October 02, 2017

Three-Dimensional (3D) Audio Laser for Virtual Reality Systems

Xavier Benavides Palos

Adam Glazier

Three-Dimensional (3D) Audio Laser for Virtual Reality Systems

Abstract:

A three-dimensional (3D) audio laser for VR systems is provided. The 3D audio laser is a system that includes a laser pointer and a dedicated audio location control. The system uses sound to orient a user to a virtual object and to provide an audible description of the virtual object. A location and a name (or other description) of virtual objects in the VR environment are known to the VR system. When the user aims the laser pointer at a particular virtual object and selects the dedicated audio location control, the VR system plays a series of tones with simulated locations at specified distances between the user and the virtual object. The distances are known to the user (*e.g.*, given in the user manual for the VR system). After the series of tones is played, the name or description of the virtual object is played. The user can thereby discover the name and location of the virtual object, even if it the user cannot visually determine them.

Keywords: virtual reality, VR, virtual reality navigation, audio laser, three-dimensional sound, 3D sound, audio location, echolocation, visual impairment, visual acuity

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.

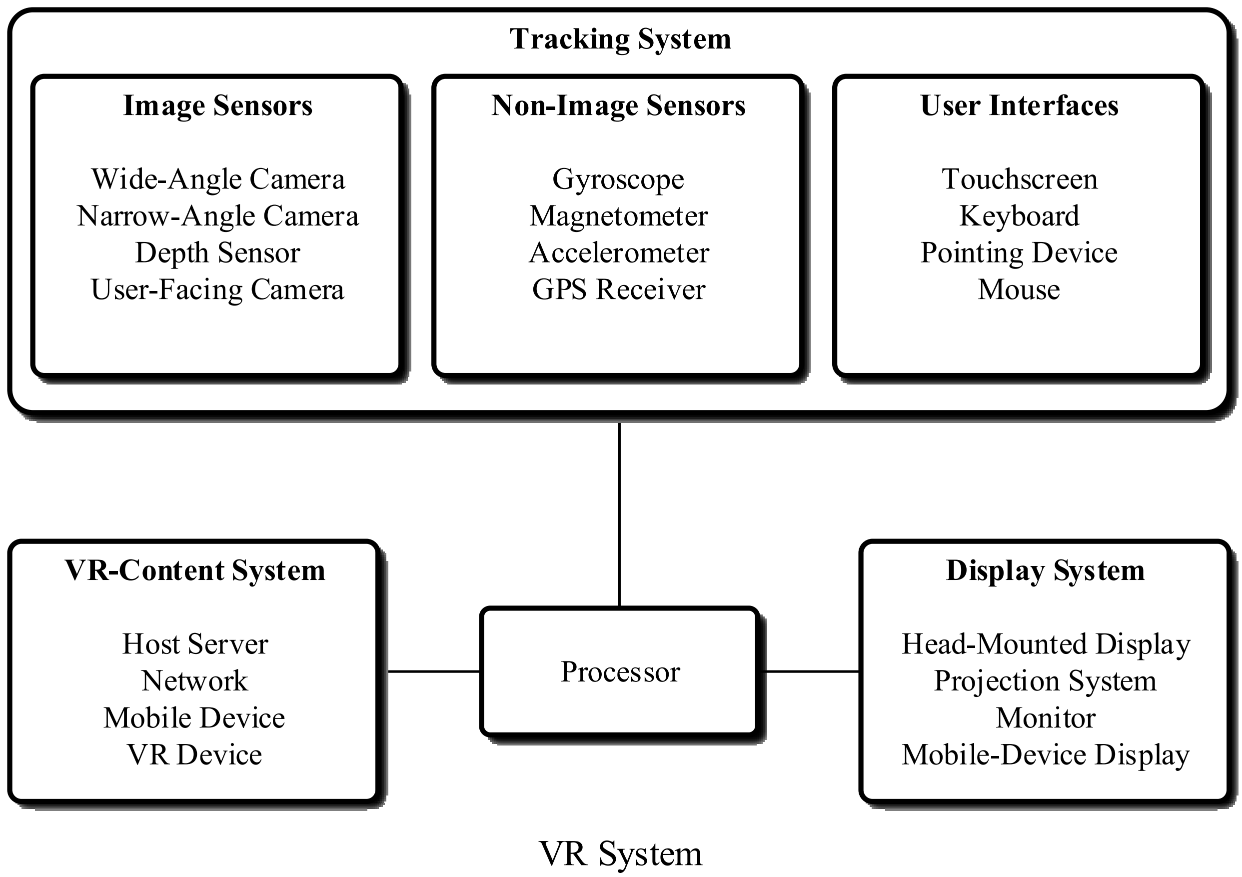

Fig. 1

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 a VR receiver, 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.

In some implementations of the VR system described in Fig. 1, it can be challenging to provide a quality VR experience to users that are visually impaired because many interactions in a VR environment are controlled by recognizing and pointing at objects using a controller. For users with reduced visual acuity, this method of interaction is difficult because the user may not be able to recognize some objects in order to locate or interact with them. This increases frustration and reduces the quality of the VR experience. Some existing solutions focus on using sound attenuation (decreasing or increasing volume) to give the user a rough of idea of the distance between the user and the object. This is of limited usefulness, however, if the user cannot identify or see the object to know what it is.

Description:

To improve navigation and interaction in a virtual reality (VR) environment for users with a visual impairment, a three-dimensional (3D) audio laser for VR systems is provided. The 3D audio laser is a system that includes a laser pointer and a dedicated audio location control. The system uses sound to orient a user to a virtual object and provide an audible description of the virtual object. A location and a name (or other description) of virtual objects in the VR environment are known to the VR system. When the user aims the laser pointer at a particular virtual object and selects the dedicated audio control, the VR system plays a series of tones with simulated locations at specified distances between the user and the virtual object. The distances are known to the user (*e.g.*, given in the user manual for the VR system). After the series of tones is played, the name or description of the virtual object is played. The user can thereby discover the name and location of the virtual object, even if it the user cannot visually determine them.

Fig. 2 illustrates the concept in a block diagram form. In the example shown in Fig. 2, VR system includes an audio location system. The audio location system includes a 3D audio laser module that contains the location and name and/or description of some or all of the virtual objects in a VR environment. The VR system includes a VR headset and a VR controller with a laser pointer and an audio location control. The user can aim the laser pointer (shown as a red arrow in Fig. 2) at a virtual object and select the audio location control. The 3D audio laser module then transmits the location of the virtual object to the user by generating a series of spatial locater tones (shown as a green dash-dot arrow in Fig. 2) that are simulated to sound as if they originate at pre-defined locations between the user and the selected virtual object. The VR headset receives the sounds from the 3D audio laser module and plays them for the user. Once the spatial locater tones have been played, the 3D audio laser module transmits the name of the virtual object (shown as an orange arrow in Fig. 2) to the VR headset, which plays the name. The name is simulated to sound as if it originates at the location of the virtual object.

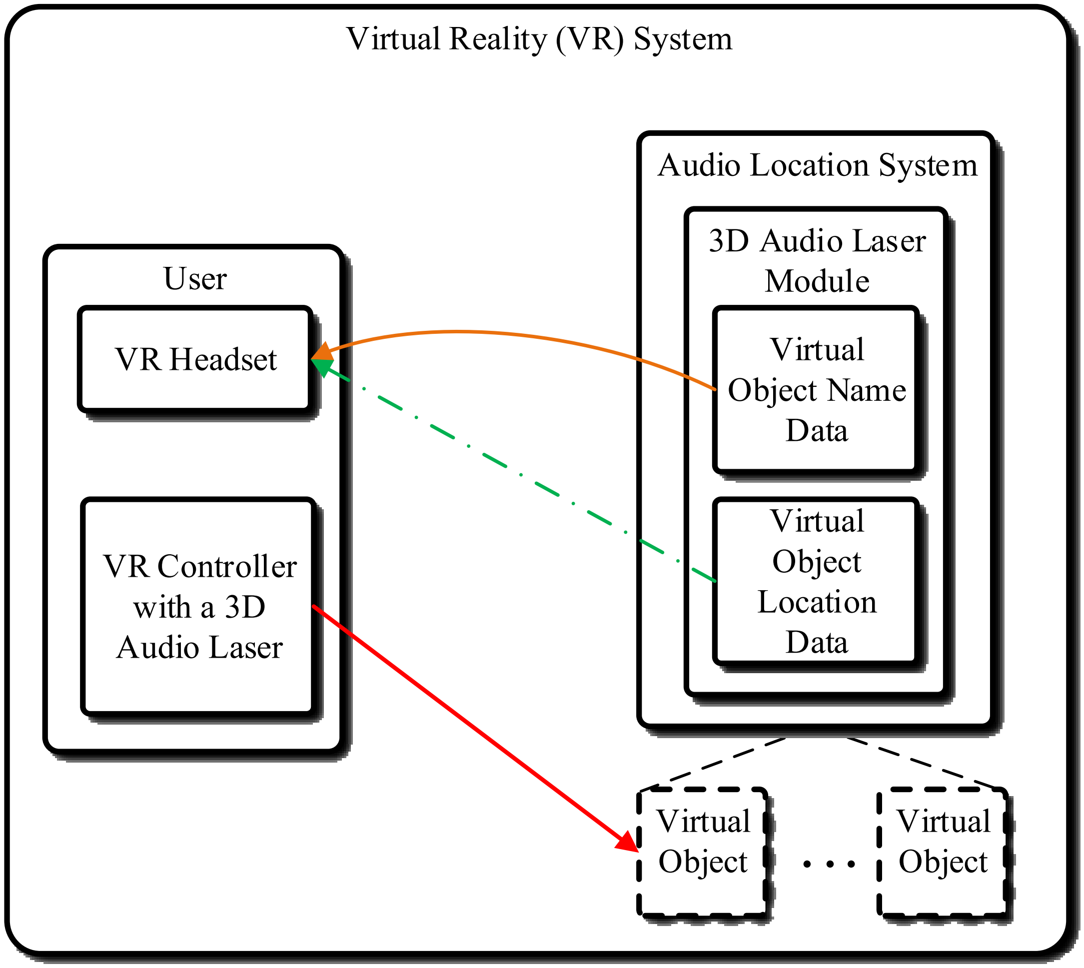

Fig. 2

Fig. 3 illustrates an example implementation of the 3D audio laser for VR systems (*e.g.*, the VR system of Fig. 1). In the example implementation shown in Fig. 3, a user aims the laser pointer at a virtual refrigerator (the laser is shown in Fig. 3 as a red arrow) and selects the dedicated audio location control. After recognizing that the user has selected the virtual refrigerator with the laser pointer, the audio location system plays the spatial locater tones to orient the user to the location of the virtual refrigerator.

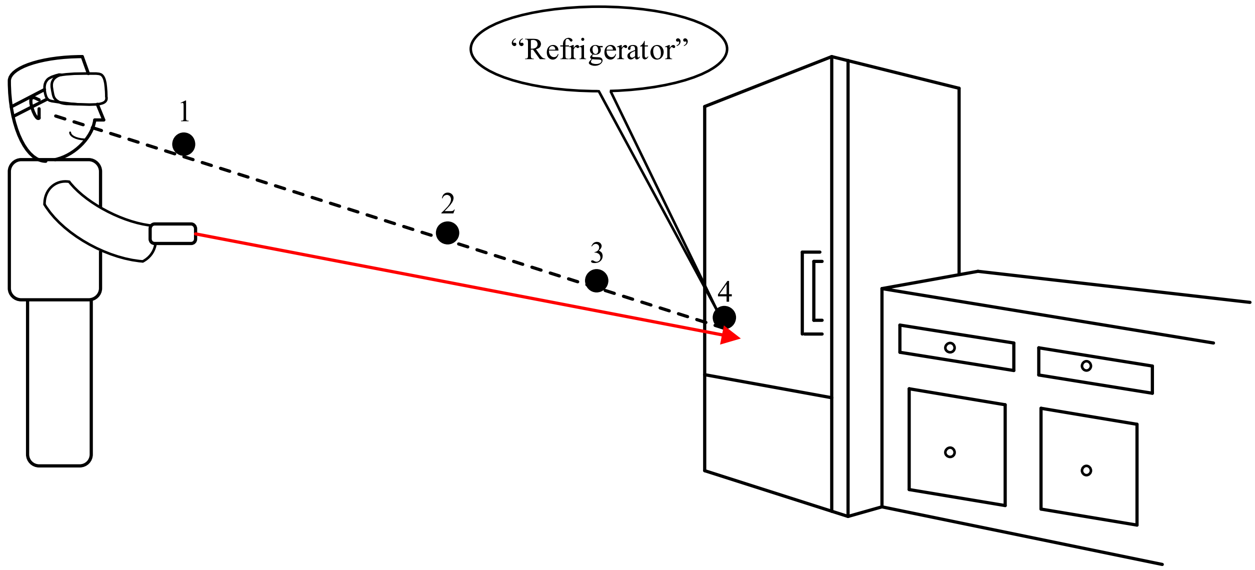

Fig. 3

The spatial locater tones include a wide spectrum of frequencies, which allows the user to perceive the tones as coming from different locations. The tones can be any of a variety of sounds, such as a click or a beep, which can be constructed using the wide frequency spectrum. In Fig. 3, there are four spatial locater tones, shown as numbered dots along a dashed line. The simulated location of tone 1 is in front of the user's face. The simulated location of tone 2 is approximately halfway between the user and the virtual refrigerator. The simulated location of tone 3 is approximately half way between the location of tone 2 and the virtual refrigerator and the simulated location of tone 4 is at the location of the virtual refrigerator. As the spatial locater tones play, the user is directed toward the location of the virtual refrigerator. After the spatial locater tones are played, the VR system plays the word "refrigerator" – simulated to sound as if it is coming from the virtual refrigerator.

In other implementations, the series of spatial locater tones can include more or fewer than four tones and/or the locater tones could be arranged in a different manner. For example, the series could be three tones, one in front of the user, one-half way to the selected virtual object, and one at the virtual object. The amount of time between tones can vary depending, for example, on the distance and the number of tones. In other cases, the tones are all played within a threshold time (*e.g.*, all the tones, whether there are two, four, or some other number, are played within one second or within half a second). As noted, the number of tones and the location of each tone are given to the user beforehand (*e.g.*, in the user manual for the VR system). This allows the user to know where the tones are supposed to be and thereby quickly learn to use the sounds to locate selected objects.

The 3D audio laser for VR systems enables users with visual impairments to enjoy a higher-quality VR experience. The 3D audio laser provides at least two enhancements. First, audio guidance, in the form of spatial locater tones, gives the user information about the location of selected objects in the VR environment. Second, the system says the name or description of selected virtual objects, which helps users to distinguish virtual objects from each other. Because many interactions in a VR environment are controlled by recognizing and pointing at objects using a controller, the 3D audio laser allows users with reduced visual acuity to fully interact with the environment, which can reduce frustration and increase the user's enjoyment of the VR experience.