# WiSeCom-Lab: Wireless Sensing

# and Communication Lab

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#### Intelligent and Soft Sensing

Intelligent sensors are capable of modifying its internal behaviour to optimize the collection of data and utilize advanced signal processing techniques, data fusion techniques, intelligent algorithms, and artificial intelligence concepts to better understand sensor data, for better integration of sensors and feature extraction, leading to measures that can be used in smart sensing applications.

#### Research Summary

In the recent past we are focused on development of intelligent and soft sensors for different water quality and quantity monitoring parameters. We also conducting experiments to use ultrasonic sensors as a general purpose intelligent sensor to monitor the environment temperature, humidity and breathing rate and body temperature monitoring in an non-invasive manner.

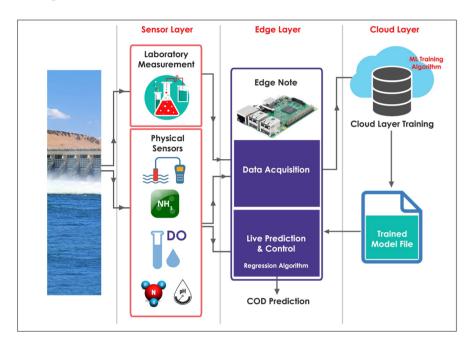


Figure: Architecture for development of IoT based Water Quality Soft Sensors

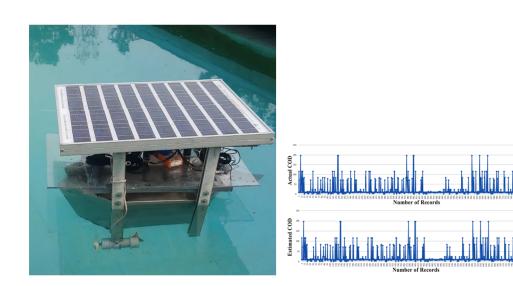


Figure: (a) A prototype for monitoring and alert generation of river water quality, (b) Graph showing measured and estimated BoD values using soft sensor model

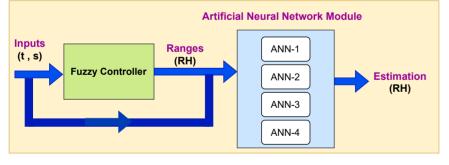


Figure: Ultrasonic sensor based contact-less remote environment temperature and humidity measurement

## Recent Publications

- [1] Ajit Kumar Sahoo and **Siba K. Udgata**, "A novel fuzzy inspired machine learning framework for relative humidity estimation using time-of-flight of ultrasonic sensor", *Measurement*, **2022**.
- [2] Rohit Kumar Bondugula, **Siba K. Udgata** and N.S. Bommi, "A Novel Weighted Consensus Machine Learning Model for COVID-19 Infection Classification Using CT Scan Images", *Arabian Journal of Science and Engg.*, 2021.
- [3] A. S. Pattanayak, B. S. Pattnaik, **Siba K. Udgata** and A. K. Panda, "Development of Chemical Oxygen on Demand (COD) Soft Sensor Using Edge Intelligence", *IEEE Sensors Journal*, vol. 20, no. 24, pp. 14892-14902, **2020**.
- [4] Ajit Kumar Sahoo and **Siba K. Udgata**, "A Novel ANN-Based Adaptive Ultrasonic Measurement System for Accurate Water Level Monitoring", *IEEE Transactions on Instrumentation and Measurement*, vol. 69, no. 6, pp. 3359-3369, **2020**.

#### Device Free Wi-Fi Sensing (DFWS)

Recently DFWS has gained attention due to its low cost and penetration power. It is unobtrusive, ubiquitous, and privacy protected. It works on the principle of observed variations CSI (channel state information) values, due to change in the transmission medium. Machine learning techniques are used to recognize patterns in CSI values in different environmental conditions which then can be used as a sensing apparatus.

#### Research Summary

We focus on the study of Wi-Fi sensing, which includes channel estimation to extract CSI values corresponding to all sub-carriers, use of advanced filtering techniques, feature extraction and pattern recognition and use of machine learning and deep learning technique for many sensing applications. Our research focuses on human activity recognition and environment monitoring.

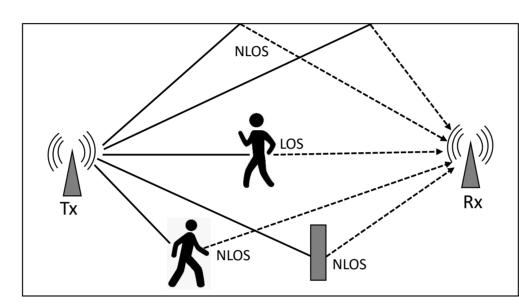


Figure: A scenario of LoS and NLoS of Wi-Fi signal propagation

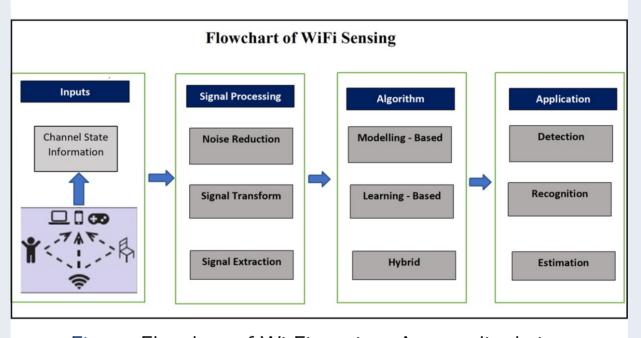


Figure: Flowchart of Wi-Fi sensing: A generalized view

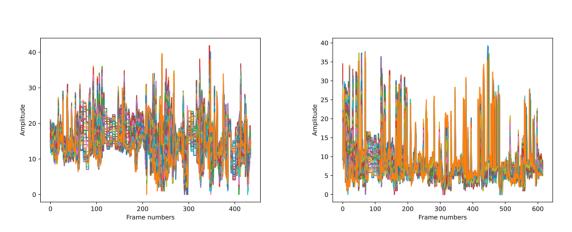


Figure: CSI plots of human walk (left) and fall activity (right)

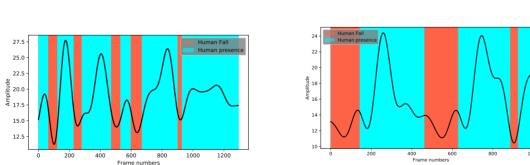


Figure: Average of CSI values plot for human walk and fall activities

Currently, we are working on the research on the use of Wi-Fi sensing model for smart home, smart agriculture, environment monitoring and healthcare among a few other applications.

#### **Recent Publications**

- [1] Sruthi Penmetsa and **Siba K. Udgata**, "An improved Wi-Fi sensing-based human activity recognition using multi-stage deep learning model," **Soft Computing**, **2022**.
- [2] Ajit Kumar Sahoo, Akhil K. and **Siba K. Udgata**, "Wi-Fi Signal-Based Through-Wall
  Sensing for Human Presence and Fall Detection
  Using ESP32 Module," Intelligent Systems. **Lecture Notes in Networks and Systems**,
  Springer, Singapore, **2022**.

#### Wireless Communication

Wireless communication systems are becoming more important due to increase in popularity of IoT based systems, 5G and 6G technologies. Wireless communication research focuses on interference modeling, transmission schedule preparation for efficient and noise free communication. With the advancement of cognitive radio, research focus is also on spectrum sensing and allocation for efficient data routing.

### Research Summary

Our research in wireless communication domain is focused on improving the quality of data communication through realistic interference model, receiver interference minimization, minimizing non-overlapping transmission schedule, and transmission power optimization. We also focus on spectrum sensing and resource allocation problem in cognitive radio environment.

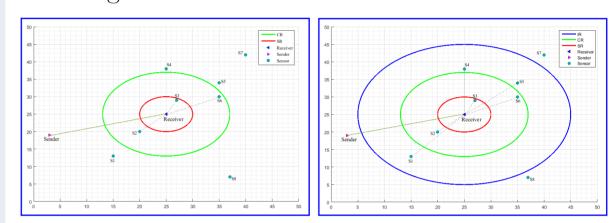


Figure: (a) Existing interference model (b) Proposed probabilistic interference model

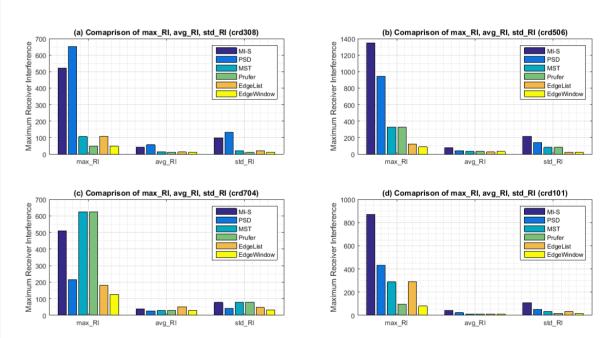


Figure: Comparison of receiver interference with proposed methods for different benchmark data sets (a,b,c,d)

#### Recent Publications

- [1] Susil Kumar Mohant and Siba K. Udgata,
  "SATPAS: SINR-based adaptive transmission power
  assignment with scheduling in wireless sensor
  network," Engineering Applications of
  Artificial Intelligence, Vol. 103, 2021.
- [2] Arun Avinash Chauhan and Siba K. Udgata, "Data Aggregation using Difference transfer for Load Reduction in Periodic Sensor Networks," Wireless Personal Communication, 115, 1507–1524, 2020.
- [3] Susil Kumar Mohanty and Siba K. Udgata,
  "Minimizing the maximum receiver interference in
  wireless sensor networks using probabilistic
  interference model," Engineering Applications
  of Artificial Intelligence, Vol. 91, 2020.

#### Contributing Research Students

• Arun Avinash Chauhan

Research Area: Wireless communication and Sensor Networks

Ajit Kumar Sahoo

Research Area: Intelligent Sensing, Device Free Wi-Fi Sensing

Rohit Kumar Bondugula

Research Area: Intelligent Sensing

<sup>a</sup> Sruthi Penmetsa

Research Area: Device Free Wi-Fi Sensing