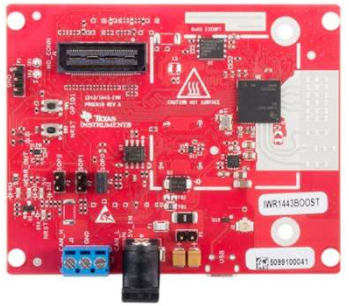
mmWave sensors in robotics: enabling robots to ‘sense & avoid’

Detailed agenda

- mmWave Sensing in Robotics – how do robots “see” using mmWave?
  - Overview and market differentiation
  - mmWave Demo Visualizer
  - ROS (Robot OS) Point Cloud Visualizer lab on TI Resource Explorer
- Autonomous robot demonstration using ROS + TI mmWave sensor (IWR1443)
- Technical Deep Dive
  - Tuning the mmWave sensor configuration for a specific application
  - How the “Autonomous Robotics with ROS for mmWave” demo works
  - Tuning Robot OS parameters in the demo

Overview



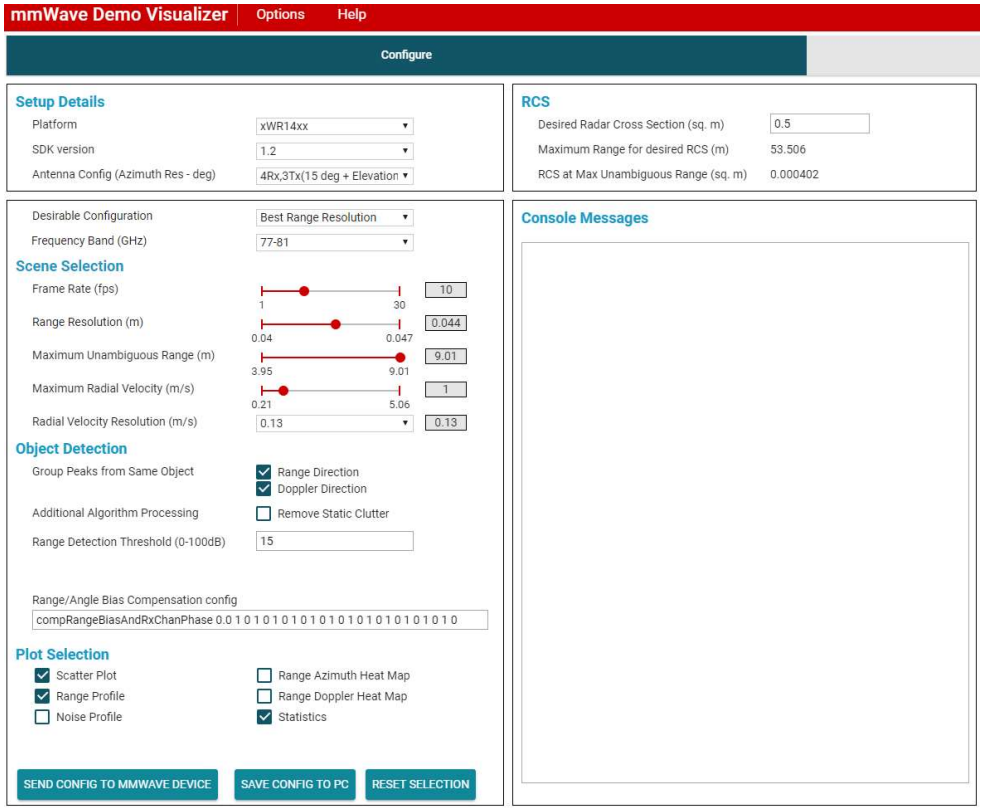
- **Goal**
  - Enable robust, high-accuracy sensing for autonomous robotics
- **Solution**
  - IWR1443 and IWR1642 are single-chip, fully-integrated, mmWave sensing devices that incorporate the full signal processing chain around the sensor. Full source code is available for customers to modify and get to market faster.
- **Key components in the system**
  - IWR1443 mmWave sensor, Power Management IC (PMIC), Robot OS (open-source software platform)
- **What steps are recommended to evaluate this solution?**
  - Follow setup guide in the “Autonomous Robotics with ROS for mmWave” lab on the TI Resource Explorer (link is on the Customer Collateral slide) which demonstrates using the IWR1443 mmWave sensor on the Robot OS Turtlebot2 platform

Key market differentiators

TI mmWave technology is uniquely equipped to solve challenges faced by the robotics community in creating truly autonomous robots
mmWave can detect both velocity and position of objects in the environment to enable more intelligent decisions
mmWave is unaffected by environmental conditions that are typical in industrial and outdoor environments
mmWave can detect transparent materials like glass that may not be detected by optical based systems
TI's single-chip mmWave sensors also integrate powerful processing cores which enable customers to implement novel algorithms

mmWave Demo Visualizer – Configure tab

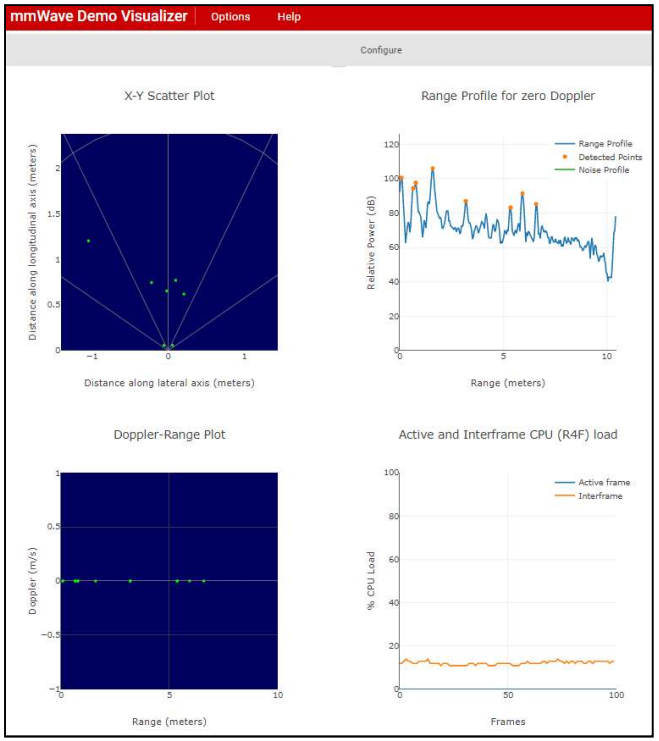
- Visualization tool for mmWave SDK out-of-box demo
- Configure tab is used to select/tradeoff desired parameters and sensing capabilities
  - Number of TX and RX antennas used (determines 2D vs. 3D with IWR1443)
  - Frequency range
  - Frame rate
  - Range resolution
  - Max range
  - Radial velocity resolution
  - Max radial velocity
  - Object detection options
  - Plot selection



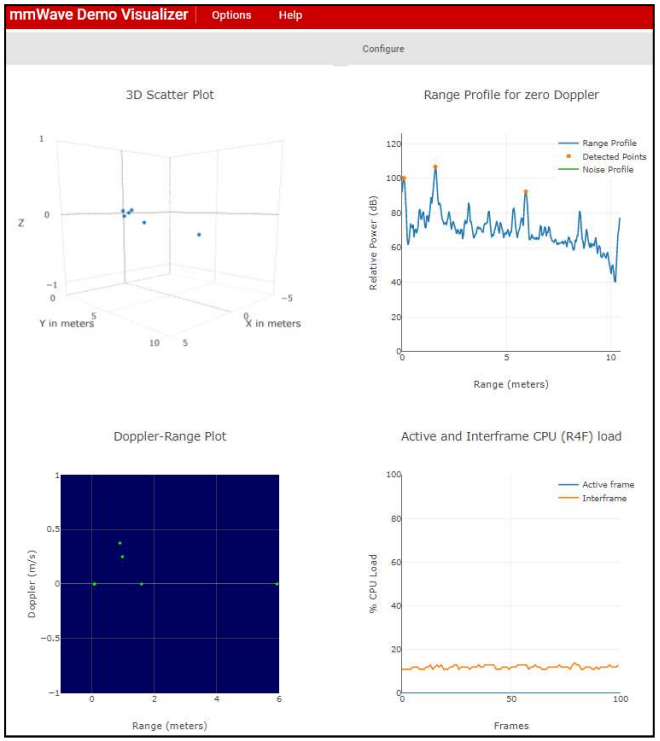
mmWave Demo Visualizer – Plots tab

- 2D configs show 2D scatter plot
- 3D configs show 3D scatter plot
- Additional plots:
  - Range Profile
  - Doppler-Range
  - Range-Azimuth Heat Map
  - Range-Doppler Heat Map
  - Noise Profile
  - Statistics

2D Config

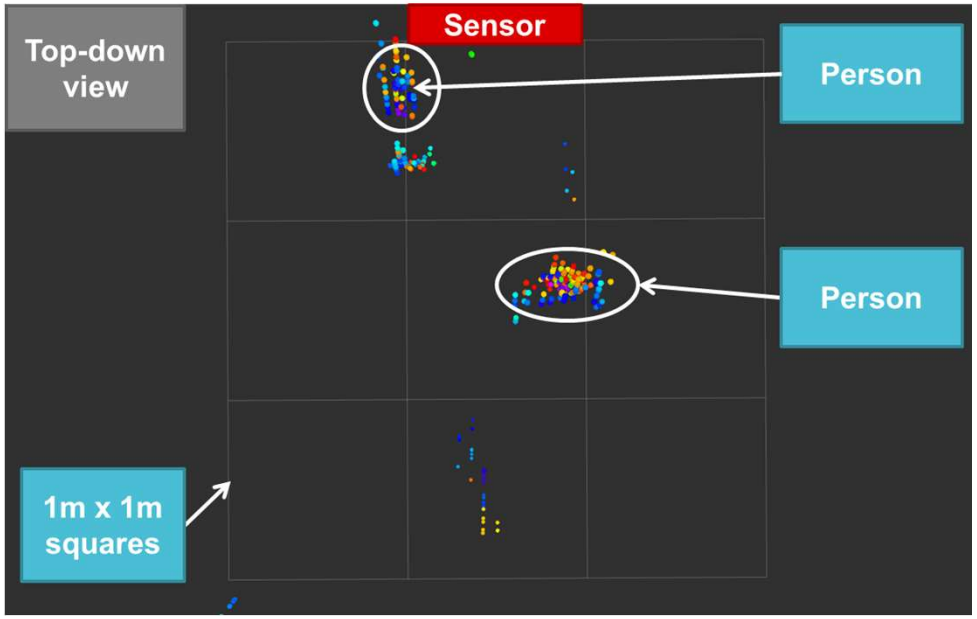


3D Config



ROS (Robot OS) Point Cloud Visualizer lab on TI Resource Explorer

- Requires mmWave SDK out-of-box demo running on mmWave EVM (detected object info is sent via UART over USB)
- Requires Robot OS running on Linux PC or Linux virtual machine
  - ROS mmWave driver converts detected object data from sensor into PointCloud format used by ROS
- ROS visualizer tool (Rviz) displays points
  - Objects show up as clusters of points (object detection threshold is reduced and peak grouping is disabled in default config to increase number of points)
  - Can configure color of points to represent elevation or intensity
  - Rviz view can easily be changed (zoom/pan/tilt) using mouse



“Autonomous Robotics with ROS for mmWave” lab on TI Resource Explorer

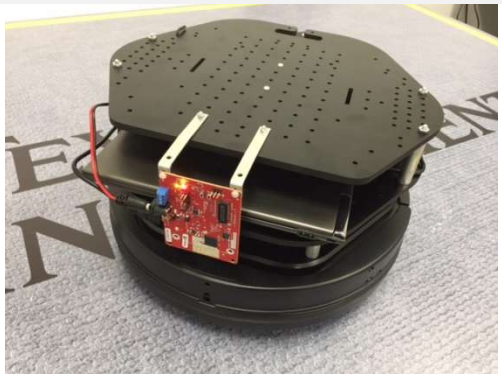
Features

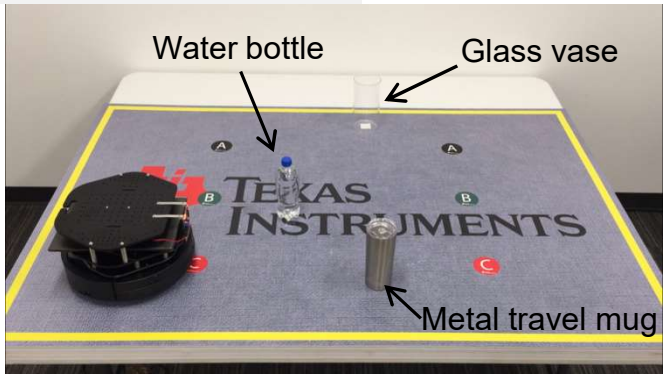
- Integrates the TI mmWave ROS driver into the ROS Turtlebot2 platform to allow the TI mmWave sensor IWR1443BOOST EVM to be used as a 3-D sensor
- Demonstrates mapping using the the TI mmWave sensor with the ROS Octomap package
- Demonstrates navigation with collision-avoidance using the TI mmWave sensor with the ROS move_base package

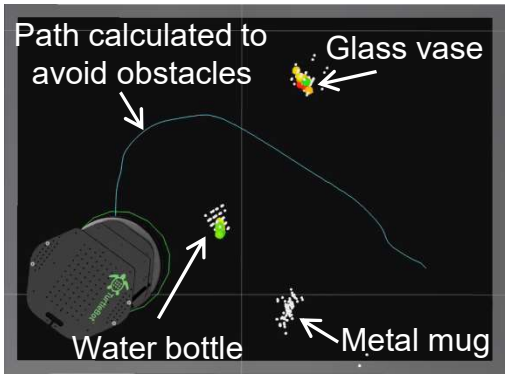
Benefits

- Accelerates customer evaluation by allowing immediate usage with the standard Robot OS robotic platform
- Provides customers with an example of using the TI mmWave ROS driver with existing ROS navigation packages

System Level View







Customer collateral

Content type	Content title	Link to content or more details
Labs on TI CCS Resource Explorer	ROS Point Cloud Visualizer lab and Autonomous Robotics with ROS for mmWave lab	http://dev.ti.com/tirex/#/?link=Software%2FmmWave%20Sensors%2FIndustrial%20Toolbox (under Labs)
Customer training series	mmWave Training Series	https://training.ti.com/mmwave-training-series
Technical blog content or white paper	mmWave radar sensors in robotics applications	http://www.ti.com/lit/wp/spry311/spry311.pdf
Selection and design tools and models	mmWave Sensing Estimator	https://dev.ti.com/mmWaveSensingEstimator
	mmWave Demo Visualizer	https://dev.ti.com/mmWaveDemoVisualizer
Videos	mmWave Demo Visualizer video	https://training.ti.com/mmwave-sdk-evm-out-box-demo
	ROS Point Cloud Visualizer lab video	https://youtu.be/lNEGT10Mk9k
	Autonomous Robotics with ROS for mmWave lab video	https://training.ti.com/robotics-sense-and-avoid-demonstration-using-ti-mmwave-sensors
Product and EVM pages	IWR1443 product page IWR1443BOOST EVM page IWR1642 product page IWR1642BOOST EVM page	http://www.ti.com/product/IWR1443 http://www.ti.com/tool/IWR1443BOOST http://www.ti.com/product/IWR1642 http://www.ti.com/tool/IWR1642BOOST