A Mobile VR Application for People With Visual Impairments to Explore Virtual Environments

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Introduction

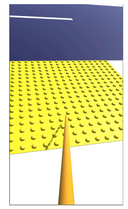
- Finding a way to overcome blindness has been one of humanity's greatest challenges. Recent studies have shown that Virtual Reality (VR) Technology may be used to train blind people for spatial knowledge acquisition.
- However, VR technology is:
  - Expensive
  - Limited to small physical spaces
  - Mainly relies on sight and sound
- We developed an iOS mobile application to make VR more accessible to users with visual impairments. This app:
  - Allows the exploration/navigation of 3D virtual maps using a smartphone as a white cane.
  - Provides auditory and haptic, vibrotactile feedback for an enhanced immersive experience

User Study

- A number of interviews were done to a blind subject about:
  - Their experience with VR technology or technology in general
  - The kinds of applications they often use
  - The types of cues they pay attention to in real life
- Some informal testing of the application was carried out to gather feedback on how to improve it
  - The user is prompted to explore a small virtual map using the application
  - User has to find the objects inside the room using the application
  - After exploring the map, the user is asked point out the location of each object
- At the end of the testing, the user is asked about what they think of the application and how it could be improved

Design & Approach

- **3D Virtual Maps**
  - Created though the Unity Editor
  - Contains 3D objects
    - Walls, floor, table, chair, etc
  - 2 Types:
    - Indoor Map
      - Small space surrounded by 4 walls
      - Has simple objects (i.e: tables / chairs)
    - Outdoor Map
      - Street with sidewalks in each side
      - Includes tactile pavement

Figures 1 & 2: Perspective view from application inside indoor map (left) and outdoor map (right). Virtual cane can be seen in the middle of each screen.

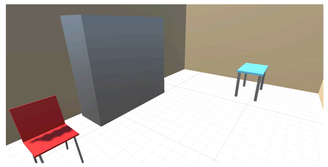


Figure 3: Indoor virtual 3D map containing three objects; a chair. a table, and a cabinet, enclosed within four walls.

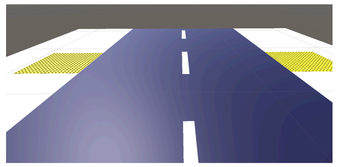


Figure 4: Outdoor 3D map featuring tactile pavement, a road, and sidewalks.

- **Virtual Cane**
  - Attached to and follows the movements of the smartphone
  - Tracking of cane movement is managed by ARKit
    - Relies on smartphone's camera and onboard sensors to estimate position and orientation of the device

Cane Interactions / Interface / Feedback

  - Hitting sounds
    - Whenever the cane comes in contact with a virtual object, an impact sound is played
    - Accompanied by strong vibration
    - Audio depends on an object's material
  - Rubbing sounds
    - If the cane touches an object and moves while still in contact with it, a continuous rubbing sound is played
    - Accompanied by weaker and continuous vibrations
  - Warning sounds
    - Alert-like sound
    - Needed to prevent users from
      - Moving the cane too far inside an object
      - Moving outside of the map zone

Conclusions & Discussions

- We were able to develop a mobile VR application for iPhone with basic features to simulate white cane interactions.
- This type of technology could prove to be useful in allowing blind people explore and navigate through virtual environments for training or entertainment purposes, while keeping it easily accessible to users.
- Mobile Virtual / Augmented Reality is a powerful tool that can help blind people, but limits to this technology still exist.
- Unlike traditional VR, outside sensors are not utilized by this application, resulting in inferior position tracking capabilities.
- The application relies on the phone's camera, thus it performs best in places with many distinguishable features, quality lighting, and few people.
- The 3D virtual maps are large in scale so it is best to use this application in wide empty spaces.

References

- [1] O. Lahav, D. Schloerb, S. Kumar, and M. A. Srinivasan, "A virtual environment for people who are blind - a usability study," J. Assist. Technol., v6, n1, 2012
- [2] J. Bai, S. Lian, Z. Liu, K. Wang, and D. Liu, "Virtual-Blind-Road Following-Based Wearable Navigation Device for Blind People" IEEE Trans. Consum. Electron. v64, 2018
- [3] Y. Zhao et al., "Enabling people with visual impairments to navigate virtual reality with a haptic and auditory cane simulation" Conf. Hum. Factors Comput. Syst., 2018
- [4] A. Rukangu, A. Tuttle, A. Franzluebbers, and K. Johnsen, "V-rod: Floor interaction in VR," Proc. - SUI 2019 ACM Conf. Spat. User Interact., pp. 19–20, 2019
- [5] B. Leporini, M. C. Buzzi, and M. Buzzi, "Interacting with mobile devices via VoiceOver: Usability and accessibility issues," 24th Comput. Interact. Conf. 2012
- [6] A. Rodrigues, K. Montague, H. Nicolau, T. Guerreiro "Getting smartphones to talkback:Understanding smartphone adoption process of blind users"ASSETS 2015
- [7] K. Suzuki, S. Nishi, D. Sakamoto, and T. Ono, "SCAN: Indoor navigation interface on a user-scanned indoor map," Proc. 21st MobileHCI 2019, 2019
- [8] G. Rega et al. "Mobile location-based games to support orientation&mobility training for visually impaired students" MobileHCI 2018
- [9] D. Sato, U. Oh, K. Naito, H. Takagi, K. Kitani, and C. Asakawa, "NavCog3: An Evaluation of a Smartphone-Based Blind Indoor Navigation Assistant with Semantic Features in a Large-Scale Environment", ACM ASSETS 2017

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