

● Monica Vatteroni, EYE2DRIVE CEO

VISION SENSORS FOR DRIVERLESS CARS

A Technology Report from Eye2Drive



EYE2DRIVE

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Executive Summary



As we stand on the precipice of a new era in the automotive industry, the evolution of sensor technology is leading the charge. This white paper aims to illuminate the challenges and proposed solutions related to vision sensor technology in this rapidly evolving industry.

Despite significant technological advances, vision sensors used in the automotive industry continue to grapple with many issues, especially under challenging light conditions. The prevalent problems include flickering, ghosting, and saturation, which

can compromise autonomous vehicles' safety and effectiveness. "The Challenges with Current Vision Sensors." are outlined in Chapter 3.

To tackle these challenges, a groundbreaking solution has emerged from EYE2DRIVE, an Italian startup specializing in vision sensor technology. EYE2DRIVE's adaptive vision sensor promises to revolutionize the industry by offering real-time dynamic range and sensitivity adjustments in hardware, significantly improving vision quality under various light conditions. This technology's unique features and benefits are outlined in Chapter 4, "EYE2DRIVE's Innovative Adaptive Vision Sensor."

The implications of this innovative technology for car manufacturers and subsystem producers are immense. Adoption of EYE2DRIVE's vision sensor can improve safety, enhance performance, and lead to more efficient manufacturing processes. These aspects are discussed in Chapter 5, "Implications for Car Manufacturing and Subsystem Producers."

Through a practical case study, Chapter 6 demonstrates the real-world applications and effectiveness of EYE2DRIVE's adaptive vision sensor within the automotive industry. Finally, Chapter 7 summarizes key findings and looks into the promising future of vision sensors in the car manufacturing industry.

By exploring the current landscape, identifying prevalent issues, and presenting a promising solution, this document aims to offer a comprehensive overview of vision sensor technology and its future in the automotive industry.

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Introduction

The automotive industry is on the cusp of a technological revolution, with advanced sensor technology powering this transformation. The evolution of sensor technology, particularly vision sensors, has far-reaching implications for developing autonomous and semi-autonomous vehicles. These technologies perceive the environment, make intelligent decisions, and navigate autonomously to enhance road safety and efficiency.

2.1 Purpose of the Document

This white paper aims to scrutinize the current vision sensor technology in the automotive industry, identify its shortcomings, and introduce the innovative adaptive vision sensor proposed by EYE2DRIVE, a forward-thinking Italian startup. This document

will equip readers with a comprehensive understanding of EYE2DRIVE's novel sensor, exploring its benefits and implications for car manufacturers and subsystem producers.

2.2 Overview of Where and How Sensors Are Being Used in a Driverless Car

In the realm of autonomous vehicles, sensors function as the eyes and ears of the vehicle, providing a constant feed of data about the vehicle's environment. This data fuels the vehicle's decision-making process and aids navigation. Various sensors, including RADAR (Radio Detection and Ranging), LIDAR (Light Detection and Ranging), ultrasonic sensors, and vision sensors, play a crucial role in these vehicles.

Vision sensors, akin to cameras, collect visual data from the surrounding environment, much like human drivers use their eyes to understand their surroundings. They play a critical role in enabling lane-keeping, detecting pedestrians, recognizing traffic signs, and more.

2.3 Overview of Vision Sensors for the Automotive Industry

Vision sensors in the automotive industry have made significant strides over the years, evolving from simple devices used for parking assistance to advanced systems capable of interpreting complex environments.

However, despite such progress, conventional vision sensors grapple with several challenges. They often struggle under challenging light conditions, such as sudden shifts in luminosity, and suffer from issues like flickering, ghosting, and saturation. These issues could compromise the safety and effectiveness of autonomous vehicles.

In the global market, several key players offer competitive vision sensor technologies, such as SONY, On Semiconductor (OnSemi), OmniVision, STMicroelectronics, and Samsung. SONY, for instance, offers high-resolution imaging sensors that enable clear, high-quality image capture. OnSemi focuses on power-efficient and high-performance image sensor solutions. OmniVision's automotive solutions include advanced imaging technologies for various applications, from rearview cameras to in-cabin monitoring. STMicroelectronics offers a wide range of products, including imaging sensors and advanced driver-assistance systems (ADAS). Samsung provides advanced sensor technologies that enhance the safety and convenience of vehicles.

However, these solutions have yet to entirely resolve vision sensors' issues, particularly in challenging light conditions. This is where EYE2DRIVE's innovative adaptive vision sensor comes into play. EYE2DRIVE's technology holds significant potential to revolutionize the automotive industry, promising a robust solution to the enduring problems of traditional sensors.

The following sections delve deeper into these challenges and explore how EYE2DRIVE's innovative adaptive vision sensor addresses these issues, its competitive edge, and the implications for car manufacturers and subsystem producers.

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The Challenges with Current Vision Sensors

The past decade has been revolutionary for the automotive industry, with vision sensor technology playing a crucial role in driving this transformation. The current solutions have facilitated significant advancements, ranging from adaptive lighting systems to autonomous driving aids. However, despite these improvements, the industry still faces significant challenges associated with the existing vision sensor technologies. Understanding these challenges is crucial for envisioning the next stage of progress in automotive manufacturing.

3.1 Overview of Current Technological Solutions

Current technological solutions in the automotive industry primarily revolve around using High Dynamic Range (HDR) CMOS (Complementary Metal-Oxide-Semiconductor) sensors for vision applications. These sensors have been a breakthrough in dealing with diverse and challenging light conditions, offering substantial benefits over previous technologies.

HDR CMOS sensors enable the capture of a broader range of light intensities, from bright sunlight to dim lighting, in a single image. This effectively mitigates the problem of overexposure or underexposure, thus providing clear, balanced images that enhance the vehicle's perception of its surroundings.

Many of the current leading players in the industry, such as SONY, OnSemi, OmniVision, and STMicroelectronics, have invested significantly in developing and enhancing HDR CMOS sensor technologies, resulting in advanced and refined solutions.

SONY, for instance, has developed a range of HDR CMOS sensors with excellent light sensitivity and superior image quality. OnSemi provides HDR CMOS image sensors that offer outstanding low-light performance. Similarly, OmniVision's HDR CMOS sensors specialize in high-resolution image capture with excellent detail preservation in a scene's very bright and dark areas.

However, while HDR CMOS sensors have indeed advanced the capabilities of vision systems in vehicles, they are still not entirely immune from issues like flickering, ghosting, and saturation, particularly in rapidly changing or extreme lighting conditions. The following sections will delve deeper into these issues and their potential impacts.

3.2. Problems and Limitations of Current Vision Sensors

Despite their advancements and advantages, the current vision sensor technologies face several significant challenges that could be improved.

3.2.1. Flickering Issues

Flickering is a recurring challenge in current vision sensor technology, which undermines the accuracy and dependability of sensor readings. The term "flickering" pertains to the intermittent emission of light from LED sources, flashing at a typical frequency of 90Hz

that is imperceptible to the human eye but detectable by a digital camera under specific lighting conditions. The problem is particularly relevant and pervasive due to the widespread use of LEDs in various road-related applications, such as traffic lights, LED headlights, LED rear-lights, road signals, and building displays. This prevalence amplifies the impact of flickering issues on vision sensors, making it a crucial concern for the reliable functioning of safety-critical systems like collision avoidance or lane-keeping systems. The issue arises when the overall scene illumination is high, prompting the camera to reduce its exposure time and, consequently, increase the frequency at which it captures the LED's refreshing cycles beyond the 90Hz mark. This adjustment can result in a partial or complete misinterpretation or even omission of scene information. The erratic presentation of images can lead to erroneous outputs by processing algorithms that cannot rely on the received information.

3.2.2. Ghosting Challenges

Ghosting is another prevalent issue with current vision sensor solutions. The phenomenon occurs when a faint residual image, also known as a "ghost," remains visible in the sensor output even after the original object or light source has left the field of view. Ghosting typically occurs following rapid transitions between light and dark conditions or when a bright light source temporarily overpowers the sensor.

This effect is also typical in multi-exposure HDR, with multiple frames acquired in sequence and then combined to obtain HDR behavior. If an object is moving faster than the acquisition, the result will be a ghosting effect.

These ghost images can lead to false readings, as the system may interpret the residual image as an actual object. In autonomous driving, for example, ghosting can confuse the system into detecting nonexistent obstacles, potentially triggering unnecessary braking or steering maneuvers.

3.2.3. Saturation Concerns

Saturation is a technical term used to describe the state where a vision sensor becomes overwhelmed by the amount of light in a scene, leading to a reduction or complete loss

of detail in the captured image. It typically occurs in situations with a HDR, such as when the vehicle is driving toward direct sunlight or in the presence of high-intensity artificial light sources.

When saturation occurs, the sensor's output image appears washed out or overly bright, with reduced contrast and detail. This can affect the system's ability to accurately identify and interpret environmental objects and features. In a worst-case scenario, a saturated image could lead to the system failing to detect an obstacle in the vehicle's path, posing a significant safety risk.

3.2.4. Low-lights Vision Concerns

Low light conditions present another substantial challenge for current vision sensor technologies. In scenarios such as nighttime driving or poorly lit environments, the sensor's ability to accurately capture and interpret visual data is significantly reduced.

Under low light conditions, current vision sensors often struggle to provide high-quality output. This issue is critical mainly because these sensors are typically designed and optimized for well-lit conditions, and their performance can degrade drastically when there is inadequate light.

The issue is further exacerbated by the fact that sensors must deal with sharp contrast levels in low light, as car headlights and street lights become much brighter relative to the surrounding darkness. This creates significant issues in distinguishing critical details in the scene, such as the presence of pedestrians or the outline of an approaching vehicle.

These low-light vision concerns highlight a significant performance gap in current vision sensor technology, further emphasizing the need for advanced solutions to ensure reliable, high-quality performance irrespective of lighting conditions.

3.3. Impact of Difficult Light Conditions and Sudden Luminosity Changes

In addition to these issues, current vision sensor technologies often struggle to adapt to rapidly changing light conditions. These challenges become more prominent in

conditions like sunrise, sunset or when the car is transitioning from a brightly lit area to a darker one (or vice versa). The resulting fluctuations in light intensity can cause severe impairments to the sensor's ability to accurately perceive and interpret the environment.

In conclusion, while current vision sensor technologies have facilitated notable advances in car manufacturing, these persisting challenges pose significant barriers to achieving reliable and efficient systems. The following section will explore how EYE2DRIVE's innovative Adaptive Vision Sensor aims to overcome these hurdles and pave the way for a new era in automotive technology.

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EYE2DRIVE's Adaptive Vision Sensor

In the pursuit of excellence and efficiency, EYE2DRIVE, an Italian startup, has revolutionized the vision sensor landscape by proposing an innovative solution that draws inspiration from the adaptability and precision of the human eye. This groundbreaking approach promises to redefine the norms of automotive vision sensor technology, bringing a new level of performance and reliability that surpasses the limitations of the current technologies.

4.1. The Concept of Adaptive Vision Sensing

EYE2DRIVE's technology is built on the foundation of adaptive vision sensing. This concept takes cues from the dynamic range and sensitivity adjustment capabilities

inherent to the human visual system. Our eyes naturally adjust to different light conditions, effectively managing transitions from bright sunlight to a dimly lit room. EYE2DRIVE has translated this biological marvel into a technological reality by developing a real-time vision sensor that can adjust its dynamic range and sensitivity. The Adaptive Vision Sensor achieves this through the hardware-level tuning of the response of its sensing elements, a notable departure from the software-driven adjustments used in traditional vision sensor technologies. By moving these adjustments to the hardware level, the Adaptive Vision Sensor can offer faster, more robust, and more reliable responses to changes in lighting conditions.

4.2. The EYE2DRIVE Advantage: A Solution to Current Challenges

The unique design and innovative approach of EYE2DRIVE's Adaptive Vision Sensor directly addresses the challenges that plague current vision sensor technologies.

4.2.1. Adaptive Technology immune to flickering

Traditionally, vision sensor technologies have been susceptible to the disruptive influence of flickering. This phenomenon, resulting from rapid fluctuations in lighting conditions, can distort sensor output, leading to inconsistent and unreliable readings. To address this issue, significant efforts have been made by industry leaders to implement various levels of mitigation in post-processing. However, EYE2DRIVE introduces a groundbreaking solution with its Adaptive Vision technology, which exhibits inherent immunity to flickering, requiring no additional mitigation measures.

The core of EYE2DRIVE's Adaptive Vision Sensor lies in its utilization of intraframe acquisition technology. Unlike conventional approaches, the EYE2DRIVE method allows for dynamic range and sensitivity adjustments without interfering with the exposure time, which can be sustained at a frequency that avoids the occurrence of flickering effects in the captured image. This unique capability ensures immediate and precise adaptation to changes in light intensity, effectively eliminating the flickering effect.

In practical terms, this remarkable feature translates to a consistent and clear image output, irrespective of the vehicle transitioning between environments of varying

brightness, such as moving from a dark tunnel to bright sunlight, or vice versa. The Adaptive Vision Sensor's ability to maintain stability in such scenarios significantly enhances the reliability and safety of vehicle systems reliant on accurate vision sensor data.

4.2.2. Preventing Ghosting through single frame acquisition

Ghosting, which manifests as residual or 'ghost' images in sensor output, presents a significant challenge for existing vision sensors. This phenomenon can lead to misinterpretation of the surrounding environment and potentially generate false readings, thereby impacting the operational safety of vehicles.

Through its single frame acquisition approach, EYE2DRIVE's Adaptive Vision Sensor inherently overcomes the ghosting issue without the need for additional processing. As a result, the overall clarity of the captured images is greatly enhanced, ensuring that the sensor output accurately reflects the current environment surrounding the vehicle.

This technological advancement not only improves the precision and reliability of the vision sensor but also plays a crucial role in enhancing overall vehicular safety, particularly in scenarios involving rapid light-to-dark transitions.

4.2.3. Limiting Saturation Through real-time adjustment of the dynamic range

Saturation is a widespread problem in vision sensor technologies, particularly in high dynamic range conditions like driving toward direct sunlight or dealing with high-intensity artificial lights. Saturation can cause a significant loss of detail in sensor output, leading to poor image quality and potentially dangerous misinterpretations.

EYE2DRIVE's Adaptive Vision Sensor tackles the saturation issue head-on through intelligent design. By continually tuning its dynamic range to the hardware level in response to the lighting conditions, the Adaptive Vision Sensor can prevent overexposure and maintain a balanced image output, always granting the best tradeoff between dynamic range and contrast of the image. This tuning ability ensures that the sensor can deliver clear, high-quality images with excellent contrast and detail, even under challenging lighting conditions.

By effectively limiting saturation, EYE2DRIVE's Adaptive Vision Sensor significantly enhances the accuracy and safety of automotive systems relying on vision sensor technology. It opens the door to a new era of improved image quality, reliability, and performance in automotive vision sensors, even under the most challenging lighting conditions.

4.2.4. Improving Night Vision through Tunable Sensitivity

One of the most impressive capabilities of EYE2DRIVE's Adaptive Vision Sensor is its enhanced performance under low light conditions. Nighttime driving or navigating through poorly lit environments presents a formidable challenge to traditional vision sensors due to their limited sensitivity and sharp contrast levels. However, with EYE2DRIVE's solution, this challenge is adeptly addressed.

EYE2DRIVE's Adaptive Vision Sensor can tune its sensitivity to optimal function under low-light conditions. By leveraging its hardware-level adjustment capabilities, the sensor can increase its sensitivity in low-light conditions to capture more detail. This means that even in case of bad light conditions, the sensor can detect and accurately interpret critical features in the environment, such as pedestrians, road signs, or other vehicles.

Furthermore, the tunable sensitivity of EYE2DRIVE's Adaptive Vision Sensor helps manage the sharp contrast presented by artificial light sources, such as streetlights or oncoming car headlights, against a dark background. This capability allows the sensor to provide a well-balanced, high-quality output regardless of lighting conditions.

This substantial improvement in night vision capability significantly enhances nighttime driving safety, further emphasizing the transformative potential of EYE2DRIVE's innovative sensor technology in the realm of automotive vision systems. In the next section, we will delve into the broader implications of this technology for car manufacturers and subsystem producers.

4.3. Performance under Varying Light Conditions

EYE2DRIVE's Adaptive Vision Sensor demonstrates exceptional performance under various light conditions. Its hardware-level adjustments enable it to rapidly adapt to

changes, maintaining consistent performance from brightly lit conditions to low light scenarios. This versatility and robust performance significantly enhance the safety and reliability of automotive systems that rely on vision sensor inputs.

In conclusion, EYE2DRIVE's innovative approach to vision sensing technology addresses the critical challenges faced by current solutions, promising a new era of reliability, safety, and efficiency in automotive vision systems. In the following section, we will explore the implications of this revolutionary technology for car manufacturing and subsystem producers.

5



Implications for Car Manufacturing and Subsystem Producers

The introduction of EYE2DRIVE's Adaptive Vision Sensor stands poised to significantly transform the automotive landscape, particularly for car manufacturers and subsystem producers. This innovative technology not only promises to address the inherent limitations of current vision sensor solutions but also introduces a host of beneficial implications that extend across the manufacturing process, product performance, and end-user experience.

5.1. Enhanced Product Performance and Safety

The introduction of adaptive vision sensor technology significantly enhances product performance, particularly for systems reliant on accurate visual data. The capability to mitigate prevalent issues such as flickering, ghosting, saturation and low light management means that vehicles can benefit from a more consistent and accurate data feed. This improved data integrity leads to better decision-making capabilities for onboard systems, directly contributing to the vehicle's overall performance.

Improved performance goes hand in hand with improved safety. Accurate real-time data ensures that automated systems, such as collision avoidance, lane-keeping, and adaptive cruise control, function optimally under all lighting conditions. This contributes to a safer driving experience, minimizing risks for passengers, pedestrians, and other road users. The technology is also effective for in-cabin applications such as the driver monitoring since fast changes in light conditions also affect this kind of application.

5.2. Streamlined Manufacturing Process

With the advent of adaptive vision sensor technology, manufacturers can anticipate a more efficient integration and calibration process. Since the sensor's sensitivity and dynamic range adjustments occur at the hardware level in real-time, the reliance on extensive software tuning is reduced. Furthermore, the overall system weight is positively affected since the reduction in redundancy of sensing technology and reduced data payload to be managed by the processing unit.

Finally, this leads to more efficient assembly lines as post-installation calibration becomes less intensive or unnecessary.

This streamlining of processes can lead to substantial time and cost savings in the production cycle.

5.3. Competitive Edge in the Market

Adaptive vision sensor technology can be a significant differentiator in the automotive market. As manufacturers strive to stand out in an increasingly competitive industry, integrating a superior, innovative vision sensor can give them a significant competitive advantage.

This advanced sensor technology can be a crucial selling point, highlighting the manufacturer's commitment to utilizing innovative technology for enhanced safety and performance. By addressing consumer demand for such features, manufacturers can attract new customers and foster stronger loyalty among existing ones, leading to improved market share and brand reputation.

5.4. Facilitating Progress Towards Autonomous Driving

Adaptive vision sensor technology's superior performance and adaptability make it a crucial element in the ongoing development of autonomous vehicles. Vision sensors play a pivotal role in autonomous systems. With improved performance under a wide range of lighting conditions, the safety and viability of autonomous vehicles can be significantly enhanced.

This advancement positions manufacturers at the forefront of the autonomous vehicle revolution, enabling them to be leaders in this rapidly evolving field. By integrating advanced sensor technology, manufacturers can make significant strides toward realizing fully autonomous vehicles complying with a high level of safety, shaping the future of the automotive industry.

Adaptive vision sensor technology provides many benefits, from enhancing product performance and safety to streamlining manufacturing processes, providing a competitive edge, and facilitating progress toward autonomous driving. We anticipate further exciting developments and advancements in this field as we move forward.

6



Case Study: EYE2DRIVE Adaptive Vision Sensor in Practice

Discussing the theory and potential implications of the EYE2DRIVE Adaptive Vision Sensor is one thing, but witnessing the technology in action can genuinely solidify its transformative power. This case study delves into real-world applications of the Adaptive Vision Sensor in the automotive industry, highlighting its practical value and efficacy.

6.1. Advanced Driver-Assistance Systems (ADAS)

One of the most prevalent applications of Adaptive Vision Sensor technology has been in Advanced Driver-Assistance Systems (ADAS). These systems, including features like

automatic emergency braking, lane-keeping assist, and adaptive cruise control, rely on accurate real-time visual data.

The EYE2DRIVE Adaptive Vision Sensor, with its superior performance under varying light conditions, can significantly improve the reliability and effectiveness of these systems. By mitigating issues like flickering, ghosting, and saturation, the sensor provides consistent and accurate visual data that enables these systems to operate optimally under all conditions. This results in improved driver safety and convenience, reaffirming the critical role of the Adaptive Vision Sensor in ADAS.

6.2. Night Vision Enhancement

Driving at night has always posed significant challenges due to reduced visibility. With their limited sensitivity under low light conditions, traditional vision sensors have needed help to provide adequate visual data during nighttime driving.

However, with its tunable sensitivity, the EYE2DRIVE Adaptive Vision Sensor has significantly improved vehicle night vision capabilities. The sensor adjusts its sensitivity under low-light conditions, capturing more details and providing a well-balanced output irrespective of the lighting conditions. This improved night vision enhances safety during nighttime driving, demonstrating the sensor's practical value.

6.3. Autonomous Vehicles

The most promising application of the EYE2DRIVE Adaptive Vision Sensor is in the field of autonomous vehicles. With autonomous driving heavily reliant on accurate real-time visual data, the performance of the vision sensor becomes critical.

The Adaptive Vision Sensor, with its ability to rapidly adjust to changes in lighting conditions and deliver consistently precise and accurate visual data, significantly enhances the safety and viability of autonomous vehicles making real autonomous driving possible. In conclusion, the real-world application of the EYE2DRIVE Adaptive Vision Sensor validates its potential to revolutionize the automotive industry. From enhancing ADAS and night vision capabilities to facilitating the advancement of

autonomous vehicles, the sensor's unique features can make a tangible impact on vehicle safety and performance.

7



Conclusion and Future Perspectives

As we conclude this comprehensive exploration of the revolutionary Adaptive Vision Sensor technology, it's essential to consolidate our key findings and cast an eye toward the future. The automotive industry stands at the brink of significant transformations, and advanced vision sensor technology promises to play a critical role in this evolution.

7.1. Summary of Key Findings

Our exploration began with identifying the prevalent challenges traditional vision sensors pose in the automotive industry, namely flickering, ghosting, and saturation. These issues became particularly pronounced under challenging lighting conditions, impairing sensor performance and, by extension, vehicle safety and reliability.

Enter the Adaptive Vision Sensor technology—an innovative solution that addresses these challenges through hardware-level adjustments and intraframe acquisition technology. By maintaining a balanced output under all lighting conditions, this technology dramatically improves the quality and reliability of visual data.

The implications of the Adaptive Vision Sensor technology for car manufacturers and subsystem producers are profound. Some potential benefits are enhanced product performance and safety, streamlined manufacturing processes, competitive advantage in the market, and strides toward autonomous driving.

7.2. Future of Vision Sensors in the Car Manufacturing Industry

Looking toward the future, we foresee vision sensor technology continuing to evolve and play an even more integral role in the automotive industry. As vehicles become more connected and autonomous, the reliance on accurate and reliable visual data will only increase.

Thanks to its proven ability to handle complex lighting conditions, Adaptive Vision Sensor technology is set to become a cornerstone of this future. As manufacturers continue to develop and refine their autonomous vehicles, we anticipate these sensors will be integral to achieving full autonomy, offering a level of reliability and safety previously out of reach.

Moreover, integrating AI (Artificial Intelligence) and machine learning with vision sensors opens exciting new possibilities. These technologies can enhance the capabilities of sensors, allowing them to predict and adapt to changes in the environment even more effectively.

In conclusion, the Adaptive Vision Sensor technology marks a significant leap forward in automotive safety and performance. As we look to the future, we are eager to witness the continued evolution of this technology and its transformative impact on the automotive industry. Indeed, the dawn of a new era in automotive vision systems has just begun.

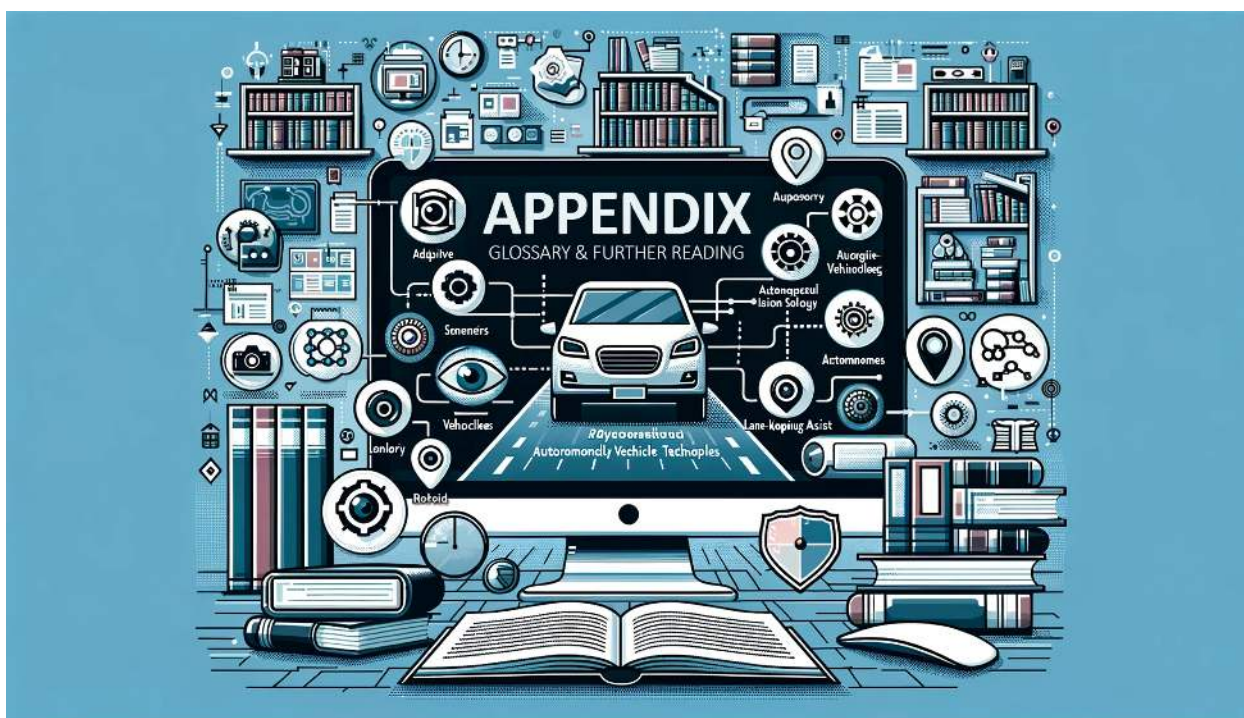


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Appendix

To supplement our in-depth analysis and discussion, this appendix provides a comprehensive glossary of the key terms used in this white paper, as well as a curated list of further reading and resources for readers seeking to delve deeper into the fascinating world of vision sensor technology.

9.1. Glossary of Terms

Adaptive Vision Sensor: A type of sensor technology that can automatically adjust its dynamic range and sensitivity based on the environmental lighting conditions.

Advanced Driver-Assistance Systems (ADAS): Systems developed to automate, adapt, and enhance vehicle systems for safety and better driving. They often use inputs from multiple data sources, including vision sensors.

Autonomous Vehicles: Vehicles capable of sensing their environment and operating without human involvement.

Calibration: The process of adjusting an instrument to ensure its readings are accurate and reliable.

Collision Avoidance: A safety system that helps prevent a vehicle from colliding with an obstacle or another vehicle.

Differentiator: A unique characteristic or feature that sets a product or technology apart from its competitors.

Dynamic Range: The ratio between the largest and smallest values that a certain quantity can assume. For vision sensors, this typically refers to light intensities. When this range is large, it is defined **High Dynamic Range**

Flickering: A problem with vision sensors where the image appears to flutter or oscillate due to varying lighting conditions.

Ghosting: A visual artifact in which a 'ghost' image appears displaced from its true position in an image captured by a vision sensor. Often occurs due to rapid changes in the scene or sensor movement.

Hardware-Level Adjustments: Changes or alterations made directly to the hardware of a device to improve its function or performance.

Integration Process: The procedure of combining different subsystems or components into a single, unified system.

Interframe Acquisition: A method of capturing image data in which multiple images are acquired and then combined to create the final image to be displayed. Mainly used to increase the Dynamic Range of the image but frequently affected by the presence of artifacts like ghosting.

Intraframe Acquisition: A method of capturing image data in which one single image with full information is acquired, reducing artifacts and improving image quality.

In-cabin: The interior space of a vehicle where passengers are seated, including seating area, controls, and features for comfort and convenience

Lane-Keeping Assist: An advanced driving assistance system that helps drivers stay in their lane by detecting lane markings and gently steering the vehicle back into the lane if necessary.

Night Vision: The ability to see in low-light conditions. In the context of vision sensors, it refers to the sensor's ability to capture usable image data in such conditions.

Saturation: In vision sensors, saturation refers to the condition when a pixel's intensity reaches its maximum value, beyond which no further light information can be recorded.

Sensor: A device or module that detects changes in physical or environmental conditions and sends this information to other electronics.

Subsystems: Individual parts of a larger system, each with a specific function contributing to the operation of the whole.

Tunable Sensitivity: The ability of a vision sensor to adjust its sensitivity to different light levels, enabling it to capture clear and balanced images in various lighting conditions.

Vision Sensor: An electronic sensor used to detect, measure, and respond to a specific visual input or light source.

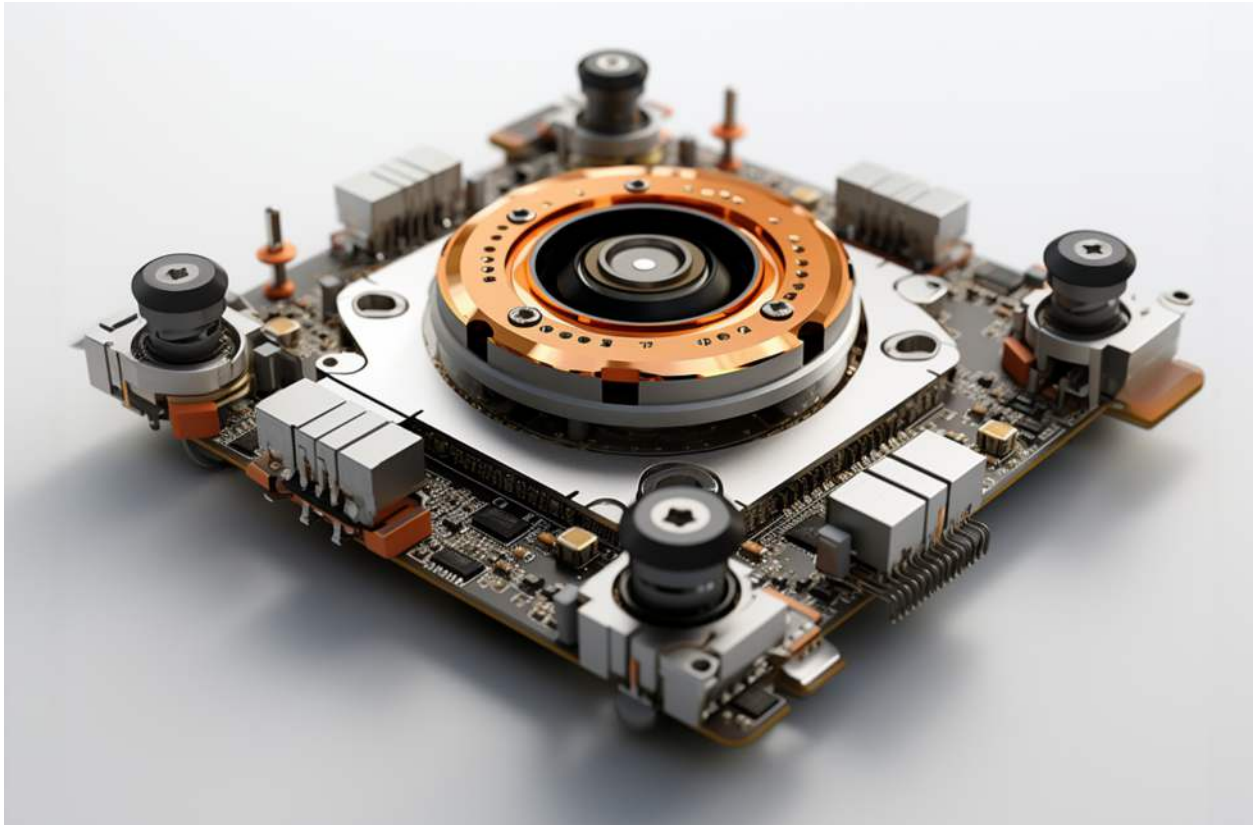
Adaptive Cruise Control: A system that automatically adjusts a vehicle's speed to maintain a safe distance from vehicles ahead.

9.2 Further Reading and Resources

1. Koopman, P., & Wagner, M. (2017). Challenges in Autonomous Vehicle Testing and Validation. *SAE International Journal of Transportation Safety*, 4(1), 63-78. DOI: [10.4271/2016-01-0128](https://doi.org/10.4271/2016-01-0128)
2. Sivaraman, S., & Trivedi, M. M. (2013). Looking at vehicles on the road: A survey of vision-based vehicle detection, tracking, and behavior analysis. *IEEE Transactions on Intelligent Transportation Systems*, 14(4), 1773-1795. DOI: [10.1109/TITS.2013.2266661](https://doi.org/10.1109/TITS.2013.2266661)

3. Stein, G. P. (2018). *Vision systems for automotive applications*. Cambridge, UK: Cambridge University Press.
4. Bergh, C., & Van Der Zant, T. (2017). Roadmap and applications of artificial intelligence in vision sensors for automotive. *Sensors and Actuators A: Physical*, 263, 433-449. DOI: [10.1016/j.sna.2017.07.022](https://doi.org/10.1016/j.sna.2017.07.022)
5. **Website:** [EYE2DRIVE Adaptive Vision Sensor](#) – For additional details and updates on the technology discussed in this white paper, visit EYE2DRIVE's official website.
6. IEEE Standards Association P2020 White Paper: <https://site.ieee.org/sagroups-2020/white-paper/>
7. D.J. Yeong, G. Velasco-Hernandez, J. Barry, J. Walsh, Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *MDPI Sensors* 21, 2140 (2021) <https://doi.org/10.3390/s21062140>

By providing both a glossary of key terms and a range of resources for further reading, this appendix equips readers with the tools to enhance their understanding and continue their exploration of vision sensor technology in the automotive industry.



About EYE2DRIVE

EYE2DRIVE is revolutionizing the automotive car imaging systems and industry.

Our silicon-based solution for digital imaging is inspired by the human eye. Using our proprietary imaging technology and artificial intelligence, EYE2DRIVE enables intelligent imaging acquisition, even in the most challenging conditions.

eye2drive.com

linkedin.com/company/eye2drive

info@eye2drive.com