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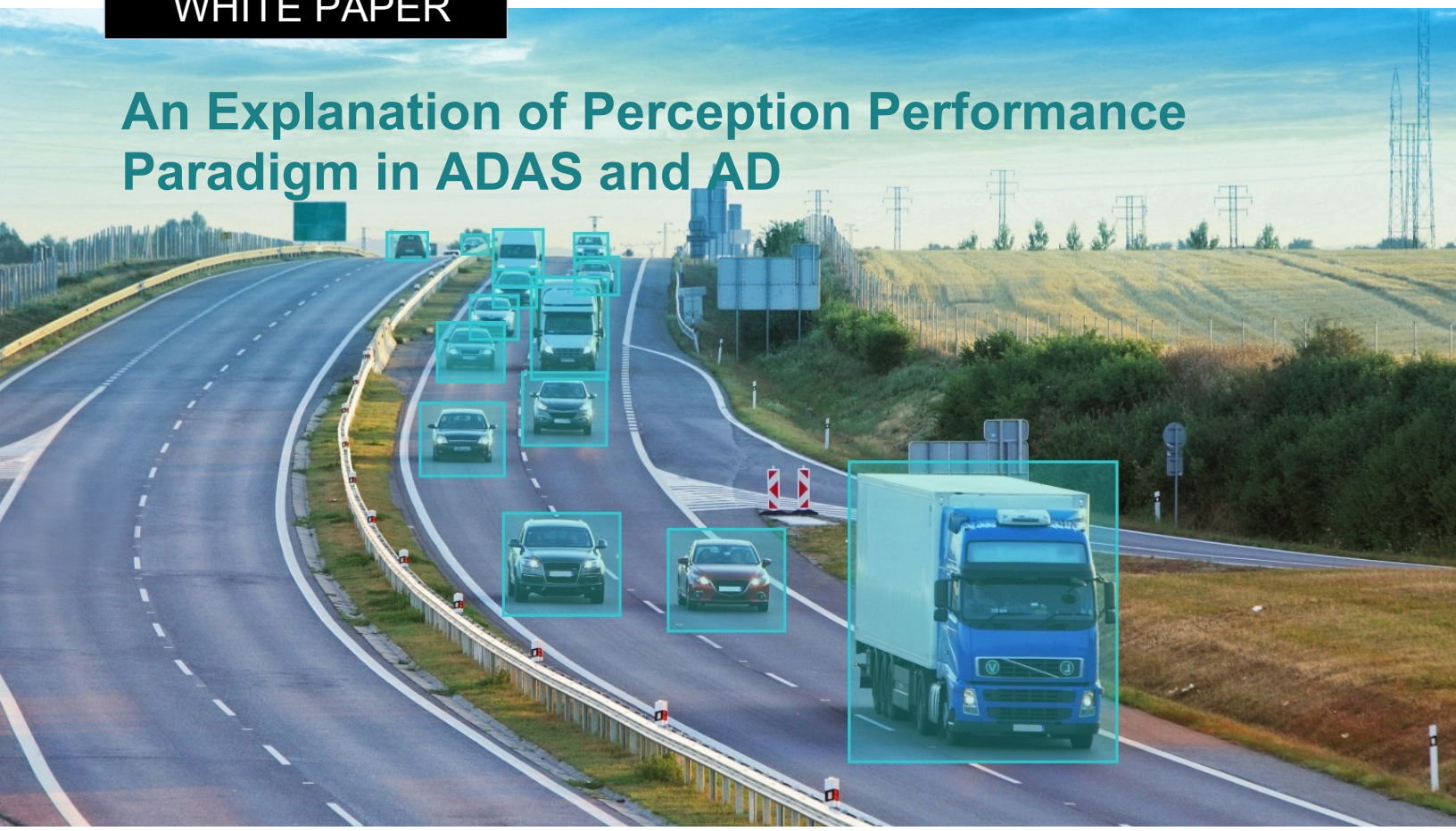
WHITE PAPER

An Explanation of Perception Performance Paradigm in ADAS and AD



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Abstract

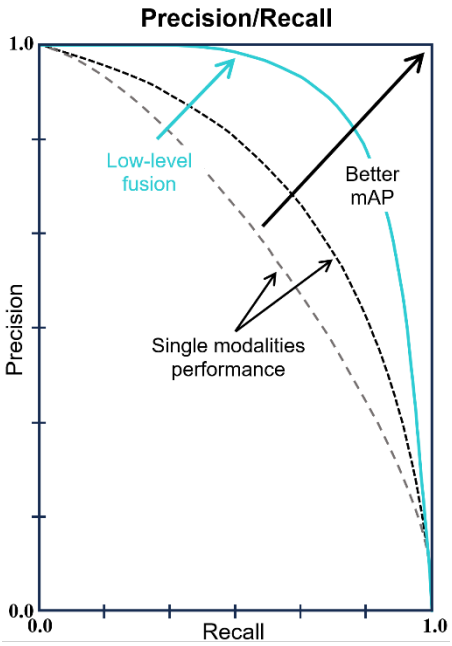
A phantom braking incident here, a long-distance drive made easy there –lowering consumer confidence in autonomous vehicles (AV) but increasing adoption of advanced driver assistance systems (ADAS). These are some of the challenges that ADAS developers navigate. These trends drive the automated and assisted mobility experience, with the perception system at its core. As ADAS developers seek to enhance the reliability of ADAS system performance, understanding how to evaluate perception systems is crucial.

Welcome to the dynamic landscape of sensor fusion and perception systems, where a convergence of technologies creates a holistic view of the environment. In the fast-evolving world of ADAS, the seamless amalgamation of data from diverse sensors is a necessity. Each sensor, with its unique strengths, contributes to a unified, reliable and enriched perception, which is essential for the safety and efficacy of ADAS. But here's the kicker: truly harnessing the power of these complex systems requires a profound understanding of their performance.

It's All About Performance, but How Do You Measure It?

Understanding the various aspects of perception performance is critical to craft superior ADAS features with exceptional capabilities. For ADAS developers, this task extends beyond merely keeping pace with industry trends; it involves setting them. This White Paper explores the various facets of performance in sensor fusion and perception systems, unpacking how this knowledge is integral to developing robust and innovative ADAS solutions that resonate with today's technological advancements and industry demands. Below are the key performance indicators (KPIs) that ADAS developers must examine when evaluating a sensor fusion and perception system.

1. **False alarms:** False alarms within the context of sensor fusion and perception refer to the perception system producing an output that does not exist. For example, if the sensor fusion and perception system detects an object in the scene that does not actually exist, this is a false positive. Conversely, if the perception system fails to detect an object that actually exists, this is known as a false negative. False positives are also sometimes referred to as "ghosts."

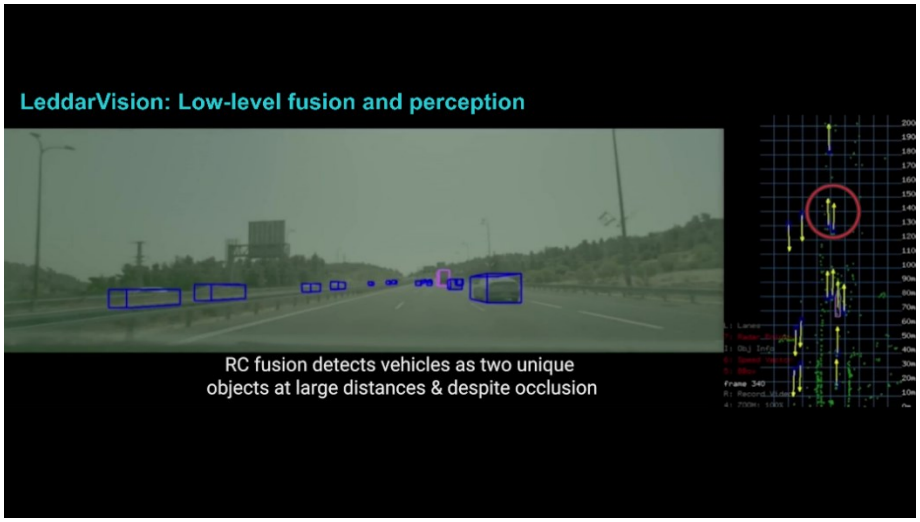
   False alarms are critical KPIs. High false alarms cause the maloperation of ADAS systems, such as the automatic emergency braking (AEB) system not activating when it should (false negative) or phantom braking incidents (false positives). Read "Evaluating Perception Systems: A Guide to Precision, Recall and Specificity" to better understand false alarms.

   LeddarTech's low-level sensor fusion and perception technology is tuned for better recall and precision, resulting in fewer false alarms. This means that ADAS developers can be more confident in their systems, and end-users –drivers and passengers– are more comfortable and trusting of the ADAS features in the vehicle.

2. **Object separation and occluded object detection:** How effectively can the sensor fusion and perception system differentiate objects at large distances, particularly in highway ADAS applications? A camera alone cannot differentiate two objects at significant distances due to low resolution. Similarly, radar cannot differentiate two adjacent objects driving at the same speed. LeddarVision's low-level fusion accurately identifies the two objects as two distinct entities using the same sensor set at distances exceeding 150 m. At significant distances, object separation enables precise lane allocation for vehicles in front of the ego-vehicle, thereby supporting adaptive cruise control (ACC) at higher velocities.

   Another key consideration when evaluating a perception system is whether it can detect occluded objects. In urban conditions, can the perception system detect and track a pedestrian on the sidewalk looking to cross the road? Will the perception system track a person hidden behind parked vehicles on the side? This functionality is crucial for enabling safe ADAS applications and is essential for protecting vulnerable road users (VRUs). Occluded object detection significantly enhances AEB performance in "cut-out" use cases, which are part of the Euro NCAP ADAS tests.

3. **Range:** Reliable and continuous detection and tracking at extended ranges allows for highway assist features at higher velocities and at more challenging operational design domains (ODDs), where the breaking profile is less forgiving (e.g., wet road conditions). The range is an important consideration for perception systems in ADAS and AD for several reasons:



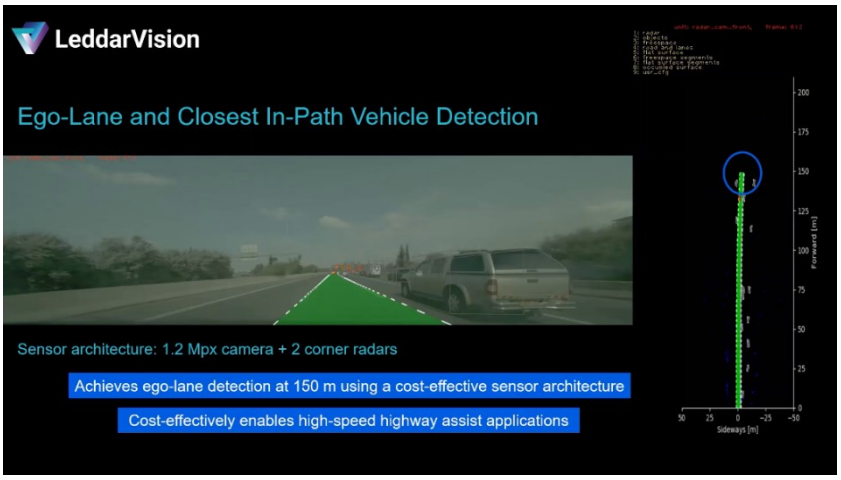
   a. **Safety:** A longer range allows the perception system to detect and react to objects or obstacles at a greater distance from the vehicle. This extra reaction time is crucial for ensuring the safety of the vehicle and its occupants. For example, detecting a pedestrian or another vehicle at a longer range gives the system more time to initiate braking or take evasive action.

   b. **Predictive capabilities:** A greater range enables the system to better understand the road environment further ahead. This, in turn, allows the system to make more accurate predictions about the behavior of other road users and objects, which is crucial for making safe driving decisions.

   c. **Highway driving:** On highways, where vehicles travel at higher speeds, having a longer range is particularly crucial. It enables the perception system to detect objects, such as slow-moving vehicles or debris on the road, at a distance where the vehicle can safely react, even when traveling at high speeds.

LeddarTech's low-level sensor fusion and perception technology, LeddarVision™, extends the effective perception range. Compared to traditional and prevalent object-level fusion, LeddarVision can up to double the effective range using the same sensor set. The LeddarVision Front-View – Entry (LVF-E) software stack doubles the supported object detection range to over 150 m using one 1-2 Mpx front camera and two short-range front corner radars.

Similarly, the LeddarVision Front-View – High (LVF-H) and LeddarVision Surround-View – Premium (LVS-2⁺) extend the object detection range to over 200 meters. Early detection is crucial for vehicles to achieve a 5-star rating in new car assessment programs (NCAP), especially as specified in Euro NCAP 2025.



4. **Operation in adverse conditions:** ADAS and AD systems must operate in various weather conditions throughout the year, not just in ideal conditions. If the perception system fails in rain, snow or other adverse conditions, it may render the vehicle inoperable, limiting its usability and practicality. A perception system that

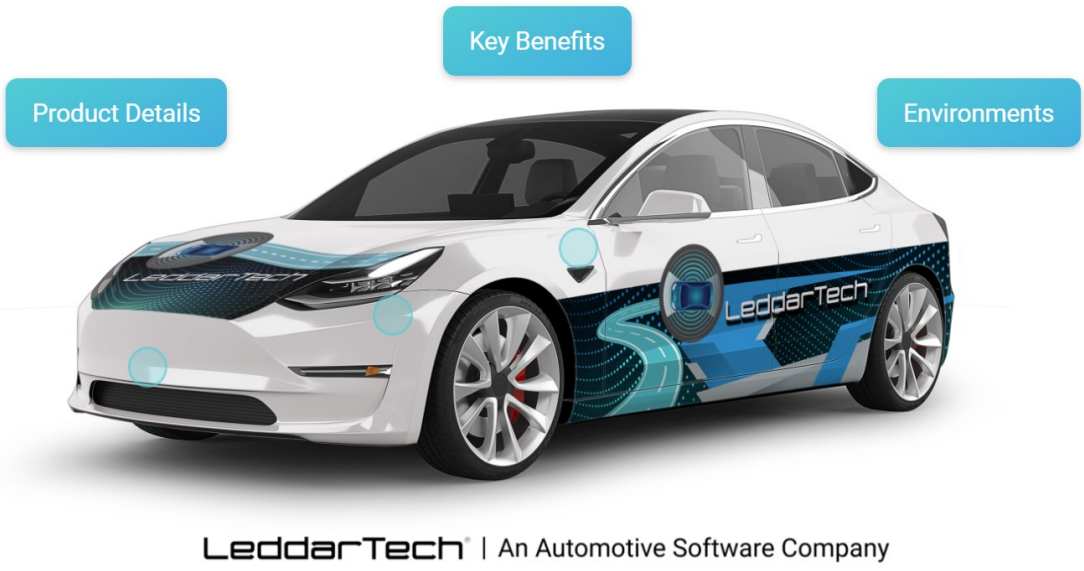
functions effectively in adverse conditions can better detect and respond to obstacles, other vehicles and pedestrians, reducing the risk of accidents. On the other hand, if the sensor fusion and perception system is unable to do so, this will negatively impact consumer confidence in ADAS and AD systems, further straining the relationship between end users and partially and fully automated vehicles.

Each sensor (camera, radar, LiDAR) has limitations. The camera does not perform well in adverse conditions such as low light, dusty environments, rain, fog or snow. Similarly, the radar and LiDAR's resolution at higher distances poses a challenge. A perception solution based on object-level fusion suffers from the individual sensor weaknesses as it fuses the output of the individual sensor perception output. However, low-level fusion solutions fuse the raw data of all sensors before applying perception algorithms to the resulting comprehensive dataset. This approach allows low-level sensor fusion and perception solutions, such as LeddarVision, to mitigate individual sensor weaknesses by leveraging other sensors' strengths.

Furthermore, low-level fusion and perception solutions do not suffer from sensor contradictions. In adverse conditions, while the camera might fail to detect an object, the radar can still identify an object at the same location. Perception systems based on object-level fusion will need to decide whether the object exists and which sensor is providing the correct output. Since LeddarVision fuses raw sensor data, it has no sensor contradictions.

LeddarVision demonstrates robust performance in adverse conditions, detecting, tracking and classifying objects under direct sunlight, at night or dimly lit areas, in rain, snow, fog and dusty environments when sensors may be degraded or rendered inoperable. Click the following image to watch LeddarVision in action, navigating challenging environments.

Interactive Demo Dashboard - Discover LeddarVision



Conclusion

In the ever-evolving landscape of automated and assisted mobility, the role of perception systems is pivotal. This is particularly relevant for ADAS and autonomous driving developers, who strive to boost system reliability and performance. When assessing the performance of perception systems, automotive OEMs and Tier 1s must consider factors such as false alarms, object separation capability at large distances, occluded object detection ability, perception range for a given sensor set and perception performance in adverse conditions. Sensor fusion and perception systems that excel in all these aspects empower automotive OEMs and Tier 1s to develop ADAS systems that enhance the mobility experience, operate reliably and achieve a 5-star performance in NCAP testing, meeting the requirements outlined in Euro NCAP 2025. LeddarTech's proprietary low-level sensor fusion and perception technology, available on an embedded processor, is at the forefront of facilitating the widespread adoption of ADAS and AD systems.

This White Paper does not constitute a reference design. The recommendations contained herein are provided "as is" and do not constitute a guarantee of completeness or correctness.

About LeddarTech

A global software company founded in 2007 and headquartered in Quebec City with additional R&D centers in Montreal, Toronto and Tel Aviv, Israel, LeddarTech develops and provides comprehensive AI-based low-level sensor fusion and perception software solutions that enable the deployment of ADAS, autonomous driving (AD) and parking applications. LeddarTech's automotive-grade software applies advanced AI and computer vision algorithms to generate accurate 3D models of the environment to achieve better decision making and safer navigation. This high-performance, scalable, cost-effective technology is available to OEMs and Tier 1-2 suppliers to efficiently implement automotive and off-road vehicle ADAS solutions. LeddarTech is responsible for several remote-sensing innovations, with over 150 patent applications (80 granted) that enhance ADAS, AD and parking capabilities. Better sensory awareness of the environment around the vehicle is critical in making global mobility safer, more efficient, sustainable and affordable: this is what drives LeddarTech to seek to become the most widely adopted sensor fusion and perception software solution.

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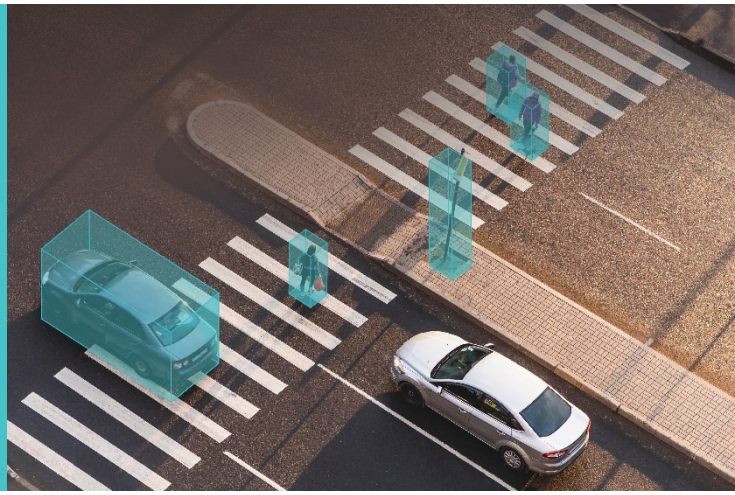

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