Point and Listen: Bringing a 3D Map to Life with Audio-Based AR

James M. Coughlan, Brandon Biggs, Huiying Shen
Smith-Kettlewell Eye Research Institute, San Francisco, CA

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We describe an inexpensive and versatile approach that uses audio-based AR to turn a standard 3D map, such as a relief map or 3D printed map, into an interactive one. Audio-based AR enables the creation of audio labels: when the user points at a specific location on the map, information about it is read aloud. In our application, which is a 3D map of a playground, such information might include the name and description of a play structure on the map.

Our goal is to enhance the accessibility of 3D maps to persons with visual impairments. While the layout of 3D maps and the shapes of structures they contain can be perceived by touch alone, the addition of audio labels conveys additional information such as the names and functions of various structures. We note that audio labels can contain much more information than standard braille labels, which are severely limited by available space on the 3D map and are inaccessible to those who don't read braille. Maps have been found to be more usable to people with visual impairments when they are made interactive (Brock, Truillet, Oriola, Picard and Jouffrais, 2015). Moreover, studies such as (Halloway, Marriott and Butler, 2018) comparing 3D models to 2D tactile graphics have found that people with visual impairments preferred 3D models, which suggests that 3D models may be superior to 2D maps (whether in tactile form or digitally conveyed on a touchscreen using audio and vibration feedback).

I. Approach

Our AR approach is based on (Coughlan, Shen and Biggs, 2020) and builds specifically on the work reported in (Biggs, Coughlan and Coppin, 2021). An iPhone is mounted rigidly above the 3D map so that its camera views it in its entirety. Computer vision algorithms (OpenCV, 2015) run on the iPhone to analyze the scene. These algorithms continuously estimate the map pose (this estimation is simplified using barcodes attached to the map corners) and the location of the tip of an inexpensive passive stylus (also containing barcodes) held by the user (Fig. 1). Whenever the stylus tip points to a pre-defined *hotspot* (3D location of interest, i.e., audio AR tag) on the object, the corresponding audio label is read aloud. We note that this approach works with virtually any rigid 3D object.

II. Ongoing and Future Work

We have designed and 3D printed a 3D map (Fig. 1), which is a 1/100 scale model of an actual playground. The design of the 3D map entails important trade-offs between material strength, fidelity and tactile interpretability; for instance, handholds on the climbing giraffe would be too fragile to include in the 3D model, and would also make the giraffe shape less recognizable when touched.

The interactive version of the map identifies dozens of hotspots, such as "Disk Swings," "Climbing Loops" and "Playhouse." We have also created hotspot volumes that identify entire *zones*, i.e., groupings of related playground structures, such as the "Tot Zone"; such volumes are situated above the structures they contain, and are triggered by lifting the stylus tip a few inches above the playground surface. Soon we will test the interactive version of the map with visually impaired participants, not only to assess the system's performance and usability but also to determine how the interactivity improves a participant's ability to answer questions about the playground's spatial layout and to physically navigate the playground.

Future work will include exploring the use of advanced iOS hand tracking features to eliminate the need for a stylus; offering audio labels in multiple languages; and providing audio instructions to guide the user to a desired destination on the map. We are planning a bronze version of the interactive map for permanent installation (including a stylus and rigidly mounted iOS device) at the playground.

Fig. 1. 3D printed version of playground map, shown with user holding pointing stylus.

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