Robust Sound Source Localization considering Similarity of Back-Propagation Signals

Inkyu An[1], Byongho Jo[2], Jung-woo Choi[2], and Sung-eui Yoon[1]

School of Computing, KAIST, Sounth Korea[1]
School of Electrical Engineering, KAIST, Sounth Korea[2]

KAIST

Motivation

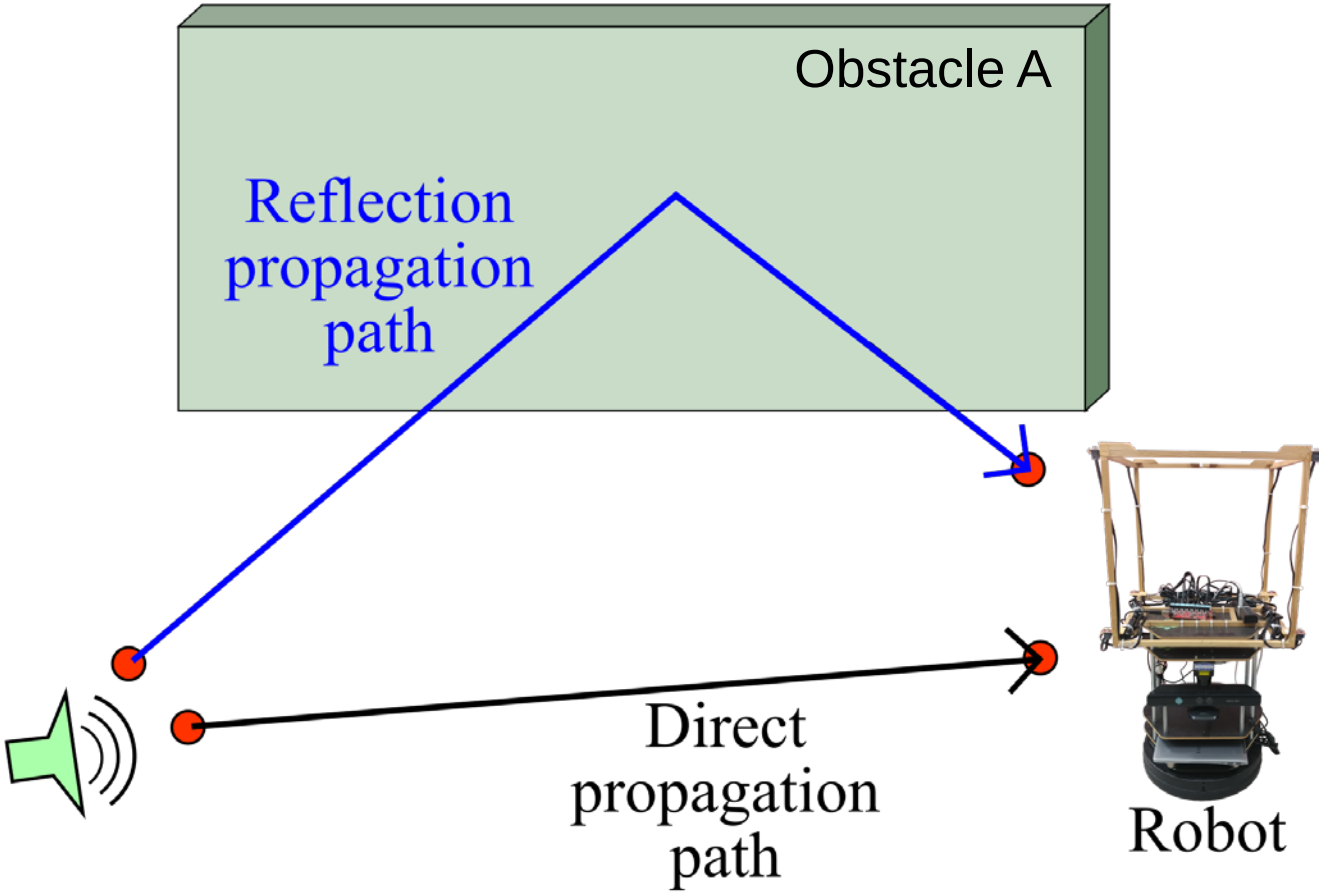
- **Accurate Sound Source Localization**
  - In real environments, we need more accurate Sound Source Localization techniques to identify many kinds of sources.
  - For increasing the accuracy, we have to consider the characteristics of the sound signals.

An example of needs to localize the sound source

Image: Room service robot, Savioke

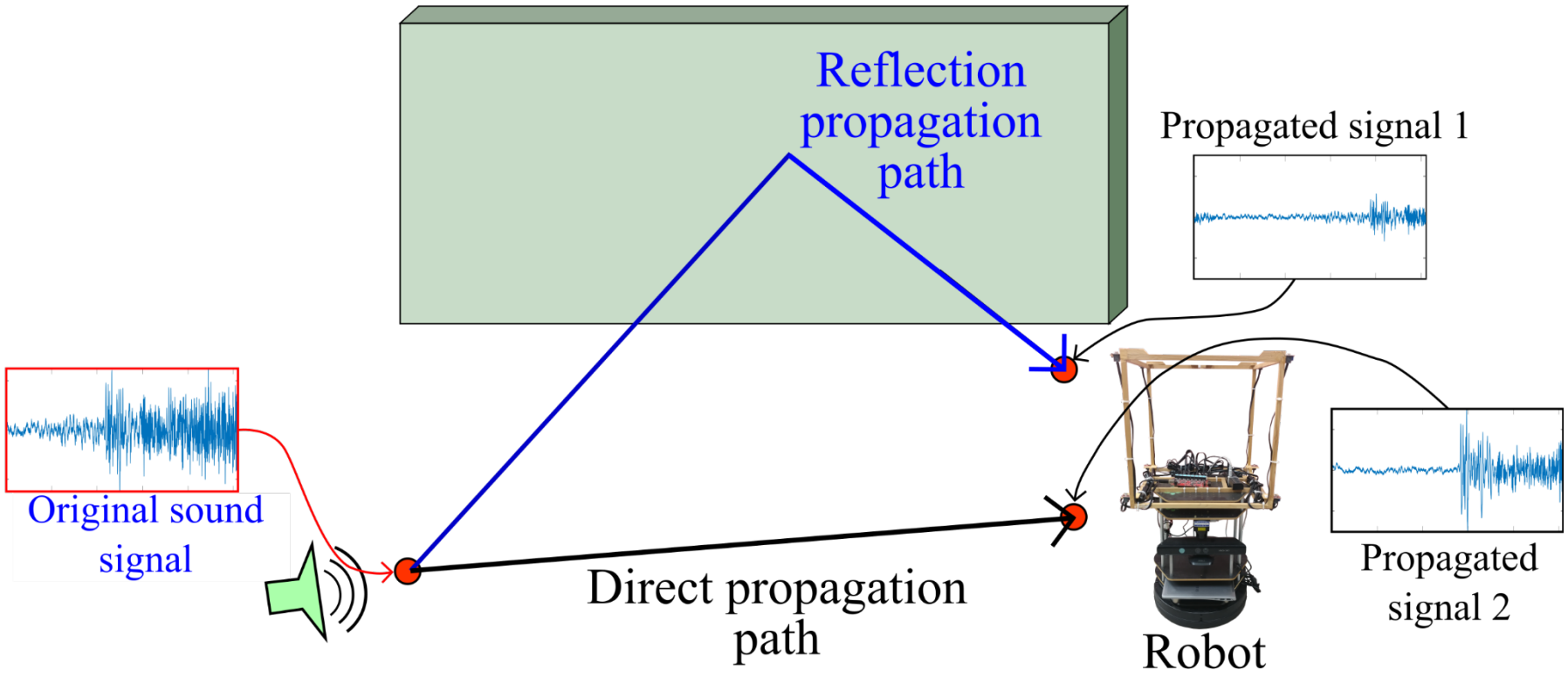
Key Idea of Our Approach

- **The Concept of Back-propagation signals**
  - Sound signals are propagated through two prominent propagation paths; Reflection and Direct propagation paths.



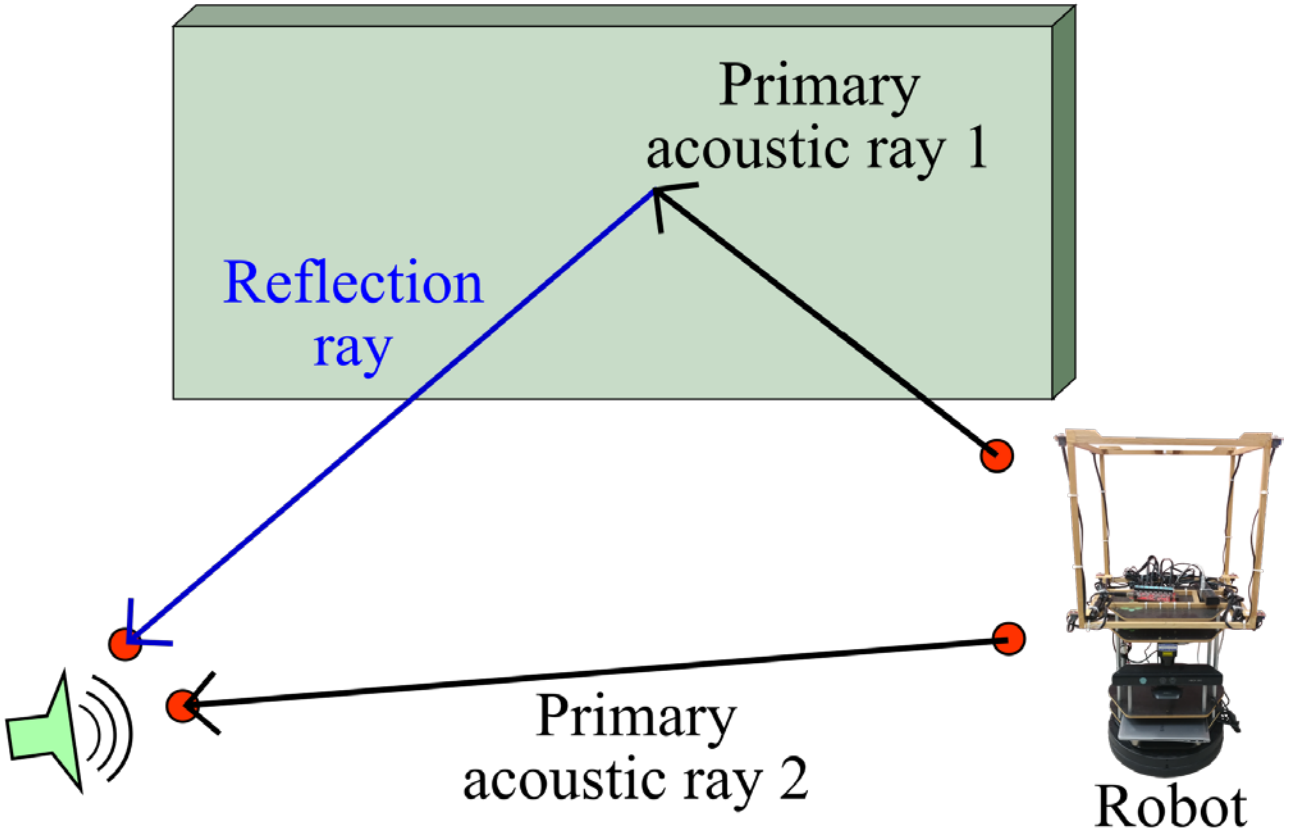
Key Idea of Our Approach

- **The Concept of Back-propagation signals**
  - The original sound signal is changed during the sound propagation of two paths because of the attenuation.



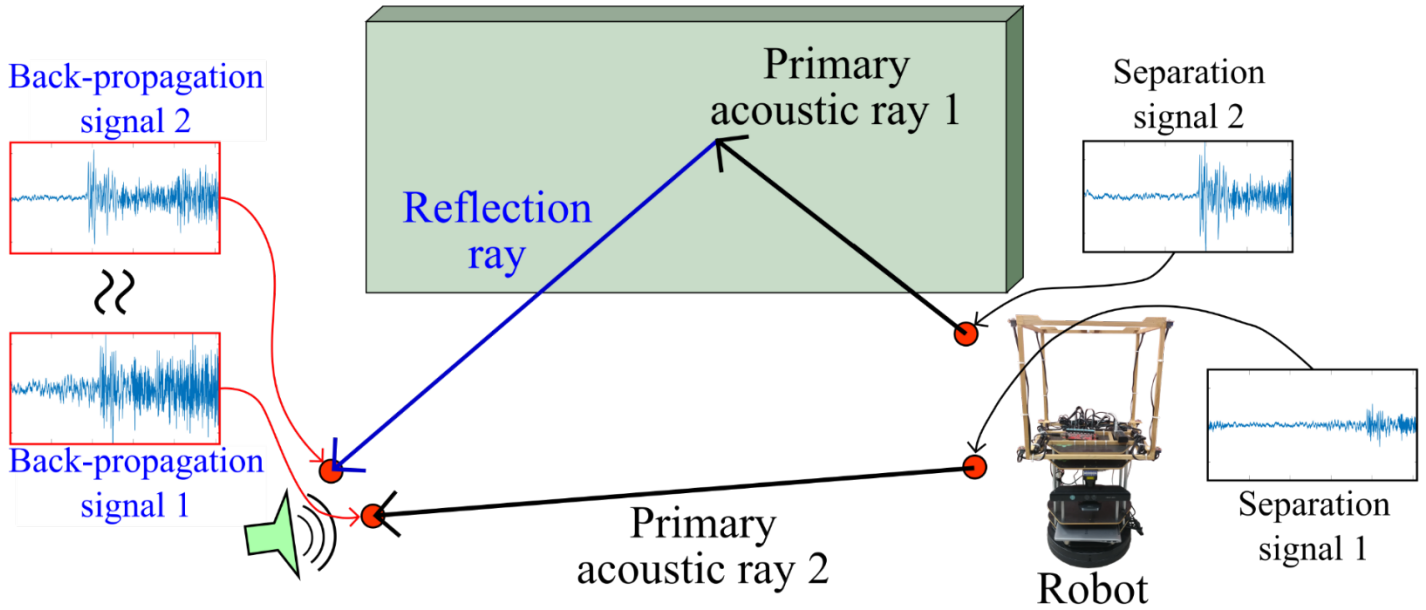
Key Idea of Our Approach

- **The Concept of Back-propagation signals**
  - We can estimate propagation paths using prior techniques. (*Reflection-Aware SSL, ICRA18 & Diffraction-Aware SSL, ICRA19*)



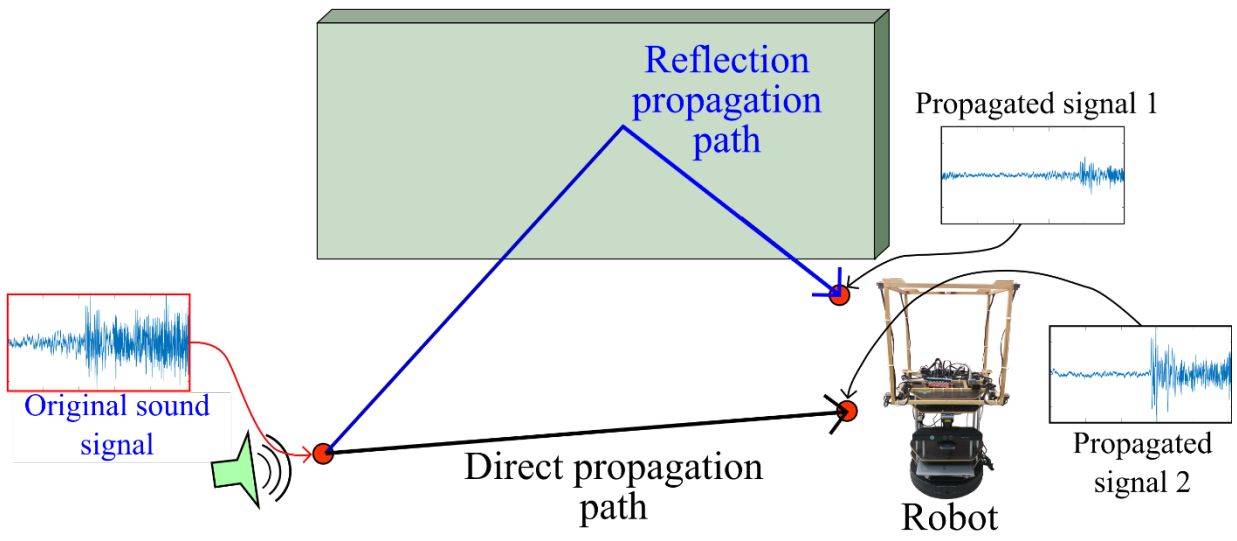
Key Idea of Our Approach

- **The Concept of Back-propagation signals**
  - We separate the sound signal came from a specific sound propagation path → Separation signals
  - We want to restore the original signal based on the acoustic rays → Back-propagation signals
  - We measure the similarity between both back-propagation signals and use the similarity to increase the accuracy



Key Idea of Our Approach

- **Computing back-propagation signals**
  - The sound propagation process is a function where the input is the original signal and the output is the propagated signals through different paths



Propagated signal

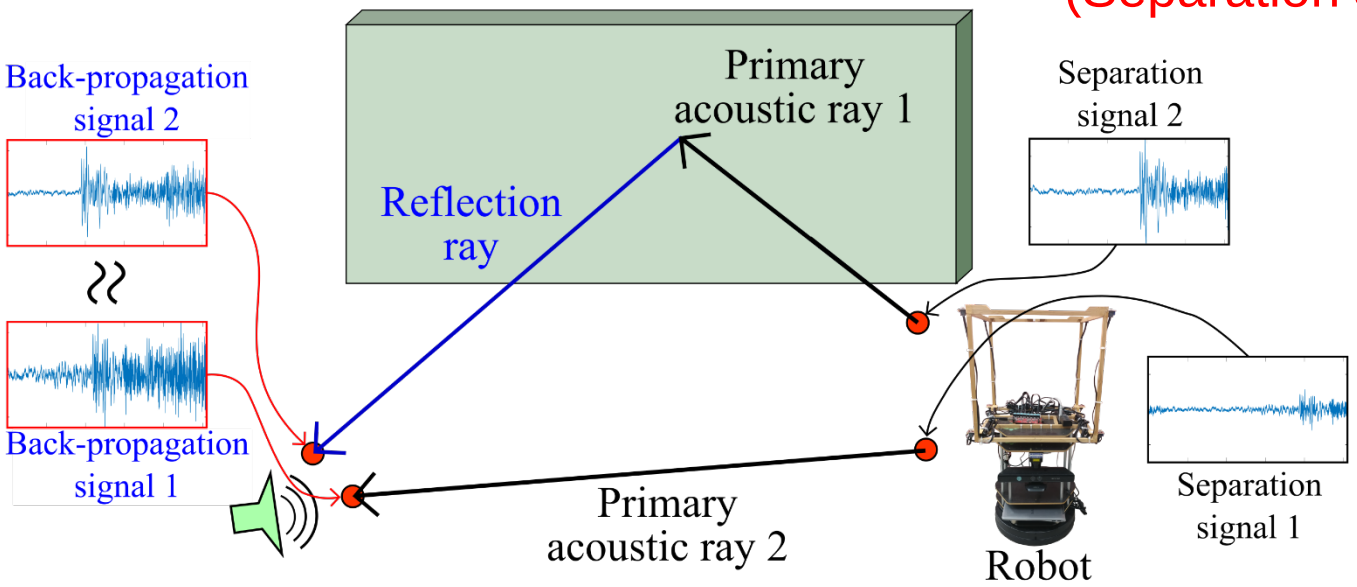
Original signal

$$\rightarrow S_{p^i} = H_i \cdot S_o$$

The Impulse response (considering attenuation)

Key Idea of Our Approach

- **Computing back-propagation signals**
  - The original signals (back-propagation signals) can be restored by using the inverse impulse response of the sound propagations.



Propagated signal (Separation signal)

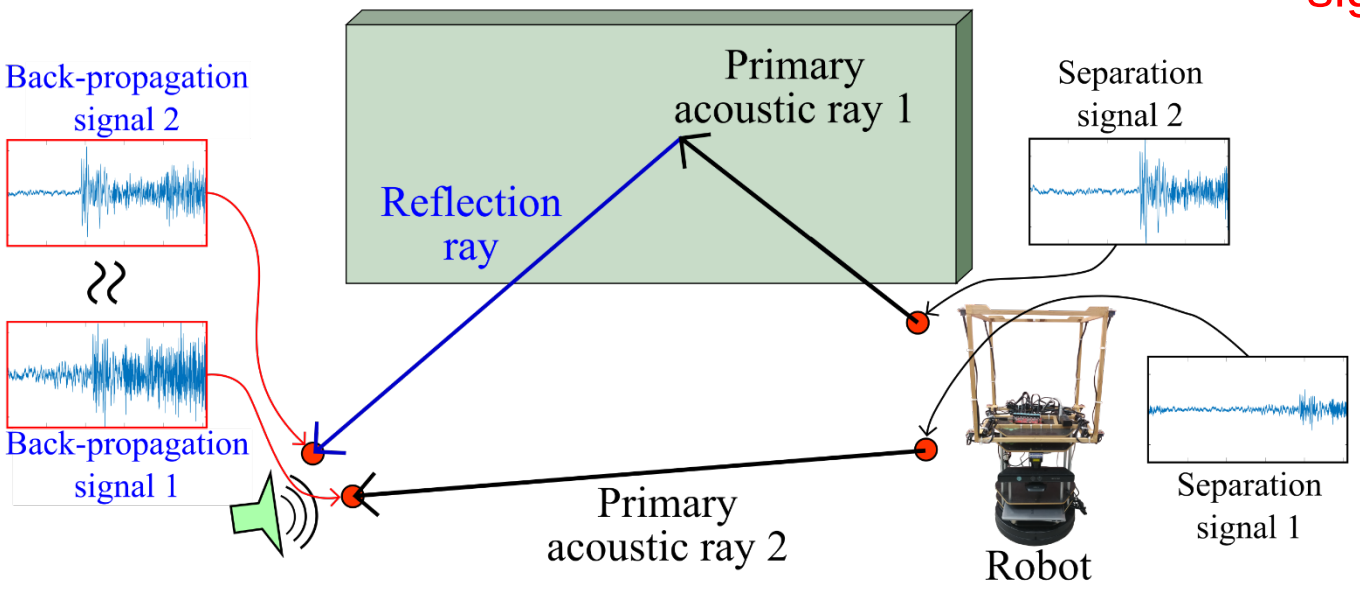
Original signal

$$\rightarrow \boldsymbol{H_i^{-1}} \cdot \boldsymbol{S_{pi}} = \boldsymbol{S_o}$$

The inverse impulse response (considering attenuation)

Key Idea of Our Approach

- **Computing back-propagation signals**
  - The sound propagation process is a function where the input is the original signal and the output is the propagated signals through different paths



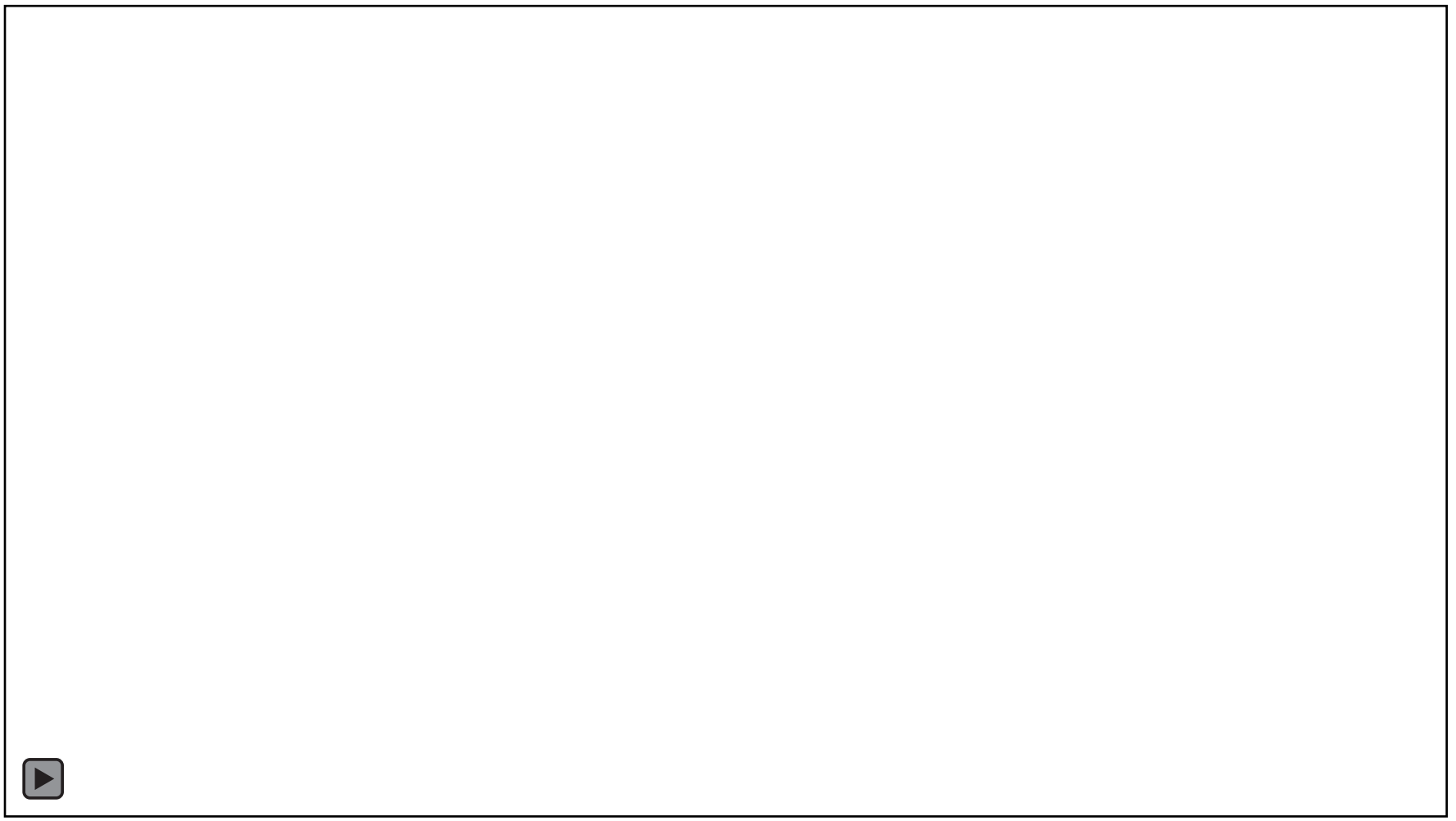
Separation signals

Back-propagation signal

$$\rightarrow \boldsymbol{H_i^{-1}} \cdot \boldsymbol{S_{s^i}} = \boldsymbol{S_b}$$

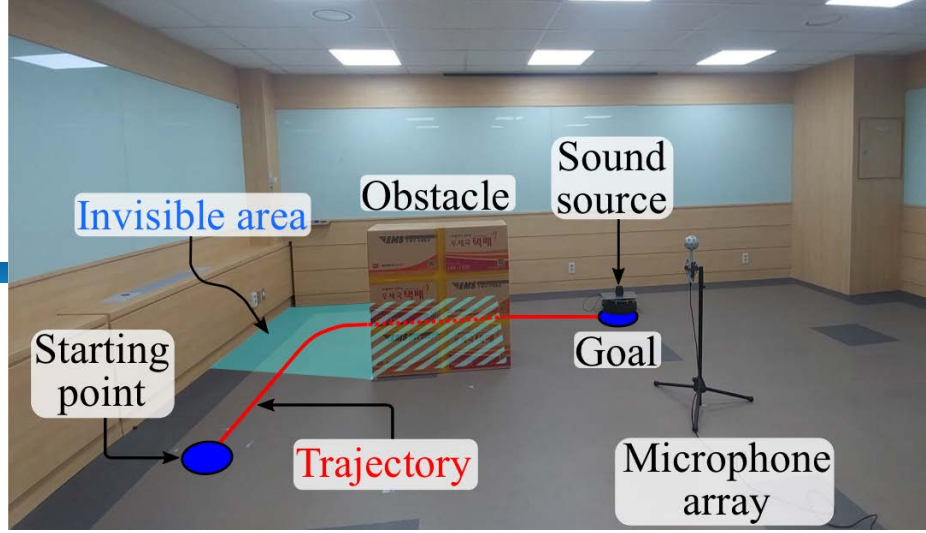
The inverse impulse response (considering attenuation)

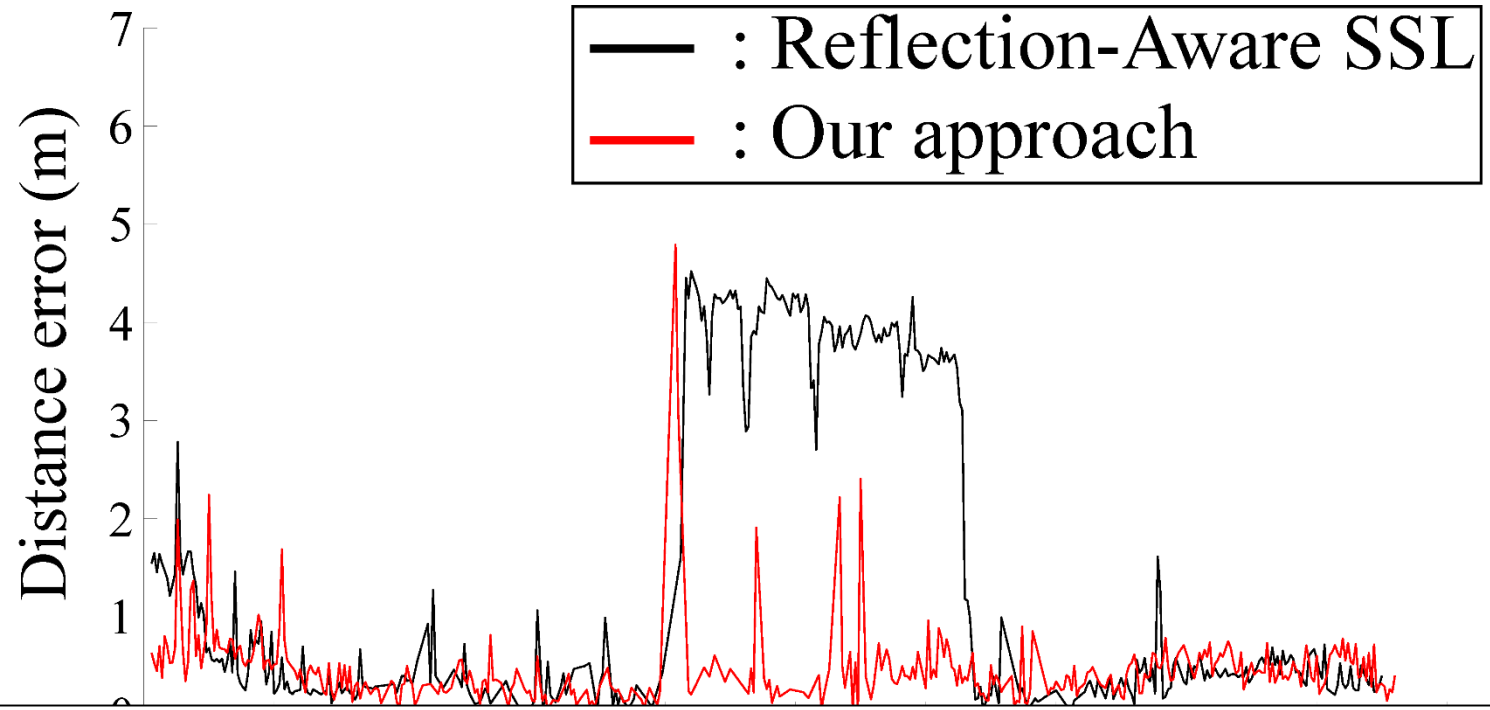
Working Video |



Result |

- The source moves along the red trajectory with a clapping sound
- The environment contains an obstacle





The avg. distance errors are 1.49m (RA-SSL) and 0.46m (Ours), 220% improvement

- **Thanks you !**

- **E-mail:**
  inkyu.an@kaist.ac.kr

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