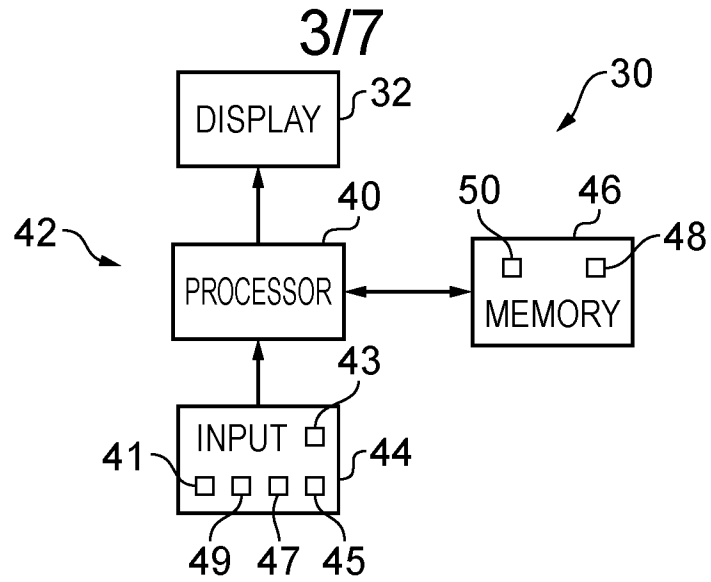


FIG. 4

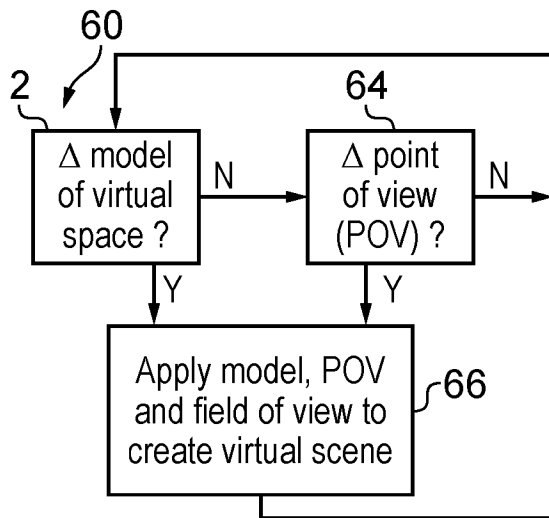


FIG. 5A

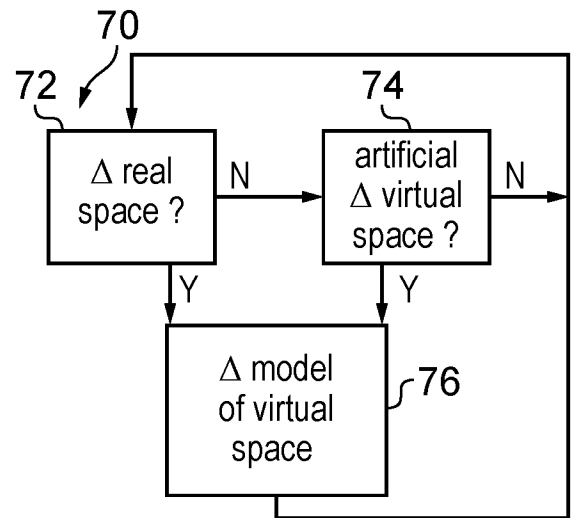


FIG. 5B

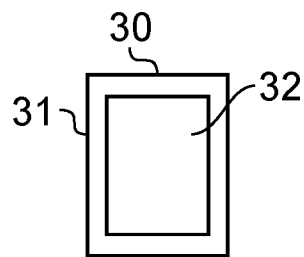


FIG. 6A

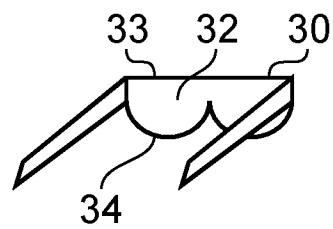


FIG. 6B

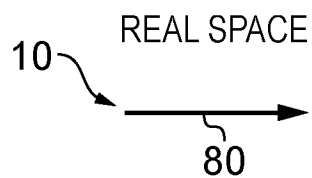


FIG. 7

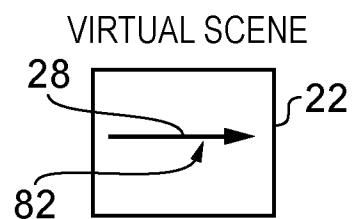


FIG. 8

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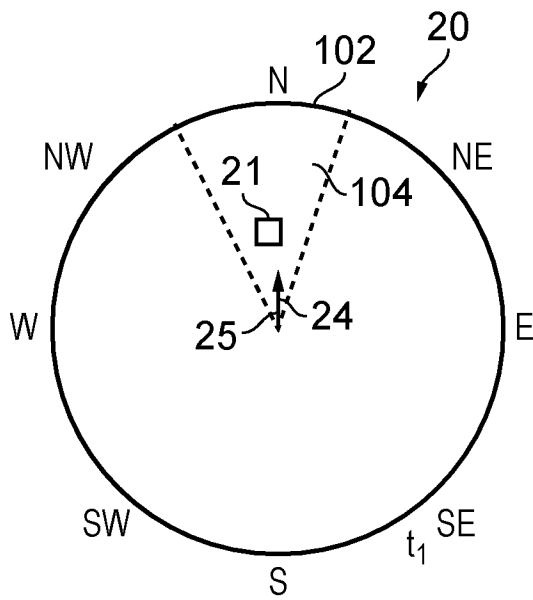


FIG. 9A

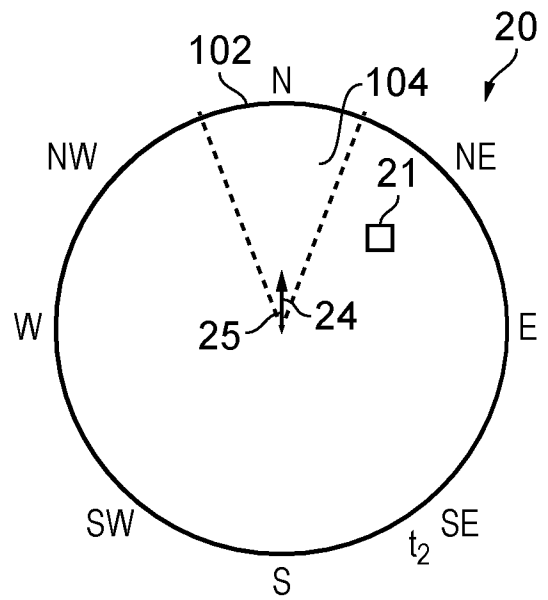


FIG. 9B

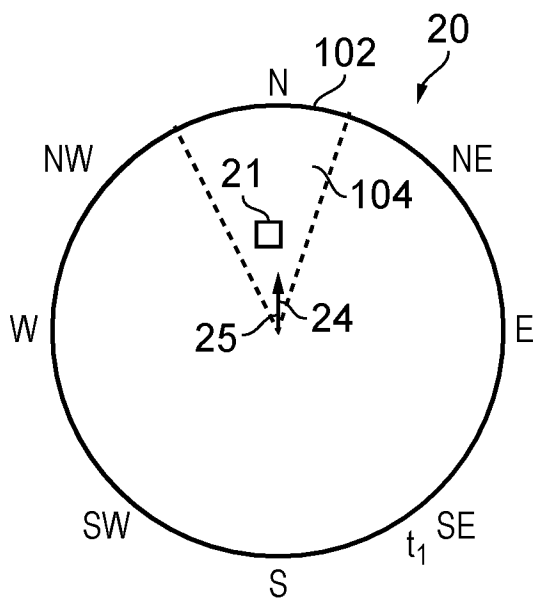


FIG. 10A

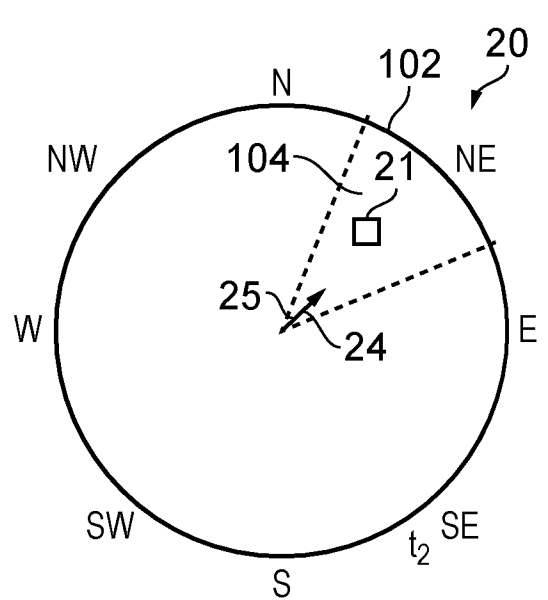
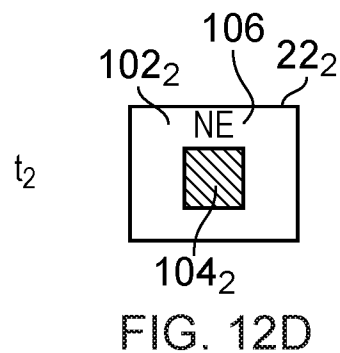
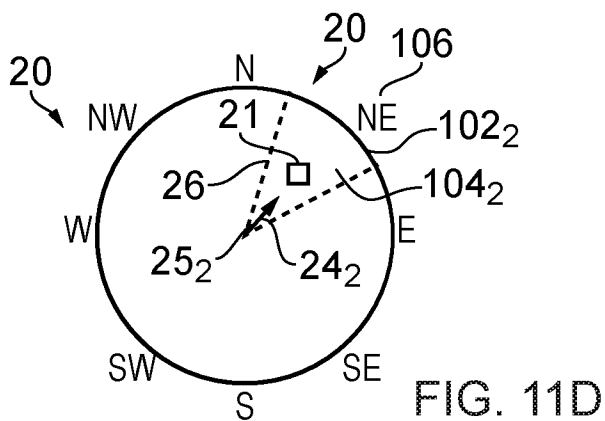
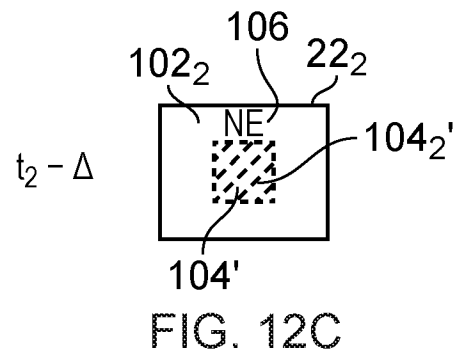
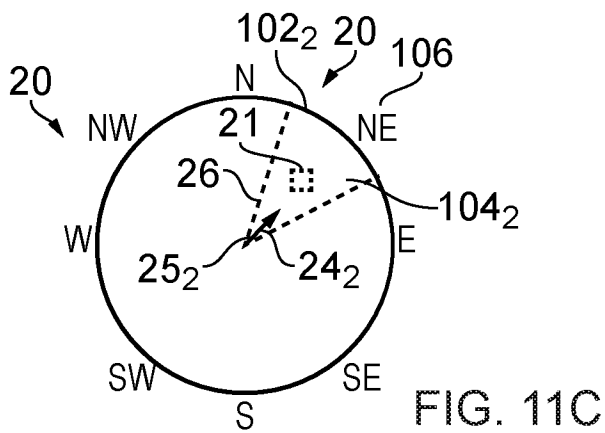
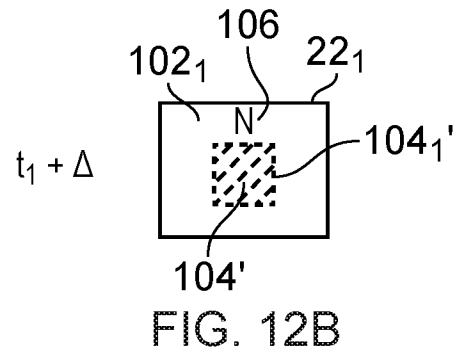
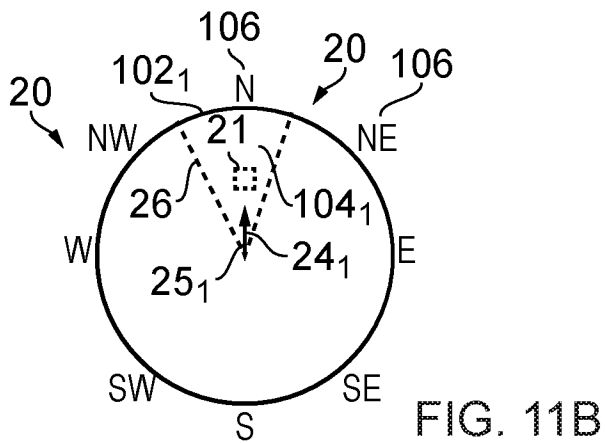
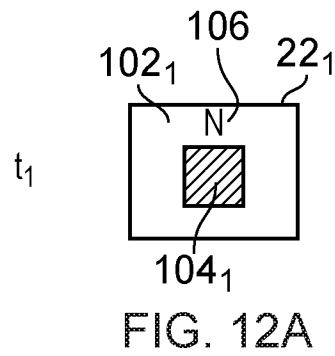
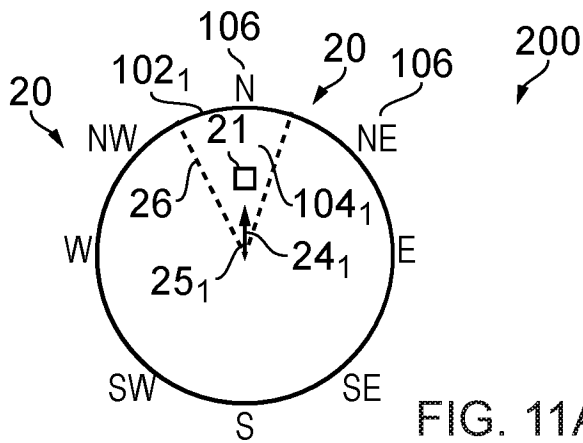
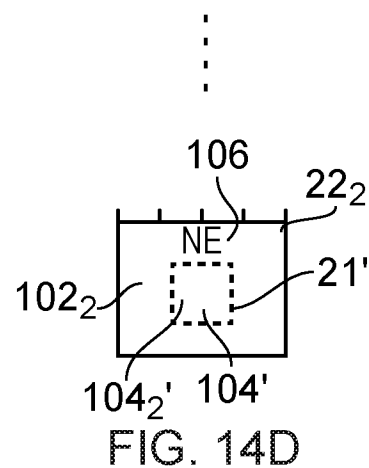
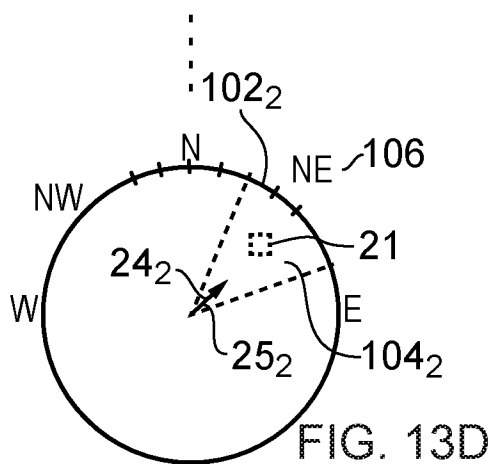
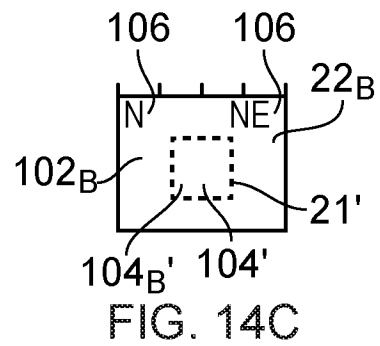
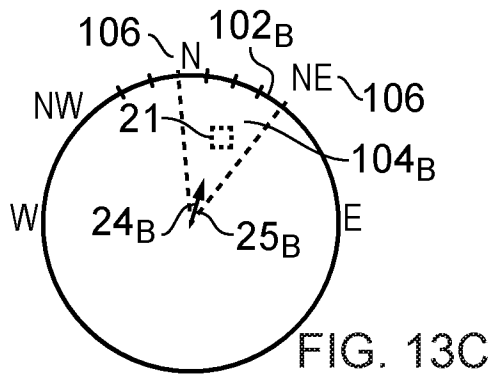
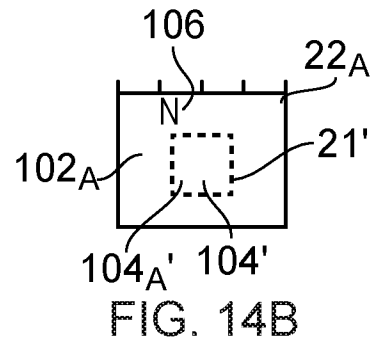
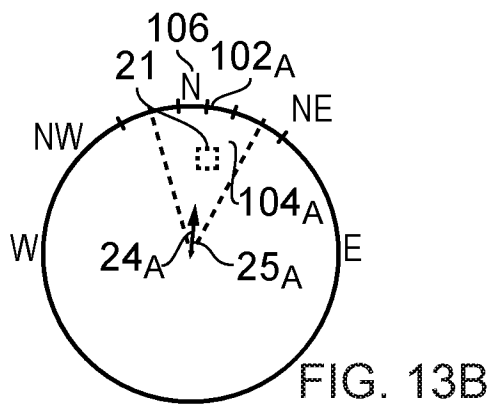
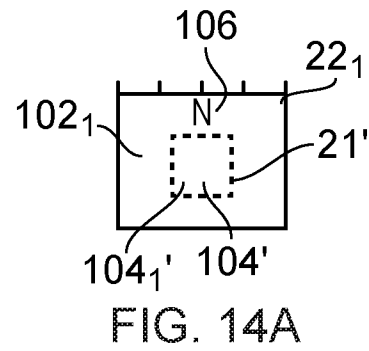
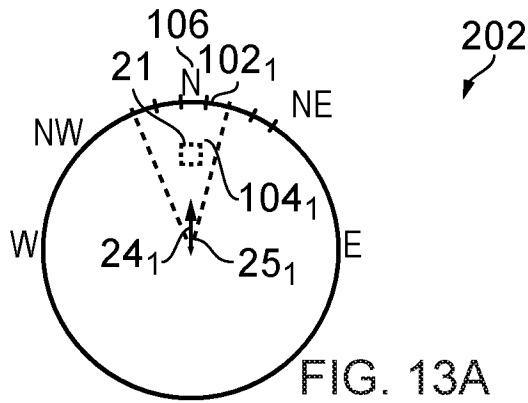


FIG. 10B

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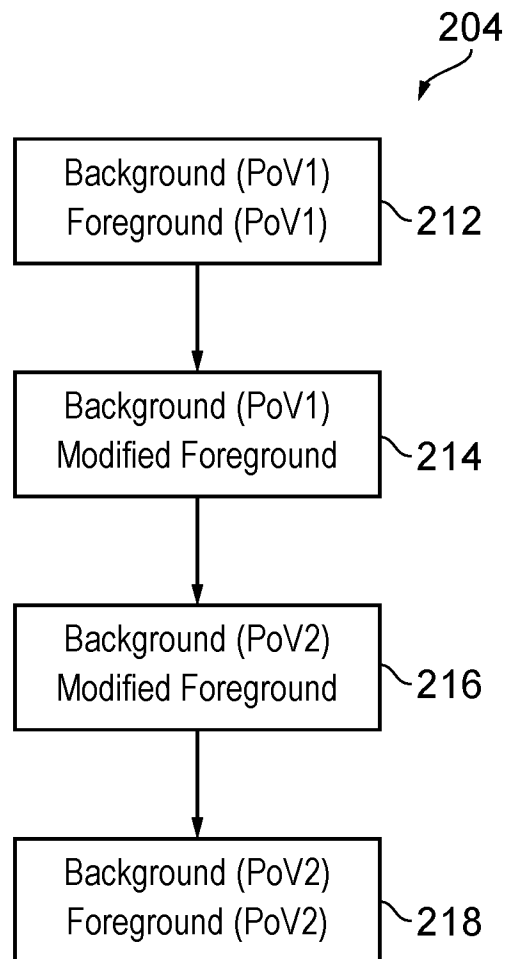


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2016/050489

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T13/80 G06T15/20 G06T19/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/321702 A1 (SCHMALSTIEG DIETER [AT]) 30 October 2014 (2014-10-30) abstract paragraph [0004] paragraph [0055] - paragraph [0059] paragraph [0068] - paragraph [0072] -----	1-15

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

21 September 2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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