PhD Seminar Talk on

# Device-Free Human Motion Detection using WiFi Measurements for Building Energy Management

Anisha Natarajan (EDM20D001)
Dept. of Electronics and Communication Engineering
Indian Institute of Information Technology,
Design and Manufacturing, Kancheepuram

**Abstract**

Human motion is a primary indicator of indoor occupancy and activity. Motion sensing has paramount importance in the energy management of modern smart buildings and is employed for automated controls of lighting and heating, ventilation and air conditioning (HVAC) equipments. The all-pervasive WiFi infrastructure in urban buildings offers an opportunistic method of human motion detection through passive sensing of WiFi received signal strength indicator (RSSI) and channel state information (CSI). This technique unfolds a plethora of Building IoT related services, in addition to sustainable energy utilization and reduced emission of greenhouse gases. In this talk, we provide a discussion on a device-free human motion detection method that leverages the WiFi RSSI and CSI samples collected from commercial-off-the-shelf (COTS) IoT devices. Utilizing a laptop, a smartphone and an ESP32 as receivers, WiFi RSSI and CSI samples are collected from two residential buildings, to constitute 6 datasets. A feature vector that exploits the data spread in time domain, is extracted from the collected samples and utilized to train a two stage ensemble machine learning model. A comparison of various RSSI based datasets indicates a mean cross-validation accuracy of up to 99.7% and 97.8% in line of sight (LoS) and through-the-wall scenarios, respectively. The detection accuracy in non LoS environments can be enhanced using CSI based features, enabling motion detection in different rooms using a single WiFi router. We also analyse cross-validation among datasets, different walk patterns and speeds, multiple occupant scenarios and effect of static activities to validate the model performance.

In the latter part of the talk, we discuss a WiFi based device-free sensing model employing ESP32- a low cost embedded IoT device, as a suitable retrofit for human motion sensing in new and existing buildings. A low complexity feature set derived from WiFi received signal strength indicator and channel state information samples collected by ESP32 is utilized for training ensemble machine learning models. The proposed model shows a mean accuracy of up to 99.4% in jointly detecting human motion and classifying the empty/ occupied room, with only a single WiFi access point. The proposed model can be employed for motion driven smart load control and for a typical residential occupancy scenario, this approach exhibits a potential monthly electricity savings of up to 66.26% compared to a no-occupancy sensing scenario and a three times reduction in $CO_2$ emissions.