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Virtual Reality Re-Centering

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Abstract:

A virtual reality player often views a virtual reality scene of a virtual world while the player is located in a physical world via a head-mounted display. If the physical world is a virtual reality room, the scene can be re-centered within a known region, where stationary objects in the physical world (furniture, walls, etc.) may be accounted for via data such as maps or dimensions of the virtual reality room. However, in instances where the physical world is not a virtual reality room, such as a random standing space or a couch of a player's house, a virtual reality content system cannot rely on such data, leaving the player's proximity to objects in the room unknown. Apparatuses and methods are described that, for such instances, establish a reference location in the physical world as a head-mounted display is donned (*e.g.*, don origin) and subsequently monitor location of the head-mounted display as the player changes location in the physical world. Such apparatus and methods may indicate to a player if thresholds of a clearance zone have been violated, allowing the player to assess his surroundings prior to continuing play.

Keywords:

Virtual reality, head-mounted display, clearance, don origin, re-center, location, position, physical world, tracking

Background:

Virtual reality (VR) environments rely on display, tracking, and VR-content systems. Through these systems, realistic images, sounds, and sometimes other sensations simulate a user's physical presence in an artificial environment. Each of these three systems are illustrated below in Fig. 1.

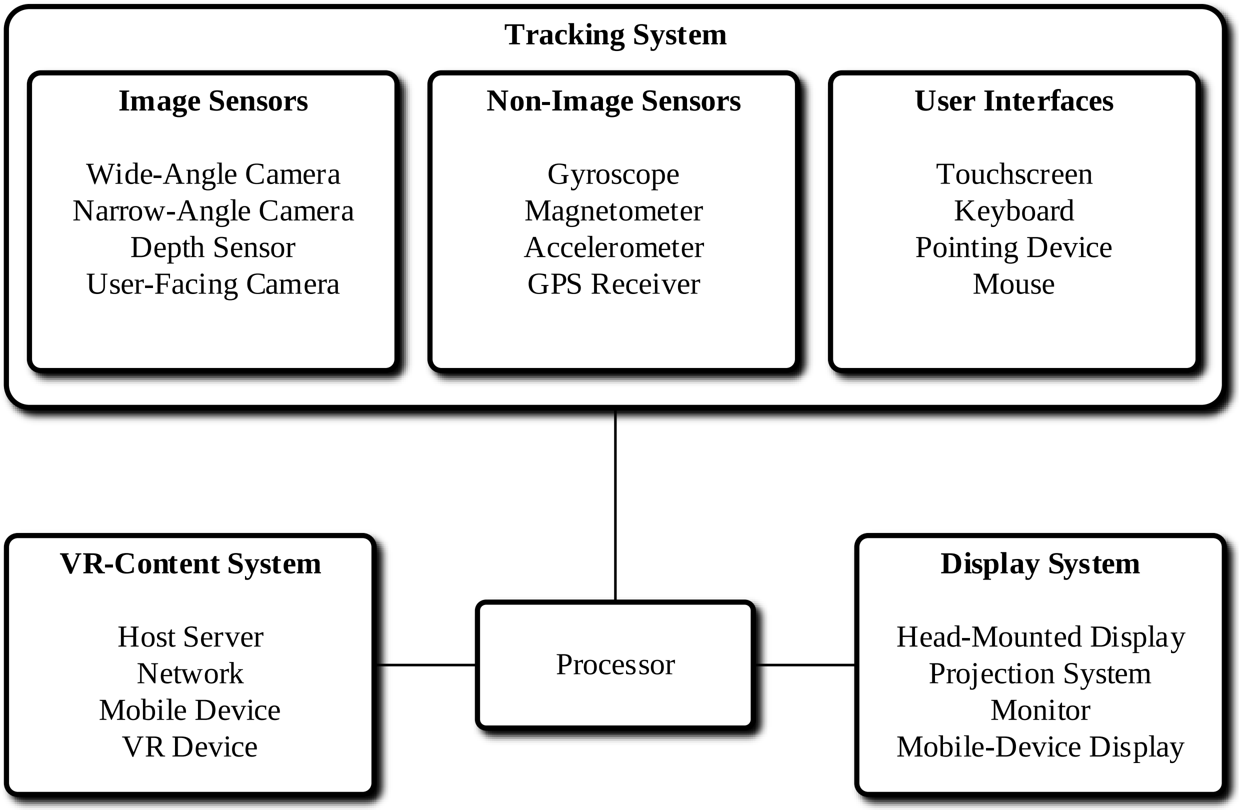

Fig. 1

The systems described in Fig. 1 may be implemented in one or more of various computing devices that can support VR applications, such as servers, desktop computers, VR goggles, computing spectacles, laptops, or mobile devices. These devices include a processor that can manage, control, and coordinate operations of the display, tracking, and VR-content systems. The devices also include memory and interfaces. These interfaces connect the memory with the systems using various buses and other connection methods as appropriate.

The display system enables a user to "look around" within the virtual world. The display system can include a head-mounted display, a projection system within a virtual-reality room, a monitor, or a mobile device's display, either held by a user or placed in a head-mounted device.

The VR-content system provides content that defines the VR world, such as images and sounds. The VR-content system provides the content using a host server, a network-based device, a mobile device, or a dedicated virtual reality device, to name a few.

The tracking system enables the user to interact with and navigate through the VR world, using sensors and user interfaces. The sensors may include image sensors such as a wide-angle camera, a narrow-angle camera, a user-facing camera, and a depth sensor. Non-image sensors may also be used, including gyroscopes, magnetometers, accelerometers, GPS sensors, retina/pupil detectors, pressure sensors, biometric sensors, temperature sensors, humidity sensors, optical or radio-frequency sensors that track the user's location or movement (*e.g.*, user's fingers, arms, or body), and ambient light sensors. The sensors can be used to create and maintain virtual environments, integrate "real world" features into the virtual environment, properly orient virtual objects (including those that represent real objects, such as a mouse or pointing device) in the virtual environment, and account for the user's body position and motion.

The user interfaces may be integrated with or connected to the computing device and enable the user to interact with the VR world. The user interfaces may include a touchscreen, a keyboard, a pointing device, a mouse or trackball device, a joystick or other game controller, a camera, a microphone, or an audio device with user controls. The user interfaces allow a user to interact with the virtual environment by performing an action, which causes a corresponding action in the VR world (*e.g.*, raising an arm, walking, or speaking).

The tracking system may also include output devices that provide visual, audio, or tactile feedback to the user (*e.g.*, vibration motors or coils, piezoelectric devices, electrostatic devices, LEDs, strobes, and speakers). For example, output devices may provide feedback in the form of blinking and/or flashing lights or strobes, audible alarms or other sounds, songs or other audio files, increased or decreased resistance of a control on a user interface device, or vibration of a physical component, such as a head-mounted display, a pointing device, or another user interface device.

Fig. 1 illustrates the display, tracking, and VR-content systems as disparate entities in part to show the communications between them, though they may be integrated, *e.g.*, a smartphone mounted in VR goggles, or operate separately in communication with other systems. These communications can be internal, wireless, or wired. Through these illustrated systems, a user can be immersed in a VR world. While these illustrated systems are described in the VR context, they can be used, in whole or in part, to augment the physical world. This augmentation, called "augmented reality" or AR, includes audio, video, or images that overlay or are presented in combination with the real world or images of the real world. Examples include visual or audio overlays to computing spectacles (*e.g.,* some real world-VR world video games or information overlays to a real-time image on a mobile device) or an automobile's windshield (*e.g.,* a heads-up display) to name just a few possibilities.

In a particular embodiment of Fig. 1, the tracking system may be used, in conjunction with a head-mounted display and a VR-content system, to conveniently manage and control re-centering of scenes presented through the head-mounted display.

Description:

As part of immersing himself in a virtual reality (VR) world, a player may don ("put on") a virtual reality head-mounted display to view a scene. If the case of a portable virtual reality system, such as a mobile device that is integrated into the head-mounted display, each time the player immerses himself in the virtual reality world, his physical world is subject to change. Unlike a virtual reality room, a changing physical world is unpredictable, effectively rendering the changing physical world to be "un-mapped" by the virtual reality system. An un-mapped obstacle of the physical world, such as a piece of furniture, a wall, stairs, or a host server connected to a WiFi router, can interfere with a player as he moves around the physical world.

While interacting with a scene presented through the head-mounted display, the player often changes his location in the physical world by taking several steps, shifting his body position, and the like. During interaction, a player may desire to re-center a scene in order for him to continue interacting with a focal point or object of interest (consider, for example, a scene in which a player has been tracking prey; if the prey disappears from a field of view, the player may wish that the scene is re-centered such that the prey is back in the field of view while he maintains his location in the physical world). However, re-centering the scene about the player's changed location may locate a player proximate to objects he wishes to avoid as play continues (it would not be desirable for the player to take a step towards his prey in the virtual world and end up encountering stairs of the physical world).

To alleviate these challenges, a VR-tracking system is used to monitor a player's location with regards to thresholds that define a clearance zone within the physical world. By the VR-tracking system continuously monitoring a player's location in the physical world (while the player is immersed in the virtual reality world), the VR-tracking system may provide data that indicates if the player has wandered outside of the clearance zone; if so, the VR-content system prompts, via the head-mounted display, the player to re-assess his physical world prior to play continuing.

An illustration of a player located within the thresholds of a physical world clearance zone is illustrated in Fig. 2 below:

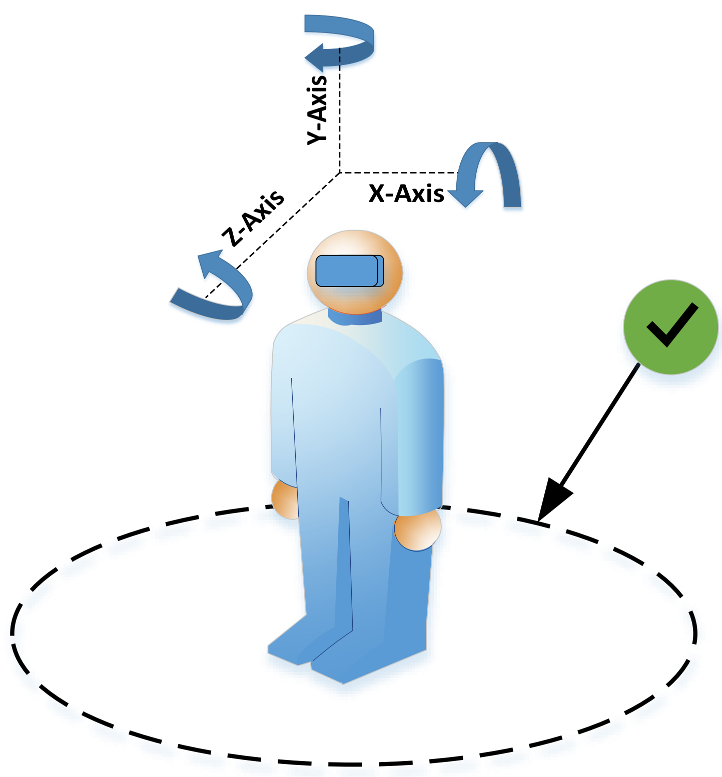

Fig. 2

As illustrated in Fig. 2, a player is located in a physical world. Thresholds defining a clearance zone within the physical world (in this example, the dashed line depicting a two-dimensional circular clearance zone) indicate a predetermined area in which a player can move about unobstructed and also in which the VR-content system can re-center a virtual reality scene without the need for the player to re-assess his surroundings. As the player dons the head-mounted display, one or more sensors in the head-mounted display (such as a proximity sensor indicating the user is donning the head-mounted display), sends a signal indicating to the VR-tracking system that the head-mounted display has been donned. The VR-tracking system establishes a don origin, after which one or more sensors of the head-mounted display (such as an accelerometer, gyroscope, laser, or GPS transceiver) is used by the VR-tracking system to monitor the player's location within the physical world. It is important to note that although the present example depicts thresholds of two-dimensional circular clearance zone, thresholds (*e.g.*, clearance zones) can be defined for any combination of one or more of six degrees-of-freedom available to the player. Thresholds may be configured and established, by the VR-content system, as necessary to maintain an unobstructed physical world for the player while he is immersed in a particular VR world.

As the virtual reality world is presented, a player may request that a VR-content system re-center a scene. At this point, based on data available from the VR-tracking system, the VR-content system ascertains whether the player is still within bounds of the clearance zone. If the player is still within the bounds of the clearance zone (for example, the player may have shifted his position while seated on a couch and would like to become more comfortable), the VR-content system re-centers the scene with no interruption to the player. However, if the player is not within bounds of the clearance zone (for example, the player has moved from the couch to a location near some stairs), the VR-content system re-centers the scene and then causes a clearance message to be displayed to the player, prompting the player to assess his location within, and surroundings of, the physical world. A sensor in the head-mounted display, such as the proximity sensor, may further indicate to the VR-content system whether the player has indeed checked his surroundings (*e.g.*, the player may be required to doff the head-mounted display to visually assess location and surroundings prior to continuing).

Fig. 3, below, illustrates a simplified flow diagram of previously described techniques performed in accordance with one or more aspects, including operations that may be performed by a virtual reality system comprising a VR-tracking system and a VR-content system:

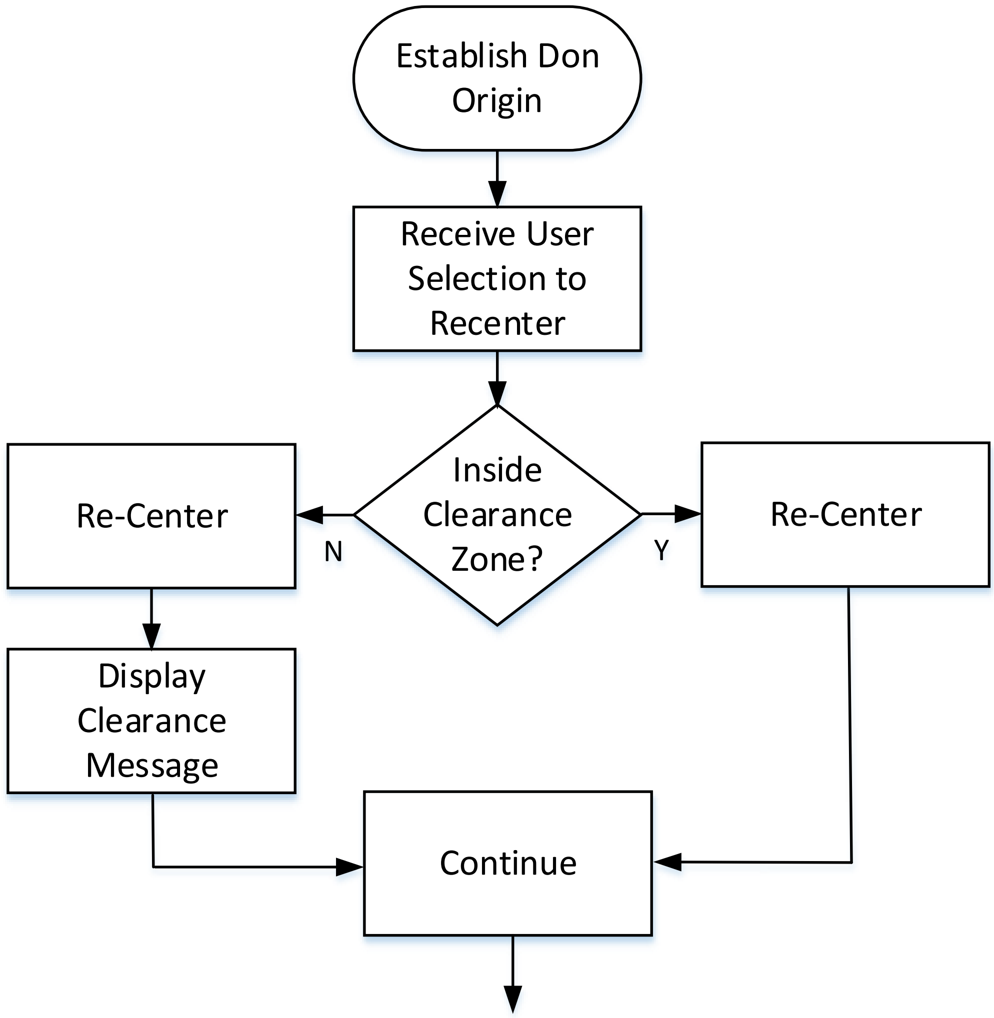

Fig. 3

As depicted in Fig. 3, once a don origin is established (by the VR-tracking system as a player dons a head-mounted display), the VR-content system may receive a selection by a user to re-center a scene that is being presented to the player. Based on data gathered by the VR-tracking system, the VR-content system determines whether the player's location in the physical world is inside a clearance zone (defined by clearance thresholds). If the player is located outside of the clearance zone, the VR-content system re-centers the scene and then displays a clearance message prompting the player to assess his location within, and surroundings of, the physical world prior to continuing play.

Although the example of a head-mounted display and visual messaging has been used to describe re-centering techniques, other embodiments are possible. Such embodiments may rely, at least in part, on audible methods (audible clearance warnings, commands, etc.), haptic methods (vibrations, etc.), and the like.