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論 文 名

A Study on Effective View-Dependent Projection Mapping by Projecting Virtual Object and Real Background with Perspectively-Correct Appearance

学位論文要旨

Augmented Reality (AR) is a direct or indirect view of a physical, real-world environment whose elements are augmented by computer-based computer-generated sensory input. The inputs could differ from audio to visual. There is a fascination with AR because the technology records the real and virtual world together, and they run jointly in real-time in three dimensions. A viewer feels as if a virtual object existed in the real-world if the viewer from an arbitrary position correctly observes its geometrical appearance. The display of an image of a virtual object with its correct appearance according to the viewer' s position is called "view-dependent" display. In AR, a viewer usually uses his/her display device, such as a tablet, a smartphone, or special glasses, to display a view-dependent image for his/her arbitrary position. In contrast, "spatial augmented reality (SAR)" includes projection mapping, multiple viewers at different positions see a typical image projected on the surface of a real object, such as a wall, a building, and even a human, by the naked eyes without their own display devices. Subsequently, if the shape of the virtual object is different from that of the real object, a viewer at an arbitrary position sees a geometrically incorrect appearance of the virtual object. To display a geometrically correct appearance of a virtual object, the physical world object, which is the main projection area, would be left with presumably have nothing projected onto some parts of its surface. Such empty areas make the viewer realize the difference between the computer-generated virtual object and the real-world relatively easy. While other researchers have proposed lots of methods to solve the "geometrically incorrect appearance" problems, as far as we know, there is no existing method to treat the "empty area" problem. In this study, we propose a view-dependent projection mapping method to solve the "empty area" problem. Our method eliminates undesired empty areas by projecting the real-world background behind the computer-generated virtual object in a view-dependent way. Thereby, there will be a 3D object (any desired virtual object) which is going to be projected onto the real-world object, and behind the 3D object, there will be the real-world background, also going to be projected all in a view-dependent matter so we can show the viewers geometrically correct projection mapping all around the desired 3D object with the backgrounds, respectively. In our case, the method works with any given 3D object and any given background so theoretically there is no limit for what this view-dependent projection mapping could offer to the viewers. To treat a far background in a large space, even outdoors, the real background image is captured by an RGB camera, not an RGB-D camera with a depth range limit and converted to an appropriate image distorted accordingly for a viewer's position by using a background plane to approximate the background shape based on homography. No longer this is just a view-dependent projection mapping of a computer-generated real-world object is being displayed onto a physical object; this is an experience of the virtual and the real-world objects existing simultaneously consistently for a viewer who is in arbitrary positions. Thus, one idea is to utilize a captured depth image of near objects to determine optimal parameters for a background containing near and far objects. In the current practice, a camera is there to capture the background and a tracking sensor is there to track the viewer; all fixed near the real object and directed toward the sides opposite to each other. The first sensor tracks the viewer's movement to display the corrects view-dependent images, and the second sensor/camera will capture the background to be displayed in real-time behind the virtual objects. This configuration allows a viewer to see only one side of a virtual object projected on the real object's surface. In effect, two Kinect sensors are used as the camera and the tracking sensor, respectively. If each Kinect sensor works as both a camera and a tracking sensor, the viewer can see two opposite sides of the virtual object. By expanding this configuration, we are planning to develop a system to allow a viewer to enjoy a 360-degree view of a virtual object merging into its factual background by using multiple Kinect sensors.