

October 2021

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### Recommended Citation

Li, Ziming and Peiris, Roshan (2021) "VR Sound Mapping: Make Sound Accessible for DHH People in Virtual Reality Environments," *Frameless*: Vol. 4: Iss. 1, Article 30.

Available at: <https://repository.rit.edu/frameless/vol4/iss1/30>

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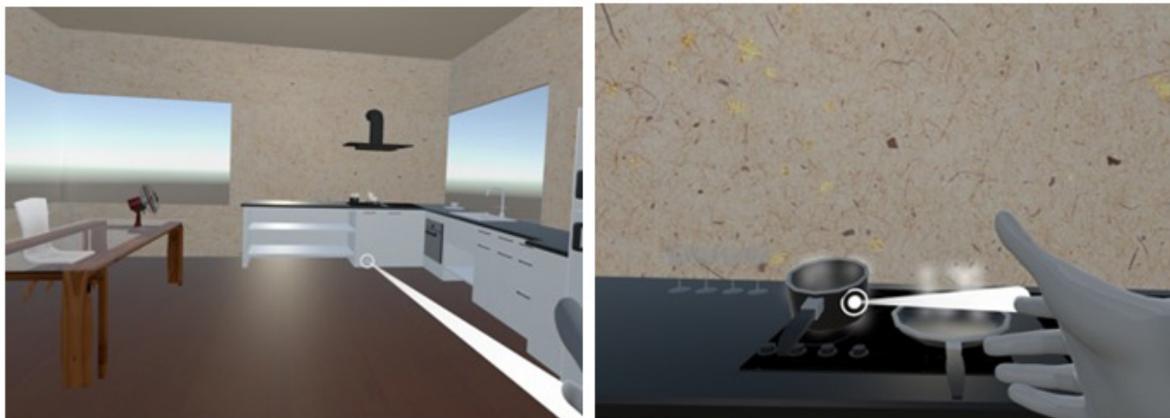
## VR Sound Mapping: Make Sound Accessible for DHH People in Virtual Reality Environments

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*Fig 1. Interacting with different sounding objects in the kitchen scene*

### INTRODUCTION

In-game audio plays an important role in enhancing the sense of reality and immersion in the gaming experience. In many games, sounds are also used to provide notifications and clues, which are essential to the gameplay. However, in this case, the deaf and hard of hearing (DHH) players may

fail to access the information conveyed by sounds, which degrades their gaming experience (Jain et al. 2021).

Our demo, “VR Sound Mapping”, provides several methods to present sound mapped visualizations for DHH people using virtual reality (VR). Our prototype software aims to study and help improve the user experience and the user performance of DHH people while playing VR first-person games.

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*Submitted April 15th, 2022*

*Accepted April 15th, 2022*

*Published online April 18th, 2022*

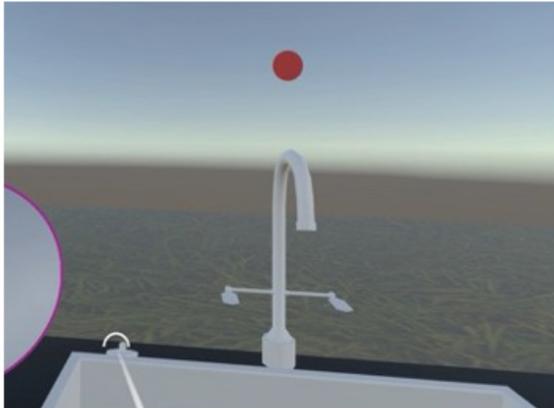


Fig 2. On-object sound indicator

VR Sound Mapping demo application is developed using the Unity game engine. It is deployed on Oculus standalone VR headsets (e.g., Oculus Quest 2) and PC- powered VR headsets (e.g., Oculus Rift S).

Players are expected to wear a supported VR headset to experience our demo application. In the application, players can see a kitchen scene with utensils and appliances that produce various sounds. Then, players can interact with these kitchen props to hear their sound effects (Fig. 1).

The demo application has sound visualization techniques integrated to improve sound accessibility for DHH people. The techniques consist of two components: an on-object sound indicator and a minimap.

The on-object sound indicator is a red dot hover over a sounding object (Fig. 2). It can visualize the loudness of the sound effect from the attached object.

A minimap shows different sound types (e.g., flowing water, dishwasher) using icons on the map located at the corner of the player's view (Fig. 3-left). It is designed to inform players of the sounds appearing in the surrounding.

In addition to the complete minimap, the visualization method has a partial minimap integrated (Fig. 3-right). The partial minimap is a variant of the complete minimap but designed to keep users focusing on the environment of their front.

With these sound accessibility techniques, DHH players can visualize different sound effects in the scene. In this way, they can be aware of the condition of various kitchen

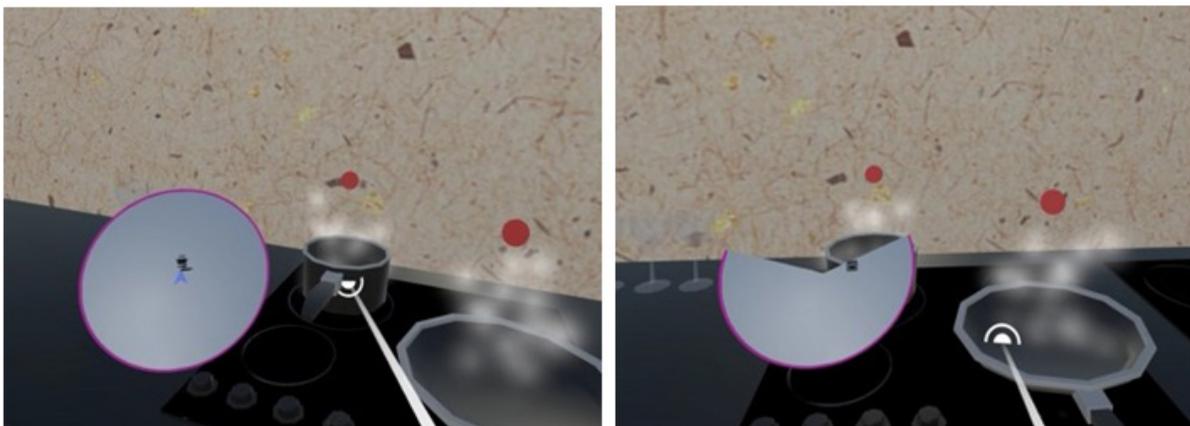


Fig. 3. (Left) Full minimap; (Right) Partial minimap

utensils and appliances in the demo application as the hearing people do, which may enhance their immersion experience.

**Keywords**—*Virtual reality, audio visualization, deaf and hard of hearing people, first-person gaming*

## REFERENCES

- [1] Jain, Dhruv, Sasa Junuzovic, Eyal Ofek, Mike Sinclair, John Porter, Chris Yoon, Swetha Machanavajhala, and Meredith Ringel Morris. 2021. “A Taxonomy of Sounds in Virtual Reality.” *DIS 2021*, 2021. <https://doi.org/10.1145/3461778.3462106>.