Vesp'R – Transforming Handheld Augmented Reality

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ABSTRACT

This paper presents first results of an interaction design study performed for a novel handheld interaction system. Human factors of mid-size, self-containing wearable computer systems are explored.

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1 INTRODUCTION

Augmented reality is well dealt with in indoor settings, were hardware is often externalized from the user. Within handheld and possibly outdoor setups, externalization is often not possible, since the setup needs to be self-containing. The user needs to carry the handheld and some peripherals which are needed for outdoor tracking (like GPS or orientation sensor) that are generally not integrated in handhelds. As a result, a clear form factor trade-off can be observed: more complex applications require larger and heavier devices, because they need more processing power, or extra peripherals. A compromise for a wearable but powerful system is hard to achieve. Many handheld AR setups run on PDAs or powerful cell phones. Ultra-mobile PCs (UMPCs) offer an interesting alternative, providing good graphics and processing capabilities at a reasonable weight. The weight, though, poses ergonomic limitations on both the duration and kind of actions being performed.

In this paper we present the first results of an interaction design study for creating an enclosure around a UMPC holding the peripherals, to which two joystick-like handles can be connected. The transformable construction allows for a good weight distribution in several poses and embeds multiple rigid and flexible controllers in the joysticks to support a wide range of actions. Next to the camera at the back of the UMPC, a wireless camera is mounted in one of the joysticks to support new kinds of interaction.

2 RELATED WORK

Wearable AR systems have been around since the nineties and make use of mobile computers. Two directions can be identified that have varying form factors: the head-mounted display and laptop direction, and the handhelds direction. Hereby a clear trend can be seen towards the latter. The range of laptop-based AR varies from lighter weight, but therefore less powerful systems, to the larger backpack-based solutions [1] [2]. On the other hand, over the last years a good amount of PDA or cell phone-based AR solutions have appeared. Inspired by acceptable processing power and small internal or external cameras, these devices form an interesting platform for predominantly marker-based AR [3]. PDAs and cell phones excel in form factor for simple applications: they are small and light, but have limited control possibilities. Only few UMPC solutions for AR are known to exist, including our system predecessors [4] [5].

There are only limited setups that truly advance the ergonomics of wearable AR. One study, the AR Mask by Grasset et al [6] partly resembles one of our grip approaches.

3 ERGONOMIC DESIGN OF HANDHELD AR

Human factors and ergonomics are often overlooked when designing spatial interfaces, which is particularly bad in ergonomically demanding setups. In handheld AR, setups need to be self-containing, especially in outdoor scenarios, which poses strict boundaries on how an interface should be designed. Users look through the handheld device at the real world, interpreting the digital and real world data shown on the display. This video see-through interaction resembles using a camcorder, metaphorically and pose wise. It is often referred to as "lens" [7], having a clear hand-eye coordination relationship. As a result, several human factors need to be regarded: the pose and grip of the user's hands to holding the display, the way the hand controls the actions restricted by the pose and lens metaphor, and the effects of focal plane, focus and small display size. The largest ergonomic constraint of handheld AR is the pose of the user, to hold the device quite high, oriented towards the head. Biomechanics studies indicate that, depending on the weight of an object in the hand, users will experience severe fatigue after latest 3-5 minutes of duration, when this object is held about 50 cm away from the body, in front of the eyes. Moving the device down a little (around 20cm) can easily double the duration of usage without experiencing fatigue [8]. Consequently, both weight and the way the device is held (below or from the sides) greatly affects the usage duration. Most users hold a handheld in power grip [9], either in one hand (with lighter devices) or from the sides with both hands. The UMPC can be held with one hand for a short time, but the uneven weight distribution will cause the device to tilt to the opposite side. Balancing the tilt can cause extreme fatigue: the counterbalance muscular activity generally pushes the user to make use of a two-handed grip after a short while. Hereby, a badly designed grip easily increases the chance on fatigue: the more strength can be put on a device in power grip, the better. The power grip fits well to the mostly viewpoint oriented usage of handheld AR, where the device is moved. It is important to notice that viewpoint control (navigation) and manipulation is strongly interwoven in handheld AR. In order to further extend interactive possibilities, it is frequently needed to access the physical controllers like a button on the handheld device, or to extend the device by adding new controllers. However, the usage of such controls is often not possible when holding the device up high [10]. At the end, what we learned from the study was: try to distribute the weight better over the hands, thereby possible

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allowing to put more force on the wrist by not grabbing the UMPC directly, next to considering possibilities to lean the arms on the body to relief weight. Still, new grips should allow the access of controls in a direct and ergonomic way. Taking the human factors into account, we designed a new enclosure (housing) for a UMPC, running the Studierstube AR environment. The housing should extend the duration of ergonomically correct usage, and include a range of controllers to extend the interactive possibilities for applications. Furthermore, the controllers should allow for enhanced control of objects without moving the viewpoint of the display. After extensive analysis of many kinds of grips and their effects on weight distribution, we came up with "Vesp'R", consisting of the "BatPack", an enclosure around the UMPC holding the peripherals, and two joystick-like handles (the "wings") that can be mounted at multiple spots. The devices are made from extremely lightweight ABS plastic (stereolithography) covered by a thin layer of velvety rubber, a hygienic and very soft material to grab. Vesp'R is derived from the Latin word for "bat", a reference the form of the devices, and Ware's "bat" interface studies [11].

Figure 1. Configuration with wings mounted at the side

The BatPack holds a GPS device, an orientation sensor, a USB camera and a receiver for the wireless camera embedded in one of the joysticks. The joysticks, both with a bimanual grip, also hold multiple rigid and flexible controllers. Most controllers are placed such that they can easily be reached by the fingers: the user does not need to access any controllers on the UMPC. Furthermore, the controllers can be used by fine finger control, supporting precise interaction. Two main joystick mounting configurations are possible that have specific ergonomic and interactive specifications. In the basic configuration, the joysticks are mounted left and right of the UMPC, resembling a Formula 1 steering wheel. This matches the quasi "steering around an object" behavior that is normal in an AR application. The ergonomic configuration with good weight distribution resembles how users normally grab the UMPC by the sides with a power grip, but now, the chance is eliminated to cover the display with the fingers. The grip also allows to quasi lean the arms against the front of the body, which stabilizes the view, and relieves the arm considerably from the down-force caused by the weight of the devices. Additionally, since the inclination of the grips and the camera can be changed, it is possible to lower the device in front of the body, looking slightly shifted at the display, still firmly holding the joysticks. The second configuration of Vesp'R takes another direction for using an UMPC for handheld AR. Inspired by Grasset et al [6], one of the joysticks is mounted below the UMPC. In this mode, the UMPC can be controlled single handed, since the weight of the construction can be held well when grabbed from below. The weight is distributed over the wrist and the arm, especially since the UMPC does not tilt sideward, as it would do when being grabbed from one side. The grip poses some force which tilts the device away from the body, but this does not pose considerable fatigue on the wrist. And, similar to the first configuration, the arm can be rested against the body, further limiting fatigue. Because the device is held in one hand, the user can now use the unattached joystick to interact with objects in close proximity or use the touch screen. Users can make use of the wireless camera to get close to markers, using a two-camera tracking method currently under further development. We believe that this method can have a substantial impact on both interaction and tracking.

4 Conclusion

In this paper we presented first results of our interaction design study for a new handheld AR interface. Specific focus was put on the human factors and ergonomics of the device enclosure and handles. Though the ergonomic design of Vesp'R is already a large step forward, the study continues to refine different grip and controller configurations. Furthermore, we are extending our work into the two camera paradigm, being an open field for research with large potential.

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