Mobiature: 3D Model Manipulation Technique for Large Displays Using Mobile Devices

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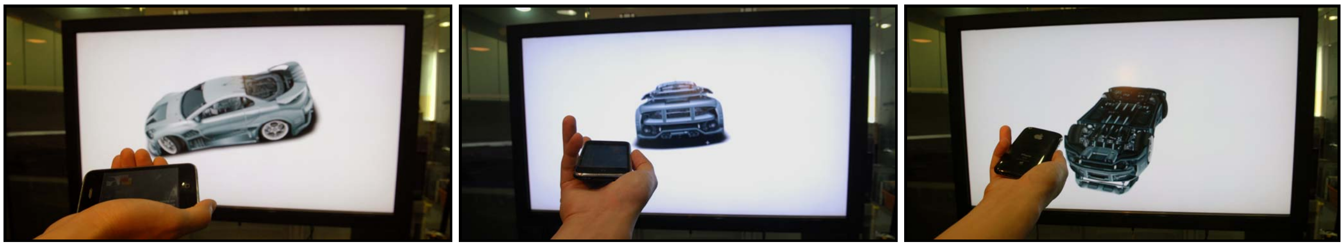

Fig. 1. Mobiature working prototype. A 3D model on a large display is aligned dynamically with respect to the orientation of a mobile device.

***Abstract*--This paper presents Mobiature (mobile miniature), a 3D model manipulation technique for large displays in which mobile devices are used as multimodal controllers. The technique enables the performance of 3D manipulation tasks such as rotation of a 3D model and selection of a particular part of the model. For performing these tasks, we develop a new method to capture the orientation of a mobile device from motion sensor data along with a new noise reduction scheme. The results of our informal usability test reveal that (a) users perceive Mobiature to be an intuitive technique that allows them to perform 3D model manipulation tasks in a convenient manner and (b) using Mobiature is an entertaining experience in itself for the users. This technique can be employed in various applications such as large display appliances (e.g., digital signages, TVs, digital window displays, etc.) and mobile devices (e.g., smartphones, PDAs, etc.) without any additional hardware modifications. Potential fields of application include advertising, entertainment, and information broadcasting.**

I. INTRODUCTION

The use of interaction techniques for 3D content adds considerable value to multimedia consumer products such as 3D TV, IPTV, digital signages, and virtual showrooms. Such techniques can be used in myriad applications across fields such as advertising, entertainment, and information broadcasting. However, the various tasks associated with 3D manipulation are difficult to perform [1]. In particular, if it is assumed that the users of consumer products involving 3D manipulation tasks are non-professionals, it is necessary to ensure that the manipulation techniques are not only efficient but also intuitive and easy to learn.

To enable user interaction with large displays, dedicated controllers (for home displays) or touch sensors (for public displays) have been widely used, and gesture interaction is recognized as a promising technology. However, all these techniques have their own limitations in terms of various design considerations such as maintenance, portability, accessibility, sanitation, intuitiveness, and efficiency [2, 3]. Meanwhile, techniques for using mobile devices as universal controllers have received considerable attention since they can fulfill the requirements associated with most of the abovementioned considerations [2]. The main approach in such techniques is to utilize the numerous sensor resources offered by mobile devices for supporting multimodal control [4,5]. The technique introduced in the present paper is an extension of this approach.

This paper presents Mobiature, an intuitive and efficient 3D model manipulation technique for large displays in which mobile devices are used as multimodal controllers. The technique enables the performance of 3D manipulation tasks such as rotation of a 3D model and selection of a particular part of the model. In subsequent sections, the interaction design, usability test results, implementations, and application scenarios are discussed.

II. INTERACTION DESIGN AND HUMAN FACTORS

Mobiature users can perform rotation tasks via motion sensing and selection tasks via touch sensing. Mobiature supports isomorphic rotation control [1]. Thus, the orientation of the 3D model is dynamically aligned to that of the mobile device in terms of absolute coordinates (Fig. 1). It is well known that this type of the isomorphic rotation technique outperforms other conventional mouse-based techniques such as Virtual Sphere or Arcball [6].

The mobile device displays the model in a static view regardless of its orientation. The selection task can be performed by touching a specific part of the model displayed on the mobile device. Then the corresponding part of the model on the large display responses. However, such interaction design allows users to select parts only on one side of the model, since conventional mobile devices support touch sensing only on one side of the device body. To overcome this problem, we incorporate a flipping button on the Mobiature UI (Fig. 2). Users can flip the models upside down on both the large display and the mobile display by simply tapping this button. By using the flipping function, entire parts of the model can be selected without losing consistency.

Such functions as isomorphic rotation and direct selection provide users with the feeling that they are directly controlling a handheld miniature version of the 3D model on the large

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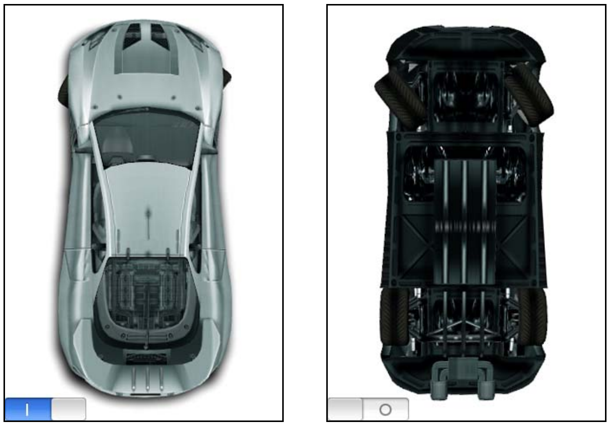
display. For this reason, we refer to this technique as mobile miniature or Mobiature.



(a) Top view mode (b) Bottom view mode

Fig. 2. Mobiature user interfaces displayed on the mobile device. Users can changes the view mode by tapping a button on the left bottom corner that allows the 3D models displayed on the large display and mobile device display to be flipped upside down altogether.

III. Implementation

Recently, smartphone manufacturers have begun to integrate motion sensors and touch sensors by default in commercially available smartphones. Mobiature is a multimodal control technique that takes advantage of the considerable amount and variety of data provided by these sensors. Raw sensor signals are transmitted through the WiFi network between the mobile devices and the large display system.

The technique essentially involves measurement of the 3D orientation of the mobile device. We employed a 3-axis accelerometer and a 3-axis magnetic sensor. As the sensors capture the orientations of the surrounding gravity and magnetic fields, we can easily derive the orientation of the device in 3-DoF. The only calibration data is the magnetic orientation of the display screen. The data is transmitted from the display system to the mobile device when the communication begins.

To reduce the effect of sensor noises, we used a simple blended low-pass filtering scheme. For every sensor dataset, an orientational quaternion is obtained and blended with the accumulated quaternion using Slerp interpolation [7]. Using the suggested algorithm, we could achieve stability, accuracy, and low latency.

IV. Usability Test and Analysis

We performed an informal usability test with 6 male participants. All of them were non-professionals with regard to 3D manipulation tasks, since the target users of Mobiature comprise consuming public. With minimal instruction, we allowed them rotate a vehicle model and select particular parts of the model for 10 min. After the trial session, an informal interview session was conducted for another 10 min.

All the participants felt that Mobiature was intuitive and easy to use. Many positive comments were received, such as “It’s easy,” “I can see the model in diverse views,” and “It works exactly the way I intended.” Five of the participants favorably described the technique using words such as “fun,” ”novel,” and “marvelous.” This demonstrates the entertaining aspect of the Mobiature technique in itself.

V. Application Scenarios

Two scenarios can be presented. The first scenario is for a virtual shopping system that is applicable to digital showrooms or interactive/3D TVs. For a customer who wishes to view a virtual model of a product more carefully, Mobiature can greatly facilitate the rotation task in 3D model manipulation. Furthermore, the selection function can be used to provide detailed information on the various parts of the product.

The other scenario is for interactive digital signage in public spaces. If the 3D model displayed on a large display attracts the attention of a passerby, he/she can approach the display and launch the Mobiature software on his/her own mobile device. The passerby can rotate the model and view it or select particular parts of the model to obtain detailed information about those parts. The anonymity of the users in this scenario is an appealing prospect for users who carry such mobile devices [2].

VI. Conclusion

We introduced Mobiature, a novel 3D model manipulation technique for large displays in which mobile devices are used as multimodal controllers. Further, the interaction design and implementation are described. We performed usability tests and observed that the technique is intuitive, efficient, easy to learn, and entertaining. Using our application scenarios, we show that the technique is useful for applications such as interactive digital signage and virtual shopping. In future studies, we plan to employ gyroscope sensors with extended Kalman filtering to improve the motion sensing performance. In addition, we will improve Mobiature to support more functions such as panning or zooming.

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