Reflection-Aware Sound Source Localization

[1]KAIST, Sound Korea, [2]UNC-Chapel Hill, USA

Inkyu An[1], Myungbae Son[1], Dinesh Manocha[2], and Sung-eui Yoon[1]

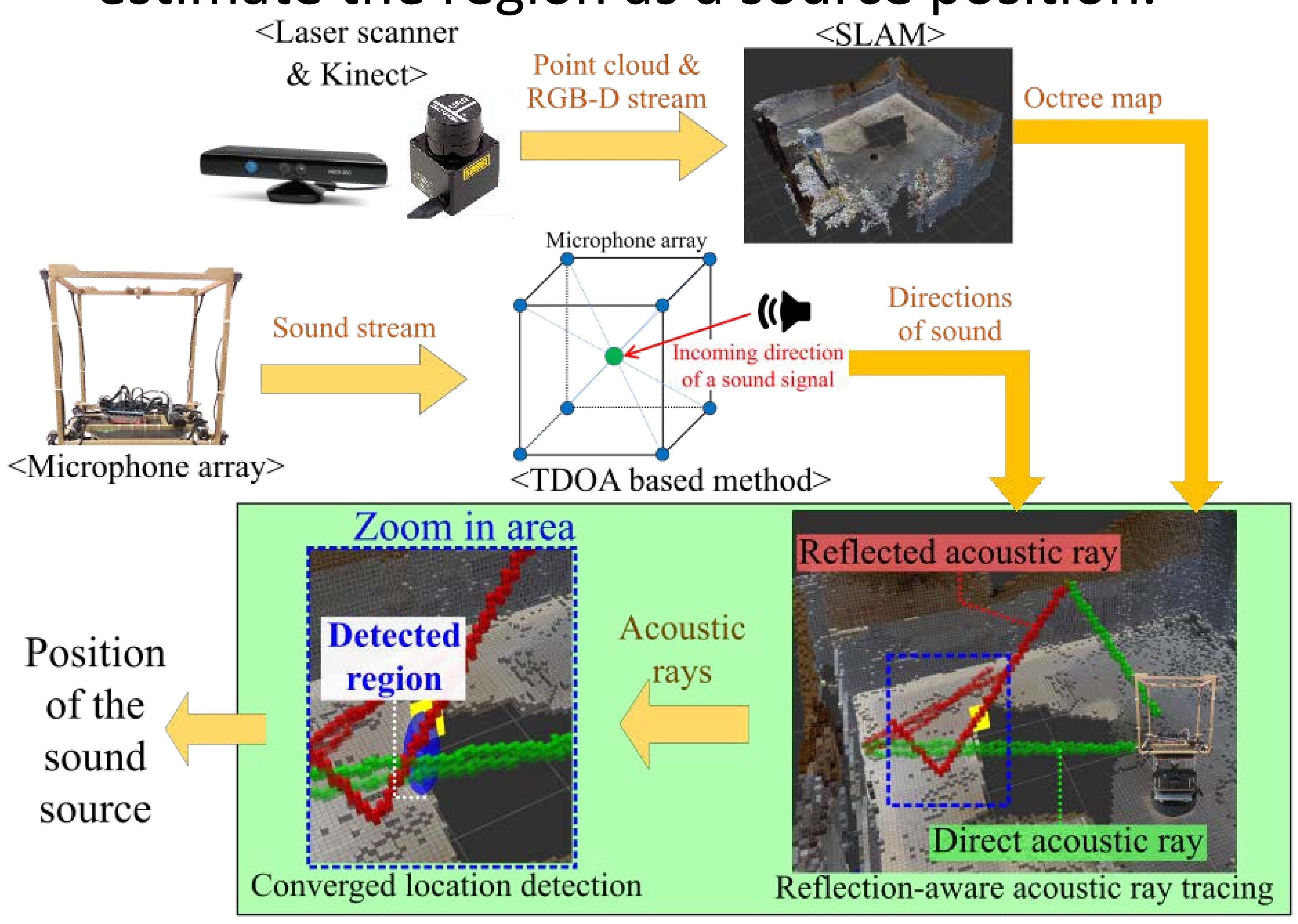
(http://sglab.kaist.ac.kr/RA-SSL)

KAIST

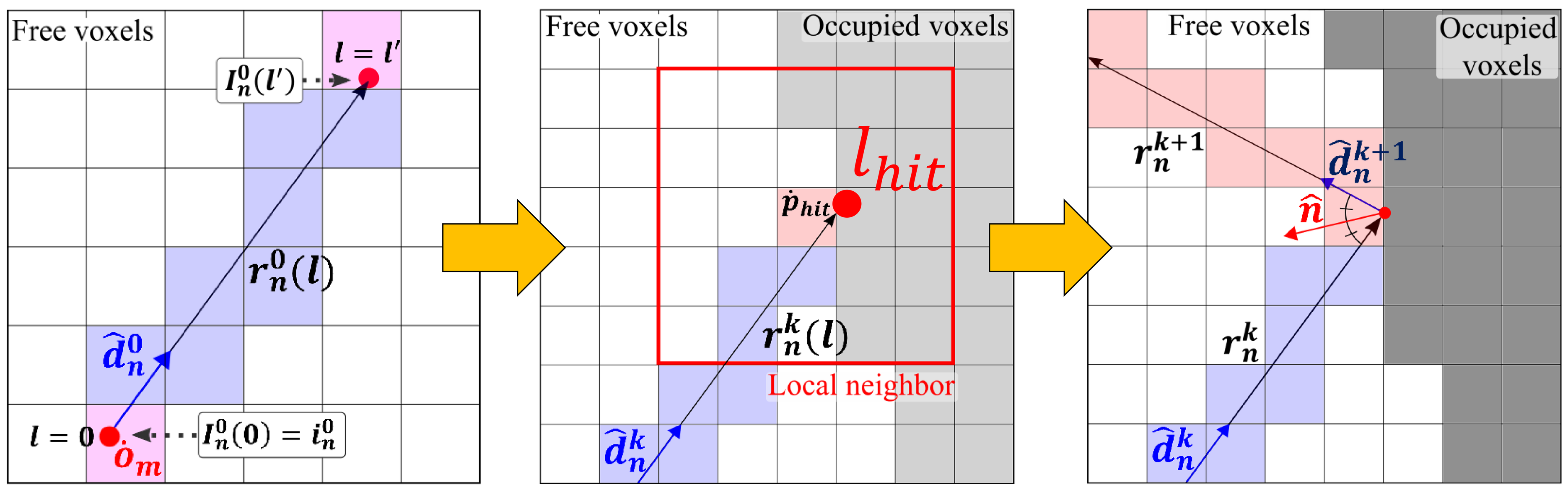
THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Key Idea of Our Approach

1. Collect the direct and indirect directions of the sound from a TDOA-based method.
2. Propagate acoustic rays to the free space considering specular reflection.
3. Find the converged region of rays, and estimate the region as a source position.

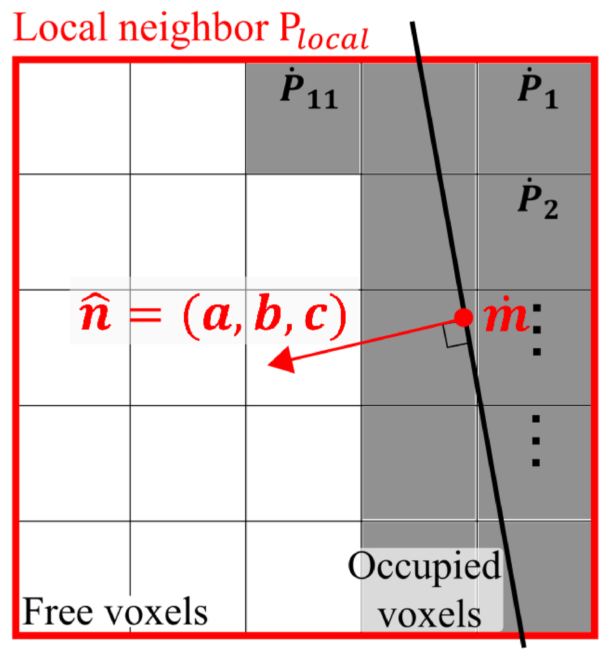


Acoustic Ray Tracing



Initializing an acoustic ray — Detecting a hit — Generating a reflection ray

- Reflection ray: $r_n^{k+1}(l) = \hat{d}_n^{k+1} \cdot l + r_n^k(l_{hit})$
- Generate N acoustic ray paths, $[R_1, \dots, R_N]$, from N directions of sound per every frame.



Computing a normal

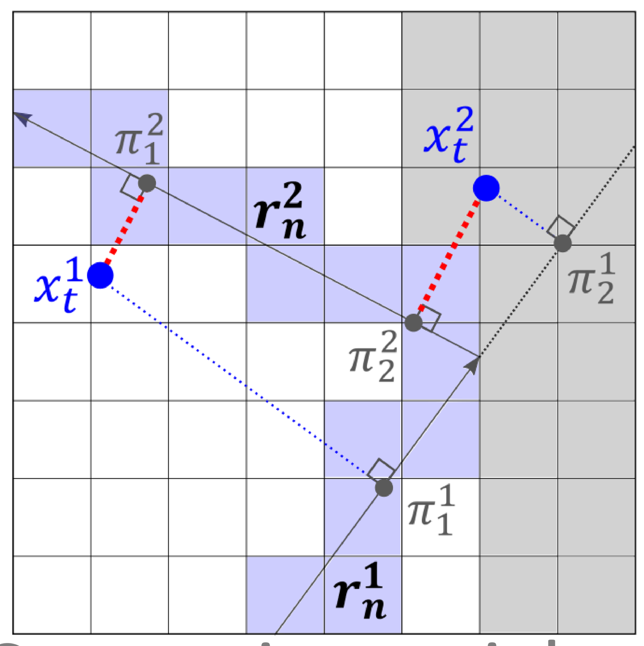
Identifying a converging 3D point

1. Sampling particles x_t^i.
2. Weight computation

$$:P(o_t|x_t^i) = \frac{1}{n_c}\left\{\max_k w(x_t^i, r_n^k)\right\},$$

where $w(x_t^i, r_n^k) \sim f_N(\|x_t^i - \pi_i^k\|, 0, \sigma_w)$

3. Resampling particles near high weights particles



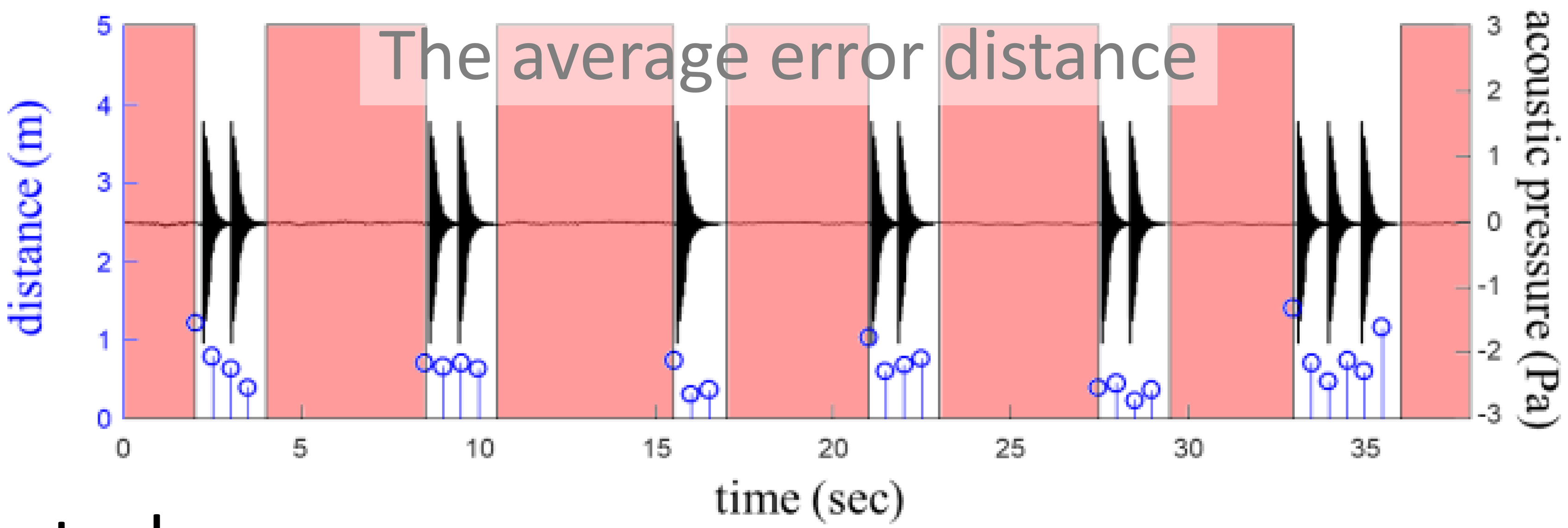
Computing weights

Benefits

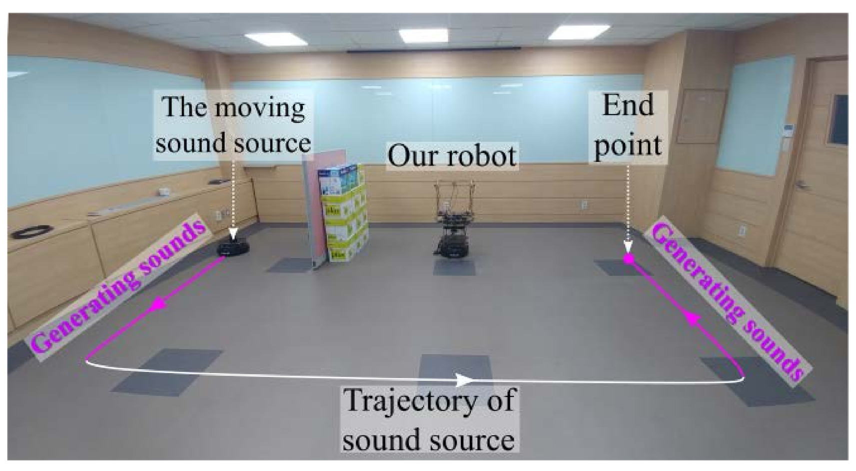
1. Use of indirect rays increases localization accuracy by 40%.
2. Can handle moving and non-line-or-sight sound source.
3. Supports intermittent sound signals in addition to continuous ones with an obstacle.

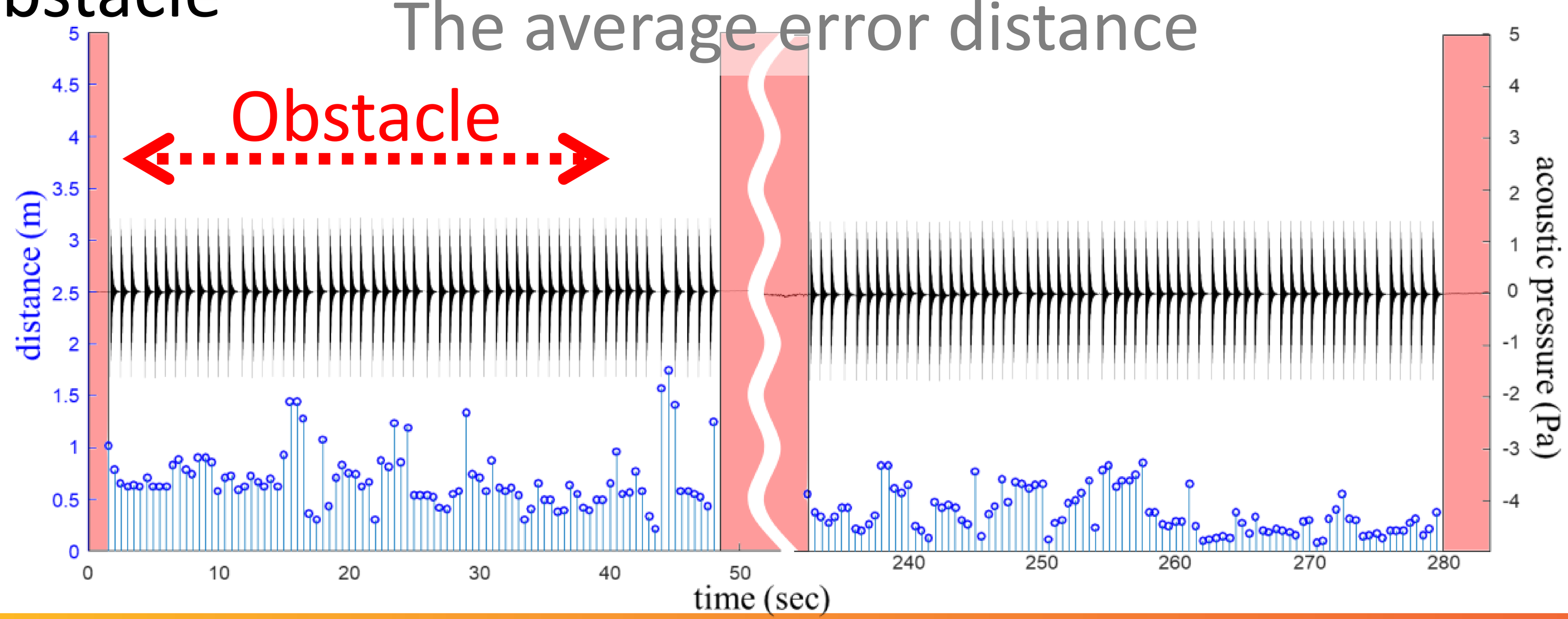
Results

1. Stationary source & intermittent signals



2. Dynamic source and obstacle





Detected regions as the sound source moves