

A Discussion of Precise Interaction for Wearable Augmented Reality Systems

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Abstract

In this paper, we discuss the research topic of precise interaction for Wearable Augmented Reality (AR). Our research focus is towards improving interaction with wearable AR systems to assist in the creation and modification of user contents. We present a set of techniques that supports both the creation and modification of virtual models for outdoor wearable AR. Based on our experience, we discuss several challenges faced during our research, in order to emphasize the focus on solving the problem of precise manipulation through the development of new interaction techniques and input devices. We believe that precision is an important problem to tackle for the industrialization of wearable AR.

1. Introduction

Our research into Wearable Augmented Reality (AR) has been focusing on user interaction with virtual contents, especially applicable to large scaled objects, such as buildings and street furniture in outdoor environment. In this paper, we discuss the challenges we have faced in our research as well as propose approaches to the problems of interaction in Wearable AR, in the context of industrialization for Wearable AR.

Industrialization of Wearable AR requires mainstream hardware. For immersive AR, there have been various consumer-ready products, such as the range of video eyewear by Vuzix¹. Cakmakci and Rolland [1] outline the challenges of head mounted display (HMD) research in a comprehensive review of the technology. Development for HMD is actively ongoing within the industry. Wearable computer platforms are not as popular, with the main drive of development towards mobile and portable devices. The wearable computer research community regards the mobile phone as the most successful wearable

computer to date. However, AR related applications for mobile phone are not widely adopted (There is no AR-related app on the lists of Top 100 free and paid apps on Android², the most popular smartphone platform in the US [2]).

Apart from the hardware challenges, social [3], psychophysical [4], and design [5] factors also affect the widespread adoption of Wearable systems. Our research is focused on the user interaction to the system, because we believe that enhancing the user experience with wearable computer systems will improve the adoption rate of the technology. As can be seen from the popularity growth of the mobile phones, one of the factors that propelled mobile devices into ubiquity is the advancement of touch screen technology, which brings natural and user friendly interaction to the mass [6].

In this paper, we present our general research approach for interaction for wearables, which is focused on the creation, modeling, and modification of virtual user contents. We also present a set of model refinement techniques, which assist in such a process. Moreover, we address the problem of precision interaction techniques to emphasize its importance in promoting a wide adoption of wearable AR technology.

2. User contents

AR is an interactive medium through which the real world environment is supplemented with virtual information. The main source of virtual information for AR is virtual models, co-located with the physical surroundings. Models play an important role in AR systems [7] to improve the AR experience by supporting the algorithms that provide improved occlusion effects [8] and more accurate tracking and registration [9], as well as augmenting the corresponding physical objects. There are several non-AR techniques for creating models; however, they lack

¹ www.vuzix.com

² <https://play.google.com>

the instantaneous contextual information offered by AR systems, which leads to a time-consuming modeling process. In-situation modeling is conducted while both virtual and physical world contents are in the AR view, thus providing a live feedback to the modeling process. Modeling on Wearable AR system enables the users to create and modify their own contents, which provides higher engagement of the users to AR systems. Our research into AR interaction is focused in this direction. We are driven to facilitate the process of user contents being created and modified on the fly.

Unlike traditional desktop-based systems whose input devices such as mouse and keyboard are fully developed, AR systems, especially wearable outdoor ones, do not have a similar range of versatile input devices and interaction techniques to support complex and precise modeling tasks. We have surveyed many approaches for modeling using wearable AR systems, including systems by Baillot et al. [10] and Piekarski & Thomas [11] using wearable computers, and by Langlots et al. [12] and Simon [13] using handheld devices and video cameras. We have discovered that the majority of the techniques only produce simple textured polyhedral models of outdoor structures. The surface details of the structures are often captured as 2D texture images instead of being properly modeled in full 3D. Therefore, we are interested in a model refinement process in which extra surface details are created and added to existing models that are created by other AR and non-AR techniques. The next section describes our research work into a set of techniques for model refinement for wearable AR systems.

3. Model refinement techniques

Our methods support model refinement with two main techniques, namely the *augmented rangefinder* and the *augmented viewport*. The augmented rangefinder technique [14] employs a hand-held orientation tracked single-point laser rangefinder for sampling corner points of a physical object. Using this approach the physical object can be either convex or concave and a matching triangular mesh is generated with the same geometry as the physical object, as illustrated in Figure 1. This technique is useful for the *addition* of surface features on existing textured polyhedral building models, or to correct the errors caused by occlusions in the LIDAR models.

The augmented viewport technique [15] utilizes physical cameras in the environment to create a window view into a distant location, through which the user can perform precise manipulation on models at a distance. This technique assists in the model

refinement process by enabling *adjustment* transformations such as translation, rotation, and scaling of the whole or parts of the virtual model to increase the matching accuracy in the positions, orientations, and sizes between the model and the physical object. Figure 2 shows two viewport windows from two cameras pointing to the same remote location. The viewport windows display the top of a physical window and a virtual window lintel (in red)



Figure 1. A model created by the augmented rangefinder technique



Figure 2. Multiple augmented viewport windows

4. Precision in interaction

Based on the experience of our previous work with interaction techniques for outdoor wearable AR systems, we raise the focus of interaction research on precise modeling and manipulation for wearable AR systems. The users of wearable AR system require the ability to create and modify complex and precise virtual objects in context. Therefore, precision is an important factor to consider for interaction research. We have found several challenges during our research.

It is a common approach to apply Virtual Reality (VR) interaction techniques into AR systems. However, most of VR interaction techniques are design to be effective in an immersive virtual environment, in which the user has a pure virtual presence, represented by an avatar. The virtual avatar is not constrained by the physical environment, enabling the user to perform such actions as flying, extending hands, or teleporting. This is not possible in AR systems. Moreover, VR interaction techniques have been known to exploit the human's proprioception, the perception of the locations of body parts in space, to assist with direct manipulations of virtual objects [16]. Being unable to visually perceive the location of their real hands in an immersive environment, the user could only rely on their proprioception to perform interactions. Where there is a sensory conflict, visual information often dominates proprioception [17] and it has been shown that human are less sensitive to the conflict between the vision and proprioception when the virtual hand is separated from the position of the real hand [18]. Therefore, such techniques that separate the position of the virtual hand from the real hand could be effective in an immersive environment. In AR systems, both the real world and virtual information are visually perceived. Therefore, an implementation of the arm extension technique, for example, for outdoor AR would introduce a conflict in which both the physical and virtual hands are visible. It is expected that the hand extension techniques, would not be effective in outdoor AR due to the visual information conflict. A new model of virtual hand interaction is required, in order to provide an intuitive interaction method for wearable computer users.

Furthermore, wearable AR systems are often set in an outdoor environment, where objects are often placed at a large distance from the user. Precision in manipulation is inherently low in action at a distance. Errors are traditionally caused by free hand operation [19] or sensors during manipulation tasks, which are accentuated at distances. Small movements of the user's hands or input device are translated to greater displacement of virtual objects at a distance; thus severely diminishing the precision of the operations. Unlike indoor systems, wearable systems are directly worn on body by the users, thus requiring certain constraints on the physical body. Complex indoors system has the freedom of infrastructure, which allows great precision, such as the tracking systems by OptiTrack³ and Vicon⁴. Therefore, designing interactions for wearable computer imposes certain

constraints on the infrastructure of the technology used.

5. Conclusion

In conclusion, we believe that for a successful track on industrialization of wearable AR systems, precision is required to be dealt with as an important research challenge. Based on our experience and previous works, precision is not only improved on the hardware, sensor developments, but can also be enhanced by directly focusing on interaction techniques and novel input devices.

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³ <http://www.naturalpoint.com/optitrack/>

⁴ <http://www.vicon.com/>

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