Application Brief

Using Radar in Vehicle Intrusion Monitoring Systems

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Introduction

As motor vehicle theft continues to rise (105% from 2022 to 2023 according to the Council on Criminal Justice), many consumers are looking for new designs to protect the vehicles. Vehicle-integrated video dashcams are one novel feature that can help meet that need. While dashcams have historically been used to record on-road accidents, a growing number of aftermarket and integrated dashcam systems are beginning to offer a new form of protection: exterior intrusion monitoring.

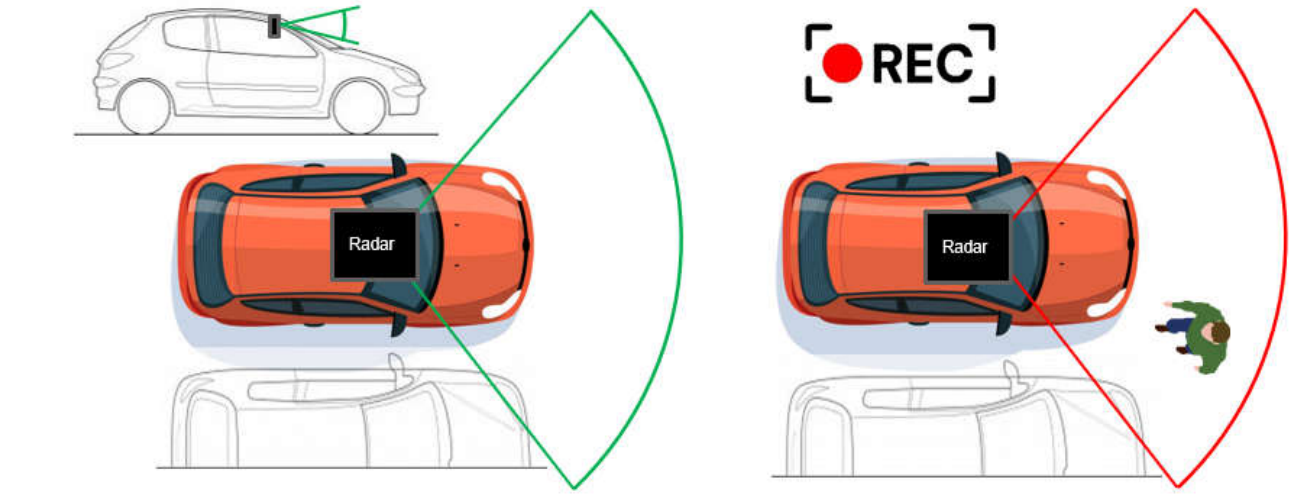

Figure 1. Exterior Intrusion Monitoring System Example

Camera-Based Design

Exterior intrusion monitoring systems leverage the fact that many modern vehicles already have exterior facing cameras for the advanced driver assistance system (ADAS). When the vehicle is parked, these cameras remain on to record any intrusion or vandalism events that occur. The most advanced of these systems use machine learning algorithms to identify suspicious activity and notify possible intruders that the actions are being recorded. Such systems can also notify the vehicle's owner in real-time when a possible intrusion event is detected.

However, camera-based exterior intrusion monitoring systems have some significant drawbacks such as power consumption, accuracy in non-ideal weather, and violating regulations. Processing multiple camera streams in real-time consume large amounts of power, up to approximately 75W in some cases. In electric vehicles, parasitic drains can directly sap the range of the vehicle. The accuracy of camera-based systems can also vary. Image processing performs very well in ideal weather conditions but accuracy is often negatively impacted by low-light and rough weather conditions. For example, water droplets can distort a camera feed to the point where image recognition is impossible. Finally, systems that continuously record possibly do not meet regulatory requirements, like the Europe Union's (EU) General Data Protection Regulation (GDPR).

Radar-Based Design

Radar sensors address many weaknesses inherent to camera-based detection. A radar-enhanced exterior intrusion monitoring system still has an exterior-facing video recorder, but the camera sensor is deactivated by default to save power. Instead, a device such as the AWRL6432 radar system-on-chip (SoC) is used as a low-power, high-accuracy wake-up condition for the video recorder. On-device processing allows the radar SoC to intelligently differentiate between passerby and potential intruders. If the radar SoC determines that an intrusion event is imminent, the SoC can trigger the vehicle to flash the headlights and begin recording video to deter the intrusion. Figure 2 shows one possible implementation of EIM – The radar detects a potential intruder, but only wakes the camera if the intruder approaches the vehicle or gets too close.

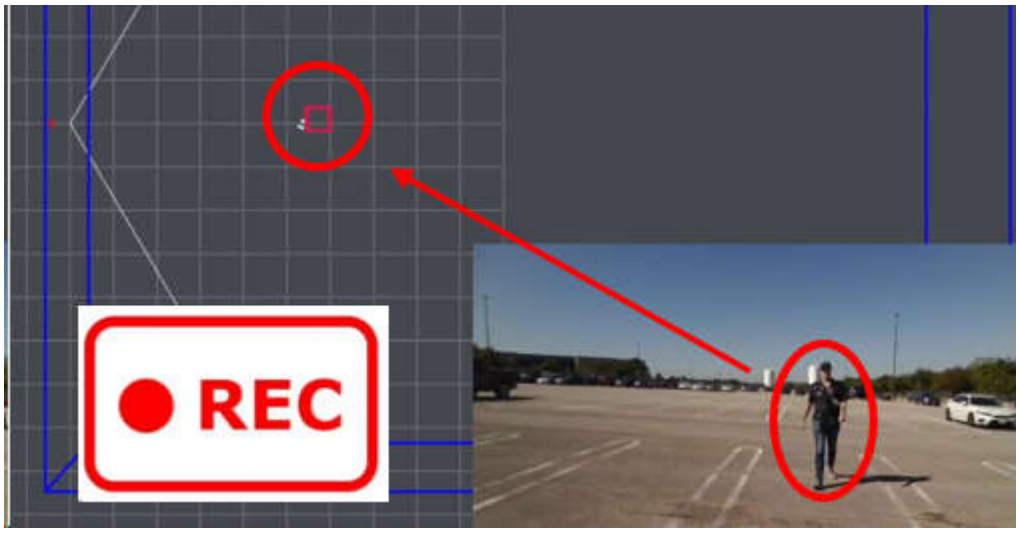

Figure 2. Approach Detection EIM Implementation

Power Savings

Using a radar can drastically reduce the passive power consumption of these detection systems. When tuned as a wake-up condition for these systems, the AWRL6432 only drew 22mW, which is three orders of magnitude lower than the average 75 W that a comparable image processing system can be used. Consider a use case where both systems are installed in an electric vehicle with an average efficiency of 2.9 mi per kWh. After 24 hours of monitoring, the camera-based system can be sap 5 miles of range from the EV. With radar as a wakeup trigger, the same vehicle can be only lose 8 feet of range.

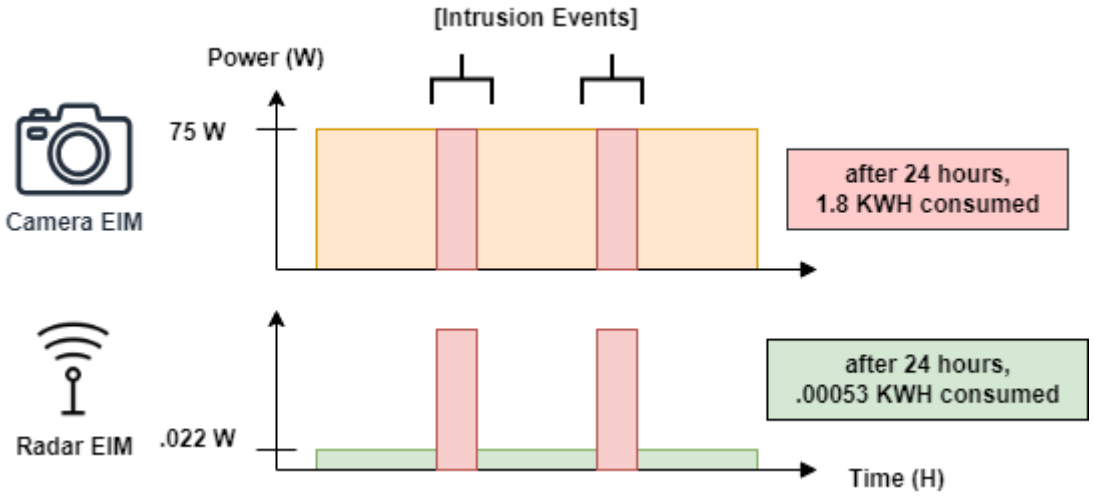

Figure 3. Power Consumption of Radar vs. Camera EIM

False Detection Mitigation

While turning on the camera or flashing the lights can still consume power during a detected intrusion, Radar-based designs can uniquely mitigate false positives to keep power consumption low. Radar adds the flexibility of defining camera wake-up logic based on an object's real-time location, velocity and acceleration. The AWRL6432 radar SoC can even classify these objects as human or non-human by processing the micro-doppler signatures with a lightweight machine-learning algorithm. With this depth of information, the on-board processor can decide whether a person is more likely to be an intruder or passerby, and act accordingly.

Radar as a Wakeup Sensor

To maximize the accuracy of an intrusion monitoring system, radar can be used to complement existing machine learning cameras. This architecture still leverages radar's position accuracy and indifference to low-light or weather conditions. But instead of directly triggering intrusion deterrence, the radar activates the machine learning cameras to gather additional data. From there, a machine learning model can leverage both the image and radar data to make the most informed decision on what to do next. Since the vehicle only begins recording after a set of intrusion-specific criteria is met, there is no need to constantly survey the surroundings, making this easier to conform to local privacy legislation.

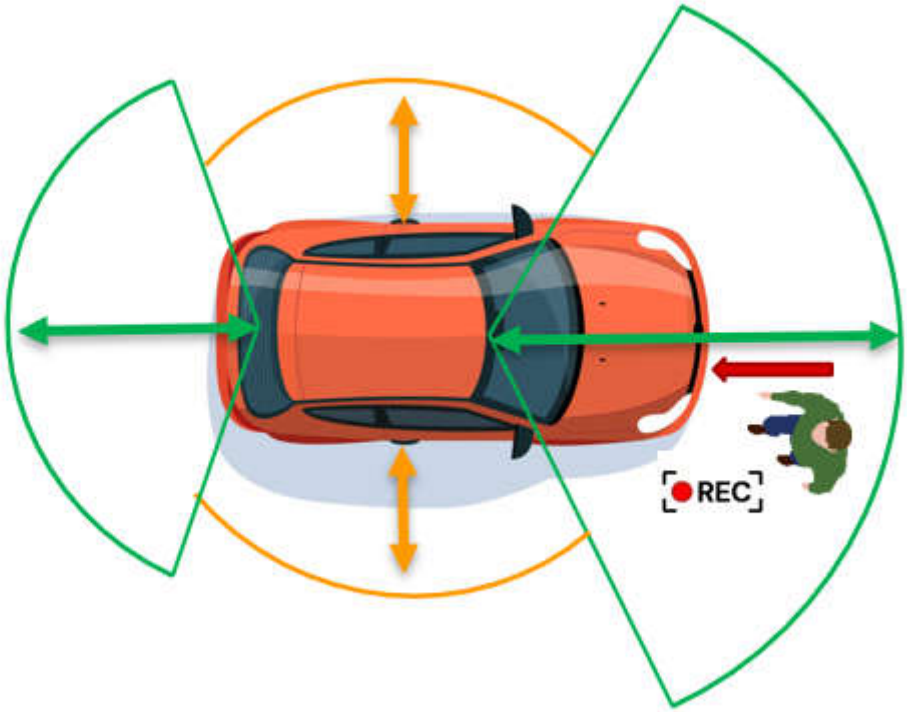

Figure 4. 360 Coverage With Multi-Use Radar

Conclusion

The field of exterior intrusion monitoring can be relatively new, but is not static. The market continues to demand lower power consumption and higher accuracy than already existing, first-generation systems can provide. TI low-power radar designs can exceed these expectations while simultaneously adding new functionality. For example, an interior sensing radar used for child presence detection (per the Euro NCAP standard) can double as a short-range exterior intrusion monitoring sensor. A 77GHz power lift gate kick-to-open module can provide crucial rearward visibility, enabling 360 degrees of radar coverage around the vehicle. TI mmWave designs not only optimize exterior intrusion monitoring power consumption, but also enable additional safety and convenience functionality at no extra cost.

Additional Resources

Evaluate the presence sensing dashcam demo

- Order the AWRL6432BOOST EVM on TI.com
- Run the Exterior Intrusion Monitoring Demo from the Radar Toolbox
- Watch the Exterior Intrusion Monitoring Demo on TI.com

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