Traxion: A Tactile Interaction Device with Virtual Force Sensation

Jun Rekimoto*
Sony Computer Science Laboratories, Inc., Tokyo, Japan
The University of Tokyo, Japan

1 Introduction

Several systems have been proposed for incorporating haptic feedback into Human-Computer Interactions. There are two types of haptic feedback. In one type, which we call "force-feedback," a real-world physical force is created. In the second type, called "tactile-display," physical sensations, such as vibrations, are created as an additional feedback method.

There have been a few previous attempts to create force without using mechanical support. Nakamura et al. combined two or three eccentrically weighted rotors to generate an illusory sensation of force [Nakamura and Fukui 2005]. Amemiya et al. also proposed a device that creates a perceptual attraction force [Amemiya et al. 2008]. However, these devices are based on the mechanical movement of a crank, the form factor of the device is much bigger and heavier than those of tactile displays.

In this demonstration, we will introduce a tactile device, called "traxtion", that creates a virtual force without requiring any mechanical links to the ground [Rekimoto 2013]. It is significantly smaller and lighter than previous virtual force devices. Our mechanism uses a human illusory sensation to create the perception of a force. The weight of the device is about 5.2 g and the size is 7.5 mm × 35.0 mm × 5.0 mm. This small form factor allows the development of several new applications using virtual force. For example, a user can be guided to a particular location by being virtually "pulled" by a device, or an input device with non-tethered force feedback would become possible.

2 Traxion Operation Principle

Traxion is a combination of a tactile actuator (ALPS "force-reactor" [ALPS 2008]) and a new way to actuate it. This component has a structure in which electromagnet coils are attached to a metal sheet supported by a spring (Figure 1). The metal sheet is placed between two permanent magnets. When a wave signal is transmitted to the coils, the metal sheet responds to it by vibrating. After the signal stops, the spring and the magnets suspend this vibration within 50 ms.

Normally, the actuator just creates vibration, but not a force. However, when an asymmetric signal is transmitted to it, it causes a motion such that the user feels as if a force is pulling the device in a particular direction, or pushing it in the opposite direction. In this case, the current is applied to the electromagnet for a short period (e.g., 2 ms) to move the weight in one direction, and then is suspended. When the weight returns to the original position (which takes around 6 ms), the current is applied to the electromagnet again and the process is repeated. As a result, the movement of the weight

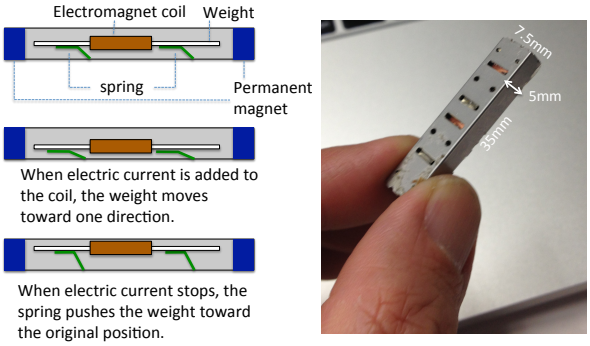

Figure 1: *Configuration of the "force-reactor" tactile device*

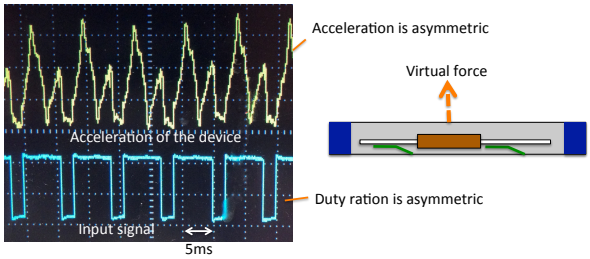

Figure 2: *Operation principle of Traxion: Asymmetric electric current is added to the coil in the actuator.*

becomes asymmetric. A human feels this as a virtual force because of the non-linearity of human force perception, known as Stevens's power law [Stevens 1957]. By changing the duty ratio of the signal, the user can also feel a force in the opposite direction, and the required response time to change its virtual force direction is also short (within 50ms). Based on the user evaluation with 10 participants, the strength of this virtual force is 29.8 g (s.d. 8.5 g).

References

ALPS, 2008. Alps Electric Press Release Force Reactor™. http://www.alps.com/e/news release/2005/0608 01.html.

AMEMIYA, T., ANDO, H., AND MAEDA, T. 2008. Directed force perception when holding a nongrounding force display in the air. In *Proc. of EuroHaptics 2006*, 317–324.

NAKAMURA, N., AND FUKUI, Y. 2005. An innovative nongrounding haptic interface 'gyrocubesensuous' displaying illusion sensation of push, pull and lift. In *ACM SIGGRAPH 2005 Posters*, SIGGRAPH '05.

REKIMOTO, J. 2013. Traxion: A tactile interaction device with virtual force sensation. In *Proceedings of the 26th Annual ACM Symposium on User Interface Software and Technology*, ACM, UIST '13, 427–432.

STEVENS, S. 1957. On the psychophysical law. *Psychological Review 64*, 3, 153–181.

*e-mail:rekimoto@acm.org

SIGGRAPH 2014, August 10 – 14, 2014, Vancouver, British Columbia, Canada.

ACM 978-1-4503-2961-3/14/08