Project Proposal: RF-Based Human Activity Recognition Using Real and Simulated Data

Michael Smith
ECE 250: Wireless Communication and Networking
University of California, Santa Barbara

May 1, 2025

Project Title

RF-Based Human Activity Recognition Using Real and Simulated Data

Team Members

Michael Smith

Abstract

This project aims to develop a machine learning system for classifying human physical activities using radio frequency (RF) signal features, such as spectrograms derived from either simulated or real RF measurements. The approach begins with synthetic data to verify the feasibility of using frequency-domain features for activity recognition. The system will then be extended using publicly available RF datasets to evaluate performance on real-world data. Optionally, I may explore generating RF features from video-based motion capture to align with recent cross-modal sensing research. Our pipeline includes signal simulation, time-frequency analysis, and convolutional neural network (CNN) classification. I will compare performance across synthetic and real datasets and analyze the model's robustness to noise and activity overlap.

I am currently basing most of my project and research on the three reference below, specifically the *A Comprehensive Survey on Machine Learning for RF Sensing* paper. so far, I have a working pipeline that begins by generating synthetic time-domain signals that approximate RF reflections corresponding to different human activities. These signals are transformed into spectrograms using short-time Fourier transform (STFT), which capture time-frequency characteristics. I label and organize these spectrograms into datasets for training. A CNN is then trained on this spectrogram dataset, achieving high classification accuracy. I've been visualizing performance using confusion matrices, which show strong class separation. I plan on further testing on real-world RF data instead of simulated and potentially generating RF datasets from Videos.

Relevant References

- H. Cai, B. Korany, C. Karanam, and Y. Mostofi, *Teaching RF to Sense without RF Training Measurements*, ACM IMWUT, 2020. doi:10.1145/3432224

- B. Korany, C. Karanam, H. Cai, and Y. Mostofi, *XModal-ID: Using WiFi for Through-Wall Person Identification from Candidate Video Footage*, ACM MobiCom, 2019. doi:10.1145/3300061.3345437
- S. Wang et al., *A Comprehensive Survey on Machine Learning for RF Sensing*, IEEE Communications Surveys & Tutorials, 2021.