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A Study of Sensors in Semi-Autonomous Cars

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ABSTRACTSensors are used in everyday objects besides innumerable applications of which most people are never aware. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life. With advances and easy-to-use platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure or flow measurement. Car sensors are intelligent systems that control different aspects such as temperature, coolant levels, oil pressure, emission levels and so much more.

KEYWORDS: GPS, Automotive Sensors, Emergency Sensors, Vision sensors,

I. INTRODUCTION

A sensor's sensitivity indicates how much the sensor's output changes when the input quantity being measured changes. Due to the increasing demand for rapid, affordable and reliable information in today's world, disposable sensors—low-cost and easy-to-use devices for short-term monitoring or single-shot measurements—have recently gained growing importance. Car sensors are advanced enough to accept a range of values, process them correctly and determine the right mixture or level for each aspect [1]. Advancements made in computers have made it possible for these car sensors to communicate this information to computers, so they can report to the driver when something is amiss. These sensors work continuously, right from the time you power your car up till you turn off the ignition. Besides all this, our car's engine has the capability or intelligence to know what is going on with itself. It can communicate directly with the computer that comes as a part of the car, and make it perform the necessary action. What exactly is happening in the car is determined using some sensors. These sensors have come a long way from the nascent stages, and they continue to play an important role in ensuring that your car's performance and fuel usage is optimal. There are a few others that go beyond the basics and give you a wonderful driving experience [1].

II. HISTORY OF CAR SENSORS

Automobile technology has developed by leaps and bounds due to the last few years, thanks to advancements made in this field as well as in related ones such as Artificial Intelligence and Mobile Connectivity. It is continuing to grow at a rapid pace, and in turn, this is changing the way we use cars. Today, cars are more than just an object to drive. We can listen to our favorite music, relax, talk to anyone we want, find whatever we want, communicate effectively, shop and do so much more, though it is not ideal to do these things while driving as such. Generally speaking, any combustion engine needs three things to work well, and they are fuel, air, and spark. Control systems present in engines handle all these three aspects including whatever else is necessary to trigger or balance them [4].

In the past, these systems were mostly mechanical or electromechanical, so each part of the engine would be assigned a task instead of a centralized system managing all of it. For example, the carburettor would take care of fuel mixture and metering while a mechanical distributor would trigger the spark and manage it. One of the main problems with these mechanical and electromechanical systems were they were maintenance-intensive. This is why an engine has to go through a thorough service once every 35,000 miles because that's the maximum they could handle. However, during the 70s and 80s, many changes came about and the engine design underwent major changes. A lot of were also related to emission controls and this required enormous research and change in engine design. As a result, the maintenance levels came down drastically [4].

One of the changes that came about was the use of car sensors. During the initial stages of car sensors, it was nothing but a transitional system that sent information to an analog processor. In turn, this processor would make decisions based on simple algorithms and the engine functions were managed like this. Obviously, there were many limitations in these early systems. The analog systems could handle only predefined values, so any value that was outside of the programmed values threw an error and the system failed. This was especially a problem when the car

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became older and there were many unexpected problems that were not programmed. During the 1990s, more changes came about. The carburettors were replaced with fuel injection engines and there was some change in the wiring part as well. In order for all these systems to work, there came a need for a centralized system that would handle different aspects such as emissions, air volumes and more. This is when car sensors emerged.

Car sensors are advanced enough to accept a range of values, process them correctly and determine the right mixture or level for each aspect. Advancements made in computers have made it possible for these car sensors to communicate this information to computers, so they can report to the driver when something is amiss. These sensors work continuously, right from the time you power your car up till you turn off the ignition. As these sensors monitor always, it is possible to send real-time signals to the computer, so the driver is aware of what is happening right when something is happening. This way, there is no delay and this makes it easy for the system and even the driver to take corrective action right away. But advancements in the last few years have put car sensors as the central part of a car system. It is no longer used merely for controlling different aspects necessary for a smooth car performance, but it also used to handle everything, starting from temperature control inside the car to headlight and tail light operations, and more. Some of the latest models even make it possible for drivers to make the most of mobile connectivity to give drivers precise information about anything they want. For example, GPS gives the route to the destination based on the current location of the car. Likewise, some systems are even capable of displaying the discounts available in different stores based on where you have parked your car. The possibilities are truly endless with car sensors.

Sensors in early 2000s

SENSORS are essential components of automotive electronic control systems. Sensors are defined as “devices that transform (or transduce) physical quantities such as pressure or acceleration (called measurands) into output signals (usually electrical) that serve as inputs for control systems.” It wasn’t that long ago that the primary automotive sensors were discrete devices used to measure oil pressure, fuel level, coolant temperature, etc. Starting in the late 1970s, microprocessor-based automotive engine control modules were phased in to satisfy federal emissions regulations. These systems required new sensors such as MAP (manifold absolute pressure), air temperature, and exhaust-gas stoichiometric air-fuel-ratio operating point sensors. The need for sensors is evolving and is progressively growing.
Some of the most prominent sensors that are to be highlighted includes:

- **Mass air flow sensor**
  This sensor, as the name suggests, calculates the volume and density of air taken by the engine.
- **Engine speed sensor**
  This sensor is attached to the crankshaft of engines and it is responsible for monitoring the spinning speed of this crankshaft.
- **Fuel temperature sensor**
  This sensor monitors the temperature of the fuel constantly to ensure that fuel consumption is optimum
- **Voltage sensor**
  This is an important sensor that manages the idling speed of the car and ensures that this speed is increased or decreased, as needed.

III. WORKING OF CAR SENSORS

Most cars today have smart sensors that monitor the other sensors, so the driver does not have to know intricate details such as which sensors are working and which are not. This has been possible through a process called multiplexing, where wires are consolidated by a microprocessor located for each area in the car. The idea behind multiplexing is to ensure that the wiring system does not get out of control. For example, the driver’s window has multiple controls. But all of it is controlled by one module called the driver door module, so this module alone is responsible for all the inputs and outputs that happen in that area. This module also communicates with different sensors that are related to its area of operations. When this action is performed, the driver door module sends a packet

of data to the communication bus of the car. In turn, this information directs another module to energize the motor of the power window. So, the communication simple is rather simple. All the information that is passed between different sensors and their controlling modules pass through either the input or output wire of the communication bus located in

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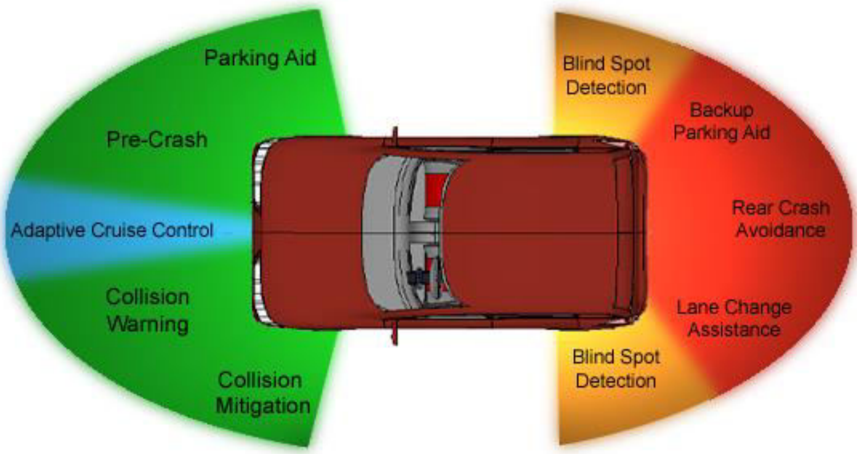
the car's central system [5]. As a manufacturer, such a setup greatly increases scalability. We can add any number of modules and sensors to your car, and the communication will not be affected in any way. Also, there is no need for you to change the wiring system, the communication bus or anything to facilitate communication between the new module and existing ones. In short, car sensors are a great advancement that enhances the usability of your car and extends the life and condition of the car. It is also fairly simple to implement and scalability is really easy, as most car models now tend to use smart sensors that are powered by modules.

IV. TYPES OF SENSORS INCARS

1. RADAR SENSORS/ DISTANCE SENSORS/HEADWAY SENSORS

Radar (Radio Detection and Ranging) sensors make up a crucial contribution to the overall function of autonomous driving: they send out radio waves that detect objects and gauge their distance and speed in relation to the vehicle in real time.Some cars and trucks are equipped with headway sensors that detect the distance between a vehicle and any vehicles or large objects in front of the vehicle. These sensors are used by adaptive cruise control and/or collision avoidance systems. There are two primary methods of measuring distance using radar. The first is known as the direct propagation method and measures the delay associated with reception of the reflected signal which can be correlated to the distance of the reflecting object as a function of the speed of light and the period or rather, the time delay in the transmission and receiving of the waves. The second method is known as the indirect propagation method or the Frequency Modulated Continuous Wave (FMCW) method. For indirect propagation, a modulated frequency is sent and received, the difference in the frequency can be used to directly determine the distance as well as the relative speed of the object.Radar signals are very good at detecting objects that strongly reflect electromagnetic radiation (e.g. metal objects). Because they operate at wavelengths on the order of a few millimeters, automotive radar systems are pretty good at detecting objects that are several centimeters or larger. They are also good at looking through (i.e. ignoring objects that are small relative to a wavelength (e.g. the water droplets in fog). Other automotive systems that use radar distance sensors include collision avoidance systems, blind spot detection systems and automated parking systems [9].



Both short- and long-range radar sensors are usually deployed all around the car and each one has their different functions. While short range (24 GHz) radar applications enable blind spot monitoring, the ideal lane-keeping assistance, and parking aids, the roles of the long range (77 GHz) radar sensors include automatic distance control and brake assistance. Unlike camera sensors, radar systems typically have no trouble at all when identifying objects during fog or rain.

2. LASER SENSORS

Laser sensors are used where small objects or precise positions are to be detected. They are designed as through-beam sensors, retro-reflective sensors or diffuse reflection sensors.Laser light consists of light waves of the same wave

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length with a fixed phase ratio (coherence). This results in an important feature of laser sensors, that is the almost parallel light beam.The result: Long ranges can be achieved thanks to the small angle of divergence. The laser spot which is clearly visible even in daylight makes the alignment of the system easier.

3. ULTRASONIC SENSORS

Ultrasonic sensors measure distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception. In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately. This enables miniaturization of the sensor head.

4. OPTICAL SENSORS / CAMERA SONSORS

Optical sensors are a class of devices that use various forms of light–matter (i.e., photon–atom) interactions to detect, interrogate, and quantify molecules for multiple applications. Autonomous cars often have video cameras and sensors in order to see and interpret the objects in the road just like human drivers do with their eyes. By equipping cars with these cameras at every angle, the vehicles are capable of maintaining a 360° view of their external environment, thereby providing a broader picture of the traffic conditions around them.Today, 3D cameras are available and utilized for displaying highly detailed and realistic images. These image sensors automatically detect objects, classify them, and determine the distances between them and the vehicle. For example, the cameras can easily identify other cars, pedestrians, cyclists, traffic signs and signals, road markings, bridges, and guardrails [10].

V. SURVEY OF SENSORS USED INCARS

In this paper we will be studying about some of the newest ways of using sensors in automotive sector. We will be focusing on some of the leading car brands in the world for our survey.During past 2-5 years most of the luxury and semi-luxury cars have come up with technologies like

1. Adaptive cruise control
2. Pedestrian detection
3. Lane keeping assist
4. Blind spot detection

Even though these are vehicle oriented terms, the back end includes sensors, neural network designs and learning procedures which build a brain to control the feature.

1. ADAPTIVE CRUISE CONTROL

Adaptive cruise control (ACC) is a system designed to help vehicles maintain a safe following distance and stay within the speed limit. This system adjusts a car's speed automatically so drivers don't have to. It is one of 20 terms used to describe its functions so that you might see adaptive cruise control as the following in advertisements and vehicle descriptions:

Advantages

- Increased Road safety
- Provide adequate spacing between them and other vehicles
- Helps to prevent accidents that result from an obstructed view or close following distance
- Helps to maximize traffic flow because of its spatial awareness
- Drivers don't have to worry about your speed

Disadvantages

- It is not entirely autonomous
- Adverse weather conditions like snow, rain, or fog might confuse the system's sensors
- Driving through tunnel will be a trouble

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Different types of ACC are listed in the following table (Table 1):

S.No.	*Name*	*Description*
1.	*Radar-Based Systems*	• Works by placing radar-based sensors on or around plastic fascias. • Each radar sensor works together to create a comprehensive picture of the vehicle's proximity to other cars or potentially hazardous objects.[6]
2.	*Laser-Based Systems*	• Uses laser technology to detect the proximity of objects to your car. • It does not operate well during rainstorms and other weather conditions.[6]
3.	*Binocular Computer Vision Systems (Optical)*	• Put into use from 2013 onwards. • It uses sensors in form of small cameras that are placed on the back of a vehicle's rearview mirror to detect front-facing objects. [6]
4.	*Multi-Sensor Systems*	• Incorporate several different sensor types to provide a driver with advanced information. • GPS data equipment or cameras to gather information about a vehicle's geographic environment and proximity to other cars [6].
5.	*Predictive Systems*	• Prediction systems are a type of ACC that uses sensory data to predict the actions of neighboring vehicles. • This means that your car might slow down to brace for another vehicle suddenly switching lanes [6].

Table 1:Types of ACC systems

Adaptive cruise control is evolving each year. Car companies are continuously making adjustments to this technology and, in doing so, creating more common and affordable options that can be purchased with a new car or added to older car models, making driving safer for everyday people.ACC can increase or decrease your car's speed to maintain a following distance that you set. Advanced versions can even slow and stop your car in traffic jams, then accelerate for you.

One or more sensors – including radar and computer-connected cameras – read the road ahead of you for traffic. They are capable of reading and responding to any cars that are in front of you in your lane.

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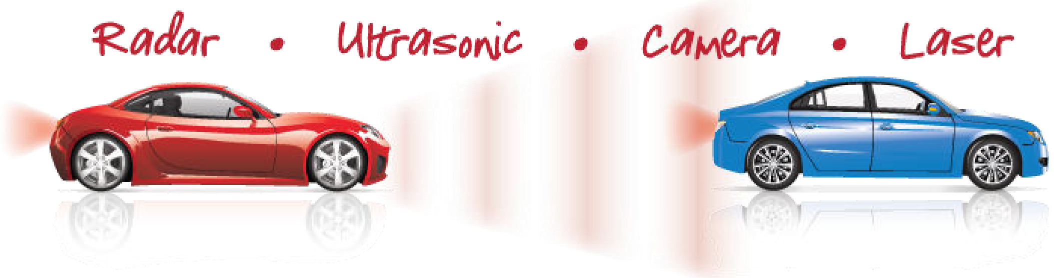

Fig. 1: Different sensors read the road ahead of you for traffic.

Accelerate to your set speed, then turn on the ACC. Tell the ACC how close you want your following distance gap to be (generally short, medium and long distances), and it's then set to begin working (Fig.2)

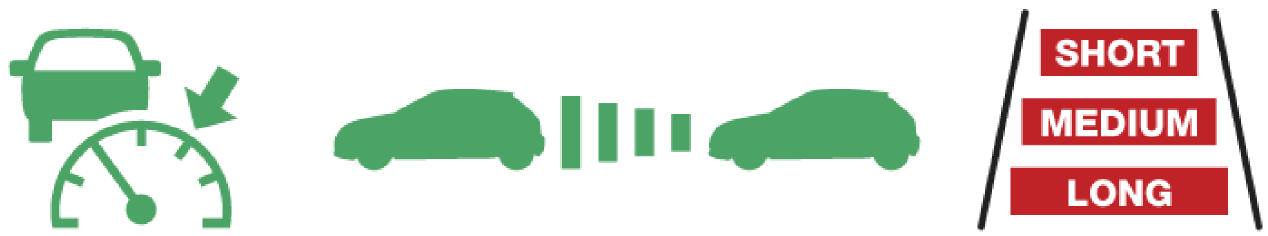

Fig. 2: Accelerating Levels

In this paper we will be reviewing ACC feature of Audi, BMW,Volvo and Mercedez Benz. The following table lists the ACC features of the mentioned brands [6]

S.No.	*Name*	*Description*
1.	Audi Traffic Jam Pilot(Audi A8)	• Came in 2018 • Not fully autonomous • Functional below 60km/hr • With this system can start, steer ,brake, accelerate, stop and start again
2.	BMW Traffic Jam Assistant	• Not fully autonomous. • Take over all steering, braking and accelerating. • It requires you to keep your hands on the wheel, even if it's doing the steering and working the pedals.
3.	Mercedes-Benz Drive Pilot	• Allows automated driving. • Can take hands off from steering wheel for around 45 seconds.
4.	Volvo Pilot Assist(Volvo S60)	• It holds driver's side system. • Allows to steer around gradual bends and slows or speed up based on actions of cars in fronts

Table 2:Types of ACC in various brands

What we need to do is to accelerate to your set speed, then turn on the ACC. Tell the ACC how close you want your following distance gap to be (generally short, medium and long distances), and it's then set to begin working. For the above brands, ACC is based on radar sensors.

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2. *PEDESTRIAN DETECTION*

A pedestrian automatic emergency braking (PAEB) system—also known as frontal pedestrian impact mitigation braking—is an emerging safety technology that provides automatic braking for vehicles when pedestrians are in the forward path of the vehicle's travel and the driver has taken insufficient action to avoid an imminent crash.

Fig 1: Sensing pedestrians

A PAEB system, like a crash imminent braking (CIB) system, is a crash avoidance system that uses information from forward-looking sensors to automatically apply or supplement the brakes in certain driving situations in which the system determines a pedestrian is in imminent danger of being hit by the vehicle. It may use a forward-facing mono camera or stereo cameras mounted near the rear-view mirror plus radar sensors in the vehicle's front grille to continuously scan the roadway and horizon for pedestrians and, in some cases, bicyclists or animals, who might cross the vehicle's travel path.PAEB systems typically use cameras, but some also use a combination of cameras and radar sensors. Unlike CIB and dynamic brake support (DBS) systems, which address rear-impact crash scenarios, many pedestrian crashes occur when a pedestrian is crossing the street in front of the vehicle. Four common pedestrian crash scenarios include when the vehicle is:

1. Heading straight and a pedestrian is crossing the road;
2. Turning right and a pedestrian is crossing the road;
3. Turning left and a pedestrian is crossing the road; and
4. Heading straight and a pedestrian is walking along or against traffic.

In less than a decade, automated-braking systems have skyrocketed from an option on a small crop of luxury cars to standard equipment on about a third of all 2019 models. The Insurance Institute for Highway Safety (IIHS) has now released its first scores for how well these systems stop for pedestrians, and among small SUVs, the results are mixed. IIHS tested 11 models from the 2018 and 2019 model years. Only four completely stopped and did not crash into the pedestrian dummies—which, amazingly, feature realistic moving legs—in each of three tests. The **Honda CR-V**, **Subaru Forester**, **Toyota RAV4**, and **Volvo XC40 all scored** the top Superior rating. Earning the mid-grade advanced rating were the Chevrolet Equinox, Hyundai Kona, Kia Sportage, Mazda CX-5, and Nissan Rogue. The Mitsubishi Outlander scored the lowest Basic rating, while **the BMW X1** ploughed through the dummies so hard that the IIHS gave it a zero.. The test procedure was like this;In the first, an adult walks straight across the road from the right side while a vehicle is traveling at both 12 mph and 25 mph. In the second, an adult is walking away from the vehicle parallel to the road in the right lane while the test car travels at 25 mph and then 37 mph. Finally, a child walks into the road like the adult, only from behind two parked cars. That test is run from 12 mph and 25 mph.The IIHS runs each test five times on dry pavement in which the dummy begins to walk at a pre-set distance walking straight in the lane, the IIHS (INSURANCE INSTITUTE FOR HIGHWAY SAFETY)gives more scoring weight to vehicles that sound a collision alert at least 2.1 seconds prior to impact.

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Drawbacks:

1. Inaccuracy. The Volvo technology doesn't appear to work 100 percent of the time. Low speeds. While it's true that most pedestrian incidents occur in areas with low speed limits, there's no doubt that they do still happen at higher speeds. Plus, safe collision avoidance is perhaps most needed at high speeds. Still, Toyota's advancement to 25 mph is a step in the right direction.
2. High cost. Higher costs and newer technology go hand-in-hand, but pedestrian detection may stay out of many buyers' price ranges for a while.
3. Off-road testing. Obviously, Volvo and Toyota testers aren't going to run out and test their new technology on live test subjects. That will only come with time and on-road usage by actual drivers. We won't see those estimates for at least another year or two.

All manufacturers are currently testing some form of collision-avoidance, many manufactures use alarm systems for pedestrian detection instead of auto-braking systems. The truth is that all cars should get some form of pedestrian detection. If this new technology saves even one life, it'll be more than worth the investment.

3. LANE KEEPING ASSISTANCE

Lane keeping systems use sensors in form of forward-facing cameras (optical sensors) to monitor the lane lines around your vehicle and will provide visual, audible, and/or tactile warnings—such as through steering wheel or seat vibrations—to alert the driver when the car approaches or crosses lane markings. These systems do not activate when you use your turn signal [2]. If your vehicle has lane keeping assist (LKA), automatic steering or braking will try to correct the vehicle if it starts to exit the lane. A lane detection system used behind the lane departure warning system uses the principle of Hough transform and Canny edge detector to detect lane lines from real-time camera images fed from the front-end camera of the automobile [3]. Lane detection system for car driver assisted becomes an important study to be implemented for safety purposes. It used to lessen possibility of traffic accidents, to monitor the position of a car effectively and to contribute for further development of autonomous navigation technology.
There are three types of systems (Table 2):

- Systems which warn the driver if the vehicle is leaving its lane with visual, audible, and/or vibration warnings (lane departure warning, LDW)
- Systems which warn the driver and, with no response, automatically take steps to ensure the vehicle stays in its lane (lane keeping assist, LKA/LKS)
- Systems which assist in oversteering, keeping the car centered in the lane, and asking the driver to take over in challenging situations (lane centering assist, LCA)

Another system is the emergency lane keeping (ELK). The emergency lane keeping applies correction to a vehicle which drift beyond a solid lane marking.

FEATURE	BRANDS
LANE DEPARTURE WARNING SYSTEMS- Most Satisfying	Hyundai, Cadillac, Buick, Jeep
LANE DEPARTURE WARNING SYSTEMS- Least Satisfying	Infiniti, Porsche, Honda
LANE KEEPING ASSIST SYSTEMS- Most Satisfying	Genesis, Tesla, Kia, Cadillac
LANE KEEPING ASSIST SYSTEMS- Least Satisfying	Audi, Honda, Lincoln, Acura

Table 3:Lane Keeping Assistance in various car brands

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The following table lists the LANE KEEPING ASSISTANCE features of the BMW, AUDI, VOLVO AND MERCEDZ (Table 3)

S.No.	Name	Description
1	Active Lane Keeping Assistant-BMW	• Dynamic radar around the entire vehicle and front cameras monitor road and traffic patterns as well as lane markings • When you set the system in place, you must keep your hands on the wheel at all times, but the system will provide steering assistance to help you stay in your lane • In conjunction with BMW adaptive cruise control, this system can help you maintain a set distance not only between lane markers to your side, but also between your BMW and the vehicle in front of you
2	Active Lane Assist-Audi	• One of the latest assistance systems from Audi is Audi active lane assist. At speeds above 60 km/h (37.28 mph), it uses a camera (OPTICAL SENSOR) mounted in front of the rearview mirror to detect the lane markings. • It observes the road to a distance of more than 50 meters (164.04 ft) and a coverage angle of roughly 40 degrees. It delivers 25 high-definition images per second.
3	Pilot Assist-Volvo	• Volvo Pilot Assist provides steering assistance to help the driver stay within the lane markings on a road except on bad weather days.It also helps maintain a set speed and distance between your car and the vehicle ahead. All of this is possible thanks to camera and radar technology scanning the road. • Activating the feature is simple. Toggle the left and right buttons on the steering wheel keypad until you see the Pilot Assist symbol on the left corner of the driver display. Press the center button to activate. To make sure steering assistance is active, check to see the steering wheel symbol on the display is green. • Volvo Pilot Assist does not allow for full autonomous driving.
4	Active Lane keeping Assist	• Active Lane Keeping Assist can detect if you're straying from your lane using Radar technology. The system can warn you by vibrating the steering wheel, and then, if necessary, it can apply the brakes to help bring you safely back into your lane.

Table 4:Lane keeping Assistance in various brands

4. BLIND SPOT DETECTION

Blind-spot monitoring uses a set of sensors mounted on the side mirrors or rear bumper to detect vehicles in the adjacent lanes. If the sensors detect something, they'll alert you via an audible and/or visual warning. Some vehicles even use a camera as the main part of the system or to complement the sensors. Manufacturers install either radar or computer vision sensors to detect other vehicles occupying the left or right blind zones. When using vision sensors, they have many parts to work and are usually composed of a video camera, display and interface, and a computer processor. Vision sensors require these components to automate industrial processes and decisions, record measurements, initiate pass/fail decisions and observe the quality of analyzable products. Some vision sensors also contain an integral processor – these are called smart cameras. Vision sensors also provide a data interchange between the video camera and the computer processing unit. Vision sensors use images to determine the presence, orientation, and accuracy of surrounding objects. Vision sensors use a combination of both image acquisition and image processing, and multi-point inspections can be done using a single sensor.

Automakers may use different terminology to describe these systems, including blind spot information systems (BLIS), side blind zone alert and blind spot assist.When a vehicle enters one of the zones, a visual alert typically appears on the corresponding side-view mirror face. Some manufacturers place the alerts on the inside of the front roof

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pillar nearest the mirror, or on an adjacent window frame. The alerts are usually an icon designed to show a vehicle approaching.

Typically, the alert light activates and remains on as long as a vehicle is within that zone, which extends far enough to cover the adjoining lane. Cameras or sensors are located underneath or at the corner of each side mirror. Some systems also include bumper-mounted sensors. Together, the monitoring system components detect when a vehicle enters the blind zone and then send an instantaneous digital signal to create the alert. The following table(Table 4) shows what do some automakers call their Blind-Spot Monitoring Systems [7] [8][9]:

Brand	Feature Name	Description
AUDI	Audi Side Assist	• Enables special driver assistance and allows people to change lanes safely during the day or night. • Benefits the driver to also remove the blind spot, which occurs when the rear-view and side-view mirrors are not adjusted properly. • Works based on two radars mounted on either side of the cars and the moving traffic. • It is automatically able to calculate if it's convenient to change lanes just by calculating the distance and speed of the car approaching from behind. If the driver is planning to change lanes, the sensors on that relevant side of the car starts blinking; thus, indicating that changing lanes is not safe at the moment. Even if the driver misses to notice this, the sensors start blinking more vigorously and signify that this is potentially hazardous.
VOLVO	Blind Spot Information System	• Warns you of the presence of other vehicles moving in your same direction while driving on multiple lane roads (such as highways) that are located in your "blind spot". • Designed to identify vehicles that your side view mirrors cannot detect that are located in your blind spot as well as cars that are advancing your Volvo at higher speeds on both the left and right sides. The light in the side view mirror will illuminate depending on which side your Volvo detects the approaching car is located on.
Mercedez Benz	Blind Spot Assist/Active Bind Spot Assist	• Blind Spot Assist uses a radar sensor system to monitor the areas on both sides of your vehicle. • Blind Spot Assist provides assistance at speeds higher than 30 km/h. A warning lamp in the exterior mirrors draws your attention to detected vehicles in the monitored area. If you then switch on the corresponding turn signal to change lane, you will also receive an optical and acoustic collision warning. For this purpose, Blind Spot Assist uses sensors in the rear bumper. • Active Blind Spot Assist uses a radar sensor system to monitor the side areas of your vehicle. In addition, it uses radar sensors at the front. • Active Blind Spot Assist provides assistance at speeds higher than about 30 km/h. A warning display in the exterior mirrors draws your attention to detected vehicles in the monitored area. If you then switch on the corresponding turn signal to change lane, you will also receive an optical and acoustic collision warning. If a risk of lateral collision is detected, corrective braking may help you avoid a collision.
BMW	Active Blind Spot Detection	• BMW's Active Blind Spot Detection system aids drivers when they change lanes by warning them of vehicles in their blind spots, helping to reduce the chance of having an accident. • The system uses radar sensors to monitor the space around the car.

Table 5:Blind Spot Detection in various brands

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VI. CONCLUSION

This paper covered a general studyon some of the newest ways of using sensors in automotive sector. We have conducted study concentrating on innovations during past 2-5 years focusing on four major brands in automotive industry. The study focused on four features which are seen in luxury brands nowadays and are considered to be essential in various aspects.

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