December 13, 2017

# Volumetric Rotational Control

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## Abstract:

Techniques are described that utilize a volumetric rotational control that can be activated and controlled in an intuitive manner using natural movements. To use the volumetric rotational control, the user operates a virtual reality (VR) controller to virtually touch a VR object that represents a selectable control that includes a collider. A collider is a physics object that can be added to a virtual object to give the virtual object "physical" properties and cause the virtual object to be subject to the "physics" of the VR environment. The user activates the volumetric rotational control by causing the VR controller to collide with the virtual object and "holding" the virtual object (*e.g.*, by pulling and holding a trigger on the controller). When activated, the selectable control represented by the virtual object transforms to display additional information and becomes adjustable via an intuitive interaction.



## Keywords:

Virtual reality, volumetric interface, virtual reality controls, user interface, rotational control


## 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.

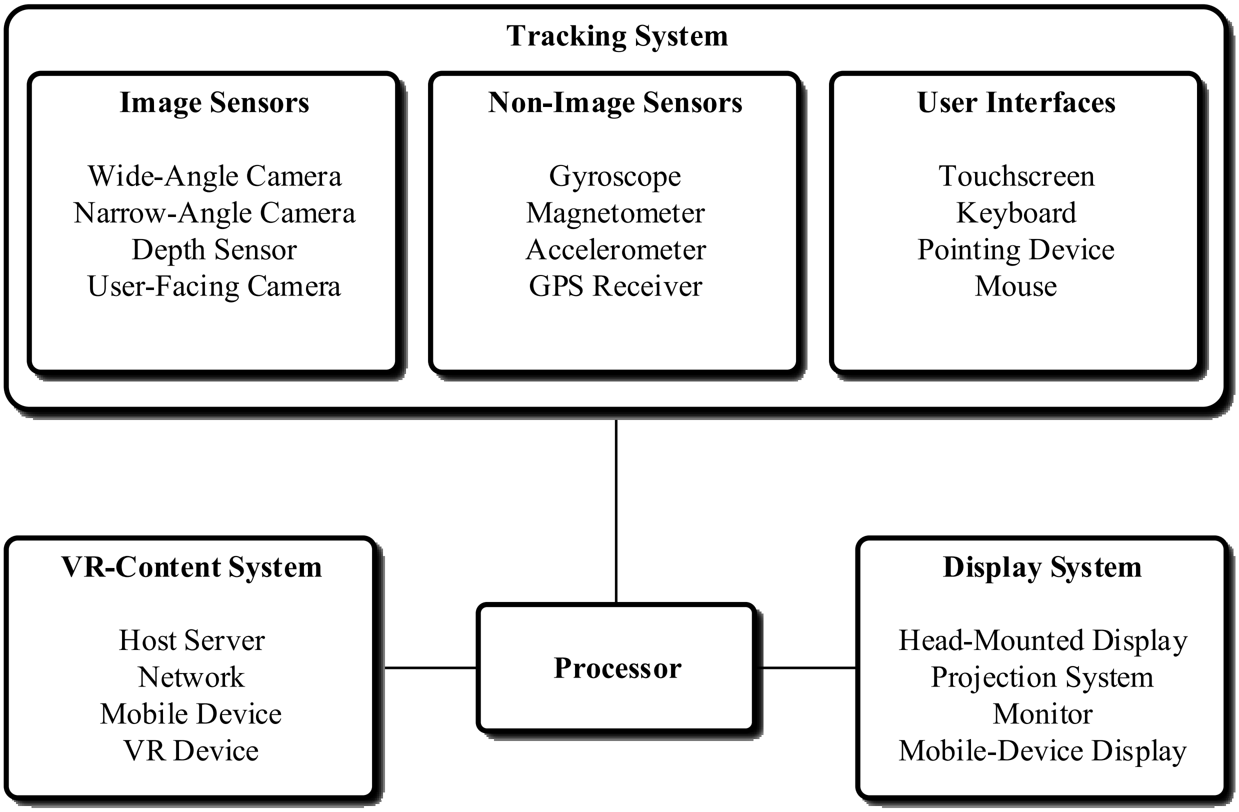


**Fig. 1**

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 environment, 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 environment, 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 environment. 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 environment (*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 environment. 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.

A particular configuration of the systems of Fig. 1 presents the user with a VR environment that includes a user interface (UI) that allows the user to adjust properties and parameters of the VR environment that is running. For example, the user may be able to adjust a variety of volumes in the VR environment (*e.g.*, sound effects, a soundtrack, or background music), adjust the brightness of the environment, or adjust the difficulty level of a game environment. To adjust a property using controls on the UI, a user may speak, gesture, or use a controller (*e.g.*, a device such as the pointing device described with reference to the tracking system of Fig. 1) to select the desired control and then adjust the property. The adjustments are often accomplished via a flat (two-dimensional or 2D) control that operates within the plane of the UI, such as slider.

An illustration of a conventional VR control is presented in Fig. 2. In this example, the control is a volume control, but it could be a control for any of a variety of functions. In Fig. 2, an un-activated volume control is shown as a speaker icon, and an activated volume control is shown as a horizontal linear slider.

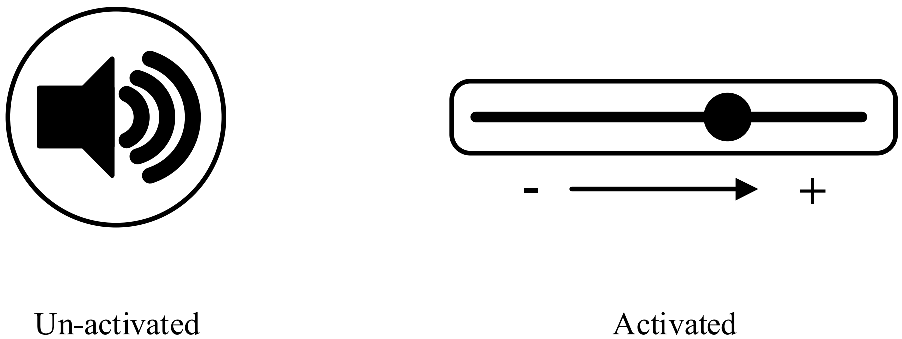


**Fig. 2**

In contrast, most interactions in VR environments involve items or icons that the user interacts with as if they were real objects. For example, if the user is in a game environment and, as part of the game, wants to make a room brighter, the player will likely interact with a virtual light source (a lamp), and make an intuitive motion, such as flipping a light switch. This is part of the immersive experience of VR. If the user has to use less-intuitive actions, and actions that are not virtual versions of "real" actions, to interact with and navigate through the VR system (*e.g.*, system volume, difficulty level), the quality of the VR experience may be reduced.

**Description:**

To address these problems, techniques are described that utilize a volumetric rotational control that can be activated and controlled in an intuitive manner using natural movements. To use the volumetric rotational control, the user operates a virtual reality (VR) controller to virtually touch a VR object that represents a selectable control. The selectable control has a "collider," which is a VR term for a physics object that can be added to a virtual object to give the virtual object "physical" properties (*e.g.*, weight, surface friction, and compressibility) and cause the virtual object to be subject to the "physics" of the VR environment (*e.g.*, the virtual gravity and momentum rules of the VR environment). The user activates the volumetric rotational control by causing the VR controller to collide with the virtual object and "holding" the virtual object (*e.g.*, by pulling and holding a trigger on the controller). When activated, the selectable control represented by the virtual object transforms to display additional information and becomes adjustable via an intuitive interaction.

As noted, because the volumetric rotational control adjusts the VR object that represents the selectable control by virtually touching it, selectable controls that work with the volumetric rotational control must include some kind of collider. The collider may conform to the object's shape and surface properties so that the object can be virtually "touched" in the VR environment. Many selectable controls and displays do not include a collider because they are activated without being touched (*e.g.*, via voice command or a pointing device) and therefore do not need to "touched" by the VR user.

The collider may be a simple collider, such as one having a simple shape, e.g., a box or a sphere. Simple colliders do not necessarily conform exactly to the shape of the objects to which they are attached. In the examples illustrated in Fig. 4, Fig. 5, and Fig. 6, the VR object that represents the selectable control has a circular shape and uses a spherical collider, though other simple colliders would work. In some cases, however, a mesh collider may be more appropriate. A mesh collider has a shape that conforms, to varying degrees, to the shape of the object to which it is attached. Mesh colliders can be useful when the object that represents the selectable control has an unusual shape, such as a lever, or is in a location near other controls that include colliders, because in those cases, a box collider or a sphere collider may interfere with the colliders on the other controls.

Fig. 3 illustrates an example implementation of the volumetric rotational control used with a selectable volume control that includes a collider. In the example of Fig. 3, the user operates the VR controller (which includes a trigger) to virtually touch the selectable volume control.

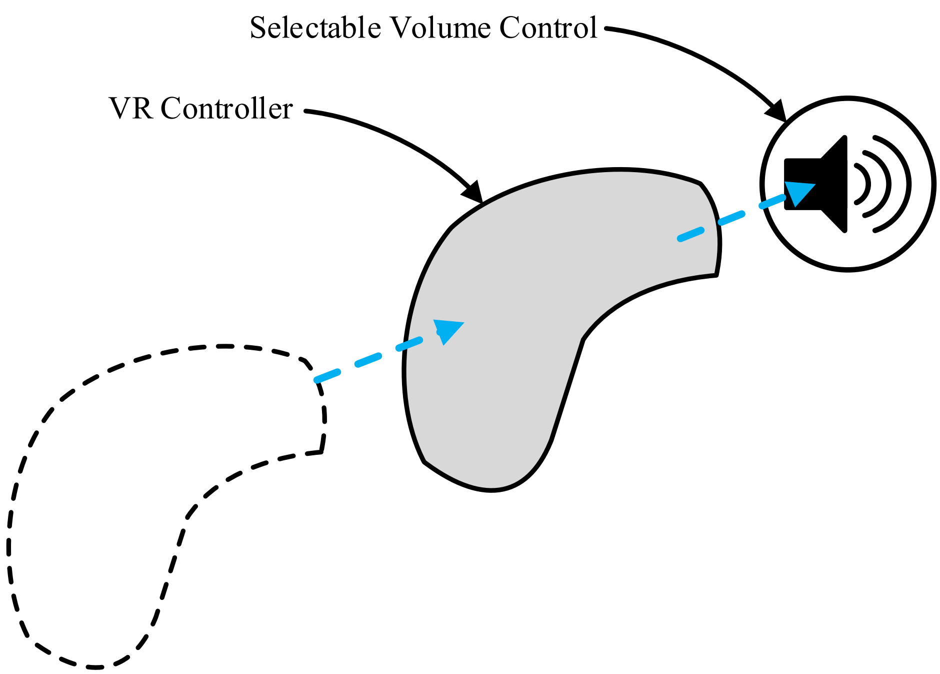


**Fig. 3**

As shown in Fig. 3, the user moves the VR controller, in the VR environment, toward the selectable volume control (shown as dashed blue arrows). When the VR controller collides with the selectable volume control, the selectable volume control transforms to display additional information about the control and the property it controls. The user can pull and hold the trigger on VR controller to "hold" the selectable volume control and enable the property controlled by the object (*e.g.*, an audio volume) to be adjusted by rotation of the VR controller. As noted, the volumetric rotational control works with selectable control objects that include a collider.

Continuing with the volume control example, Fig. 4 illustrates the transformation of the object that represents the selectable control. In Fig. 4, the user has collided the VR controller with the selectable volume control, which has expanded around the VR controller.

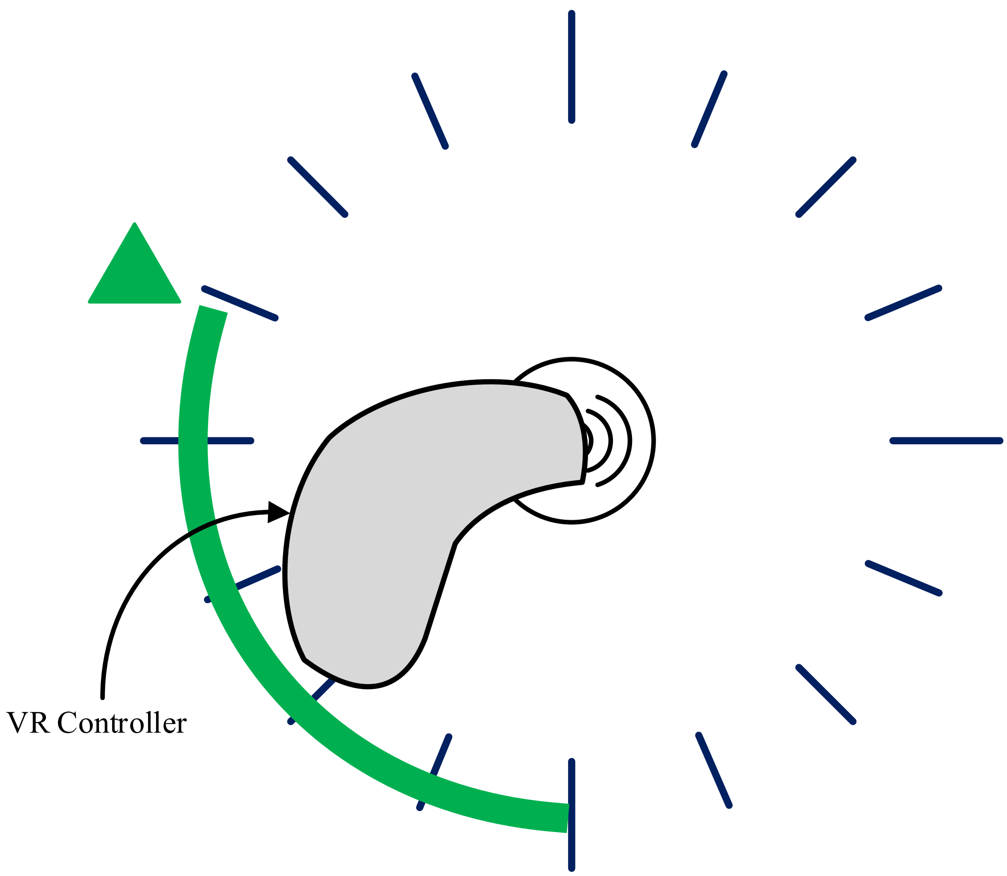


**Fig. 4**

The expansion provides a clearer view of the control and improves resolution. Additionally, a green line shows the current level of the property controlled by the selectable control object (*e.g.*, the volume level) and a green arrow indicates the default point from which additional adjustments will be made when the user pulls the trigger and rotates the VR controller (*e.g.*, the location of the controller relative to the display). The arrow is an optional feature and both the line and the arrow may be displayed in different colors, shapes, or thicknesses.

Fig. 5 illustrates an example of the result when the user rotates the VR controller clockwise and adjusts the volume level. A yellow line shows the amount of increase and the optional green arrow marks a new default position.

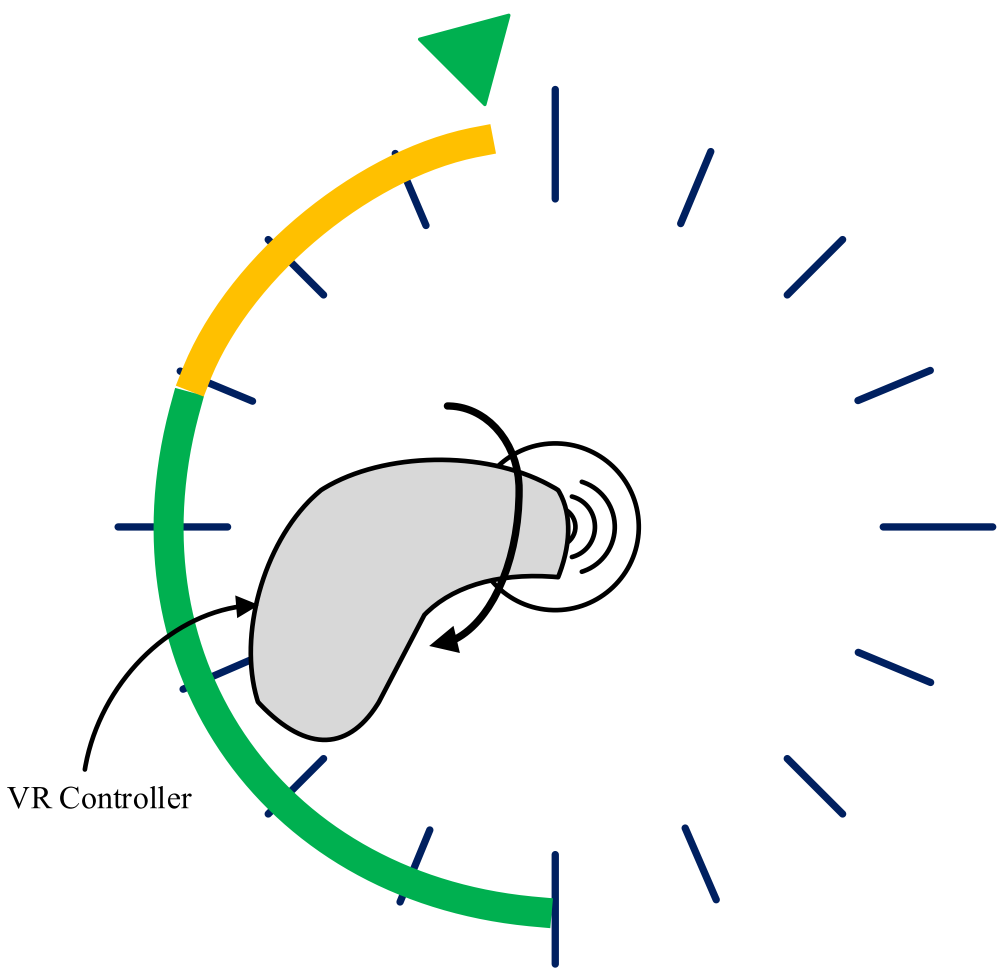


**Fig. 5**

The expanded display may take a variety of different forms. For example, because the user's wrist does not typically have 360 degrees of rotation, the expanded display may also show fewer than 360 degrees. For example, Fig. 6 illustrates examples of the expanded display of the selectable control object with 270 degrees and 180 degrees.

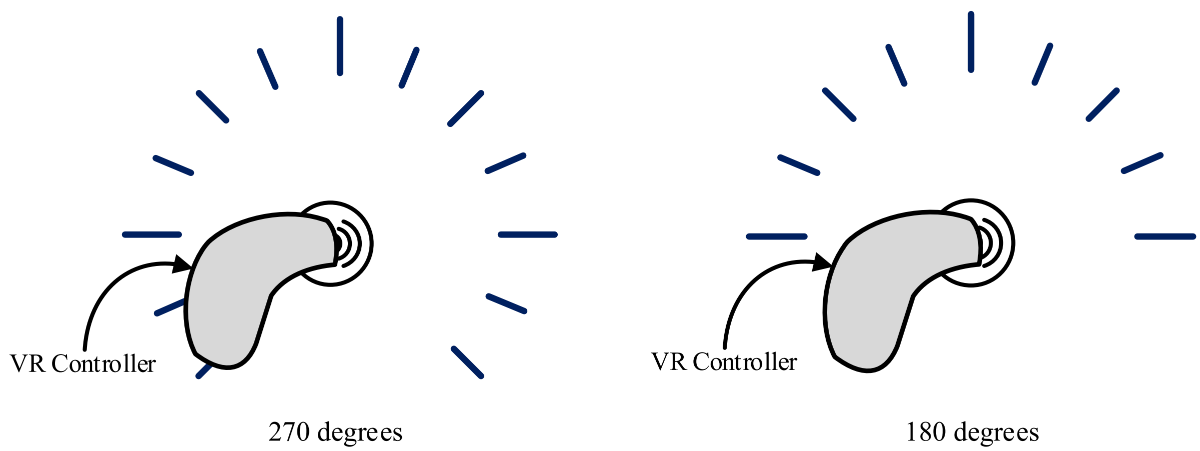


**Fig. 6**

In its expanded form, the selectable control object is also positionally parented to the controller (the expanded display is the child). The positional parenting allows the expanded display to move with the controller. Thus, if the user activates the expanded display, and then moves the controller laterally (as opposed to rotational movement) the expanded display will stay centered around the controller as shown in Fig. 4 and Fig. 5. If the user moves the controller out of the collision range of the selectable virtual object, then the object reverts back to its original appearance, as shown in Fig. 2 and Fig. 3.