Demonstration of a 3-DoF Magnetic Haptic Display for Contactless Force Presentation*

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***Abstract*—Haptic displays using contactless actuation of magnets have been proposed as a new method that could solve the shortcomings of existing haptic displays, but they have not yet reached a level where they can replace conventional methods. Therefore, this study proposes a device that can present a force of 0.6 N or more in a workspace of 150 mm square or larger by using a set of electromagnets that generate a uniform magnetic field gradient and a permanent magnet whose orientation can be controlled. In the demonstration, we will show an application that presents the sensation of touching a virtual soft object using the proposed device.**

***Index Terms*—haptic display, force feedback, electromagnet**

I. Introduction

Depending on the method, existing haptic display devices have disadvantages such as restriction of user motion and visual occlusion due to physical connections, and lack of quantifiability due to the use of illusions. As a new method that can solve these problems, several haptic displays have been proposed that use a magnetic field to actuate a magnet contactlessly [1]–[3]. However, most of these devices are difficult to completely replace existing devices in terms of the freedom of hand posture and the degree of freedom of the force that can be presented. Therefore, in this study, we propose a haptic display that can quantitatively present a force of 0.6 N or more in 3 degrees of freedom within a more than 150 mm square workspace, using a grounded part consisting of large electromagnets called square Maxwell coils [4] and a handheld part equipped with a rotating permanent magnet.

II. Device overview

The proposed device (Fig. 1) consists of a grounded part that generates a magnetic field with an almost uniform gradient in the workspace, and a handheld part equipped with a permanent magnet whose direction can be freely controlled. The grounded part consists of three pairs of square Maxwell coils, each up to 242 mm square, arranged orthogonally. The handheld part consists of a 20 mm diameter, 20 mm long neodymium magnet mounted on a gimbal mechanism and rotated by three orthogonal coils. The grounded part consists of three pairs of square Maxwell coils, each up to 242 mm square, arranged orthogonally. The handheld part consists of a 20 mm diameter, 20 mm long neodymium magnet mounted on a gimbal mechanism and rotated by three orthogonal coils. The position and orientation of the handheld part is tracked by an optical motion capture device (OptiTrack V120 Duo, NaturalPoint, USA), and software on a PC implemented in the Unity game engine (Unity Technologies, USA) simulates the virtual environment, and controls the currents in the coils of the grounded and handheld parts to generate a prescribed force vector. The Maxwell coil in each axis consumes an average of about 0.32 kW of power.

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III. Description of the Demonstration

In the demonstration, we will show an application that uses the proposed device to touch a virtual soft object (Fig. 2). The application is implemented in Unity and the soft body simulation engine Obi Softbody (Virtual Method Studio, Spain) and can simulate deformations and forces when manipulating elastic objects. Visitors can experience the forces generated by moving the handheld part of the proposed device while looking at the PC screen.

References

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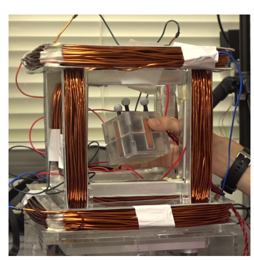

Fig. 1. Proposed device. The handheld part is grasped by the user.

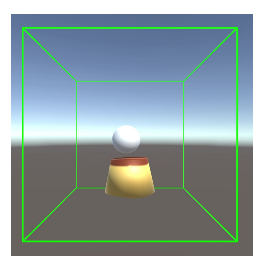

Fig. 2. Soft body manipulation application.