Top 10 Radar Projects for Senior Thesis/Capstone Projects

Introduction

The following is a list of 10 projects which can be considered for engineering student Senior Thesis, Capstone Project, or Master's Thesis. The projects are meant to provide both a means of gaining experience with millimeter wave radar sensors and create new features or capabilities valuable for others. All of the projects are built around the OmniPreSense OPS243 radar sensors which operate as either a Doppler radar (speed/direction, OPS243-A) or FMCW radar (ranging, OPS243-C). Unique capabilities in the sensor API provide access to final speed/range information, post FFT data, or the raw sampled data. The API defined in the AN-10 API Interface application note describes the control the user has over the sensor to configure the data output and radar signal processing.

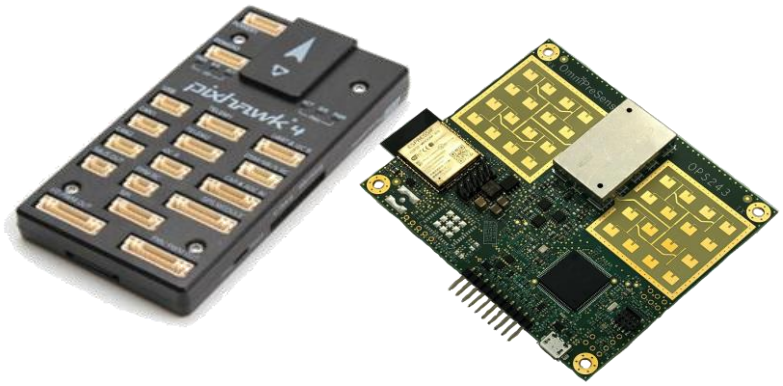
1) Drone Pixelhawk Driver for OPS243-C Altimeter

This project involves writing a driver to run on the Pixhawk drone flight controller taking in data from the OPS243-C to report height measurements to control drone operation. Example code would take in range readings from the sensor and feedback control of motors for constant height. The code would allow a drone to fly at fixed altitudes above rough terrain to support applications such as spraying agricultural fields.

Degrees: Electrical Engineering, Computer Science, Computer Engineering, Electromechanical Engineering

Year: Undergraduate

Sensor: OPS243-C-FC-RP



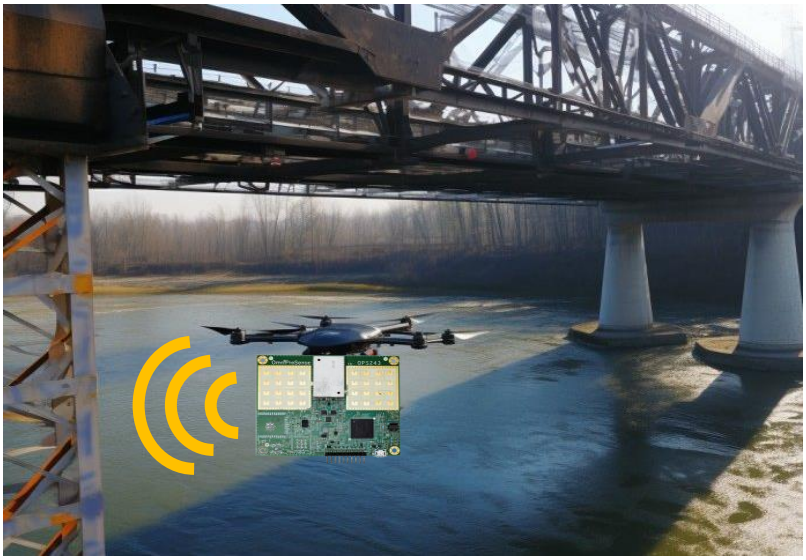
2) Drone Pixelhawk Driver for OPS243-C Collision Avoidance

This project involves writing a driver to run on the Pixhawk drone flight controller taking in data from the OPS243-C to detect objects in front of the sensor for collision avoidance. Example code would take in range readings from the sensor and control of motors to reduce speed such that a drone would not run into objects such as trees, walls, poles, and power lines. Code could be use to enable drone inspection of objects at fixed distances. An extension of the code could enable the drone to pan left/right or up/down and monitor the object signal magnitude as reported by the radar to understand the 3D position of the object relative to the drone.

Degrees: Electrical Engineering, Computer Science, Computer Engineering, Electromechanical Engineering

Year: Undergraduate

Sensor: OPS243-C-FC-RP



3) Vehicle Classification Utilizing OPS243-A Classifier Object

The project utilizes the object classifier API command in the OPS243-A to output information about vehicles as they pass thru the sensor field of view. Data reported including signal magnitude (max, avg.), total detection time, speed, field of view transit time, length, etc. are used to build a machine learning (ML) model which can classify the detected vehicles as large truck/bus, car, motorcycle, or bicycle. Collected data is utilized to train a TinyML model which may be coded in Python to run on a Raspberry Pi or similar. Successful testing of live data from the sensor will report speed and classification while achieving greater than 95% accuracy.

Degrees: Electrical Engineering, Computer Science, Computer Engineering

Year: Undergraduate

Sensor: OPS243-A-CW-RP

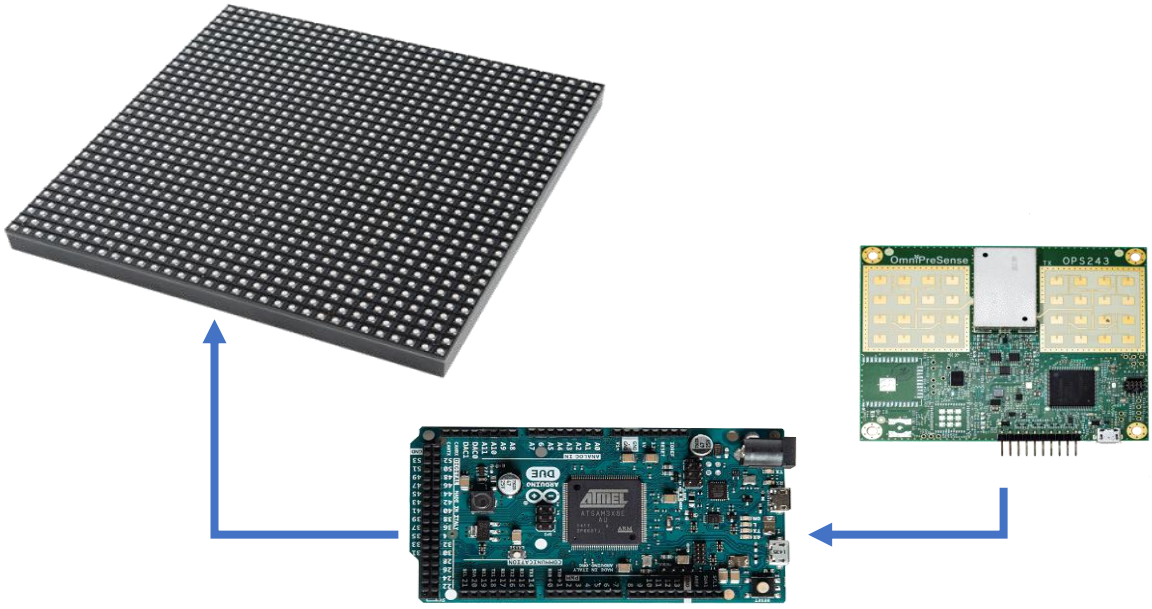
4) Radar Speed Sign LED Driver Board

This project involves reading speeds from an OPS243-A and processing it thru an Arduino Due to drive an LED display as a radar speed sign. As a bonus, if excessive speed is detected, special messages or flashing speed number and/or changing colors are used to encourage safer driving. The project utilizes a design write-up by Sparkfun found **here**.

Degrees: Electrical Engineering, Computer Engineering

Year: Undergraduate

Sensor: OPS243-A-CW-RP



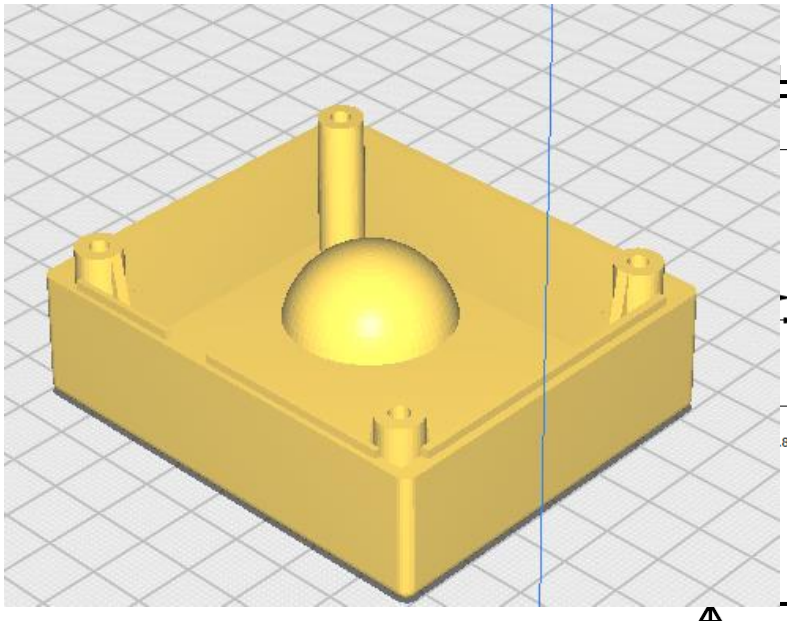
5) 3D Printed Lens for OPS243

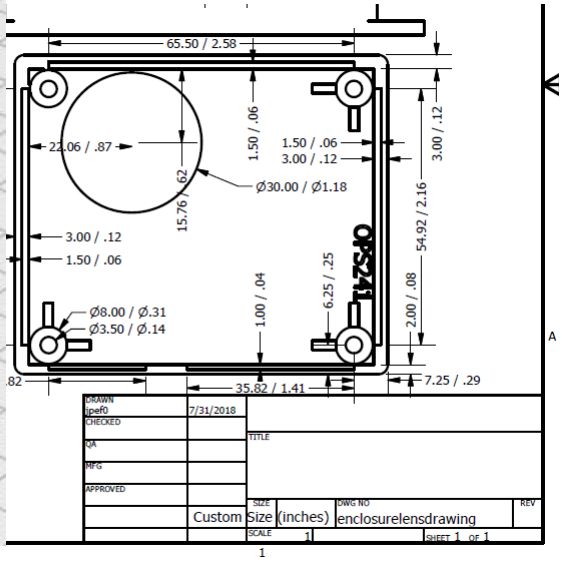
The project involves design of a 3D printed lens to focus the beamwidth of the OPS243 from its default 20° (H) x 24° (V) to a noticeably tighter beamwidth (ex. 10° (H) x 12° (V)). The design would make use of standard, low cost 3D printing material (PLA, ABS, etc.). Design equations for the focus point, etc. would be generated. A mounting structure would also be designed for proper placement of the lens over the sensor. A successful design would measure the -3dB points to confirm the desired beamwidth has been achieved and transmit power measurements with and without the lens measured to show potential increase in detection capability.

Degrees: Electrical Engineering, Optical Engineering, Physics

Year: Undergraduate, Masters

Sensor: OPS243-A-CW-RP or OPS243-C-FC-RP





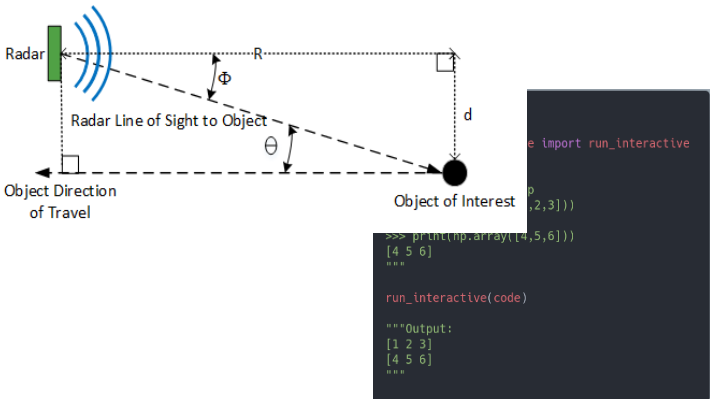
6) Automatic Cosine Error Detection and Correction

This project utilizes speed data from an OPS243-A to determine the path a vehicle makes relative to the sensor, calculating the cosine error in the speed readings, and enabling automatic correction of the final reported speed. Test data taken based on known object speed and position relative to the sensor is analyzed and equations are generated to determine the cosine error correction. The equations are coded in Python and run on a Raspberry Pi or similar to output correct speeds within ±1% of actual speed. An extension of the equations or algorithms may be used for determine the lane a vehicle is traveling in for multi-lane roads.

Degrees: Electrical Engineering, Computer Science, Computer Engineering

Year: Undergraduate

Sensor: OPS243-A-CW-RP



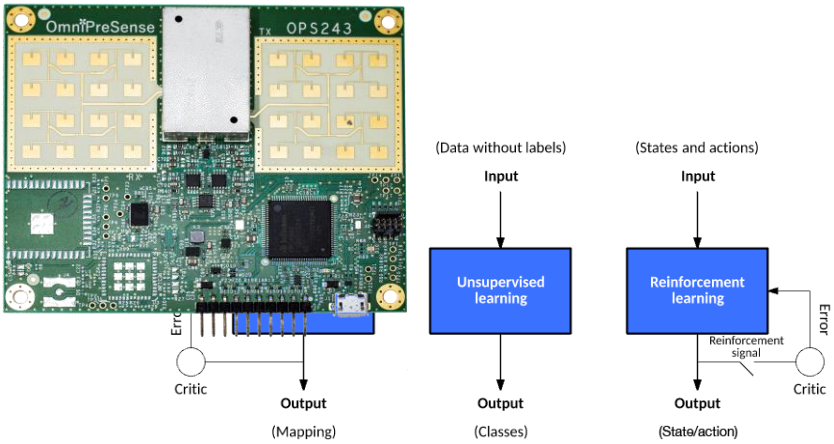
7) Machine Learning Material Classification using FMCW Radar

A material classification sensor is developed based on the OPS243-C making use of its FMCW operation. Returned signals from the OPS243-C are captured for various material types (metal, brick, wood, flesh, etc.) and a machine learning model is developed to correctly classify the material. Signal analysis makes use of the raw and FFT data provided by the sensor API for processing and may leverage the ability to adjust the chirp ramp rate and/or bandwidth used. The ML model is implemented in Python to run on a Raspberry Pi or similar for testing with target accuracy of >95%. Real world applications for such classification include determining rocks in grain, quality of plywood construction (glue, voids), and metals hidden under garments.

Degrees: Electrical Engineering, Computer Science, Computer Engineering, Materials Engineering

Year: Undergraduate, Masters

Sensor: OPS243-C-FC-RP



8) Pickle Ball and Paddle Serve Speed

This project utilizes the OPS243-A and multi-object speed reporting to measure the speed of the paddle and pickle ball during serve. The sensor is positioned at the back of the court and measures the forward motion of the serve and the speed of the ball moving (negative speed) from the sensor. Data captured is analyzed and an algorithm is generated which separates out the paddle/arm speed from the ball speed (ex. Clustering algorithm). From this a smash factor similar to golf may be calculated. The algorithm is implemented in Python and run on a Raspberry Pi to capture, store, and output statistics on the individuals service. Additional calculations may be processed utilizing micro-Doppler techniques to remove arm, body, and leg movements or work to determine the spin placed on the ball.

Degrees: Electrical Engineering, Computer Science, Computer Engineering

Year: Undergraduate, Masters

Sensor: OPS243-A-CW-RP

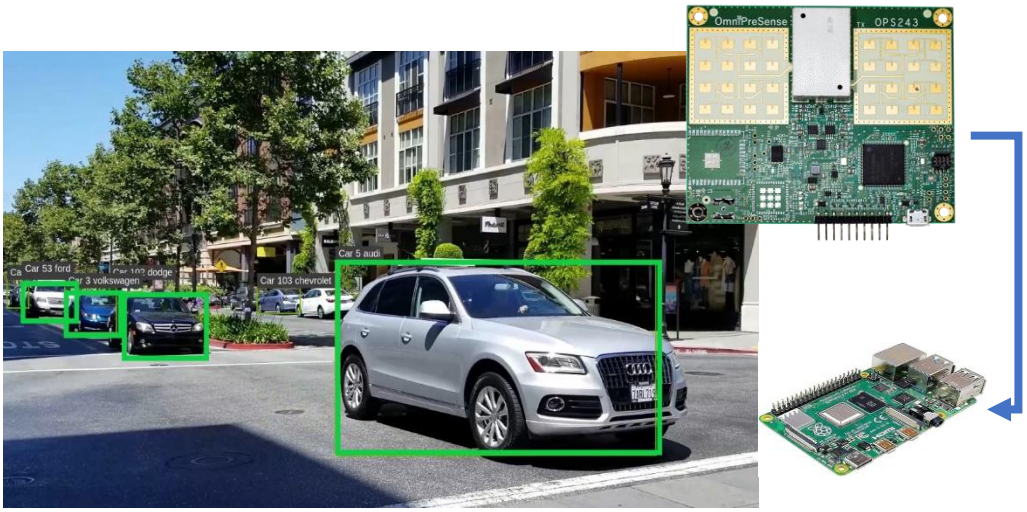
9) Radar and Camera Integration for Vehicle Speed Detection

The project utilizes a Raspberry Pi with a camera and OPS243-A to detect the speed of vehicles and when excessive, takes a picture for license plate recognition (LPR). On board LPR algorithms may be run or images may be passed off to cloud based solutions (ex. Plate Recognizer) for license plate reporting. Enhanced algorithms may be employed which can perform object detection for classifying vehicle type (truck, car, motorcycle) and/or lane detection for assigning proper speed to vehicles when two or more are present in the field of view. For a head start, see following **GitHub** repository.

Degrees: Electrical Engineering, Computer Science, Computer Engineering

Year: Undergraduate, Masters

Sensor: OPS243-A-CW-RP



10) Bullet Speed or Gun Muzzle Velocity Detection

This project leverages the OPS243-A running at very high speed to detect the speed of a bullet from a gun. The sensor is configured for very fast speed detection to compensate for the extremely fast speed of the bullet. The sensor should output the speeds for visual reporting to a PC, tablet, or similar.

Degrees: Electrical Engineering, Computer Science, Computer Engineering

Year: Undergraduate

Sensor: OPS243-A-CW-RP

Revision History

Version	Date	Notes
A	September 10, 2024	Initial release.