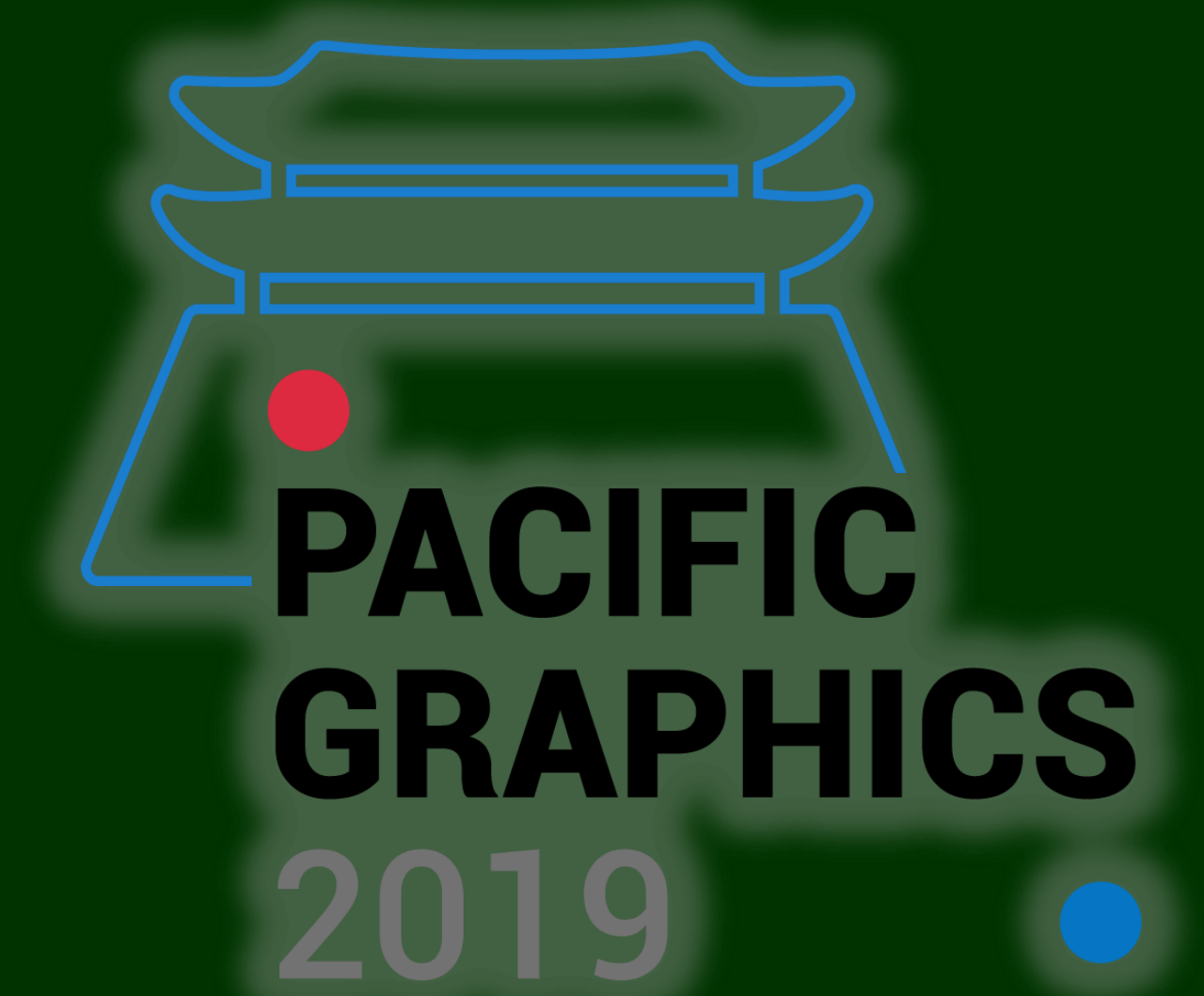




Haptic Interfaces for Tangible Digital Painting in VR

Minyoung Kim *minyoung.mia.k@ewhain.net*
 Young J. Kim *kimy@ewha.ac.kr*
 Ewha Womans University, Seoul, South Korea



Introduction

Since the concept of virtual reality (VR) was introduced, many researchers have made various efforts for virtual painting 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, Quill and CanvoX to resurge such an interest.

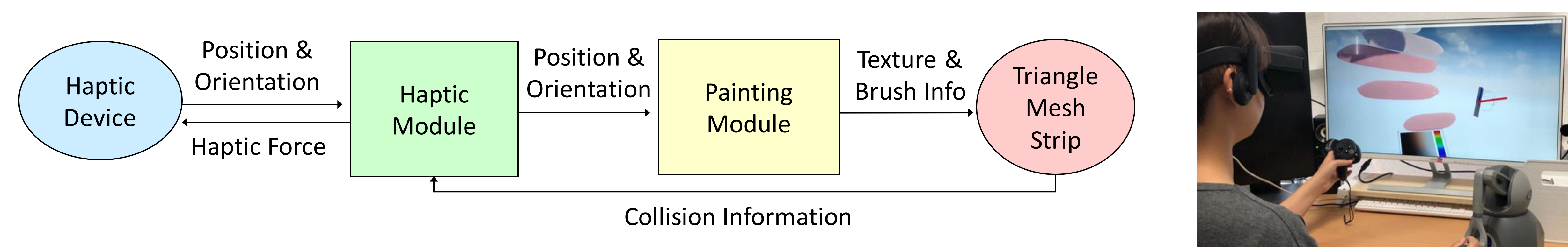
Due to the nature of VR painting, which draws in the air users, only rely on visual feedback to check the progress of painting. However, the visual depth cue that users can perceive does not always match the geometric depth in the VR, which is the main cause of unintended stroking results. Therefore, 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.

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.

System Overview

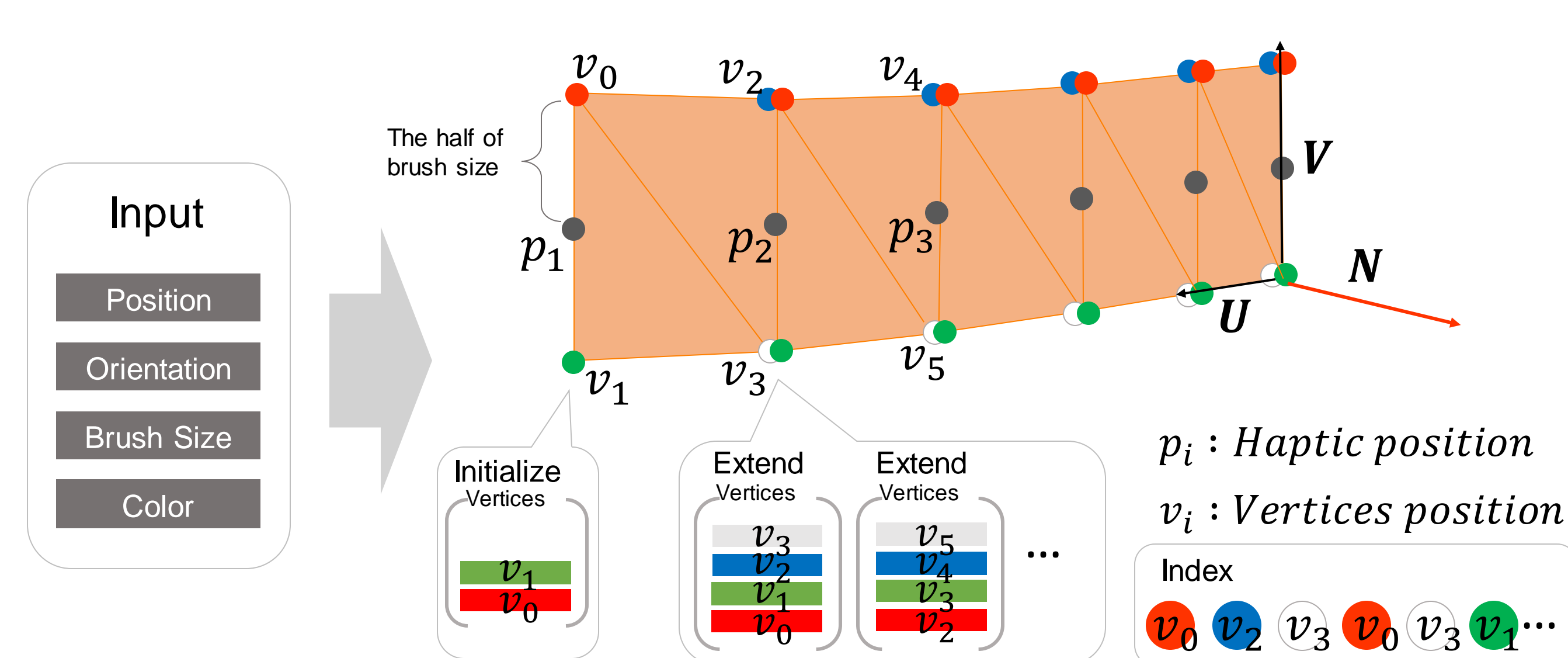
The suggested system consists of three sub-modules.

- **The painting module** is for painting in VR using user's haptic input can change the size and color of strokes.
- **The haptic module** communicates with a haptic device and handles stylus input and force output.
- **The user module** engages a user with viewpoint navigation in a virtual environment.



VR Painting System

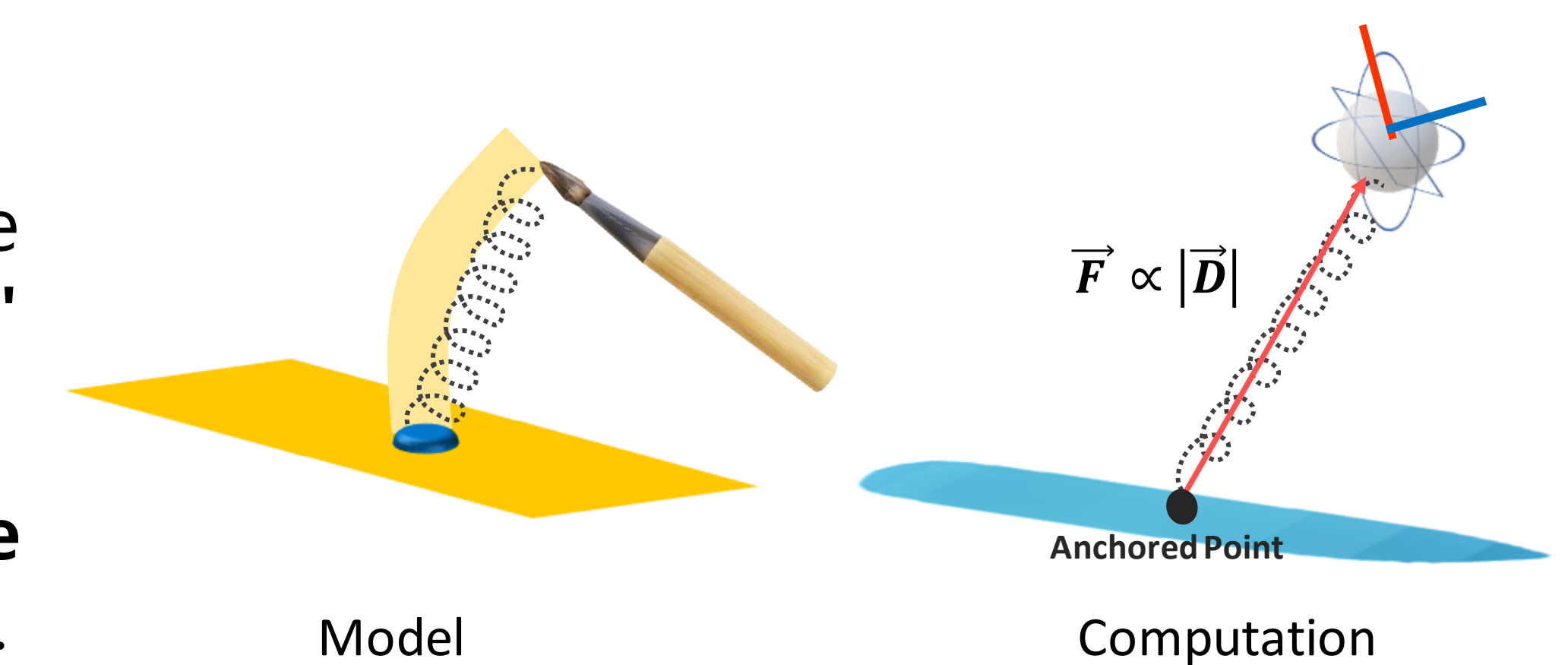
- Painting strokes are represented by **triangular mesh strips**.
- Users employ a haptic stylus to **create a drawing trajectory** corresponding to painting strokes.
- The mesh is created by **Mesh component** on Unreal Engine 4. Users can draw strokes with **four different textures**.
- Users use an extra HMD controller to execute **assisting functions for painting**.



Haptic Interface

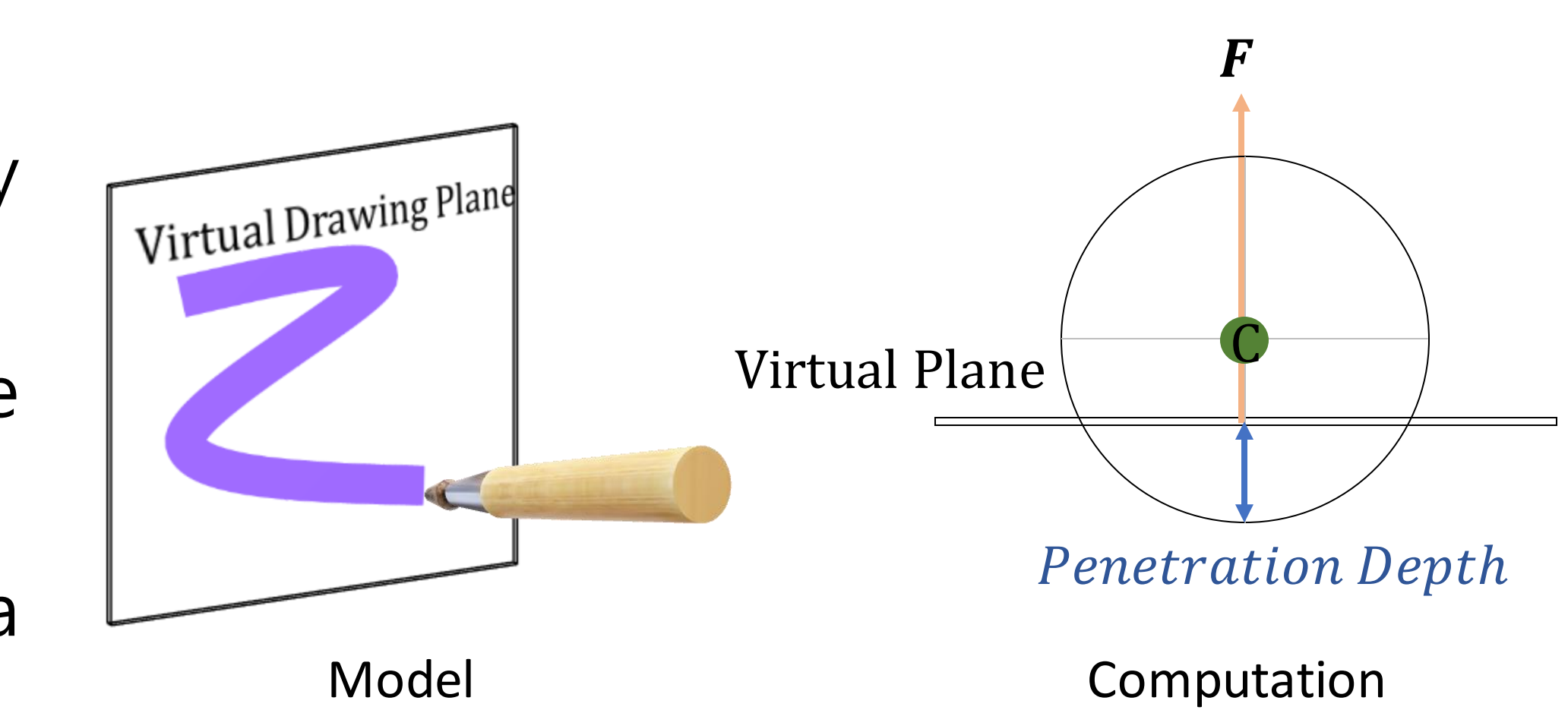
Force Drawing Anchor

- This mode displays **elastic forces** in proportion to the distance between the users' stylus position and the **"anchored" position**.
- This force display provides a **intuitive sense of the relative depth** and makes the system responsive to the user's intention.



Virtual Drawing Plane

- This mode simulates a virtual planar canvas surface by generating **penalty-based elastic forces**.
- Our system uses the **penetration depth** of the haptics with the plane, and the resulting force size is proportional to the depth.
- This emulates a **physical canvas** and helps the users to make a consistent contact with the virtual canvas.



Results

- By using the force drawing anchor mode, The distances between the strokes were **continuous**, and proper results were obtained.
- **Relative spatial depth** can be felt using the virtual drawing plane when the user paints the surface of water and the indoor and outdoor of buildings, which helps to **establish parallel strokes**.
- Both haptic models were able to **reduce the visual stress** by compensating the spatial depth, with **physical reactions**.

< The Burano Island in Italy > - 880 Strokes and 60000+ vertices



< The bedroom by Vincent van Gogh > - 873 Strokes and about 70000 vertices

