Technical Article Occupancy Detection with mmWave Sensors in a Moving Car



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Car designers have successfully integrated millimeter-wave (mmWave) sensors into several automotive in-cabin applications.

One of these applications is the ability to detect occupants inside the vehicle in a variety of lighting conditions and sensor placements, regardless of movement. This can help automotive systems detect an unattended child left behind in a car or the position of the occupants for temperature control.

Azcom Technology has demonstrated how the AWR1642 mmWave sensor, in combination with Azcom's proprietary algorithms, can reliably recognize whether a seat is free or occupied. We conducted drives at varying speeds, with different environmental (urban, highway) and cabin (light, temperature) conditions and analyzed different seats configurations.

In our demonstration, we suspended the mmWave sensor from the sunroof, angled toward the back seat (as shown in Figure 1), although in a final installation the sensor would likely be inside the seat back, around the rearview mirror or even inside the roof. Because of mmWave's ability to sense through a variety of materials, including those that make up the vehicle, sensing performance would not change when installed inside a seat or roof. All processing, including Azcom Technology enhancements, runs on the sensor, while the graphical user interface on the host machine helps visualize the results.



Figure 1. mmWave Sensor Installation on the Sunroof of a Vehicle

1



The main challenge for this use case is achieving sufficient detection robustness when the engine is on and the car is moving. The combination of these two events introduces a set of disruptions to the signal coming from several vibration modes, which are not present in a static setup. For this reason, we designed a new algorithm that is less sensitive to vibrations from the road and capable of detecting all possible combinations of seat occupancy.

We applied and validated these enhancements on top of the Vehicle Occupant Detection Reference Design. Figure 2, 3, 4 and 5 are some snapshots from sample drives, along with a graphical representation of the detected passengers.

In Figure 2, no passengers are occupying the rear seats while driving in the city, which the algorithm detected without errors. Statistics are calculated at the rate of the processing frame: 6 fps in this case. In a real-world product, a second-stage decision-maker at a lower frequency would make the detection even more robust.

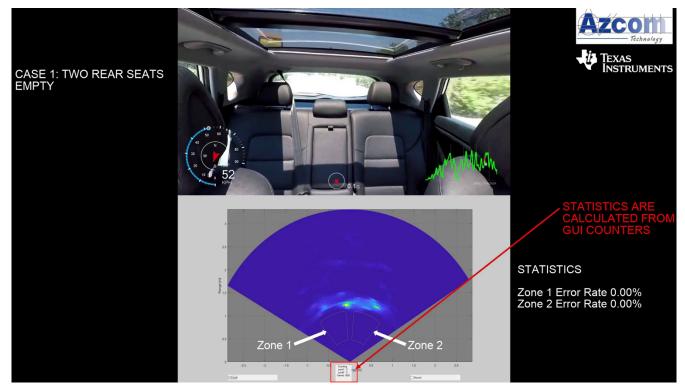


Figure 2. No Passengers Detected in Rear Seats



In Figure 3, the algorithm successfully detects the presence of one passenger in Zone 1, as highlighted by the red-colored box.

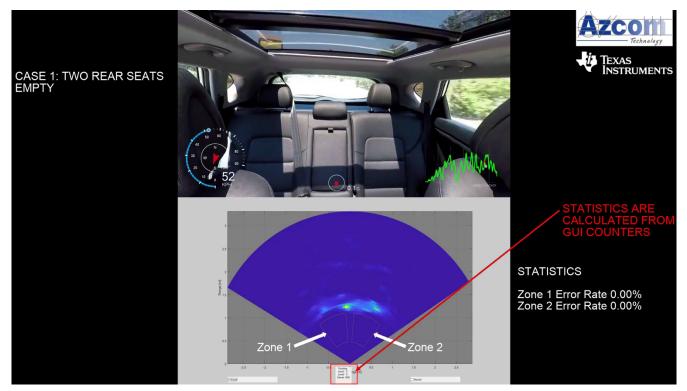


Figure 3. One Passenger Detected in the Rear Seats

Figure 4 focuses on the accuracy of the algorithm when using a different car cabin. By testing two different car models, we demonstrated reliable occupant detection when driving at variable velocities.

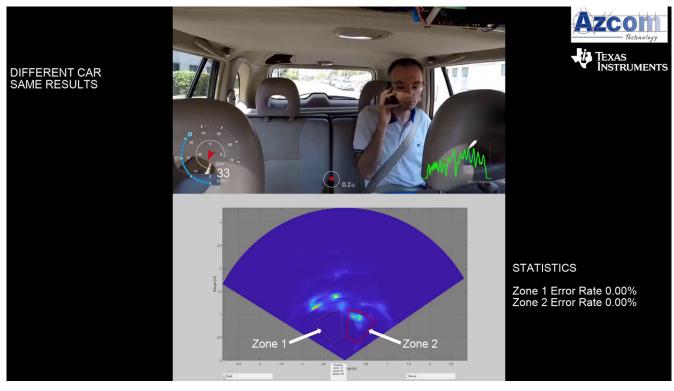


Figure 4. Occupancy Detection in a Different Car Cabin

3



Figure 5 illustrates the extension of the design to four seats in two rows. Though the scenario is more complex and challenging, after ad-hoc tunings and optimizations the algorithms have behaved as good as in the single-row setup.

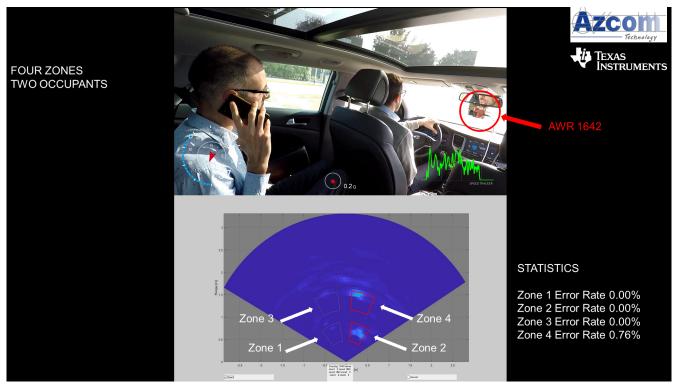


Figure 5. Four-seats Configuration

With know-how in occupancy-detection applications and deep expertise on TI platforms, signal processing, and radio-frequency and embedded systems design and development, Azcom Technology offers a range of value-added R&D services that can help you build an mmWave-enabled product by considerably reducing time to market.

To get a better overview of Azcom's portfolio of design and development services for mmWave sensor product development and support, see the Azcom webpage for mmWave.

Additional Resources

- · Check out the blog post, "Detecting vehicle occupancy with mmWave sensors."
- Learn more about automotive mmWave sensors.

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