

# Application Fields and Innovative Technologies

## Low-Cost CSI-Based Activity Monitoring and Feedback for Single-Resident AAL Environments

D. Helmer, D. Gibietz, H. Hinkelmann, T. Hollstein. *Gerontechnology* 25(s)

**Purpose** The study aims to develop and evaluate a privacy-friendly, non-invasive, and cost-effective approach to detecting relevant patterns of inactivity in single-person households. The starting point is the increasing need to continuously monitor the activity and mobility of older people living alone without relying on burdensome, acceptance-critical, or highly personal technologies such as wearables or cameras—a key challenge in AAL research. Based on current work on WiFi-based sensing, passive channel state information (CSI) from a commercially available WLAN router is collected, an approach that was fundamentally established by Halperin et al. [1] and is becoming increasingly important in activity and gesture recognition [2,3]. The aim of this work is to transfer these methods to an ESP32 receiver in a low-cost scenario and to enable the distinction between activity, inactivity, and potentially critical behavioral changes using a ring buffer-based mobility measure. In addition, we investigated whether an immediate visual feedback system (color lamp) is suitable as a low-threshold intervention for short-term behavioral activation. **Method** An ESP32 module was used for continuous recording of movement activity. This module is capable of passively recording the CSI data transmitted by the WiFi router. The ESP32 was set to monitor mode and configured to extract the amplitude information of the subcarriers for each WiFi packet received. The CSI frames were queried at a constant sampling rate and stored in a cyclic ring buffer representing real-time data segments. The ring buffer was continuously evaluated, with statistical parameters (including variance of subcarrier amplitudes, moving differences, short-term signal energy) being calculated to derive a robust mobility measure. At the same time, all packets were examined for disruptive events such as abrupt increases in packet loss or atypical CSI jumps in order to identify external interference (e.g., door openings, signal reflections, strangers) and exclude it from the mobility measurement evaluation. All data processing was performed locally on the ESP32 without storing personal data or transferring it to external systems. **Results and Discussion** Initial tests in a real single-person living environment show that the system is capable of reliably detecting clear differences between phases of normal activity and prolonged inactivity. The test was conducted for two weeks in the person's living room. The mobility measure derived from the CSI data responded consistently to movements, while longer static phases led to a stable decrease in the activity value. At the same time, the results reveal methodological limitations: The system is sensitive to macroscopic disturbances such as door movements, large reflective objects, or the brief appearance of other people in the detection area. Despite these limitations, the approach represents a practical and promising contribution to AAL applications. It is cost-effective, requires only a standard Wi-Fi setup and an ESP32, and does not require wearables, cameras, or complex infrastructure. Installation is technically low-threshold and can be implemented in existing households without any modifications. Overall, the results suggest that CSI-based activity detection can be a robust, low-cost mechanism for providing early warning of reduced mobility while enabling easily understandable intervention.

### References

1. Halperin, D., Hu, W., Sheth, A., & Wetherall, D. (2011), Tool release: Gathering 802.11n traces with channel state information (CSI). In ACM SIGCOMM Computer Communication Review, 41(1), 53–57
2. Wang, W., Liu, A. X., Shahzad, M., Ling, K., & Lu, S. (2015), Understanding and modeling of WiFi signal based human activity recognition. In Proceedings of the 21st Annual International Conference on Mobile Computing and Networking
3. Abdelnasser, H., Mohamed, M., & Youssef, M. (2015), WiGest: A ubiquitous WiFi-based gesture recognition system. In IEEE Conference on Computer Communications (INFOCOM)

**Keywords:** channel state information, monitoring, ambient assisted living, low-cost activity detection

**Affiliation:** Frankfurt University of Applied Sciences, Germany

**Email:** [daniel.helmer@fb2.fra-uas.de](mailto:daniel.helmer@fb2.fra-uas.de)

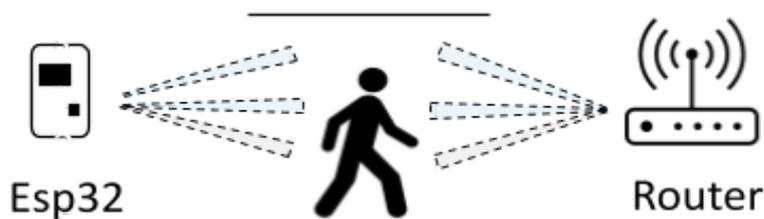


Figure 1: Interference field of wave propagation