Effective Gesture-Based User Interfaces on Mobile Mixed Reality

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ABSTRACT

To help people who are blind or have low vision (BLV) travel independently, virtual reality (VR) and mixed reality (MR) are used to train the BLV users to acquire spatial knowledge for trip planning. The VR apps utilizes auditory and haptic feedback to help BLV people interact with virtual environments to build mental maps. In this project, we improve a MR cane iPhone app by designing and integrating a laser pointer tool and a gesture-based menu to assist BLV users in learning spatial layout of a virtual environment more efficiently. A laser pointer allows BLV users to quickly explore a virtual environment. A gesture-based menu helps BLV users easily manipulate the user interface of the MR cane app.

CCS CONCEPTS

• **Computer-centered → Mixed reality**; *Auditory feedback*; Accessibility technologies; Accessibility systems and tools.

KEYWORDS

mixed reality, face detection, augmented reality, virtual reality, audio feedback,haptic feedback, 3D environment

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1 INTRODUCTION

People who are blind or have low vision (BLV) face challenges when traveling and exploring an unknown environment. This phenomenon has become significantly increased during the COVID pandemic. Various virtual reality apps were proposed to allow people with BLV to explore virtual environments and learn spatial layouts. Researchers from Microsoft [1] [3] have designed a cane with a brake to provide BLV users with realistic tactile and auditory feedback to explore virtual environments. To allow the general blind community to easily access VR, we have developed a mixed reality (MR) cane proposed on an iPhone [2]. When using the MR cane to interact with virtual objects, iPhone will simulate real-world feedback through vibration and sound. The purpose of the MR cane is to provide realistic tactile and spatial audio feedback when users explore the virtual environment that simulates the real-world space. The MR cane not only guides the user's movement through voice instruction but provides realistic feedback to assist users in learning the spatial layout by themselves.

BLV users often have to explore the complex virtual room multiple times to establish a solid mental map. It reduces the learning efficiency of users and causes exhaustion. Also, the MR cane requires users to place the device on the selfie stick. It is inconvenient for them to navigate app interfaces by physically interacting with the screen. It distracts them from learning attention. In additionally, the original MR cane app design lacks a convenient interface and the tools to effectively get the virtual room's spatial layout. Therefore, we designed and implemented two new features: a laser pointer and a gesture-based menu, and integrated them into the MR cane mobile app. The new features allow BLV users easily navigate different app functions and explore the VR environment.

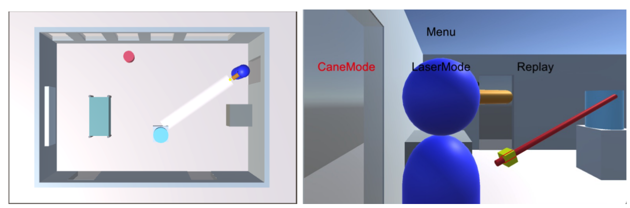

Figure 1: Demonstration diagram of the laser pointer and gesture-based menu. The left image shows that a user explores a virtual object using the laser pointer tool that emits the laser beam interacting with the virtual object of the virtual room; the right image shows that a user switches different functions using the gesture-based menu.

2 SYSTEM DESIGN AND IMPLEMENTATION

While a long cane allows BLV user to explore the real-world environment, recognize objects and avoid obstacles, the MR cane app uses iPhone on a selfie stick to simulate a long cane in VR and allows BLV users to explore a VR environment. It utilizes Augmented Reality (AR) techniques to track the iPhone's poses in the real world, which is then synchronized to the simulated long cane in the VR environment. Using the MR Cane, BVI individuals could interact with the virtual objects in the VR environment to gain perceptual understanding of spatial information through auditory and vibrotactile feedback. In this work, to improve user experience and user interface, we have developed a laser point tool and gesture-based menu, and integrate these new features in the existing MR cane app.

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2.1 Laser pointer

In the MR cane app, BLV users learn a virtual object when the simulated cane contacts a virtual object so they often have to walk around to find virtual objects in a virtual room. The proposed laser pointer tool allows the users efficiently explore a virtual room. The laser pointer emits an intense beam of the ray cast from the iPhone (simulated cane), along with the direction of the iPhone. When the beam hits a virtual object in the room, users will get the physical and spatial information of the pointed object in real-time through a verbal message. The laser pointer tool allows the users quickly explore a virtual room, without any movement. They can easily measure objects in the virtual environment by pointing out the iPhone to the object. The feature allows BLV users quickly explore a virtual environment to get a rough mentor map, or enhance their previous learning.

2.2 Gesture-based menu

Users may need to use different virtual tools to learn the layout of the virtual space in the MR Cane mobile app. They sometimes need to switch among various features such as virtual cane, laser pointer tool, etc. In the existing MR Cane mobile app, users have to swipe fingers on the iPhone's screen to switch to different function, and it is not an easy task since the iPhone is attached to the selfie stick. Moreover, it may distract their attentions. We propose a gesture-based menu to tackle this challenge. Users hold the self-stick with an iPhone and the pose of the iPhone changes, when they raise their forearms. iPhone's pose is tracked by ARKit. If the pitch value of the iPhone is within a predefined range, the gesture-based menu will remain open; otherwise, the gesture-based menu will stay closed. The gesture-based menu options will automatically switch to the next every two seconds. Also, it will notify users the content of the current option. The menu will be changed when the gesture-based menu is closed.

3 EXPERIMENT

Due to the lack of suitable BLV testers, we recruit four participants with normal vision. The participants are asked to keep their eyes covered during the experiment to simulate BLV test users. In the experiment, they must use the laser pointer and gesture-based menu to explore a virtual room. The virtual room contains four virtual objects, including a wood table, plastic chair, water dispenser, and stone table, which are immediately created inside the room. The virtual room also includes four walls. After finishing the exploration, the participants need to reconstruct the layout of the virtual room and finish a post-survey.

The participants are required to complete a tutorial session. First, they are provided an overview of the experiment, including the technology used in the experiment and how the laser pointer and gesture-based menu work, then they start the tutorial. In the beginning, they hold the selfie stick with the default setting. We ask them to switch the virtual cane to the laser pointer by using the gesture-based menu. They move the laser pointer to interact with different virtual objects. They are encouraged to move around and use the laser pointer to explore the virtual space until they feel comfortable with the basic functions of the MR cane.

After the tutorial session, we lead participants to the start point of the virtual testing room. The participants are required to use the gesture-based menu to switch the virtual cane to the laser pointer and explore the testing room freely. They can explore the room within ten minutes or end the experiment early once they are familiar with the layout of the virtual testing room. After the exploration, the participants are required to draw the structure of the virtual experiment room with simple shapes and the name of virtual objects on a paper.

At the end of the experiment, we ask the participants to complete a post-survey, including their feedback and suggestions.

After the test, each participant is required to reconstruct his/her mental map of the virtual testing room on a paper. We measure the accuracy by superimposing the mental maps on the ground truth map and comparing the differences of directions and object names. The average directional error of four objects is less than 10 degrees, and two participants recognize all four objects and other two participants only recognize two objects correctly. These testing results indicate that the participants can efficiently establish a mental map of the virtual room using the laser pointer. The post-survey indicates that participants strongly agree that using the laser pointer tool can help them quickly obtain spatial information, and gesture-based menus provide easier access to different functions than physically interacting with the iPhone's screen.

4 CONCLUSION

In this work, we introduced the laser pointer, which can help users quickly obtain spatial information in virtual environments without distance limitations. We also introduced the gesture-based menu as a new interface based on iPhone's pose detection, which allows BLV users easily switch the built-in functions of MR cane mobile apps. These new features allow BLV users to quickly manipulate a mobile MR application, which provides BLV users a simple accessible platform to explore a virtual environment and help them to prepare independent travel. In the future, we will recruit BLV participants to enrich the design of our project.

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