ROSENSE: REFINING LOS SIGNAL PHASE FOR ROBUST RFID SENSING VIA SPINNING ANTENNA

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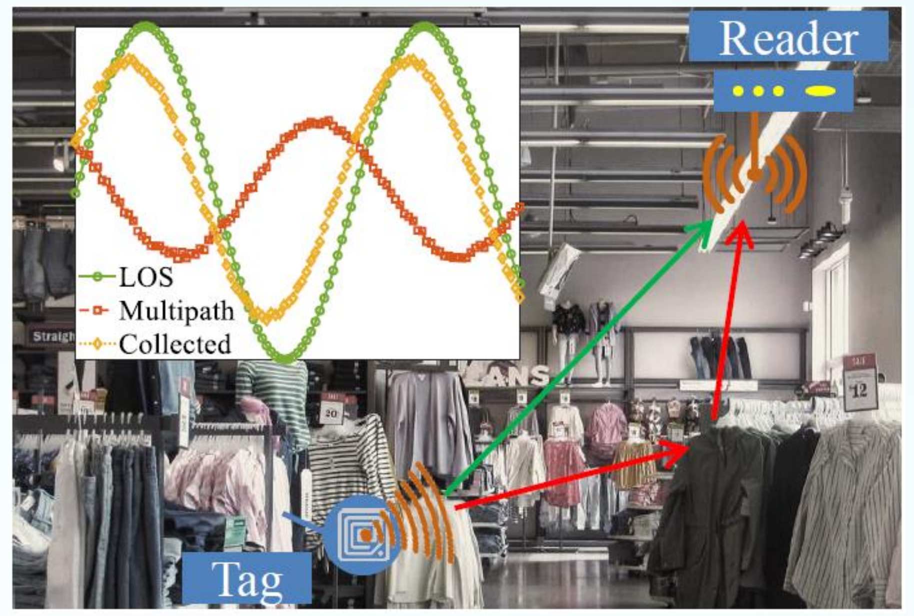
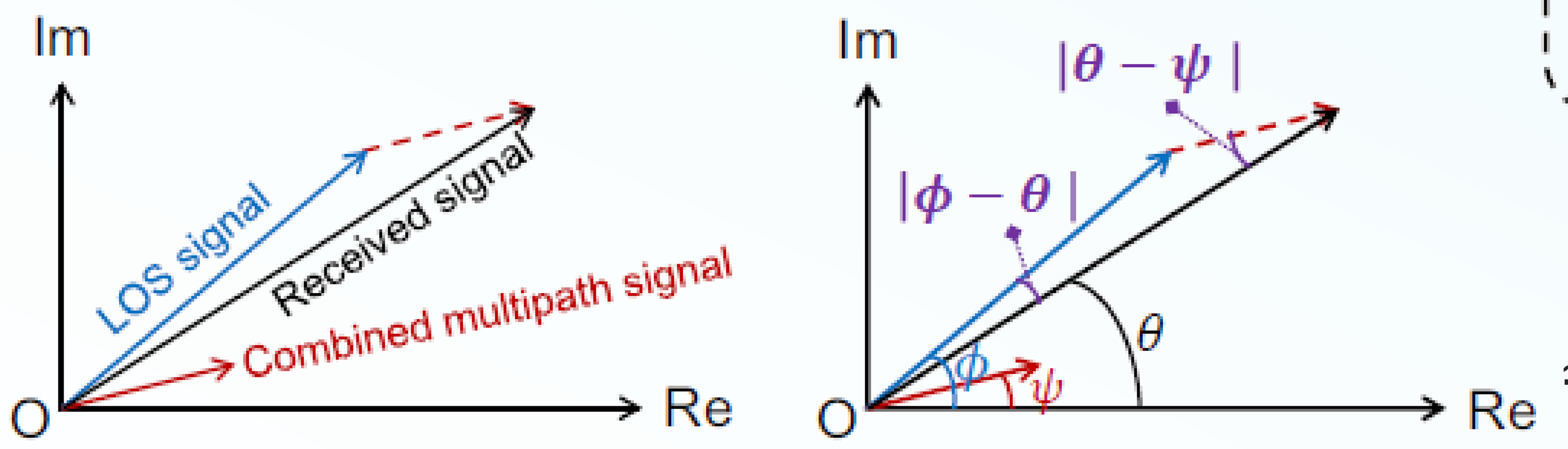
This project will be soon available at https://zhuyn-tsinghua.github.io/

Motivation

Multipath effect induced by environmental reflections is a critical problem that limits the robustness of RFID sensing.





Weakness of SOTA methods:

SDR-Based: overhead ☒ ubiquity☒

CPIX: accuracy ☒ applicability☒

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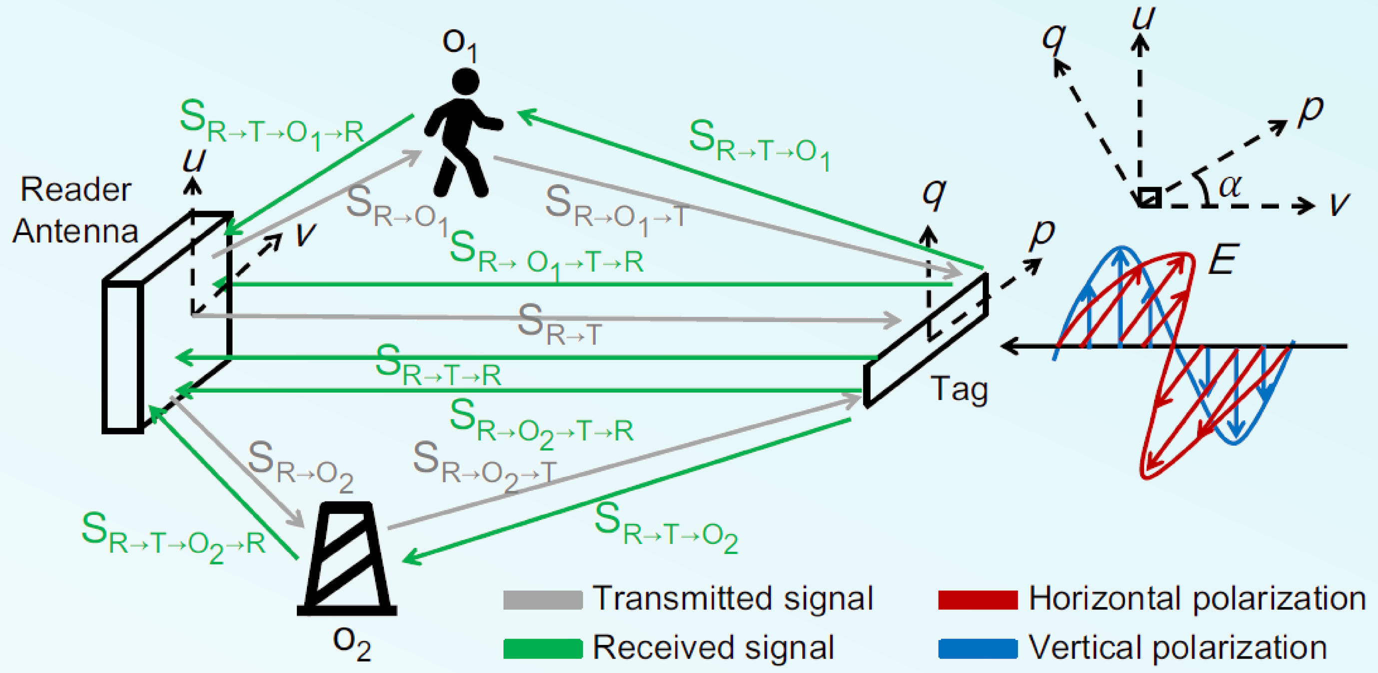
System Design



RFID signals collection at spinning angles

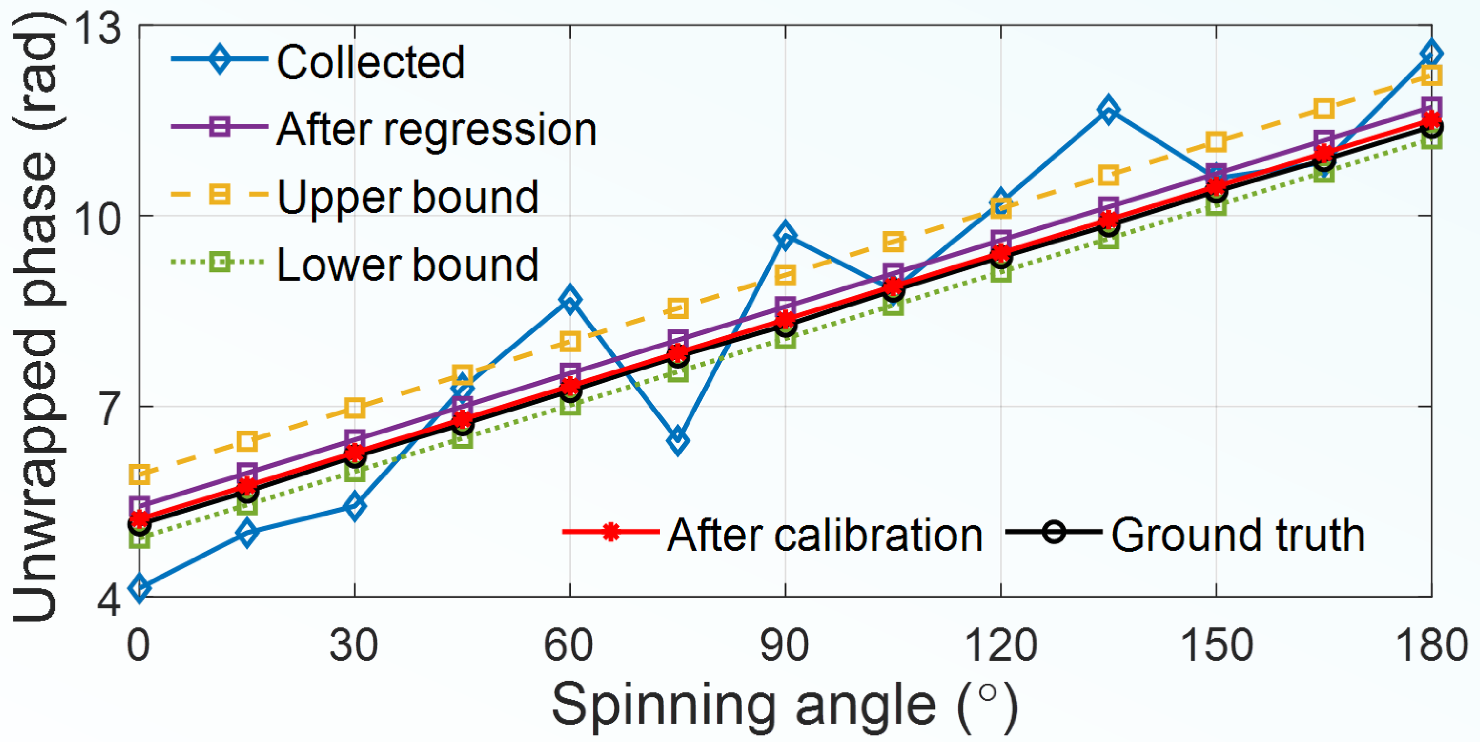
↓ *Raw signal features*

Linear regression on phase vector

Intercept drift calibration using RSS

↓ *Refined phase shift*

RFID sensing with existing systems



Two properties of LOS signal when spinning antenna:

Linearity of phase changes

Stability of RSS

$$b^* = \arg\min_{b} \sum_{k=1}^{M} \left(2\Delta\alpha \cdot k + b - \hat{\theta}_k\right)^2$$

$$\Delta b^* = \arg\min_{-\varepsilon \le \Delta b \le \varepsilon} \max_{1 \le k \le M} \left\{ \frac{\left|2\Delta\alpha \cdot k + b^* + \Delta b - \hat{\theta}_k\right|}{\left|\hat{P}_k - \sum_{L=1}^{M} \hat{P}_L / M\right|^{\sigma}} \right\}$$

Refined phase: $2\Delta\alpha \cdot k + b^* + \Delta b^*$

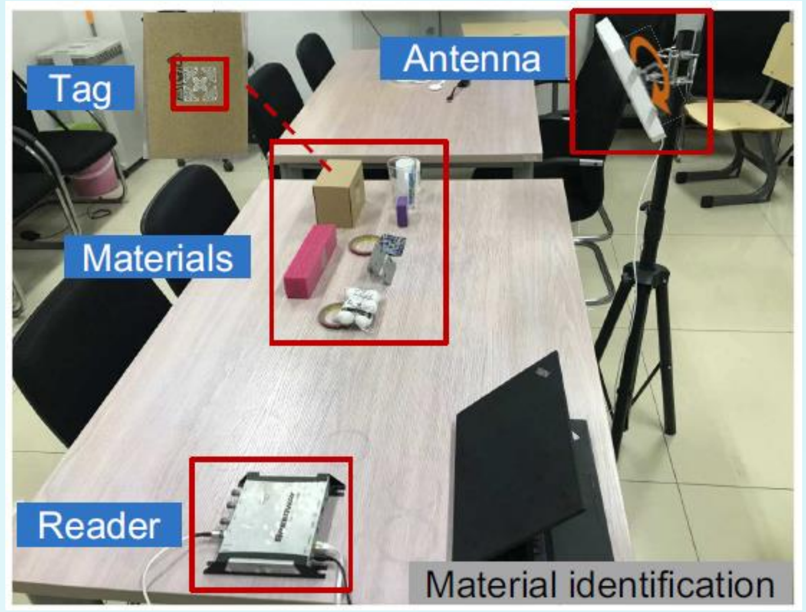
Error of collected phase: **1.820 radians**

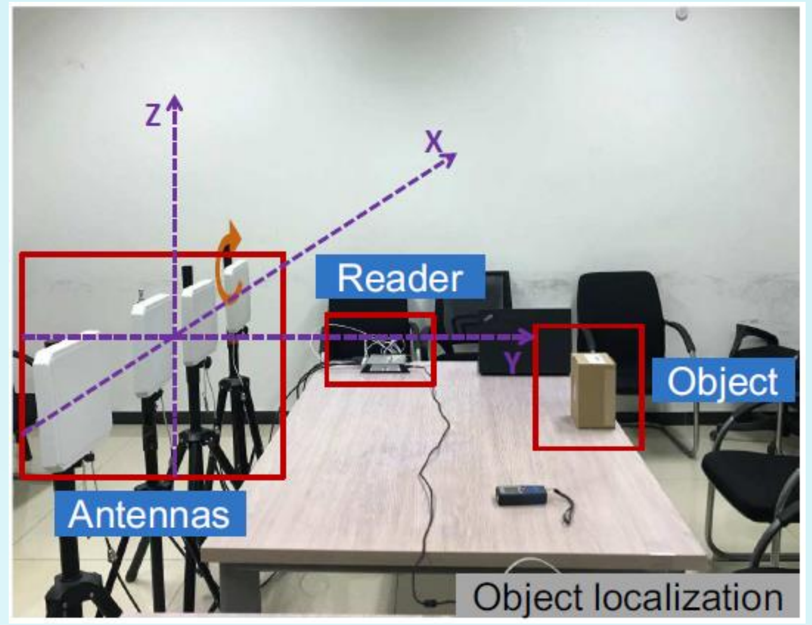
Error of regressed phase: **0.308 radians**

Error of calibrated phase: **≤0.107 radians**

Evaluation

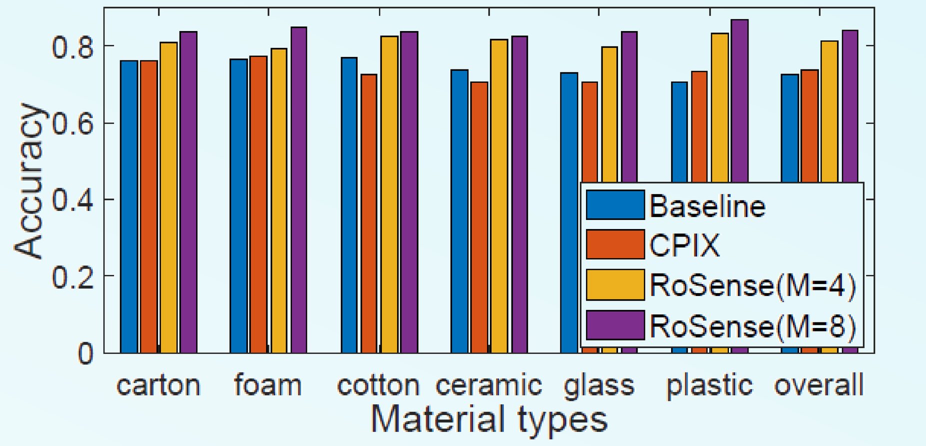
Two typical sensing cases: *material identification* and *object localization*



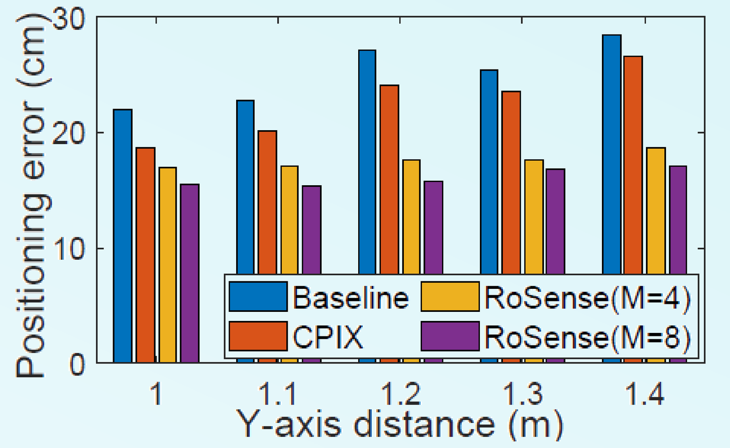


Experimental Results

Effectiveness of RoSense ☑ (outperforming SOTA methods)



(a) Material identification



(b) Object localization

Universality of RoSense ☑

TABLE I: Performance on different tag types

Tag Model	Material Identification	Object Localization
AZ9662	↑ 8.25% accuracy	↓ 10.36cm error
H47	↑ 11.74% accuracy	↓ 11.38cm error
L27D	↑ 5.86% accuracy	↓ 7.54cm error

TABLE II: Performance on different reader antenna types

Antenna Model	Material Identification	Object Localization
E9028PCRNF	↑ 11.74% accuracy	↓ 11.38cm error
Laird S9028PCL	↑ 9.53% accuracy	↓ 12.22cm error
Alien ALR8698	↑ 11.26% accuracy	↓ 11.95cm error