

# Visualization of 3D Sound Field using See-Through Head Mounted Display

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## 1. Introduction

- Sound field visualization technology
    - Helps us understand the sound source position and propagation.
    - Use Cases : acoustic education and design, detecting noise, etc.
  - Popular method is to superimpose the sound information onto the image taken by a camera.
- Merit** Easy to understand  
**Problem** Difficult to visualize the depth information by using a 2D display



- **Video and Optical See-Through Head Mounted Display(ST-HMD)** is developed.
  - Stereoscopic viewpoint vision
  - Wearable and movable
  - Realizes **natural Mixed Reality (MR)**

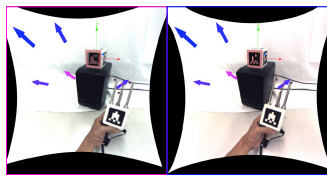


**Proposal** Visualizing 3D sound field with MR by using ST-HMD

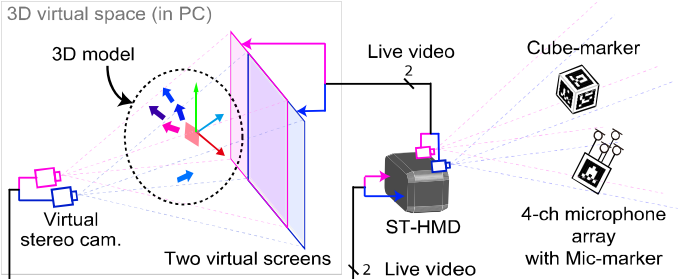
➔ We propose a system measuring and visualizing **3D sound intensity map** using handy microphone, AR marker and ST-HMD.

## 2. Measuring System using Video ST-HMD

### A. Proceeding Flow



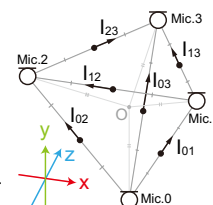
- 3D virtual space in Unity5.5 is used for superimposing 3DCG model onto videos.
- Left and right of virtual stereo camera take video only in the faced screen.



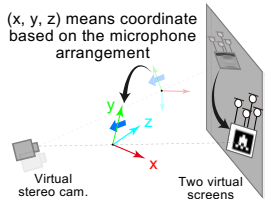
### B. 3D Sound Intensity Calculation

3D sound intensity is calculated from six intensities measured by handy microphone.

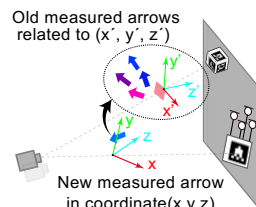
$$\begin{cases} I_x = (I_{01} - I_{02} - 2 \cdot I_{12} - I_{13} + I_{23})/4 \\ I_y = (I_{01} + I_{02} + I_{03})/\sqrt{6} \\ I_z = (-I_{01} - I_{02} + 2 \cdot I_{03} + 3 \cdot I_{13} + 3 \cdot I_{23})/4\sqrt{3} \end{cases}$$



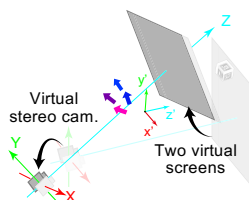
### C. Handy Microphone & Head Tracking



While Mic-Marker is detected by left video  
➢ (x, y, z) is decided by the position and rotation of Mic-Marker.  
➢ Measure a sound intensity and represent a 3DCG arrow repeatedly by moving handy microphone



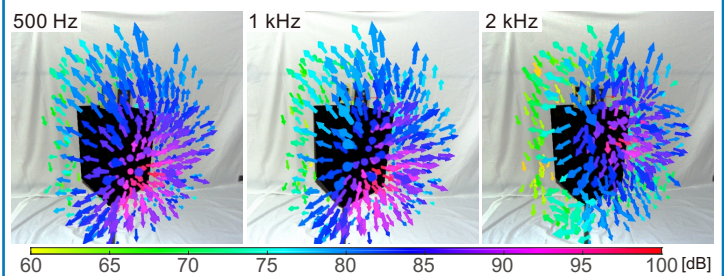
While Box-Marker is detected by left video  
➢ (x', y', z') moves with Box-Marker motion caused by head movement.  
➢ The sound intensity arrows are related to this coordinate.



While Box-Marker isn't detected  
➢ Use **head tracking sensors**  
- Gyro sensor, Acceleration and magnetic field sensor, External tracking camera.

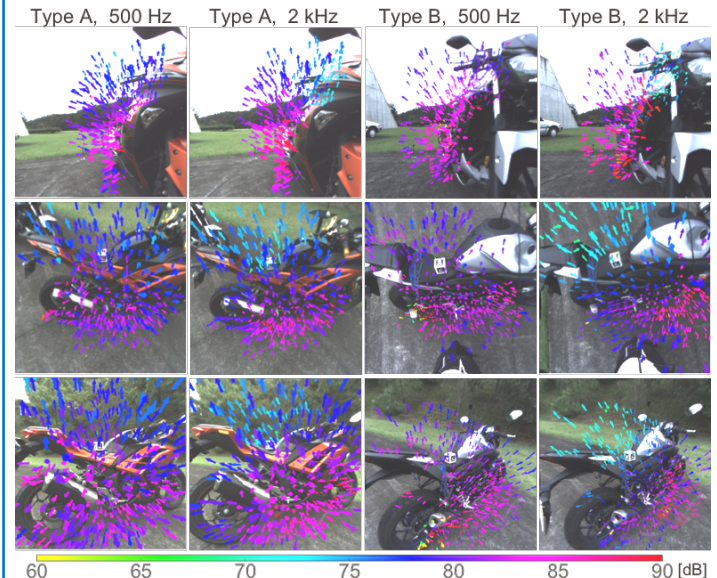
## 3. Examples of 3D Intensity Map

### A. 2-way loudspeaker with noise (Video ST-HMD)

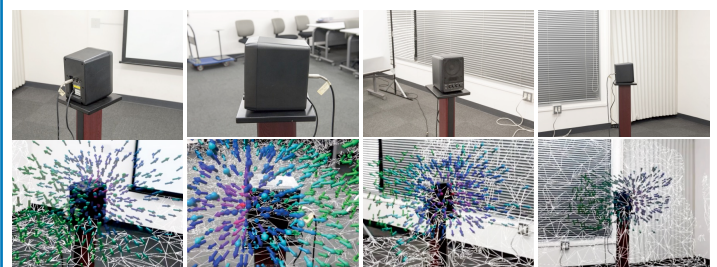


### B. Two different type of motorcycles (Video ST-HMD)

- Only type A has a cover for engine.



### C. Loudspeaker with noise (Optical ST-HMD : HoloLens)



## 4. Conclusion

- ST-HMD helps us understand the entire of 3D sound field more **intuitively** and **interestingly**.
- Future Works : Visualizing another sound information, improving by removing unnecessary markers and cables, etc.