Pacific Graphics (2019)
K. H. Lee and Y. Kim (Editors)

Poster

Haptic Interfaces for Tangible Digital Painting in VR

Minyoung Kim[1] and Young J.Kim[1]

[1]Dept. of Computer Science and Engineering, Ewha Womans University

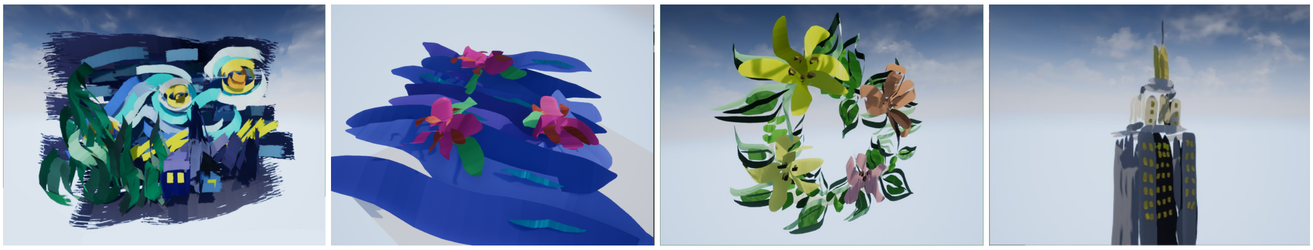


Figure 1: *Results of the Proposed Haptic VR Painting System*

Abstract

In this paper, we propose haptic interfaces based on force feedback to provide a tangible painting experience to users. Through this system, the user can perform surface-based painting holding a haptic stylus, while utilizing both visual feedback from the worn HMD and haptic feedback from the force feedback during painting. In particular, the haptic interfaces assist users with guided VR painting via responsive painting strokes, and the users can reduce redundant drawing works and achieve a better painting performance.

CCS Concepts

• ***Human-centered computing*** → *Haptic devices;* • ***Computing methodologies*** → *Virtual reality;*

1. Introduction

Since the concept of virtual reality (VR) was introduced, many researchers have made various efforts for virtual painting in virtual environments without being impeded by physical constraints, such as canvas size or painting material. Recently, a few VR painting softwares have appeared such as Tilt Brush [Goo16], Quill [Fac16] and CanvoX [KKK18] to resurge such an interest.

Due to the nature of VR painting, which draws in the air without any contact with a solid medium, users only rely on visual feedback to monitor the progress of painting. However, the visual depth cue that users can perceive does not always match the geometric depth in the VR environment, which is the main cause of unintended stroking results [AKA*17]. Therefore, users have to repeatedly draw strokes to fix it. This may reduce users' overall productivity and also can result in significant physical fatigue as well when they work for a extended period of time [Kos17].

In this paper, we propose haptic interfaces using force-feedback devices to address the problems of the existing VR painting systems. Through this system, users can experience more effective and less stressful VR painting.

2. System Overview

The suggested system consists of three sub-modules including painting, haptic and user modules (Figure 2). The painting module is responsible for creating painting strokes in VR space using the user's haptic input that can change the stroke size and color. The haptic module communicates with a haptic device and handles stylus input and force output, and performs haptic rendering using collision information based on the stroke position (haptic proxy) and the haptic stylus position. Finally, the user module engages a user with viewpoint navigation in a virtual environment.

3. VR Painting System

In our surface painting system, painting strokes are represented by triangular mesh strips. Users employ an off-the-shelf haptic stylus to create a painting trajectory corresponding to painting strokes. The mesh vertex is determined by the position of the stylus pen and the brush size, specifically, tangentially to the stroke direction. Users hold an extra HMD controller with the user's non-occupied hand to perform assisting functions for painting such as changing the brush color or its size, or executing undo operations.

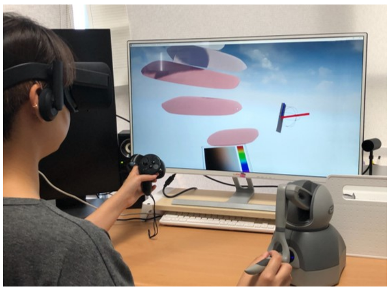
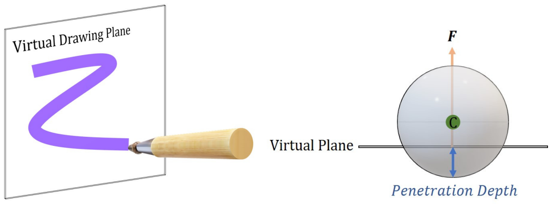


Figure 2: *Tangible Haptic VR Painting System*



(a) Model (b) Computation

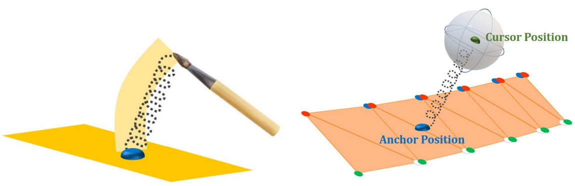
Figure 4: *Virtual Drawing Plane*

4. Haptic Interface

To overcome the limitations of existing VR painting systems, which rely only on visual feedback, our system provides a force feedback-based drawing guide. To implement our system, UnrealHapticPlugin [RGWZ18] was used along with a 3D System's Touch device [Sys19], Unreal Engine 4.

4.1. Force Drawing Anchor

Figure 3 shows the force-drawing-anchor mode that displays elastic forces in proportion to the distance between the users' stylus position and the "anchored" position on a triangular mesh selected by the user. This force display provides a more intuitive sense of the relative depth w.r.t. the painted surfaces, and makes the system responsive to the user's intention for continuous painting tasks.



(a) Model (b) Computation

Figure 3: *Force Drawing Anchor*

4.2. Virtual Drawing Plane

Arora et al. [AKA*17] concluded that a physical surface affects drawing accuracy in VR. Our virtual-drawing-plane mode is inspired by this observation, and simulates a virtual planar canvas surface by generating penalty-based elastic forces (Figure 4-(a)). When this mode is activated, our system calculates responsive forces using the penetration depth of the haptic interface with respect to the virtual drawing plane, and the magnitude of the resulting forces is proportional to the penetration depth as shown in Figure 4-(b). This mode emulates a physical canvas and helps the users to make a consistent contact with the virtual canvas for stroking.

4.3. Simulating Diverse Painting Material

Realizing different texture types of brush strokes enhances user experiences in VR painting. Painting materials can have different viscosity values, and we simulate this behavior by applying different kinetic friction to the brush stroke. When users start to draw a painting stroke, the friction is applied to the opposing direction to the haptic interface's velocity, reflecting the viscosity of each texture.

5. Result

The results of our painting system are provided in Figure 1. For drawing the petals and leaf veins, the force drawing anchor was used. Relative spatial depth can be felt using the virtual drawing plane when the user paints the background of night sky, the surface of water and the exterior wall of the building, which helps to establish parallel strokes.

6. Conclusion

In this paper, we propose haptic interfaces for responsive VR painting system that can provide force feedback between the user and the painting, serving as a drawing guide. This drawing guide is implemented via several drawing modes to improve the user's VR painting experience. In the future, we would like to extend the physical limit of the workspace of haptic device during VR painting.

References

[AKA*17] Arora R., Kazi R. H., Anderson F., Grossman T., Singh K., Fitzmaurice G.: Experimental Evaluation of Sketching on Surfaces in VR. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17* (2017), 5643–5654. 1, 2

[Fac16] Facebook: Quill by Facebook. https://quill.fb.com/ /, 2016. 1

[Goo16] Google: Tilt brush by google. https://www.tiltbrush.com/, 2016. 1

[KKK18] Kim Y., Kim B., Kim Y. J.: Dynamic deep octree for high-resolution volumetric painting in virtual reality. In *Computer Graphics Forum* (2018), vol. 37, pp. 179–190. 1

[Kos17] Koskinen T.: *Differencies and similarities in the creating process between 2D and 3D digital printing*. Master thesis, Lahti University, Finland, 2017. 1

[RGWZ18] Rüdel M. O., Ganser J., Weller R., Zachmann G.: Unrealhaptics: A plugin-system for high fidelity haptic rendering in the unreal engine. In *International Conference on Virtual Reality and Augmented Reality* (2018), Springer, pp. 128–147. 2

[Sys19] Systems D.: Touch Haptic Device. https://3dsystems.com/haptics-devices/touch, 2019. 2