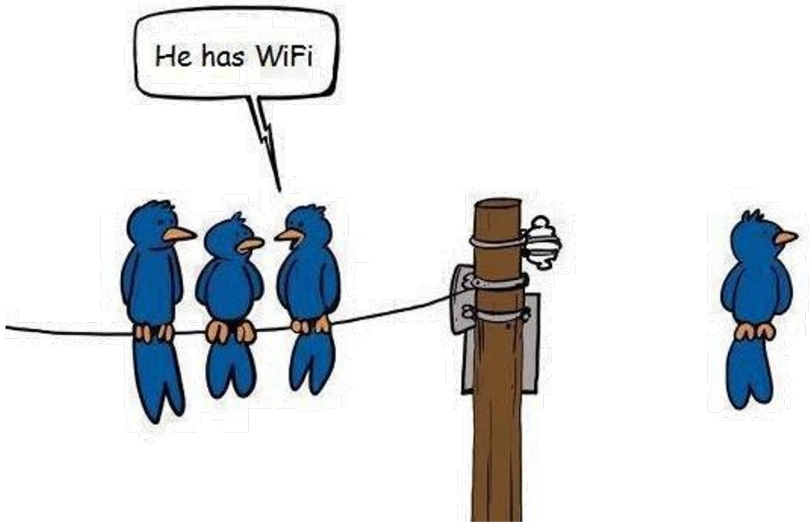
# COM-405: Mobile Networks

## Lecture 12.1: MS Projects in SENS Lab

Haitham Hassanieh

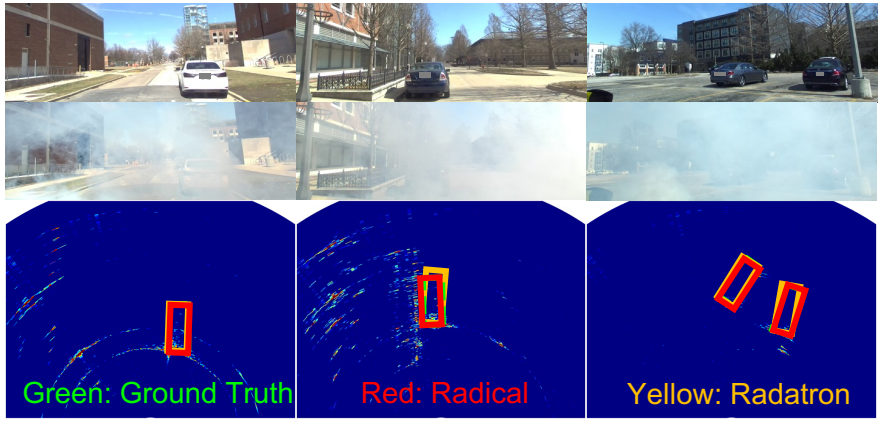



EPFL

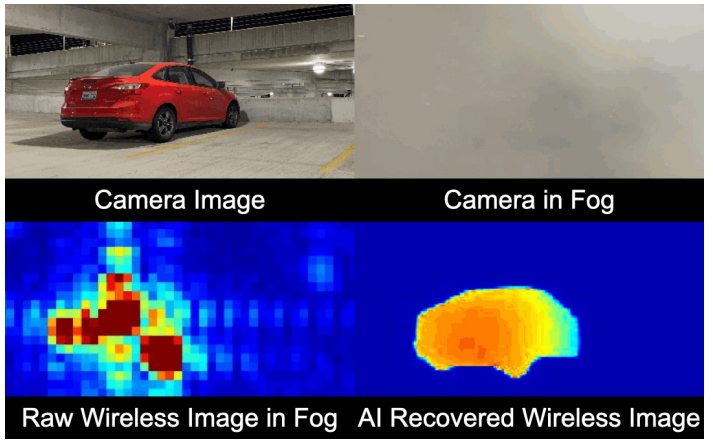
SENS
Laboratory of SEnsing
& Networking Systems

# Projects on Wireless Sensing & Imaging

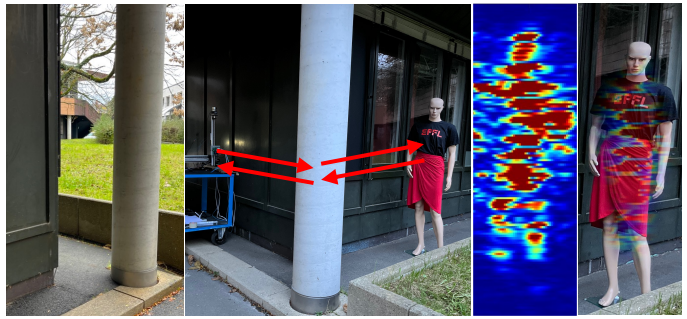
**Radatron**
[ECCV'22, ICASSP'23]
Accurate Object Detection



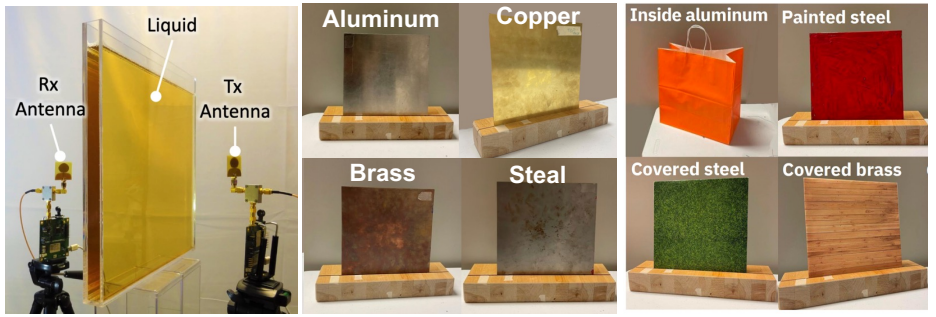

**Radical** [CVPR'24]
Self-Supervised Learning for Radar Detection




**Hawkeye** [CVPR'20]
High Resolution 3D Imaging



**RFIect** [MobiCom'24]
Around the Corner Imaging

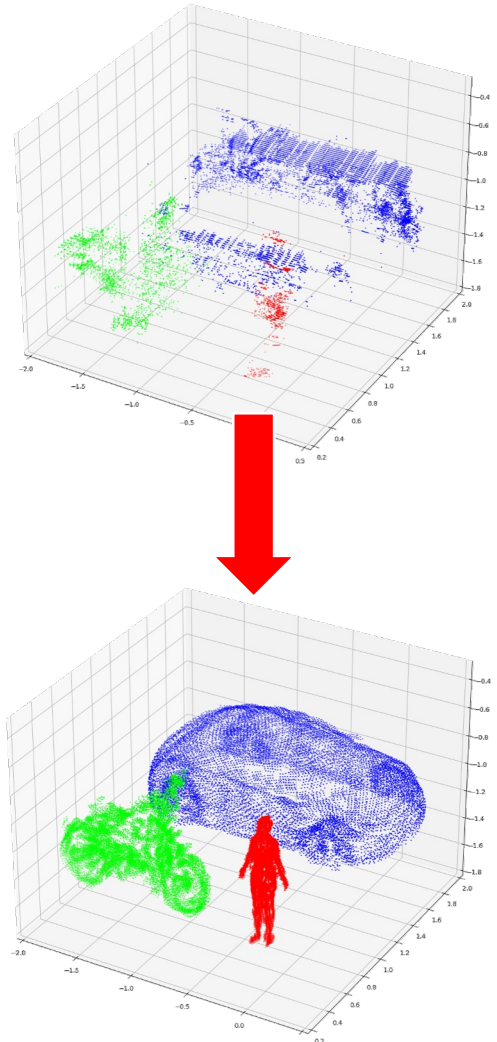



**LiquID** [MobiSys'16] **& RFVibe** [MobiSys'23]
Liquid and Material Identification

Code:
https://github.com/JaydenG1019/HawkEye-Data-Code
https://github.com/waleedillini/radatron
https://github.com/yiduohao/Radical

# Open Projects on Wireless Imaging

## 3D Radar Shape Reconstruction



**1.Retrieval-based 3D reconstruction for mmWave pointclouds**

1. The goal of this project is using a data-driven approach to reconstruct complete shapes from partial/sparse mmWave radar point clouds detections.
2. This is done by training a feature extractor and classifier on simulated mmWave radar to classify the point clouds into three classes of shapes; cars, bikes, and humans.
3. The next step is to retrieve a full shape of the predicted class and measure the similarity of that shape and the ground truth.

**2.Transformer-based 3D reconstruction network for mmWave radar pointclouds**

1. The goal of this project is adapting a transformer-based network for 3D shape completion to partial mmWave point clouds
2. using existing datasets for 3D point clouds extracted from mmwave radars

**3.Enhancing mmWave radar heatmaps using deconvolution:**

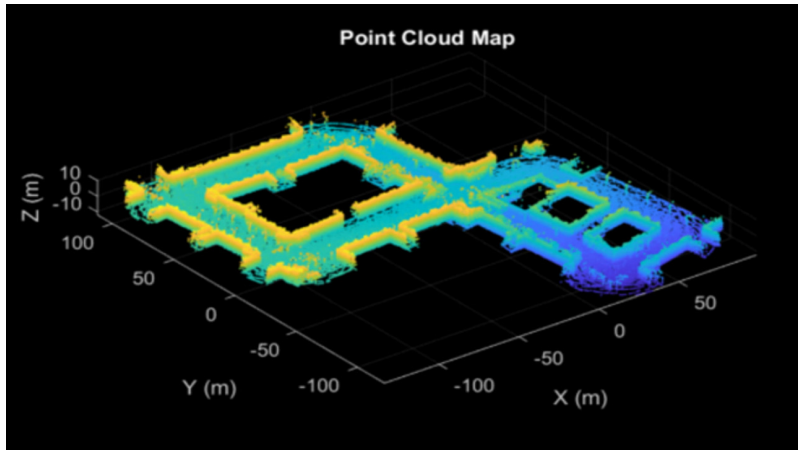
- The goal of the project is studying the point spread functions of different mmwave radars and building a method that uses this PSF to enhance target detection and suppress sidelobes

**4.3D fusion of multiple radars:**

1. using horizontal and vertical radar heatmaps to generate a 3D representation
2. expanding the current method to include multiple targets per range-bin
3. Possibly using Multi hypothesis testing to increase/decrease confidence in targets along the time dimension

# Open Projects on Wireless Imaging

## Radar SLAM




**1.Dual-radar SLAM: using a multiple-radar system to perform 3D SLAM using radar heatmaps.**

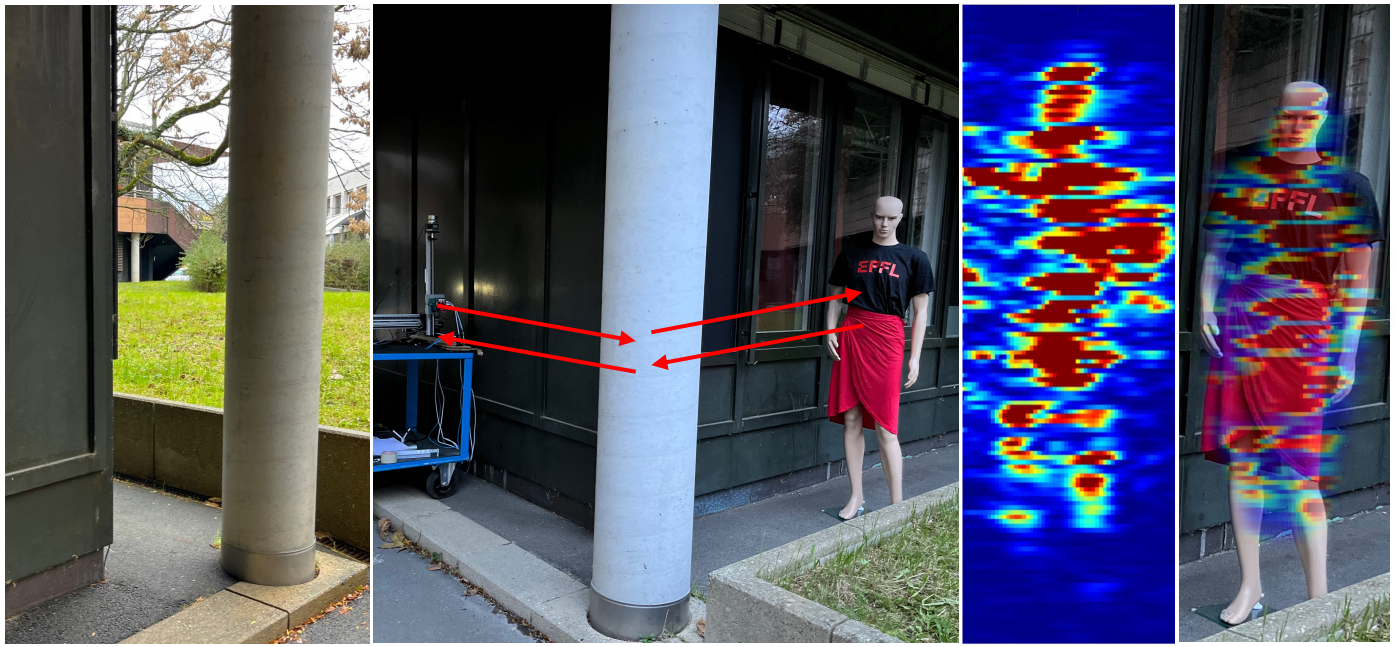
1. Integrating an additional radar sensor to existing 2D radar slam platform
2. Using the additional sensor information for 3D SLAM

**2.SLAM pipeline using Cascaded radar**

1. Building a radar-SLAM platform using the cascaded radar instead of the single-chip radar
2. This will probably produce more accurate maps and odometery results

# Open Projects on Wireless Imaging

## Around the Corner Imaging



**1.Around the Corner Imaging with Complex/Composite Surface Reflectors**

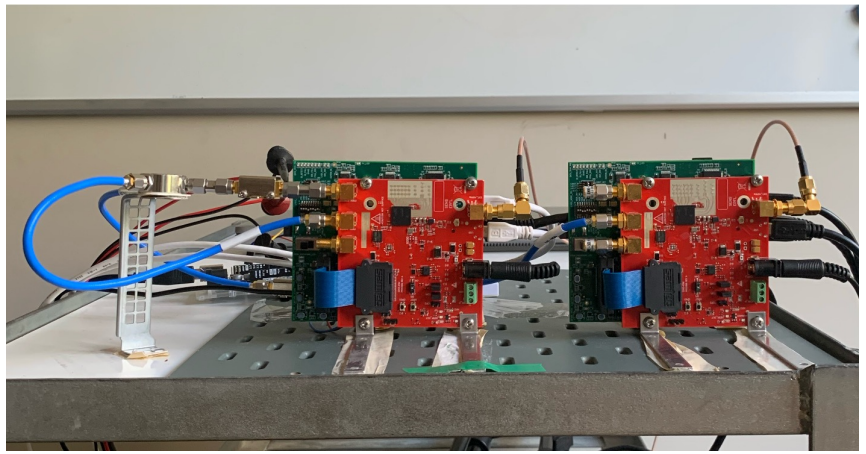
1. imaging on more complex or composite surfaces that reflect around
2. study the multiplane ghosts i.e. ghost objects detected from reflections on multiple planes.

**2. Around the Corner Detection for Self Driving Cars.**

1. Adapt the techniques for around the corner imaging to be able to detect cars, pedestrians, and bikes coming around hidden corners.
2. Involves collecting a lot of radar data and applying radar processing and neural networks for accurate detection.

# Open Projects on Wireless Imaging

## Coherent Distirbuted Radars



**1.PCB Design of new Radar**

- Iterate over a PCB design of radars with ability to share clocks and synchronize with each other.

**2.Imaging from multiple distributed radars**

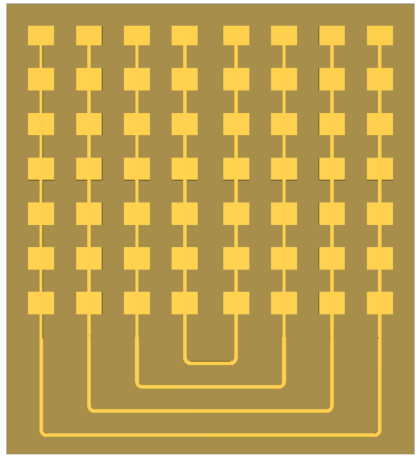
1.Involves experimenting with two synchronized radar that we already built to debug the synchronization problem.

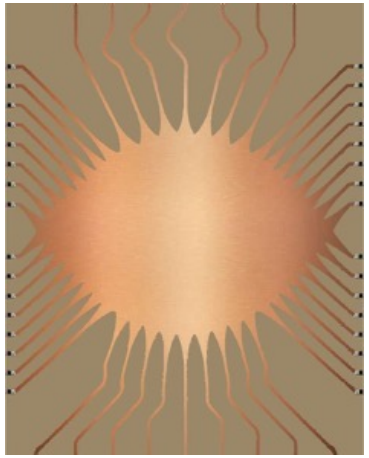
2.Develop processing algorithms to better combine data from two synchronized radars.

**3.Test multiple synchronized data on self-driving cars as an applications**

# Open Projects on Wireless Imaging

**Retrorefelective Tags**





**1.Test the performance of retroreflective tags**

**2.Combat specularity with retroreflective tags**

- Image with the tags placed on a car and see if you get reflections from specular parts

**3.Develop machine learning and neural networks to enhance imaging and detection**

- Use the retroreflective tags as key points and features that allow us to improve the imaging system

# Open Projects on Wireless Imaging

## Imaging Inside Boxes

**1.360 degrees Imaging**

- image a full object front and back with a metal reflector behind

**2. Sparse Antenna Array Patterns**

- Explore minimizing the number of antennas in the array to get a good image.

**3. Sparse Paths**

- Explore minizming the path that the robotic arm needs to travel to image an object with SAR.

**4. Adaptive Imaging**

- Create a real time SAR imaging platform that updates the outputs as the scans are measured

**5.Learn optimal diffusion patterns and radar point spread functions.**

1.Use machine learning to learn these patterns
2.Use a simulated ray tracer to verify the accuracy of these patterns
3.Enhance the radar imaging system.

# Open Projects on 5G and Cellular Networks

## 5G Testbed


- **Build Real-World 5G Testbed**
  - Simplify complex 5G deployment tasks through an intuitive framework with minimal overhead, making it easier to scale, monitor, and troubleshoot
- **Comprehensive API for Private 5G Network Control**
  - Develop comprehensive API for private 5G networks to provide seamless control over user management, network slicing, and infrastructure optimization.
- **Offloading 5G Lower PHY Processing onto Digital Signal Processors (DSPs)**
  - Offload lower PHY processing onto dedicated DSPs to maximize efficiency and reduce latency
- **Customized RF Amplifier Circuit with Digital Predistortion**
  - Create a high-power amplifier with digital predistortion to boost software-defined radio integrated circuits for reliable 5G communication

# Open Projects on 5G and Cellular Networks

## Private 5G for Robotics


- **Autonomous Furniture**
  - Build a private 5G network to control and interact with autonomous furniture.
- **Autonomous Chemistry Lab**
  - Build a private 5G network to control the navigation of drones in an autonomous chemistry lab.

# Open Projects on 5G and Cellular Networks

**Joint communication and sensing in 6G**

The goal of this project is to build a joint communication and sensing platform using an RFSoC FPGA as baseband and a Sivers phased antenna array system.

- **Part 1, RFSoC:**
  - using the RFSoC to generate OFDM symbols
  - synchronizing several DACs on the FPGA board to send the ofdm symbols as well as analog phase control to the phased array system
  - student will need some experience with vivado/HDL tools

- **Part 2, Sivers phased array:**
  - Testing (or implementing) integrated communication and sensing signals using hybrid OFDM+FMCW signals
  - Using gnu radio to set up the boards and establish communication baselines.