

A Study on a Drawing Tool of a Spatial Drawing Application in Virtual Reality

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Abstract

A system for spatial drawing must have a display device that shows stereoscopic images to the user, a controller serving as a brush for drawing, and a function that creates a line and a curved surface and visualizes the virtual space. Herein, a software framework was designed for spatial drawing by analyzing the functions for spatial drawing applications in a virtual environment based on existing studies and produced a virtual reality spatial drawing application with virtual drawing tools. The application employed a traditional painting metaphor. Furthermore, a brush module and a palette module were designed for the spatial drawing interface and linked to the line and surface generator modules to change drawing attributes, e.g., color and texture.

Keywords: *Virtual Reality, Spatial Drawing, Drawing Tool.*¹

1. Introduction

For a long period time, humans have used images for sharing information and delivering messages. They have experienced the joy of creation through aesthetic drawings. Drawings on the walls of caves, ancient Egyptian hieroglyphics, and fresco murals in the Renaissance have aimed to tell stories using images, and in the modern era, drawing is a familiar method of expression that presents visual and tactile experiences to humans, e.g., sketching on a paper with a pencil or coloring using paints [1]. With the advancement of digital technology and the distribution of computers, many people have started using keyboards and mice, the two most representative user interface devices that have created an interface gap between traditional drawing interfaces used by designers and artists. However recently, many smart devices and computers have started using pen-type interface devices and smartphones implemented with touch interfaces. These advancements have made it possible to interact with intuitive interfaces using hands again. In particular, virtual reality (VR) technologies visualize three-dimensional (3D) images in real time to users by using immersive display devices, e.g., cave automatic virtual environment (CAVE) and head-mounted displays (HMDs) to expand the scope of expression from the flat surface to a space and change the paradigm of drawing.

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‘Cave Painting’ showcased a study that draws images in a space using an actual brush-like device in the CAVE system [2]. Tilt Brush and Quill are representative VR painting applications with which the user can wear an HMD and engage in a creative painting process freely in a 3D space [3][4]. The act of drawing in a space has advanced from exhibitions to the performance of drawing in front of many audiences. Furthermore, educational courses for spatial drawing have emerged. As the needs of the development of spatial drawing applications based on VR technologies increase, this study focus on virtual drawing tools based on the spatial drawing framework via analysis of the existing spatial drawing studies. We implemented the VR spatial drawing application and proposed virtual drawing tools for the application.

2. Spatial Drawing Framework Design

A spatial drawing system comprises a display device that shows stereoscopic images, a controller that serves as a brush and palette for drawing, and a software package that creates lines and curved surfaces in a virtual space. As shown in Figure 1, the spatial drawing framework structure is designed based on previous studies on several spatial drawing applications. In the spatial drawing process, a user draws a line and a surface using a hand-tracking device. The hand-tracking module acquires the position and orientation data from HMD controllers and the hand joints or fingertips of the hand-tracking device, e.g., Leap Motion [5]. The head-tracking module tracks the movement of the HMD and the 3D visualization module updates the virtual environment in real time based on the head-tracking module [6].

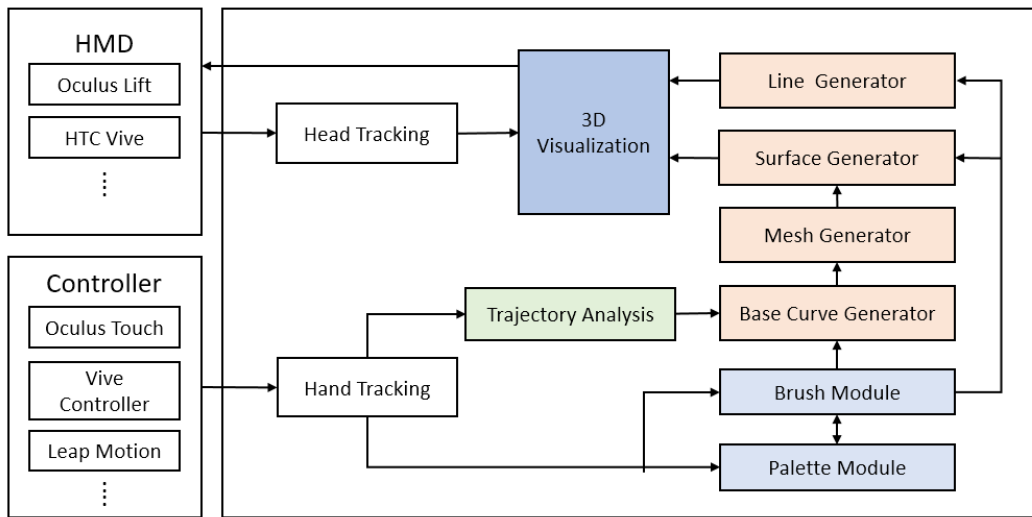


Figure 1. Structure of the spatial drawing framework

The trajectory analysis module calculates the curvature and velocity from continuous input data obtained from the hand-tracking module. The base curve generator creates base curves that show the center of the curved surface using the position data obtained from the trajectory analysis module. The base curve generator generates efficient base curves using the velocity and curvature obtained from the trajectory analysis module. The mesh generator creates curved meshes using the base curve and the orientation of the controller. The user can set drawing attributes such as the color and texture on the curved surface using virtual drawing tools, e.g., a brush and a palette. The line generator creates lines with the color of the brush module. The

surface generator creates various types of curved surfaces by implementing the color or texture set on the brush module.

3. Virtual Drawing Tools of the VR Spatial Drawing System

Spatial drawing applications support virtual drawing tools to create various lines and curved surfaces. Users can use the brush and palette menus to set the attributes of the line and surface color and texture in a virtual environment. The brush menu can be manipulated by the user with a controller, and these settings are saved in the spatial drawing application when lines and curved surfaces need to be generated using the line generator and the surface generator. As shown in Figure 2, virtual drawing tools in spatial drawing applications can be designed diversely [7]. Since the spatial drawing tool, which is different from the tools used for a flat monitor, is placed in the virtual environment, the brush and palette menus must be modeled in 3D. Depending on the number of HMD controllers or the number of hands, the virtual drawing tools must design a brush menu and a palette menu design suitable for single-handed and two-handed interfaces.

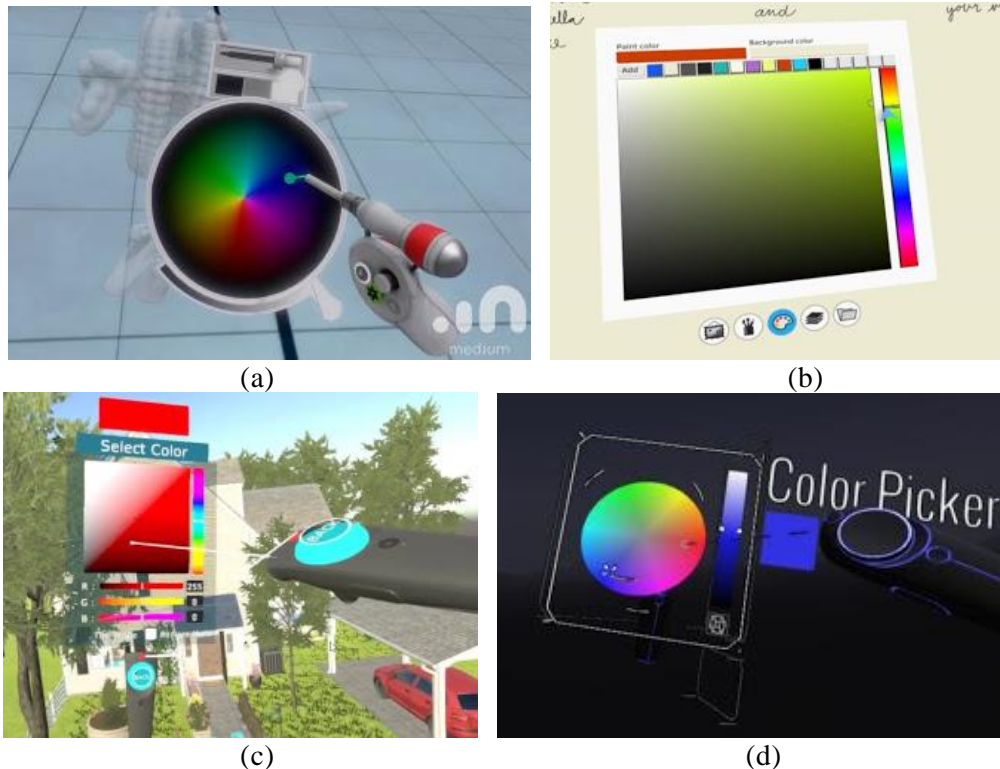


Figure 2. The design of virtual drawing tools in virtual reality: (a) Medium by Oculus, (b) Quill by Story Studio, (c) Modbox by Alientrap, and (d) Tile Brush by Google.

The spatial drawing application is implemented based on the spatial drawing framework. The virtual drawing tool of the proposed application uses the metaphor of traditional painting. The tool supports a two-hand interface. The brush module is connected to the dominant hand, and the palette module is connected to the non-dominant hand. The brush module is required to determine the attributes for lines and surfaces and visualize the selected attributes to the user. In the line-drawing mode, the brush module is expressed in the shape of a sphere as shown in

Figure 3. The size of the sphere represents the thickness of the line drawn. The user can change the radius of the sphere using the touch pad of the controller. If the sphere makes contact with the palette module, the color of the palette that made contact with the sphere is used as the color of the sphere. In surface-drawing mode, the brush module is expressed in the shape of four prisms as shown in Figure 3. The length of the shape represents the width of a surface drawn. Using the touch pad of the controller, the length of the four prisms can be changed. If the shape makes contact with the palette, the color of the palette is used as the drawing color of the curved surface.



Figure 3. Brush module for drawing a line and a surface

The palette module is designed as a circular plate with color blocks. In this study, this module expresses key colors and the developer of the drawing application sets the RGB values of the color blocks. These blocks have an area for detecting collision with the brush module. When the collision occurs, the palette module sends the color data to the brush module based on the selected color block.



Figure 4. Palette module with color blocks

4. Conclusion

Our research analyzed existing spatial drawing studies conducted in VR environment. This topic has gained increasing attention in arts and entertainment industry. We designed a drawing framework that could be used for creating spatial drawing applications. Based on the spatial drawing framework, a VR-based spatial drawing application was developed with the aid of Coexistent Reality Software Framework engine and HTC Vive as hardware [8]. In particular, this study investigates a virtual drawing tool of a spatial drawing application and implements the drawing tool with the brush and palette modules. The virtual drawing module has the metaphor of traditional painting for an intuitive user interface. The controller of the dominant hand connects to the brush module that displays different shapes according to the drawing mode. The controller of non-dominant hand connects to the palette module that displays a circular plate with color blocks. The line and surface generators allow the user to set the color and texture using the drawing tool in a virtual space.

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