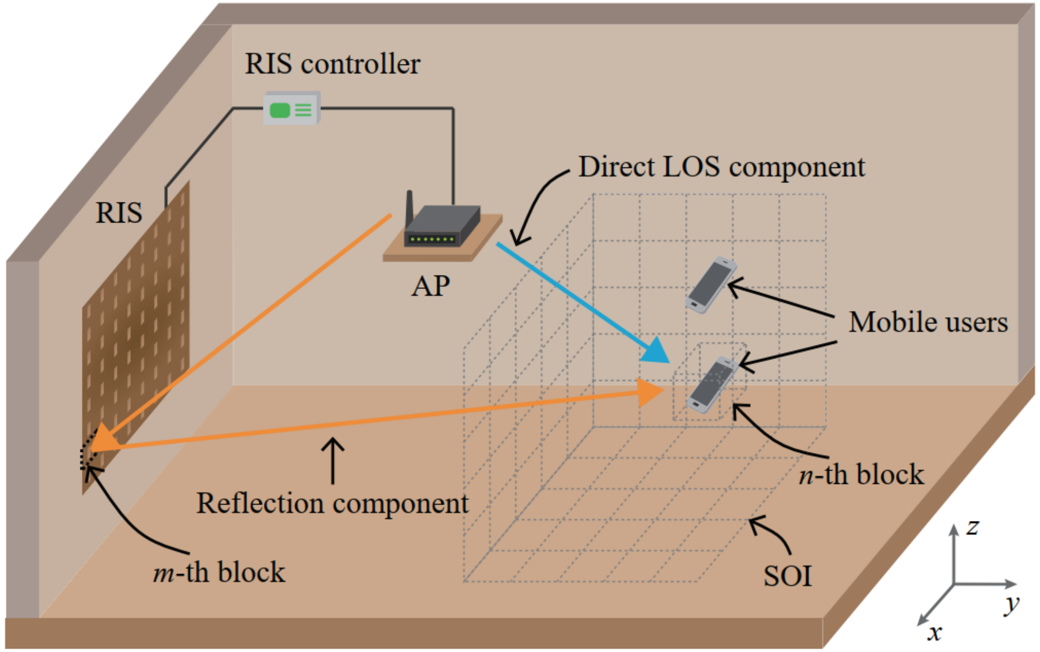
MetaLocalization: Reconfigurable Intelligent Surface Aided Multi-user Wireless Indoor Localization



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MetaLocalization: Reconfigurable Intelligent Surface Aided Multi-User Wireless Indoor Localization

IF 10.7 SCIE JCR Q1 计算机科学1区 Top EI

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Abstract:

The received signal strength (RSS) based technique is extensively utilized for localization in the indoor environments. Since the RSS values of neighboring locations may be similar, the localization accuracy of the RSS based technique is limited. To tackle this problem, in this paper, we propose to utilize reconfigurable intelligent surface (RIS) for the RSS based multi-user localization. As the RIS is able to customize the radio channels by adjusting the phase shifts of the signals reflected at the surface, the localization accuracy in the RIS aided scheme can be improved by choosing the proper phase shifts with significant differences of RSS values among adjacent locations. However, it is challenging to select the optimal phase shifts because the decision function for location estimation and the phase shifts are coupled. To tackle this challenge, we formulate the optimization problem for the RIS-aided localization, derive the optimal decision function, and design the phase shift optimization (PSO) algorithm to solve the formulated problem efficiently. Analysis of the proposed RIS aided technique is provided, and the effectiveness is validated through simulation.

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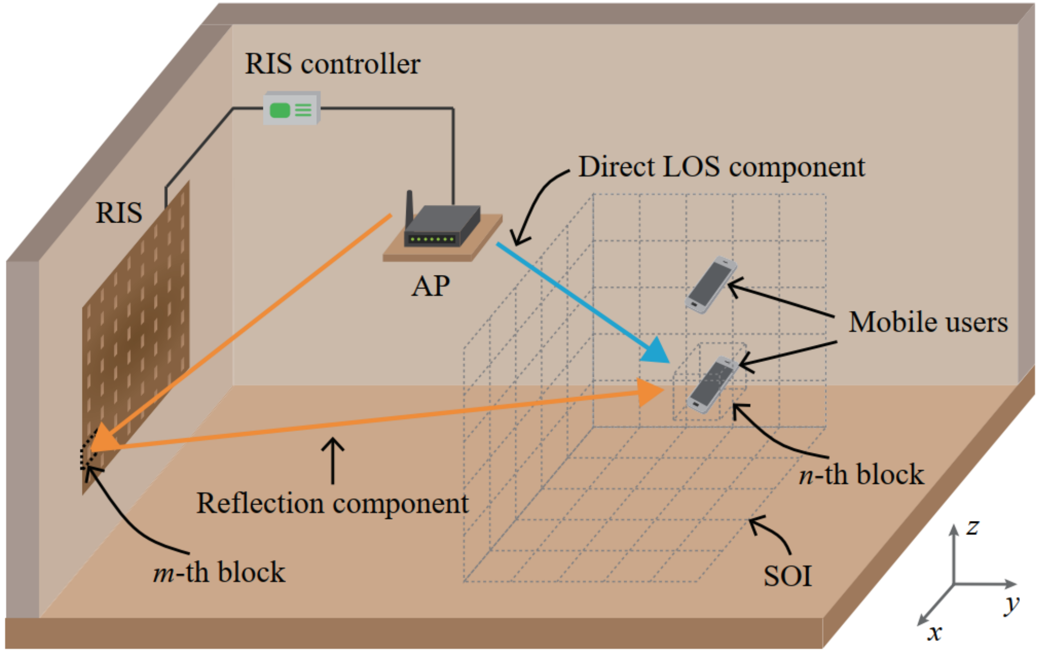
[1] H. Zhang, H. Zhang, B. Di, K. Bian, Z. Han and L. Song, "MetaLocalization: Reconfigurable Intelligent Surface Aided Multi-User Wireless Indoor Localization," in *IEEE Transactions on Wireless Communications*, vol. 20, no. 12, pp. 7743-7757, Dec. 2021

介绍框架

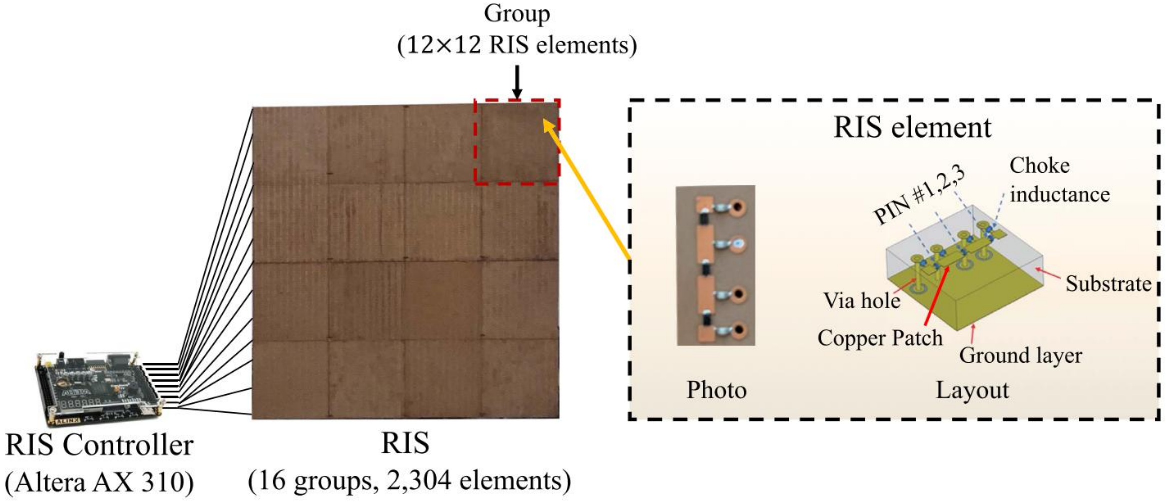
- 背景/简要介绍
- 研究方法
- 实验结果
- 总结



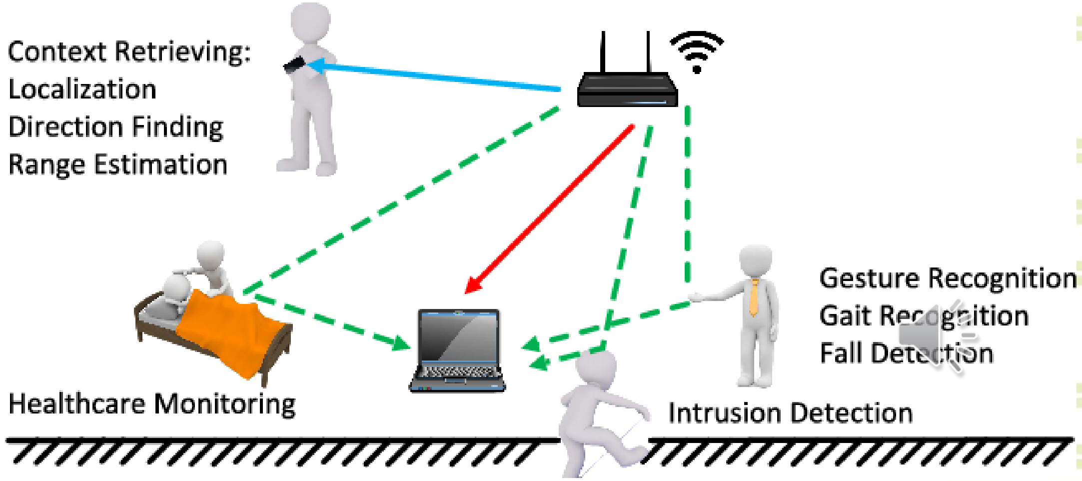
智能反射表面辅助的无线感知

- 什么是智能反射表面?
  - 一个由许多可重构单元组成的表面。
  - 可以让接收信号中包含更多环境信息

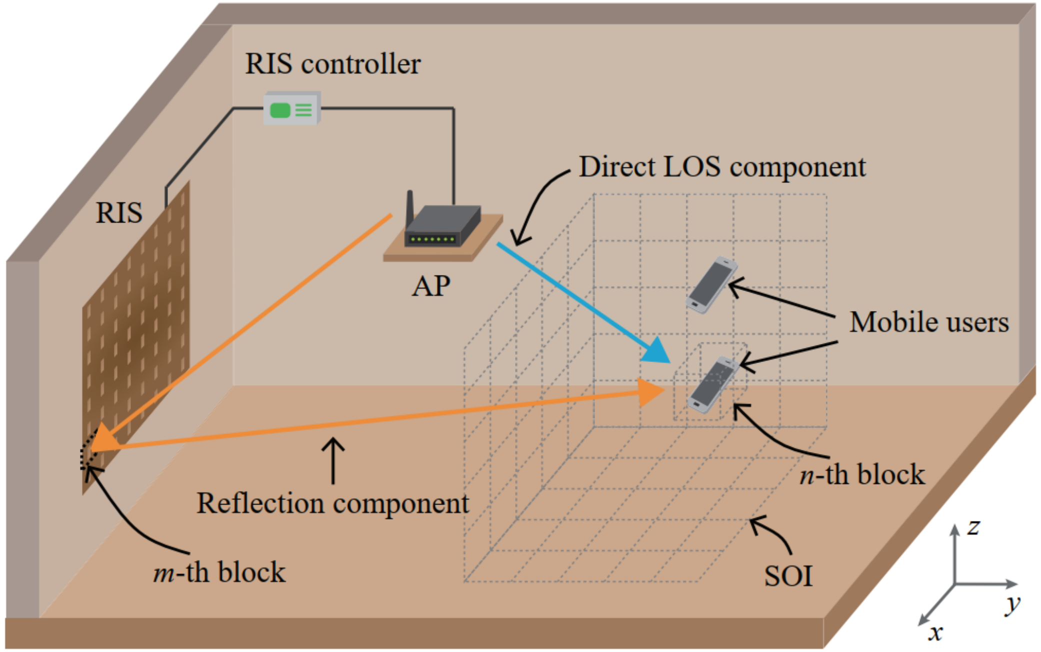
  → 对无线感知有很大的增益
  - 如何控制智能反射表面的被动波束成形?



- 什么是无线感知?
  - 通过收集无线信号来感知环境中的变化与活动。
  - 定位 (localization) /姿势识别 (gesture recognition)
  - 如何从接收信号中恢复出感知信息?



智能反射表面辅助的无线感知



- 被动感知
  - 感知用户的位置 （localization）
- 仅仅基于接收信号的幅度信息 (RSS)
  - 对硬件要求较低（同步）
- 可以通过多次测量迭代提升感知精度
  - 基于贝叶斯理论

智能反射表面辅助的无线感知

- 接收信号模型

$$s_n(\mathbf{c}) = s^t + 20\log_{10}\left| h_{\mathrm{lo}} + \sum_{m\in\mathcal{M}} h_{m,n}(c_m) \right| + \xi,$$

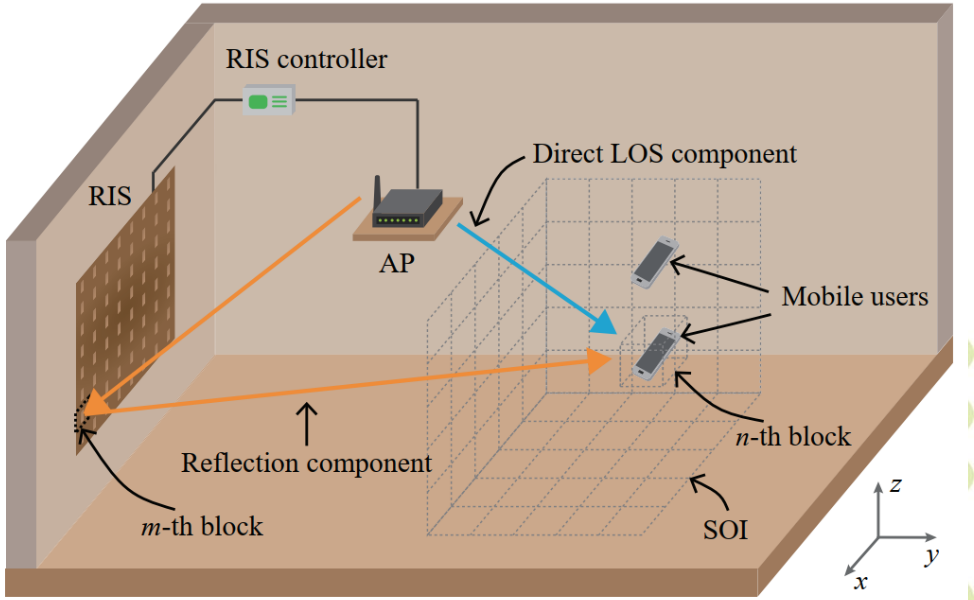
噪声

接收信号(dB)

发射信号

直连信道

智能反射表面信道



- 感知功能实现
  - 基于贝叶斯理论的用户位置估计
  - 基于梯度下降的智能反射表面状态设置优化

智能反射表面辅助的无线感知

- 定位 (localization)
  - 从接收信号中估计接收用户的位置
    - 在不同位置获得这个接收信号的概率 (噪声假设)
    - 关于用户位置的先验信息 (通过不断的接收信号进行迭代)

重要假设：基于信道模型，我们可以计算出无噪声情况下在不同位置接收信号的幅度

$s = 1$ $\bar{s} = 1.2$ $s = 2$

位置1 位置2

Proposition 1: The optimal decision function $\mathcal{L}^*(n'|\mathbf{c}, s_i, \{p_{i,n}\})$ for problem (P2) can be expressed as

$$\mathcal{L}^*(n'|\mathbf{c}, s_i, \{p_{i,n}\}) = \begin{cases} 1, & s_i \in \mathcal{R}_{i,n'}, \\ 0, & s_i \notin \mathcal{R}_{i,n'}, \end{cases} \quad (13)$$

where the decision region $\mathcal{R}_{i,n'}$ is defined as

$$\mathcal{R}_{i,n'} = \Big\{ s_i : \sum_{n \in \mathcal{N}} p_{i,n}(\gamma_{n,n'} - \gamma_{n,n''})\mathbb{P}(s_i|\mathbf{c}, n) \le 0, \forall n'' \in \mathcal{N}/\{n'\} \Big\}. \quad (14)$$

- 智能反射表面状态设置

$$l_a(\mathbf{c}) = \sum_{i \in \mathcal{I}} \sum_{\substack{n,n' \in \mathcal{N} \\ n \neq n'}} p_{i,n}\gamma_{n,n'} \cdot Q(d_{i,n,n'}) \longrightarrow$$

估计的位置离真实位置越近，概率越大，损失函数的值越小

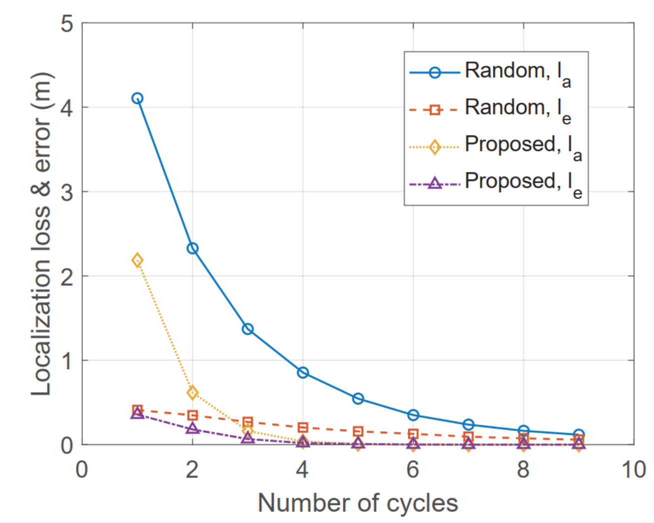
损失函数

  - 基于梯度下降的方法进行优化

智能反射表面辅助的无线感知

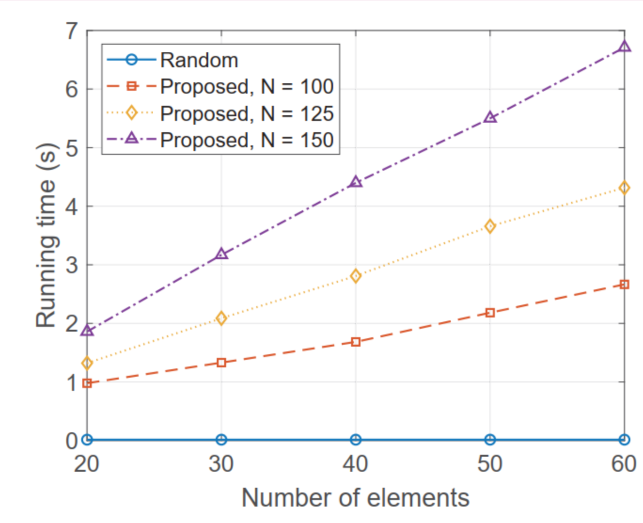
- 实验结果

1



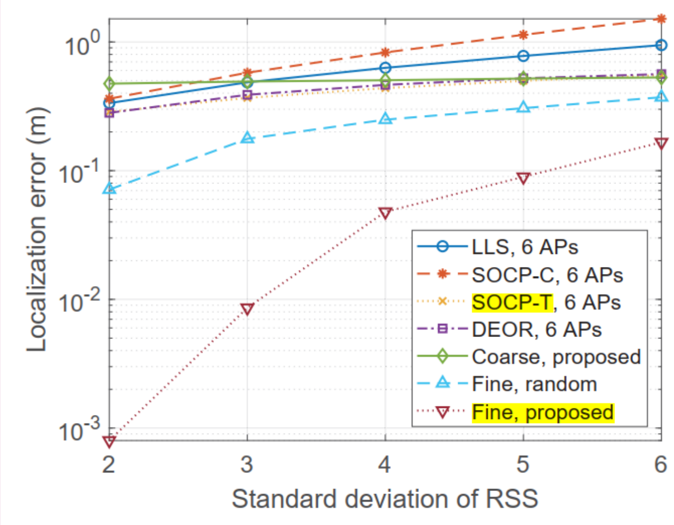
- 通过不断收集数据，迭代对位置的估计

2



- 优化智能反射表面设置
- 1600 RIS elements → 26 mins

3



- 与其他基于幅度信息的定位方法比较

智能反射表面辅助的无线感知

- 总结
  - 无线领域比较早期的智能反射表面辅助无线感知的工作
  - 缺少实验数据的支撑，未有对多径信道影响的考虑，在实测中可能出现一些问题

MetaRadar: Multi-Target Detection for Reconfigurable Intelligent Surface Aided Radar Systems IF 10.7 SCIE JCR Q1 计算机科学1区 Top EI 2022 Cited 60

Haobo Zhang; Hongliang Zhang; Boya Di; Kaigui Bian; Zhu Han; Lingyang Song

IEEE Transactions on Wireless Communications

Year: 2022 | Volume: 21, Issue: 9 | Journal Article | Publisher: IEEE

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MetaSensing: Intelligent Metasurface Assisted RF 3D Sensing by Deep Reinforcement Learning IF 17.2 SCIE JCR Q1 计算机科学1区 Top EI 2021 Cited 57

Jingzhi Hu; Hongliang Zhang; Kaigui Bian; Marco Di Renzo; Zhu Han; Lingyang Song

IEEE Journal on Selected Areas in Communications

Year: 2021 | Volume: 39, Issue: 7 | Journal Article | Publisher: IEEE

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