Project Proposal – Team 03

Team Members:

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Project/Team Title: CSI Human Detection (CSI-HD)

Introduction / Problem Statement:

In an era where global warming is plaguing our society, any effort, no matter how big or how small, is quintessential in preserving the globe for our future generation. The effort that we are focusing on is to improve the power efficiency of buildings. Some buildings like office buildings have rooms or areas where electrical appliances are perpetually on in the event that anyone would want to use them. However, this is very wasteful as people do not always use those rooms or areas. Current measures include using manually operated electrical switches to turn on or off the electricity in the room, or motion sensors to detect the presence of a person. For example, toilets use motion sensors to detect people entering the toilet before turning on the lights and fans, and once a certain amount of time has elapsed, the power is turned off. However, if someone is having a very bad day, he may be stuck in the toilet bowl for a long time. This runs the risk of the appliances turning off while he is still in the toilet, which makes his day worse. Thus, we want to develop an IoT solution to effectively detect the presence of a person, regardless of whether he is motionless, so as to efficiently control the electrical appliances in a room or area.

Proposed IoT Solution:

Room-level **presence detection** (occupied vs empty) using a Convolutional Neural Network (CNN), using commodity Wi-Fi at 2.4 GHz.

Sensors /Actuators/Hardware Used:

1x GPU - To train the model
1x LED lights up when a human is detected.
4x ESP32 - 1 Transceiver, 3 Receiver

Machine Learning Models:

We will be collecting the CSI data from the ESP-32 receivers. The raw data will be amplitude and phase data across 114 subcarriers (tentative number), stored in euler representation in complex numbers. We will also consider a set of 10 consecutive CSI samples (tentative number) as a single data point for our model to perform

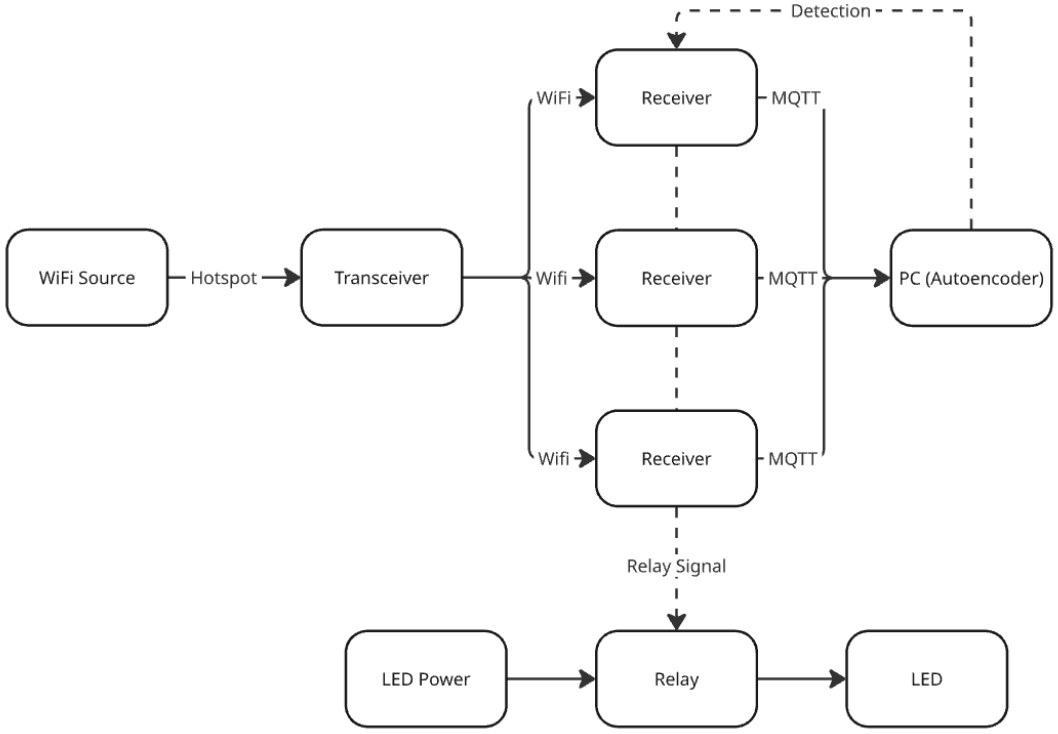
time-based aggregation. Each ESP-32 will generate a (1,114,10) CSI tensor. We expect the CSI's amplitude and phase data to change depending on the presence of a person, as the human body will scatter or absorb different subchannel Wifi signals differently.

We can train an autoencoder on the CSI patterns of an empty room, and use anomaly detection to determine the presence of a human. One potential method of detection could be an increase in reconstruction error rate indicating the presence of a human. We will attempt to use open source datasets for initial training.

CSI based human detection has been done before and research papers have been published.

System Architecture:

MQTT: Receiver -> Central PC -> LED



Other Cool Features:

Coarse localization (zone A/B/C) using polar coordinates
WiFi Detection

Progress so far:

Literature Review on the paper,
Look up on ESP32 Wifi libraries (MQTT and CSI)

Possible Limitations or Challenges:

Getting clean CSI data from multiple ESP-32s could be challenging. Firstly, hardware variations between each unit's wifi antenna could cause our CSI data to be skewed and reduce model accuracy. Secondly, CSI data is affected strongly by other wifi signals in the environment. Ambient wifi sources and movement of items in the environment like furniture will change the CSI data, requiring us to standardise the environment every time we want to collect data. This also means that our model may not generalise well across different locations where the baseline CSI data is different.

Timeline:

Week	Hardware	Network	ML
Recess	Solder antenna area		
7	CSI data collection	Data format Pub and Sub interface	Source for open source datasets
8	Breadboard testing of LED circuit	Connect and send data from receiver to central PC, using hiveMQ	Collect data with 1 receiver Build & train autoencoder on open source data
9	Solder LED circuit		Collect data with 3 receivers Train model on collected data
10	Hardware verification		Model testing
11			Model fine tuning
12	Presentation Preparation		
13			

References:

Wi-Fi based Human Fall and Activity Recognition using Transformer-based Encoder–Decoder and Graph Neural Networks - DOI 10.1109/JSEN.2025.3593126