**Context-Aware BLE Indoor Positioning for Room-Level Mobility Monitoring** Wang H, Fang Q.
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**Purpose** Many indoor positioning systems (IPS) remain difficult to deploy in real homes because they require substantial configuration, depend on continuous wireless networking, or impose non-trivial privacy and maintenance burdens [1]. This project presents a BLE-based IPS that targets room-level location estimation while remaining practical for smart-home use [2]. The intended capabilities include room-level localization, accurate detection of room transitions, identification of traversal pathways for known BLE devices, and timestamping to enable correlation with other sensor streams [3,4]. Design priorities also include self-installation with minimal or no in-home visits, reasonable cost, and secure data collection to support privacy-aligned deployments. **Method** The IPS uses a distributed, multi-room architecture in which room-installed nodes capture BLE signals from known wearable devices or tags and forward summarized measurements to a central hub for room-level inference. A lightweight signal-smoothing step is applied to improve robustness to indoor interference and short-term RSSI fluctuations, enabling more stable room attribution. To reduce deployment burden, the system includes a brief, user-guided calibration workflow via a mobile application, where each room is labelled and short calibration data are collected to characterize room-specific signal patterns. Validation used mobile app entries as ground truth and compared them against IPS-inferred locations, with two subjects completing 150 trials each (300 total) in both a residential home (4 rooms) and a smart-home environment (5 rooms). To assess resilience and practical utility, we additionally evaluated (i) room-transition detection speed under repeated traversals and (ii) the value of complementary sensing (motion and ultrasonic) as corroboration for room presence. **Results and Discussion** Room detection performance was high across both environments. The IPS achieved 96.67% accuracy in the residential home and 95.33% in the smart-home setting when comparing mobile app ground truth with IPS-determined locations (300 trials per site). These results indicate that the approach generalizes across different indoor layouts and RF conditions without requiring extensive per-site engineering. Rather than emphasizing implementation-specific filtering parameters, these findings show that lightweight signal stabilization combined with brief calibration can deliver consistent room-level localization in realistic home settings. Sensor-based detection showed that PIR motion sensing can serve as a strong corroboration channel: the motion sensor achieved 93.00% accuracy, while the ultrasonic sensor (2 m threshold) achieved 78.67% accuracy. In practice, this suggests PIR is suitable as a complementary presence confirmation layer, whereas ultrasonic performance may be more sensitive to placement, geometry, and line-of-sight constraints. Room-transition detection occurred on a timescale consistent with practical monitoring: adjacent transitions averaged approximately 1.47–2.83 seconds (depending on site and room pair), while far-room transitions averaged approximately 5.20–6.55 seconds. Collectively, these results support a deployable, room-level BLE IPS that can capture mobility-relevant outcomes, such as time spent in key rooms and patterns of room-to-room movement using a practical workflow suitable for older-adult monitoring in smart-home contexts. This positions the system as a scalable sensing layer for gerontechnology applications where interpretable, room-level mobility metrics are needed to support wellness monitoring, caregiver insight, and aging in place.

**References**

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