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Advanced Driver Assistance Systems (ADAS) – Towards Safe Driving Environment

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ABSTRACT: India's road safety record has been a cause for concern for several years. According to the World Health Organization (WHO), India has one of the highest rates of road traffic fatalities globally, accounting for over 150,000 deaths each year. In recent years, the automotive industry has witnessed a remarkable transformation driven by technological advancements. One of the most significant developments in this domain is the emergence of Advanced Driver Assistance Systems (ADAS). These technological advancements have the potential to revolutionize road safety and transform the driving experience. ADAS is a set of intelligent features that assist drivers in various aspects of driving, such as collision avoidance, lane-keeping assistance, adaptive cruise control, automatic emergency braking, blind spot detection and automated parking. The prime objective of the ADAS system is to control injuries by decreasing the number of car accidents with the help of modern algorithms and tools. Airbags, seatbelts and all of the essential passive safety parts are standard equipment. Now cars are often equipped with new advanced active safety systems that can prevent accidents. The functions of the Advanced Driver Assistance Systems are still growing. ADAS systems work together to create a safer and more efficient driving environment.

KEYWORDS: Advanced Driver Assistance System, adaptive cruise control, blind spot

I. INTRODUCTION

The number of road traffic accidents is one of the major societal problems in the world today. According to estimated data from the WHO 1.2 million people are killed and as many as 50 million are injured each year [1]. In India nearly 5 lakh accidents have taken place in 2016, killing roughly 1, 50,000 people and leaving many others injured. India is a developing country and the rate of motorization is very high. [11] Traffic rules and regulations drafted by the law aren't followed by many citizens. This is another reason for an accident. Accidents sometimes are unintentional. Some serious acts like drunk and drive, ignoring the signboards, and over speeding might result in severe casualities. Government of India has mandated speed alerts from 2019 with limit as 80kmph. Many of these accidents could be avoided if the automatic systems are used to help humans when braking. Advanced Drive Assistance System (ADAS) has the potential to increase safety and provide comfort driving as driving situations are electronically controlled and decisions are simplified for the driver. As most road accidents occur due to human error, ADAS is designed with a human machine interface to automate, adapt, and enhance vehicle technology for safety and better driving. In this system, various cameras and sensors are embedded like ultrasonic sensor, gas sensor, temperature sensor, alcohol sensor to detect obstacles or driver errors and reacts to them instantly to increase safety during the driving process [10]. Advanced stop start systems are another kind of ADAS that have become common on new vehicles. These systems enable a vehicle to start quickly when stopped at traffic signals.

Nowadays, most automobiles are equipped with standard safety features. Technological advancements and the expansion of automation measures have contributed significantly to the popularity of car safety mechanisms. The following are a few examples of available systems:
Adaptive cruise control (ACC)
Anti-lock braking systems
Forward collision alert
High beam protection system
Lane departure alert
Traffic lights traction control recognition
Navigational assistance

II. TYPES OF ADAS

In the automotive industry there are two main types of ADAS that are revolutionizing. These are:

1. Passive ADAS systems

In passive ADAS systems the computer alerts the driver to potential dangerous circumstance without directly taking

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control of the vehicle. These systems use sensors and cameras to detect potential hazards and provide warnings and alerts to the driver. Passive ADAS provides real-time data about the driving environment and alerts about possible risks via a human-machine interface (HMI) to take corrective action and make informed decisions on the road. These rely on the driver's response to the alerts and warnings provided. Typical warning systems include sirens, flashing lights, blind spot detection. The driver receives critical information that allows him to make the best judgments on the road.

2. Active ADAS systems

Active ADAS are proactive in their approach to ensure road safety. These systems are equipped with advanced sensors and advanced computer algorithms that continuously monitor the vehicle's surroundings and assess potential risks. They can actively intervene when necessary, taking control of the vehicle to prevent accidents. Automatic emergency braking (AEB) detects an impending accident and applies the brakes without the driver's assistance. Functional features include adaptive cruise control (ACC), lane-keeping assist (LKA), lane centering (LC), and traffic jam assist.

III. LEVELS OF ADAS SYSTEMS

ADAS can be divided into five levels that help in making the driving experience more comfortable and safe. Not only it helps the driver but also helps in preventing many road accidents especially in a country like INDIA where road accidents are more in number. These levels are set by The society of Automotive Engineers across the globe [7].

Level 0: No Automation

ADAS cannot control the car and can only provide information for the driver to interpret on their own. The driver has complete control and responsibility for all aspects of driving. Some ADAS that are considered level 0 are: parking sensors, surround-view, traffic sign recognition, lane departure warning, night vision, blind spot information system, rear-cross traffic alert and forward-collision warning.[7]

Level 1: Driver Assistance hands on/shared control

This can take control over one functionality. Basic automation features are introduced, such as adaptive cruise control or lane-keeping assistance. However, the driver remains fully in control and must actively monitor the driving environment. Adaptive cruise control, emergency brake assist, automatic emergency brake assist, lane-keeping, and lane centering are level 1 features.

Level 2: Partial Automation/ hands off

This can take control over multiple functionality to aid the driver. ADAS itself controls both steering and braking/accelerating simultaneously under some situations. The Driver must continuously supervise the road and surroundings and intervene if necessary. Highway assist, autonomous obstacle avoidance, and autonomous parking are level 2 features.

Level 3: Conditional Automation/ eyes off

The vehicle can manage most driving tasks under certain conditions, but the driver must be prepared to take over when alerted by the system within a specific timeframe. The driver can disengage from actively monitoring the environment in limited scenarios.

Level 4: High Automation/ mind off

The vehicle can perform most driving tasks without driver intervention in specific driving conditions and environments. However, the driver may still take control if desired or required (specific driving conditions are not met).

Level 5: Full Automation/ steering wheel optional

The vehicle is fully autonomous and can perform all driving tasks without any human intervention in all driving conditions. A human driver is not needed, and occupants are just the passengers.

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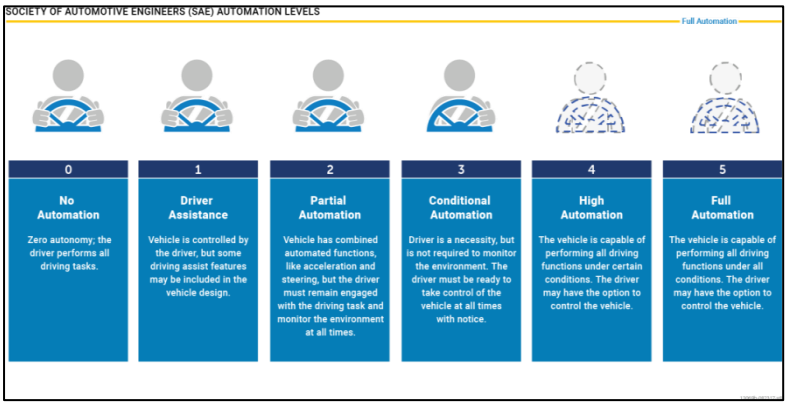

Fig . 1 ADAS Levels

IV. ADAS IN INDIA

As per the current scenario, the level 2 of ADAS system has been introduced in many cars in India in brands like Mahindra, MG and Tata. These systems include various features like forward collision warning, auto emergency braking, lane departure warning, lane keep assist, adaptive cruise control, smart pilot assist, traffic sign recognition and high beam assist among others. These features help reduce driver stress and crashes.
Cars with ADAS in India
Mahindra XUV700
MG Hector
MG Astor
Tata Harrier
Tata Safari
Toyota Innova Hycross

V. ADAS FEATURES IN VEHICLE

40% of the accidents in India happen on the highways.
More than 80% of accidents are due to driver error and close to 70% are due to over speeding.
~40% accidents happen at junctions where traffics merge.
Number of vehicles increasing at a CAGR of ~10%.[11]
The following applications are some of the most prominent ADAS features which can help reduce accidents.

1. Adaptive cruise control

Adaptive Cruise Control (ACC) utilizes sensors, such as radar or lidar, to maintain a selected cruise control speed but also adjust it to keep a safe distance from the vehicle ahead. It is helpful on highways, where drivers find difficult to maintain their speed and cars in the surroundings for lengthy durations. Depending on the actions of nearby objects in the immediate area, advanced cruise control may automatically accelerate, decelerate, and at times stop the vehicle. This smart driver assistance technology allows drivers to choose a speed. By reducing the need for constant speed adjustments, ACC enhances driver comfort and reduces fatigue during long highway journeys while mitigating the risk of rear-end collisions by maintaining a safe distance from the vehicle ahead.

2. Blind spot monitoring

It is another passive system that enhances driver awareness and safety during lane changes by expanding the driver's perception of surrounding traffic. It uses sensors and radar to monitor the areas in the driver's blind spots, providing timely alerts either visual, auditory or both and haptic feedback to prevent potential collisions when changing lanes.

3. Automatic Emergency Braking

Automatic Emergency Braking (AEB) is an active safety system that uses sensors and cameras to monitor the road ahead for potential collisions. If the driver does not respond in time, AEB can automatically apply the brakes to stop or reduce the severity of a potential crash. This system can detect pedestrians, cyclists, and other vehicles.

4. Following distance warning

using various integrated technologies such as lasers, radar, infrared, ultrasonic, visual imaging, and occasionally in conjunction with cameras Following distance warning (FCW) monitors the speed and distance of cars directly in front.

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This will notify the driver of an imminent collision with another car or item directly in its route. FCW systems can avoid 9 to 53 percent of rear-end incidents and 19 to 60 percent of wounded drivers.

5. Automatic parking

Automatic Parking Systems (APS) streamlines the parking experience by autonomously steering the vehicle into parking spaces. By merging the data of several sensors, cameras, and intelligent algorithms, this technology identifies suitable parking spots and precisely guides the vehicle into position without the driver's assistance. The vehicle's sensors provide information on its location, its destination, calculates precise steering angles, coordinating with sensors to ensure accurate maneuvering until it is correctly parked.It enhances convenience and confidence in tight or challenging parking situations.

6. Driver Monitoring

A Driver Monitoring System (DMS) utilizes sensors, cameras, and advanced algorithms to assess the driver's behavior enhancing safety by monitoring the driver's attentiveness and detecting signs of fatigue or distraction. The system typically uses an infrared camera or sensors to capture the driver's facial features and monitor their eye movements, head position, and even changes in steering behavior. The advanced algorithms then process this data in real-time, comparing it to predefined patterns and alerting the driver in the form of visual prompts, auditory signals, or haptic feedback, if signs of fatigue or distraction are detected.

7. Lane Departure Warning

Using cameras or other sensors a Lane Departure Warning (LDW) system is a prominent feature in ADAS that aims to help drivers stay in their lanes and avoid unintentional lane drifts. The lane departure warning system uses image processing and pattern recognition algorithms to analyze the vehicle's position in relation to the lane markings. A further evolution of this feature is Lane Keep Assist (LKA), another active system which detect when a driver unintentionally drifts and can gently steer the vehicle back into its lane using either the brakes or steering assist.

8. Navigation system

Car navigation systems provide on-screen instructions and voice prompts to help drivers follow a route while retaining their concentration on the road. Specific navigation systems can show precise traffic information and, if required, suggest an alternate way to avoid traffic bottlenecks. Advanced systems may even offer heads-up displays to reduce driver distraction.

9. Detection of driver drowsiness

Driver drowsiness detection warns drivers of sleepiness or other potential road distractions. There are several ways to determine whether a driver's attention is decreasing. The sensors can analyse the driver's head movement and pulse rate to determine whether they indicate drowsiness. Other systems send out driving alerts comparable to lane-detecting warning signals.

VI. CONCLUSION

India is gradually making strides toward adopting ADAS technology. The system is one of the crucial emerging features in forthcoming cars as it is durable and ensures maximum safety to the passengers as well as the public. This methodology can be embedded in all types of vehicles at an affordable cost. A 2022 Consumer Reports survey found that vehicle owners are happy with ADAS features, like the backup camera (69%), blindspot warnings (64%), and adaptive cruise control (63%). Though many ADAS features are designed for convenience and comfort, there are many features that can increase safety and in the end reduce accidents, injuries and deaths. The Government has taken some steps in this direction, like making ABS mandatory in cars and motor cycles from April 2018, automatic headlamps for two-wheelers and speed governors. These ADAS features, along with the drive by the Government in improving infrastructure (Roads, signage, lighting), highway audits, creating awareness, can help reduce accidents and deaths in India. But, these features can be valuable in reaching achieving the numbers.

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