Poster: MR Telepresence System with Inertial Force Sensation Using a Motion Platform and an Immersive Display

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Abstract

This paper presents a telepresence system for a ride, such as on a roller coaster, using a motion platform that can provide a seated user with the sensation of inertial force. Most conventional studies using a motion platform with a few degrees of freedom have not generated an inertial force when a ride accelerates, because a motion platform cannot simulate the same motion of a real roller coaster. We propose a new telepresence system that can provide a user with an inertial force sensation using a motion platform with a few degrees of freedom and an immersive display. In our research, the inertial force sensation is generated by acceleration of gravity produced by inclining the motion platform. The inclination of the seated user is estimated from an image sequence captured using an omnidirectional camera placed on an actual running roller coaster. In our experiments, the inertial force sensation is realized using a motion platform and an immersive display.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Prototyping;

1 Introduction

Telepresence is a technology that enables users to feel as if they are at a remote site. This study presents a telepresence system for a ride, such as on a roller coaster, using a motion platform and an immersive display as one of the entertainment contents. Information provided to a user in telepresence includes motion information, such as of a vibration or an inclination, generally presented by a motion platform. In a roller coaster simulation, the motion platform plays an important role and requires many degrees of freedom to simulate the motion of a real roller coaster [1]. However, such a motion platform is very expensive, requires a large amount of space, and is complicated to control. Therefore, in recent years, roller coaster simulation using a motion platform with a few degrees of freedom has been developed [2]. This motion platform is easy to control and is cheaper than a motion platform with many degrees of freedom. However, there is one drawback: a motion platform with only a few degrees of freedom cannot produce the inertial force that is generated when a ride moves. Therefore, a motion platform with a few degrees of freedom cannot generate the same motion as a real roller coaster.

This paper presents a new telepresence system that can provide a user with a sensation of the inertial force produced when an actual ride is accelerating. In our telepresence system, we employ an immersive display and a motion platform that can incline the user's seating. Figure 1 shows an example of the telepresence system using a motion platform with a few degrees of freedom. In general, as the motion platform has limited degrees of freedom and a narrow range of motion, it is difficult to precisely simulate an inertial force for the user. In our research, the inertial force sensation is generated by acceleration of gravity obtained by inclining the motion platform. The amount of inertial force is estimated using an image sequence that has been captured from the viewpoint of a user actually riding on a roller coaster.

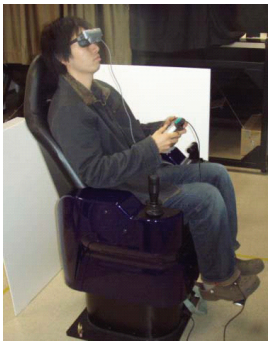

Figure 1: Experimental environment using motion platform with a few degrees of freedom

2 Realization of Inertial Force Sensation

In this study, the inertial force sensation is achieved by inclining the motion platform. Figure 2(a) illustrates the forces that a user experiences in a real environment. The user experiences a resultant force that is the resolution of an acceleration of gravity and an inertial force. Figure 2(b) illustrates the forces that a user feels in an experimental environment. The resultant force in real world is generated by acceleration of gravity in the experimental environment. Because the inertial forces work in the same direction as in an actual environment the user experiences a sensation of inertial force.

2.1 Estimation of the motion of roller coaster

In our experimental environment, an inertial force is generated by inclining the motion platform according to the amount of inertial force in a real environment. In order to estimate the amount of this force, the acceleration of the roller coaster needs to be known. In our study, the motion of the roller coaster is estimated from the image sequence, which is captured from viewpoints of the user actually riding on a roller coaster.

We use an existing method [3] for estimating the camera position and posture from multiple image sequences obtained using an omnidirectional multi-camera unit. This method uses the structure-from-motion technique which is based on tracking natural features, and the perspective n-point problem (PnP) techniques. The camera parameters are estimated by tracking natural features automatically and by making use of a robust approach, RANSAC. Figure 3, the result of estimated camera parameters, confirms that the camera parameters can be recovered smoothly. The acceleration of the roller coaster is estimated by using extrinsic camera parameters, and the inertial force is estimated by this acceleration.

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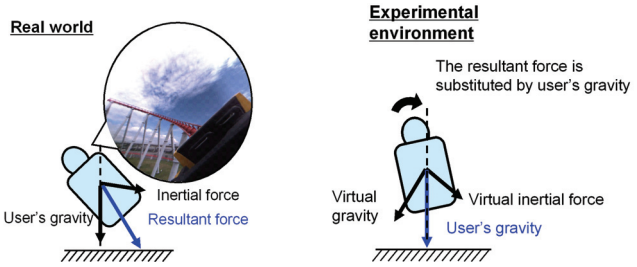


(a) Roller coaster (b) Motion platform

Figure 2: Realization of inertial force sensation

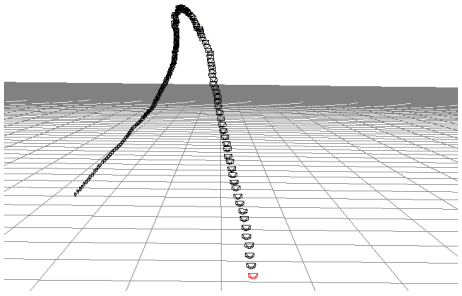
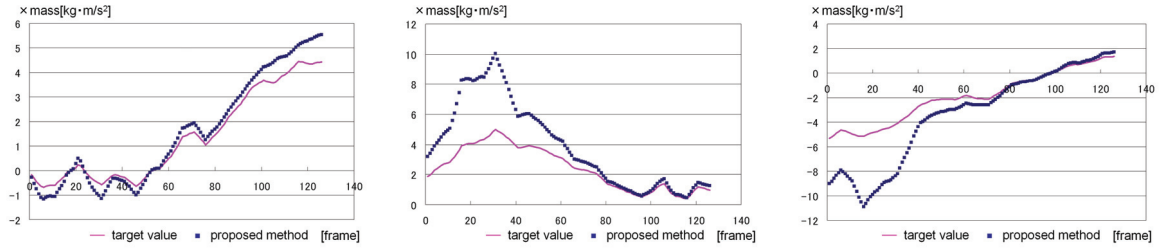


Figure 3: Result of estimated camera motion



(a) X-axis (b) Y-axis (c) Z-axis

Figure 4: Result of estimated inertial force

2.2 Estimation of Inclination of Motion Platform and generation of user's view

The proposed method generates an approximation of the inertial force from acceleration of gravity by inclining the motion platform to an inclination that is different from that of a real roller coaster. In our research, the resultant force that a user experiences in the real world is substituted by acceleration of gravity in telepresence. The motion platform is inclined so as to fix the direction of a resultant force vector to a user's body as shown in Figure 2.

The inertial force cannot be reproduced only by inclining a motion platform, because there is inconsistency between the visual aspect and the physical inclination of the user. Because the motion platform inclines in a different direction from the body of the roller coaster in an actual environment, it is necessary to change the image shown to the user appropriately. The image is presented to the user so as to fix the relationship between the position of the roller coaster and the user. The image can be easily made because the image sequence is captured using the omnidirectional camera unit. Since the user cannot distinguish the inclination of the motion platform from visual information, the user experiences the sensation of inertial force. In order to achieve this effect, it is necessary to cover the user's field of view with an immersive display.

3 Construction of Telepresence System

Figure 1 shows a prototype telepresence system with a HMD (Daeyang, i-visor FX601) and a motion platform (Kawada Industries, JoyChair). In this system, the user sees an image made from a panoramic sequence captured using a multi-camera unit (PointGreyResearch, Ladybug2). The user sees 800 × 600 resolution images at 30 fps on the HMD. The motion platform can rotate on roll and pitch axes, and each axis has a movable range of ± 15 degrees.

Figure 4 shows comparisons between a target value and the amount of estimated inertial force using the proposed method. As shown in this figure the user can experience an inertial force sensation that is proportional to the actual inertial force.

4 Conclusion

This paper presents a telepresence system for a ride, such as on a roller coaster, using a motion platform and an immersive display. The important contribution of this research is the construction of a new telepresence system that can provide a user with the sensation of an inertial force similar to that generated when an actual ride is accelerating. The inertial force is estimated automatically by recovering the camera motion from the omnidirectional image sequence. The inertial force sensation is approximated by an acceleration of gravity. In our experiments, we have confirmed that the user can feel an inertial force sensation using the prototype system.

Our future work includes verification of the validity of the proposed method by conducting a subjective evaluation experiment. In particular, it is necessary to consider the amount of virtual inertial force that is different from the amount of actual inertial force.

Acknowledgements

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