3D Hapkit: A Low-Cost, Open-Source, 3-DOF Haptic Device Based on the Delta Parallel Mechanism

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***Abstract*— We present our work on an open-source, low-cost, 3-Degree Of Freedom (3-DOF) haptic device for use in haptic education. The device is based on three open-source 1-DOF haptic devices in a delta configuration and can be produced using commonly available rapid prototyping methodologies such as 3D printing and laser cutting. We also demonstrate a simple interaction with a virtual environment.**

I. Introduction

Haptic interfaces, including virtual reality and teleoperation, are becoming essential to modern human-computer interfaces. Due to the field's rapid development and the growing number of haptics courses being offered, there is an increasing need for affordable multi-DOF haptic devices to expose students to these interfaces. Our device is designed around the Hapkit, an open-source 1-DOF haptic feedback device widely used in haptic education [2]. To achieve 3-degrees of freedom, we arranged three Hapkits in a star formation [1]. The Hapkits were spaced 120° apart, and connected via 3-D printed connectors and laser cut links in a delta parallel configuration. To increase the workspace of the delta parallel mechanism, we rotated the original handle by 50° (see Fig. 1).

The three Hapkits are set up in a one-leader, two-follower configuration. The follower Hapkits track their positions and communicate this information to the leader Hapkit using the I^2C protocol. The leader Hapkit computes the position of the end effector, calculates the desired force, and sends back the torque outputs to the follower Hapkits.

II. Manufacturing and Methods

The modified actuating arms, sector pulleys, board holders, connectors, and end-effectors were manufactured with an FDM 3D printer using ABS filament. The base, linkages and end-effector mounting plate were laser cut using 1/4in acrylic. Material costs for one of our devices, including electronics, mechanical parts, and material, is less than $300. However, if the cost of the Hapkits is factored out, the cost of our device is less than $80.

III. Virtual Render

To verify our 3-DOF haptic device, we created a 3-dimensional haptic simulation of a virtual surface with two holes using the Processing environment. (see Fig. 2). Users are able to control the position of a ball in the virtual environment (shown in green) by moving the handle. When the ball makes contact with the surface, our 3-DOF haptic device resists movement through the surface.

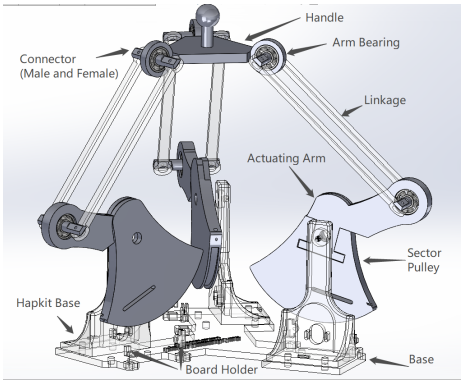

Fig. 1. 3 DOF Hapkit Overview

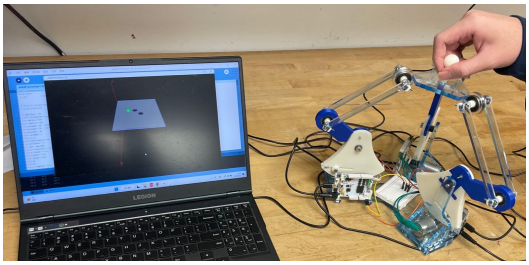

Fig. 2. Virtual Surface Simulation (left) with 3-DOF haptic device (right)

IV. Conclusions and Future Work

We present a low-cost, open-source 3-DOF haptic device, lowering the price point from that of commercially available interfaces with similar degrees of freedom to one that enables wide-scale classroom deployment. All source files can be accessed at our GitLab(git.lcsr.jhu.edu/hamr/3d_hapkit). Moving forward, we plan to quantify the device's workspace and force outputs. We also plan to deploy this 3D Hapkit in the Johns Hopkins University Haptic Interface Design Course in Fall 2023.

References

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