Advance Driver Assistance Systems (ADAS)

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Abstract

Advanced Driver Assistance Systems (ADAS) is an integrated system within the automotive industry that ensures all the possible safety features and improving experience in driving. The report will keep an eye on two important components of ADAS: Blind-Spot Detection (BSD) and Forward Collision Warning (FCW). BSD alert the drivers of any obstacles or another car that appears in the blind spots or not visible in the mirror. lowering the chances of accidents when changing lanes or performing similar actions. On the other hand, FCW systems keep an eye on the speed and distance of the vehicle ahead, alerting drivers to possible collisions so they can act to avoid them. These technologies set the threshold for the rapid advancements of ADAS while clearly displaying how these technologies can be used for the prevention of accidents, improving the flow of traffic, and minimizing the driver fatigue. With all its advantages, all these bring about various challenges such as those in the level of system limitations, and user acceptance where there are still regulatory barriers necessitating the importance of ongoing improvement and further adaptation. Following the above, there is focus on the accurate detection of objects in addition to measuring the distances, which are the key capabilities of ADAS. These functionalities are important for predicting the objects on the road, preventing collisions, and making sure overall road safety. As the demands from the society to ensure that their vehicles are safe and performance are very high, Manufacturers pushed to develop more advanced ADAS technologies to fulfill their expectations. By focusing on how ADAS helps greatly reduce the number of road accidents, car crashes, and traffic issues. An analysis of the elements, main sensors, core mechanism, and functions for BSD and FCW would give a highly detailed picture of how these systems contribute to vehicle safety.

Keywords: ADAS, ACC, BSD, FCW, Camera, LiDAR, LDW, RADAR, Sensors, Autonomous Driving, V2X

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List of Abbreviations

ADAS	Advance Driver Assistance Systems
BSD	Blind Spot Detection
FCW	Forward Collision Warning
ACC	Adaptive Cruise Control
CDCP	Center for Disease Control and Prevention
WHO	World Health Organization
AI	Artificial Intelligence
LDW	Lane Departure Warning
LKA	Lane keep Assist
AEB	Automating Emergency Braking
TSR	Traffic Sign Recognition
FMCW	Frequency Modulated Continuous Wave
STN	Steering Threat Number
GPS	Global Positioning System
V2X	Vehicle-to-Everything
AR	Augmented Reality
AR-HUD	AR Head-Up Displays

1. Introduction

The Road Accidents lead to huge financial losses, loss of human lives and property damage increases every year. As reported by the Center for Disease Control and Prevention (CDCP), the financial losses coming from injuries caused by car accidents exceeded 99 billion dollars in 2006 [1]. These issues arise from several causes including travel longer distances, the flow of traffic, and the response of the distances between the objects within a lane like vehicles and animals are generally judged slowly. The World Health Organization (WHO) highlighted that globally approximately 1.3 individuals died from road accidents, including 31% and 22% car occupants and pedestrians [2],[3].

With the increasing demand for safer and better-performing vehicles, the automotive industry is focusing more on innovation, particularly in Advanced Driver Assistance Systems (ADAS). ADAS serves a significant step towards in enhancing driving safer and experience. It uses sensors like LIDAR, cameras, and lasers to help drivers identify and respond to potential dangers, thus making road safety and reducing the chance of accidents [4],[5],[6]. This report highlights two important ADAS technologies: Blind Spot Detection (BSD) and Forward Collision Warning (FCW). BSD warns drivers about objects in their blind spots, which is important for changing lanes safely. Meanwhile, FCW observes the distance and speed of the vehicle ahead, alerting drivers to potential collisions so drivers can avoid them [7].

This report outlines the precise look at BSD and FCW. As fundamental parts of ADAS, these applications not only enhance the vehicle safety but also tackle the challenges such as system limitations as well as user acceptance. By exploring the functionalities, main sensors, core mechanisms, unique systems feature, purpose to provide how these functionalities help to minimize the road accidents, improving traffic flow, reduction of driver fatigue, this underscores the continuous need for innovation and updated in ADAS.

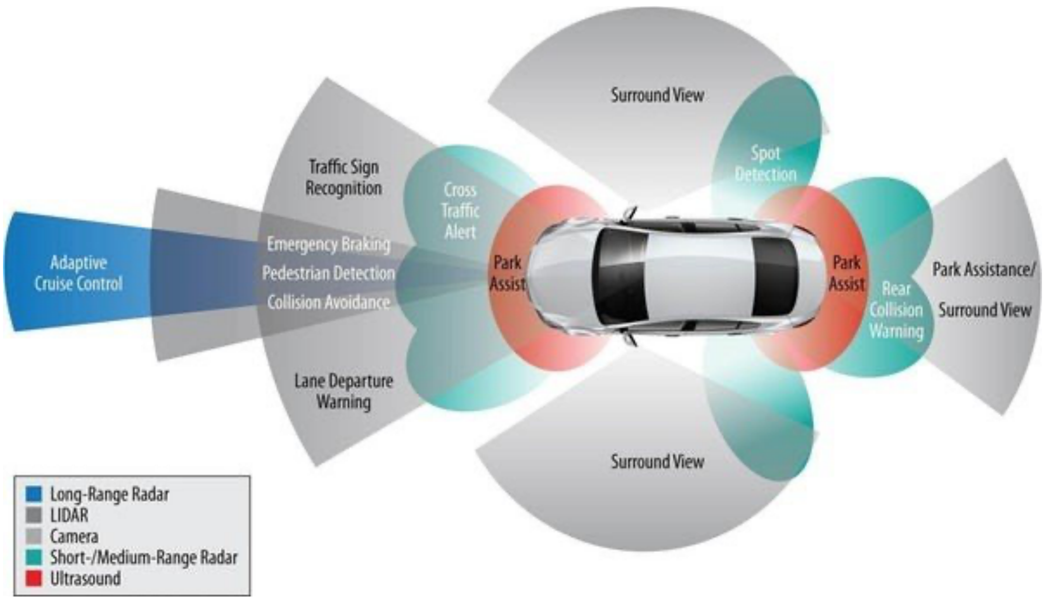

Figure 1: ADAS Sensors [8]

2. Advance Driver Assistance Systems ADAS

The Automotive industry has seen a revolutionary transformative shift in recent years, with the focus on the advancements of ADAS. This development marks a significant improvement in Automotive technology, providing vehicles with the ability to recognize the surroundings and operate intelligently. Central to this advancement is the combination of advanced sensor technologies similarly RADAR, LiDAR, and Cameras including advanced computational algorithms supported by Artificial Intelligence (AI). The combination of technologies gives ADAS the capability to perform tasks such as lane keeping assistance, collision avoidance, as well as adaptive cruise control, greatly enhancing driving safety and comfort. Researchers such as Bukshetwar (2024) and Fu Yuli and their colleagues (2023) have emphasized the important part of AI in processing as well as interpreting sensor data, the capability is critical for instantly adapting to changing in road conditions and effectively implementing safety protocols [9],[10].

Putting Advanced Driver Assistance Systems (ADAS) into use isn't easy; there are important complications to overcome, especially with security. These systems need powerful security against different cyber threats that could compromise vehicle networks and the artificial intelligence that runs ADAS. Aryan Mehta and others [11] have investigated these risks and suggested thorough security measures. Also, it's a challenge to make sure ADAS can be relied on in all sorts of weather, leading to new testing methods like simulation and advanced sensors for spotting dangerous conditions on the road. Constant innovation in this area is a major advancement, and research is ongoing to improve ADAS, aiming for vehicles that are safer, more advanced, and capable to perform autonomous operations [11].

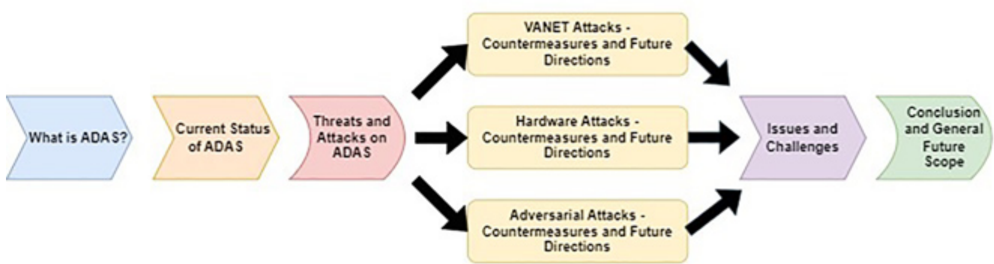

Figure 2: Overview & Security Challenges in ADAS [11]

2.1. Levels of Driving Automation

The SAE International's J3016 standard outlines the level of automation in ADAS, ranging from Level 0 (no automation) to Level 5 (complete automation) [12]. The automitve industry has been focusing on developing and testing with vehicles that have Level 3 and Level 4 automation, where vehicles can handle more driving functions on their own.

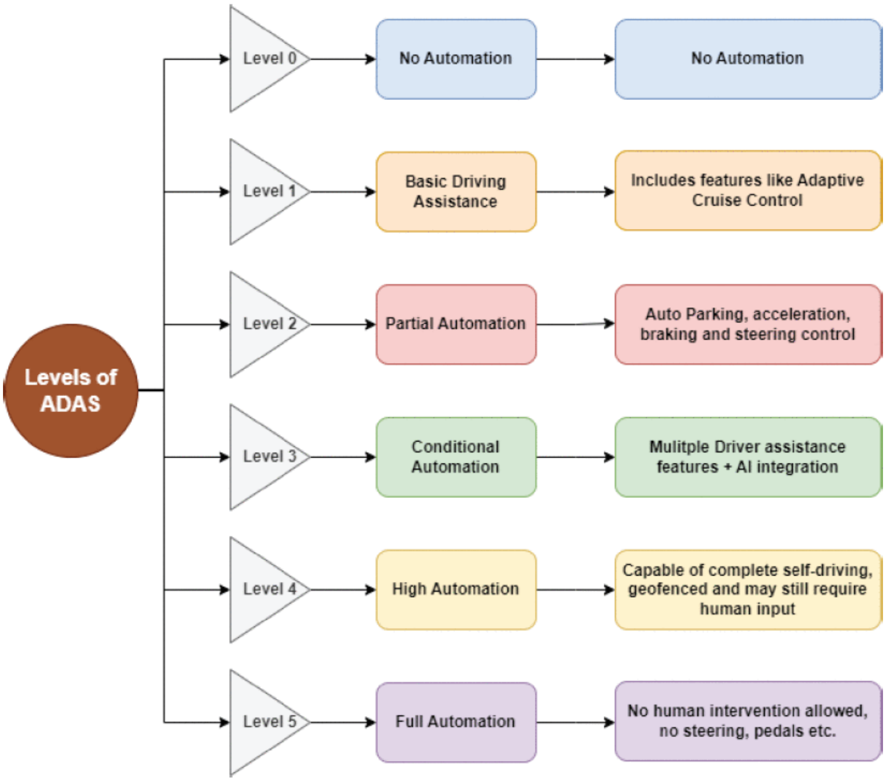

Figure 3: Automation Levels of ADAS [11]

1. At Level 0, "No Automation," the driver does everything alone and is responsible for all driving tasks without help from the system [12].

2. At Level 1, "Driver Assistance," there are features like steering or speed assistance, but the driver is still mostly in control of the vehicle [12].

3. At Level 2, "Partial Automation," allows the system to handle both steering and speed, but the driver needs to stay alert and be ready to take over when the system needs help [12].

4. At Level 3, “Conditional Automation,” cars can handle more complex driving situations with less help from humans. They're getting better at navigating city driving and bad weather on their own. The system tells the driver only when it needs help [12].

5. At Level 4, “High Automation,” is making big progress in specific areas like certain locations or weather conditions. In these controlled settings, there's no need for the driver to pay attention, and pilot programs in cities are becoming more common [12].

6. At Level 5, “Full Automation,” is still mostly in the testing phase. Automotive companies are trying out their systems in different places to make sure they work well. They're focusing on improving AI for driving, combining sensors for a better understanding of the environment, and making sure the technology works in many different situations [12].

Moving between these levels isn't just about technology; it also involves rules, ethics, and how people feel about it. People need to accept the technology, and laws and regulations have to catch up. Figuring all this out will determine how quickly we see more advanced automated vehicles on the roads [12].

2.2. Features of ADAS

Advanced Driver Assistance Systems (ADAS) are designed to enhance safety and convenience for drivers. The following sections detail several features of ADAS.

Adaptive Cruise Control (ACC)

ACC keeps a constant speed and distance from the vehicle ahead, changing its speed based on traffic. This reduces the need to manually speed up or slow down, making driving safer and more comfortable [13].

Lane Departure Warning (LDW)

LDW systems, utilizing camera sensors to detect lane markers, warn drivers if their vehicle starts to leave its lane without using a turn signal. This function plays a key role in avoiding accidents caused by distractions or fatigue [14].

Lane Keep Assist (LKA)

Expanding on LDW's capabilities, LKA proactively makes minor steering adjustments to ensure the vehicle stays in the center of its lane, minimizing the risk of accidentally drifting out of the lane and improving safety during extended journeys [15].

Automating Emergency Braking (AEB)

AEB systems use sensors to analyze potential collisions with other vehicles, pedestrians, or objects ahead. If the driver fails to perform promptly, the system automatically engages the brakes to prevent or minimize the impact of the crash [16].

Blind Spot Detection (BSD)

BSD keeps an eye on the areas of the vehicle that the driver can't see and alert the driver when other vehicles are in these blind spots. This helps with safely shifting lanes and enhance the driver's understanding of their surroundings [17].

Forward Collision Warning (FCW)

FCW systems, installed with cameras at the front, monitor the speed and distance of the vehicle ahead, alerting the driver of possible collisions with visual and sound warns, helping to avoid accidents [18].

Traffic Sign Recognition (TSR)

TSR feature uses cameras and image recognition technology to analyze and recognize traffic signs, offering drivers visual or auditory warns to guide them follow traffic rules [19].

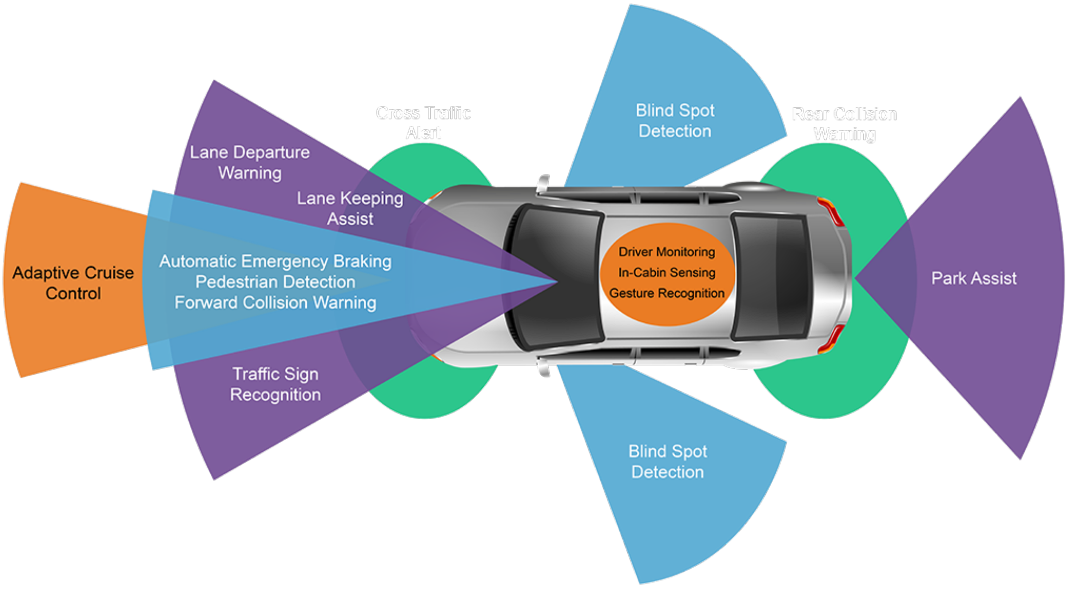

Figure 4: Features of ADAS [20]

These ADAS technologies, work together to create a safer and more effective driving experience, greatly minimizing the chances of accidents due to human mistakes. Ongoing advancements in technology holds the potential for further precise and complicated ADAS functionalities ahead.

3. Key Components of ADAS

ADAS is a very efficient system that is supported by various components, lets examine these components and perceive their significance in delivering such useful functionality in ADAS.

3.1. Sensors

At present, drivers are primarily responsible for steering the vehicle. However, Advanced Driver Assistance Systems (ADAS) can control few parts of the car. Sensors are used mainly to confirm safety steps are taken in specific situations. A single sensor alone unable to provide complete safety. That's why several different and supporting sensors are used together in ADAS. Therefore, multiple supporting sensors are used for ADAS requirements. Together, sensors provide information to enhance the safety and improve the driver's control [21].

3.2. Software

Software plays a vital role in ADAS, and projects like DESERVE have made progress in developing ADAS applications. They achieve this by reusing software from different areas and making it standard, which clsrifies combining different modules [22].

3.3. Actuators

Actuators are most important part for constructing electric vehicle systems. The FAST project in the German zwanzig20 BMBF cluster is working to improve actuator technologies, making things like automated driving in real-time [23].

3.4. Processors

The processors are essential for creating instant 3D maps of the vehicles surroundings. A paper talks about combining the Imaging sub-system (ISS) in the 'TDA3' group of processors from Texas Instruments to handle the needs of visual and analytic things in ADAS systems [24].

3.5. Mapping Systems

Mapping systems collect geographical information, and a research suggests developing a common software system for figuring out where things are in autonomous cars. This is based on the AUTOSAR approach, enhancing ADAS software easier to manage and transferable [25].

4. Sensors used in ADAS

Advancements in sensor technology for Advanced Driver Assistance Systems (ADAS) have significantly enhanced what these systems are capable to do, making driving safer and more convenient. Below are the recent updates and new advancements in ADAS sensor technology:

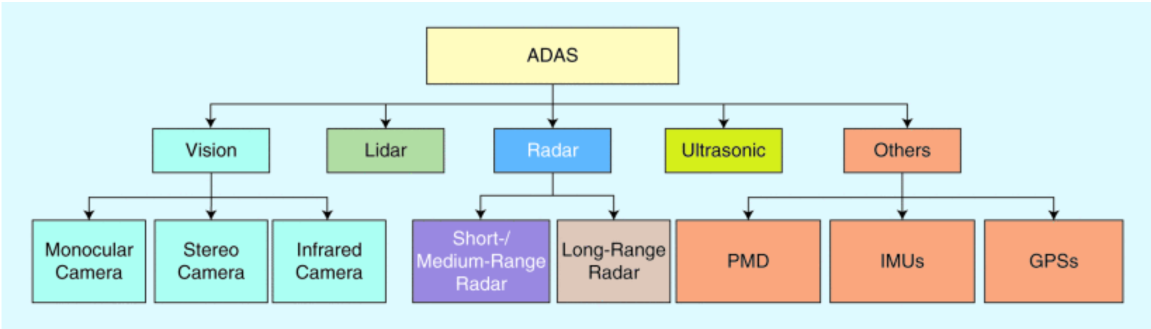

Figure 5: ADAS Sensors [58]

4.1. Radar Sensors

The advancements of radar sensors has been aimed at making them stronger and better at detecting objects from far away, which is very important for adaptive cruise control (ACC) and automatic emergency braking (AEB) features. Their ability to work well even in harsh weather conditions helps keep autonomous vehicles safe, making them essential [26].

4.2. Camera Sensors

Advancements in camera sensor technology has improved their ability to recognize surroundings, especially under difficult conditions such as poor lighting and harsh weather. These sensors play an important role in systems like Lane Departure Warning (LDW), Lane-Keeping Assist (LKA), Traffic Sign Recognition (TSR), and Driver Monitoring Systems (DMS), focusing advanced algorithms to better analyze data [27].

4.3. Ultrasonic Sensors

Mainly used in parking assistance systems, ultrasonic sensors have gotten improvements at detecting exactly where obstacles are, making it easier to move into parking spots and objects detect around the vehicle.

4.4. LiDAR Sensors

LiDAR technology has advanced, focusung on creating detailed 3D maps of the area around the vehicle. Recent developments have addressed the aging effects of LiDAR sensors, especially looking at problems like the weakening of the laser beam quality and the decrease in power output throughout their lifespan. These improvements are important to monitoring the accuracy of ADAS features [28].

Sensor fusion technology has also advanced,using combinations of Radar, LiDAR, and Cameras to increase the functionalities of ADAS, especially in autonomous vehicles [29].

5. Blind Spot Detection (BSD)

Focusing sensor-based technology, Blind Spot Detection (BSD) is a sophisticated safety function that supports drivers detect vehicles in their blind spot. Actively scanning these challenging visibility areas for traffic that might for traffic that could otherwise be missed. To improve the driver's situational awareness, the device usually sounds a beep or displays visual indications like flashing lights on the side mirrors when a vehicle accesses the blind area. This is especially valuable when changing lanes or merging into traffic—frequently risky actions because of limited sight [30],[31].

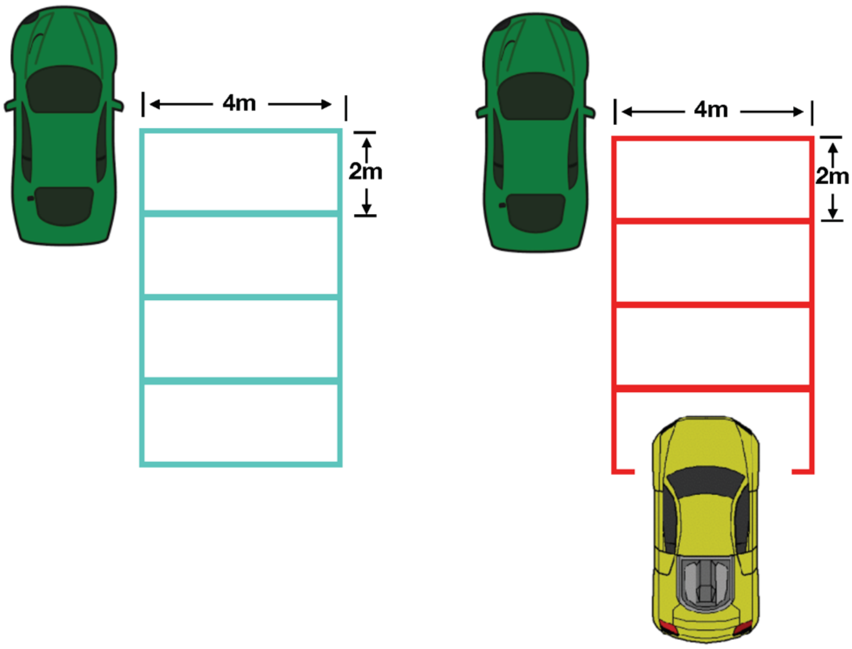

Figure 6: Bird's-eye view of blind spot region [32]

5.1. Working Principle

The Blind Spot Detection (BSD) system operates on the principle of monitoring areas around the vehicle that are typically not visible to the driver through conventional mirrors, known as the blind spots. BSD utilizes sensors, often RADAR or ultrasonic, placed on the sides of the vehicle to detect other vehicles in adjacent lanes. When a vehicle enters the blind spot area, the BSD system warns the driver through visual, auditory, or haptic signals, thereby preventing potential side-swipe accidents while lane changes. The system continuously scans the blind spot areas, especially helpful during highway driving, where the speed and the position of surrounding vehicles change rapidly. This technology typically enhances driving safety by aiding drivers in making safer lane-changing decisions and reducing the collision avoidance caused by the failure to detect vehicles in the blind spot areas [33].

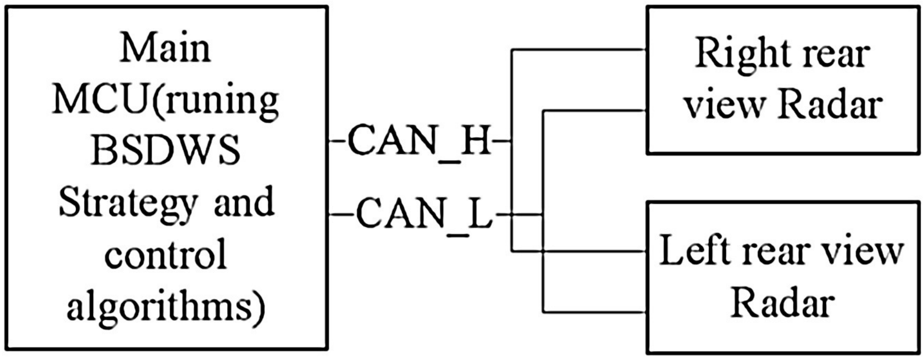

Figure 7: Work Flow of BSD [36]

The layout of the blind spot detection and warning system is illustrated in Figure 6. It includes two radars and a main MCU, featuring radars for the left and right rear views that are linked through a local CAN bus.

5.2. Process Flow of BSD

In the realm of driver assistance system, the Blind Spot Detection (BSD) system acts like a vigilant guardian, sorting through data to protect the driver. At its core, a combination of radar, ultrasonic, and camera sensors work together to verify the areas around the vehicle that the driver can't easily see. As the car moves, these sensors monitor the sides, using complex algorithms to make sense of the data they collect. If another vehicle or an obstacle moves into these hidden spots, the BSD system quickly alerts the driver with lights, sounds, or vibrations to prevent collision like side-swipes. This smart cooperation between sensors and software gets even better with new developments in machine learning and the merging of various sensor technologies. Advanced technologies, like Frequency Modulated Continuous Wave (FMCW) radar, enhance the efficiency of the BSD system, enabling it to detect dangers accurately, even in poor weather conditions [34],[35].

5.3. Algorithm of BSD

A basic algorithm for a Blind Spot Detection (BSD) system usually means figuring out how far the main vehicle is from another object (like another car) to see if it's in a blind spot area. Here's a simpler explanation that apply on measuring the distance using sensor information:

1. **Initialize Variables**

- Let $\mathbf{P}_{host} = (\mathbf{x}_{host}, \mathbf{y}_{host})$ be the position of the host vehicle.
- Let $\mathbf{P}_{object} = (\mathbf{x}_{object}, \mathbf{y}_{object})$ be the position of the detected object.
- Define $\mathbf{D}_{threshold}$ as the distance threshold for the blind spot area.

2. **Data Acquisition**

- Obtain $\mathbf{P_{host}}$ **and** $\mathbf{P_{object}}$ from sensor data. For simplicity, these can be derived from radar or ultrasonic sensors that provide distance and angle information relative to the host vehicle.

3. **Calculate Euclidean Distance**

- Calculate the Euclidean distance **(D)** between the host vehicle and the detected object using their positions:

$$\boldsymbol{D} = \sqrt{\left(x_{\{object\}} - x_{\{host\}}\right)^{2} + \left(y_{\{object\}} - y_{\{host\}}\right)^{2}}$$

4. **Determine Blind Spot Status**

- If $\mathbf{D \leq D_{threshold}}$, then the object is within the blind spot area. Generate an alert for the driver.
- Otherwise, no action is required as the object is outside the blind spot area.

5. **Repeat Process**

- Continuously repeat steps 2 to 4 to monitor the blind spot areas in real-time.

This algorithm serves as a foundational approach to detecting objects in a vehicle's blind spot area using distance calculations. In practice, BSD systems may use more complex methods to account for the relative speed, direction, and predicted path of detected objects to enhance accuracy and reliability.

6. Forward Collision Warning (FCW)

The forward collision warning (FCW) system supports to spot detection on the road that might not be easily seen and tells the driver if there's a prevention of collision with them. Unlike older FCW systems that used infrared and radar, we're now using a camera-based system. This system identifies objects in the vehicle's lane, determines their distance from the vehicle, and warn the driver if the vehicle is approaching them at a speed that could lead to a collision. In essence, the FCW only triggers a warning if there's a potential for the vehicle to collide with an object at its current pace.

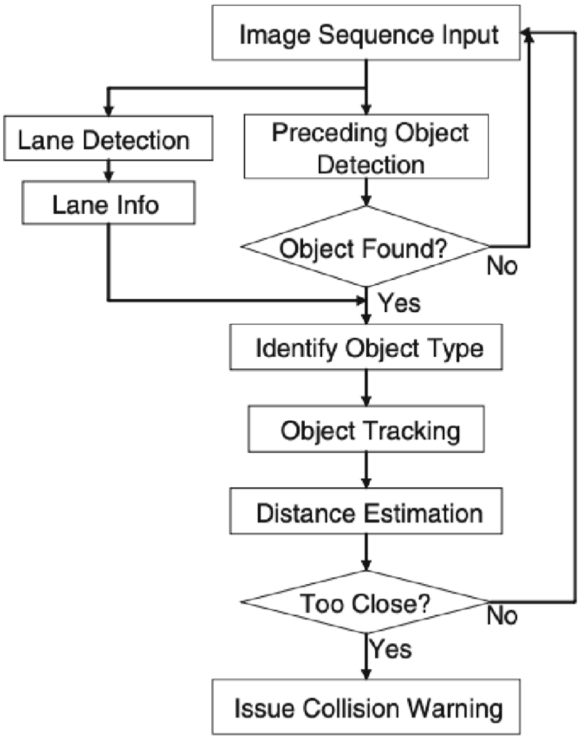

Figure 8: Forward Collision Warning [36]

Recent studies on Forward Collision Warning (FCW) systems have led to advancements by combining short-range communication with radar for improved timing of potential collisions, using advanced image recognizing techniques to spot vehicles more effectively, and developing warning systems that work well even when it's hard to see. Other advanced features include using machine learning to predict how vehicles might move, helping to prevent crashes, and starting systems where vehicles can warn each other about emergency stops using camera sensors to know exactly where nearby vehicles are. These advancements show a move forwards to FCW systems that not only response faster and more dependably but also monitor to different driving situations, making roads safer and reducing the chances of accidents [37],[38],[39],[40],[41].

6.1. Collision Warning Algorithm

Figure 8 illustates a typical situation where a vehicle might collison with the vehicle ahead. Whenever one vehicle approaches another too closely, alarms should activate based on their distance apart and their closing speed. Based on how far apart they are and how fast they're moving towards each other. If the driver doesn't take action to avoid a collision, the ADAS system, like the Emergency Braking System (EBS), should step in to support, for example, by automatically braking. In this scenario, a collision is considered unavoidable if steering or braking can't stop it from happening. For situations like this, the chance of a collision can be determined by looking at the vehicle's side-to-side movement: if the vehicle can't move to the side quickly enough to avoid the other vehicle, then it's not safe [42],[43],[44].

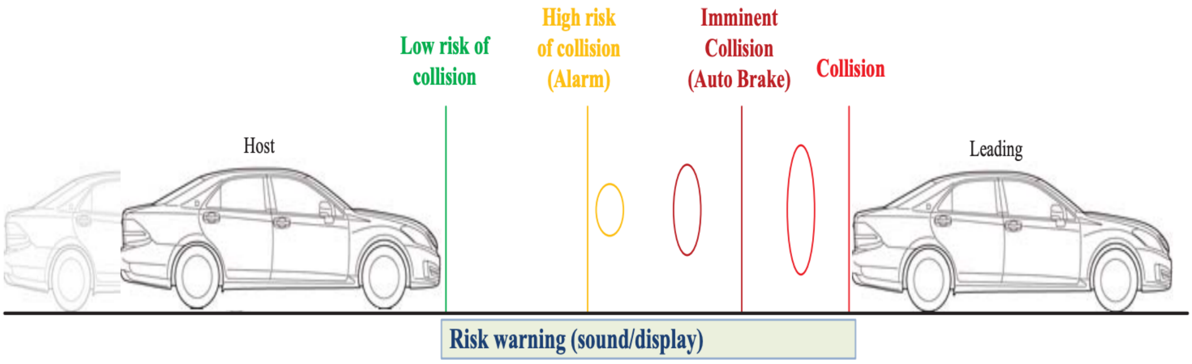

Figure 9: Collision Avoidance by Steering or Braking [46]

The Steering Threat Number (STN) is a calculation that compares the sideways force a vehicle needs to avoid a collision (because of steering) with the strongest sideways force the vehicle can actually make [42],[44]. STN is really important for figuring out how dangerous a situation on the road is and supports us know how likely a collision might happen. If we call the time before a collision might happen TTC, the needed sideways force for avoiding a crash at TTC a_{yh}^{req}, and the vehicles strongest sideways force a_{yh}^{max}, then we can write the STN like this:

$$\text{STN} = \frac{a_{yh}^{req}}{a_{yh}^{max}}$$

From this, we can understand that if the STN is 1 or less, the driver can prevent a crash by steering. But if STN is more than 1, steering alone won't stop a crash from happening, and that's when the car needs to automatically brake hard to help. Although there are different ways to work out the sideways force needed, we usually just use a set number for the maximum sideways force a car can make [45][46].

6.2. Sensors in FCW

Recent researches have shown that using a mix of high-technology sensors is important to making Forward Collision Warning (FCW) systems work better. By combining several types of sensors like RADAR, LIDAR, cameras, and ultrasonic sensors, FCW systems get a full picture of the environment. This array of sensors enables the system to carefully monitor the area ahead of the vehicle, detecting potential collision with great precision. For instance, merging the information from millimeter-wave RADAR and cameras, as demonstrated in the 2023 research by Chenxu Sun and colleagues, has greatly improved how well these systems can spot hazards. This combination supports cut down on false alerts and missed warnings, enhancing the system gives reliable alerting for collisions in all sorts of driving situations, even when things like weather make it hard for the sensors to work [47].

Additionally, the use of deep learning has advanced the developent of algorithms that can precisely calculate the distance and speed of vehicles, tackling issues that come with handling sensor data. Zhenfei Zhan and others in their 2023 research show how neural network models, trained on large amounts of data, support the foresight of FCW systems. These advancements in sensor technology and data analysis signify a move towards preventive safety strategies. FCW systems now have the ability to not only respond to immediate risks but also predict potential crashes well before they occur, playing a major role in enhancing road safety and decreasing the likelihood of accidents [48].

6.3. Brakes in FCW

Recent researches on Forward Collision Warning (FCW) systems have targetted on developing the coordination between sensors and brakes to better prevent collisions. An important improvement is using short-range communication systems with radar to get a head start on detecting and responding to potential collision situations, like when a vehicle ahead brakes suddenly. This approach contributes quicker warnings, supprted by GPS, giving drivers more time to response and avoid collision. Furthermore, develping a multi-step FCW that uses machine learning, such as an algorithm that gets smarter as it learns, has been a big leap forward. This system looks at things like how fast the vehicle in front is going, how close a collision is, and the difference in speed between vehicles to give accurate and timely warns. These advancements focus the current progress in FCW systems, with a strong highlight on using the latest technology to make driving safer and cut down on rear-end crashes [49],[50].

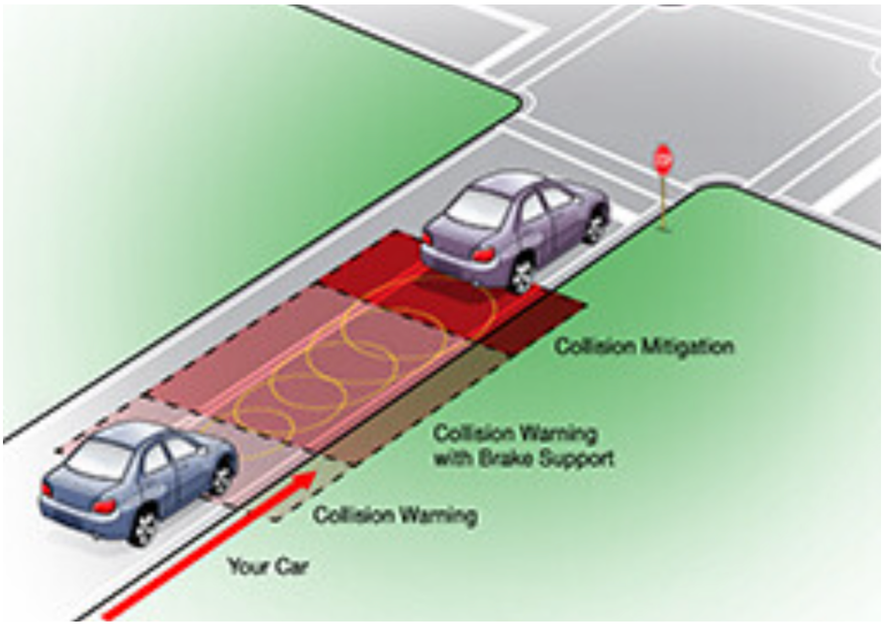

Figure 10: Overview of Brakes for FCW [51]

7. Challenges and Limitations

The current challenges and limitations of ADAS including techincal problems as well as real-world application difficulties, showing just how complicated it is to use this technology when driving. One significant challenge is how changes in light, shadows, wrong alerts, missed detections, and bad weather can make the sensors less accurate. This means there's a need for improved technology that can trasnfer information quickly and deal with blocked views to keep the system working well [58]. Moreover, as ADAS technology rapidly advances, driver training hasn't kept up, developing a gap between what drivers need to know to use these features properly and what they're currently being taught. This situation focuses the urgent need to update driving lessons to match the advance abilities and challenges of the latest ADAS [59].

Tackling these challenges requires current advancements in sensor technology, algorithm development, and system architecture to boost the accuracy, dependability, and effectiveness of ADAS. Moreover, there's an increasing demand to enhance driver knowledge and training about what ADAS can and cannot do, to assure they're used correctly and trusted for enhanced road safety. As ADAS technologies continue to develop, overcoming these obstacles will be important in moving forward more to autonomous and safer driving experiences.

8. Future Direction in ADAS Development

Future improvements in Advanced Driver Assistance Systems (ADAS) are set to transform vehicle safety and make driving more effective by bringing in new technologies and innovative methods for automating vehicles. One main area of advancement is using Augmented Reality (AR) to support how ADAS is tested, which aims to blend simulations with actual driving experiences to speed up the creation of complex ADAS testing scenarios [52] Furthermore, improved technologies inside the vehicle will soon collect detailed information about the driver's health, feelings, and how well they're paying attention, serving ADAS to provide safety features that are more tailored to the individual and react more precisely to what's needed [53].

In addition, ADAS is evolving to support how connected and self-driving vehicles work by constantly upgrading sensors and communication tech. For example, using Ethernet for car networks that can handle lots of data, necessary for ADAS, highlights how Ethernet and Time-Sensitive Networking (TSN) standards can back the growing need for more sensors that self-driving cars rely on [54].These tech advances are steering the industry towards ADAS solutions that are more unified, smart, and adaptable, promising big changes for road safety, driving comfort, and transportation as a whole.

8.1. V2X Communication

The next big step for Advanced Driver Assistance Systems (ADAS) is expected to be the broad adoption of V2X, which stands for Vehicle-to-Everything communication. This technology allows vehicles to talk together, to road infrastructure, to pedestrians, and to cloud-based services. Through this communication, they can share important information like traffic conditions, road hazards, and updates for navigation. V2X will give vehicles a much better understanding of what's happening around them, which will make driving safer and more efficient [55]. For example, cars could get warnings about potential crashes at crossroads or get live updates from traffic lights to help keep traffic flowing smoothly.

8.2. Augmented Reality

Integration of Augmented Reality (AR) with Advanced Driver Assistance Systems (ADAS) is setting the stage for a major leap in increasing driver awareness and safety. This method involves projecting critical information and alerts directly onto the driver's view, blending the physical and digital worlds smoothly. Research, like the study by [56] has recognized into how moving your head affects seeing depth in AR while driving simulations. This research recommends systems that move with the driver's head, adjusting AR shows to their line of sight, can improve both driving performance and safety. Moreover, a important study by [57] examine the widespread use of AR Head-Up Displays (AR-HUD) in vehicles. Borrowing from aviation, this tech projects vital ADAS data and AR symbols onto the car's windshield, making driving safer and more informative with instant, easy-to-understand alerts and directions.

Conclusion

This paper briefly emphasizes the transformative impact ADAS, specifically Blind Spot Detection (BSD) and Forward Collision Warning (FCW) in enhancing the road safety monitoring the flow of traffic, minimizing the driver fatigue. It is also point out how these innovation mark important move in vehicle safety. Applying sensors and artificial intelligence to understand and prevent potential collisions on the road. This report also acknowledges difficulties like technical limitations, how customers receive these systems, and focus on the essential for current development and adaptation. It is also mentioned the important role of accurate detection and calculating the distance of objects in managing traffic safety, coupled with increasing the customer demands for safer as well as more effective vehicles, encouraging manufacturers to develop more advanced ADAS technologies. Concluding on a positive note on future development of ADAS to further lessen the road accidents and improve the comprehensive driving experience.

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