# Combining mmWave Radar Technology with Autonomous Robotics: The Future of Path Planning Technology

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## I. MOTIVATION

Frequency Modulated Continuous Wave radars or FMCW radars are often called “radars of the future,” because of their compactness and low power requirements, which are desirable in a variety of modern applications [1]. Radars implementing this special class of technology transmit a frequency-modulated signal continuously to measure range, velocity and angle of targets. FMCW radars are a relatively low-cost option used for various applications such as automotive radar sensors, human vital signs monitoring, and near field 2-dimensional imaging. FMCW radars often work in the millimeter wave (mmWave) range allowing for a compact radar device, and an improved sensing accuracy. Texas Instruments (TI) has provided a variety of commercial mmWave sensors based on FMCW technology, including the IWR1443 single chirp mmWave sensor operating in the 76 to 81 GHz range [2].

The main objective of our project is to use the FMCW sensor together with a microcontrolled robot chassis in order to create a mobile robot system that navigates through an unknown environment based on a continuously updated point cloud map. A Simultaneous Localization and Mapping (SLAM) technique will be used to estimate the robot’s position and orientation on a coordinate plane [3]. Typically, the point cloud used by SLAM driven robots are high density and constructed from data captured by lasers or other high resolution detectors. However, in using a FMCW based mmWave radar sensor, we construct a sparse, that is, low density, point cloud. The advantages include smaller map storage sizes, essential with the hardware chosen, and significantly lower costs compared to lasers, which makes our system design classroom accessible.

Our system can be used in a variety of applications, both in the classroom and outside. For educational purposes, our robotic radar system can be used to introduce the concepts of radar technology as well as the integration of autonomous robotics and radar technology. Furthermore, students who undertake projects utilizing our system gain experience in coding, circuitry, embedded systems, data and storage management. Outside the classroom, our system can be used in any setting requiring an autonomous robot without a priori knowledge of the environment. Human rescuing planning it is one of our main interests in developing this radar system. Compared to optical or light based sensing technology, mmWave radar provides accurate path planning under challenging conditions such as bright or no light, dusty or smoky environments. Autonomous cars are also a topic of interest as the radar-robot system is a small-scale analogue of a self-driving vehicle, which is capable of sensing its environment and moving safely with no human input.

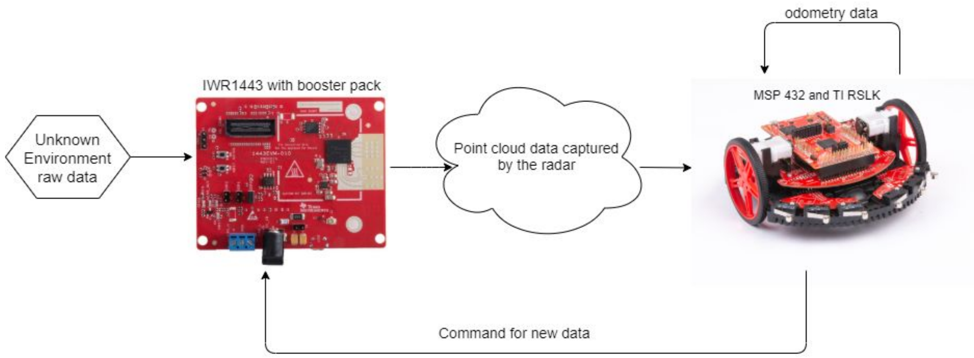


Figure 1. Schematic of how the IWR1443 radar interacts with the MSP432 and the TI RSLK

## II. SYSTEM DESIGN

The data sensing of our system is performed by the IWR1443 integrated single-chip mmWave sensor based on FMCW. The radar transmits a chirp signal from 3 transmitting antennas and receives the reflected signal from 4 receiving antennas. The IWR1443 is used on its BoosterPack, an evaluation board with direct connectivity to TI's Launchpad or a computer. The point cloud data from the mmWave sensor is processed by the TI MSP432 SimpleLink Microcontroller Launchpad. The communication interface between the BoosterPack and the Launchpad is done via pin connection. The Launchpad communicates and commands the robot chassis, a component of the TI Robotics System Learning Kit (TI-RSLK). For software, we base our application on the TI mmWave software development kit (SDK) codes. Python is also required for post-processing. Our software is written and runs on TI Code Composer Studio Integrated Development Environment (IDE). Figure 1 shows a high-level chart illustrating the key components of the proposed system.

## III. BILL OF MATERIALS

| Component | Quantity | Price |
|---|---|---|
| IWR1443BOOST | 1 | $299.00 |
| TI-RSLK MAX | 1 | $109.00 |

## IV. REFERENCES

[1] Jankiraman, M. (2018). FMCW Radar Design. Artech House. [2] Texas Instrument, *Single-chip 76-GHz to 81-GHz mmWave sensor integrating MCU and hardware accelerator,* Texas Instruments, May 2017. [Online] Available: http://www.ti.com/product/IWR1443 [3] Cadena, C., Carlone, L., Carrillo, H., Latif, Y., Scaramuzza, D., Neira, J., ... & Leonard, J. J. (2016). Past, present, and future of simultaneous localization and mapping: Toward the robust-perception age. IEEE Transactions on robotics, 32(6), 1309-1332.