UNIVERSIDAD FRANCISCO DE VITORIA

ESCUELA POLITECNICA SUPERIOR

Fundamentals of Computer Engineering

Practical work I

Self-driving Cars: Transporting people in a safe and efficient way.

GROUP 7

Abstract

In this practical work we will discuss the impact that self-driving cars have had in society as we know it today. This new technology wave has brought some incredible new advancements regarding safety; however, many are to think that this has its drawbacks too.

Therefore, here we will continue to explain what this is. To achieve this, we will explain the history of this technology, among its advantages and disadvantages, as well as how do they behave, with its algorithms and hardware components. It is also necessary and fundamental to know that a self-driving car is not the same as an autonomous vehicle, they each have their differences which are described later.

To show this, we will also focus on present day cases, such Tesla, Waymo and Uber, as well as China's new integration of autonomous vehicles in the 2022 Winter Olympics Games. This can give us a sneak peek to the future and what great new advancements await us just around the corner.

Resumen

En este trabajo práctico analizaremos el impacto que han tenido los coches autónomos en la sociedad tal y como la conocemos hoy en día. Esta nueva ola de tecnología ha traído nuevos avances increíbles con respecto a la seguridad; sin embargo, muchos piensan que esto también tiene sus inconvenientes.

Por ello, seguiremos explicando en qué consiste este proyecto. Para lograrlo, explicaremos la historia de esta tecnología, entre sus ventajas y desventajas, así como su comportamiento, con sus algoritmos y componentes de hardware. También es necesario y fundamental saber que no es lo mismo un coche autónomo que un *self-driving car*, cada uno tiene sus diferencias que se describen más adelante.

Para mostrar esto, también nos centraremos en casos actuales, como Tesla, Waymo y Uber, así como en la nueva integración de vehículos autónomos de China en los Juegos Olímpicos de Invierno de 2022. Esto puede darnos un adelanto del futuro y de los grandes avances que nos esperan a la vuelta de la esquina.

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1. Introduction

In the last couple of decades, technology has been evolving at an incredible speed, bringing a big number of new benefits and tools along the way. Us, humans, have learned how to use them in our favour, creating innovative projects and devices to make our lives somewhat easier, bringing big opportunities for humanity.

This new wave started with the Sixth Generation, from 1995 to now; in which a lot of elements that we use daily were created, such as mobile phones, artificial intelligence, and robots. This leads us to one specific topic: self-driving vehicles. Autonomous automobiles are, most likely, one of the biggest and most ambitious projects created in the past decade, not only because of the hard work that takes to develop them, but also because it's putting people's life at risk if it isn't built in the right way. This is constantly confronting different laws as well as taking care of what is considered ethically and morally correct.

Consequently, because of its sudden rise, self-driving vehicles are becoming more and more popular as time passes by, which incites a plethora of people into buying them. Now, this last fact shouldn't be seen as something negative or concerning, however, since people's lives are involved, we should focus on perfecting this new technology and figuring out the possible risks it could bring for humans, and how to prevent them. As a result, this leads us to the objective of trying to find different ways to improve it and make it as safe as possible.

In addition, we would like to focus on how computer science and artificial intelligence have had, and still do, an influence in autonomous vehicles: what elements of computing are involved? Is it completely safe for people? Does Artificial Intelligence cover all the aspects needed as good as a human brain would? How will it evolve in a few years? Will self-driving vehicles take over the whole world? These are questions we hope to find an answer to with our investigation.

Lastly, we would like to know if autonomous vehicles are the most efficient and accessible way of transporting humans, not only for the passengers inside the car, but also for the people surrounding them in the road; whether it's other drivers or

pedestrians. When we talk about its accessibility, we mean it in terms of law and price, since a lot of countries still have different rules to regulate its use; in most cases, making the autopilot forbidden.

1.1 Motivation

You may be wondering, what pushed us into choosing this matter as the main topic of our investigation. The answer is very simple; autonomous vehicles have had incredible growth in the past decade, and it won't stop anytime soon. We personally see it as the future of human transportation in a few years from now. Moreover, there's a lot of information regarding this topic that can be used in many ways.

In addition, this innovative project involves a lot of elements related to computer science and artificial intelligence, which makes it even more enticing for us, that is because it's something we can find passion and interest in.

Furthermore, we see a lot of potential in self-driving vehicles, which is why we want to focus on making it the safest and most efficient transportation method for people. We won't only be focusing on its performance, but also on making sure that there aren't as many restrictions in the future like the ones we have now. If we can make this possible, the world will become simpler to live in, allowing us to evolve faster, which is our main motivation.

1.2 Objectives

As mentioned before, our ***general objective*** is investigating the influence of computer science and artificial intelligence for the development of autonomous vehicles and making this method the safest and most efficient way of human transportation.

From this general objective, we have more ***specific*** ones, such as:

1. Studying the influence of Artificial Intelligence in self-driving and autonomous cars.
2. Evaluating their accessibility and freedom of use.
3. Investigating the laws that regulate the use of autopilot.
4. Estimating how they will evolve throughout the years.
5. Evaluating if autonomous cars will replace regular vehicles, and the different benefits they bring to the world.
6. Studying the different techniques that can be implemented to autonomous and self-driving cars.

1.3 Practical work outline

In order to fully understand the topic of the project, we will be discussing, and defining, the differences between self-driving cars and autonomous vehicles, taking in consideration the way they both function. We will also be investigating the background and founding fathers of the technology, so that way we can understand why, and when, autonomous vehicles and self-driving cars were created. We will explain the laws that control the autopilot feature on autonomous and self-driving cars; and the way you can use them, or not, depending on where you are in the world. This will be specifically focused on the European Union and the United States of America.

Furthermore, a description and differences of the driver in control and vehicle in control will be included, as well as classification and explanation of the different levels of autonomous vehicles and self-driving cars will we will state the different benefits, or consequences, that a person may potentially face find when using the technology.

To understand the future of the technology we will defining a life expectancy for the autonomous and self-driving cars in the future. Estimating the way they will evolve, grow, perform, and change humanity from the present time to the following years. It is essential to have description of the different hardware components that take place in the autonomous vehicles, and their primary function to make the technology work efficiently in order to get how the function.

We will be discussing the different elements needed to make self-driving cars work efficiently. Hardware and software components will be taken in consideration as well as the strategies that have had the most impact in the world using autonomous and self-driving cars. Uber, Waymo and China will be taken in consideration for this investigation.

2. Self-Driving and autonomous vehicles

The difference between autonomous vehicles and self-driving vehicles is essential in order to understand the levels of technology begin them.

If we take a look at the Oxford English Dictionary, the definition of autonomous is "denoting or performed by a device capable of operating without direct human control". On the other hand, self-driving refers to the vehicles that have the technology to drive themselves but depending on the situation human involvement is required.

The differences between both vehicles are crucial to understand the investigation, because as explained before, there is a factor that is different between each other, which is something that many people still don't know nowadays. Consequently, this generates a lot of confusion when referring to either one of them.

2.1 History of autonomous vehicles and self-driving cars

The idea of an autonomous vehicle was first presented in 1925 by an electric engineer called Francis Houdina, who built a car which could be controlled by radio. It was tested in Manhattan and drove along 19 kilometers between the Fifth Avenue and Broadway. It became popular by 1939 at the New York World's Fair by Norman Bel Geddes representing General Motors, a multinational that manufactures, assemblies, and distributes facilities throughout North America, Canada, and other countries around the world. It produces components, engines, as well as financial services. The aim of the multinational was to display an image of how the world would be in 20 years.

In 1958, General Motors made this idea a real concept. The car was supplied with pick- up coils, a component that answers to a change in magnetic flux by generating voltage, at the front end of the vehicle that detected the current flowing through a wire

place in the road. The flow could be changed in order to tell the vehicle to move the steering wheel left or right.

Autonomous vehicles were upgraded in the late 70's by the Japanese, they added a system with a camera that transferred all the information recorded of the highway. The addition of the camera caused a disadvantage in the car as it could only travel at maximum speed of 20 miles per hour, or 32 kilometres per hour. This problem was then solved by the Germans who design and built an autonomous car that could travel at a speed of 56 miles per hour or 90 kilometres per hour.

2.2 Description of the technology/topic

As time passes by, the automotive industry has improved and made a headway to a more autonomous world. These upgrades and innovations in this sector have helped to make a safer road environment. The way autonomous vehicles and self-driving cars work has been explained prior in point *2. Self-driving and autonomous vehicles*; however, it's also important to describe how you can use them in the world.

Even though this industry has been developing throughout the years, depending on the country you circulate, different legislations take place as some laws have been set in order to restrict some aspects of autonomous vehicles. Said laws will be discussed in the following point.

2.2.1 Legislation regulations

As mentioned prior in point 2.2, many different laws have been created to regulate the use of autonomous vehicles. In the European Union, the autopilot system is not completely legal to use, this is because of the *UN/ECE R79* regulation.

Consequently, many companies that manufacture autonomous cars with the autopilot feature, like Tesla, have created different updates on the software for the EU

countries regulations; this is to adapt to their restricting laws and give the European population the opportunity to use their vehicles, but with less features included.

On the other hand, this autopilot feature is easier to use outside of the European Union, however, it's not as easy as thought. If we go to the United States of America, the use of automated steering is legal to use, but not all around the country.

In addition, each state has different laws and legislation regulations in the US. We can only find the fully legal use of this feature in a few cities of the nation since that's how they legislation system works. The following map shows the legal levels of each state.
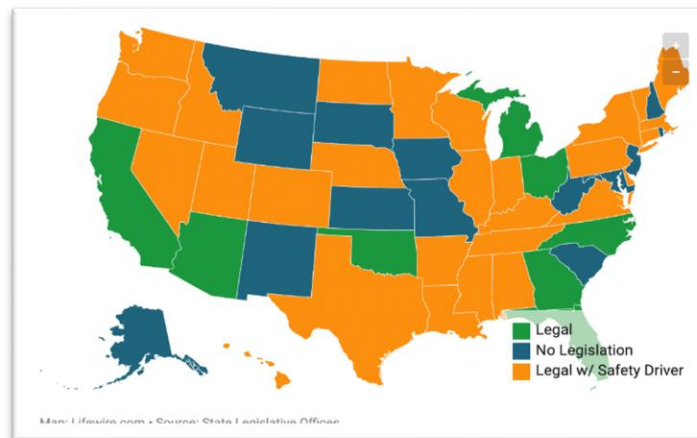

Figure 1. *Map of the United States of America's Legislations*

As we analyse the map, we can see that we have 3 different levels of legislation when it comes to the use of the feature of autopilot, these said levels are: Legal, No legislation or Legal with Safety Drivers.

Legal

- Arizona
- California
- Florida
- Georgia
- Michigan
- North Carolina
- Ohio
- Oklahoma

Legal with Safety Drivers

- Alabama
- Arkansas
- Kentucky
- Virginia
- Texas
- Tennessee
- Louisiana
- Mississippi
- Delaware
- Indiana
- Illinois
- Pennsylvania
- New York
- Connecticut
- Massachusetts
- Vermont
- Maine
- Wisconsin
- Minnesota
- North Dakota
- Nebraska
- Colorado
- Utah
- Idaho
- Nevada
- Oregon
- Washington
- Hawaii

No legislation

- Alaska
- New Mexico
- Kansas
- Missouri
- West Virginia
- South Carolina

- Maryland
- New Jersey
- Rhode Island
- New Hampshire
- Iowa
- South Dakota
- Wyoming
- Montana

Based on these different legislations between the EU and the United States of America, we can see that the use of autonomous cars isn't as accessible in Europe as it is in the US. However, the latter doesn't have much freedom either, only in a few states of the country. Lastly, we can conclude that the use of self-driving cars is far more accessible and common than the autonomous ones.

2.3 Control systems

The control systems working in self-driving cars are often divided into two groups: Driver-in-Control and Vehicle-in-Control.

- ***Driver-in-Control:*** system where the vehicle has semi-automated functions for driver assistance, but the driver is still ultimately responsible and in control.
- ***Vehicle-in-Control***: where the vehicle is fully autonomous and does not require a driver. The vehicle will likely be restricted to certain locations and conditions.

The Association of Automotive Engineers, also known as SAE, published in 2014 a classification system that includes six categories ranging from driver assistance to fully automated systems. Rather than looking at the vehicle's capabilities, this classification system is based on how much driver intervention is required.

- ***Level 0:*** Complete manual control. The driver of the vehicle performs every task.

- ***Level 1:*** The vehicle has semi-automated features for example speed monitoring through cruise control, but the driver is still responsible.
- ***Level 2:*** The vehicle is able to perform steering and acceleration tasks, but the driver is still responsible and can take control at any point.
- ***Level 3:*** The vehicle can detect its environment and can perform most tasks, but human override is still needed.
- ***Level 4:*** The vehicle is able to perform all driving tasks based on condition restrictions like weather or limited areas. Human involvement is optional.
- ***Level 5:*** The vehicle can perform all driving tasks under all type of conditions. No human intervention is necessary.

2.4 Advantages and disadvantages

Due to the new rise of self-driving cars, we have yet to discover all the benefits and perks that they present. However, one key advantage we were able to find is the comfort and convenience that these autonomous vehicles allow us to have. We could go from place A to place B while having breakfast or talking to your relatives. However, regarding the fact of this being a new technology, we cannot prioritise comfort over human lives, nevertheless we could be playing videogames in a near future.

Another huge convenience we may find within this technology is safety, thanks to the lack of human presence we can overcome the human risk with careless mistakes such as somnolence, rage or with distractions at the road. Nonetheless all these errors can be fixed. For example, new cars that are not yet autonomous, don't let you change from lane to lane unless you use the turn signals. The car also controls the distance with the car ahead to prevent any crashes. This safety advantage can also be applied to traffic regulations, so they are followed with ease.

Self-driving cars will also have a huge impact on people with disabilities, that can't usually use a standard car without all the cutting-edge technology, this will give more independence to move freely. Lastly, nowadays, people are more concerned with

gas prices and electricity, this is a good another good aspect of self-driving cars, that they can control in the most efficient way possible, to reduce the CO_2 emissions.

Despite all the advantages mentioned before, perfection is far from our reach and self-driving cars are no exception. These new automobiles can be seen as an opportunity or as a threat to some jobs. A main disadvantage on these cars is the starting price point which might not be accessible for everyone, although in a near future this might change.

Laws are a big obstacle on autonomous vehicles, for example in the European Union, cars cannot be fully autonomous, like in the U.S., luckily this is just a matter of time for us to improve this technology and for the authorities to make them legal worldwide. However, this is understandable, due to the constant pressure of cyberattacks or bugs in the system that might lead to fatal incidents or spyware with hackers.

Taxi drivers and delivery riders are also concerned about the rise of this new advancement because machines can do the same job, in a way more efficient way and the price in the long run is much cheaper.

2.5 The future of the technology

As we have seen throughout history technology grows in an exponential way, self-driving cars will follow the same path and within no time we will all have one of these smart cars at our garage. This is industry will be expanded in such way that prices will drop making it more accessible for everyone, although this time is yet to come, we can already see some manufacturers who announced new products at a more reasonable price, such as Nissan.

There are also many different projects and strategies planned for the future using this new wave, companies such as Uber, Google, and many more will be using autonomous vehicles and self-driving cars for future improvements. This will

consequently bring a lot of changes in the work industry regarding vehicles as the main matter, taxi drivers being the most affected ones.

This will be further explained in the point *4. Most important strategies implemented.*
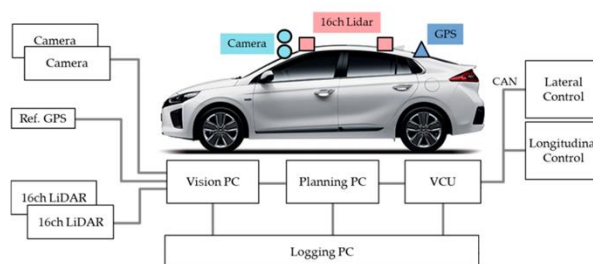
3. Essential elements of the autonomous vehicles

Figure 2. Components of Autonomous Cars

As seen on the image, these are the fundamental *hardware and software* elements to make an autonomous vehicle function efficiently. These are the following:

- *Camera:* captures images of the environment and different objects the vehicle is currently in. This information collected by the camera is then transferred to other components, to make the vehicle work smoothly and safely.

- *GPS:* Global Positioning System, also known as a GPS, used for precisely locating any person or object in the world, evaluating your current position, and allowing you to move from point A to point B without having to know the address; the system can provide you with it in case you are clueless.

- *Vehicle Network:* fundamental element of autonomous cars. It interconnects the different components of the car, working similarly to a computer bus. This allows exchange of information between the elements.

- *16inc LiDAR:* Light Detection and Ranging o Laser Imaging Detection and Ranging, also known as LiDAR, it's a sensor capable of detecting different distances using laser signals.

- **_Planning PC:_** this feature is extremely important because it can evaluate the surroundings of the autonomous vehicle and choosing a path that it can follow properly, without crashing, with the information captured by the cameras and sensors.

- **_VCU:_** Vehicle Control Unit, also known as VCU, receives different instructions and information from the sensors to detect obstacles on the road.

- **_Computer Vision PC:_** with the use of artificial intelligence, computer vision can identify different objects in the road, such as cars, people, traffic lights, and more through the cameras of the vehicle. This is also thanks to the information captured by the sensors.

- **_Logging PC:_** This is considered the memory storage of the vehicle. This component stores the data and information captured by the CAN Transceivers, cameras, sensors and the bus and it retrieves them when needed in a short period of time.

- **_Sensor Fusion and perception:_** this feature can combine all the information retrieved from various sensors and compiling it to assure the most certain and safe navigation of the vehicle; making the passenger safe.

- **_CAN Transceivers:_** they can receive different signals emulated by the vehicle network and sending or executing different set of instructions in return to the bus. They include the following components.

  - **_Lateral Control:_** this allows the vehicle to remain in the centre of the road. This makes the car more stable when driving between different lanes.

  - **_Longitudinal Control:_** takes control of the gear management of the vehicle and the switch between throttle and the brakes.

3.1 Technologies used in self-driving cars

3.1.1 Hardware

The control system of a Self-Driving car is principally based on an artificial neural network capable of sending signal between them in a small period of time. Artificial neural networks are trained with situations and photos of real life, so they can react in a specific moment in the less time possible avoiding a disaster or a crash..

The computer is divided into three modules that at the same time create clusters (NODOS) connecting all the information and deciding over the entry information. These are the following components:

- *Operator Cluster:* The operator cluster it's the man-machine interface, it could be a keyboard or a screen. You communicate with the machine with this hardware.

    On the other hand, the car needs hardware outside the car which gives information to the central computer, one of them is the sensors.

- *Computer Vision:* Process where we use camera pictures to determine what is surrounding the car, such as other vehicles, people, and elements on the road.

- *Sensor Fusion:* This is the process where we combine the information of different sensors around the car and create a better understanding of the environment

- *Vehicle Status Viewer:* in charge of evaluating the behaviour of the driver in case that they might need to take the steering wheel to take care of an emergency. This assures that the passenger is always aware and paying attention, despite of not driving.

If we compare the elements used in self-driving cars with the ones used in autonomous vehicles, we can see that, even though they use similar components, the latter is far more complex; needing to retrieve more information in order to make it one hundred percent safe without human supervision.

3.2.2 Software

Self-driving cars use the most advanced technology in the market to ensure safety and comfort, leaning in hardware and software. Despite the incredible advancements in hardware, software has had a huge impact with all the new complex algorithms. A self-driving car uses software with image recognition to establish the difference between objects, people, as well as the road.

A great example and perhaps the most popular, is Tesla's algorithm which is implemented in all their cars. Although autonomous cars are illegal in most countries as mentioned before. However, it has been proven to be effective. It can detect different lanes as well as traffic lights and moving objects, such as pedestrians and cars. Elon's cars use cameras to detect all this, however other brands such as Nissan use LIDAR sensors.

The A.I. uses machine learning (Deep Learning) to improve its software, collecting data from all the Tesla's around the world, using all these scenarios to improve and avoid any future collision and make this A.I. as close to perfection as possible.

4. Most important strategies implemented

4.1 Uber case

Uber is also trying to replace their in-person drivers to the idea of autonomous cars only that it is still a bit in development as they tried a few years ago and there was a problem with this new technology.

What happened was that in March 2018 in Arizona an Uber autonomous vehicle hit a woman. This happened because the software of the did not correctly detect the woman as a pedestrian. Also, the automatic emergency braking system was not activated, if it had been activated the mishap of killing a person would not have happened so the idea that Uber had of autonomous driving was put into question whether it would be good to do it or not.

After a few years Uber has managed to sell the entire group of autonomous cars that Uber built to Aurora for 4,000 million which is a start-up founded by former employees of Uber and Google that is being funded by Amazon.

Uber has not been able to make money in the last few years, in fact it only has losses in 2020 it was estimated that Uber would have losses of more than 1.1 billion dollars, much higher than the 887 million it lost in 2019. This sale managed to save itself from those losses, Uber's own employees say it was like an angel falling from the sky.

Uber also has its own legal disputes in many countries where they have complaints of unfairness and among other complaints are also for the working conditions of their workers.

In this same 2022 Uber has reached an agreement with Hyundai to turn them into autonomous cars and is the Hyundai IONIQ 5 known as the Robotaxi and that is constituted by its 30 sensors throughout the car, among them we find radar and LIDAR cameras so that it can have a generalized view of 360 degrees.

It is also an electric car with rear and traditional propulsion that can reach up to 306hp. So far it has already made more than 100,000 successful trips on public roads in Los Angeles, Las Vegas, and Singapore.

4.2 Waymo (Google) case

Google and Waymo are companies that receive the services of the multinational Alphabet Inc. since this company is dedicated to give them a series of products which are electronic services, software, and internet.

This project was launched by Google in 2017 and would be responsible for developing and manufacturing the sensors necessary for this self-driving car to work.

What Waymo had planned to do from the beginning was to be able to manufacture a car without steering wheels and even without pedals and many engineers thought it was crazy, what the engineers said is that they should manufacture the cars like Tesla anyway the co-founder of Larry Page was not in favour of this project.

However, Waymo wanted to continue its project and has continued to strengthen its strategy, having to make very important decisions. One of them was that in 2017 they reached an agreement with Fiat to test their new technology in some vehicles in California and Arizona.

Waymo relies on the development of the hardware necessary for the vehicle to be effective, as well as the necessary sensors. It has been achieved the creation of an automated driving ecosystem, which can be integrated into some vehicles, only if the manufacturers are willing to reach an agreement with Waymo.

In the United States, Waymo has already developed its own cabs, which charge you their own fares. Now, they have already been used in some suburbs of Phoenix and they are also all over California Arizona Texas New Mexico and in a while, they will also be in Los Angeles. And they are already managing to stand up to their competitors Uber and GM (General Motors).

4.3 China

China is not going to be left behind either. Trough the last 5 years, Baidu, the Chinese version of Google, and many other companies have joined the race to develop their own autonomous cars. Six years ago, an important controversy was generated around Baidu since, based on a legal void, they started to test a prototype in a real traffic situation without the government permission. They said that nothing bad happened to anyone, but the government developed laws to regulate this.

Around a year later, SAIC motors and NIO, two Chinese companies, received licenses to test their cars in real traffic situations in the suburbs of Shang Hai, and Baidu was allowed to put their prototypes to circulate in Pekin, capital city of China, around an area of 106 road kilometres.

China is taking advantage in this field. In the Shougang park, west Pekin, and where the 2022 Winter Olympic Games would take place, after a development step, held in Shang Hai, Baidu will deploy their "APOLLO GO", a vehicle which would serve as a taxi inside the place (Around 4 square kilometres), but without a driver, which will

suppose a quite big step in the commercialisation of autonomous cars, and the government is planning to expand this service to other 30 cities in the following three years.

We must also highlight the creation of Xiong'an, an area 95km away from Pekin where the government has ordered the creation of a city specially created for autonomous vehicles to circulate in it. They are planning to introduce to everyday life traffic lights with artificial intelligence vision, among other new technologies.

5. Conclusions

5.1 General Conclusions

When working on this project, a lot of complications were found along the way; mainly involving teamwork strategies and the amount of work put on the investigation by each teammate.

Furthermore, we found ourselves confused when defining the topic we wanted to work on, what the purpose of the project was, the different objectives we wanted to set, and the points we had to define in the practical work outline. This occurred because each person had a different point of view, so we had to work together to implement all the ideas into the project; not leaving anyone out.

Finally, we oftentimes had to talk to each other to distribute the tasks equally throughout the whole journey, taking in consideration the written document, the speakers, and the PowerPoint slides. It was, overall, a very stressful and nerve-racking experience, however, we think we have come to a successful final product.

5.2 Topic Conclusions

After investigating on different factors of self-driving cars and autonomous vehicles, we have concluded on the general and specific objectives of the project, finding the pursued answers to prove the hypothesis.

After studying the influence of Artificial Intelligence, there are many elements in which this technology takes place. It's seen on many features, such as computer and image vision, sensor fusion, vehicle status viewer, obstacle detection and many more. We can conclude that AI is an essential feature of autonomous and self-driving cars, and that they wouldn't be able to work efficiently and safely without it.

Furthermore, the study of the accessibility of autonomous vehicles and the laws that regulate the autopilot take a big place on the investigation. We have concluded that, as for now, the complete use of autonomous cars and the autopilot feature isn't fully accessible in the whole world, due to many legislation regulations that control it. It is only possible to use it in a few states of the US. That is because, in the European Union, the autopilot feature isn't legal to use.

As for the evolution in the future, autonomous and self-driving cars have an amazing potential and many projects planned for the next following years, mainly involving delivery methods and taxis fully controlled by the car, without any human supervision. This concludes that they have a very big evolution ahead of them.

Moreover, it is safe to say that autonomous vehicles and self-driving cars will most likely replace regular ones in a few years from now. That is because of the huge number of projects and strategies made by companies like Uber and Google and the country of China, that bring many ideas to the table that won't require the human control over the car anymore. Said strategies involve the replacement of traditional taxi drivers, since they won't me further needed to take the steering wheel.

When it comes to the benefits they can bring, we're talking about safer driving, reduction of accidents of the road, better management of battery and fuel of the vehicle, more free time for the passenger during the trip, respecting signals, traffic lights, and many more. We can conclude that the advantages are way bigger than the disadvantages for humanity.

Finally, it's safe to say that this new wave will make a lot of improvements for humans and the way we move around the world, doing it in a safer and more efficient way.

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