

Buru-Navi3: Movement Instruction Using Illusory Pulled Sensation Created by Thumb-sized Vibrator

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1 Introduction

Buru-Navi3 is a new force display technology that uses actuators which vibrate asymmetrically to create a continuous pulling force sensation without an external fulcrum. The user does not feel the discrete simple vibrating sensation that is so common in conventional mobile devices today. Instead, the user feels a smooth sensation of being pulled, akin to what we feel when someone leads us by the hand. For all users, the haptic or somatosensory cues created by Buru-Navi3 are, like lead-by-hand navigation or a guide dog for people with visual impairment, intuitive in indicating a certain direction. We have recently succeeded in creating a sensation of being pulled with a *thumb-sized* actuator that asymmetrically oscillates.

At our booth, the user can experience for the first time a novel haptic interaction in mobile devices with our innovative tiny prototype force display. The force display is the smallest and lightest ever with two degrees of freedom (DoF). We also implement a pedestrian navigation system that tracks the position and orientation of the user, which helps the user walk along a path sequentially from point to point and understand directional cues for navigation by actively moving the hand.

2 Force Feedback Technique

Our approach to creating a sensation of being pulled exploits the characteristics of human perception, using different acceleration patterns for the two directions to create a perceived force imbalance. A brief and strong force is generated in a desired direction (e.g., leftward), while a weaker one is generated over a longer period of time in the reverse direction (e.g., rightward). Although the average magnitudes of the two forces are the same, reducing the magnitude of the longer and weaker force to below a sensory threshold makes the holders feel as if they are being pulled to the desired direction (e.g., leftward). Using two orthogonally placed actuators allows the holders to feel a force sensation in the four or eight principal directions on the azimuth plane.

3 Implementation

We have fabricated a prototype [Fig. 1(a)]. The size is greatly decreased by 95% (to $18 \times 18 \times 37 \text{ mm}^3$) compared with the earlier one. The weight is greatly decreased by 92% (to 19 g). With this tiny and light force display, the directed force sensation is perceived just as strongly as with the previous larger prototypes.

We implemented an indoor pedestrian navigation system which consists of a tablet computer with a pair of the force display attached, and fiducial markers on the ceiling. A front camera of the

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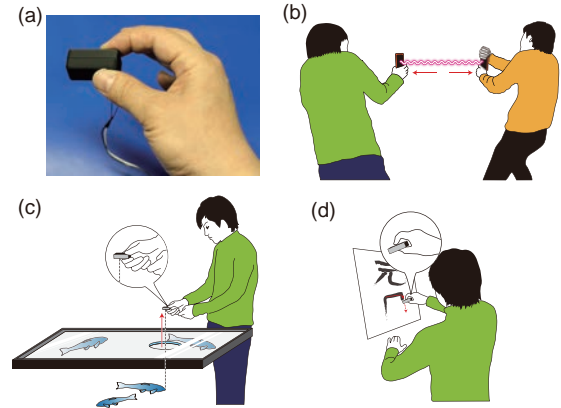


Figure 1: (a) Proposed novel thumb-sized Buru-Navi3. (b) Tug-of-war using a pair of Buru-Navi3, (c) angling game and (d) calligraphy guidance using a Buru-Navi3 device.

tablet computer faces the ceiling and captures the marker grid there. A server calculates the position and orientation of the camera after receiving the images and then sends a command to change the force direction. The direction of force is updated and presented so as to help users walk along the path. Figure 1 shows other applications using Buru-Navi3. With a motion capture system, we can track the user's hand with pinching the Buru-Navi3 device. Therefore, the amplitude and direction of force sensation are altered. Users can experience the tug-of-war application together with no ropes [Fig. 1(b)], feel a nibbling sensation on the hook and being pulled sensation with no fish lines in the angling game [Fig. 1(c)], or learn calligraphy with the Buru-Navi3 device [Fig. 1(d)].

4 Vision

A pilot study proved that active sensing of a sensation of being pulled or pushed effectively helps the user walk along a desired path. We will provide a novel haptic interaction to audiences at this SIGGRAPH Emerging Technologies with our device and tracking system [Amemiya and Gomi 2014]. Buru-Navi3 will open a new horizon of applications in mobile devices, such as not only a pedestrian route navigation system but communication, entertainment, and education.

References

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