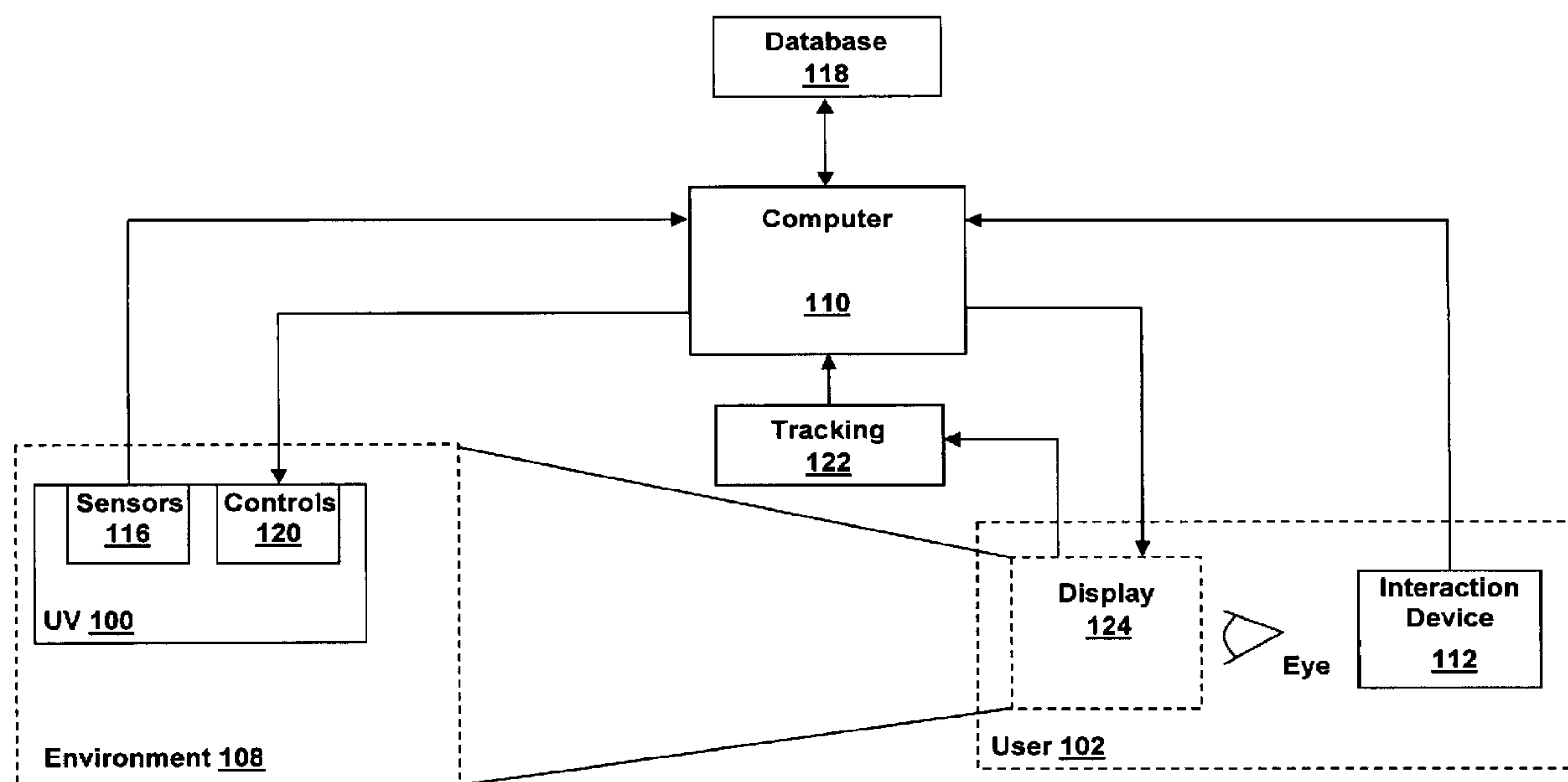




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(72) **Inventeur/Inventor:**
BAILLOT, YOHAN, US
(73) **Propriétaire/Owner:**
EXELIS INC., US
(74) **Agent:** HICKS & ASSOCIATES

(54) **Titre : SYSTEME DE REALITE AUGMENTEE ET PROCEDE OFFRANT UNE CONFIGURATION ET UNE COMMANDE DE VEHICULES SANS PILOTE**
(54) **Title: AUGMENTED REALITY-BASED SYSTEM AND METHOD PROVIDING STATUS AND CONTROL OF UNMANNED VEHICLES**



(57) **Abrégé/Abstract:**

An augmented reality system identifies and controls a vehicle located within an environment. A tracking system obtains viewpoint information corresponding to a real-time view of the environment. A processing system receives information from one or more sensors. Information includes sensor location information and status information about the vehicle. Processing system generates graphics using said sensor location information and said viewpoint information. Graphics include visual representations of said status information and controls. A display displays the generated graphics such that the graphics are superimposed on the real-time view. The graphics appear attached to the vehicle. An interaction device activates a displayed control.

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(71) Applicant (for all designated States except US): **ITT MANUFACTURING ENTERPRISES, INC.** [US/US];
1105 North Market Street, Suite 1217, Wilmington, DE 19801 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **BAILLOT, Yohan** [FR/US]; 1311 Northgate Square, Reston, VA 20190 (US).

(74) Agents: **DAVIDSON, Scott, J.** et al.; Davidson Berquist Jackson & Gowdey LLP, 4300 Wilson Blvd, 7th Floor, Arlington, VA 22203 (US).

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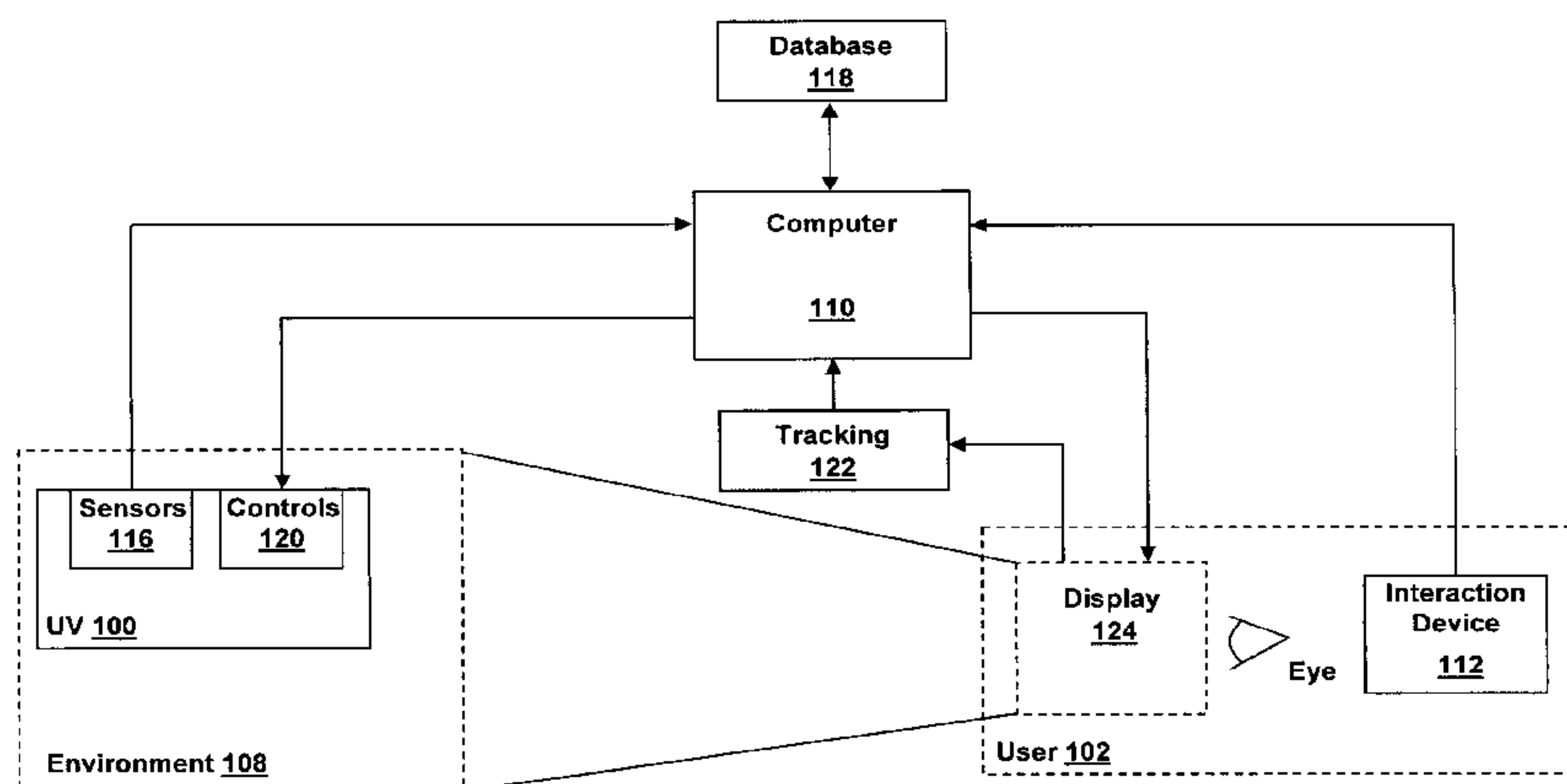


Fig. 1

(57) Abstract: An augmented reality system identifies and controls a vehicle located within an environment. A tracking system obtains viewpoint information corresponding to a real-time view of the environment. A processing system receives information from one or more sensors. Information includes sensor location information and status information about the vehicle. Processing system generates graphics using said sensor location information and said viewpoint information. Graphics include visual representations of said status information and controls. A display displays the generated graphics such that the graphics are superimposed on the real-time view. The graphics appear attached to the vehicle. An interaction device activates a displayed control.

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AUGMENTED REALITY-BASED SYSTEM AND METHOD PROVIDING STATUS AND CONTROL OF UNMANNED VEHICLES

FIELD OF THE DISCLOSURE

[0001] This relates to using augmented reality-based systems with unmanned vehicles (UV).

INTRODUCTION

[0002] It has long been desirable to provide a remote user with control of an unmanned vehicle (UV) in such a way that the remote user can easily navigate the unmanned vehicle through a complex and three-dimensional urban environment.

[0003] Prior art systems include: Operator-vehicle interface (OVI), Uninhabited Combat Aerial Vehicle (UCAV) Operator's Console, Advanced Unmanned Air Vehicle Interface (AUAVI), Common Operator Control Unit (COCU), systems developed by the Air Force Research Lab at the Wright Patterson Air Force base, and systems developed by the Space and Naval Warfare Systems Center San Diego.

[0004] Prior art systems typically attempt to navigate a UV through a complex environment by using command and control concepts involving computer graphics or by using Tele-operation. Existing command and control concepts involving computer graphics are based on Virtual Reality or Augmented Virtuality. Tele-operation does not involve any graphics, but just provides the viewpoint of the UV to the control user using a video from a video camera attached to the UV.

[0005] Virtual Reality is adapted to long range command and control where the UV is not visible to the user. In close-range/urban situations, virtual reality cannot effectively be applied, as it requires detailed models of the urban environment which typically do not exist and even if the models existed they would not include new changes (e.g. a car moving in the environment) that are of concern when controlling a UV, particularly through a narrow urban canyon. Virtual Reality control is best employed for large motion and large overhead views and therefore is best suited for long range UV control where obstacles and difficult terrain are far from the UV. In long range UV control, it is of less concern if distant obstacles are not detailed. Having a rough representation of overall topology is typically sufficient.

[0006] Tele-operation shows an image of the environment from the viewpoint of the UV and provides the control of the UV using this image. Tele-operations attempt to control a UV by creating an image as if the user were inside the UV. Tele-operation reduces the field of view of the controller to the view of the camera attached to the UV and the controller's ability to look around is limited by the speed at which the camera can rotate. Both the view of the camera and the speed at which it can rotate are inferior to the capabilities of a human. Thus, peripheral situational awareness is greatly diminished compared to a user actually inside the vehicle. Consequently, the control of the UV is reduced as well. For example, it is much more difficult to go through a narrow tunnel without hitting the walls by using a camera for the view of the environment than it is with the large field of view and the look-around capability of human vision.

[0007] Augmented Virtuality is employed to superimpose the video of the current view of a UV on top of a virtual model of the environment. The video collected and thus mapped on the virtual world provides the controller with updates of what really happens in the environment as currently seen by the camera. Augmented Virtuality suffers from the same limitations as the above mentioned systems, as the image the human controller sees is limited by the capabilities of the camera and the virtual model of the environment does not account for small changes in the environment.

[0008] In addition to the limitations described above, all the above mentioned techniques require the use of remote command centers or at best traditionally large and heavy remote that is carried by an operator to control in most cases a single UV. As a consequence, only one user can control a given UV as well. So, for a soldier to be able to use a given UV, the soldier must first find the UV's human controller and let the human controller know what he needs the UV to do. In addition, none of these methods allow identifying a specific UV in the real world. As a consequence, it might be difficult for a user to find a UV in the environment or differentiate two similar UVs which are far away.

[0009] The system described herein solves the shortcomings of prior art systems by allowing a UV to be identified and controlled from the point of view of any user able to see the UV, thereby allowing close collaboration between any user and the UV. In the case where there are multiple UVs within an environment, the system allows a UV in the environment to be distinguished from other similarly looking UVs in the environment.

The system allows a UV to be controlled by using a control interface that is rendered into a see-through display worn by the user, thereby removing the need for a large and heavy remote control. The control interface can be implemented by attaching control widgets (buttons, knobs, etc) to UVs displayed on the user's view. The UVs can then be controlled by the acting on these widgets. Further, the system enables each individual UV to be controlled by several users of the augmented reality system.

BRIEF DESCRIPTION OF THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

[0010] The following description, given with respect to the attached drawings, may be better understood with reference to the non-limiting examples of the drawing, wherein the drawings show:

[0011] **Figure 1:** Exemplary UV information and control system;

[0012] **Figure 2:** Exemplary UV information and control system using an optical see-through display;

[0013] **Figure 3:** Exemplary UV information and control system using a video see-through display;

[0014] **Figure 4:** Exemplary UV information and control system using a camera and video display potentially at different locations;

[0015] **Figure 5:** Exemplary view of information superimposed on top of a view of an environment with exemplary UV identification and control information;

[0016] **Figure 6:** Exemplary view of information superimposed on top of a view of an environment with exemplary UV identification and control information;

[0017] **Figure 7:** Exemplary view of information superimposed on top of a view of an environment with exemplary UV identification and control information.

THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

[0018] The status and control system described herein makes use of Augmented Reality (AR) technology to show the information directly in the view of the user. AR is like Virtual Reality, but instead of using completely artificial images, AR superimposes 3D graphics on a video or a view, by transparency, of the real world. A very simple example of AR is used in football games to show the first down with a yellow line. An example

AR system that can be employed is one of the examples described in U.S. Application No. 11/441,241 in combination with the present disclosure.

[0019] The AR visualization system comprises: a spatial database, a graphical computer, a viewpoint tracking device, a display device, and an interaction device.

[0020] The working principle of an Augmented Reality system is described below. A display device that displays dynamic images corresponding to a user's view is tracked. That is, the display's position and orientation are measured by a viewpoint tracking device. A spatial database and a graphical computer contain information relating to objects in the environment which can be the UVs and geolocated data captured by these UVs. This information is superimposed on top of the environment using the see-through display in accordance with the display's position and orientation, thereby creating an augmented image. The interaction device allows UVs shown in the augmented image to be controlled. The interaction device allows the user to select a specific point of what he sees through the display (for example a window or a widget).

[0021] Fig. 1 shows an exemplary embodiment of an AR system used to provide a remote user **102** with a way of viewing and controlling a UV **100**. User **102** is located some distance away from UV **100** and has a perspective of the environment **108** that allows user **102** to view the UV **100** in the context of the environment **108**.

[0022] Sensors **116** include sensors that allow a UV's location to be monitored (e.g. GPS tracking information) and can include sensors that provide information about the operating conditions of the UV (e.g. remaining power or fuel, video captured by the UV, etc.), and conditions within the UV's immediate vicinity (e.g. temperature, air content, chemical samples captured by the UV, a LIDAR sensor attached to the UV, etc.).

Controls **120** receive commands and use commands to control the UV **100**.

[0023] Computer **110** collects information from sensors **116** attached to UV **100**. It should be noted that although Fig. 1 shows a single UV **100** such a representation is not intended to be limiting and any number of UVs **100** could be located within the environment **108**.

[0024] Computer **110** updates database **118** with the information received from sensors **116**. Database **118** stores the information from sensors **116**. Database **118** may additionally contain model information about the environment **108**, such as a 3D model

of a city. Model information may be used to provide advanced functionality in the system, but is not necessary for basic system implementation. Graphical computer **110** continuously renders information from the database **118**, thereby monitoring a UV's location within the environment and generating graphics from current information received from sensors **116**. Graphical computer **110** associates generated graphics from information received from a particular UV with that UV's current location.

[0025] Computer **110** also receives information regarding the viewpoint of the see-through display device **124** captured by the tracking device **122**. Computer **110** takes rendered information from database **118** and tracking information about the viewpoint of the display device **124** and places current information from sensors **116** in relation to the current view of the display device **124** by using a common 3D projection process. Since computer **110** associates information from a UV with the UV's location, when computer **110** places information from sensors **116** in a current view, information is attached to UV **100**.

[0026] The display device **124** is able to show the image generated by the graphical computer **110** superimposed on a view of the surrounding environment **108** as "seen" by the display device **124**. Thus, user **102** has an augmented view of environment **108** with information superimposed thereon that allows user **102** to interpret visualize information received from a UV **100**. By attaching graphics to a UV **100**, corresponding information remains visually associated with a UV **100** as the UV **100** moves through a static user view or as the user's view changes.

[0027] Further, graphics can include controls that allow a user to control a UV **100**. Interaction device **112** allows a user **100** to manipulate controls displayed on display **124**. Thus, interaction device **112** can include any device that can interact with a GUI, e.g. a mouse, a gyro-mouse, a joystick, etc. When the interaction device **112** is a mouse, the interaction device can have a pointer being displayed in the field of view of the user **102** which allows user **102** to see what is currently selected by the interaction device **112**. Using the interaction device **112**, user **102** can select a part of the displayed graphics and perform an action on it. Although a mouse is described, any interaction device allowing the user **102** to select a part of the image that he sees can be used. For example, a camera can be embedded in the display that "looks" at the same picture that the user **102** sees. In

this example, user **102** could use his finger as a pointing device. The camera would capture the finger and attach a cursor at the tip of the finger so that pointer can then be driven by the tip of the finger to select a part of the display. Since there is no mouse button available in this case, may be the user **102** would speak or push a button in his gloves to perform the actual selection once above the area that he wants to select. Details of specific exemplary functions available to interaction device **112** are described in accordance with Figs. 5-7.

[0028] Figs. 2-4 illustrate the exemplary types of displays that can be incorporated into the system. Fig. 2 shows display device **124** implemented using an optical see-through display. Optical see-through displays achieve showing the image generated by the graphical computer **110** superimposed on a view of the surrounding environment **108** typically by using an optical beam splitter (there are other optical assembly existing) that lets through half of the light coming from environment **108** in front and reflecting half of the light coming from a display **124** showing the image generated by the graphical computer **110**, in effect combining the real world environment **118** and the graphics. Optical see-through displays are typically in the form of goggles that are worn by the user.

[0029] Fig. 3 shows the display device **124** implemented using a video see-through display. Video see-through displays achieve showing the image generated by the graphical computer **110** superimposed on a view of environment **108** by using a video camera **126** to take the video of environment **108** and show it on the display **124** after the image from the graphical computer **110** has been overlaid on top of it using video rendering device **128**. In the case of a video see-through display, the camera capturing the view of the real world environment **108** and the display showing this video can be co-located in a single display device as shown in Fig. 3 or placed at different locations as shown in Fig. 4. Video displays can be implemented using various types of display technologies and can be located anywhere in proximity to user **102**.

[0030] The three exemplary configurations (optical see-through, co-located video and screen, and video and screen at different locations) described above are mentioned for understanding the implementation of an AR system and are not intended to be limiting.

Any AR system which is able to superimpose graphics that appear attached to the real world could be used.

[0031] It should be noted that the elements shown in Figs. 1-4 can be combined in any number of ways when appropriate (e.g. tracking **122** and computer **110** can be combined within the same physical device). Further, the elements shown can be distinct physical devices that communicate with each other in any appropriate manner. For example, sensors **116** can communicate with computer **110** via radio communications, across a network using network protocols, or using any other appropriate method of electronic communications.

[0032] Fig. 5 is an exemplary view of information superimposed on top of a view of an environment **108** with exemplary UV identification and control GUI. Fig. 5 illustrates the principle of identifying unambiguously two similar UVs within the same environment. In this example, the similar UVs are distinguished by unique identifiers, “Chopper 1” and “Chopper 2.” Further, information can be shown regarding the state of each UV. In this example, below each UV is an indication of the amount of fuel each UV has left (i.e. 45% and 80%). Any other characteristics or status information could be included with or instead of the fuel reading. As the UVs move throughout the environment the information (e.g. unique identifiers) remain “attached” to the UVs.

[0033] Fig. 5 also illustrates the concept of using an augmented display to provide control functions to a UV. As shown in Fig. 5, Chopper 2 is surrounded by directional arrows **500**. A user **102** can control Chopper 2 by manipulating an arrow using interaction device **112**. Computer **110** receives the commands from the interaction device **112** and transmits commands to the controls **120** of a UV **100**. In this case, manipulating a particular arrow might cause Chopper 2 to move in that direction.

[0034] Fig. 6 illustrates an alternative control interface for controlling a UV. As shown in Fig. 6, there is a cross **600** next to the UV. A user **102** is able to control the UV by selecting the cross **600** with interaction device **112** and dragging and dropping the cross **600** to a particular location in the environment, thereby indicated to the UV to go to this location. Since the pointing/interaction device is 2D (like the display), it is necessary that a model of the environment exists in this case so that the depth is constrained (here to the depth of the window).

[0035] Fig. 7 illustrates the concept of using a control interface to gather information from a UV. As shown in Fig. 7 the control interface includes a video button **700** above the UV. Pushing video button **700** causes video captured from a camera on the UV to be displayed in a video window **702**. Button **704** allows the user **102** to change the position of the camera, thereby controlling what the camera is capturing. It should be noted that when model information is incorporated in the system, it can be used to prevent occlusion of a landmark by video window **702**. Fig. 7 also illustrates the general use of action buttons. In addition to gathering information from a UV, action buttons can perform any number of predetermined functions. For example, action button **706**, when activated, makes the UV return to the home base. Action buttons can also make a UV perform a series of steps so that complex operations can be completed. For example, an action button could make a UV perform all the steps necessary for a refueling operation.

[0036] It should be noted that the GUI control system is not limited to a UV and can include any type of electro-mechanical devices. For example, the system could be used for controlling robots where the robots are stationary, but have tools that can be controlled (e.g. welding, drilling, etc.).

[0037] The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

CLAIMS

1. A method of identifying and controlling an unmanned vehicle located within an environment comprising the steps of:

receiving information from one or more sensors coupled to the unmanned vehicle, where the information includes sensor location information and status information about the vehicle;

obtaining viewpoint information corresponding to a real-time view of said environment and the unmanned vehicle;

generating graphics using said sensor location information and viewpoint information, wherein the graphics include visual representations of controls and the status information;

displaying the generated graphics on a display remote from the unmanned vehicle such that the graphics are superimposed on the real-time view, wherein the graphics appear attached to the unmanned vehicle; and

activating one of the displayed controls.

2. The method of claim 1, wherein visual representations of status information include:

an identifier that identifies the unmanned vehicle.

3. The method of claim 1 or 2, wherein the displayed control includes:

an action button that when activated displays information captured from a number of said one or more sensors coupled to the unmanned vehicle.

4. The method of any one of claims 1 to 3, wherein the displayed control includes:

arrows that upon being selected move the unmanned vehicle in the direction selected.

5. The method of any one of claims 1 to 4, wherein the displayed control includes:
an icon next to a vehicle that upon being moved to a location moves the unmanned vehicle to a corresponding location.
6. The method of any one of claims 1 to 5, wherein the displayed control includes:
an action button next to a vehicle that upon being activated commands the vehicle to move to a predetermined location.
7. The method of any one of claims 1 to 6, wherein the displayed control includes:
an action button next to a vehicle that upon being activated commands the vehicle to perform a series of operations.
8. An augmented reality system for identifying and controlling an unmanned vehicle located within an environment comprising:
one or more sensors coupled to the unmanned vehicle;
a tracking system that obtains viewpoint information corresponding to a real-time view of said environment and the unmanned vehicle;
a processing system that receives information from said one or more sensors, where the information includes sensor location information and status information about the unmanned vehicle, and generates graphics using said sensor location information and said viewpoint information, wherein the graphics include visual representations of controls and said status information;
a display that displays the generated graphics remote from the unmanned vehicle such that the graphics are superimposed on the real-time view, wherein the graphics appear attached to the unmanned vehicle; and
an interaction device that activates one of the displayed controls.

9. The augmented reality system of claim 8, wherein visual representations of status information include:

an identifier that identifies the unmanned vehicle.

10. The augmented reality system of claim 8 or 9, wherein the displayed control includes:

an action button that when activated displays information captured from a number of said one or more sensors coupled to the unmanned vehicle.

11. The augmented reality system of any one of claims 8 to 10, wherein the displayed control includes:

arrows that upon being selected move the unmanned vehicle in the direction selected.

12. The augmented reality system of any one of claims 8 to 11, wherein the displayed control includes:

an icon next to a vehicle that upon being moved to a location moves the vehicle to a corresponding location.

13. The augmented reality system of any one of claims 8 to 12, wherein the displayed control includes:

an action button next to a vehicle that upon being activated commands the vehicle to move to a predetermined location.

14. The augmented reality system of any one of claims 8 to 13, wherein the displayed control includes:

an action button next to a vehicle that upon being activated commands the vehicle to perform a series of operations.

15. An augmented reality system for identifying and controlling an unmanned apparatus located within an environment comprising:

one or more sensors coupled to the apparatus;

a tracking system that obtains viewpoint information corresponding to a real-time view of said environment and the unmanned apparatus;

a processing system that receives information from said one or more sensors, where the information includes sensor location information and status information about the unmanned apparatus, and generates graphics using said sensor location information and said viewpoint information, wherein the graphics include visual representations of controls and said status information;

a display that displays the generated graphics remote from the unmanned apparatus such that the graphics are superimposed on the real-time view, wherein the graphics appear attached to the unmanned apparatus; and

an interaction device that activates one of the displayed controls.

16. The augmented reality system of claim 15, wherein the unmanned apparatus is a robotic device and the interaction device controls the robotic device.

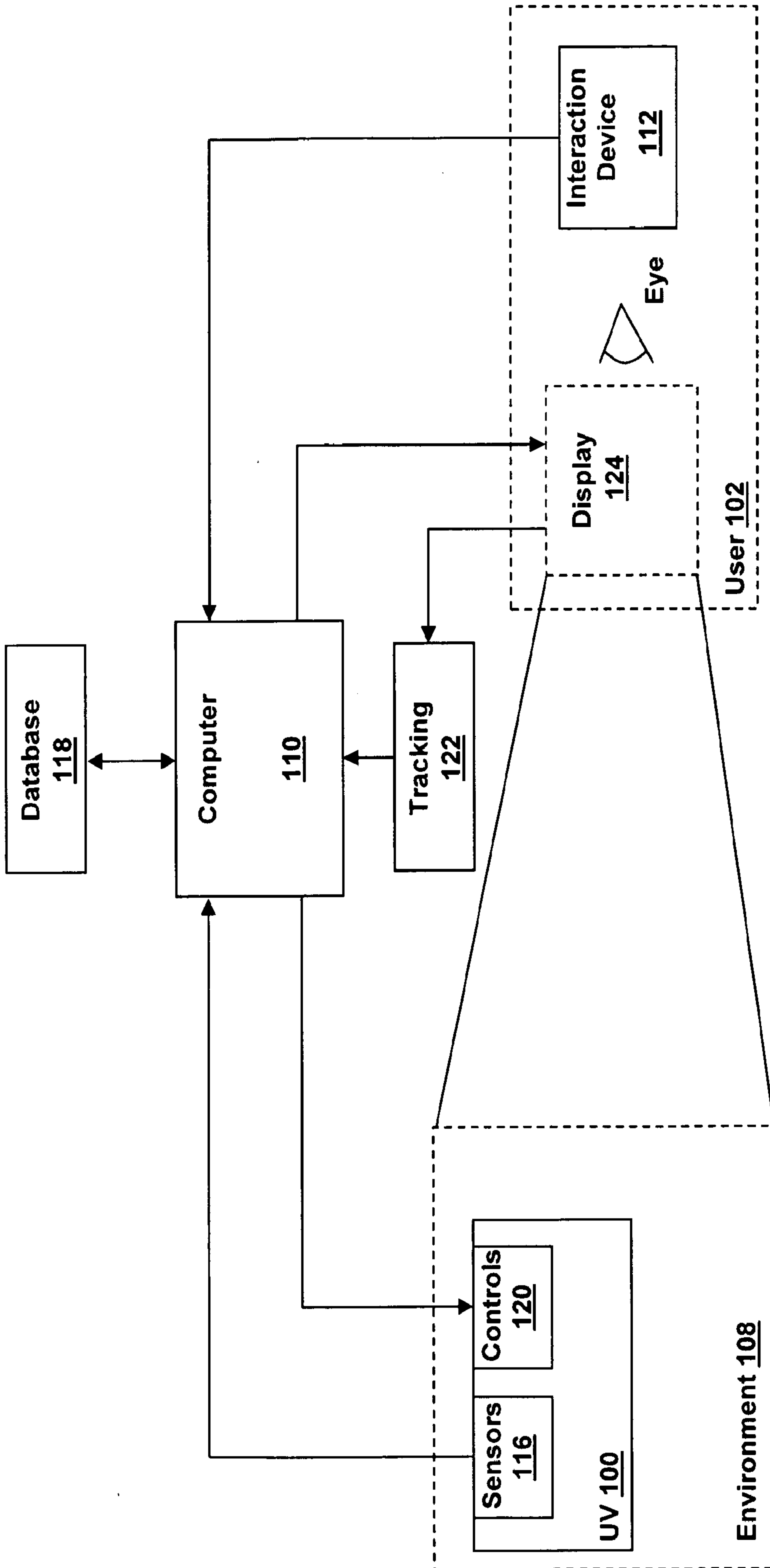


Fig. 1

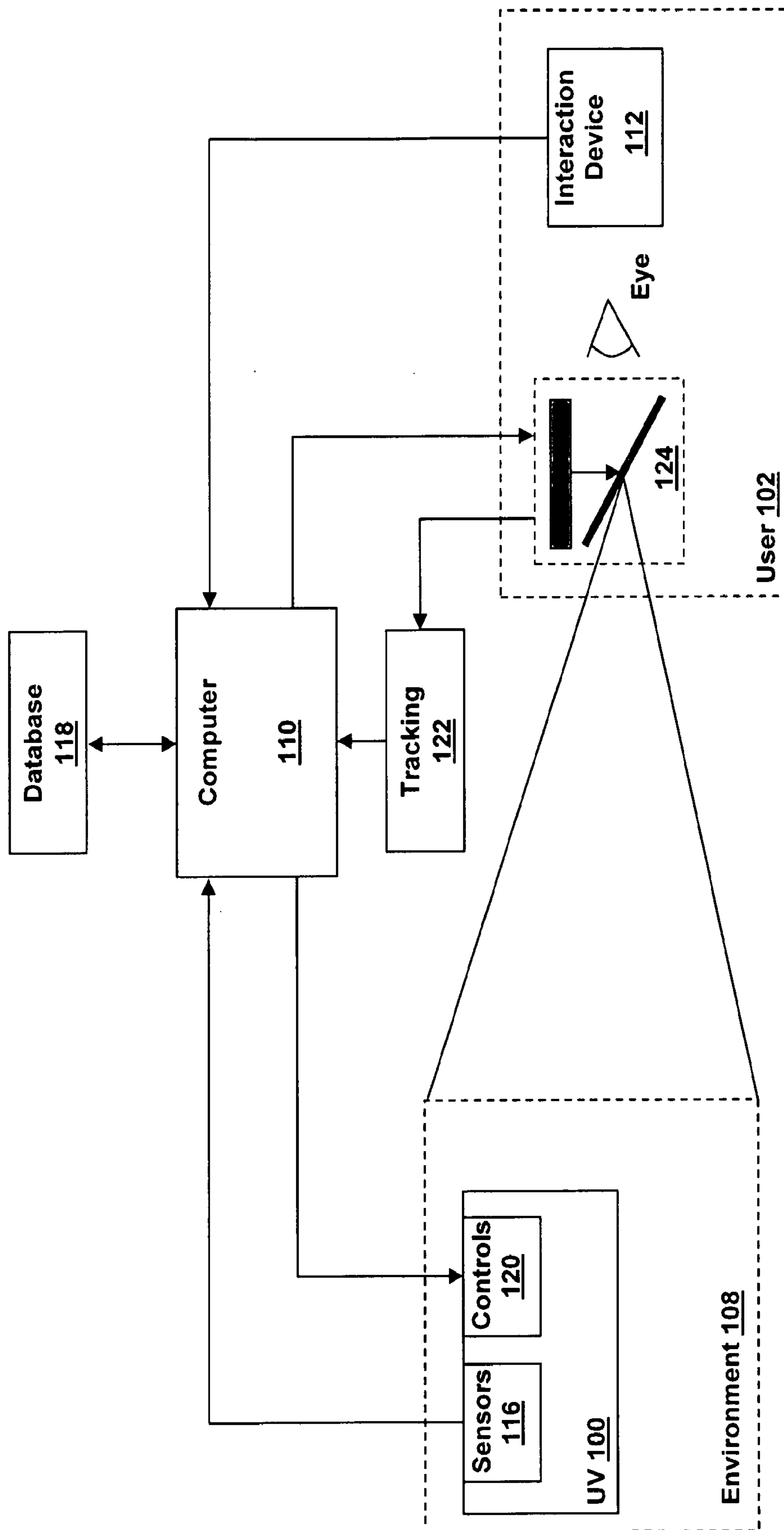


Fig. 2

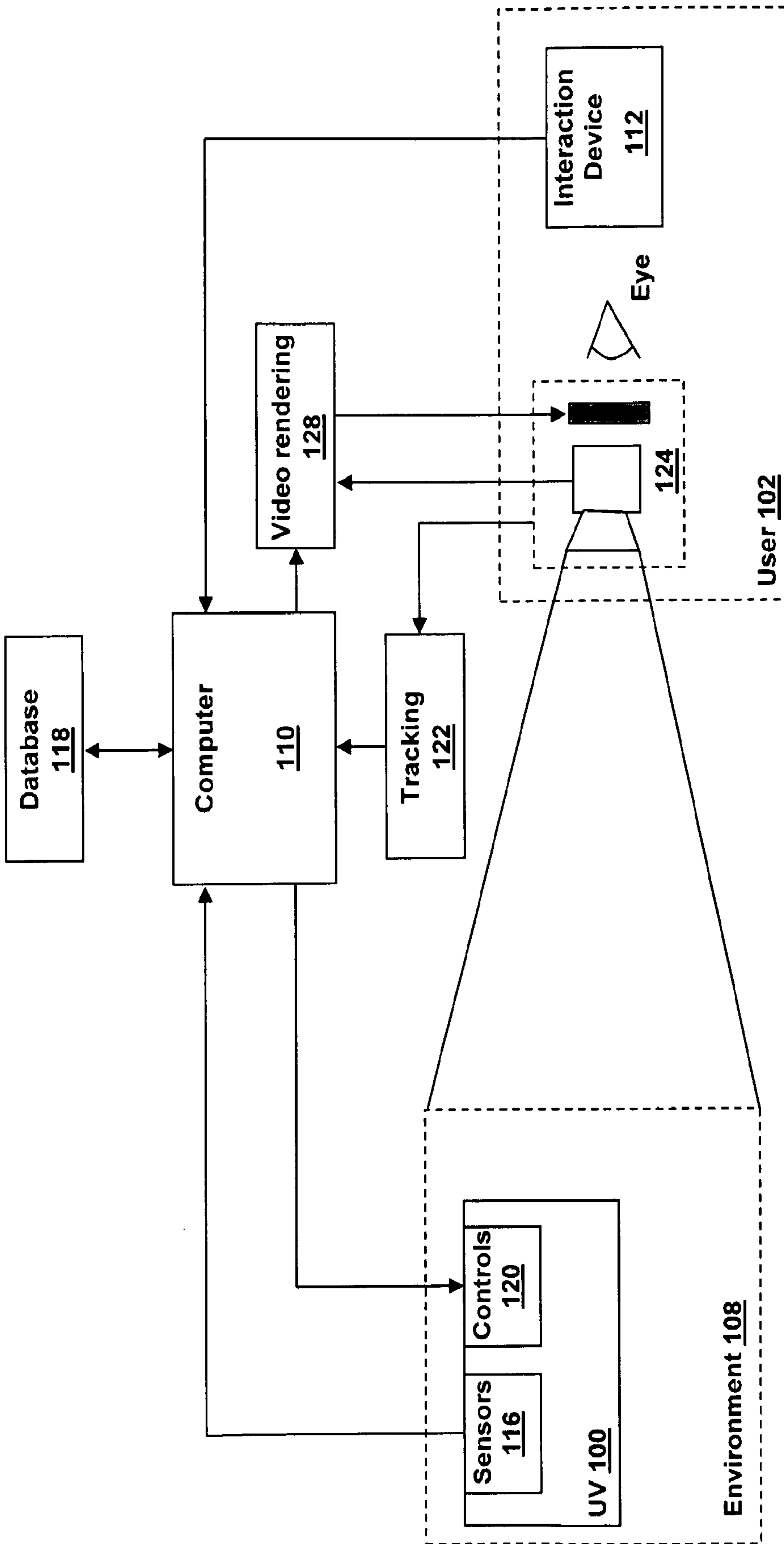


Fig. 3

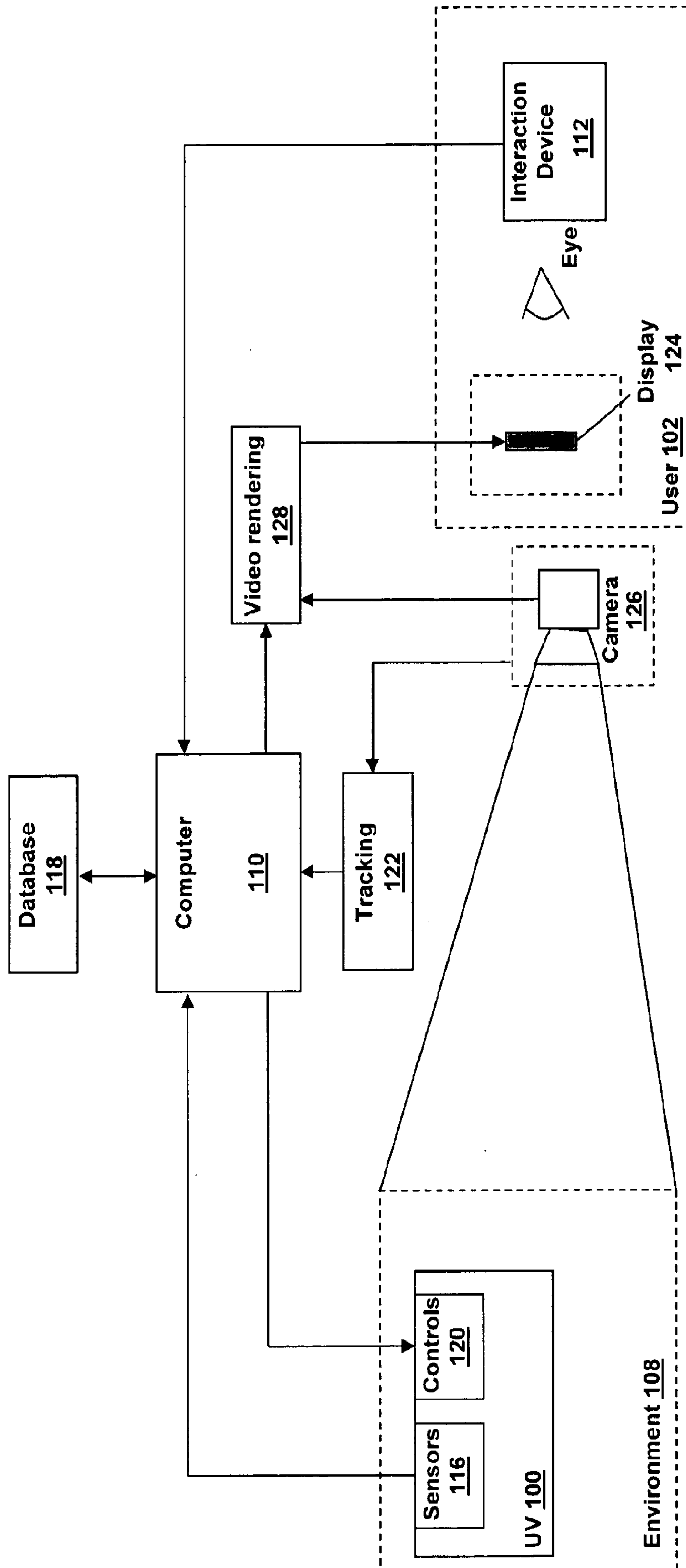


Fig. 4

User's View

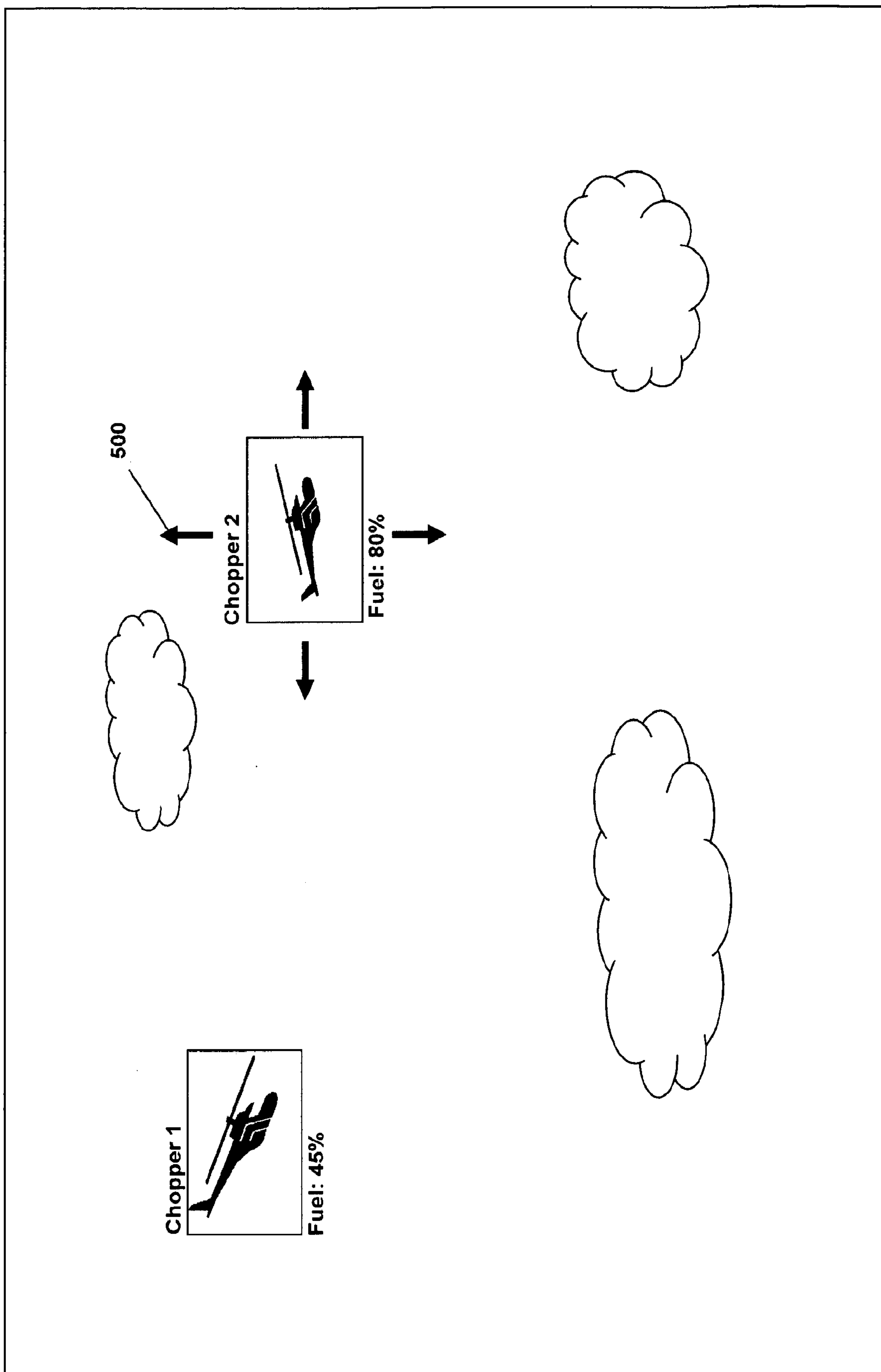


Fig. 5

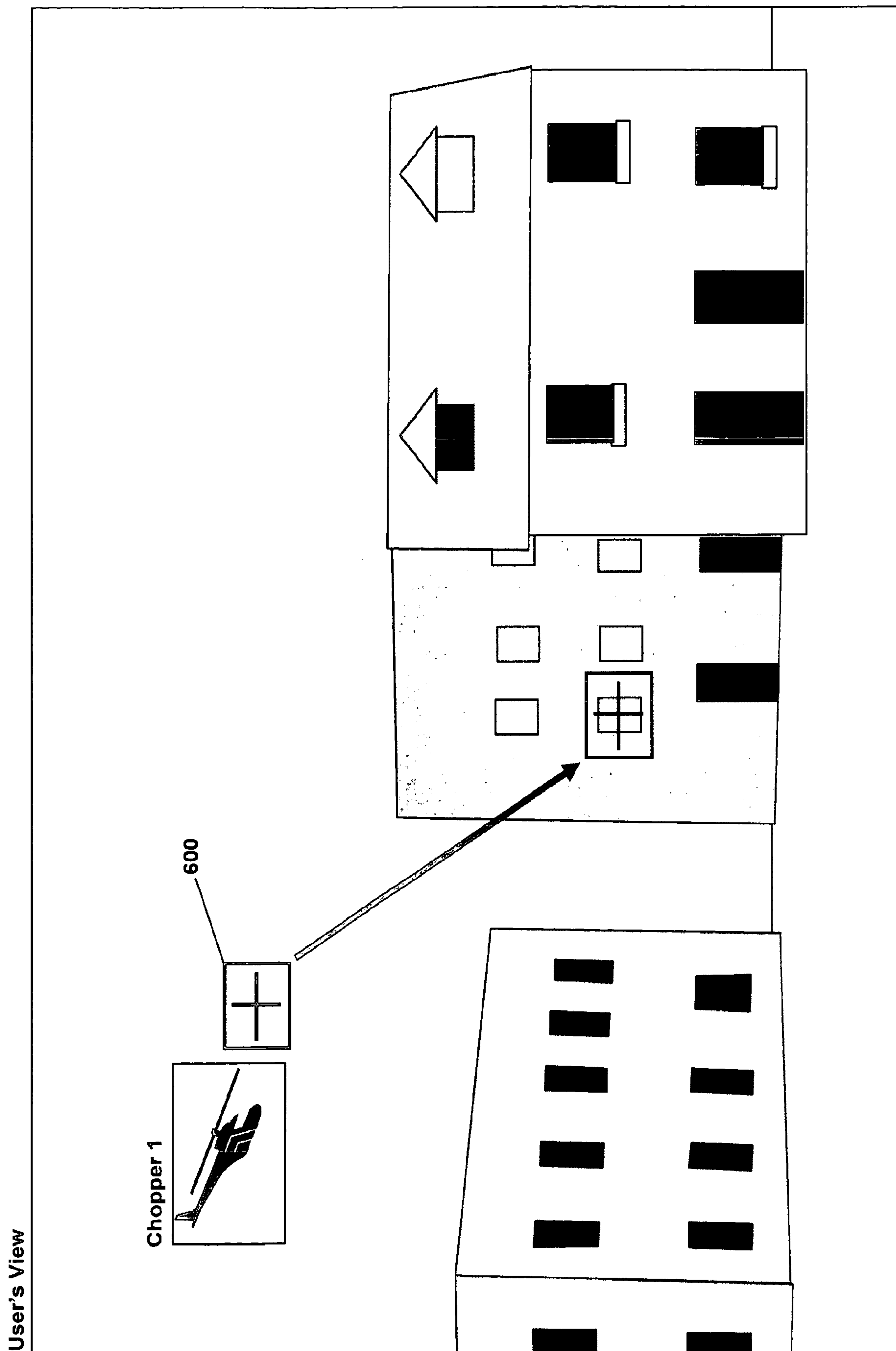


Fig. 6

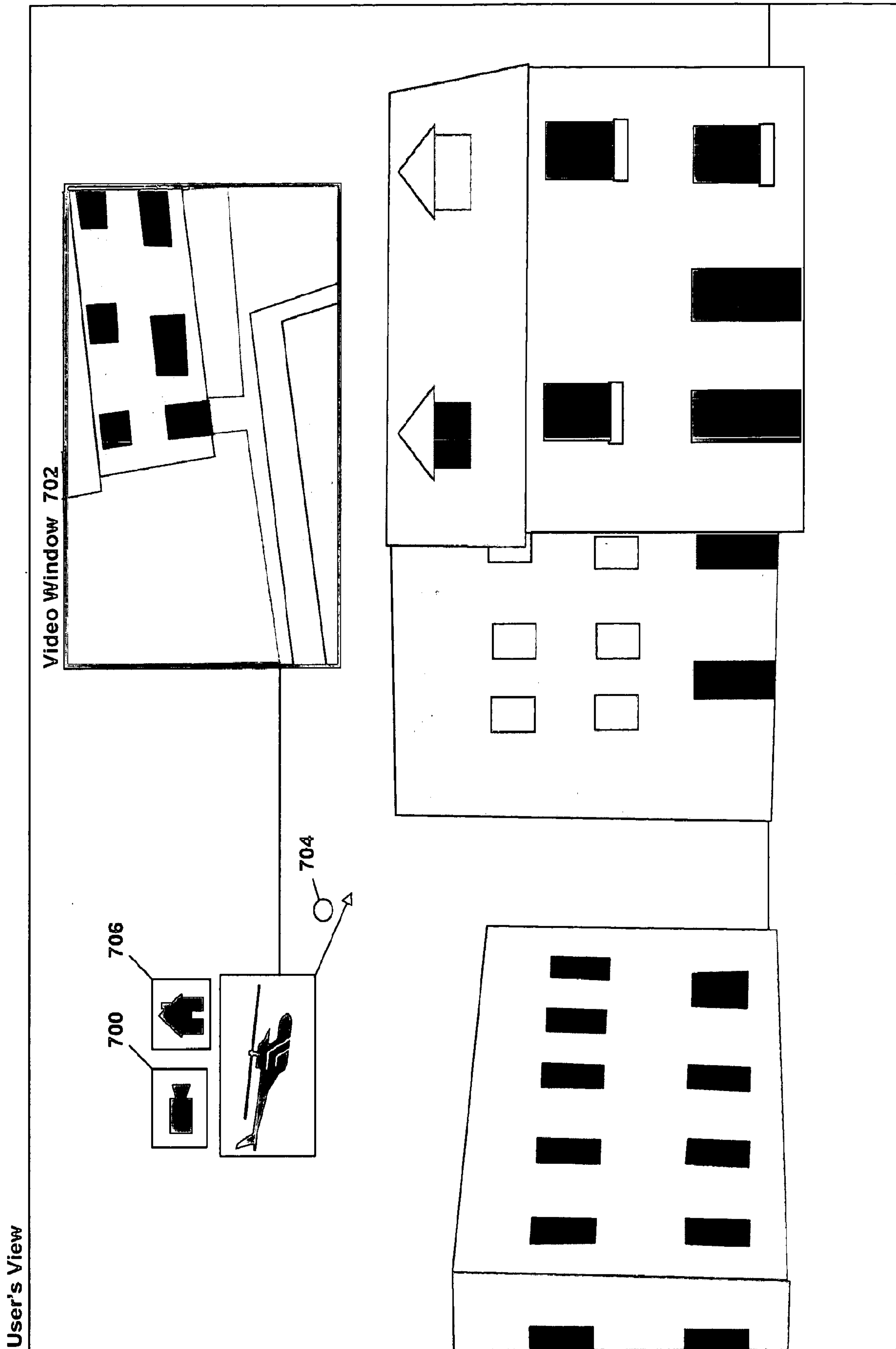


Fig. 7

