

Powered Shoes

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Abstract

Powered Shoes is a locomotion interface using roller skates actuated by two motors with flexible shafts. The device is light-weighted and wearable. It enables the user to walk in virtual environment while his/her position is maintained. The user can walk in arbitrary direction in virtual environment.

CR Categories: H.5.1 [Information Systems]: Multimedia Information Systems—Artificial, augmented, and virtual realities ; H.5.2 [Information Systems]: User Interface—Haptic I/O

Keywords: locomotion interface, walking, wearable

1 Introduction

In most applications of virtual environments, such as training or visual simulations, users need a good sensation of locomotion. We have developed several prototypes of interface devices for walking since 1989. These locomotion interfaces create infinite surface by the use of motion floors, which needs bulky or complex drive mechanism. The Powered Shoes project aims to develop motor-driven roller skates instead of motion floors.

The goal of this project is to develop a wearable locomotion interface that enables the user to omni-directional walking while the position is maintained. In order to achieve this goal, compact and light-weighted actuation mechanism must be put underneath the sole of the shoes. We therefore use a flexible shaft to drive the rollers. The motors are equipped in a backpack. The whole system is wearable.

The motion of the feet is measured by optical sensors. The roller skate moves opposite to the measured direction of the walker, so



Figure 1: Overall view of the Powered Shoes.

that motion of the step is canceled. The position of the walker is fixed in the real world by this computer-controlled motion of the roller skates. The walker can freely change direction while walking.

2 Technical Innovation of the Project

The major innovation of this work is a new actuation mechanism that cancels the displacement of the walker. Existing locomotion interfaces employ motion floors for creation of infinite surface. The easiest way to realize an infinite floor is the use of a treadmill. However, a treadmill has difficulty in realizing omni-directional walking. Motion foot-pad for each foot is an alternative. It has ability to simulate omni-directional walking as well as walking on uneven surface. The major limitation of this method is that severe accuracy is required for the foot-pad to trace the walker. Actually, the walker has to be careful about miss tracing of the foot-pad. We developed the CirculaFloor to overcome drawbacks of treadmills and foot-pads. However, the system is too complicated to achieve sufficient walking speed.

The Powered Shoes employs active roller skates. A compact and light-weighted drive mechanism is put underneath the sole. A large force is required to move the walker so that the motor for the locomotion interface can't be put underneath the sole. We therefore used a flexible shaft in order to separate the motor from the roller. Motors and batteries are the heaviest parts of the system, so that we put them in a backpack.

The active roller skate is designed to fit in the sole. It has three rollers, two of which are connected by a timing belt and driven by a motor. Diameter of each roller is 16mm and overall height of the mechanism is 20mm. Overall weight of the mechanism is 700g, which is as same as a trekking shoes. The mechanism allows the user to walk in 600mm/s.

3 Larger implications of the project beyond this demonstration phase

It has often been suggested that the best locomotion mechanism for virtual worlds would be walking. It is well known that the sense of distance or orientation while walking is much better than that while riding in a vehicle. However, the proprioceptive feedback of walking is not provided in most applications of virtual environments. The Powered Shoes is a new locomotion device that provides such a sense of walking. It will make revolution in entertainment or training simulators.

One of the serious applications will be an "evacuation simulator." Analysis of evacuation of people in disasters is important in social safety. However, it is impossible to carry out experiments with human subjects during an actual disaster. Virtual environment is inevitable for such experiments. Since evacuation is done by walking or running, the Powered Shoes will be an indispensable interface device for the experiments.

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