Rolling Handle for Hand Motion Guidance and Teleoperation

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Abstract. This paper presents a grounded haptic device able to provide force feedback. The device is composed of a biaxial rocker module and a grounded base which houses two servomotors actuating a mobile platform through three constrained coupling structures. The mobile platform can apply kinesthetic haptic feedback to the user hand, while the biaxial rocker module has two analog channels which can be used to provide inputs to external systems.

1 Introduction

Grounded haptic feedback systems have been used in a plethora of applications, including robotic teleoperation and guidance. Representative examples of such interfaces include the Virtuose (Haption, FR), Omega.x (Force Dimension, CH), Falcon (Novint Tech., USA) and Phantom (Geomagic, 3D Systems, USA) series. Most common haptic devices are designed as robots of the impedance type, having small amounts of inertia and friction, enabling to freely and naturally move in space when no force feedback is provided. In such systems, the user controls the position of the device that, in turn, provide a force feedback.

In this paper, we present the preliminary design of a force feedback haptic handle for virtual rendering and robotic teleoperation. It improves upon the handle presented in [2], that did not enable the user to provide any input. With respect to [2], the proposed device includes a biaxial rocker module and it is able to provide significantly larger forces.

2 Rolling Handle with Force Feedback

2.1 The parallel mechanism

The design of the bilateral handle is inspired from [2], for which the mechanism was in turn originally inspired by [3]. Three identical supporting legs, as shown in Fig. 1, are evenly placed around the the z axis of the two platforms, forming an interlaced structure with no interference between them. Two revolute joints

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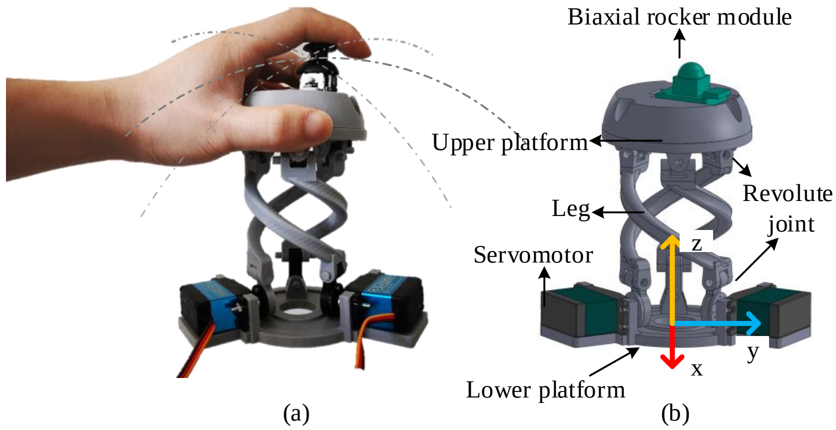

Fig. 1. (a) The device in its resting position, with the lower platform secured to an external support and the user hand posed on the upper one. (b) CAD of the device. The grey dotted lines show the surface of the sphere on which the upper platform moves. The user can provide directional input information through the biaxial rocker module.

on the two sides of the leg generate reciprocal force and constrain the mobility between each linkage.

Gruebler–Kutzbach criterion (G–K criterion) or modified G-K can be used to analyze the mobility of the proposed handle, achieving a motion along 2 degrees of freedom (DoF). The motion of the upper platform is confined on the surface of a sphere centered in the center of the lower platform.

Two servomotors are installed on the lower platform, with the motor shaft connected to the distal revolute joint on the leg, providing 2-DoF actuation. The two legs equipped with the servomotors have an active rotation on the lower joint and a passive rotation on the other three joints. By varying the actuation of the servomotors, the upper platform can reach any position within its workspace (the surface of a sphere, as mentioned above and shown in Fig. 1).

2.2 User input for bilateral control

On the top of the upper platform, we installed a biaxial rocker module as to enable the user to provide directional 2-D input. This module has one button digital output and (X, Y) 2-axis analog output through rocker potentiometer. The two analog channels can also be used to represent the rotation angle about two mutually perpendicular axes, for instance, two of the Euler angles $(Roll - Pitch - Yaw)$ in 3D space. This input can also be used to control the free-space motion of the handle, similarly to a standard impedance-type haptic interface.

3 Use cases

We develop a goal-following game to test the effectiveness of the haptic force feedback generated by the handle as well as the intuitiveness of using the biaxial rocker module. A 2D GUI interface was developed with Matlab. The servomotors of the handle were controlled through an Arduino board.

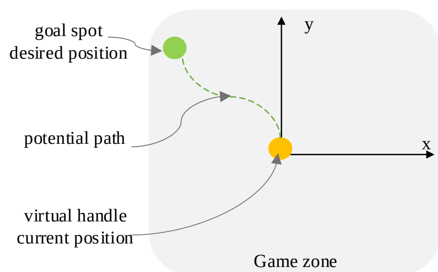

Fig. 2. The handle moves towards the goal point (in green, invisible to the user) to guide the user towards it. The closer the position of the user in the virtual environment (yellow point) to the goal spot, the smaller tilt of the handle with respect to its vertical resting position.

Fig. 2 shows the considered 2D environment. The current position of the user in the virtual environment is shown in yellow, controlled by the user through the biaxial rocker module. A random goal point, not visible by the user, is generated. The handle tilts toward the (invisible) goal point, guiding the user towards the objective position. The closer the position of the user in the virtual environment to the goal spot, the smaller tilt of the handle with respect to its vertical resting position. The task ends when the user reaches the goal point.

Preliminary tests indicated that the device is easy to use and intuitive to follow. An extensive human subjects will be subject of future work.

4 Conclusion and Future Work

The proposed device is inspired from our previous work presented in [2]. We improved upon its design by including more powerful motors, able to provide force feedback to the user, a biaxial rocker module, to enable the user to provide 2D navigational input to the system, and making the design more ergonomic and comfortable to use.

In future work, we will integrate the proposed device in a power wheelchair, so as to provide the driver with information about the presence of surrounding obstacles [1]. This scenario is inspired by the collaborative Inria project DORNELL, where we aim at developing a multisensory haptic handle for helping disabled people using mobility aids such as power wheelchairs, white canes, and walkers.

References

1. Devigne, L., Aggravi, M., Bivaud, M., Balix, N., Teodorescu, C.S., Carlson, T., Spreters, T., Pacchierotti, C., Babel, M.: Power wheelchair navigation assistance using wearable vibrotactile haptics. IEEE Trans. Haptics **13**(1), 52–58 (2020)
2. Kuang, L., Marchal, M., Aggravi, M., Robuffo Giordano, P.: Design of a 2-dof haptic device for motion guidance. In: Proc. Eurohaptics (2022)
3. Okada, M., Nakamura, Y.: Development of a cybernetic shoulder-a 3-dof mechanism that imitates biological shoulder motion. IEEE Trans. Robotics **21**(3), 438–444 (2005)