Ask the Expert: Automotive Image Sensor Modality Enables Safer Vehicles

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Introduction

Most new cars are loaded with dozens of sensors that detect the details of the surrounding environment. These sensors are there for one purpose: to make the vehicle safer. One of the sensors with the greatest impact are the image sensors. Derived from digital photography, image sensors can capture scenes, recognize objects, and even identify light and color. Collectively, they are changing the way cars operate and are making our roads safer. Ask the Expert Joseph Notaro, Vice President, Worldwide Automotive Strategy and Business Development, **onsemi**, shares his insights on emerging sensor technology.

Q. Please summarize the use of sensors in the automotive industry over the past five years, noting their increasing capabilities.

A. The use of electronic sensors on vehicles has increased significantly over the years. Engine NOX and temperature sensors, air bag MEMS inertial sensors, ESP gyroscope MEMS sensors, and a few other simple sensors have now been joined by more complex one−mmWave radar, high−resolution image (camera), ultrasonic, and Light Detection and Ranging (LiDAR) sensors. They can sense all around the vehicle, thereby providing a complete 360−degree view of the surrounding environment. These sensors are also showing up inside vehicles to monitor the driver, as well as the passengers, to help improve safety and comfort.

Q. What types of sensors are used in ADAS?

A. All the sensors mentioned above are used primarily in advanced driver assistance systems (ADASs) now included in most new vehicles to provide increased driving safety. Today, image sensors are dominating with mmWave radar sensors. LiDAR is still expensive for today's vehicles but is already playing a dominant role in fully autonomous vehicles. LiDAR that scans an area with infrared (IR) light then reads the reflections on a photomultiplier sensor provides the much needed depth perception and distance measurement not possible with image sensors.

Q. What is ISO 26262 and ASIL—and why are they important?

A. ISO 26262 is an automotive safety standard defined by the International Organization of Standardization (ISO). It is a variant of the IEC 61508 safety standard that relates to the electrical and electronic safety systems in a production road vehicle. It is a functional standard that attempts to address all the potential failures and malfunctions that can occur in sophisticated electrical and electronic equipment in vehicles. ISO 26262 is designed to assess the risks of possible failure modes and define ways to mitigate their effects. The standard attempts to provide a total definition of how these systems should be specified, designed, implemented, integrated, tested, and validated. Automotive Safety Integrity Level, or ASIL, is part of ISO 26262. It defines four levels of risk due to the failure or malfunction of automotive electrical or electronic equipment. Level A refers to minimal risk while level D identifies risks for major breakdowns of things like antilock brakes, steering, or air bags. These standards help ensure that the modern vehicle is designed for maximum possible safety.

Q. Define modality from onsemi's perspective.

A. Modality just describes how the sensor functions based on the physical principle behind its operation. For example, an image sensor captures photons coming through the lens while radars transmit electromagnetic wave signals and detect the reflection of these waves from objects. The various sensors used for ADAS and autonomous driving (AD) complement one another. For example, on a foggy day, the image sensor may find it difficult to pick up and identify a stopped vehicle ahead, potentially resulting in a collision. However, the radar sensor will clearly see through the fog and identify the threat. An ultrasonic sensor would pick up an obstacle while parking your car. A LIDAR scanner is the most likely to effectively identify and locate a vulnerable road user (VRU) such as a pedestrian, runner, bike rider, or child playing in the street at very large distances. A good sensor mix plays a key role in ADAS/AD.

Q. How are image sensors used inside the vehicle?

A. Image and radar sensors are increasingly being added to vehicles to monitor the driver and provide an alarm or corrective action if he or she is falling asleep or not paying attention. The blinking status of the eyes and breathing conditions have been found to be accurate predictors of driver state of health, distraction, or sleep. Additional sensors are being used to detect other people, or pets, in the back seat and elsewhere. That ensures that a child or a pet will not be forgotten inside the vehicle on a hot day.

Q. How do image sensors work?

A. Image sensors for automotive applications are based on CMOS technology. They are made up of a matrix of pixels that convert photons of light into electrons. A lens focuses the image to be captured on the sensor that includes circuitry that generates a digital output. The pixels may also have different color filter arrays (CFAs). Red−green−blue (RGB), also known as Bayer, CFAs are normally used for human vision applications for high color fidelity reproduction. Machine vision applications often require sensors with red−clear−clearclear, or RCCC, CFAs that let them recognize red objects. CFAs can also be fine−tuned for different wavelengths – i.e. to increase quantum efficiency (QE) at near infrared wavelengths to improve performance in low light conditions, depending upon the applications in which the image sensor is being used.

Q. How is Artificial Intelligence (AI) used in ADAS?

A. All sensors used in ADAS/AD systems create large amounts of data. The quantity of data generated is growing exponentially with newer sensors incorporating better resolution being deployed. In order to develop effective systems, useful information needs to be extracted from this huge amount of data. What does this mean? DATA: There are some red and green spots surrounded by many black and blue spots. INFORMATION: There is a VRU (red shirt, green pants) far away on the road (black asphalt, blue sky). AI gives the ability to extract useful information from this sea of data.

AI gives electronic systems the ability to understand the world surrounding the car and not only see it. The vehicle's central processing computer needs to understand what is happening outside the vehicle so it can take the appropriate actions (steer left, brake early to avoid the VRU, etc.). AI can be deployed at the edge (near the sensor), and/or in the central processing unit, or a combination of both.

Q. What are some of the key features/benefits engineers should look for in automotive sensors for ADAS-era systems?

A. When safety is involved, we (automotive ecosystem partners) cannot settle for "good enough." People's lives are at stake, and the difference between a "good" sensor and a "great" sensor can make the difference between life and death. For image sensors, high sensitivity, low dark current, and high dynamic range are key features for ADAS. High sensitivity and low dark current determine how good the image sensor performs in low light conditions. High dynamic range (HDR) determines the image sensor's performance in the most demanding lighting conditions. HDR is an indication of the sensor's ability to see the darkest black and the brightest white and everything in between in the same image. Imagine driving through a dark tunnel on a sunny day: The vehicle needs to see, at the same time, inside (very dark) and outside (very bright) the tunnel. Another important feature, especially for human vision applications, is LED Flicker Mitigation (LFM), which minimizes or eliminates visual artifacts that occur because of the pulsed nature of automotive LED-based headlights, taillights, and road signs.

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