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Intuitive Spatial Drawing System based on Hand Interface

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[요 약]

VR 관련 기술들의 발달로 인하여 VR 기기의 성능이 좋아지고 보급화가 가능한 가격이 되면서 많은 사람들이 VR 기술을 쉽게 접할 수 있게 되었다. VR 드로잉 어플리케이션은 사용자에게 복잡하지 않으며 완성도가 높은 어플리케이션으로 교육 및 공연 등에 사용되고 있다. 컨트롤러를 사용하여 공간 드로잉 하는 인터페이스 방식은 사용자의 드로잉 인터페이스가 컨트롤러에 제약적이 된다. 본 연구에서는 HMD 전면부에 Leap Motion을 부착하여 HMD 전면부에서 움직이는 사용자의 손을 추적하여 곡면을 그림으로써 컨트롤러를 사용해보지 않은 사용자도 직관적으로 드로잉 어플리케이션을 사용할 수 있는 시스템을 제안하였다.

[Abstract]

The development of Virtual Reality (VR)-related technologies has resulted in the improved performance of VR devices as well as affordable price arrangements, granting many users easy access to VR technology. VR drawing applications are not complicated for users and are also highly mature, being used for education, performances, and more. For controller-based spatial drawing interfaces, the user's drawing interface becomes constrained by the controller. This study proposes hand interaction based spatial drawing system where the user, who has never used the controller before, can intuitively use the drawing application by mounting LEAP Motion at the front of the Head Mounted Display (HMD). This traces the motion of the user's hand in front of the HMD to draw curved surfaces in virtual environments.

색인어 : 핸드 인터랙션, 직관적 인터페이스, 공간 드로잉, 곡면 드로잉, 가상현실

Key word : Hand interaction, Intuitive interface, Spatial drawing, Surface drawing, Virtual reality

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Ⅰ. Introduction

As a means of expressing one's personality and desires, mankind has always used various tools and methods to express itself through drawing. As time passed, tools and spaces used for drawing have evolved and expanded in various ways as well, from engraving murals in caves to pencil drawing on paper in the classroom and spray-painting on walls. As digital technology has evolved and computers entered into common use, new ways of drawing that utilize computers have been newly introduced as well. Typical examples of such drawing applications include Microsoft Paintbrush and Adobe Photoshop. During the digitalization process of drawing, input interfaces such as keyboard and mouse devices came into use in lieu of tools similar purposes to those actually used for drawing such as brushes and pens. Since the new user interface lacked intuitiveness for drawing purposes, other input tools such as tablets with a pen-like interface have also been introduced. Due to the popularity of mobile devices such as smart phones and tablet computers, the touch-sensitive interface has become one that is both intuitive and familiar.

Recently, as three-dimensional (3D) stereoscopic technology has been applied with the development of Virtual Reality (VR) technology, users have been allowed to newly experience a sense of space and three-dimensionality by using a display device such as Head Mounted Display (HMD). This eliminates the visual range limitation of using typical screens, and the user can interact within the entire user-centered space. Virtual reality utilizes that users a different way to experience virtual environments and interact with objects and people. The future technology has a positive impact on various areas such as game, entertainment, education, health care and social media[1], [2]. The VR input device is a general-use controller provided by the HMD manufacturer. Because the controller is designed for a variety of uses, it contains many buttons and functions, making it necessary for users to familiarize themselves with the user instructions.

In this study, our research is described for the development of an application that enables spatial drawing using hands of the user to provide an intuitive drawing interface without controllers.

Ⅱ. Spatial Drawing in Virtual Realty

The development of Virtual Reality technology has resulted in improved the performance of VR devices as well as affordable price arrangements, granting many users easy access to VR technology. VR content is currently being produced predominantly in the various industries that serve entertainment needs such as games and movies. Due to stimulating a human sense of reality, VR technology is being applied to the education field as it stimulates the learning ability of the user, and it is also being experimentally applied to various fields to demonstrate many other possibilities [3]. In the art field, a sense of space has been regarded as an important element from the past [4]. In the paintings, perspective was used for showing a sense of space in a plane. What played a decisive role in order to express a sense of space is a linear perspective based on a geometric principle and perspective has been developed by many painters thereafter and it provided an opportunity of being able to make infinite space in canvas. VR technology has an advantage that it could deliver a sense of space by providing 3-dimensional information, not plane information. The spatial drawing application is the most used application type among virtual reality applications. The Media art and 3D content industries are paying more attention to 3D-based VR drawing applications because they can improve the quality of the final end-products by expressing them in 3D while also adding visual effects that provide liveliness that differs from that of existing drawing applications[5].

The most popular spatial drawing applications are Tilt Brush[6] from Google, and Quill[7] from Oculus, as shown in Figure 1 and 2, respectively. As shown in Figure 2, the act of drawing itself can be a performing art, attracting the interest of many artists. Spatial drawing content is also used as promotional material for various companies and organizations.

Fig. 1. Tiltbrush by Google

Fig. 2. Art Performance by Quill

Ⅲ. Hand Interface Drawing

Users run the application wearing the HMD in virtual space and either select the palette menu in the drawing application or use the controller provided while manipulating the drawing content. Even with the same drawing application, the interface method changes depending on the shape and size of the controller used. Since the shape and movement of the user’s hand is restricted by the controller, every time the controller changes, the drawing point of the controller fails to match up properly with the user’s drawing coordinate, making it necessary to cognitively synchronize hand and controller. The system proposed in this study mounts LEAP Motion controller to the front of HMD as shown in Figure 3. Because the LEAP Motion controller allows for the tracking of the user’s hands and fingers in the three dimensions, many applications use the LEAP Motion controller for more complex interactions and simulations in virtual reality and augmented reality (AR)[8], [9].

The system is developed using the Unity game engine and the architecture is shown in Figure 4. Hand tracking module collect joint data of hands from LEAP Motion. Curve generation module creates base curve with index fingertip position. Mesh generation module creates a surface based on the base curve. Colors and textures are applied to the surface depending on the user’s choice.

Fig. 3. Leap motion mounted to HTC Vive

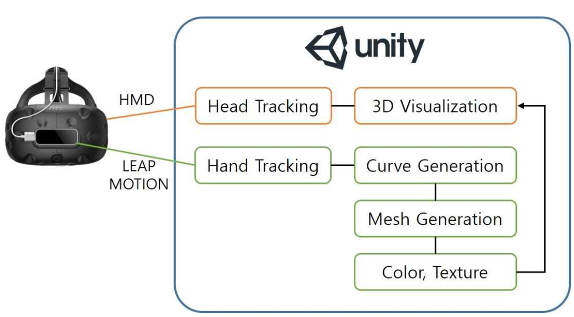

Fig. 4. System Architecture

In order to create a curved surface in space, a base curve is required that indicates the position and direction of the curved surface, as well as setting the direction and size of the width of the curved surface. When directly using the user's hand as the input interface, it uses the 22 joint positions mapped to the LEAP Motion controller as inputs, as shown in Figure 5. The index finger is used as the finger to draw the curved surface by tracing the coordinates of the fingertip and finding the normal vector(V_{normal}) using the normal vector between the index fingertip and the index finger joints. If the controller is used as an input device, the curved surface can be created by using the controller’s position and orientation data to change the position and direction of the width of the curved surface.

Since only normal vector can be found at the index fingertip, when the finger is moved to create a curved surface, the direction vector($V_{direction}$) is obtained with previous point and current point. The width direction vector is calculated using the normal vector and directions vector. We generates a curved surface using the unity game engine, as shown in Figure 6.

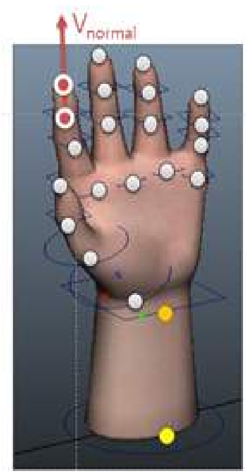

Fig. 5. Leap motion joint mapping

Fig. 6. Curved surface drawing in virtual environment

Because the proposed system uses fingers for drawing, it does not have the functionalities of controllers (i.e. buttons and touchpads). In such an environment, the visualized hand can be used as a user interface in a virtual space. Most hand model with skeletons is animated with the reference point and relative orientation data.

Because Leap Motion's data only outputs position data, the orientation data of each joint should be calculated. When the quaternion values are calculated based on the axis of two joints and mapped to the hands model, the application can visualize the movement of the user's hand.

The palette menu is designed where the color, texture and other design components can be changed in order to draw various curved surfaces as shown in Figure 7. The proposed spatial drawing system is designed so that the user can use the hands to select the menu as shown in Figure 8.

Fig. 7. Palette design for curve drawing

Fig. 8. Hand interface with palette menu

Ⅳ. Conclusions

The research in this paper configured a drawing application that can be applied to various fields in VR. While existing VR drawing applications use controllers, the proposed system uses the user's hand interface to support intuitive drawing. The proposed system has been consistently on display at exhibition halls. Because of the limitation of the device where it only traces the human hand in the space in front of the HMD, continuous research is planned to expand the range of recognition using additional wearable devices.

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Fig. 9. Spatial drawing system in exhibition

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