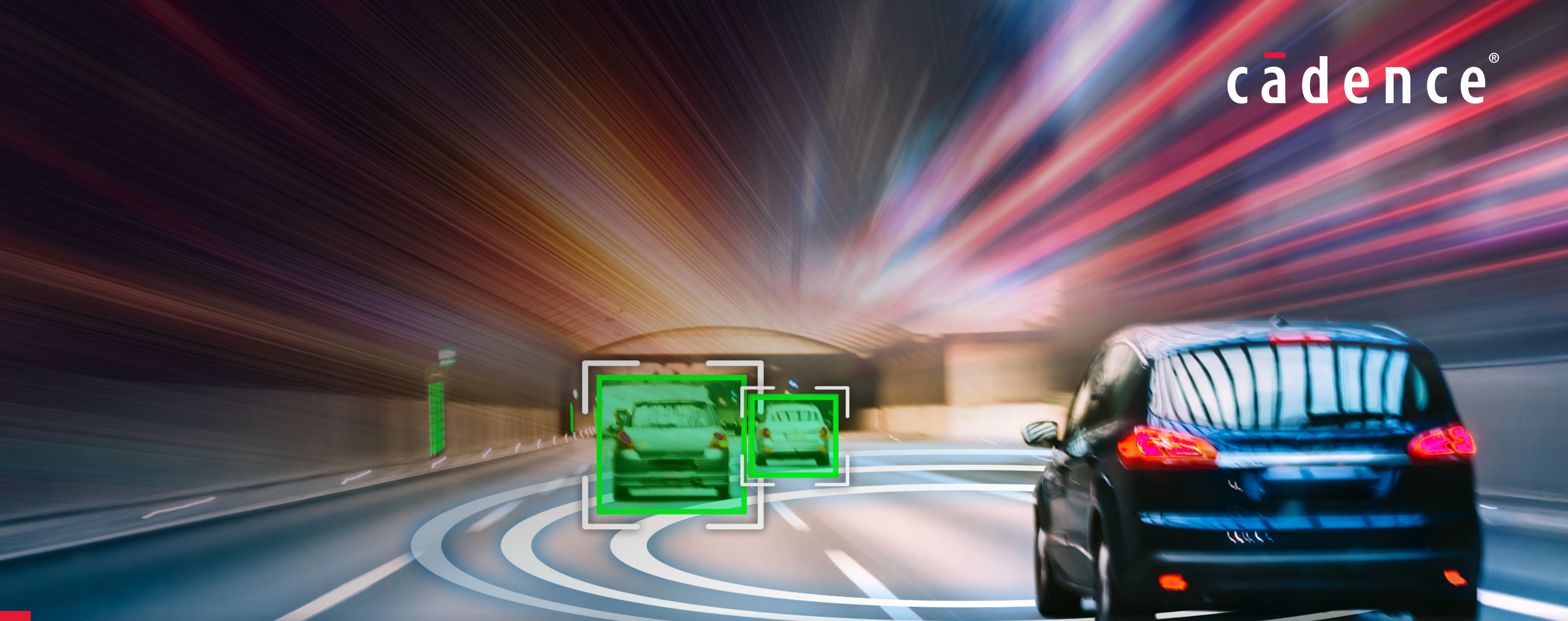

Computer Vision and AI for Automotive Safety: Staying Alert on the Road

Introduction

The future of the automotive experience is practically here. We're not necessarily talking about automotive pods that will automatically take you to where you need to be—though that is on the horizon, as well—but all cars, luxury to mid-level to even entry-level cars that are coming off the production lines now have technological advances that were only dreamed about a generation ago.

Multiple applications of a sensor coupled with cutting-edge AI technology can be applied to the automotive environment, especially towards advanced driver assistance systems (ADAS). Some examples of such sensors include short-, medium-, and long-range radar, lidar, and ultrasound; however, in this document, we will focus on camera, or image-based sensors. Camera-based applications are fitting for monitoring both inside the cabin of the vehicle as well as outside the cabin to assist the driver and passengers with safety and comfort.

Some of the safety features now being developed include monitoring the alertness, health, and mental state of the driver through in-cabin monitoring in the vehicle. Similarly, safety features for monitoring outside of the cabin that are currently in production include:

- Traffic light recognition
- Front collision warning (FCW)
- Lane departure warning (LDW)
- Pedestrian detection systems (PDS)
- Surround or 360° view systems

These advances would not be possible without sophisticated computer vision and AI technologies.

Driver Distraction

Four main types of distractions include:

- Visual: Taking your eyes off the road
- Manual: Taking your hands off the steering wheel
- Cognitive: Taking your mind off driving [2]
- Auditory: In-vehicle sounds masking outside sound

Texting while driving is especially dangerous because it combines three of those distractions [3]. That said, distracted driving also includes other activities such as eating, talking to other passengers, and adjusting the radio or climate controls. Age of the driver also seems to play a role in the percentage of distracted driving that occurs, particularly for younger, newer drivers (see Figure 1). [4]

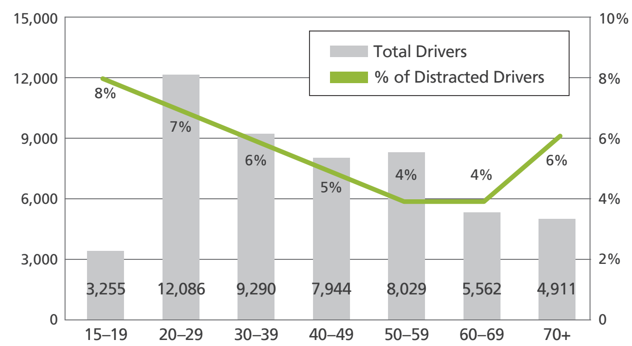

Figure 1: Total drivers and percentage of distracted drivers by age group, 2017 [4]

To address these concerns, car makers are developing in-cabin monitoring solutions to assess the driver's alertness, while at the same time monitoring the area outside of the car to improve overall driver safety. These monitoring options all fall under the category of ADAS sensors.

ADAS Sensors

For ADAS, multiple camera sensors are strategically placed looking inside and around the vehicle for maximum coverage. Then, vision and AI processors take input from these sensors to interpret the vehicle's surroundings, thereby creating a "circle of safety" around and inside the vehicle. Some of these safety features include:

- **Front-view monitor system:** Monitoring for lane departures, collision avoidance, pedestrians, traffic signs, etc.
- **Rear-view monitor system:** Providing parking assistance, assisting with reversing the vehicle, detecting objects and obstacles, and providing rear-end collision alerts
- **Side-view monitor system:** Augmenting the side-view mirror, expanding driver's view, and reducing blind spots
- **Surround-view system:** Providing a panoramic or 360° view around the vehicle
- **Driver monitoring system:** Monitoring the driver (and passengers) inside the vehicle, providing alerts if the driver takes their eyes off the road, monitoring the driver for drowsiness, etc.

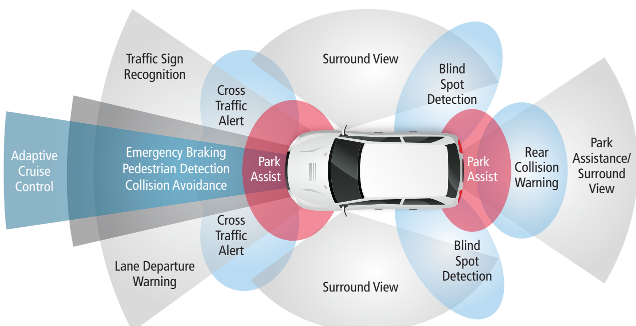

Figure 2: ADAS: the circle of safety

Requirements for Vision Sensors

There are two ways to approach using vision and AI processing in a complex system like a car. You can either a) place the sensors alone on the edges of the system, which then transfers the massive amount of raw data to the CPU in the center of the system where the data is then processed by a vision and/or AI processor, or b) you can embed vision/AI processors to the sensors themselves that pre-process the data before it arrives at the CPU, reducing the amount of data that needs to be transmitted.

To meet the safety-critical and high-performance needs of next-generation applications, the latter embedded approach is most commonly used in a complicated system like a vehicle.

The Cadence Solution

Table 1 shows some examples and requirements for vision sensors in this market.

For a vehicle equipped with such monitoring systems, there could be anywhere from 15 to 20 cameras installed in the vehicle. Each of these cameras captures images and video at resolutions between 1080p and 4K at frames rates of 60 or higher to help achieve real-time monitoring. Additionally, cameras may not be configured the same way. For example, in a driver monitoring system, the camera could be operating in the near infrared (near-IR) spectrum to combat various illumination conditions. In a rear-view camera system, the camera sensor may capture visible light images but through a fisheye or wide field of view (FOV) lens. Additionally, high dynamic range (HDR) processing is a common requirement in most applications these days. Fortunately, specialized processors exist today to perform lens distortion correction, HDR tuning, and various image processing functions in real time.

However, performing analytics on these pre-processed images is still a complex task. Finding and identifying faces inside a cabin or detecting objects and vehicles on the road is something that can be accomplished using proven computer vision approaches, but there are limitations on accuracy, analytics per second, and number of detections for hardware at the edge. Fortunately, advances in deep learning techniques have enabled high performance, increased accuracy, and more inferences per second on similar hardware. To achieve this level of real-time performance, the platform must be equipped with an optimized pipeline, and multiple instruction slotting capabilities, as well as a significant number of multiply accumulate (MAC) units to provide efficient compute throughput.

		VISION					VISION + AI	
Automotive Vision Camera Segments	Use Cases	Image Enhancement, Noise Reduction, HDR	SLAM, Object Tracking	Depth Perception	Image Stitching	Lens Distortion Correction, De-Warping	Object (traffic light, lane, and people) Detection	Head Position and Orientation Tracking, Drowsiness Detection
Front-View Monitor System	Camera mounted in the front-view mirror to monitor road	•	•	•	•	•	•	
Camera Monitor System	Side-view mirror replacement	•	•	•	•	•	•	
Rear-View Camera	Intelligent rear-view camera	•	•	•	•	•	•	
Surround-View System	360° view, fisheye camera	•			•	•	•	
Driver Monitor System	In-vehicle monitoring	•				•		•

Table 1: Vision and AI processing are integral to vision use cases

This is where the Cadence® Tensilica® Q7 DSP comes in. The Vision Q7 DSP is the sixth generation of vision and AI DSPs from the Tensilica family. It provides the perfect balance of high performance and low power that is essential to enable vision and AI applications at the edge. The Vision Q7 DSP can deliver up 768 GMACs per second and 1.82 Tera operations per second (TOPS), up to 2X greater performance in the same area compared to its predecessor, the Vision Q6 DSP. It can easily process HDR, lens distortion correction, and other image-processing algorithms while maintaining high frame rates and also having headroom for additional compute. For example, the Vision Q7 DSP is capable of running more than one of the monitoring systems listed in Table 1 simultaneously—while at the same time, achieving real-time performance. Also designed for ISO 26262 certification, the Vision Q7 DSP is the perfect solution to bring intelligence to ADAS applications.

For applications requiring compute beyond 768 GMACs/s, the Vision Q7 DSP can be paired with the Tensilica DNA 100 processor, Tensilica's deep neural-network accelerator IP, to deliver both high performance and power efficiency across a full range of compute from 0.5 TeraMAC (TMAC) to hundreds of TMACs.

Conclusion

We do have the technology to make these sensors a reality. The next generation of automotive safety is coming quickly, and the Tensilica family of processors will be instrumental in getting us there.

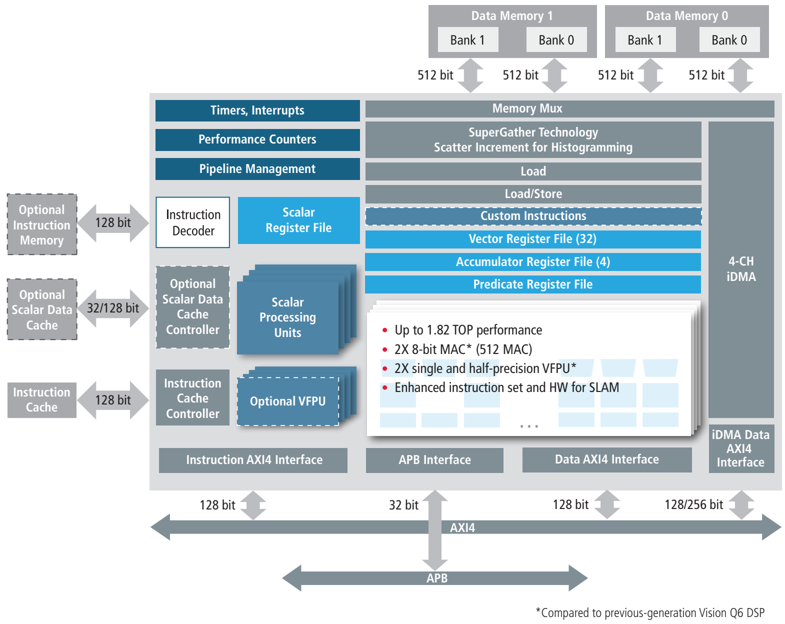

Figure 3: Tensilica Vision Q7 DSP block diagram

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