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Ambient Wi-Fi Sensing for Location-Aware Human Activity Recognition: Towards Cooperative Indoor Health Monitoring with Smart Textile Systems

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ABSTRACT
Smart textile systems and wearable sensors can provide valuable body-level physiological and motion information for health monitoring. However, their long-term use may be affected by wearing comfort, user compliance, battery maintenance and sensing continuity. Ambient Wi-Fi sensing offers a complementary, device-free approach by reusing existing communication infrastructure to capture human activities and spatial context without cameras or body-worn devices. This study investigates location-aware human activity recognition as an ambient sensing layer for future cooperative indoor health monitoring with smart textile systems.
A Static–Dynamic Multi-View Task-Cooperative Network, termed SD-MVTC-Net, is proposed to jointly perform indoor localization and human activity recognition using Wi-Fi channel state information. The method constructs multiple sensing views from channel amplitudes, conjugate phase differences between receiving links, and their temporal-difference components. These representations capture relatively stable location-dependent multipath structures and short-term channel perturbations induced by human movement. A heterogeneous view-adaptive fusion module learns the task-specific contributions of different sensing views, while a cross-task bidirectional gating mechanism enables controlled information exchange between the localization and activity-recognition streams.
The method was evaluated using commodity Wi-Fi devices in two representative indoor environments with different spatial layouts and multipath characteristics. Four participants performed five representative activities—standing, bending, stepping in place, sitting down and standing up, and waving—at multiple predefined reference locations. Across two representative indoor environments with different spatial layouts and propagation conditions, SD-MVTC-Net achieved activity-recognition accuracies of 88.75% and 91.00%, reference-position classification accuracies of 89.58% and 99.33%, and mean localization errors of 0.279 m and 0.0096 m, respectively. The localization errors were calculated under predefined reference-point supervision and do not represent unrestricted continuous-space positioning accuracy.
The results demonstrate that ambient Wi-Fi sensing can jointly provide human-activity information and spatial context in indoor environments. Such environmental information may complement the physiological and body-motion measurements obtained from smart textile systems, providing a basis for future cooperative health-monitoring frameworks that integrate ambient and wearable sensing modalities.

Keywords: Wi-Fi Channel State Information; Ambient Sensing; Human Activity Recognition; Indoor Localization; Smart Textile Systems