International Conference on Artificial Reality and Telexistence
Eurographics Symposium on Virtual Environments (2022)
R. Kondo and T. Teo (Editors)

AmplifiedCoaster: Amplifying the Perception of Ascent and Descent in Virtual-Reality-Equipped Electric Wheelchair in an Electric Wheeled Ramp

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Abstract

We introduce a novel virtual reality (VR) ride system consisting of a head-mounted display (HMD), an electric wheelchair and an electric wheeled ramp as an amusement park attraction. The electric wheeled ramp which is a customized electric wheelchair can carry a user wearing an HMD and is able to control its speed, acceleration, and orientation. This system presents the sense of continuous moving on a slope and the sense of movement on a slope with varying curvatures in the ascending and descending experiences, thus amplifying the perception of virtual ascent and descent.

CCS Concepts
• ***Human-centered computing*** → ***Human computer interaction(HCI);*** *Virtual reality;* • ***Computer systems organization*** → *Robotics;*

1. Introduction

Rides in amusement parks and motion platforms (MPs) [Ste65] provide extraordinary experiences and attract many people. However, these have complex structures and high installation costs. To address these problems, systems that incorporate the use of cars [RKK17] or electric wheelchairs [YYU*20] have been developed as MPs. Cars and electric wheelchairs are widely used in MPs because they can seat users and allow speed and acceleration adjustment. These vehicles are limited to present motions with two degrees of freedom, forward and backward, and turning motion. In previous studies using a ramp [YYU*20], the degree of freedom of pitch axis rotation can be added, but to achieve virtual continuous ascent and descent, the slope size becomes large, and many slopes with different curvatures are needed to achieve virtual ascent and descent on slopes with different curvatures.

Therefore, we proposed a novel system that presents the sense of continuous moving on a slope (Figure1) and the sense of movement on a slope with varying curvatures (Figure2) in the ascending and descending experiences by combining an electric wheeled ramp with a VR ride composed of HMD and an electric wheelchair.

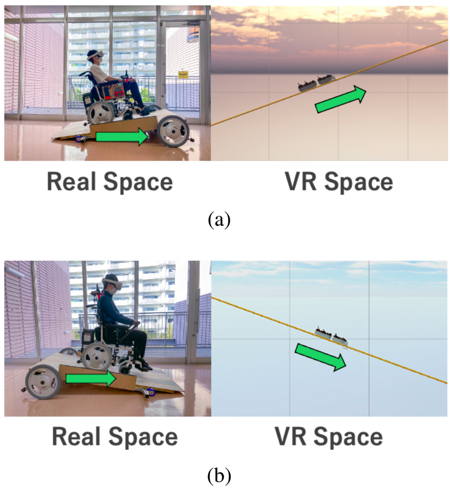

Figure 1: *Continuous (a) ascent and (b) descent*

2. SYSTEM AND IMPLEMENTATION

ROS2 (Robot Operating System 2) was used to send speed information (rpm) to the electric wheelchair and electric wheeled ramp, and to receive position and orientation information of the electric wheelchair, and Unity-Robotics-Hub was used to integrate ROS2 and Unity. To match the angle changes between the VR roller coaster and the electric wheelchair, Unity obtains the posture information for the roller coaster and the electric wheelchair, and constantly corrects them to minimize the difference.

DOI: 10.2312/egve.20221312

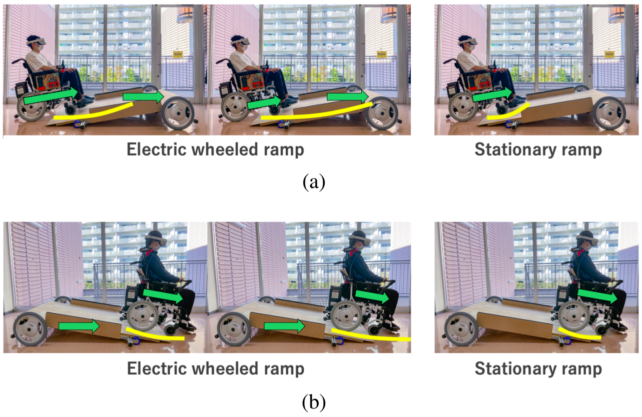

Figure 2: *Curvature changing (a) ascent and (b) descent*

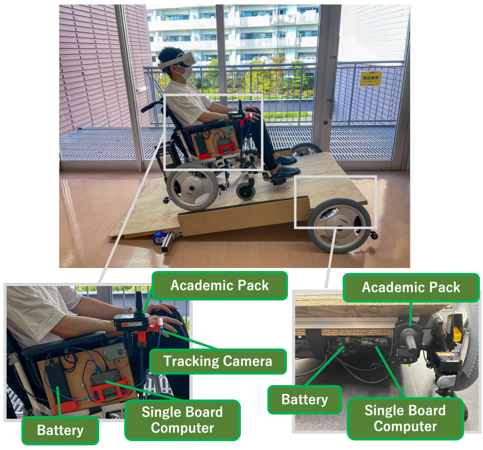

Figure 3: *Hardware of the proposed system.*

Continuous ascending and descending perception realized by the electric wheelchair carrying the user stops on the translating ramp and presenting the user with an image of a roller coaster ascending and descending (Figure 1).

In ascending and descending on a slope with varying curvature, the electric wheelchair rides up or down on a moving ramp, presenting a sensation of ascending and descending that combines translational and rotational motion in the pitch direction (Figure 2). By controlling the speed at which the electric wheelchair rides up or down the moving ramp, the speed of angular change in the pitch direction is adjusted. The smaller the speed of the wheelchair, the more the wheelchair moves on a gently curved slope with a larger curve radius.

The proposed system consisted of an electric wheeled ramp developed by using the same motorized unit as the electric wheelchair (YAMAHA TOWNYJOY X PLUS+) in which a user can ride (Figure 3). The width, depth, maximum height, and angle of the ramp were 90 cm, 182 cm, 32 cm, and 10°, respectively. To prevent the electric wheelchair from slipping when running on the ramp, we applied nonslip stickers to the surface of the ramp.

Figure 3 displays the hardware assembly. The motors of the electric wheelchair and the electric wheeled ramp are controlled using Academic Pack, an option for research and development provided by Yamaha Motor Co., Ltd. We used the Academic Pack to relay a serial communication connection between the two vehicles and single-board computers (Raspberry Pi 4 Model B). Furthermore, Intel Realsense Tracking Camera T265 is installed with the electric wheelchair to acquire position and rotation information.

To visually present ascending and descending perception, we used an HMD, Oculus Quest2, to perform real-time wireless communication with a PC (Oculus Link Air). For creating visual content, we used the Unity2020.3.16f1 game engine. We presented users with visual content that simulates ascending and descending on a roller coaster. The maximum angle of inclination for the roller coaster is 20°, which is two times that of the electric wheeled ramp. The speed of the roller coaster vehicle was set at four times the speed of the electric wheeled ramp

3. FUTUREWORK

Two types of user studies were conducted to evaluate the sense of continuous moving on a slope and the sense of movement on a slope with varying curvatures in the ascending and descending experiences. The results of the user studies revealed that adding the electric wheeled ramp to the VR ride by using a wheelchair and an HMD enhances virtual ascending and descending experiences. However, the validity of the system is limited by the scale of the user studies (n=7). Therefore, we plan to increase the number of participants for further validation.

Furthermore, although the case in which the electric wheelchair moves forward on the slope was investigated, increasing the inclination angle of the electric wheelchair again by moving backward after moving forward is possible. Therefore, the proposed system may be able to present multiple ascending and descending experiences by repeatedly moving the wheelchair forward and backward on the electric wheeled ramp.

4. Acknowledgments

This work was supported by JST, CREST Grant Number JPMJCR19A4, Japan. We would like to express our gratitude.

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