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How do expert hapticians evaluate grounded force-feedback devices?

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***Abstract*— The specifications typically reported for grounded force-feedback (GFF) devices do not capture performance quality in a consistent or meaningful way. We designed a study to identify the physical interrogations that expert hapticians employ when evaluating such a device. We report pilot data from one expert who tested three commercial GFF devices in unpowered and powered modes while demonstrating hand motions and describing the interactions. Finally, we outline how we will record expert interactions with a high-resolution apparatus and link measurements with interview data.**

I. Introduction

A grounded force-feedback (GFF) device is a mechatronic system that is mounted to a stationary surface, measures the user's motion and/or force, and outputs forces and/or motions in response. Their documentation typically includes a subset of attribute specifications that may be helpful for evaluating the device [1], [2], e.g., as collected and visualized at Haptipedia.org [3]. However, Seifi et al. showed that experts' opinions about a device's capabilities go beyond its low-level specifications and involve their experience in physically testing it [4]. We aim to investigate the motions and haptic cues experts rely on to determine device quality.

II. Methods

We selected three GFF devices (a Novint Falcon, a Geomagic Touch, and a Geomagic TouchX) that are commonly used, have similar workspace sizes, and span low to high cost (300–10,000 USD). As a first step, we recruited one expert haptician with over 10 years of haptics research experience, including with the Falcon and Touch. We first asked the expert to interact with the unpowered devices (up to two simultaneously) and verbalize thoughts for each. We then rendered four sample applications (Fig. 1) from the CHAI3D library [5] in turn on each device; the expert explored each environment and commented on rendering quality. We observed hand motions and noted comments.

III. Preliminary Analysis and Future Plans

To pilot our methods, we qualitatively analyzed this expert's data. In unpowered mode, the expert explored the center and limits of the workspace. They described the workspaces for the Touch and TouchX as more *"predictable"* than that of the Falcon, which had *"sharp weird"* corners. The TouchX felt *"nice and light,"* while the Falcon had the highest internal friction and inertial forces and felt as if *"there is a lot of play in the plastic."* In powered mode, the expert tried simple up/down and left/right motions, complex diagonal and circular trajectories, as well as fast motions. They noted that each device represented the demos differently. The TouchX *"felt as it was not there,"* and forces were consistent in different directions. The Touch was easy to move but had significant vibrations and instabilities at several positions. The Falcon could render high stiffness, but the feel of subtle object interactions was lost or spatially inconsistent.

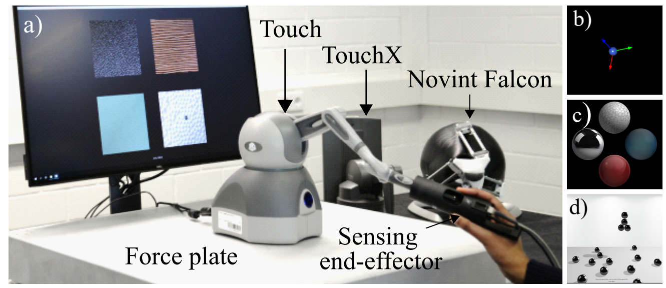

Fig. 1. Experts compare the feel of GFF devices while their interactions are recorded by the Haptify benchmarking system. The four tested CHAI3D demos are a) four textures, b) a force field with/without damping, c) four objects with different physical properties, and d) many small magnets.

With this evidence that our setup supports meaningful sensation discrimination and articulation, we plan to enroll 10 experts in a full study. We will additionally record expert-device interactions using Haptify [6], a benchmarking system for GFF devices (Fig. 1) consisting of a seven-camera Vicon motion-capture system, a custom force plate, and a sensing end-effector with force sensor and accelerometer. With it, we can evaluate rendering performance by comparing output forces computed by CHAI3D and measured by Haptify, linking to experts' qualitative descriptions of device feel and quality. These results should inspire new measurement-based device specifications based on expert interrogation.

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