

Toward Accurate Indoor Localization: Validation and Optimization of Received Signal Strength Difference-Based Direction of Arrival Estimation

Myoungsun Kim⁽¹⁾ and Wonbin Hong⁽¹⁾

(1) Pohang University of Science and Technology, Pohang, Republic of Korea
(whong@postech.ac.kr)

This paper extends the validation of the Received Signal Strength Difference (RSSD)-based Direction of Arrival (DoA) estimation method to complex indoor environments characterized by rich multipath effects. A calibration method, previously validated under direct-path dominant conditions, was applied to address orientation variation challenges in decentralized localization systems. The calibration equation, which accounts for the orientation angle (θ_{org}) and the incident angle (θ_{inc}) with respect to the Line-of-Sight (LoS) path, is expressed as:

$$RSSD_c(\theta_{inc}, \theta_{org}) = RSSD_{tag}(\theta_{inc}) + RSSD_{anc}(\theta_{org})$$

where $RSSD_{tag}$ represents the RSSD contribution from the incident angle and $RSSD_{anc}$ corresponds to the orientation misalignment between anchor and tag.

Experiments are conducted in a 10 m × 14.5 m indoor space, as shown in Fig. 1 (a). Measurements were taken at multiple positions and tag orientations ranging from -45° to 45° in 15° increments. The Ultra-wideband commercial module's receiver sensitivity determines measurable positions based on tag orientation. Experimental results highlight the effectiveness and limitations of the proposed calibration method in indoor environments. At point A, located (-2 m, -6.45 m) relative to the anchor, the calibrated RSSD reference guide closely matched the measured RSSD data across different tag orientations. This demonstrates the validity of the proposed method under certain indoor conditions. However, at point B, located (-4 m, -8.45 m) relative to the anchor, the alignment between the calibrated RSSD and measured RSSD data deteriorated, indicating increased susceptibility to multipath effects. Notably, even when the tag was positioned near the wall, if oriented toward the anchor with $\theta_{org}=45^\circ$, the DoA estimation error was significantly reduced to 1.94° , demonstrating that proper orientation can mitigate multipath-induced errors. These results emphasize the critical influence of environmental factors such as proximity to walls, tag orientation, and anchor placement on RSSD-based DoA estimation accuracy.

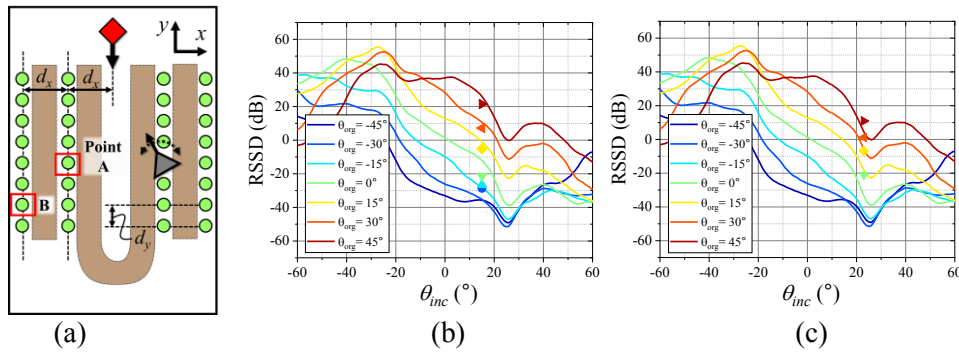


Figure 1. A schematic of the indoor experimental environment ($d_x=2$ m and $d_y=0.5$ m). Calibrated $RSSD_c$ and $RSSD_m$ varying θ_{org} at (b) Point A and (c) Point B.

By quantifying the impact of multipath effects, this study expands the applicability of RSSD-based DoA estimation to complex indoor scenarios. The findings provide a foundation for refining calibration techniques, enabling robust and scalable localization solutions for decentralized systems in multipath-prone environments.