WonderScope: Practical Near-surface AR Device for Museum Exhibits

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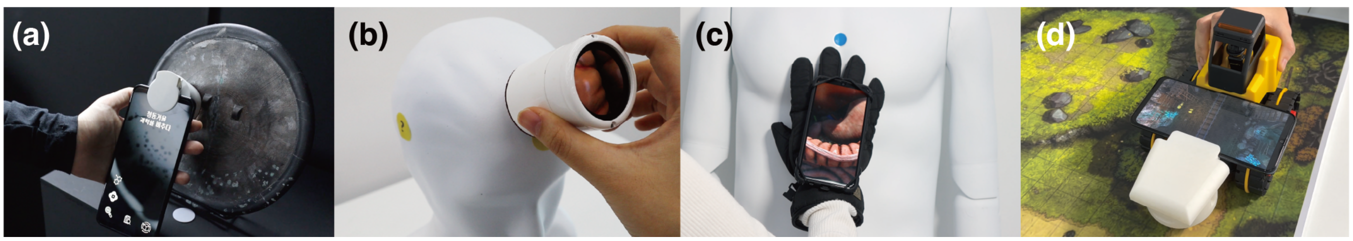

Figure 1: Applications of near-surface augmented reality using WonderScope

ABSTRACT

Mobile augmented reality (AR) applications have become essential tools for delivering additional information to museum visitors. However, interacting through a mobile screen can potentially distract visitors from the exhibits. We propose WonderScope which is a peripheral system for mobile devices that enables practical near-surface AR interaction. Using a single small RFID tag on the exhibit as the origin, WonderScope can detect the position and orientation of the device on the surface of the exhibit. It performs on various surfaces of different materials based on the result of data fusion from two types of displacement sensors and an accelerometer of an inertial measurement unit (IMU). The mobile application utilizes the data for spatial registration of digital content on the exhibit's surface, which make the users feel like seeing-through or magnifying the surface of exhibits.

CCS CONCEPTS

• **Human-centered computing** → *Displays and imagers.*

KEYWORDS

near-surface interaction, museum, interactive exhibition

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1 INTRODUCTION

Many museums use mobile AR technologies to provide digital information on the physical exhibits. However, visitors interacting with digital content keep a distance from real exhibits, which distracts visitors from the exhibits. Therefore, in this study, we propose a near-surface AR device for providing digital information on the surface of the real exhibit, such as magic lens interaction, which can enhance the situatedness of information and visitor experience.

Researchers in human-computer interaction have suggested near-surface AR technologies that track the position and orientation of handheld devices on the surface of another device (e.g. tabletop) or physical objects (e.g. map). Systems such as MetaDesk [Ullmer and Ishii 1997], LightSense [Olwal 2006], and MagPad [Xu et al. 2015] use separate installations to sense the position of passive lenses and mobile devices. THAW [Leigh et al. 2015] and devEye [Coconu and Hege 2017] utilized visual pattern displayed or printed on the surface through a smartphone's camera without any additional installation. However, printing specific patterns on the surface of exhibits or using additional installations for every exhibits can be impractical. To overcome this problem, we suggest WonderScope, a peripheral mobile device. It enables tracking of the position and the orientation of a mobile device based on the original

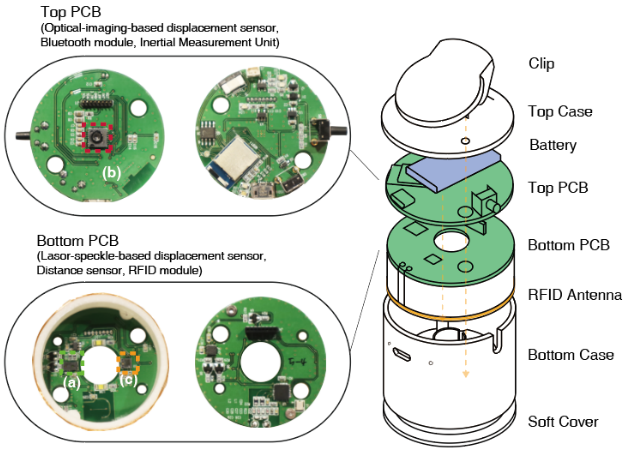

Figure 2: Hardware configuration of WonderScope

position of the RFID tag by combining relative displacement from two types of displacement sensors and an inertial measurement unit (IMU). A small and thin RFID tag is used which can be attached to any type of exhibit without any change in volume. In addition, we propose various applications of WonderScope using mobile devices and different types of exhibits.

2 WONDERSCOPE MODULE

The WonderScope module is in a cylindrical shape (45 * 50 mm), reasonably sized to be combined with a mobile device. It contains a Bluetooth low-energy (BLE) module for communication with a mobile device, an RFID reader for identifying exhibits, two types of displacement sensors, and an inertial measurement unit (IMU) for tracking its position (Figure 2).

2.1 Identifying exhibits and setting an origin

The bottom PCB contains a distance sensor (VL6280). When the distance from the exhibit is under 4-5cm, the RFID reader (13.56Mhz, ISO 14443A) is activated. The reader antenna can detect a tag up to 15 mm away in a maximum of 102 ms. The RFID tag is used to identify the exhibit and to set the origin of the device position relative to the exhibit.

2.2 Tracking movement and orientation

After WonderScope sets its origin, it determines its orientation using the IMU and its relative position from the tag using the IMU and the two displacement sensors, PAA5100 and PAT9125, optimized for coarse and glossy surfaces, respectively. A Kalman filter for each displacement sensor combines the data and the IMU data. WonderScope then weighs and combines the two Kalman filter outputs based on their accuracy to produce a displacement estimate that is reliable over a wide range of surface profiles: acrylic surfaces, papers with or without patterns, woodblocks, fabrics, and wool felts. WonderScope can reliably estimate its displacement at up to 13 mm of hovering height and under 0.81m/s of moving speed in contrast to an ordinary mouse sensor which has a shallow focal depth. Based on the displacement and orientation data from WonderScope, the mobile application rotates and translates the visual information in an opposite direction, and can make users feel like the digital contents are spatially registered with an exhibit.

3 APPLICATIONS

3.1 Handheld type

As shown in Figure 1a, WonderScope can be mounted on a smartphone and used like a magnifying lens. The user can hold and move it along the surface of an exhibit while exploring the information space. In addition, it can be combined with a smartwatch and used like a loupe (Figure 1b). The smartwatch's smaller screen can make the interaction restricted. However, the lens-like display provides a more realistic seeing-through experience.

3.2 Wearable type

WonderScope is sufficiently small and can be used in wearable form. With 3D printed parts, it can be combined with a glove and smartphone, as shown in Figure 1c. It provides a more sensory experience when the user gropes the exhibit surface. For example, a smartphone shows the inside of a body and produces a heartbeating sound with vibration making the seeing-through experience becomes more realistic.

3.3 Built-in type

WonderScope can be customized to fit any content by adding simple 3D printed parts. For example, we added 3D printed parts to combine WonderScope and a smartphone to an existing construction vehicle toy as Figure 1d. It fits the narrative that finds minerals underground, and the user can move the vehicle on the board with AR enhancement. In this manner, customizing the hardware of WonderScope can engage the user in the content's narrative.

4 FUTURE APPLICATION

WonderScope has potential practical applications not only in museums and science communication but also in other fields of gaming, education, advertisement, and so on.

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