Human Presence and Activity Detection from WiFi CSI Data using DNN

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***Abstract*—WiFi sensing can be used to monitor specific human movements and also to predict the movements after learning it using any machine learning paradigm. In this project, a deep neural network is implemented for a pruned large dataset of human mobility through a WiFi network delivering CSI data. The hyperparameter optimization technique is used to find out specific values of several parameters of the machine learning model to detect human presence and several movement activities with XX% of accuracy.**

***Index Terms*—DNN, WiFi, sensing, CSI, machine learning, human activity detection, surveillance**

I. Introduction

In this era of conflict between surveillance and privacy concerns, WiFi sensing brings a very optimal lineup to monitor necessary surveillance data pruning through unnecessary personal details by the implementation. It also benefits through lower data storage and processing time than camera recorded video or image data. Therefore, to implement any surveillance system where specific movements are needed, one need not record heavy cam-feeds and occupy huge processing overhead, rather can use WiFi channel state information (CSI) data to learn the specification of the movements and then classify those.

Channel State Information (CSI) obtained from commercial WiFi chipsets has proven to be efficient in detecting human interactions inside any radio wave. Due to high availability & practical usability, the WiFi network can be the most effective radio network to collect CSI data. The popularity of approaches that measure Received Signal Strength (RSS) by narrowband radio devices is due to cost-effectiveness and ubiquity. However, recent progress in signal descriptors, such as CSI, obtained through low-cost chipsets like ESP32, Intel 5300 NIC, and IEEE 802.11n chipsets offer enhanced accuracy compared to RSS. Due to high temporal variance in RSS, slow movements of humans end up hidden in the inherent signal variability [4]. Comparatively, the structure of CSI is temporally more stable than RSS because it captures small-scale multipath propagation over multiple sub-carriers in frequency domain [5] [6]. CSI indicates different physical qualities of the channel, such as shadowing, frequency selective fading, multipath propagation, and interference effects. Hence, CSI is currently a good alternative for RSS.

Compared to traditional technologies, CSI-based detection has several advantages. It detects humans through walls, does not depend on lighting, preserves user privacy, and importantly, occupants are not required to carry any devices. Hence, it is widely used to quantify the human presence interaction with the wireless channel in the form of occupancy detection, activity/gesture/identity recognition, and human positioning.

The attributes of WiFi CSI data vary depending on routers and network specifications. The values are also hugely impacted by the orientation of the environment, i.e., the room structure, furniture in the room, openings as doors or windows in the room, moving items like flying curtains, ambient or any other sound, etc. These variations are difficult to characterize by naked human realization. That is why a blind machine learning paradigm like a deep neural network, convolutional neural network, and so on can be used to train and classify the CSI dataset. In this project, a deep neural network (DNN) with an optimized number of hidden layers is implemented. The neural network trains a weight array by the larger portion of the dataset and then implies the weight array directly over the test dataset, which is a subset of the whole collection of the CSI dataset.

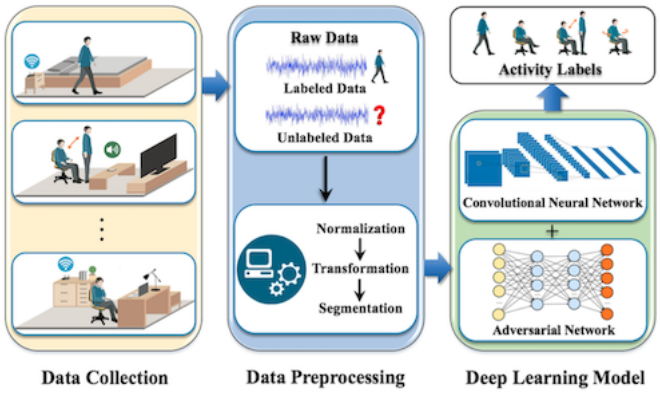

Fig. 1. System Framework

II. Problem Statement

There are various implementations of human activity recognition. However, the purpose of this problem is to identify as many common human actions as can be detected, like - entering into a room, walking around the room, standing or sitting idle in the room, exiting the room, etc. For the detection system to work, the problem can be divided into three subproblems as shown in Figure 1, like -

1) Data Collection
2) Data Preprocessing
3) Deep Learning Model

In our specific implementation, we have concentrated on implementing an efficient deep learning model, i.e., the third sub-problem, while a pre-processed proven dataset is used from an open-source collection [7].

The dataset is collected on ten activities in three specific room setups for two different people. The room schematics are shown in Figure 2. Three Intel 5300 NIC Devices [3] are used to collect the CSI data.

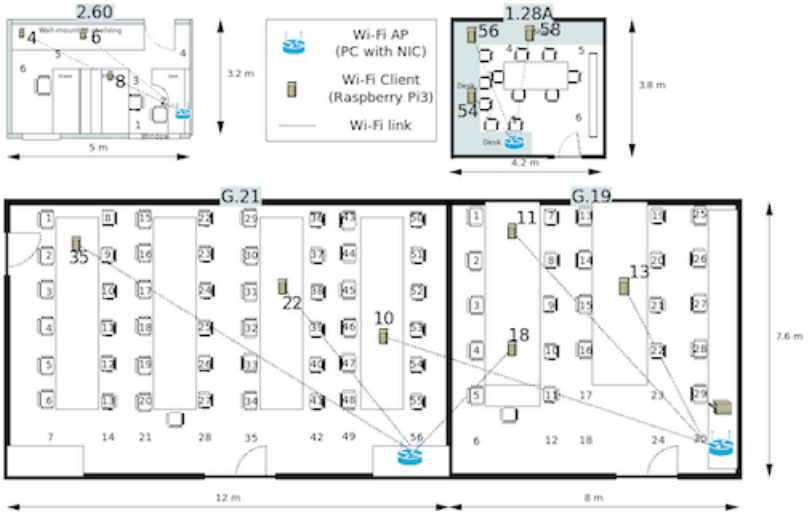

Fig. 2. Schematics of the Experiment Rooms

Afterward, the dataset is split into 70% training set & 30% test set to run hyperparameter optimization technique to find out optimal parameters of the machine learning model using Deep Neural Network (DNN).

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