Active Touch Sensing of Being-Pulled Illusion for Pedestrian Route Navigation

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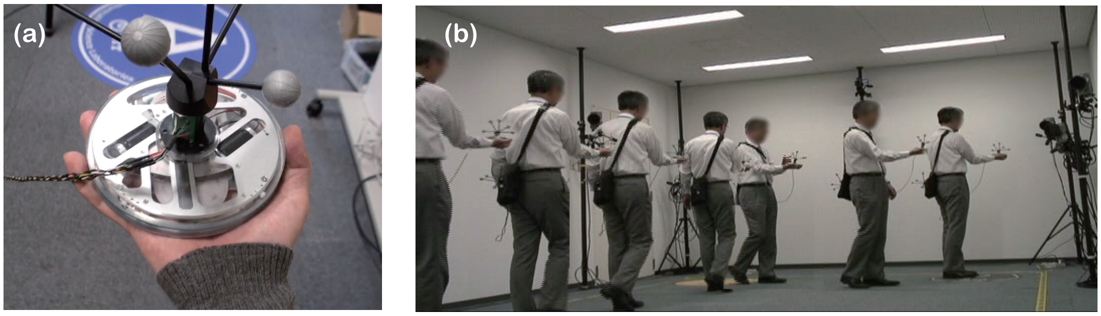

Figure 1: *(a) Proposed novel three-DoF force feedback display. (b) Superimposed walking picture every 3 sec.*

1 Introduction

Locomotion is a vital activity for human beings. When walking through unfamiliar places such as a large convention center, we usually rely on visual information from a map or a compass. In contrast, kinesthetic cues are intuitive for all users to indicate a certain direction such as lead-by-hand navigation or a guide dog for people with visual impairment. However, mobile devices have not provided a stable pulling or pushing force feedback because both the user and device must be physically connected to an external ground to provide it. Over the last several years, we have designed and developed several prototypes to generate asymmetric oscillation [Amemiya et al. 2006], and succeeded in creating a sensation of being pulled without grounding by using a sensory illusion produced by the asymmetric oscillation [Amemiya and Sugiyama 2010].

In this work, we propose an intuitive pedestrian navigation system with our novel prototype of a force display. The force display is the smallest and lightest ever with three degrees of freedom (DoF) and implements a navigation system that tracks the position and orientation of the user. The tracking system helps the user walk along a path sequentially from point to point and understand the directional cue 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, while a weaker one is generated over a longer period of time in the reverse direction. 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. Changing the desired direction by a rotational mechanism allows the holders to feel an omni-directional force sensation in the azimuth plane. This approach with rotation mechanism provides precise angular resolution of force direction. However, it takes a short time for rotating a unit to change the pulling direction largely. To reduce its time, we decided to stack two units, which allows the system to switch from one unit to the other when the rotation angle is large. This mechanism allows the system to cover the all direction in a shorter time.

In addition, the new prototype can create not only a translational but also a rotational force (or torque) sensation around the yaw-axis by the effect of a momentum wheel with the rotational mechanism. Three DoF planar force feedbacks (thrust forces in the xy-plane and rotational force around the yaw) provide a haptic cue sufficient for pedestrian navigation.

Furthermore, the position and orientation tracking system allows user to actively sense the updating force direction by moving their hand or walking around so as to maximize information gain. These exploratory activities maximize the information gain using spatial and temporal information changes.

3 Implementation

The system consists of a ϕ126-mm force display [Fig. 1(a)], a shoulder bag (containing a battery, an ultra-mobile PC, and a control device), a tracking server, and a motion capture system [Fig. 1(b)]. The force display comprises two slider-crank units to generate the asymmetric force pattern and the rotational mechanism to rotate the slider-crank units and present a torque sensation. Reflective markers are attached on the force display. Their position and orientation are recorded using motion a capture system and calculated by a server. Then, the server sends a command to change the force direction. Using all possible via points and connection paths predefined, our system automatically finds the shortest path including the via-locations using a dynamic programing search technique.

The direction of force is updated and presented so as to help users walk along the shortest path. In our system, participants select some destinations (nodes) on a tablet computer and then are instructed to walk in the direction they feel they are being pulled.

References

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