Rendering and Displaying Tactile Properties of Virtual Objects via ViESTac and FerroVibe

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I. Introduction

Tactile devices are being researched for various applications including virtual reality, assistive technology, gaming, and medical simulators. They vary in shape and size and use different actuation principles to cue sensations to one or multiple fingers via vibrations, normal and shear forces. The FerroVibe [1] is a wearable, mobile fingertip device that uses a novel actuation principle based on a permanent magnet suspended in ferro-fluid. It provides vibrations and force feedback to cue contact point orientation and texture information. To compare and evaluate the FerroVibe against other tactile devices, ViESTac [2], a virtual reality suite designed in CHAI3D [3], will be used to demonstrate its capabilities.

II. The Demonstrator

The proposed demonstration aims to present the capabilities of FerroVibe and ViESTac in rendering realistic tactile sensations in a virtual reality environment. It showcases the potential the FerroVibe as a wearable and mobile tactile device that can provide convincing contact orientation and texture feedback simultaneously to the user, and ViESTac as a benchmark framework for evaluating and comparing tactile devices.

The experimental setup for the demonstration will consist of a FerroVibe, a screen for displaying the virtual scenarios of ViESTac, and a Leap Motion controller for tracking hand positions in free space, Fig. 1. We will present four scenarios to evaluate the performance of the FerroVibe in rendering different tactile properties of virtual objects.

1. Contact orientation discrimination: The FerroVibe will be tested on its ability to cue contact point orientation as users distinguish between various contact angles on a hemispherical surface.

2. Vibrotactile texture perception: In this scenario, users will evaluate the roughness of the texture on a scale from rough to smooth, with reference to a baseline frequency. This will assess FerroVibe's capacity to deliver tactile feedback on texture.

3. Stiffness magnitude estimation: Users will tap on different virtual spheres that will result in the FerroVibe to vibrate at a frequency that corresponds to the stiffness of that sphere. This will allow users to differentiate between the virtual spheres based on their perceived hardness.

4. Object positioning: In this scenario, users will engage in a pick-and-place task where they will pick up a virtual object, move it to the target using the shortest route, and place it in its designated hole. The role of the FerroVibe will be to provide 3-DoF tactile guidance.

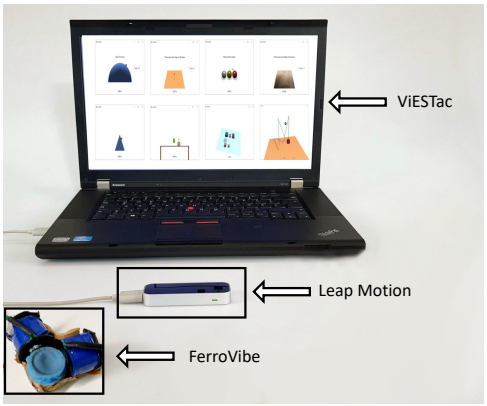

Fig. 1. Demonstration Setup: A laptop with ViESTac, FerroVibe tactile device, and Leap Motion controller

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References

[1] H. Singh, B. Suthar, S. Z. Mehdi, and J.-H. Ryu, "Ferro-fluid based portable fingertip haptic display and its preliminary experimental evaluation," 2018, pp. 14–19.

[2] P. Banerjee, E. Muschter, H. Singh, B. Weber, and T. Hulin, "Towards a vr evaluation suite for tactile displays in telerobotic space missions," in *2023 IEEE Aerospace Conference*. IEEE, 2023.

[3] F. Conti, F. Barbagli, D. Morris, and C. Sewell, "CHAI: An open-source library for the rapid development of haptic scenes," vol. 38, no. 1, 2005.