ARTIFICIAL INTELLIGENCE IN AUTOMOTIVE INDUSTRY

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Abstract: *The first use of artificial intelligence in the automotive industry took place in the early second half of the 20th century. The purpose of these technologies was to make driving safer and more efficient. Some of the first technologies developed were ABS, EFI and TPMS. The first autonomous driving model was also developed by Tesla Inc. in 2015. Today, there are a variety of artificial intelligence technologies in cars. The paper describes the technology of ABS, electronic stability control, automatic braking technology, adaptive cruise control, airbags, automatic traffic sign recognition and autonomous and semi-autonomous driving. With the development of all these technologies, there is a risk that the driver will rely too much on artificial intelligence, which could lead to road accidents. There is also a risk that drivers will lose their driving skills because they rely too much on artificial intelligence and could become dangerous on the road if they drive a car that is poorly equipped with artificial intelligence.*

Key words: *Artificial intelligence, Autonomous driving, Motor vehicles, SAE levels, Automatization*

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1. Introduction

Artificial intelligence (AI) is a term that appears in every area of our daily lives. Nevertheless, its occurrence is becoming more and more frequent. The incessant increase in the appearance of artificial intelligence in everyday life is one reason for this paper. Since the application of artificial intelligence is a very broad topic that can hardly be covered in this modest paper, the paper will focus on only one of its many applications, namely its use in the automotive industry. The reason we are interested about the application of artificial intelligence, particularly in the automotive industry, is that it is one of the most recent implementations of artificial intelligence and there is almost no household without at least one personal automobile.

The main major areas of AI application in manufacturing companies are process optimization, quality control, predictive maintenance and collaboration between humans and robots (Oswaldo et al., 2025; Kovic et al., 2023; Peres et al., 2020).

The aim of this paper is to explore the usability of artificial intelligence in automobiles, how useful it is and how potentially harmful it is, to determine the current possibilities of artificial intelligence in this sector, its progress and what to expect from it in the near future. The main contributions of this paper are a brief review of the history of the entry of artificial intelligence into the automotive industry, the use of artificial intelligence in cars today and possible problems we might face when talking about artificial intelligence in the automotive industry.

The paper is divided into five chapters. The second chapter deals with the brief history of AI in the automotive industry. In the third chapter, we described different examples of AI in today’s vehicles, their capabilities, their tasks and the availability of this technology. In the fourth chapter, we show possible plans of AI, some of its developments, goals as well as potential dangers in using this technology. The short discussion and conclusion are given in the fifth chapter.

2. The entry of artificial intelligence in automotive industry

2.1 The difference between artificial intelligence and machine learning

Firstly, we need to briefly explain the terms machine learning and artificial intelligence. Machine learning and artificial intelligence are very different from each other. Machine learning (a branch of artificial intelligence) is the capacity of computers to learn via the manipulation of algorithms and the organisation of the knowledge they produce from processed data while artificial intelligence is a technology that performs tasks that normally require the logical reasoning of human intelligence (Bednigo et al., 2025). In this paper we will introduce technologies for recognising traffic signs, early detection of accidents, lane assistance and other similar technologies developed for easier and safer vehicle control on the road. Such technologies usually involve a database that is inserted before the technology is deployed, or the technology in the field autonomously recognises potential candidates for inclusion in the database and autonomously includes or excludes them from the database.

On the other hand, machine learning is a technology that not only performs its tasks like artificial intelligence, but also learns from its own processed data and constantly tries to improve and update the algorithm or programme so that it is as effective as possible. In addition to the division into machine learning and artificial intelligence, we can also divide these technologies into supervised and unsupervised learning. Supervised learning would be that which learns from labelled data, while unsupervised learning would learn from unlabelled data. (Bednigo et al., 2025)

2.2 The development of artificial intelligence in automotive industry

One of the first usage of artificial intelligence in automotive industry was the usage of ABS (germ. „Antiblockiersystem “), system which stops wheel lock when braking and enables safer vehicle control. It was invented in 1929. by Frenchman Gabriel Voisin. First implementation of ABS on a vehicle wasn't on a car but rather on an airplane in 1945. ABS was used in aircraft industry decades before it appeared in cars. First electrical ABS on all wheels was implemented in 1978. by Mercedes-Benz and Bosch groups which put it in Mercedes-Benz S-class (W116). It was applied on all wheels and it had electrical parts on all wheels. It worked with inductive sensors which were present on every wheel, and they measured the speed of the wheels in real time. That data would be analyzed by first digital ABS ECU (electrical control unit) which would be getting analog signals and decide which wheel is in danger of being locked. If the wheel gets into risk area (are where the wheel spins in a way where there is a danger of wheel lock), ECU will send a signal to the solenoid valve which would then temporarily lower the pressure in the brake pipe of that wheel until the danger passes and later would rise it up again. Speed of possible responses per second of this system was from 3 to 5 cycles in a second (3-5 Hz). In today's modern ABS systems the usual number is 15-20 Hz. Another pioneering artificial intelligence technology in the automotive industry was EFI (electronic fuel injection) (Rivard, 1973). Its aim was to reduce engine wear, fuel consumption and the emission of harmful gases. Although it was invented in 1958, the first commercial application was the Bosch D-Jtronic system of 1968, which consisted of various sensors: pressure sensor, temperature sensor, fuel injection sensor and voltage sensor.

Fig. 1. Image of the first car with electrical ABS (W116)

All these factors were important for the system to calculate when and how much fuel with how much air should be injected into the engine so that the mixture of fuel and air is perfect for maximum power delivery with minimum fuel consumption. Unlike the earlier fuel injection systems that used mechanically operated carburettors, EFI followed this system as an electrical technology. Although the first commercial EFI was developed in the 1960s, its mass production and introduction gained momentum in the 1980s.

Since then, it has been increasingly used. The last technology we will mention in this part of the article is TPMS (Type Pressure Monitoring System) technology. This is an electronic device that constantly measures the pressure in the tyres and sends a signal to the central unit if it changes outside the standard values. It was first introduced on the Porsche 959 in 1986 (Trabaldo, 2014). Each wheel had its own sensor that sent high-frequency signals to the control unit when the tyre pressure was incorrect, which then alerted the driver to the faulty tyre pressure with beeps and warning lights. Although it was initially an optional feature in luxury cars, it is now mandatory in many cars for all newly manufactured vehicles.

2.3 Tesla, Inc. and semi-autonomous driving

One of the first companies that implemented artificial intelligence through the semi-autonomous driving as an additional equipment in its car was Tesla, Inc. back in October 2014. At the time, it was available in the new Tesla sedan for 4.250$. That equipment was based on cameras and sensors that warned the driver about an incoming collision before it happened and about leaving the driving lane. Technology itself that was implemented in those vehicles wasn't developed by Tesla itself, but by other companies that developed it for it and those were: GM Motors, Wayo and Wandex (Ajitha & Nagra, 2021). That equipment was forerunner of the Tesla autopilot that came out on the market a year later in 2015.

„*Technical package with autopilot (includes convenient Autopilot features available via software update, built-in North American maps and navigation with free updates for 7 years, LED cornering lights and fog lights, automatic keyless entry, illuminated door handles, power lights, electrochromic mirrors, power-folding and heated side mirrors with memory, and GPS-enabled Homelink*."– Tesla sedan equipment description (Tesla, 2015).

Tesla, Inc. continued the development of these devices and in 2015 developed the Tesla Autopilot, the first fully autonomous driving vehicle. The first implementation was in the Model S and Model X, software version 7.0. A major problem with this first version was difficulties in recognising stationary objects such as pedestrians or other obstacles on the road. The chip itself was the Mobileye Eye Q3 processor, which was based on a 40 nm process. It had 4 cores with a clock speed of 500 MHz. It processed the data received from satellite images, radars, ultrasonic sensors and cameras and used this information to control the speed and steering of the vehicle. (Ingle & Madhuri, n.d.)

Fig. 2. Pedestrian and vehicle detection in autopilot

Fig. 3. Tesla's model interior

3. Today's usage and development of artificial intelligence

Today, artificial intelligence is developing in 2 directions: Increasing vehicle safety in traffic and the safety of other road users as well as facilitating and automating driving itself. In the last ten years, the second direction of artificial intelligence development has gained considerable momentum.

Many companies and major vehicle brands are developing their own semi-autonomous and autonomous driving systems, such as automatic lane keeping, automatic braking and the like.

3.1 Antiblockiersystem or ABS

ABS is standard equipment in almost every car today. It is part of a series of systems that utilise artificial intelligence to increase vehicle safety. ABS prevents the wheels from locking in the event of sudden braking, so that you do not lose control of your vehicle and skid. Each wheel is equipped with a sensor that measures the rotational speed of the respective wheel. If the wheel slows down, the sensor knows that there is a risk of locking and sends a signal to the electronic control unit (ECU), which processes the signal in real time and decides whether it needs to intervene or whether there is a real risk of the wheels locking. If this is the case, the ABS system is activated by temporarily reducing the pressure of the brake fluid in this wheel. When the wheel turns again at normal speed, the pressure is increased again to the previously increased value (Barik & Prasant, 2018). This process is repeated continuously. The possible rate of these repetitions is 15 to 20 times per second (15-20 Hz).

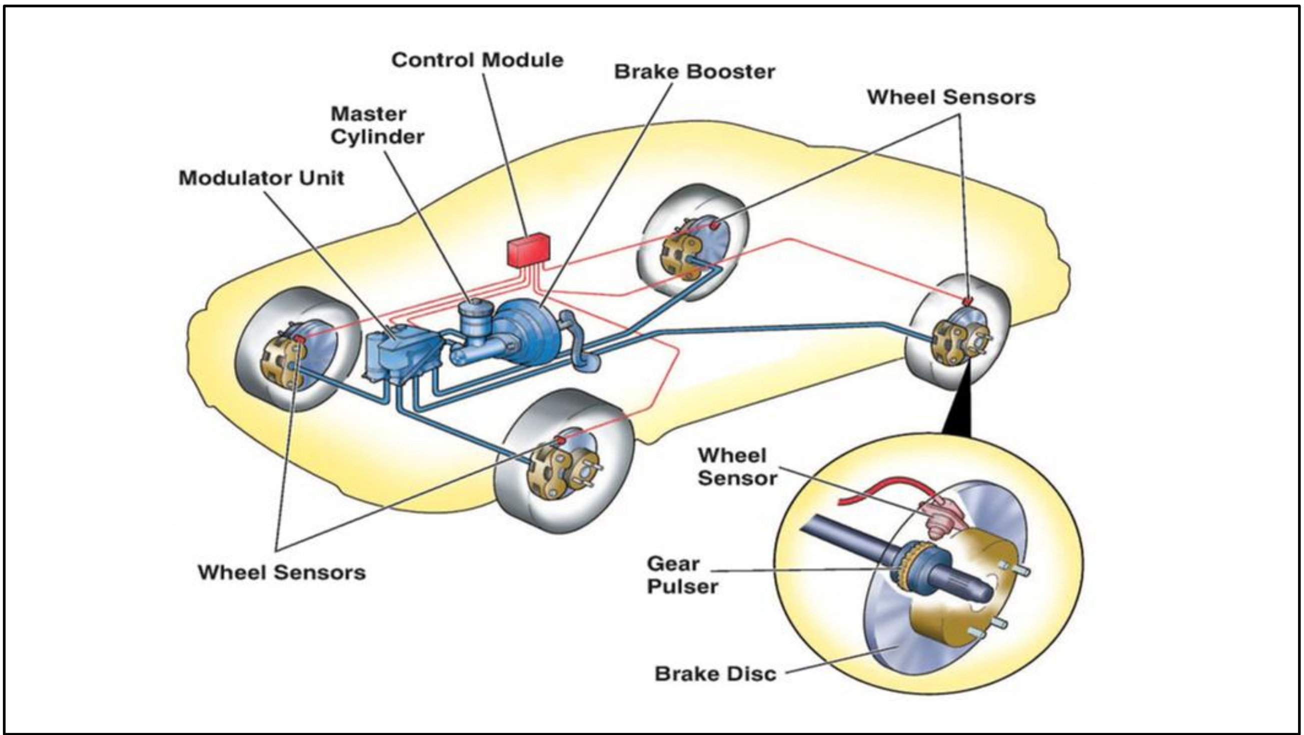

Fig. 4. ABS system in an automobile

3.2. Electronic stability control (ESC)

ESC (Electronic Stability Control) or ESP (Electronic Stability Programme) is a system that electronically controls the stability of a vehicle. It is used to correct the trajectory of the vehicle and bring it back on track if it loses control of the vehicle in a bend. ESC has 3 types of sensors: a sensor on each wheel that measures the wheel speed, a sensor that monitors the position of the steering wheel and a sensor that monitors the rotation of the vehicle around its vertical axis.

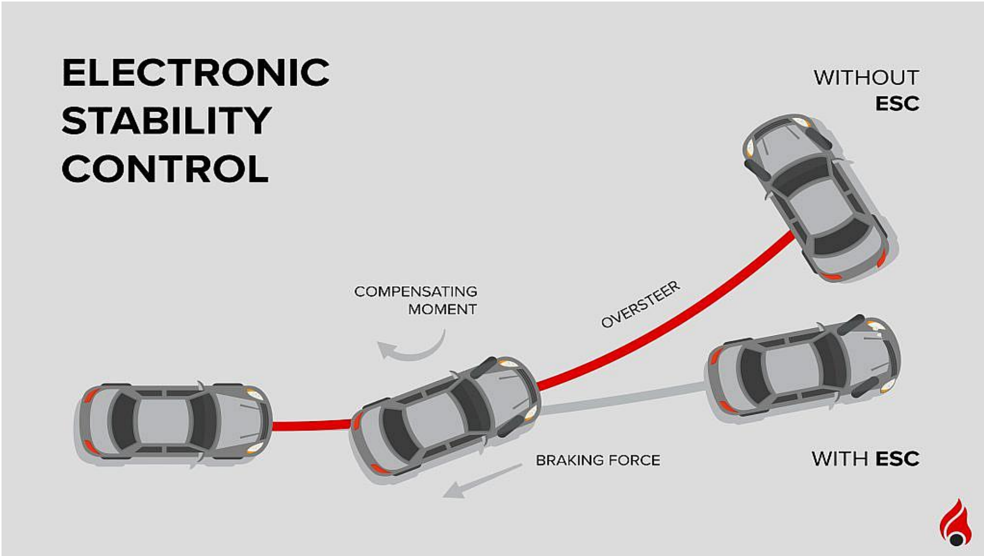

Fig. 5. Comparison of the trajectory of a car in a sharp turn with and without the ESC system

If the rear of the vehicle drifts to the left, the sensor on the steering wheel informs the control unit of the desired direction of the vehicle, i.e. where the driver wants to steer the vehicle. The sensor for the rotation of the vehicle around its axis then reports information about the angle of the vehicle in the bend. Based on this information, ESC activates the braking of the right front wheel to try to correct the trajectory of the vehicle. In the event that the car slips to the left at the front, ESC brakes the left front wheel based on the data sent by the steering wheel sensor, i.e. the data on the desired direction and the vertical axis angle sensor, i.e. the data on the current trajectory in relation to the desired one. It was introduced in the late 1990s and has been mandatory in all new vehicles since 1 November 2014. It is estimated to have reduced the total number of accidents by 12% (preventing one in eight road accidents).

3.3. Autonomous Emergency Braking technology

Autonomous emergency braking is an artificial intelligence system in which the vehicle warns the driver of an imminent collision in the event of a possible collision and then, if necessary, takes over the braking completely and stops the vehicle autonomously. The European Parliament has decided that all cars must be equipped with an AEB system from 2022. It has 3 functional levels. At the first level, safety parameters are monitored: the distance to vehicles or pedestrians in front, the distance to edge lines or lanes and the driving speed. The distance to obstacles or cars is usually monitored using radar technology. The second functional stage is a possible accident risk – the car assesses that there is a risk of an accident and initially warns the driver with sound and light signals. This is followed by partially autonomous braking (50 to 100 per cent braking intensity). In the third stage, the brakes are activated by opening an electromagnetic valve and brake fluid, which is pressurised to 50 to 100 bars in a hydropneumatic energy tank, flows into the hydraulic system. This increased pressure in the system generates a force on the brake pads, which press against the brake discs and stop the car.

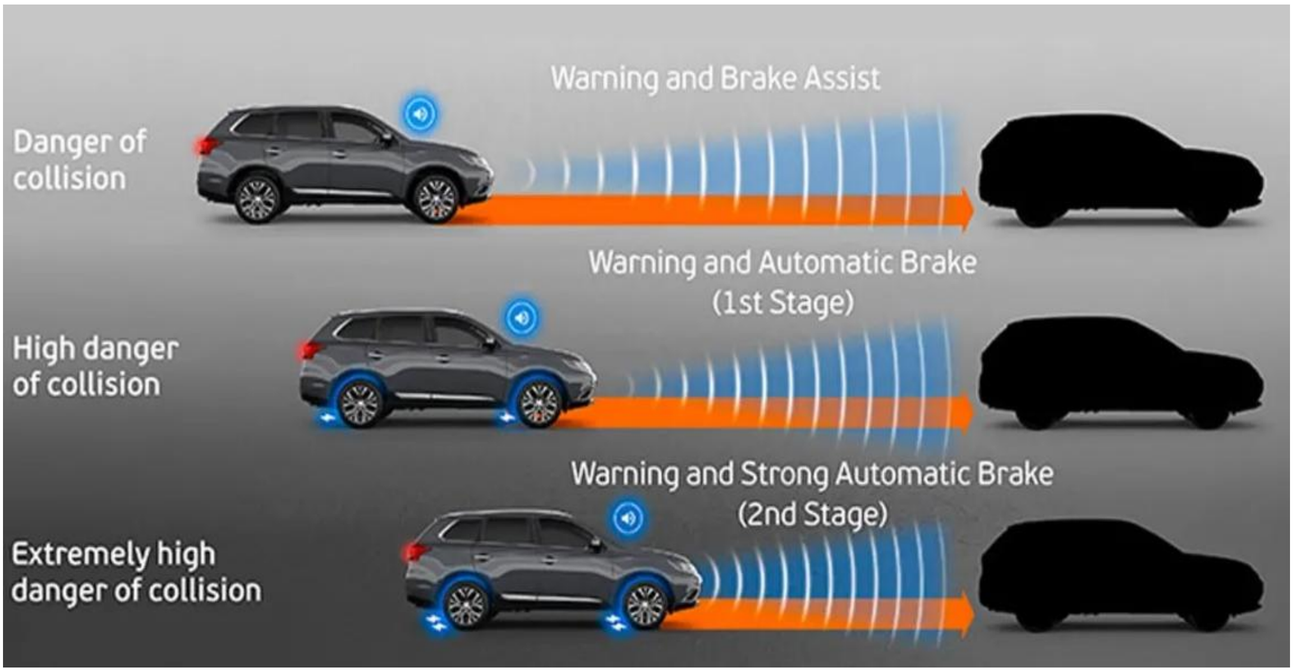

Fig. 6. Visual display of the distance for activating different levels of AEB

3.4 Adaptive Cruise Control

ACC (Adaptive Cruise Control) is an artificial intelligence technology designed to make long car journeys easier and more pleasant. Before we switch on the cruise control, we tell the car whether it should maintain a small, medium or large distance from the vehicles in front (the size of the distance also depends on the driving speed, a small distance at a speed of 60 km/h will be smaller than at a speed of 120 km/h). While driving, the car uses the radar and camera to constantly monitor whether there is a vehicle in front of it.

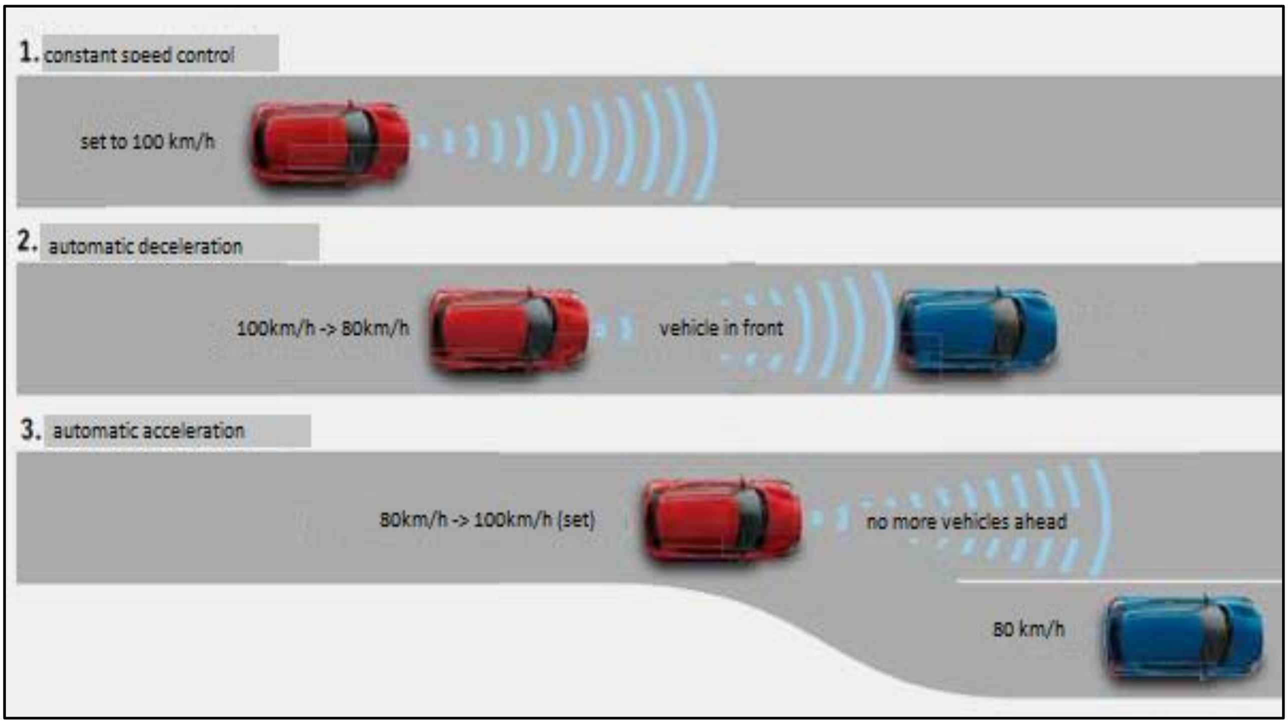

Fig. 7. Example of speed adjustment with adaptive cruise control

If there are no vehicles or obstacles in front of the car while it is travelling, adaptive cruise control behaves like normal cruise control. If the vehicle in front slows down and the car approaches it, adaptive cruise control reduces the fuel supply or brakes gently to maintain the desired distance between the vehicles. If the vehicle in front leaves the lane or accelerates, the adaptive cruise control accelerates the car back up to the desired speed. Adaptive cruise control usually has an automatic emergency braking function (chapter 3.3). One of the disadvantages of adaptive cruise control is excessive braking in the event of a collision with a vehicle. The car brakes much harder than the driver himself would, which can be unpleasant for other passengers. In addition, adaptive cruise control may not work properly in storms, bends or faded lane markings on the road.

3.5. Airbags

In the 1950s, as road traffic increased, so did the number of road accidents. As there were no adequate safety measures and technologies in motor vehicles at the time, the fatality rate was high. For this reason, John W. Hetrick applied for a patent for the concept of an airbag in cars in 1952, which was approved in 1953. "The concept was an inflatable airbag in the steering wheel and on the dashboard, activated by a valve that opened rapidly and inflated the airbag with air accumulated in a tank in the event of a collision" (Viano, 2024). Although it was initially a rather dangerous technology, as in the first versions of this technology the incorrect activation of the airbag often caused more harm than good (there were even deaths recorded due to the airbag inflating too late or too early), with further improvements in the technology it has become an essential part of the equipment of every car produced in the last 20 years. Some countries such as the United States of America, Brazil and India have made it a legal requirement for car manufacturers to fit airbags in all new cars. Most of the new airbags are based on Supplemental Restraint System (SRS) technology.

Airbags work as follows: The car constantly monitors the impact sensors (accelerometers, gyroscopes, pressure sensors). If the sensors detect a force that is too great to be considered an impact (usually at speeds above 25 km/h), the sensors are activated. The control unit receives a signal from the sensor and sends a signal to the airbag inflator. The airbag inflator ignites a small pyrotechnic charge which triggers a chemical reaction.

This chemical reaction releases a gas (usually sodium azide – NaN_3), which fills the airbag within ten milliseconds. As the airbag expands, it pops out of its frame, steering wheel, side support, etc. In newer versions of this technology, the airbags are also activated outside the vehicle to protect pedestrians who have been hit by the car. Some newer models also cut off the fuel supply, unlock all vehicle doors and notify emergency services in the event of an accident. The latest innovation in this area is adaptive airbags, which adjust the force or speed at which the airbag inflates, the timing of the inflation and the selective inflation of the airbag (the airbag is divided into several sections that inflate one after the other). The system decides which technologies should be used and how, depending on various factors such as the size of the front passenger, the seating position, the severity of the impact, the impact angle and the use of the seat belt.

3.6. Traffic Sign Recognition (TSR)

Automatic traffic sign recognition (TSR) is a technology designed to offer drivers additional safety when driving. It is based on recognising traffic signs that the car encounters on the road and then memorises them. These are usually signs with speed limits, STOP signs, roads with right of way, etc. It is required in all cars with semi-autonomous and autonomous driving systems. The technology itself works with the help of cameras, which are usually located behind the windscreen and constantly take pictures of the road. The images are then pre-processed into formats that are easier to process. The image is normalised to a size of 32x32 or 64x64, colours are standardised to minimise differences in brightness, contrast is increased in areas of the image with lower brightness, Gaussian smoothing is applied to reduce detail and noise, and finally image variations are created (the image is rotated and scaled) to enable better generalisation and models for object recognition. The most commonly used models for object recognition are YOLO (You Only Look Once) or SSD (Single Shot Multibox Detector).

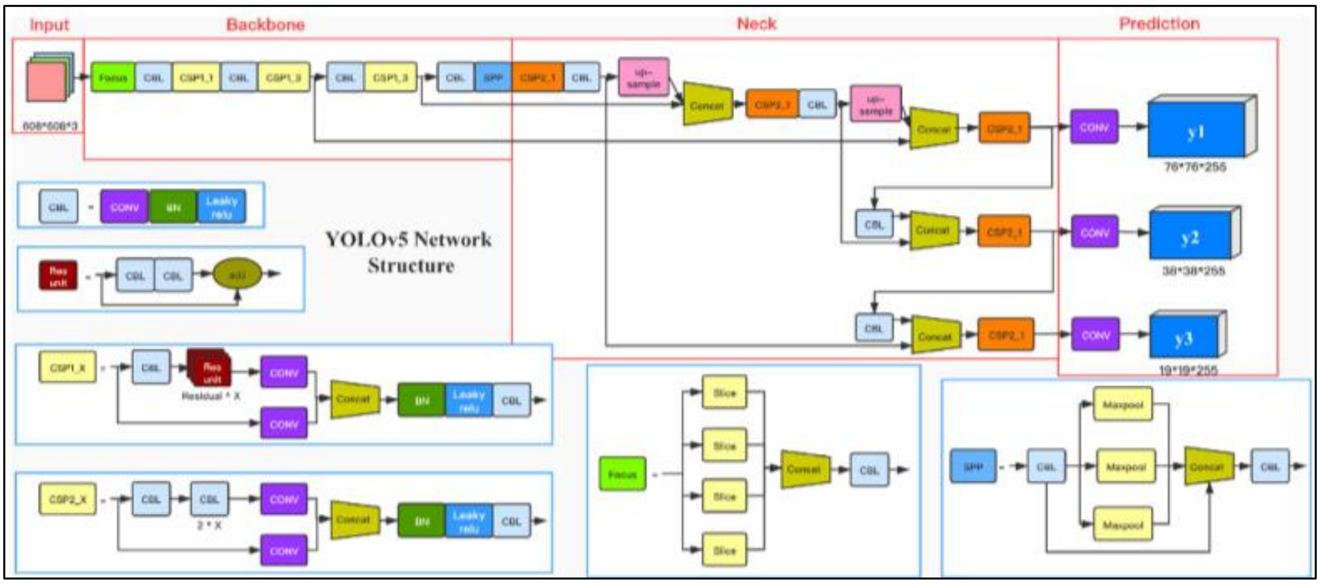

Fig. 8 YOLOv5 diagram

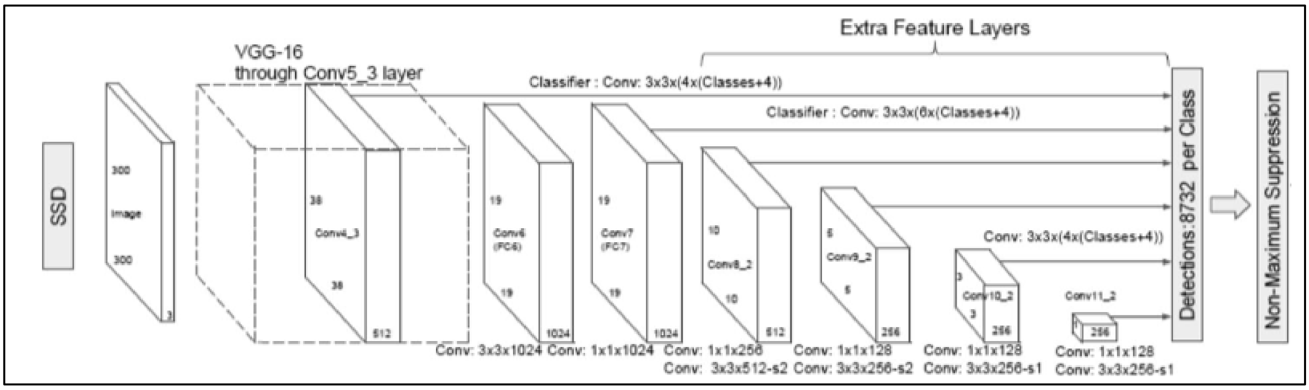

Fig. 9. SSD diagram

The system then identifies the signs using various techniques such as colour segmentation (red and blue) and shape recognition (triangle, octagon, circle) and classifies the signs into 3 categories: Regulations, Warnings and Information.

The signs are identified with the help of CNN (Convolutional Neural Network). "The Convolutional Neural Network (CNN) was developed for visual object recognition based on deep learning and has successfully overcome the shortcomings of conventional object recognition" (Zhu & Wei, 2022). These signs are then used to make decisions during (semi-)autonomous driving or are simply shown to the driver on a digital display. Some of the problems that this technology has to deal with and that make its work difficult are: damaged signs, poor lighting of the signs, graffiti on the signs, etc.

Fig. 10. Display of detected traffic signs using TSR

3.7. Autonomous and semi-autonomous driving

Although the functionality of the first autonomous driving system has already been described by Tesla, Inc. Since then, many manufacturers have begun to develop their technologies for autonomous driving.

3.7.1 Autonomous driving levels (SAE levels)

The automation of vehicles is categorised according to SAE (Society of Automotive Engineers) levels. A vehicle can have 6 SAE automation levels. SAE Level 0 is a level without automation, where the driver controls every aspect of the vehicle. An SAE Level 1 vehicle is capable of assisting with steering, acceleration and braking, but the driver must monitor these actions. A Level 2 vehicle steers, brakes and accelerates in certain situations, and the driver must be prepared to take control of the vehicle. At Level 3, the vehicle can fully control steering, braking and acceleration, but the driver must always be ready to take control of the vehicle. SAE Level 4 means that the vehicle can perform most tasks independently, with the driver only having to take control in certain situations. An SAE Level 5 vehicle is a fully automated vehicle and can act like a human driver in any situation. (SAE ORG, 2025)

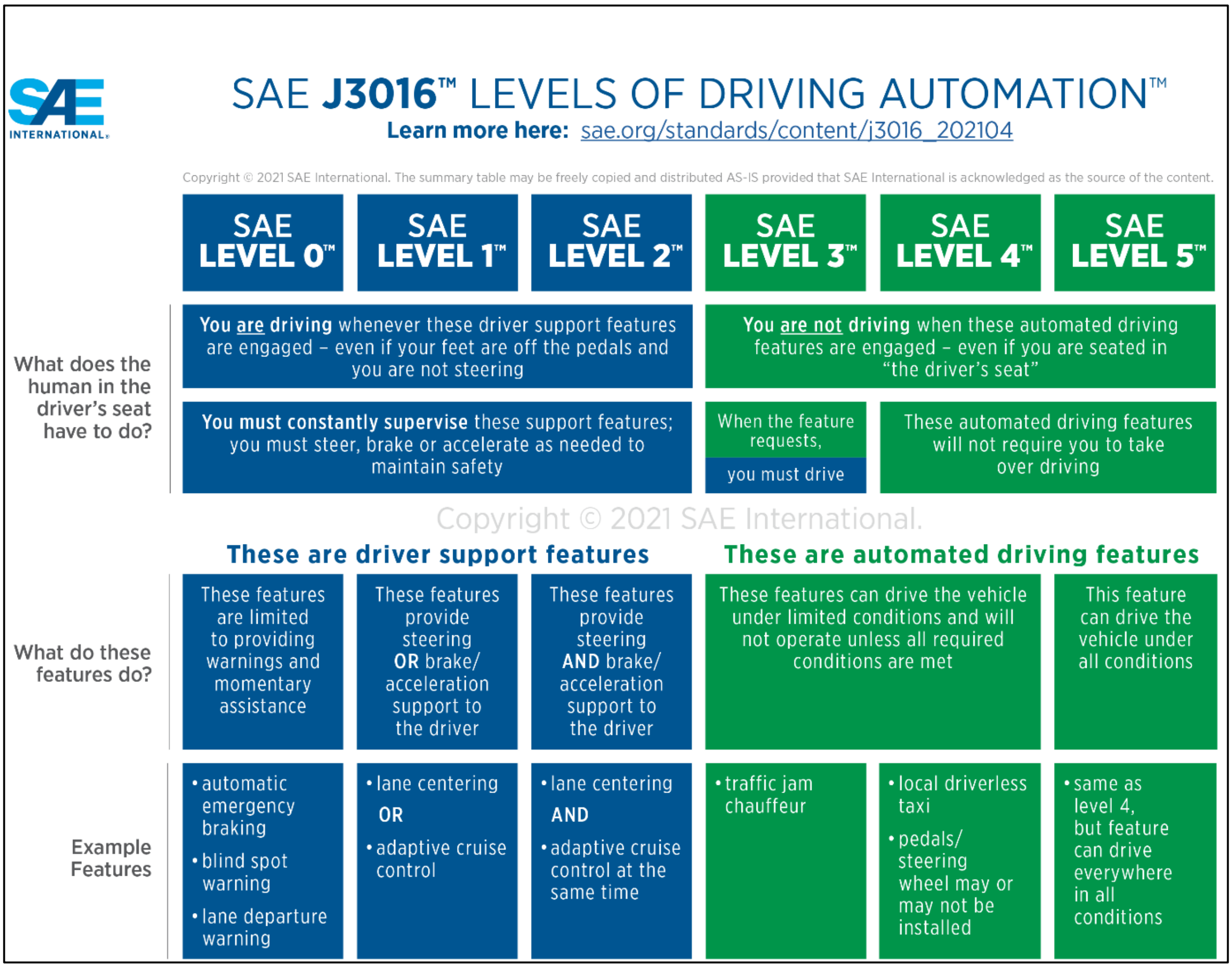

Fig. 11. SAE automation tables

3.7.2 Some of the leading semi-autonomous driving technologies

Tesla Autopilot is a technology that is one of the best-known services of this type of artificial intelligence. As this technology is an SAE Level 2 technology, it includes the following services: automatic steering, i.e. keeping the vehicle within the lane, cruise control, i.e. keeping a safe distance between the vehicles in front of you, autopilot navigation, automatic lane changing, automatic parking and reacting to traffic signs such as a STOP sign. A similar technology is the Mercedes-Benz DRIVE PILOT. Mercedes-Benz DRIVE PILOT, SAE Level 3, offers automated driving, which relieves the driver of decision-making in traffic, as well as assistance when driving in traffic jams at speeds of up to 60 km/h.

The technologies that make this possible are LiDAR, radar, camera and ultrasonic sensors. LiDAR, or Light Detection and Ranging, is a technology for determining the distance to an object. To do this, laser pulses are emitted and the time it takes for the reflected beam to return is measured. (Mercedes-Benz, 2025) GM Super Cruise technology is a General Motors company. Like Tesla Autopilot, this is an SAE Level 2 technology. It provides the driver with automatic lane keeping, adaptive cruise control to maintain a safe distance from vehicles ahead, and automatic lane changing. (Chevrolet, 2025) This artificial intelligence is realised through radar sensor technologies, cameras, LiDAR data and GPS.

Fig. 12. View of the virtual cockpit when using Mercedes-Benz DRIVE PILOT technology

Fig. 13. GM Super Cruise technology lane keeping assist

4. Possible problem of artificial intelligence

4.1. Overreliance on artificial intelligence

Although it makes driving much easier and safer, artificial intelligence in the automotive industry can also have negative consequences. One of the most important negative consequences is drivers' over-reliance on artificial intelligence to help them drive. In the future, drivers may no longer be able to operate older vehicle models that lack sufficient artificial intelligence. This could endanger other road users.

Similarly, in the event of serious malfunctions of the artificial intelligence in the car, the driver could rely solely on it to carry out a certain traffic action without checking whether it is safe before starting. This risk may only result in minor damage to the bumper of the car because the driver relied too much on the parking sensors to estimate the distance of the end of the car from the wall when parking the vehicle, and it can be much more dangerous. One example is a driver who no longer pays attention to the road when driving semi-autonomously with cruise control. When the vehicle in front brakes, the artificial intelligence or adaptive cruise control and automatic emergency braking do not react in time and a collision occurs.

4.2. Loss of driving skills by people

When learning to drive, many young drivers rely too much on technology that makes driving easier. As a result, they cannot safely drive vehicles that do not have this technology. The most common example is drivers who learn to drive cars with an automatic transmission and are therefore unable to safely operate a vehicle with a manual transmission. For this reason, many states issue two categories of driving license: a license that only allows you to drive cars with an automatic transmission and a license that allows you to drive cars with a manual transmission. Some of these countries are: United Kingdom, Japan, Germany, France, Italy and Spain. (Gov.UK, 2025)

If the driving test is taken with an automatic transmission, upon successful completion of the test, the participant will receive a driving license which only allows them to drive vehicles with automatic transmissions. However, if a person has passed the driving test in a car with a manual gearbox, they will receive a regular driving license which allows them to drive cars with both manual and automatic gearboxes.

Fig. 14. UK license to drive a car with automatic transmission

Fig. 15. UK driving license with manual transmission

4.3. Legal regulation of offences and accidents caused by artificial intelligence errors

In addition to the risk of losing the knowledge required to operate older, less technologically advanced cars, there is also a great risk of road accidents caused by the failure of some of the artificial intelligences on which the driver has relied too much when driving. There are many cases where the vehicle simply makes a mistake when relying on some type of artificial intelligence (mostly autonomous and semi-autonomous driving). In one case in San Francisco, a self-driving vehicle failed to stop in time and struck and killed a pedestrian. The manufacturer claimed that the driver, who was in the vehicle, was responsible for the accident. (Szymkowski, 2018)

There was also a case where a Tesla car in autonomous driving mistakenly identified the railway tracks as a road for motor vehicles, turned onto them and continued driving on them. (CBS, 2024)

Not all countries have yet enacted clear laws for autonomous driving offences. The companies almost always emphasise that the driver is obliged to monitor the system and take control if necessary. In the event of an accident, the driver is therefore at fault for not adapting the driving to the conditions on the road. However, some cars have the ability to drive autonomously, without human passengers in the vehicle. One such example is the arrival of a car from a parking space at the place where the passenger or driver is located. In this case, if the vehicle commits an offence, the driver cannot be sued for not driving or supervising the driving of the vehicle themselves. These issues need further consideration, all possible problems and cases need to be defined, and detailed laws need to be written to provide answers to all possible cases.

Fig. 16. Article about the accident in San Francisco

Fig. 17. Article about a traffic violation committed during autonomous car driving

5. Discussion and conclusion

Today, it is almost impossible to imagine an industry that does not include AI technologies. One of the many industries in which it has gained importance is the automotive industry.

The first implementations of AI in the automotive industry appeared at the beginning of the second half of the 20th century. These technologies was designed to make driving safer and more efficient. Today, there are more and more efforts to make driving easier with various technologies: adaptive cruise control to automatically maintain the distance between vehicles, automatic emergency braking when a vehicle in front is approaching, automatic recognition of traffic signs and semi-autonomous and autonomous driving. Although it is a good goal to make driving easier, there is a risk that people will lose their driving skills. It can happen that people who rely too much on AI when driving forget to rely on their senses. This is bad for two reasons. Firstly, they “gamble” by believing that AI will not make a mistake, i.e. that it will fulfil its task correctly and without error. Unfortunately, this is not always the case. There have been accidents where drivers have relied solely on the AI technology in their vehicle and not on their own senses and overview of the road conditions.

Another reason is that drivers learning to drive in an AI-equipped car can be dangerous in traffic if they are driving a car with very little equipment. For this reason, some countries have started to issue special driving licenses for people who have passed their driving test in a car with automatic transmission. After passing the test, these people were not allowed to drive a vehicle with a manual gearbox, while those who had passed the test in a car with a manual gearbox were allowed to drive cars with both manual and automatic gearboxes. The question of the loss of driving skills with the further development of AI remains unanswered and may be the subject of consideration and investigation in future scientific papers as the technology continues to improve and more data is collected for research.

The use of artificial intelligence in the automotive industry has steadily increased in recent decades, and this trend is expected to continue in the coming years. The problems identified so far, such as safety and efficiency, will remain challenges for future research and the application of artificial intelligence throughout the entire life cycle of the automotive industry from production and use to disposal.

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