Haptikfabriken Polhem – A New 3D Haptic Device

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In a public pre-view, a new spatial (3D) grounded haptic device named Polhem is introduced and demonstrated. With an all-metal structure it is equipped to compete with other high-quality devices while reducing cost, enabling customization and providing open source control.

Background

Spatial haptics, where the user can touch and bi-directionally interact with virtual environments with the sense of touch, has been known to the Virtual Reality community for over 20 years. The use of high-quality haptic devices has still been limited to certain applications e.g. interactive assembly (Perret et al, 2013) and surgery simulation where the relatively high cost of the hardware can be justified. However, to reach wider dissipation, the cost, especially of custom-made devices, need to be lowered. One initiative in that direction is the WoodenHaptics project (Forsslund et al, 2015), where a completely open-source haptic device can be fabricated in wood by the user and modified to explore the design space of various workspaces, force qualities and materials, and to tailor it to different applications. To create a professional, durable device suitable for end-users, significant redesign is however required.

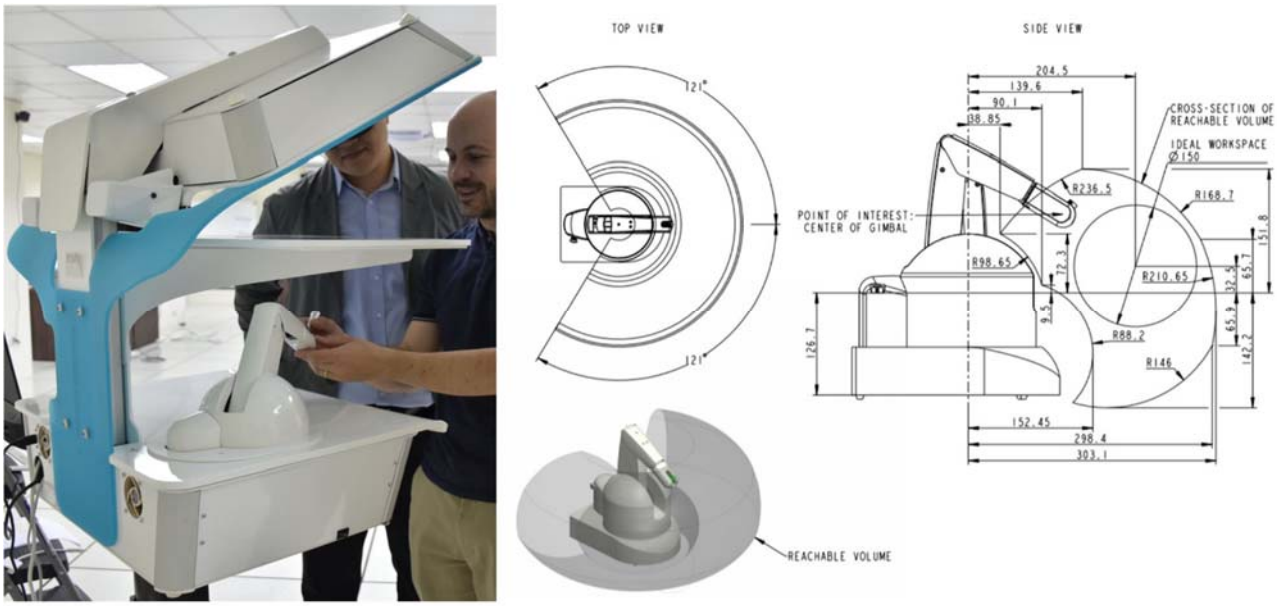

Figure 78. Left: Polhem haptic device used in the context of the oral surgery simulator Kobra. Right: Workspace.

Introducing Polhem Haptic Device

Like some of its historical predecessors (see e.g. Salisbury & Srinivasan, 1997), Polhem is an under-actuated 6-DoF input and 3-DoF output force-reflecting device. It has been designed from scratch to have several benefits that could be useful to the community: It has an all-metal structure for rigidity and durability. The relatively large motors enable high continuous forces without risk of overheating, and it can be customized without significant redesign, allowing for tailored devices with different workspaces and force characteristics. From a computer perspective it supports a full-stack open-source API and firmware, allowing for user innovation in e.g. control theory. The device is connected through USB or a Digital Acquisition Card, the later offering higher update rates (5khz+) which allows for high-stiffness applications. Finally, it is priced to compete with more expensive all-metal devices and high-end plastic-based devices.

Polhem is structurally like other serially linked haptic devices, with three motors driving first, second and third linkages respectively. The second and third motors are however being placed off axis from each other, in such a way that inertia about the first axis is reduced compared to what had otherwise been required in order to accommodate the large motors. Incremental encoders are employed on all axes, including the manipulandum gimbal, enabling e.g. continuous rotation of the manipulandum (the user handle). The standard workspace is shown in figure 1 and consist of an ideal doughnut-shape of 150 mm diameter where maximum continuous force is guaranteed to be well over 5 N. The reachable workspace is however larger, as shown by the shape surrounding the circle in the top right corner.

Future Work and Acknowledgments

There are many possibilities for future iterations of the device, to name a few: wireless connectivity, improved USB control performance and faster and temperature-controlled overdrive of motors for increased peak forces. Eventually costs will be driven down with volume production and advances in digital fabrication methods and materials.

Haptikfabriken is an initiative from Forsslund Systems AB to design and produce affordable high-quality haptic devices for multiple applications. The Kobra oral surgery simulator is also developed by Forsslund Systems AB. The author is the founder of the company.

References

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