People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

Mohamed Boudiaf University of M'Sila

Faculty of Mathematics and Computer Science

Department of Computer Science

N° :……..

FIELD: MATHEMATICS AND COMPUTER SCIENCE

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OPTION: ARTIFICIAL INTELLIGENCE

Thesis presented for obtaining the Academic Master's degree

by:

Mekhalfia Mohamed Zakaria

Entitled

An Innovative Smart System for The Safety of Driver

Defended in front of the jury composed of:

Dr. Akhrouf Samir	University of M'sila	President
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Dr. Bounif Mohamed	University of M'sila	Examiner
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DEDICATION

رحم الله ضحكة لا تنسى وابتسامة لا تفارق البال. رحم الله وجها كان يشع نورًا وفرحًا

أهدي هذا العمل لجدتي التي وافتها المنية وأنا أعمل في هذا المشروع ، رحمها الله وجعلها مع الذين أنعم الله عليهم من النبيين والصديقين والشهداء والصالحين

وحسن أولئك رفيقا.

ACKNOWLEDGMENTS

Firstly, I thank God who gave me the strength to complete this work, so Alhamdulillah for everything

I would also like to express my deep gratitude to my supervisor Dr. Said Gadri, for his support, valuable advice, and availability throughout the development of this dissertation. I would also like to thank Dr. Mohamed Chatra, head of the department, for his support and encouragement.

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Thank you to everyone who has contributed, directly or indirectly, to the success of this dissertation.

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List of Abbreviations

AI: Artificial Intelligence

ML: Machine learning

DL: Deep learning

RNNs: Recurrent Neural Networks

ANNs: Artificial Neural Networks

ASIRT: Association for the Safety of Registration and International Road Travel

MICO: Ministry of Interior and Local Authorities

NHTSA: National Highway Traffic Safety Administration

LPG: Liquefied Petroleum Gas

CNN: Convolutional Neural Network

HFC: Hypersomnia Foundation's Conference

D-ORS: Observer Rated Sleepiness vehicle behavior

B-ORS: Observer Rated Sleepiness Driver behaviour

EEG: Electroencephalogram

ECG: Electrocardiogram

LBP: Local binary patterns

SWM: Steering Wheel Movement

RL: Reinforcement learning

ZIP: Zone Improvement Plan

General Introduction

In recent decades, technological advances have led to a revolution in the field of Artificial Intelligence (AI) that is affecting every aspect of our daily lives. From smart home devices like Amazon's Alexa and Google Home to self-driving cars, AI has become an integral part of our society. Although the technology may seem intimidating at first, it's actually quite simple and it can be used for a variety of purposes, from making your life easier to helping you get ahead in your career. So what exactly is AI? In simple terms, the term refers to computer systems that are capable of performing tasks normally requiring human intelligence. This includes making decisions, solving problems and understanding language. And how does it work? The answer is complex, but the basics are simple. AI is a system that can learn from experience, make decisions and take actions. This is made possible by a subfield of AI known as machine learning.

Machine learning (ML) is a technique that allows computer systems to automatically improve their performance on atask through experience. In other words, the system learns from the data it is provided and improves its ability to make predictions and decisions over time. With its growing capabilities, AI is becoming more intelligent and it will continue to do so at an exponential rate as time goes on.

Deep learning (DL) is a subset of machine learning that uses neural networks with many layers to model complex patterns in data. It has become increasingly popular in recent years due to its ability to achieve state of the art performance on a wide range of tasks. One of the most famous deep learning algorithms is the Convolutional Neural Network (CNN), which is commonly used for image recognition tasks. CNNs are designed to automatically and adaptively learn spatial hierarchies of features from input images, allowing them to recognize patterns in images and classify them accordingly. Other popular deep learning algorithms include Recurrent Neural Networks (RNNs) and Artificial Neural Networks (ANNs).

As AI and deep learning continue to develop, they have the potential to revolutionize our world in ways we cannot yet imagine, with applications in fields such as healthcare, finance, and transportation.

Nowadays, these three terms: AI, ML, and Deep Learning are the most common buzzwords.

Chapter 1:

Driving Safety: Issues and proposed solutions

1.1 Problem Statement

Close your eyes for just a second while driving, and it could lead to a deadly accident. Drowsy driving is a growing concern, and its time to develop innovative solutions that can help keep drivers alert and safe on the road. In this thesis, we introduce an advanced real-time fatigue detection system that leverages deep learning to identify the early signs of fatigue in drivers. However, our project is not limited to detecting drowsiness. We have expanded our scope to include preserving driver safety from various aspects. For instance, we have developed a system that detects gas levels in vehicles to ensure drivers using gas as fuel are safe. We have also incorporated monitoring of temperature and humidity to understand their impact on driver fatigue. Additionally, our system includes a recommended safe distance feature, which helps drivers maintain a safe distance on highways to prevent accidents. Join us on a journey to develop a smarter, safer future for drivers everywhere.

1.1.1 Drowsiness

According to the latest research conducted by the Association for the Safety of Registration and International Road Travel (ASIRT), there are approximately 1.3 million deaths worldwide each year as a result of a road accident. An average of 3,700 people die every day on the roads. Another 20 million to 50 million suffer of non-fatal injuries, often resulting in long-term disabilities [1] The situation in Algeria is not deferential, with 32,200 road accidents recorded in 2018 against 29,300 in 2017 and 23,000 in 2016 according to statistics of the Ministry of Interior and Local Authorities (MICO). In 2022, the toll is even heavier with 1,105 deaths and 40,000 injured [2]

Statistics vary from country to country, but indicate that the total number of victims is constantly increasing.

One of the main causes of these accidents is drowsiness while driving. According to studies conducted by the National Highway Traffic Safety Administration (NHTSA), fatigue is responsible for about 100,000 car accidents each year in the United States. More than a third of road accidents are due to fatigue [3] .

The figure below “Figure 1” shows the number of deaths according to 3 factors (drowsiness, speeding, alcohol/drugs/medication) in 2006 to 2015

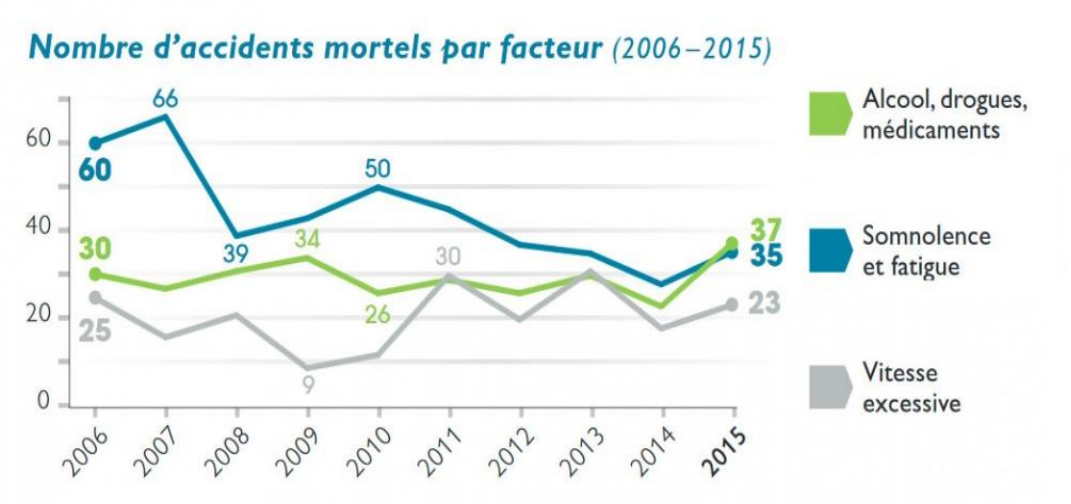

Figure 1*: number of deaths according to 3 factors: drowsiness,speeding,alcohol/drugs/medication) [56]*

The figure "Figure 2" below shows police-reported accidents at the state level related to driver fatigue, drowsiness, or falling asleep at the wheel.

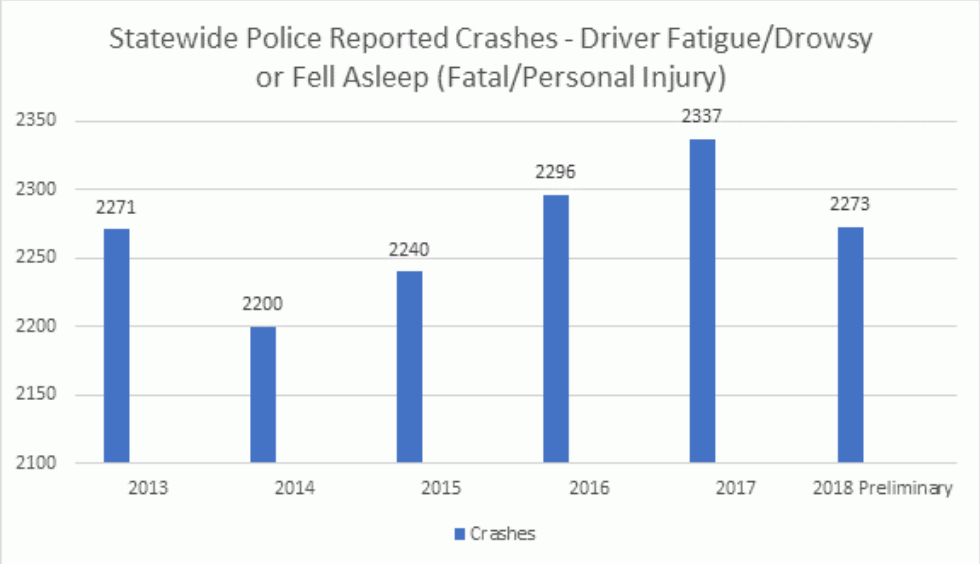

Figure 2: *Drowsy Driver crashes statewide in 2018 [4]*

1.1.2 Gaz detection

The gas of LPG :

Liquefied Petroleum Gas (LPG) is a clean, efficient, and readily accessible energy source for both individuals and professionals.

Naftal, with its multiple solutions for packaging and distribution in butane, propane, and fuel, makes LPG easy to install and use on a daily basis, especially as a fuel for vehicles.

LPG (Liquefied Petroleum Gas) is a mixture of hydrocarbon gases mainly composed 20% of propane and 80%of butane [5]. It is produced from the processing of natural gas and crude oil, and is stored in liquid form in special tanks. It is primarily used as an energy source for heating, cooking, vehicles, and industrial equipment

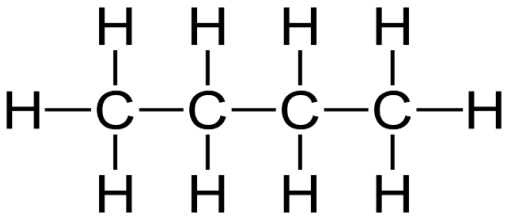

Figure 3*: Chemical and molecular formula of Butane*

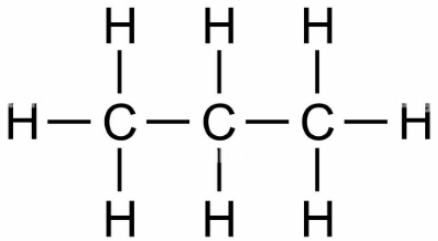

Figure 4 *: Chemical and molecular formula of Propane*

Installation of LPG kit in the car:

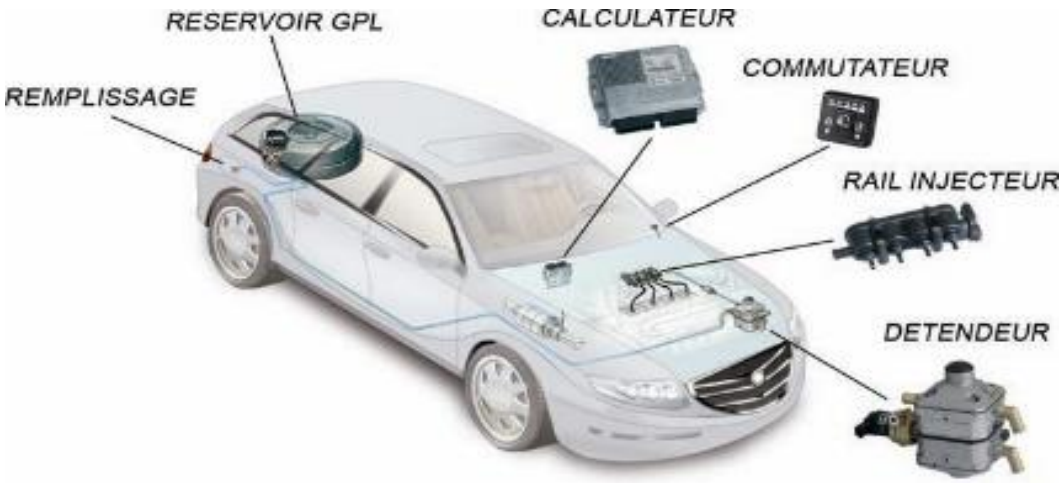

Figure 5: *Diagram for connecting to a LPG car*

Installing LPG in a car is typically done in a specialized workshop. The process involves choosing the appropriate conversion system, installing a GPL tank in the trunk of the vehicle, installing the distribution system, adjusting the car's injection system, and testing and certifying the installation. It is important to note that the installation of LPG in a car must be carried out by a qualified and certified professional to ensure safety and compliance with regulations. With proper installation, LPG can offer a cost effective and environmentally friendly alternative to traditional gasoline or diesel fuel.

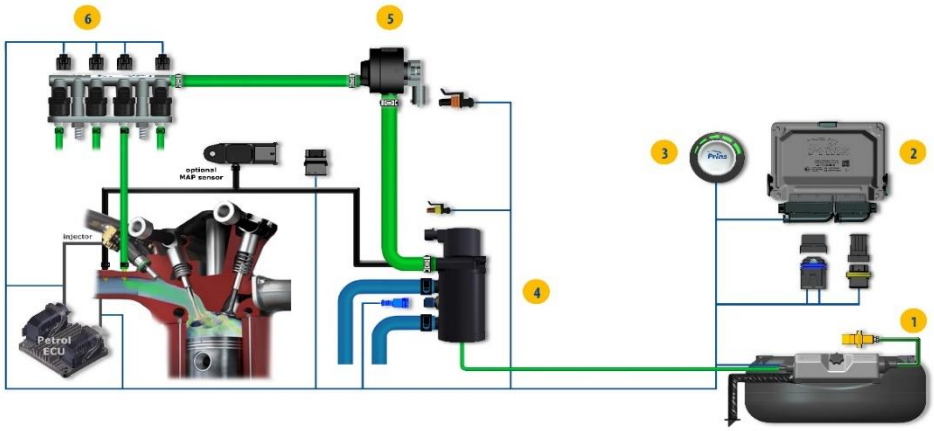

Figure 7: *Diagram for connecting to a LPG car*

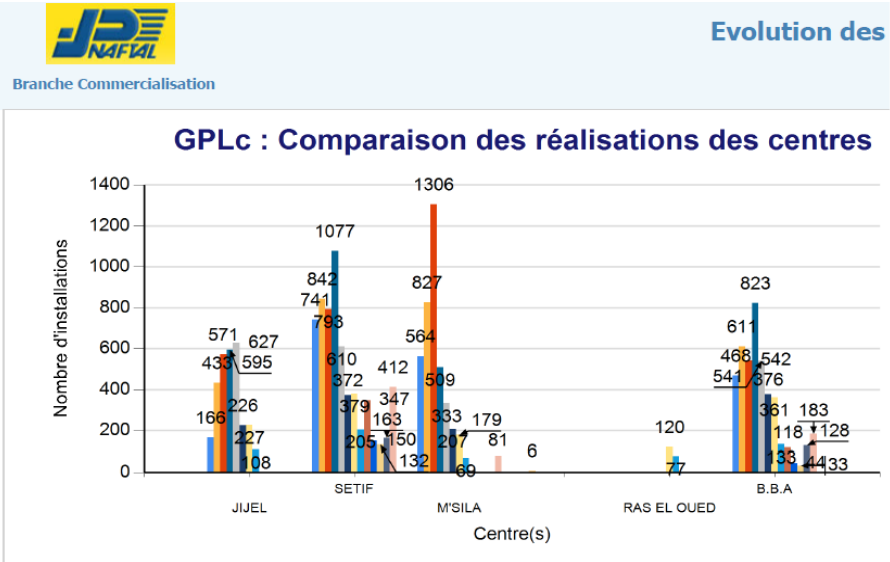

Figure 6: *Comparison of center achievements*

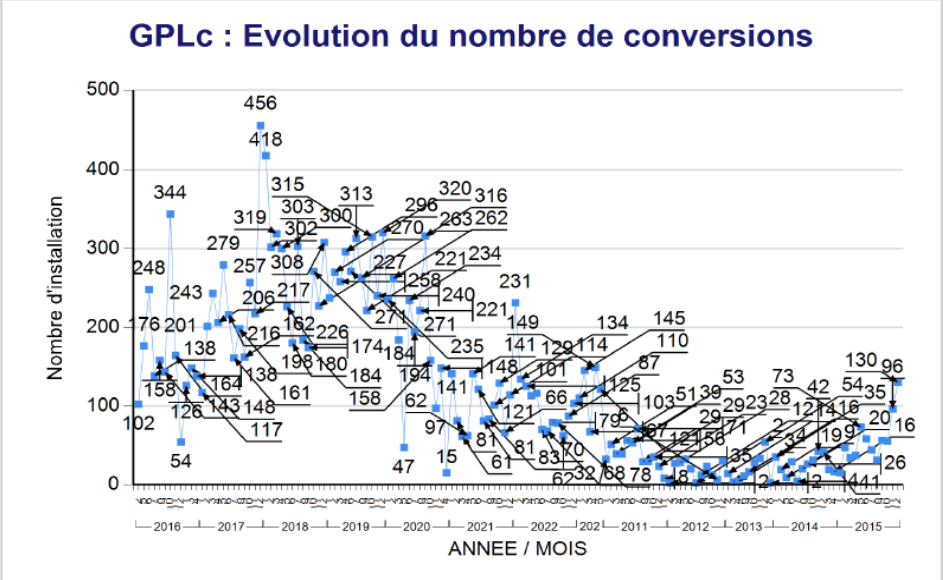

Figure 8: *Evolution of the number of conversions from gasoline cars to LPG*

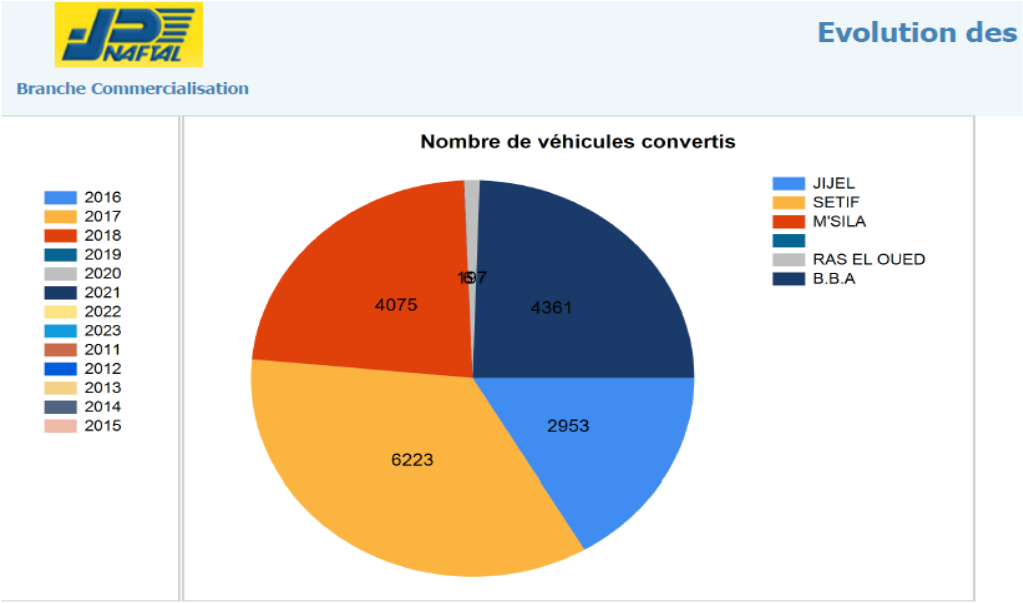

Figure 9: *Number of vehicles converted to LPG in the eastern region*

The risks of LPG:

Gas leaks from vehicles running on LPG pose a significant threat to the safety of drivers and passengers in Algeria. Despite the continuous efforts to modernize the gas infrastructure in the country, gas leaks remain a persistent problem, which can result in explosions and fires.

According to the Algerian Ministry of Energy, there were 1,529 gas related accidents in Algeria in 2020, resulting in 63 deaths and 1,536 injuries,These statistics underscore the critical importance of gas safety for both drivers and passengers [6].

The use of LPG as a fuel in vehicles has become increasingly popular in Algeria due to its cost effectiveness compared to traditional fuels. However, this alternative fuel presents risks to drivers and passengers in the event of a gas leak. The dangers of LPG gas leaks are not limited to vehicle fires or explosions; even a small leak can cause headaches, dizziness, and nausea, and in some cases, asphyxiation.

In addition, gas leaks from LPG vehicles can have negative environmental effects due to the release of greenhouse gases and other atmospheric pollutants. The International Energy Agency reports that greenhouse gas emissions from natural gas production in Algeria increased by 3.2% between 2019 and 2020, further emphasizing the need for improved gas safety measures in the country [6]

Figure11 :*Cars running on GPL*

Figure10 :*Cars running on LPG*

Figure 13: *Car running on LPG in flames near Rouen [7]*

Figure 12: *Explosion of a vehicle in El Meneaa, Algeria" [52]*

Proposed solutions to avoid the risks and damage of LPG:

Set up a LPG gas leak detection system so that it can detect gas leaks before they cause damage.

This system resembles a sensor connected to a mobile application that needs to be placed in the trunk of the car with the LPG tank. This sensor has the ability to detect gas leaks before the gas reaches the driver of the car.

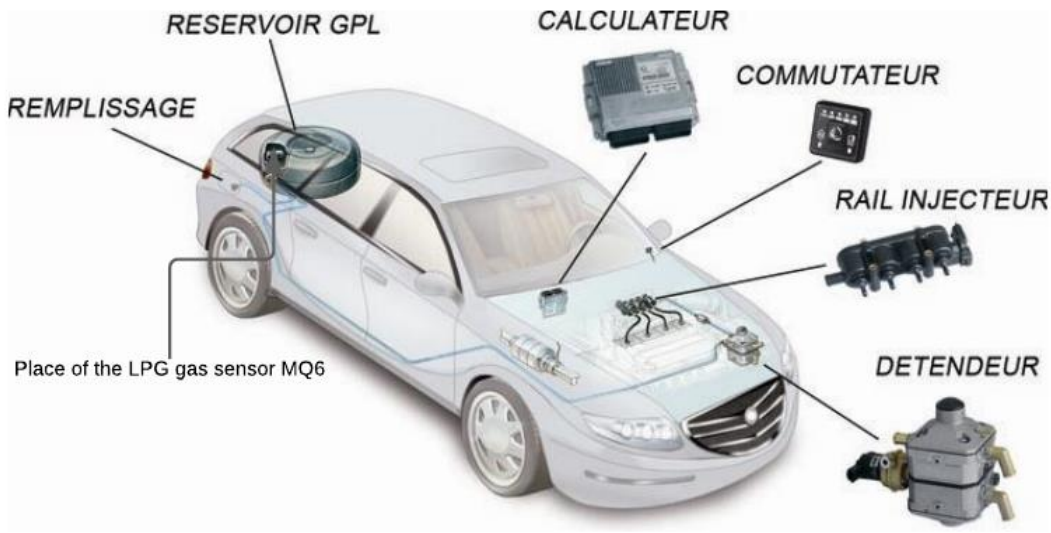

Figure 14:*Place of the LPG gas sensor MQ6*

1.1.3 The Safety Distance: A Key Element for Safe Driving

Failure to maintain a safe distance is one of the leading causes of accidents on highways. If a driver does not maintain a sufficient distance with the vehicle in front, they may not have enough time to react in case of emergency. For example, a vehicle that brakes suddenly can lead to a rear end collision if the following driver does not have enough distance.

To ensure safe driving, it is important to maintain a sufficient distance between your vehicle and the one in front of you. This distance allows you to have enough time to react to any potential hazards. The National Safety Council recommends a minimum following distance of three seconds.

To determine your following distance, you can use an overhead road sign, a tree, or another roadside marker as a reference point. Note when the vehicle in front of you passes that marker, and then count the number of seconds it takes for you to pass the same spot (count 1;2;3). If the time is less than three seconds, increase your following distance by leaving more space between your vehicle and the one in front of you.

It is important to think of following distance in terms of time, not space. Highway engineers use a standard of 2.5 seconds to represent the time it takes a driver to perceive and react to hazards. The National Safety Council also uses this standard and recommends adding a little extra time for safety when following the three-second rule for maintaining a safe following distance [7] .

Sometimes Three Seconds Is Not Enough:

During ideal road and weather conditions, passenger vehicles are recommended to follow the three-second rule for maintaining a safe following distance. However, it is crucial to slow down and increase the following distance even more during adverse weather conditions or reduced visibility. If you are driving a larger vehicle or towing a trailer, it is also essential to increase your following distance accordingly.

Distractions, such as texting, reaching for a drink, or checking a navigation device, can also lead to rear end collisions, even if you are following the three-second rule. If you are distracted, you may not have enough time to react to a hazard, which is another reason why it is crucial to avoid distractions while driving [8] .

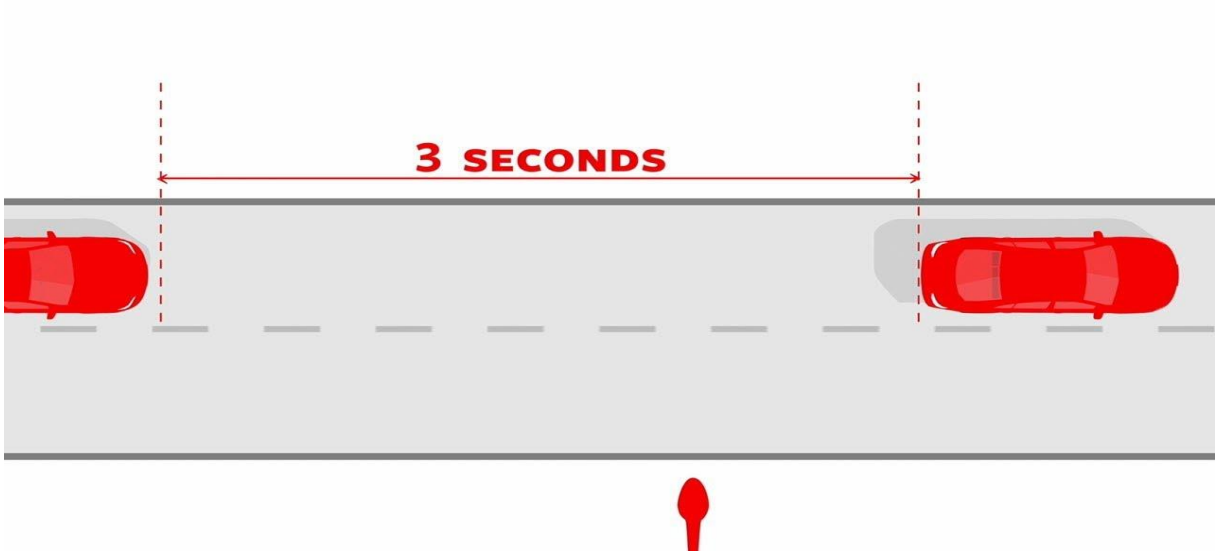

***Figure** 15: 3-Second Rule for Safe Following Distance*

Excessive speed is also a common cause of accidents on highways. If a driver is driving too fast, they will need a greater braking distance to stop. This can lead to collisions in case of emergency or heavy traffic.

In addition, driver fatigue can also cause accidents on highways. Tired drivers have slower reaction times and may have difficulty concentrating, which can lead to collisions.

Weather conditions, such as rain, snow, or fog, can also cause accidents on highways. Drivers should be cautious when driving in difficult weather conditions and increase their safety distance to avoid collisions.

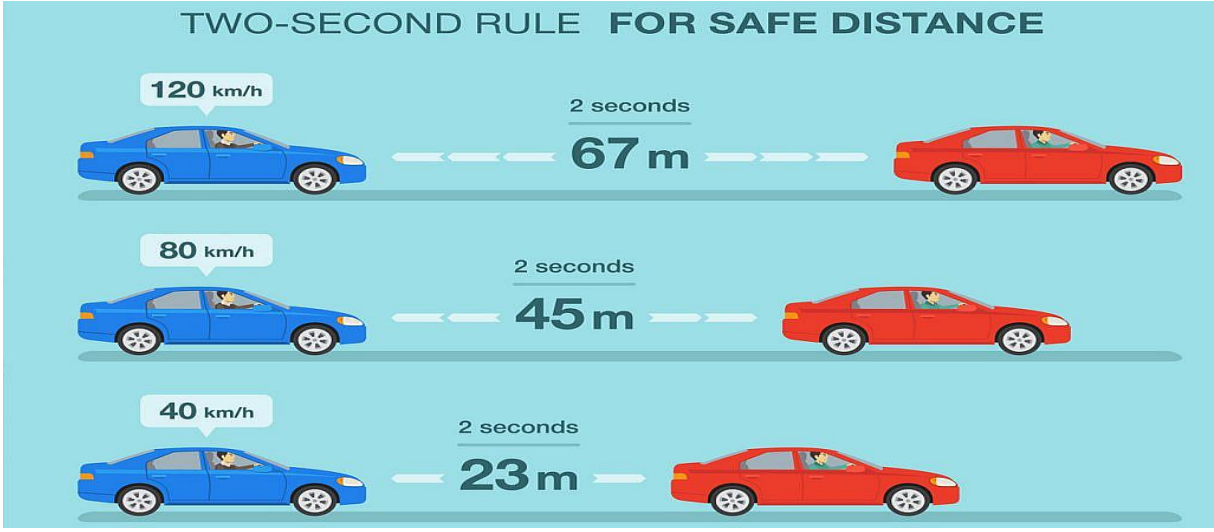

Figure 16: *Weather conditions*

Safety distance forward:

The recommended distance between your vehicle and the one in front of you is known as the safety distance, and it should be at least 3 seconds. When driving at 50 km/h, your vehicle covers a distance of 15 meters per second, meaning that the safety distance should be twice this distance, or 30 meters. Similarly, when driving at 100 km/h, your vehicle covers a distance of 30 meters per second, and so the safety distance should also be 60 meters.

To quickly calculate the safety distance traveled in 2 seconds, you can multiply the tens digit (for speeds from 10 to 90 km/h) or the first two digits (for speeds from 100 to 130 km/h) of your speed by 6. For example, at 50 km/h, you would travel 30 meters in 2 seconds (5 x 6), and at 100 km/h, you would travel 60 meters in 2 seconds (10 x 6).

On the motorway, the minimum safety interval corresponds to the 2 lines of the emergency lane, which is approximately 40 meters long. At a speed of 130 km/h, two lines are required, which means that the minimum safety interval should be 90 meters [9].

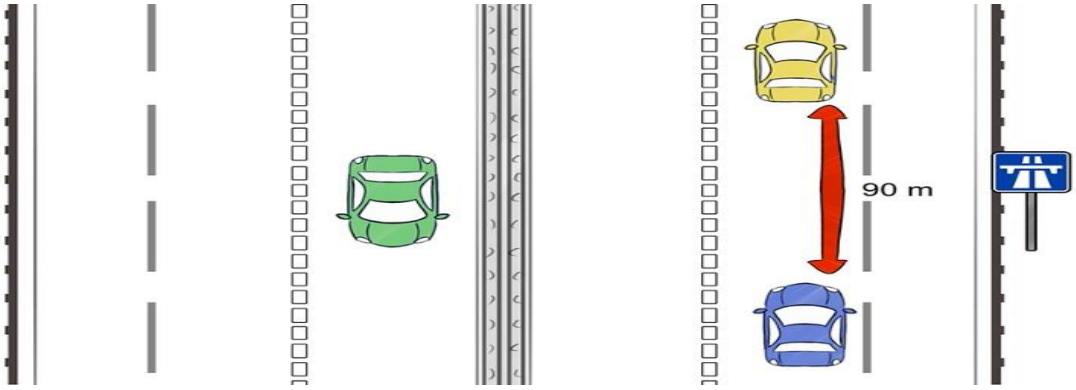

Figure 17: *2lines of the emergency lane [9]*

Backward safety distance:

Maintaining a safe distance not only applies to the front of your vehicle, but also to the back and sides. However, the backward safety distance is the most challenging to maintain, as it depends on the driver who is following behind you.

To ensure a safe backward distance, it is important to regularly check your rearview mirror and alert the driver behind you by flashing your brake lights if they are too close. This signal will indicate that they need to either slow down or overtake you.

In urban areas, it is recommended that the driver should be able to see the front number plate of the vehicle behind them in their interior mirror to ensure a safe backward distance. On the motorway, the safe backward distance can be maintained by ensuring that two lines of the hard shoulder are visible in the interior mirror between your vehicle and the one following you.

Safety distance on the sides:

The recommended lateral safety distance between your vehicle and other users is 1 meter in urban areas and 1.50 meters outside built-up areas. However, it is important to remember that maintaining a good safety distance should not prevent the driver from slowing down and adjusting to the situation at hand.

In the event that the recommended safety distance cannot be maintained, such as when encountering a stationary cyclist on a narrow path, it is advisable to reduce speed to a walking pace before overtaking.

The lateral safety distance is approximately equal to the width of a fully opened car door.

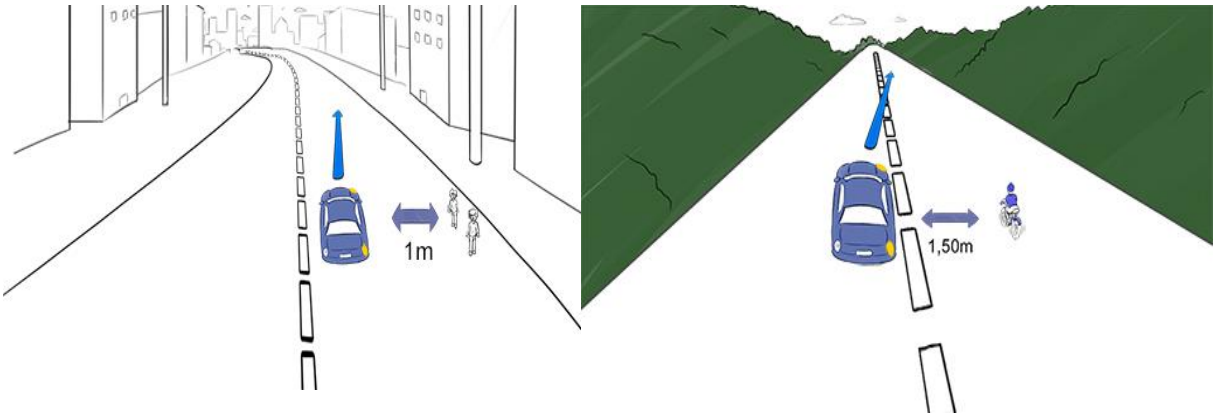

Figure 18: *Safety distance on the sides*

In summary, respecting the safety distance, reasonable speed, vigilance, and caution are key elements to avoid accidents on highways. Drivers should always be aware of their surroundings and be ready to react in case of emergency.

1.1.4 Effects of Temperature and Humidity on Drowsy Driving

Drowsy driving is a common problem among drivers, and temperature and humidity can have a significant impact on this phenomenon. High temperatures and humidity levels can increase drowsiness among drivers.

When it's hot, the human body uses energy to regulate its temperature, which can lead to increased fatigue. In addition, high temperatures can cause dehydration, which can also lead to drowsiness and fatigue among drivers.

High humidity can also worsen drowsiness among drivers. When the air is humid, sweat doesn't evaporate as quickly, which can make drivers uncomfortable and tired.

Drowsy driving can be dangerous as it can lead to decreased vigilance, slower reaction times, and decreased ability to make decisions. This can increase the risk of road accidents.
To avoid drowsy driving, it is important to take regular breaks, drink enough water to stay hydrated, and maintain a comfortable temperature in the vehicle. Drivers should also be aware of their level of fatigue and be prepared to stop and rest if necessary.

Figure 20: *Temperature*

Figure 19 : *Hot Humid Weather*

In this work, we will answer the following questions:

- How can we effectively detect drowsiness in drivers in order to reduce road accidents caused by fatigue?
- How can we design and develop an advanced automotive safety system that combines driver drowsiness detection, gas detection for gas powered cars, temperature and humidity monitoring, and recommended safe distance on the highway?
- What are the most effective methods and technologies for detecting drowsiness in drivers?
- How can we make these technologies available to users so that they can use them?

1.2 Objectives

The objectives of this research are as follows:

- Determine effective methods for detecting drowsiness in drivers to reduce road accidents caused by fatigue.
- Evaluate the most effective methods and technologies for detecting drowsiness in drivers
- Design and develop a safety system that integrate driver drowsiness detection, gaz detection for gaz powred cars, temperature and humidity monitoring, and recommended safe distance on the highway
- Propose solution to make these technologies accessible to users so they can use them.

Chapter 2

Driver Drowsiness

2.1 Introduction

Drowsiness is a state of sleepiness or lethargy characterized by a strong desire to sleep or a decrease in alertness. People who experience drowsiness may have difficulty staying awake and alert, which can affect their ability to perform tasks safely and effectively. Drowsiness can be caused by lack of sleep, changes in sleep patterns, taking certain medications, sleep disorders and underlying health problems. It is important to treat drowsiness to avoid accidents and injuries, as well as to improve overall quality of life.

A large number of people drive their vehicles day and night on the roads in particular: drivers of taxis, buses, trucks, and especially those who travel long distances. The majority of these drivers suffer from sleep problems during the driving period. This could be a source of several risks to the safety of the driver and the equipment at the same time. Various studies have proved that around 20% of all road accidents are fatigue related, up to 50% on certain roads. Driver drowsiness is an important factor leading to a large number of vehicle accidents. Recent Algerian statistics estimate that annually many thousands of deaths and more than 100.000 injuries can be attributed to drowsiness related crashes [10]. The development of technologies to detect or prevent drowsiness at the wheel is a major challenge in the field of accident avoidance systems. Due to the dangers caused by drowsiness in traffic, Methods must be developed to counteract its effects. Driver inattention may be the result of a lack of alertness when driving due to driver fatigue and distraction. The main objective in the present work is to use the DL approach to develop a new method to detect driver drowsiness. Since we are processing images, we preferred to use a Convolution Neural Network (CNN) model. For our case, the developed CNN based system can detect driver drowsiness and fatigue using the driver's eye movements. The results show that the proposed approach can effectively detect drowsiness and fatigue in real time,
providing an opportunity to prevent accidents caused by driver fatigue and consequently increasing the degree of security on vehicles [11]

2.2 Factors Causing Driving Drowsiness

Drowsiness can be a frustrating and annoying problem for those who suffer from it, as it can affect their ability to stay focused and alert throughout the day. Lack of sleep is often the most obvious cause of drowsiness, but there are many other factors that can contribute to this

condition. Understanding the factors that cause drowsiness can help prevent this condition and improve overall quality of life.

Figure 21 : *Factors Causing Driving Drowsiness [54]*

In this context, let's look at some of the common factors that can cause drowsiness These include:

- Driving for long periods without rest breaks or sleep is a significant risk factor for drowsiness while driving. Taking regular breaks to rest and recharge can help reduce the risk of fatigue and drowsiness, which can impair driving performance and increase the risk of accidents.
- Eating too much fat would increase the risk of accidents
- Not getting enough sleep before a long trip can also contribute to drowsiness while driving. It is important to prioritize getting enough sleep to ensure that you are well rested and alert while driving.
- Being awake for more than 24 hours at a time can also cause drowsiness and impair driving performance. It is best to avoid driving when sleep deprived and to prioritize getting enough sleep to ensure optimal driving performance.
- Alcohol consumption is another significant risk factor for drowsiness while driving. It is essential to avoid driving after consuming alcohol and to designate a sober driver or use alternative transportation options.
- Mental pressure, such as stress or anxiety, can also contribute to drowsiness while driving. It is important to manage stress and anxiety effectively and practice self care to reduce the risk of drowsiness while driving.

- Finally, certain medications can cause drowsiness as a side effect. It is important to discuss any medication side effects with your healthcare provider and avoid driving if drowsiness is a potential side effect. Additionally, illnesses and stress can cause fatigue and exhaustion, leading to drowsiness and impaired driving performance. It is important to prioritize rest and self care to reduce the risk of drowsiness while driving.

Furthermore, people try to compensate for fatigue by drinking coffee or other caffeinated beverages. This can be dangerous, however, because it may mask the effects of drowsiness and make you feel more alert. But after a short period of time the caffeine wears off and you become as drowsy as before. Driving after a sleepless night can also be dangerous because you're not fully rested and your body needs sleep to function properly. Stress is another common cause of drowsiness while driving. If you're stressed out, your body releases stress hormones that can make you feel tired and reduce your ability to concentrate. [11]

Figure 22 :*Why Do I Get Sleep From Drinking Cofee ?*

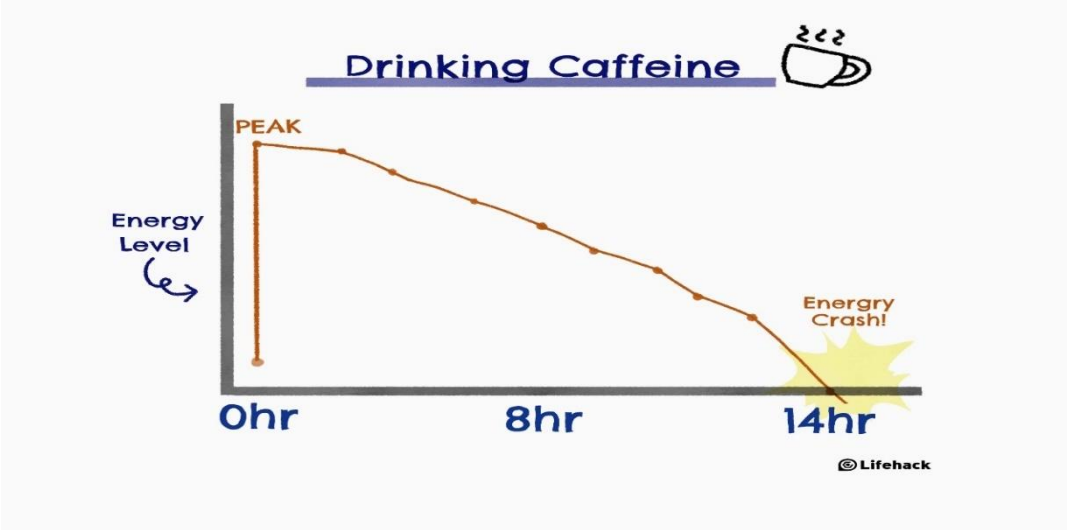

Figure 23:*Drink Caffeine With bad Strategy [55]*

2.2.1 Explain figure 23 :

When you consume caffeine, it is quickly absorbed into the blood and can stimulate the central nervous system, increasing alertness and energy. However, the effect of caffeine does not last very long, and once it is metabolized by the body, energy can drop rapidly, leaving a feeling of fatigue and drowsiness.

2.3 Measuring Sleepiness in Patients with Hypersomnia Disorders: The HFC Drowsiness Scale

To evaluate the severity of sleepiness, it is important to have a reliable and validated measurement tool.

2.3.1 HFC drowsiness scale

The HFC (Hypersomnia Foundation's Conference) Drowsiness Scale is a tool that allows for the assessment of sleepiness in patients with hypersomnia disorders. This scale ranges from 1 to 9 and measures the level of sleepiness in a patient at a given moment. The higher the score, the more sleepy the patient is.and the observerrated sleepiness is classified into two types, D-ORS used for vehicle behavior and B-ORS used for driver behavior. Each one is classified into three scales [12]

HFC	Description
1	Wide awake, vivid attention
2	Highly concentrated, focused attention
3	Attentive but calm
4	No activation, no drowsiness, no pronounced tendency for reactive behavior
5	Slightly dozing, ready to respond
6	Signs of drowsiness but effortlessly awake
7	Obvious drowsiness, but mainly focused on driving tasks
8	Battling with drowsiness. Difficulty with driving tasks, but mainly perceptual
9	Feeling foggy, listless, inactive for long periods of time, microsleep is occurring or may be occurring

Table 1 : *HFC drowsiness scale [13]*

2.3.2 The B-ORS and D-ORS

The B-ORS and D-ORS sleepiness scales are two types of sleepiness ratings made by observers using the HFC Drowsiness Scale. B-ORS is used to assess driver behavior, while D-ORS is used to evaluate vehicle behavior. Observers rate the driver's level of sleepiness using the B-ORS scale, which is then correlated with driving performance measures such as following distance and reaction time. Similarly, observers rate the vehicle's level of sleepiness using the D-ORS scale, which is then correlated with vehicle performance measures such as speed and position on the road. These two scales are particularly useful for assessing sleepiness in drivers and can help prevent accidents caused by drowsiness.

D-ORS0 (Alert)	B-ORS0 (Alert)
Awareness: driver's reactions are high and fast Driving: normal	Blink: normal Yawning: no Body position: sitting still Body movements: hardly
D-ORS1 (First signs of sleepiness)	B-ORS1 (First signs of sleepiness)
Awareness: driver's reactions are relatively normal and fast Driving: light steering wheel operation	Blink: sporadic prolonged closure of the eyelids, followed by increased blinking frequency Yawning: occasionally Body position: sometimes change position Body movements: sometimes
D-ORS2 (Severe sleepiness)	B-ORS2 (Severe sleepiness (microsleep))
Awareness: driver reacts slowly Driving: cannot drive steadily and turns the steering wheel too far	Blink: driver's eyes are half-closed, and his/her gaze vacant Yawning: frequently Body position: frequently change Body movement: frequently

Table 2: *D-ORS and B-ORS. [13]*

2.4 Hours at risk for drowsiness related road accidents

Hours at risk for sleepiness related road accidents tend to occur during periods of the day when the human body is naturally programmed to sleep. According to several studies, the most risky hours of the day are usually between 2am and 5am and between 1pm and 3pm in the afternoon. During these periods, the human body may experience reduced alertness and attention, which can make driving more difficult and increase the risk of accidents.

Figure 24: *Hours at risk for drowsiness-related road accidents*

A study conducted by the National Road Safety Administration (NHTSA) in the United States found that sleepiness related road accidents tend to occur more frequently at night, typically between midnight and 6 a.m. However, other studies have also identified afternoon periods as being at risk for sleepiness related accidents. [14]

2.5 The likelihood of drowsy driving varies bye age

The percentage of drivers who are likely to drive while drowsy may vary with age. Statistics suggest that younger drivers are more likely to drive drowsy than older drivers, but drowsiness at the wheel remains a significant problem for all age groups.

According to a 2016 survey by the National Sleep Foundation, drivers aged 18 to 29 were the most likely to report drowsy driving, at 71%. Drivers between the ages of 30 and 64 were less likely to report drowsiness, at 52%. Drivers over the age of 65 were even less likely to report drowsiness, at 19%. [15]

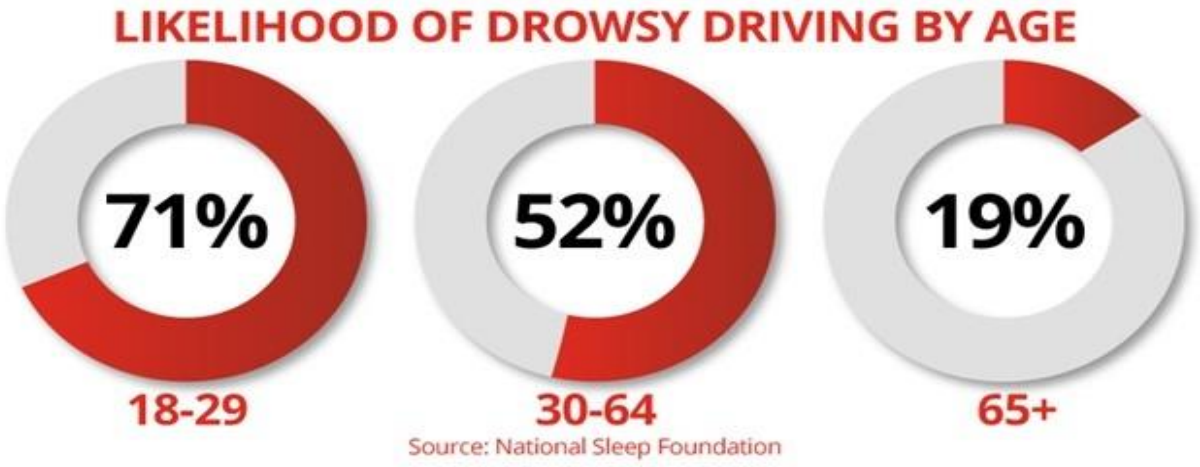

Figure 25: *Liklihood Of Drowsy Driving By Age*

These figures can be explained by factors such as irregular sleep patterns, risky driving habits and increased substance use, such as alcohol and drugs, among younger drivers. However, older drivers may also be vulnerable to drowsiness due to age related physiological changes, such as sleep disturbances, medications and underlying health conditions.

It is important to note that the vulnerability to drowsiness while driving can vary considerably depending on the individual and the driving environment. It is therefore essential to take the signs of drowsiness at the wheel seriously and to take appropriate measures to prevent accidents.

2.6 Drowsiness Detection Techniques

Drowsiness detection techniques are designed to help individuals identify signs of drowsiness and take measures to remedy it before it becomes dangerous.

There are many different ways to detect drowsiness and several systems that use a combination of these techniques:

2.6.1 Electrocardiogram (ECG) and Electroencephalogram (EEG):

The ECG and EEG techniques are two types of electrophysiological measurements used in medicine to assess the electrical activity of the heart and brain, respectively.

-EEG: The electroencephalogram (EEG) measures the electrical activity of the brain by recording the electrical signals generated by neurons. This measurement is used to evaluate the quality and quantity of sleep in patients with sleep disorders such as sleep apnea, restless leg syndrome, and insomnia. EEG signals can be analyzed to identify characteristic patterns of brain activity during sleep, such as slow and delta waves, which can indicate deep and restorative sleep. Studies have shown that EEG analysis can be useful in assessing drowsiness in vehicle drivers and helping to prevent accidents caused by sleepiness. [16]

Figure 27: *Different views of the driver when he was conducting the test of EEG [27]*

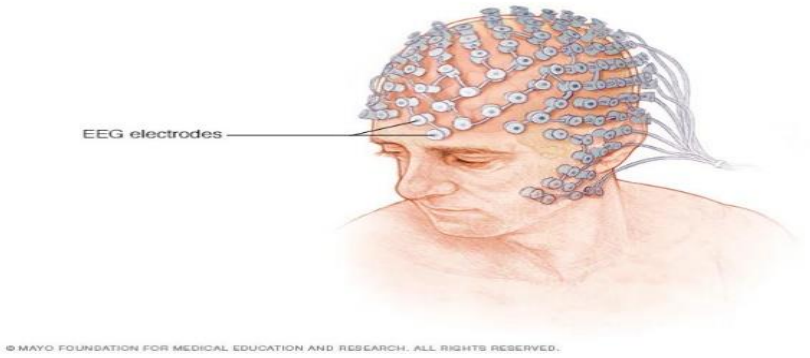

Figure 26: *EEG (electroencephalogram) [17]*

-ECG: The electrocardiogram (ECG) measures the electrical activity of the heart by recording the electrical impulses generated by cardiac cells. This measurement is used to evaluate the impact of drowsiness on the cardiovascular system, as drowsiness can lead to changes in heart rate and blood pressure. ECG analysis can help identify cardiac anomalies that may occur due to drowsiness, such as arrhythmias and heart blocks, and monitor the

effectiveness of cardiac treatments in patients with sleep disorders. Studies have also shown that ECG analysis can be useful in assessing drowsiness in vehicle drivers and helping to prevent accidents caused by sleepiness. [17]

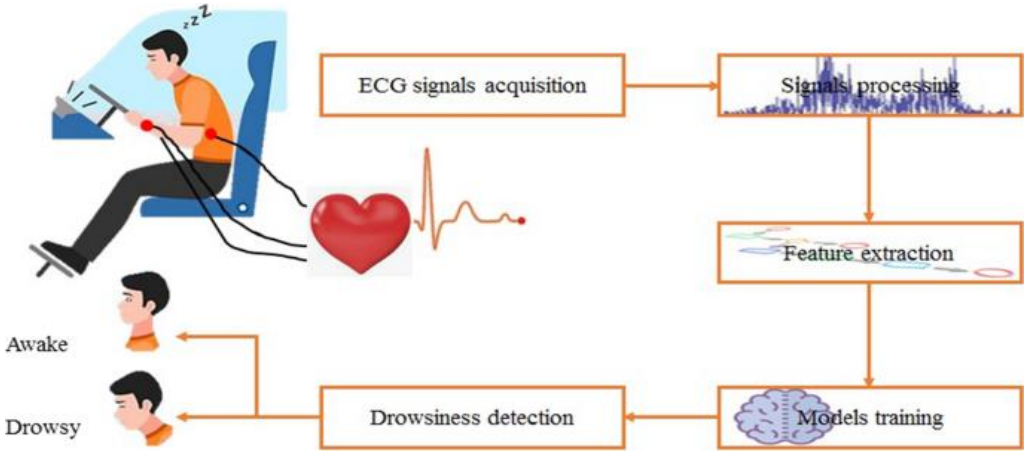

Figure 28 : *ECG Technique [25]*

2.6.2 LBP (Local Binary Pattern) :

Local binary patterns (LBPs) have garnered increasing interest in the fields of image processing and computer vision. As a non-parametric method, LBP efficiently summarizes local image structures by comparing each pixel with its neighboring pixels. Its most important properties include its ability to tolerate monotonic changes in illumination and its computational simplicity. LBP is widely used for detecting emotions on the face, such as happiness, sadness, and excitement. In the context of drowsiness detection, LBP is used to detect the driver's face by dividing the image into four quadrants and detecting the top and bottom parts. In " Figure 29", LBP is seen to extract the image from the video, divide it into blocks, generate LBP histograms from each block, and form feature histograms. [18] [11] [19]

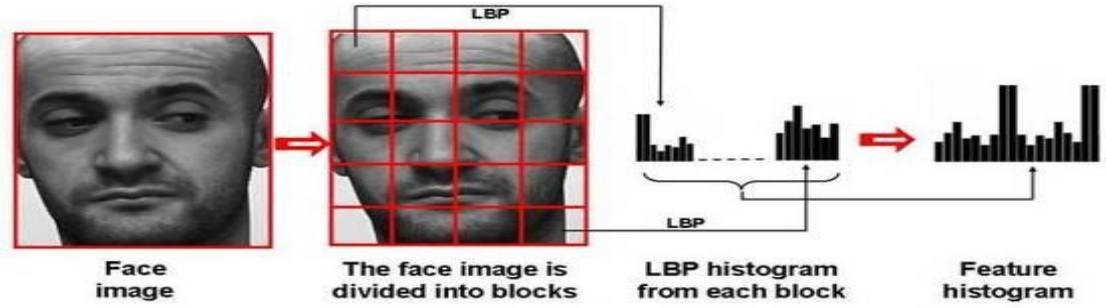

Figure 29 : *LBP histogram feature extraction*

2.6.3 Steering Wheel Movement (SWM)

A widely used method for detecting the level of driver drowsiness is measuring steering wheel movement using a steering angle sensor. By mounting an angle sensor on the steering column, the driver's steering behavior can be recorded. When the driver is drowsy, the number of micro corrections made on the steering wheel decreases compared to normal driving. Furlough and Graham found that sleep deprived drivers made fewer steering wheel reversals than normal drivers. To eliminate the effect of lane changes, the researchers only considered small steering wheel movements (between 0.5° and 5°) that are necessary to adjust the lateral position within the lane." Figure 30 " illustrates the detection of drowsiness using steering wheel movement.

Overall, steering behavior is influenced by various factors such as the driving task, driver traits, and driver states. Drivers constantly assess the situation ahead and make small, smooth steering adjustments to correct for road bumps and crosswinds by turning the steering wheel in small increments.

By analyzing small SWMs, it is possible to determine the driver's level of drowsiness and issue an alert if necessary. In a simulated environment, light side winds were added to a curved road to create variations in the lateral position and force drivers to make corrective SWMs. While car companies such as Nissan and Renault have adopted SWMs, their effectiveness is limited to specific environments and is highly dependent on the geometric characteristics of the road and, to a lesser extent, on the kinetic characteristics of the vehicle. [19] [20]

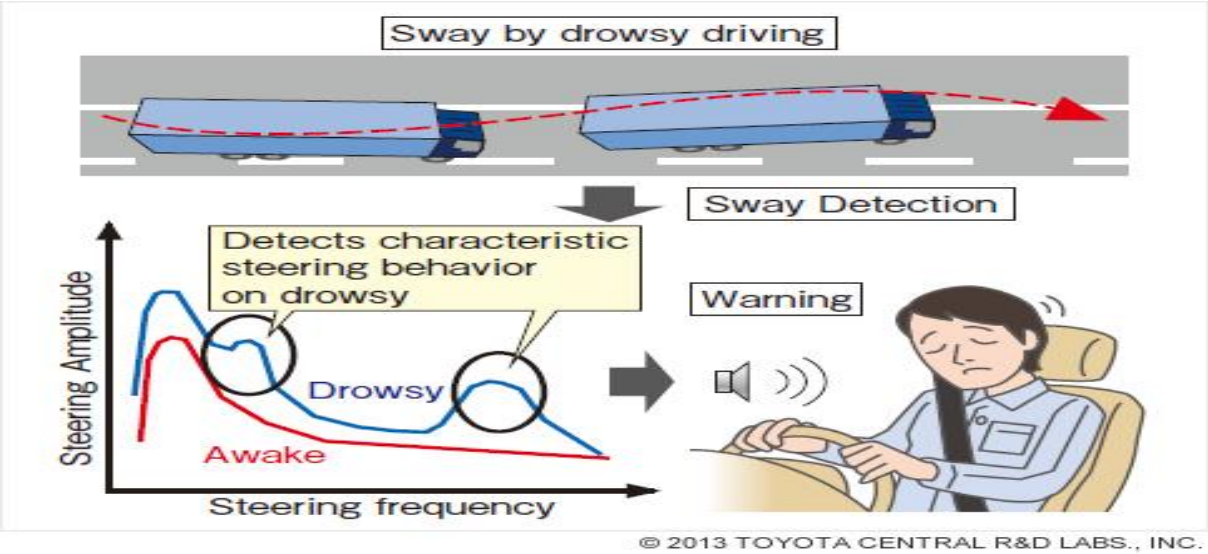

Figure 30 : *Steering Movement Based Detection*

2.6.4 Optical Detection

One approach to implementing an optical detection system for drowsiness involves using infrared or near infrared LEDs to illuminate the driver's face and eyes. A camera system then captures images of the driver's face and eye movements in real time. Computer algorithms can analyze these images to detect signs of drowsiness, such as changes in blink rate and duration. In addition to monitoring the driver's eye movements, the camera system can also track facial features and head position, such as yawning or sudden head nods, to provide additional indicators of drowsiness. Overall, optical detection systems offer a promising approach to real time drowsiness detection and improved driver safety.

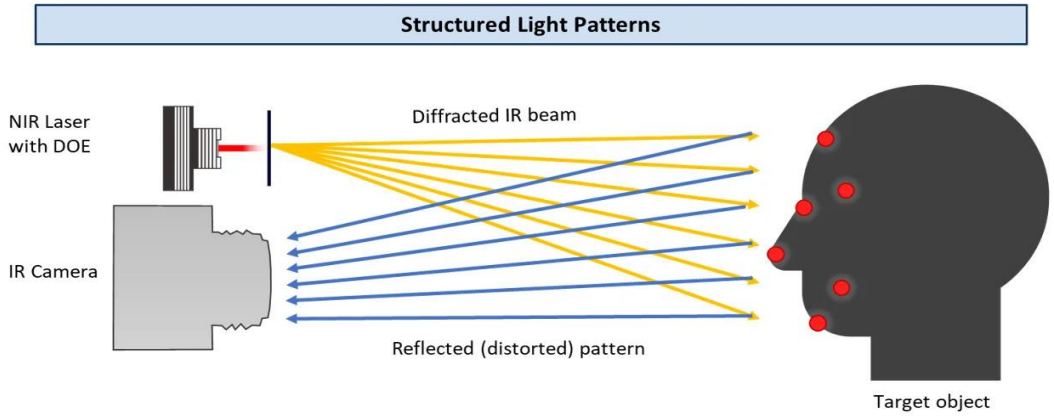

Figure 31: *Exemple Using Near-Infrared Light for Driver And Occupant Monitoring*

2.6.5 Eye Blinking Based Technique

This technique uses a camera to detect drowsiness. The camera scans the driver's face and detects the number of blinks, eye closure, mouth opening, and other facial movements that occur during driving " Figure 32" shows blink-based drowsiness detection. In this system, the position of the irises and eye states are monitored through time to estimate eye blinking frequency and eye close duration [11] [21]

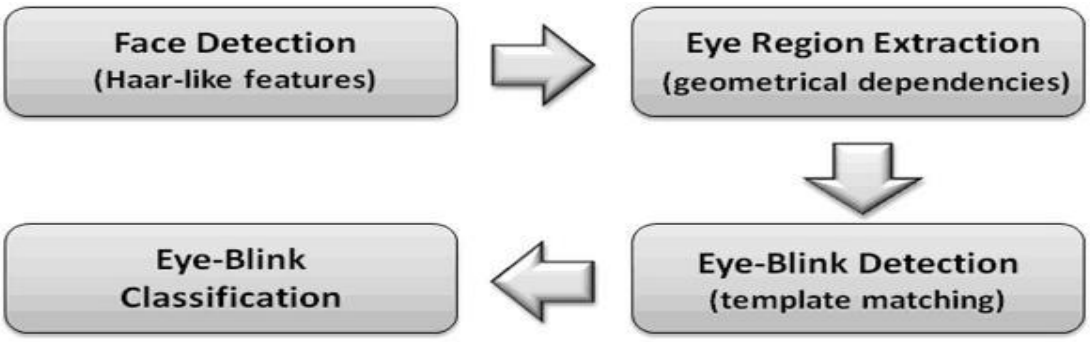

Figure 32 :*Scheme of the proposed algorithm for eye-blink detection [21]*

2.6.6 Yawning Based Technique

Researchers have developed a technique for detecting driver drowsiness based on measuring yawning frequency. Yawning is a physiological response that occurs when we are tired or bored, and it can be detected by measuring the frequency and duration of yawns. While the frequency of yawns typically increases with time awake in healthy individuals, it decreases in drowsy drivers compared to normal driving. This technique offers a promising approach to real time drowsiness detection and improved driver safety. [22] [11]

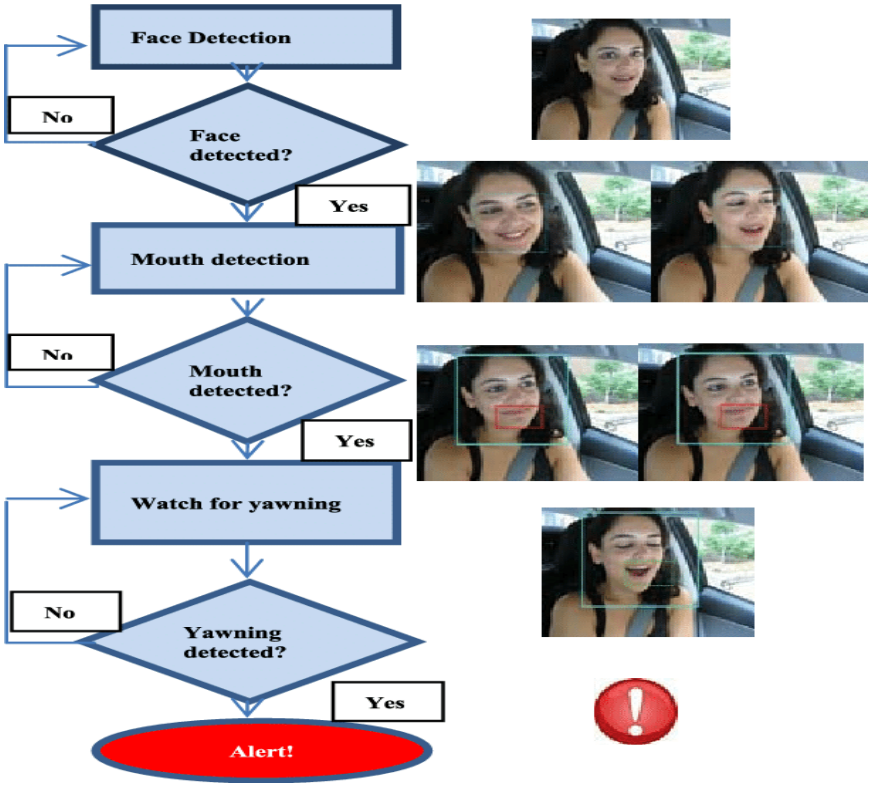

Figure 33 : *Yawing Detection Algorithm [22]*

2.7 Drowsiness Detection Background

Drowsiness detection can be divided into three main categories; Behavioral drowsiness detection, Physiological drowsiness detection, Vehicle based measures [23]. The Behavioral Drowsiness Detection (BDS) approach is based on the driver's performance. It uses video cameras, eye tracking and other sensors to measure how well the driver is performing certain tasks such as keeping their eyes open and looking in the correct direction [23]. In this category, Advanced Driver Assistance System (ADAS) has been developed [24]. The system uses advanced technology to analyze and monitor the driver's eye condition in real time under real

driving conditions. They use different algorithms for various tasks like face tracking, eye tracking etc. they give separate results for face tracking, eye tracking, eye state analysis [25]. The physiological drowsiness detection (PDS) approach which relies on a combination of sensors measuring heart rate, pulse rate, respiration rate, brain wave signals, and skin conductivity to determine whether a driver is sleepy or not [26]. Physiological changes can be measured by using one of the following instruments: Electrooculogram(EOG) Electrocardiogram(ECG), Electroencephalogram (EEG) or brainwave sensor [25] [27].The Vehicle based measures approach that uses data from the vehicle itself to determine if a driver is becoming sleepy or not. This can include things like looking at how hard the driver is pressing on their brakes and acceleration, steering wheel behaviors or lane departures [28] [29]. and how often they have to make corrections while driving [19] . Other vehicle parameters, such as vehicle position and steering wheel angle, are used to perform data fusion across multiple measurements for a more reliable system [30] [31]. The application of deep learning approach proposed by researchers has yielded surprising results in many fields of research, including: computer vision [32] [33], image processing [34] [35], object detection [36] [37], network optimization [37], handwritten digits and character recognition [38] [39], sensor networks [40] [41], sentiment analysis [41], system security [42], Diabetes Detection [43] [44]. The DL approach gives better results in terms of accuracy but needs massive data. Many models are currently used, including DNN, CNN, RNN, LSTM to develop systems that helps efficiently in drowsiness detection, our proposed model is one of them [11].

Chapter3:

Machine Learning and Deep Learning

3.1 Introduction

Nowadays, Artificial intelligence has become increasingly popular and widespread in recent years, with more and more people becoming interested in the field. One of the reasons for this is the rapid pace of technological advancements, which have made it possible to develop AI applications that were once thought to be impossible. As a result, AI has become a common topic of conversation not only among technology professionals but also among the general public, including children

So, when discussing artificial intelligence, which has become a major topic not only for industry professionals but also for the general public, including children, it is important to understand the two pillars of AI which are machine learning and deep learning.

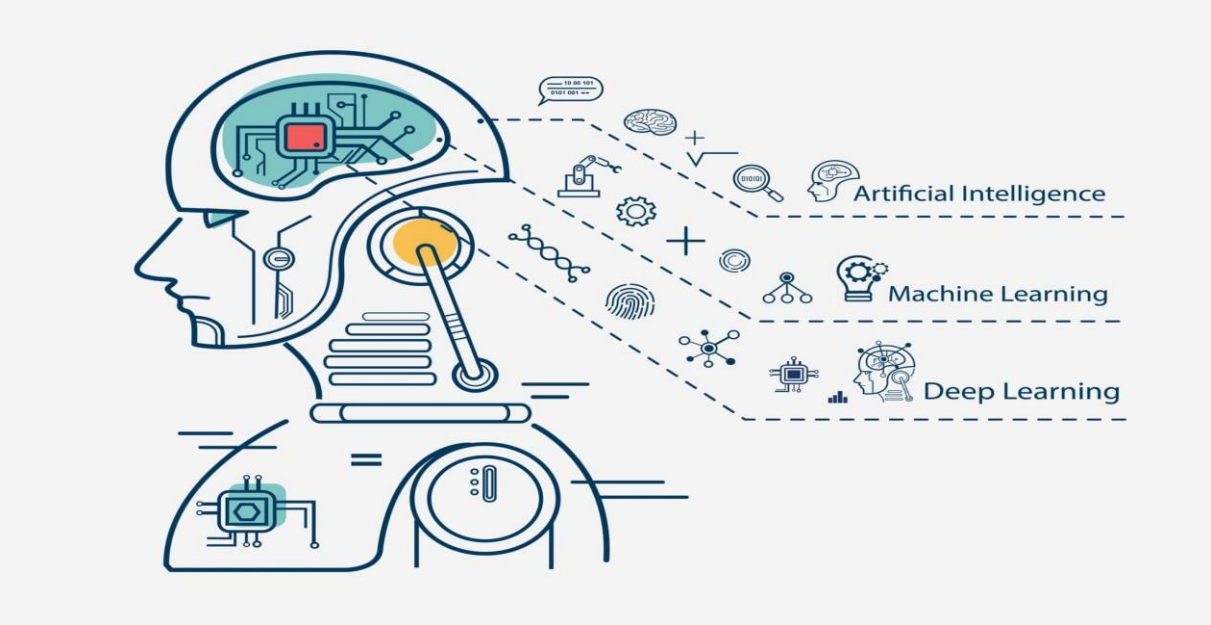

Figure 34 : *IA,ML,DL*

Follow us in this chapter to fully understand these two terms.

3.2 Machine Learning

Today, intelligent systems that offer artificial intelligence capabilities often rely on machine learning to solve complex problems. These systems can learn from experience and make decisions that are based on what they have learned. They can recognize patterns and make predictions about the future based on those patterns. In other words, machine learning is a

type of artificial intelligence that allows computers to learn from data and make predictions based on patterns. Machine learning is used in everything from self-driving cars to online shopping recommendations, Google, Facebook and Amazon are all using machine learning to make their services better. For example, when you search for something on Google, the results you see are tailored to what you've searched before. That's because Google is using machine learning to customize your results based on the information in your search history. We can define Machine Learning with this sentence: To predict the future, we rely on the past

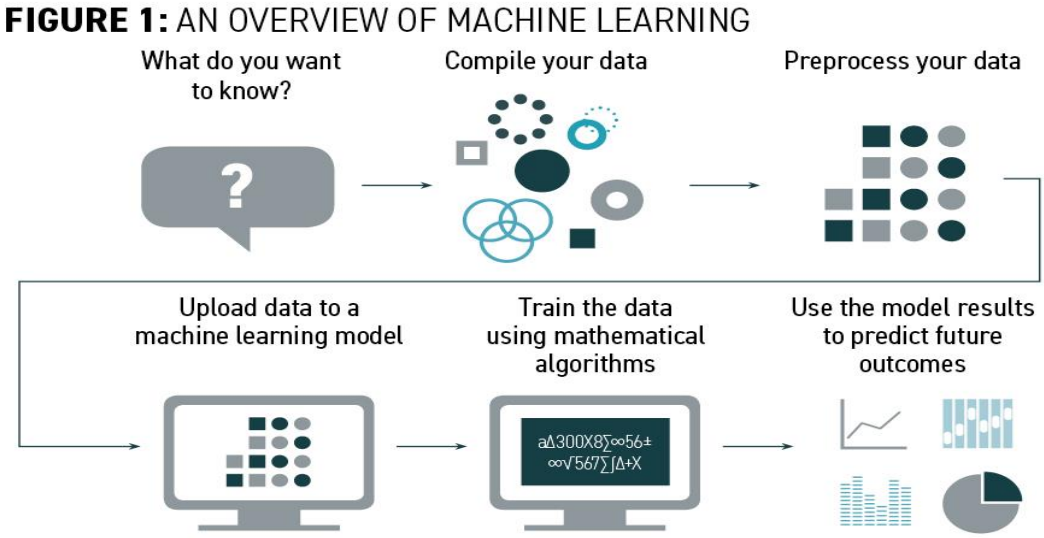

Figure 35: *An Overview of Machine Learning*

3.3 Brief history of AI, ML, and DL

AI (Artificial Intelligence) has been around since the 1950s, with early research focused on rulebased systems and symbolic reasoning. In the 1980s, the focus shifted to machine learning (ML), which uses statistical methods to enable machines to learn from data. This led to the development of neural networks and deep learning (DL) in the 1990s, which aimed to mimic the structure and function of the human brain. However, the lack of computing power and large datasets limited progress in DL until the mid2000s, when advances in hardware and the availability of large amounts of data led to a resurgence of interest in DL

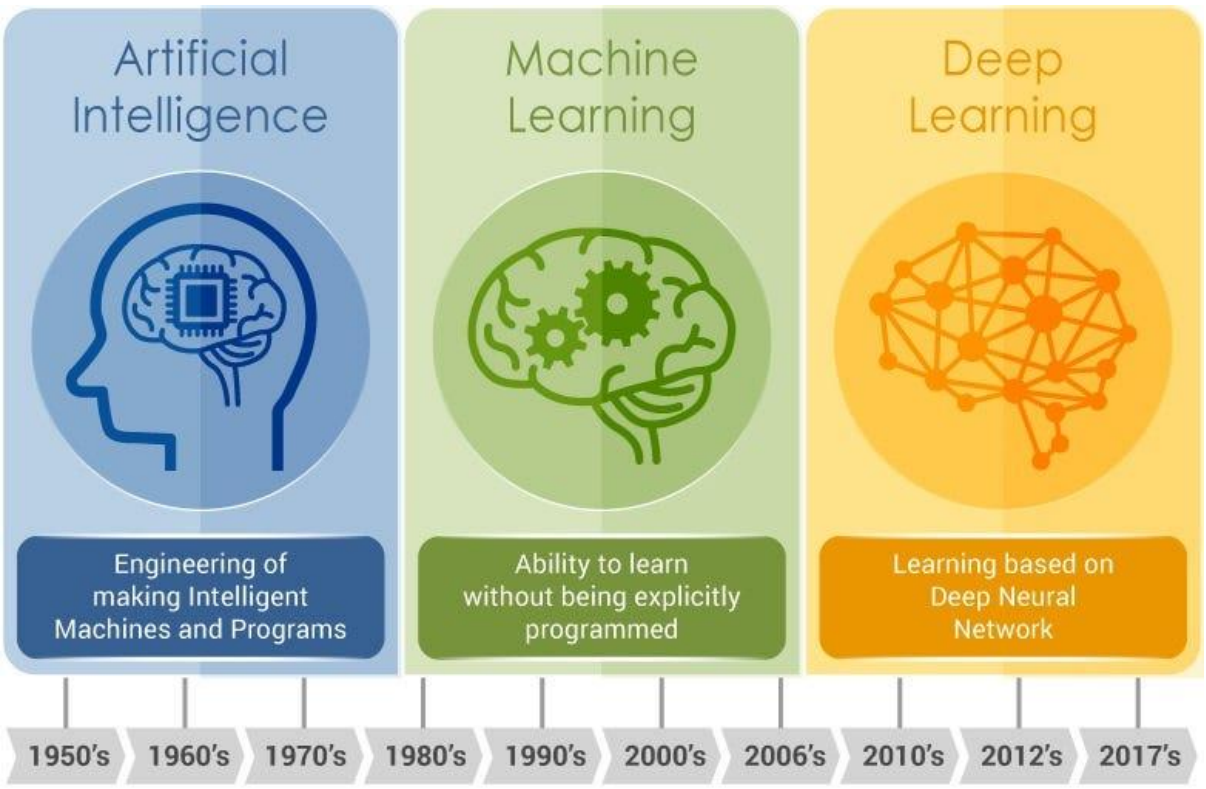

Figure 36: *History of AI, ML, and DL*

Before seeing the motivations of Machine Learning, one must first know these terms:

- True positive (TP) = the number of cases correctly identified as patient
- False positive (FP) = the number of cases incorrectly identified as patient
- True negative (TN) = the number of cases correctly identified as healthy
- False negative (FN) = the number of cases incorrectly identified as healthy

Accuracy: An accuracy metric is a measure of how often a Machine Learning model correctly predicts the outcome of a binary classification problem. It is calculated as the ratio of the number of correct predictions to the total number of predictions made by the model. For example, if a model predicts the outcome of 100 binary classification problems and is correct in 80 of them, its accuracy metric would be 80/100 or 80%.

The accuracy metric is a useful tool for evaluating the performance of a Machine Learning model

Precision: Precision measures the proportion of true positives (correctly predicted positive instances) out of all predicted positives (true positives and false positives). It is calculated as TP/ (TP + FP), where TP is the number of true positives and FP is the number of false positives. Precision is a useful metric when the cost of a false positive is high, and we want to minimize the number of false positives.

Loss value: used to optimize an ML algorithm or DL model. It should be computed using the training and validation data sets. Its simple interpretation is based on how well the ML algorithm or the DL built model is doing in these two datasets. It gives the sum of errors made for each example in the training or validation set.

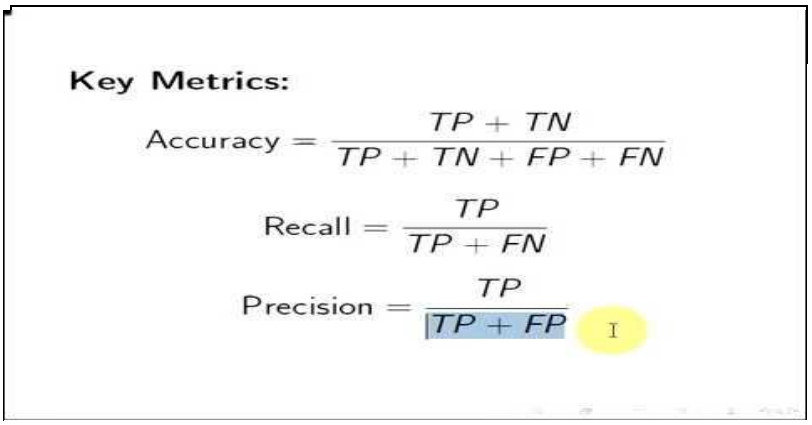

Figure 37 : *Key Metrics [58]*

Recall: recall is a metric used to evaluate the performance of a classification model. It measures the proportion of true positive cases that were correctly identified by the model. In other words, it measures the model's ability to correctly identify all the positive cases in the data. Recall is calculated as the ratio of true positives to the sum of true positives and false negatives.

3.4 Motivations to Use Machine Learning:

ML has become increasingly popular in recent years, as more and more organizations recognize its potential to drive innovation and improve business outcomes. By leveraging the power of ML, businesses can gain insights from large and complex datasets, automate repetitive tasks, and make accurate predictions and decisions. Here are some motivations to use Machine Learning:

-**Efficiency**: Machine Learning algorithms can quickly process large and complex datasets, making it possible to automate tasks that would otherwise be too time consuming to perform manually.

-**Accuracy**: Machine Learning models can provide highly accurate predictions and classifications, especially when trained on large, diverse datasets.

-**Personalization**: Machine Learning can be used to create personalized experiences for users, such as personalized recommendations or targeted advertising.

-**Scalability**: Machine Learning algorithms can be easily scaled up or down to handle large or small datasets and can be deployed across different platforms and devices.

-**Automation**: Machine Learning can automate repetitive tasks, freeing up time for humans to focus on more complex and creative work.

-**Insights**: Machine Learning can uncover patterns and insights in data that would be difficult or impossible to identify through manual analysis.

-**Innovation**: Machine Learning can enable the development of new products and services, as well as improve existing ones, by providing new ways to analyze and interpret data.

3.5 Type of Machine learning

There are three main types of Machine Learning:

1. Supervised Learning
2. Unsupervised Learning
3. Reinforcement Learning

There are also other subfields of Machine Learning, such as Deep Learning, which involves training neural networks with many layers, and Transfer Learning, which involves using knowledge gained from one task to improve performance on another task.

3.5.1 Supervised Learning

In Supervised Learning, the machine learns under supervision. It contains a model that is able to predict with the help of a labeled dataset. A labeled dataset is one where you already know the target answer.

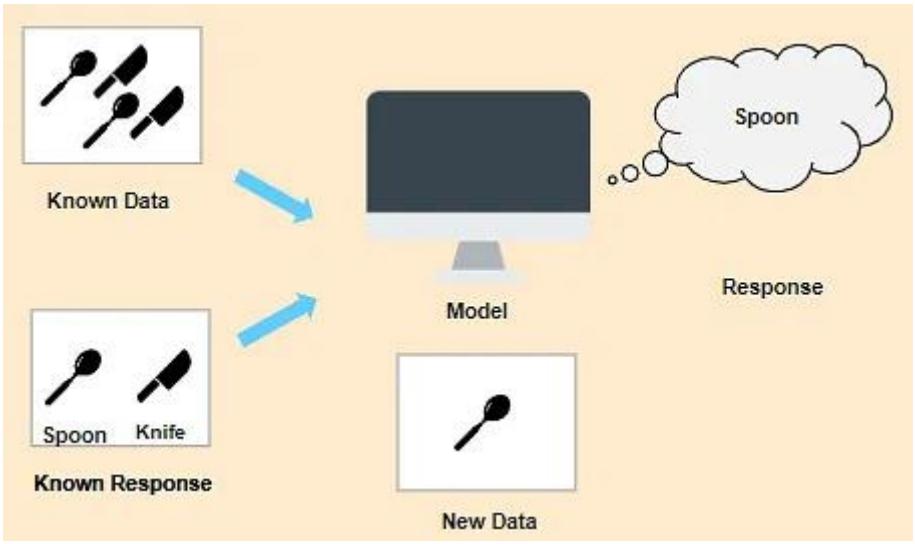

Figure 38 : *Supervised Learning [45]*

In “Figure 38”, we have images that have been labeled as either a spoon or a knife. This labeled data is fed into the machine, which then analyzes and learns the associations between these images based on their features such as shape, size, sharpness, etc. When a new image is presented to the machine without any label, the machine can accurately predict that it is a spoon based on the information it has learned from the labeled data [45].

Supervised learning can be further divided into two types:

1. Classification
2. Regression

a) Classification :

Classification is used when the output variable is categorical, meaning it has two or more classes. For exemple, yes or no, male or female, true or false, etc.

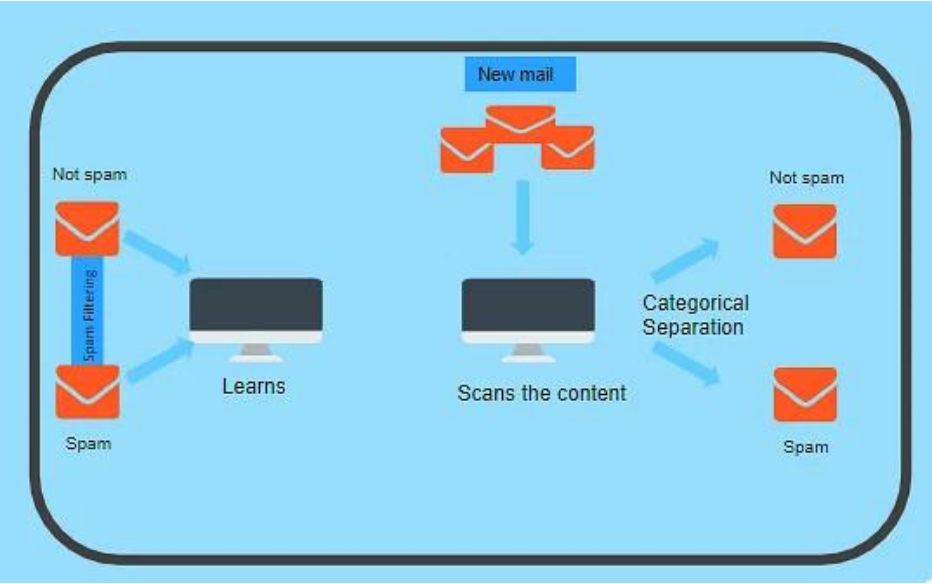

Figure 39 : *Classification exemple [45]*

In order to predict whether an email is spam or not in "Figure 39", the machine needs to be taught what constitutes a spam email. This is achieved by analyzing a large number of spam filters that review the email content, header, and search for any false information. Specific keywords and blacklist filters are used from previously blacklisted spammers.

All of these features are used to assign a spam score to the email. The lower the overall spam score of the email, the less likely it is to be a scam.

Based on the content, label, and spam score of the incoming email, the algorithm determines whether it should be placed in the inbox or the spam folder.

b) Regression :

Regression is used when the output variable is a continuous or real value. In this case, there is a relationship between two or more variables, meaning that a change in one variable is associated with a change in the other variable. For example, salary based on work experience or weight based on height, etc.

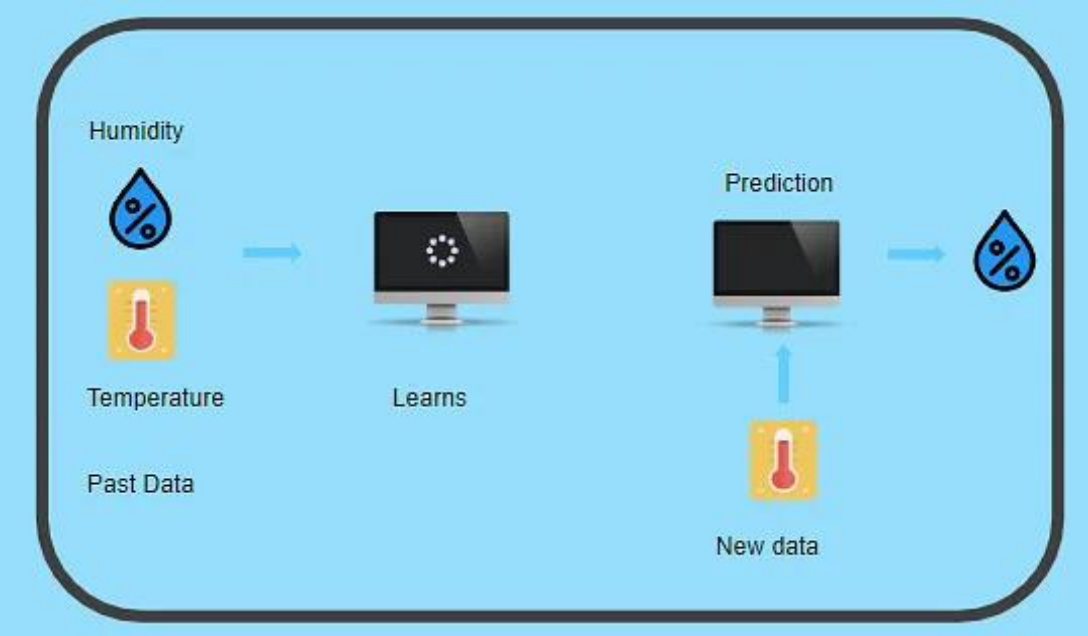

Figure 40: *Regression [45]*

Let's consider two variables in " Figure 40 " - humidity and temperature. In this case, 'temperature' is the independent variable and 'humidity' is the dependent variable. If the temperature increases, then the humidity decreases.

These two variables are fed into the model and the machine learns the relationship between them. After the machine is trained, it can easily predict the humidity based on the given temperature.

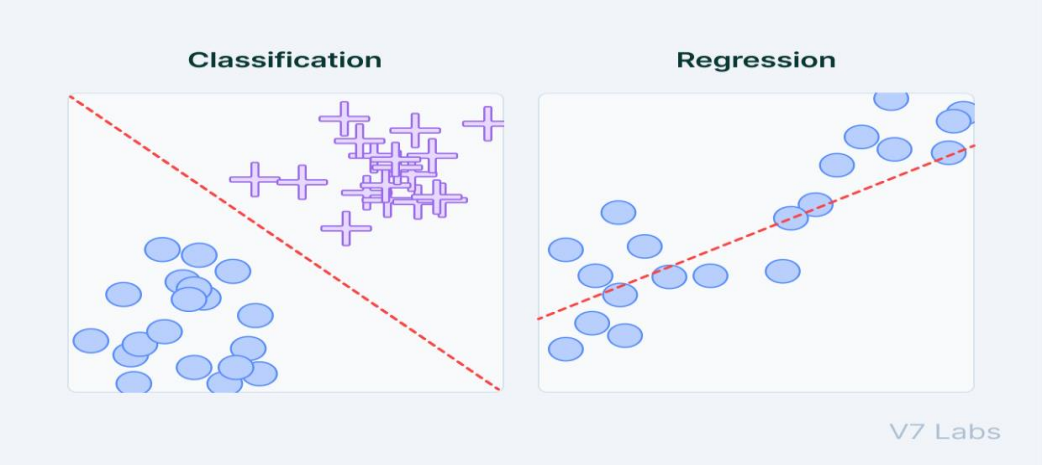

Figure 41:*Graph Of Classification and Regression*

c) Real Life Applications of Supervised Learning:

- Risk Assessment :

  Supervised learning is used to assess risk in the financial services or insurance domains to minimize the risk portfolio of companies.
- Image Classification :

  Image classification is one of the key use cases for demonstrating supervised machine learning. For example, Facebook can recognize your friend in a picture from an album of tagged photos.
- Fraud Detection :

  To identify whether the transactions made by the user are authentic or not.
- Visual Recognition :

  The ability of a machine learning model to identify objects, places, people, actions, and images.

3.5.2 Unsupervised Learning

In Unsupervised Learning, the machine uses unlabeled data and learns on its own without any supervision. The machine tries to find patterns in the unlabeled data and provides a response.

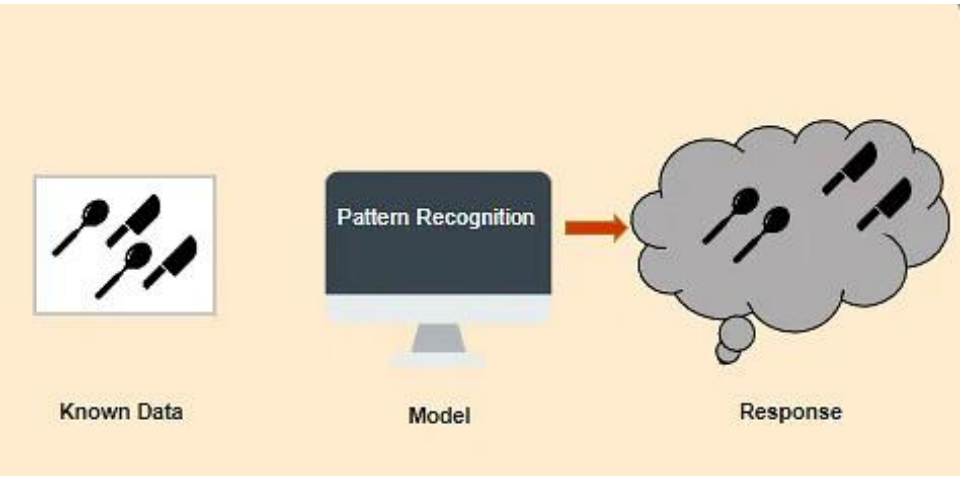

Figure 42 : *Unsupervised Learning [45]*

Let's consider a similar example as before in " Figure 38", but this time we do not inform the machine whether it's a spoon or a knife. The machine identifies patterns from the given set and groups them based on their patterns, similarities, etc.

Unsupervised learning can be further classified into different types:

1. Clustering
2. Association

a) Clustering Unsupervised Learning :

Clustering is the process of dividing objects into clusters that are similar to each other and dissimilar to objects in other clusters. For example, identifying which customers made similar product purchases.

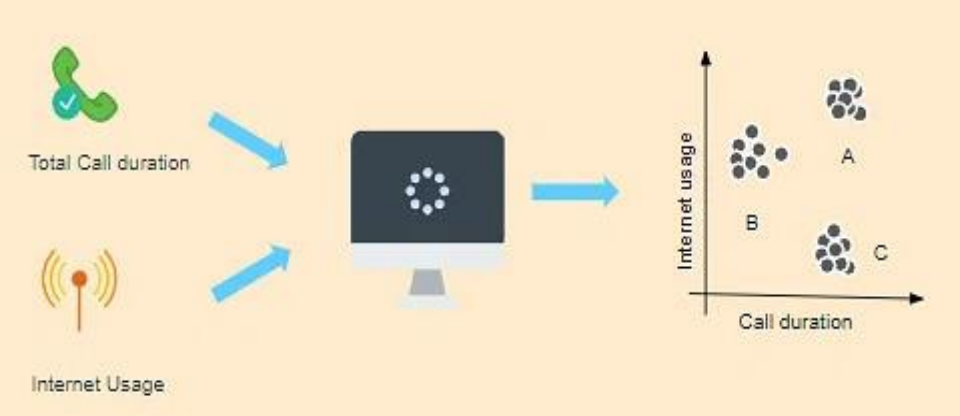

Figure 43 : *Clustering [45]*

Suppose a telecom company wants to reduce its customer churn rate by providing personalized call and data plans. The behavior of customers is studied, and the model segments customers with similar traits. Several strategies are adopted to minimize churn rate and maximize profit through appropriate promotions and campaigns.

In «Figure 43", you can see a graph where customers are grouped. Group A customers use more data and also have high call durations. Group B customers are heavy internet users, while Group C customers have high call duration. So, Group B will be given more data benefits plans, while Group C will be given cheaper call rate plans and Group A will be given the benefit of both.

b) Association Unsupervised Learning

Association is a rule based machine learning technique used to discover the probability of co-occurrence of items in a collection. For example, identifying which products were purchased together.

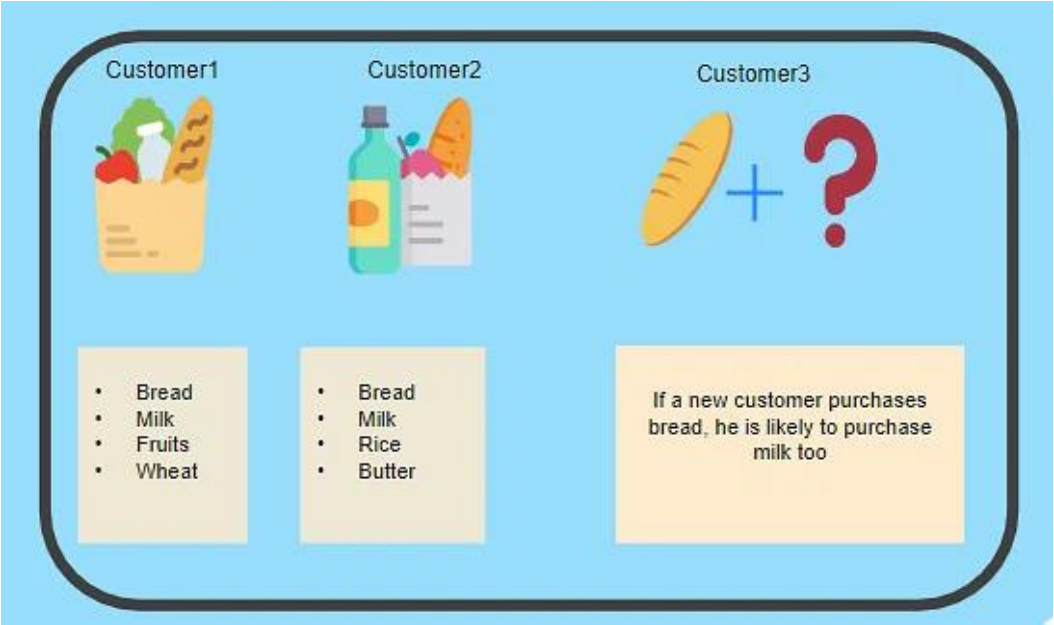

Figure 44 : *Association [45]*

In "figure 44" Let's say a customer goes to a supermarket and buys bread, milk, fruits, and wheat. Another customer comes and buys bread, milk, rice, and butter. Now, when another customer comes, it's highly likely that if they buy bread, they'll also buy milk. Thus, a relationship is established based on customer behavior, and recommendations are made.

c) **Real Life Applications of Unsupervised Learning:**

- Market Basket Analysis

  It's a machine learning model based on the algorithm that if you purchase a certain group of items, you're less or more likely to buy another group of items.

- Semantic Clustering

  Semantically similar words share a similar context. People post their queries on websites in their own ways. Semantic clustering groups all these responses with the same meaning into a cluster to ensure that the customer finds the information they want quickly and easily. It plays an important role in information retrieval, good browsing experience, and comprehension.

- Delivery Store Optimization

  Machine learning models are used to predict demand and keep up with supply. They're also used to open stores where demand is higher and optimize routes for more efficient deliveries based on past data and behavior.

- Identifying Accident Prone Areas

  Unsupervised machine learning models can be used to identify accident prone areas and introduce safety measures based on the intensity of those accidents.

3.5.3 Supervised Learning VS Unsupervised Learning

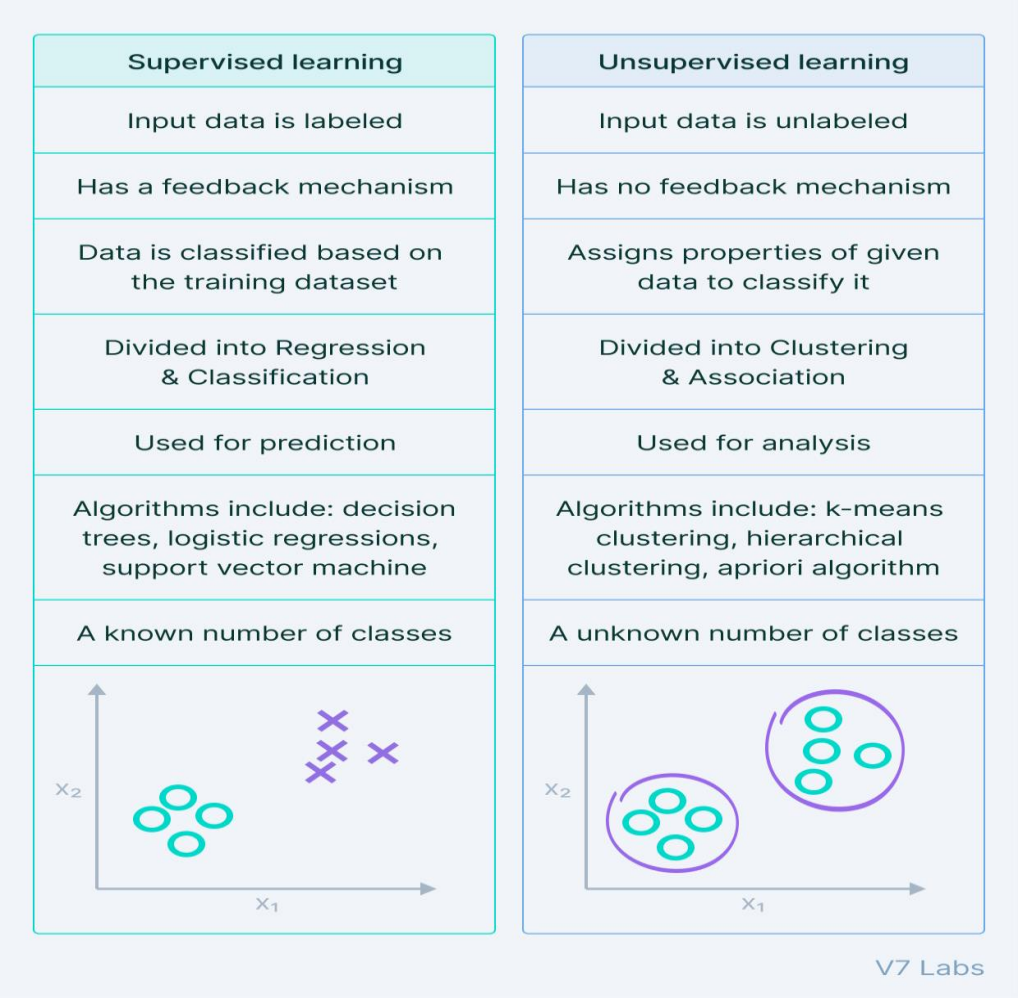

Figure 45: *Supervised Learning VS Unsupervised Learning*

This is the major difference between supervised and unsupervised learning lies in the presence or absence of classes " Figure 45 ".

3.5.4 Reinforcement Learning

Reinforcement learning enables an agent to acquire a behavior that has never been previously defined by humans. By interacting with its environment, the agent discovers the various consequences of its actions and learns from its own experiences, without possessing pre existing knowledge of the goals or effects of its actions.

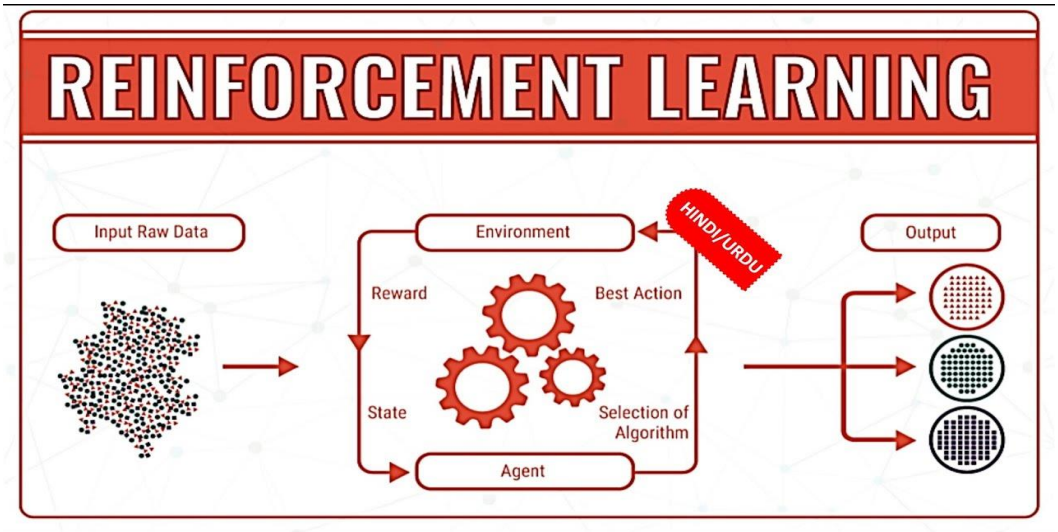

Figure 46: *Complete process of reinforcement learning [53]*

3.6 Lifecycle Machine Learning

The machine learning life cycle is an iterative process that involves several stages, from data collection to model deployment and maintenance. Each stage is important to ensure that the model is performing well and meets the specific needs of the project. The stages include data collection and preparation, model selection and training, as well as model validation and testing before deployment in production. Ongoing model maintenance is also essential to maintain its performance and adapt to changes in the production environment.

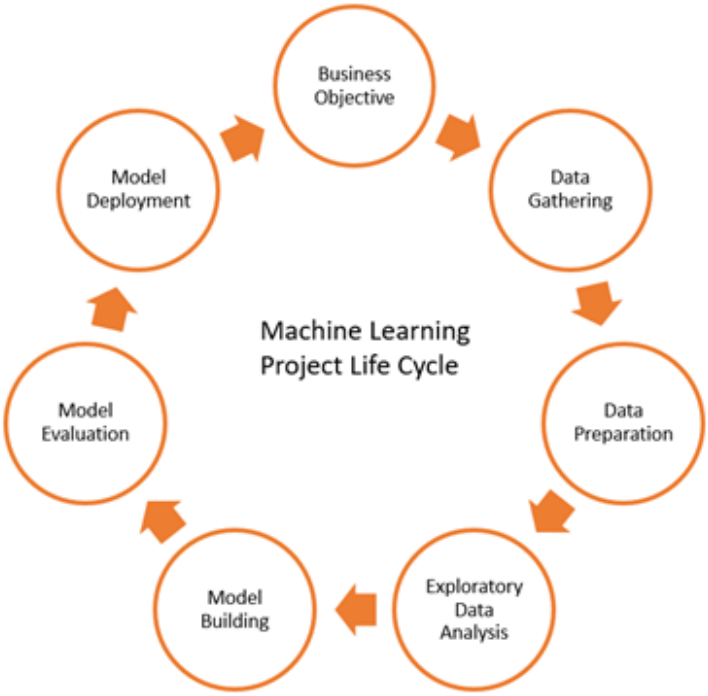

Figure 47: *Lifecycle Machine Learning*

3.7 Deep Learning

Prerequisite:

Prior to reading this section of our thesis, it is recommended to have a basic understanding of RNNs (Recurrent Neural Networks) and formal neurons, as well as a general knowledge of neural networks.

Deep Learning is a branch of machine learning that enables a machine to learn from data using an artificial neural network. Artificial neural networks consist of interconnected layers of neurons, which are capable of capturing complex relationships between data. Deep Learning has experienced great success in recent years, particularly in the fields of computer vision and speech recognition.

Artificial neural networks are inspired by the biological neural networks found in the human brain. Like biological neurons, artificial neurons are capable of processing information and communicating with other neurons. Artificial neural networks are thus able to simulate certain functions of the brain, such as pattern recognition and decision making

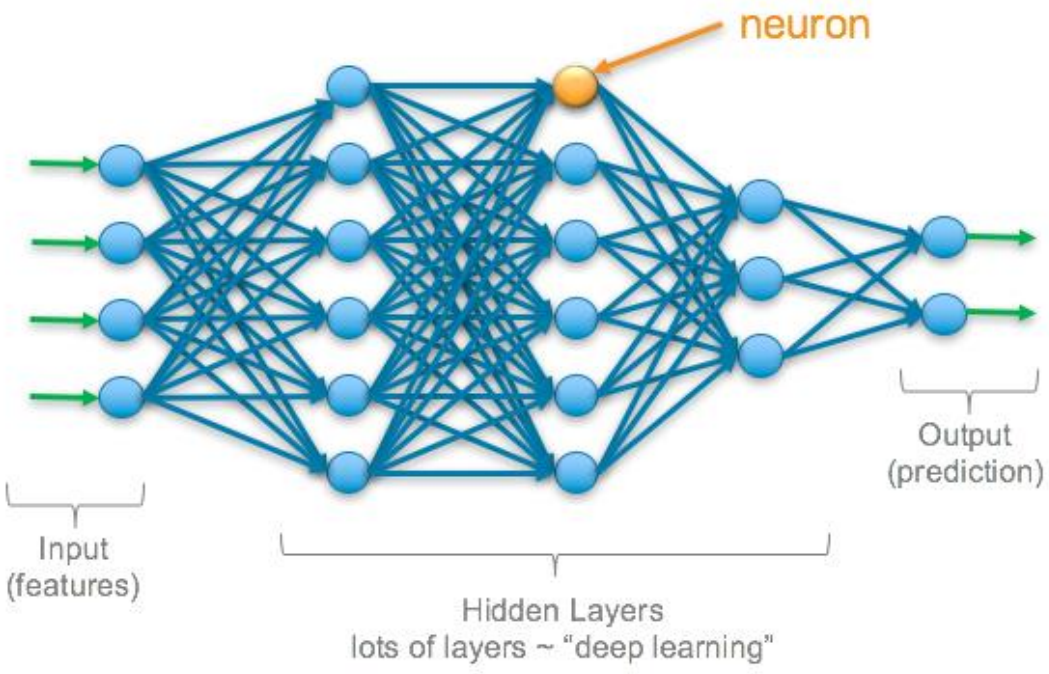

Figure 48: *Simple Architecture of Deep Learning*

3.7.1 How does Deep Learning work?

Deep Learning works by using artificial neural networks that are inspired by the biological neural networks in the human brain. These networks consist of interconnected layers of neurons, which are capable of capturing complex relationships between data.

Artificial neural networks are trained on massive amounts of data to learn to recognize patterns. To do this, the data is split into a training set and a validation set, and the neural network is iteratively adjusted to minimize prediction error on the validation set.

Once the neural network is trained, it can be used to make predictions on new data. The data is fed into the neural network, which calculates an output based on the relationships learned during training.

Deep Learning uses optimization algorithms, such as backpropagation, to adjust the weights of the connections between neurons in the network and improve the accuracy of predictions. Deep neural networks, which are neural networks with many layers, are able to capture more complex relationships and achieve more accurate predictions than simpler neural networks.

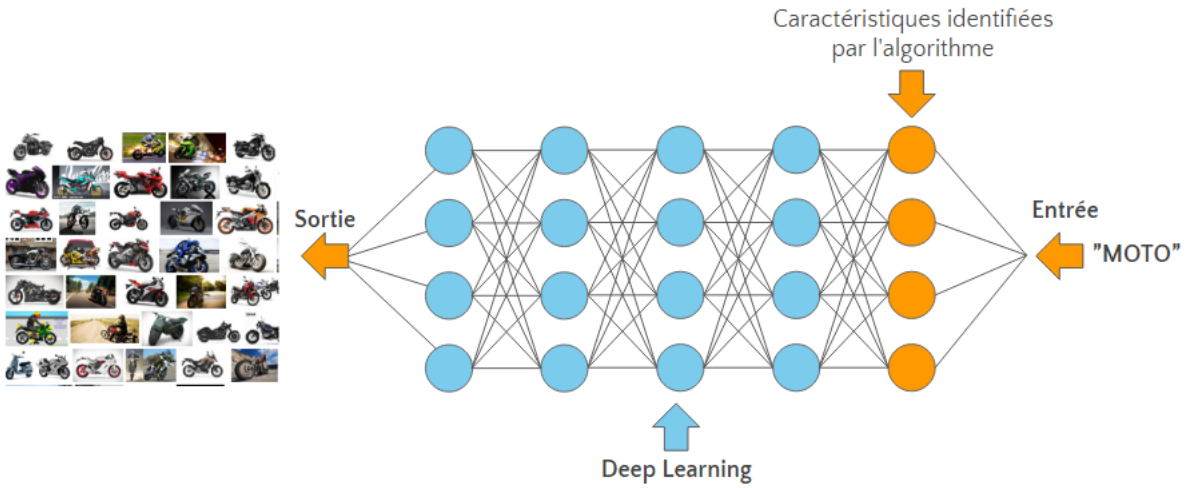

Figure 49 : *Exemple of Deap Learning*

In the given example, the raw image data is fed into the input layer of a neural network. The input layer then identifies patterns of local contrast based on factors such as color and luminosity. The first hidden layer focuses on specific facial features, like eyes, nose, and lips, and maps these features to the correct face template. This process continues in subsequent hidden layers until the correct face is identified and sent to the output layer. By adding more hidden layers to the neural network, more complex problems can be solved, such as identifying faces with specific complexion types. As the number of hidden layers increases, the neural network becomes more adept at solving complex problems.

3.7.2 Deep learning models

There are several models of deep learning, each with its own advantages and disadvantages. In this subsection, we will mention the 10 most famous models and focus on the CNN model.

Here is the list of top 10 most popular deep learning algorithms [46] :

- Convolutional Neural Networks (CNNs)
- Long Short Term Memory Networks (LSTMs)
- Recurrent Neural Networks (RNNs)
- Generative Adversarial Networks (GANs)
- Radial Basis Function Networks (RBFNs)
- Multilayer Perceptrons (MLPs)
- Self Organizing Maps (SOMs)
- Deep Belief Networks (DBNs)
- Restricted Boltzmann Machines(RBMs)
- Autoencoders

Convolutional Neural Networks (CNNs) :

CNNs, also known as ConvNets, are neural networks composed of multiple layers that are primarily utilized for image processing and object detection tasks. The first CNN, originally named LeNet, was developed by Yann LeCun in 1988. It was specifically designed for character recognition, including ZIP codes and digits.

CNN's are widely used to identify satellite images, process medical images, forecast time series, and detect anomalies.

Convolutional Neural Networks (CNNs) consist of multiple layers that are responsible for processing and extracting features from data:

Convolution Layer: The convolutional layer is a key component of convolutional neural networks and is always present as at least the first layer.

Its objective is to detect the presence of a set of features in the input images. To achieve this, it performs a convolutional filtering operation: this involves sliding a window representing the feature over the image and calculating the convolutional product between the feature and each scanned portion of the image

Rectified Linear Unit (ReLU): CNNs utilize a ReLU layer to process elements and generate rectified feature maps as output.

Pooling Layer: Pooling is a downsampling operation used to decrease the dimensions of a feature map.

The pooling layer then takes the resulting two dimensional arrays from the pooled feature map and converts them into a single, long, continuous, linear vector by flattening them.

Fully Connected Layer: A fully connected layer, also referred to as a dense layer, is a layer in a neural network where every neuron is connected to every neuron in the preceding layer. This means that each input feature is connected to every neuron in the layer, and each neuron in the layer is connected to every neuron in the subsequent layer.

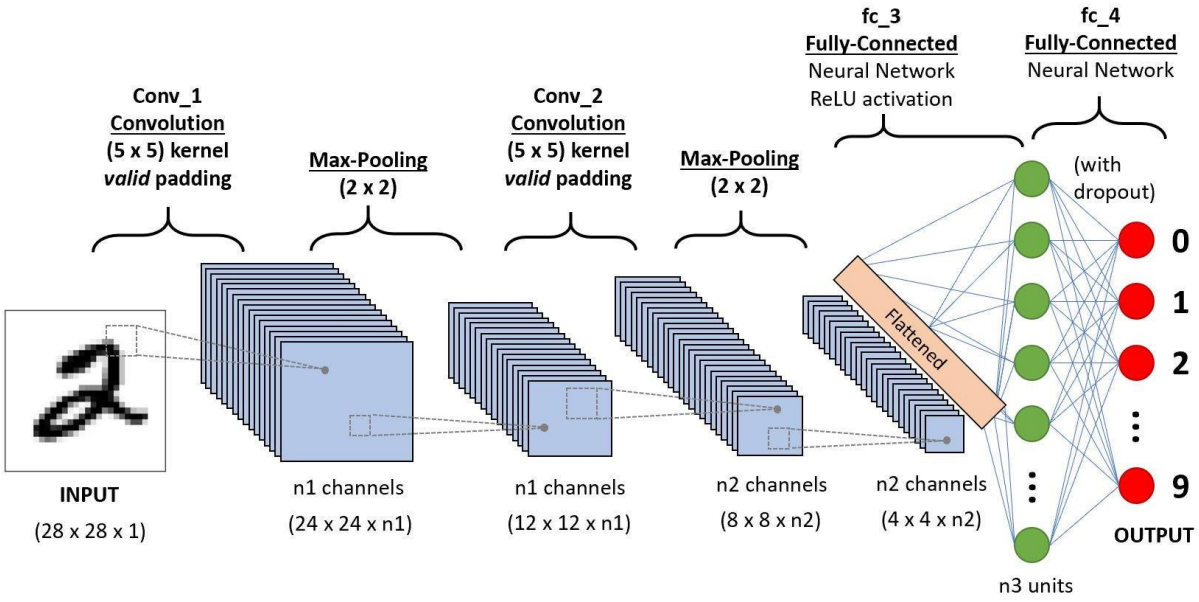

Figure 50 : *Convolution Neural Network [47]*

3.7.3 Deep Learning VS Neural Networks.

Deep Learning can be simply defined as neural networks with multiple hidden layers

Neural networks are a mathematical modeling technique that uses interconnected artificial neurons to mimic the functioning of biological neural networks in the human brain. Neural networks are capable of capturing complex relationships between data and providing accurate predictions using optimization algorithms to adjust the weights of connections between neurons.

Deep Learning uses deep neural networks to learn from massive amounts of data and solve complex problems more effectively than traditional machine learning methods. Deep neural networks are neural networks with multiple hidden layers, capable of capturing more complex relationships between data and obtaining more accurate predictions.

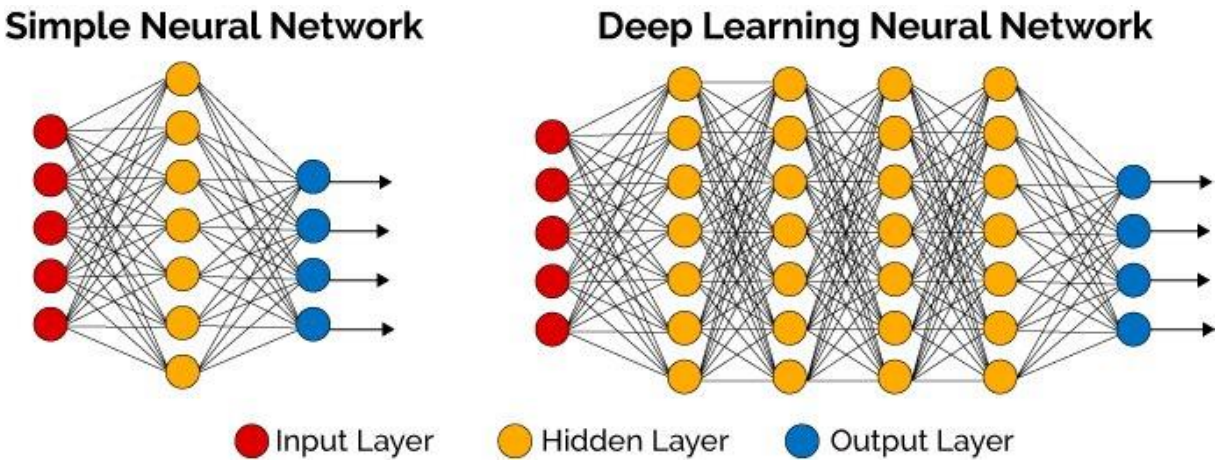

Figure 51: *DL Neural Netword and Simple Neural Networdk [47]*

3.7.4 Motivation Deep Learning

These are the five main motivations in Deep Learning:

- Unstructured data analysis: Deep Learning algorithms can be trained to examine textual data by analyzing social media posts, news articles, and surveys to provide valuable insights into businesses and customers.
- Data labeling: Deep Learning requires labeled data for training. Once trained, it can label new data and autonomously identify different types of data.
- Feature engineering: A Deep Learning algorithm can save time by not requiring humans to manually extract features from raw data
- Efficiency: When a Deep Learning algorithm is properly trained, it can perform thousands of tasks over and over again, faster than humans
- Training: Neural networks used in Deep Learning can be applied to many types of data and applications. Additionally, a Deep Learning model can adapt by retraining it with new data.

3.7.5 Machine Learning Vs Deep Learning

Machine Learning is a branch of AI that focuses on creating applications capable of learning from data to improve their accuracy over time, without human intervention. Machine Learning algorithms can learn to find patterns for more accurate decisions and reliable predictions, but this often requires human intervention to train them.

Deep Learning is a subset of Machine Learning that enables computers to solve more complex problems. Deep Learning models are also capable of generating new features by themselves.

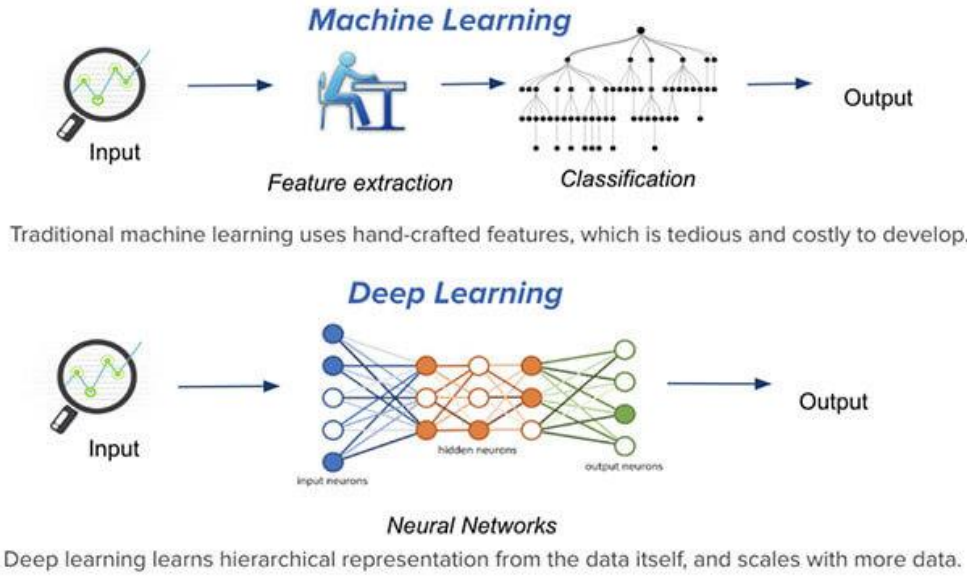

Figure 52: *ML vs DL [47]*

The " Figure 52" demonstrates the difference between Machine Learning and Deep Learning, where feature extraction requires human intervention in ML, while in Deep Learning, features are extracted by the models themselves.

3.7.6 Some possible applications of Deep Learning include:

- Social media: Deep Learning can be used to analyze large amounts of images, which can help social media platforms learn more about their users. This can improve the relevance of targeted ads and follow recommendations.
- Financial service : Neural networks used in Deep Learning can be used to predict stock values and develop business strategies. They can also detect security threats and protect against fraud.
- Healthcare domain : Deep Learning can play a central role in the healthcare domain by analyzing trends and behaviors to predict diseases in patients. Healthcare professionals can also use Deep Learning algorithms to determine optimal tests and treatments for their patients.
- Cybersecurity: Deep Learning is capable of detecting advanced threats more effectively than traditional malware defense solutions. It uses a more proactive approach by identifying unknown suspicious activities rather than simply reacting to a database of known threats.

- Digital assistants: Digital assistants are among the most common examples of Deep Learning. Thanks to natural language processing (NLP), assistants such as Siri, Cortana, Google, and Alexa can answer questions and adapt to users' habits.

3.7.7 Limitation of deep learning

Even though Deep Learning has experienced exponential growth in recent years due to its learning capabilities, it also has limitations that need to be taken into account before deciding to use it:

Here are some limitations of deep learning [48]:

- Lack of transparency: When a neural network explores millions of data points to find patterns, it can be difficult to understand how it arrives at its solution. This lack of transparency in data processing makes it difficult to identify unwanted biases and explain predictions, despite these challenges, data experts are increasingly approaching the creation of highly accurate Deep Learning models that can learn without supervision, making Deep Learning faster and less laborious.
- Large quantities of data: To achieve more accurate and abstract answers, Deep Learning requires vast amounts of data for training. Like the human brain, a Deep Learning algorithm needs examples to learn from its mistakes and improve its results.
- Lack of flexibility: The machines still learn in a narrow manner, which can lead to errors. The deep learning networks require data to solve a specific problem. If asked to perform a task outside of that scope, the machines are likely to fail

Chapter 4:

Design, Experimentation, and Obtaining Results

4.1 Introduction

Before starting to code the application, we focus on the specification phase to define and clarify the main functionalities of our application. This chapter aims to provide a precise definition of functional and non-functional requirements, as well as the intended objectives, we will also present the chosen tools, discuss the technologies used in the design and development of our system, such as the architecture of our CNN model, the programming languages used, the databases, and the servers. Furthermore, we will showcase the features of this system, including the screens of the mobile application.

4.2 Specification phase

4.2.1 Functional Requirement

In this section, we outline all the functional requirements that our system should meet. System requirements specification is the process of identifying and documenting the system's needs, including functionalities, performance, constraints, and quality requirements, to guide the system's design, development, and implementation. It involves understanding business requirements, user needs, and technical requirements.

The system must enable to the driver:

The system must allow user authentication through a login and password to access various functionalities.

The system must enable to the arduino:

- Capture gas/temperature/humidity data.
- Transmit the captured data from the Arduino to the mobile application.
- Trigger an alert if the level of LPG is high
- Trigger an alert if the level of temerature and humidity is high
- Trigger an alarm if the distance between vehicles is less than the set limit.

The system must enable to the Application:

- Detecting drowsiness while driving.
- Trigger an alert if the level of drowsiness is high.
- Trigger an alert if the level of LPG and Temerature and Humidity is high than the set limit.
- Trigger an alarm if the distance between vehicles is less than the set limit.

4.2.2 Non-Functional Requirements

These are the system's required characteristics that are not specific to particular functionalities. They encompass requirements related to performance, hardware, or design. These needs may also include implementation constraints such as the choice of programming language

The system must meet the following requirements/

- **Ergonomics of the mobile application interface:** The application should be easy to use, with user interfaces that are user friendly, meaning they are simple, ergonomic, and tailored to the user
- **Reliability:** The system must exhibit reliability to ensure that the collected data is accurate and dependable. The sensors and Arduino should be properly calibrated, and the data must be transmitted reliably to the mobile application to ensure the accuracy of information.
- **Performance**: The system must deliver high performance to ensure a smooth and responsive user experience. The mobile application should be fast and responsive, allowing for quick access to drowsiness and gas data.
- **Maintenance**: The system should be easy to maintain to ensure continuous availability. Electronic components such as Arduino and sensors should be easily replaceable and upgradable in case of failure or obsolescence.
- **Compatibility**: The system must be compatible with a variety of smartphones and tablets to facilitate easy usage by a wide range of users. The mobile application should be designed to be compatible with popular mobile operating systems such as Android and iOS.
- **Scalability**: The system should be capable of handling a large number of simultaneous users. The mobile application should be able to efficiently manage a substantial amount of drowsiness and gas data from multiple drivers and display it effectively.

4.2.3 Functional Requirements Modeling

The purpose of functional requirements modeling is to provide a clear and precise description of the functionalities that the system should deliver, along with the interactions between these functionalities. This aids in better understanding user needs and ensuring that the system meets user expectations.

Activity diagram:

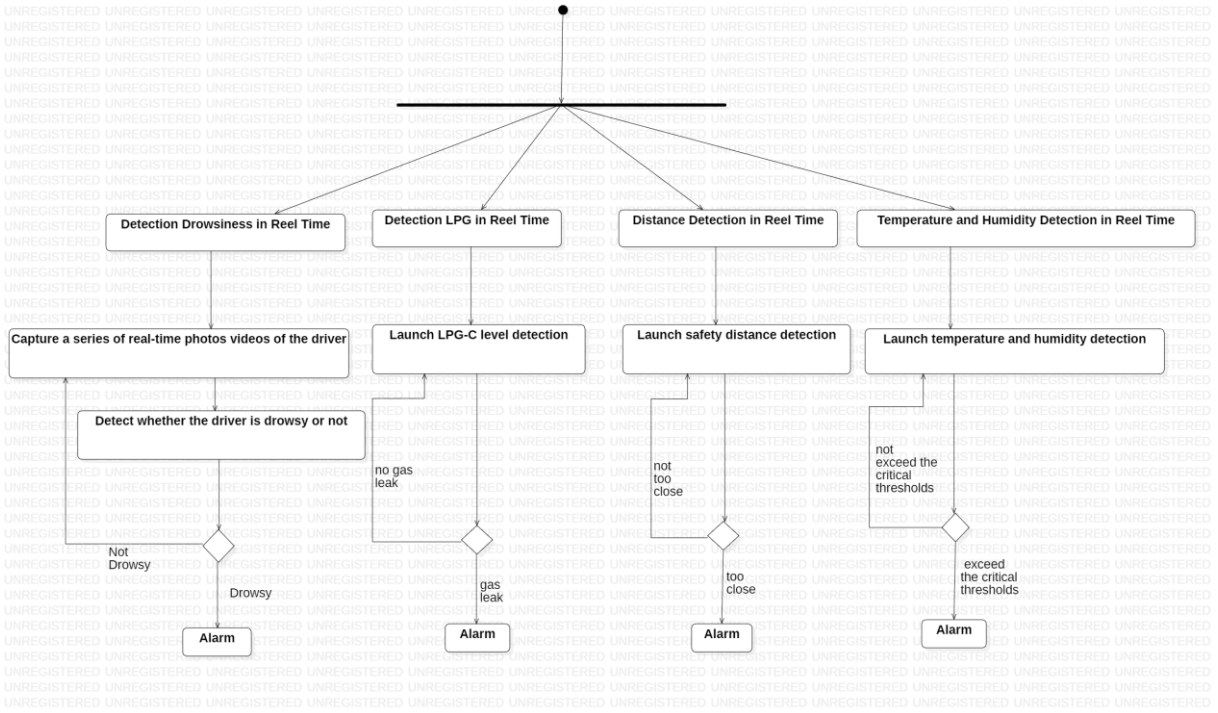

Figure 53*: Activity diagram*

Sequence diagram:

Graphical sequence diagrams represent the interactions between actors and the system in a chronological order, following the syntax of the Unified Modeling Language (UML). These interactions are depicted within the context of a use case scenario diagram. To simplify the representation, the main actor is typically positioned on the left side of the diagram, while any secondary actors are placed on the right side of the system. The objective is to describe the flow of actions between the involved actors or objects.

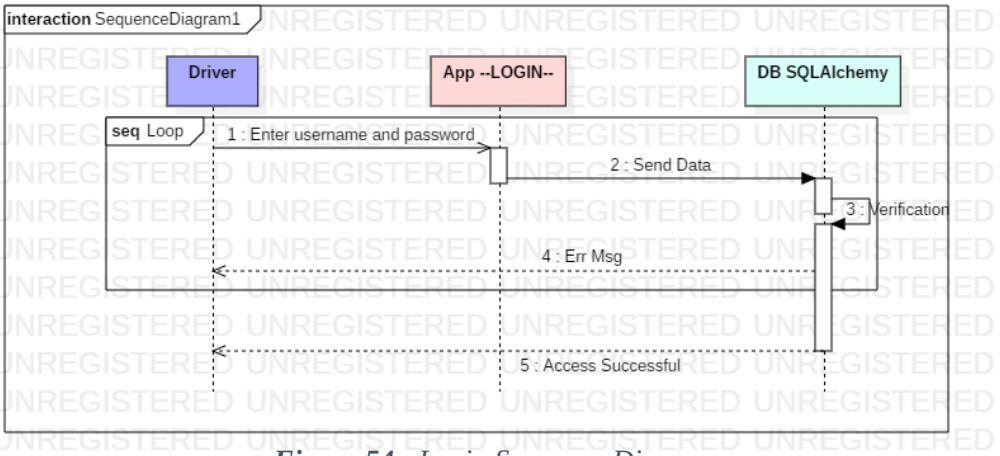

Figure 54 : *Login Sequence Diagram*

Scenario for a login sequence diagram:

1. The user enters their username and password and clicks the "Login" button
2. The application sends a login request message to the authentication server.
3. The authentication server verifies the provided username and password.
4. If the credentials are not valid, the server Displays an error message to the driver.
5. If the credentials are valid, the server sends a success message back to the Driver. (See Figure 54)

Register sequence diagram:

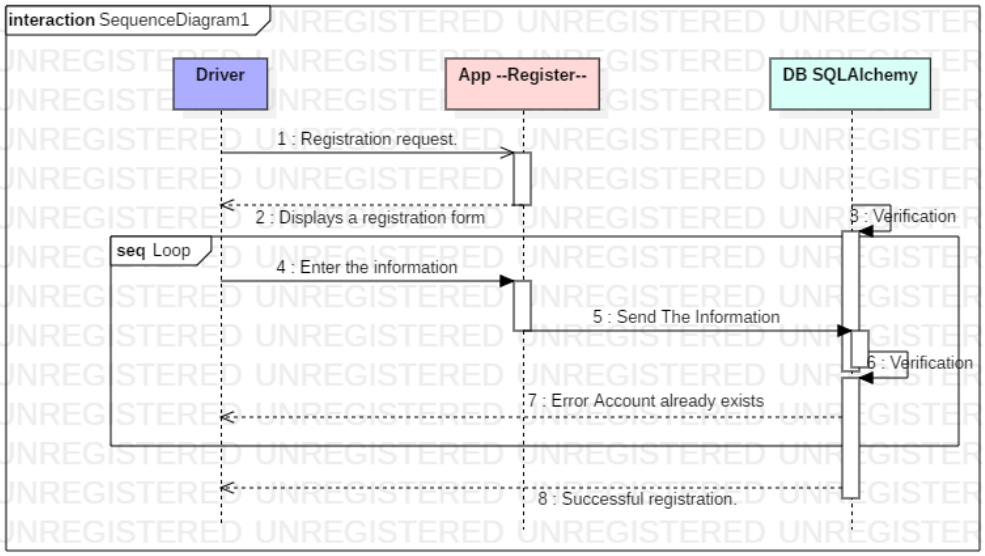

***Figure 55** : Register Sequence Diagram*

Scenario for a Register sequence diagram:

The user requests to register in the application with the system. The application responds by displaying a complete form with all the required information fields (name, last name, email, password, etc) for the user to fill in. If the input does not contain any errors (such as incorrect character types or exceeding character limits), the system sends a request to the database to verify the existence of the user. If the user does not exist, the registration process is successful. Otherwise, an error message is sent to the user. (See “Figure 55”)

4.3 Expremention and results

We divided the tools into three categories: tools for building the CNN model, tools for developing the application, and tools for the Arduino system.

4.3.1 Starting with the characteristics of the used PC:

- Intel(R) Core(TM) i7-3612QM CPU @ 2.10GHz Processor, 2101 MHz, 4 core(s), 8 logical processor(s)
- Installed Physical Memory (RAM) : 12.0 GB
- Intel® HD Graphics 4000 + NVIDIA GeForce GT 635M
- Samsung 256GB SSD + 1TB HDD

4.3.2 The tools and programming languages used to develop our CNN model:

- Python
- Anaconda
- Keras
- Tensorflow

4.3.3 The tools and programming languages used to develop our Mobile Application:

- React Native
- Expo
- Visuel Studio Code
- FastApi
- Flask

4.3.4 The tools and programming languages used to develop our Arduino system:

- Arduino Uno
- Arduino IDE 2.1.0
- ArduinoJson.h
- MQ6 LPG Gas Sensor
- BreadBoard
- DHT11 Temperature Humidity Sensor
- HC-SR04 Ultrasonic Sensor for Distance Measurement
- ESP8266 WiFi Module
- 2 LEDs and Buzzer

4.4 Definition of tools

Python: Python is a popular, powerful, and easy to learn programming language that is used in many different fields. It is one of the most powerful tools in the fields of artificial intelligence and data science, and its strength lies in the large number of libraries it contains

Anaconda: Anaconda is a popular Python distribution that is widely used in the fields of data science and analysis. It comes with Python and many pre installed libraries and tools, making it a convenient solution for projects related to machine learning and data science. Additionally, Anaconda makes it easy to manage virtual environments and packages, simplifying the process of development and deployment.

Keras: Keras is a popular open source deep learning library written in Python that provides a user friendly interface for creating, training, and deploying deep learning models, leveraging underlying computational frameworks such as TensorFlow, Theano, or CNTK. Keras enables developers to quickly build artificial neural networks for tasks such as classification, regression, image recognition, and more.

Tensorflow: TensorFlow is an open source machine learning framework that is widely used for creating, training, and deploying machine learning models, especially deep neural networks. TensorFlow offers great flexibility and excellent performance thanks to its distributed computing and hardware optimization capabilities. It is used in various fields such as computer vision, natural language processing, speech recognition, and more.

Flask: Flask is a web development framework in Python that is known for its lightweight, flexibility, and ease of use. It is commonly used to design fast and efficient web applications, and includes a range of features such as handling HTTP requests, user sessions, and cookies. Due to its many advantages, Flask is highly popular within the Python web development community.

FastApi: FastAPI is a web development framework for Python that stands out for its speed, performance, and ease of use. It is based on Python type annotations to provide automatic documentation, data validation, auto-completion, and error handling. Although it is particularly suited for creating RESTful APIs, FastAPI can also be used for developing complete websites.

React Native: React Native is an open source framework developed by Facebook for building cross-platform mobile applications using JavaScript and the React library. It allows developers to create mobile apps for both iOS and Android by sharing a significant portion of the source code between the two platforms. React Native utilizes reusable components and provides high performance by directly communicating with the native APIs of the operating system.

Expo: expo is a platform for developing mobile applications based on React Native. It offers a set of tools and services to facilitate the development, testing, and deployment of React Native mobile apps. Expo allows developers to create apps without the need to set up and manage native development environments. It provides features such as access to device APIs, easy app deployment, and the ability to share apps under development with other users.

Visuel Studio Code: Visual Studio is an integrated development environment (IDE) developed by Microsoft. It is used to create a variety of applications, including desktop, web, and mobile apps. Visual Studio offers advanced code editing, debugging, project management, and deployment features, making it a popular tool among developers. It supports multiple programming languages such as Python, C#, C++, JavaScript and provides extensions for further customization and integration.

Arduino IDE 2.1.0: Arduino IDE 2.1.0 is an integrated development environment (IDE) specifically designed for programming Arduino boards. It provides a user friendly interface and a set of tools for writing, compiling, and uploading code to Arduino microcontrollers. The IDE includes features such as syntax highlighting, code completion, and a serial monitor for debugging and interacting with Arduino devices.

Figure 56 : *ArduinoJson Library*

ArduinoJson.h: ArduinoJson.h is a C++ library for parsing and generating JSON (JavaScript Object Notation) data on Arduino boards. It enables Arduino projects to work with JSON data structures, making it easier to communicate and exchange data with other devices

or web services. The library provides functions for parsing JSON strings, creating JSON objects, and manipulating JSON data.

Figure 57: *MQ6 LPG Gas Sensor*

MQ6 LPG Gas Sensor: The MQ6 LPG Gas Sensor is a gas detection module designed to detect the presence of LPG (liquefied petroleum gas) in the surrounding environment. It is commonly used in gas leak detection systems for safety purposes. The sensor operates based on the principle of resistance changes in the presence of LPG gas, providing an analog output that can be read by a microcontroller or Arduino board.

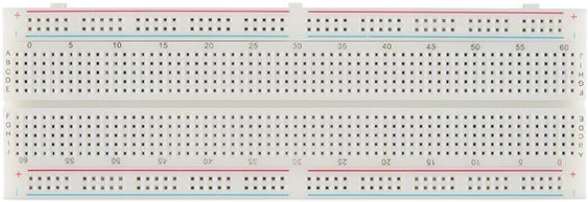

Figure 58: *Breadboard*

Breadboard: A breadboard is a prototyping board used in electronics and circuit design. It provides a platform for quickly and easily connecting electronic components without the need for soldering. A breadboard typically consists of a grid of interconnected metal clips or sockets that allow components and wires to be inserted and connected. It is commonly used for testing and prototyping circuits before they are permanently soldered onto a printed circuit board (PCB).

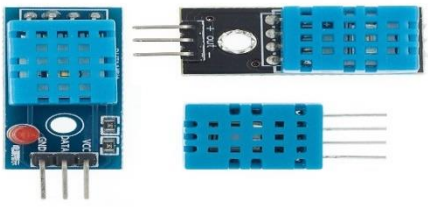

Figure 59 : *DHT11 Temperature Humidity Sensor*

DHT11 Temperature Humidity Sensor: The DHT11 Temperature Humidity Sensor is a sensor module used to measure both temperature and humidity levels in the surrounding environment. It provides digital output signals that can be read by microcontrollers or Arduino boards. The sensor is commonly used in applications that require environmental monitoring or control, such as weather stations or home automation systems

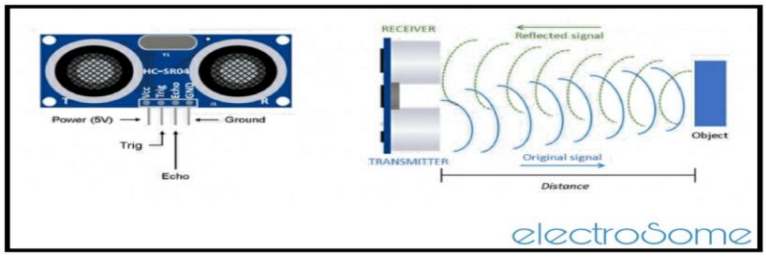

Figure 60 : *HC-SR04 Ultrasonic Sensor for Distance Measurement*

HC-SR04 Ultrasonic Sensor for Distance Measurement: The HC-SR04 Ultrasonic Sensor is a distance measuring module that uses ultrasonic waves to determine the distance between the sensor and an object. It emits ultrasonic pulses and measures the time it takes for the sound waves to bounce back after hitting the object, allowing for distance calculation. The sensor is widely used in robotics, proximity sensing, and obstacle detection applications.

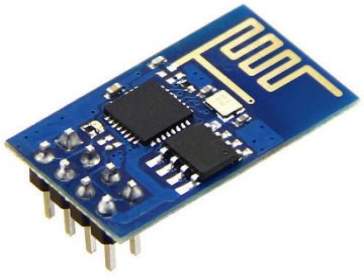

Figure 61 : *ESP8266 WiFi Module*

ESP8266 WiFi Module: The ESP8266 WiFi Module is a popular and versatile module for adding Wi-Fi connectivity to Arduino or other microcontroller based projects. It enables devices to connect to Wi-Fi networks, access the internet, and communicate with other devices over Wi-Fi. The module provides both Wi-Fi client and access point modes, allowing for various wireless communication scenarios.

Figure 62: LEDs

LEDs: LEDs (Light Emitting Diodes) are electronic components that emit light when an electric current passes through them. In the context of "2 LEDs," it refers to two individual LED components. LEDs are commonly used in electronics for visual indicators, status notifications, or as light sources. They come in various colors and can be controlled by microcontrollers or other electronic circuits.

Figure 63: *Buzzer*

Buzzer: A buzzer is an electronic component that generates sound when an electric signal is applied to it. It is typically used for audible alerts, alarms, or simple sound effects.

4.5 Our System

4.5.1 Drowsiness Detection

Our model is built using CNN technology. In this subsection, we will present the database used for building this model, the architecture of the model, and the results obtained.

Starting with the database used for building this model:

We have used the Drowsiness_dataset present on the Kaggle platform [49]. The original dataset contains four classes to classify images as open-eye, closed-eye, yawning, or no yawning. However, the objective of this work is to is to classify Drowsiness according to whether the eyes are closed or open. Therefore, we will only use datasets of two classes.

Characteristics of this Database:

- The dataset contains a total of 1452 images in two categories.
- Each category has 726 images.
- There is no need to balance the records as they are already balanced.
- labels: open eye=0, closed eye=1.
- The class designation is coded such that 0 represents an open eye and 1 represents a closed eye.

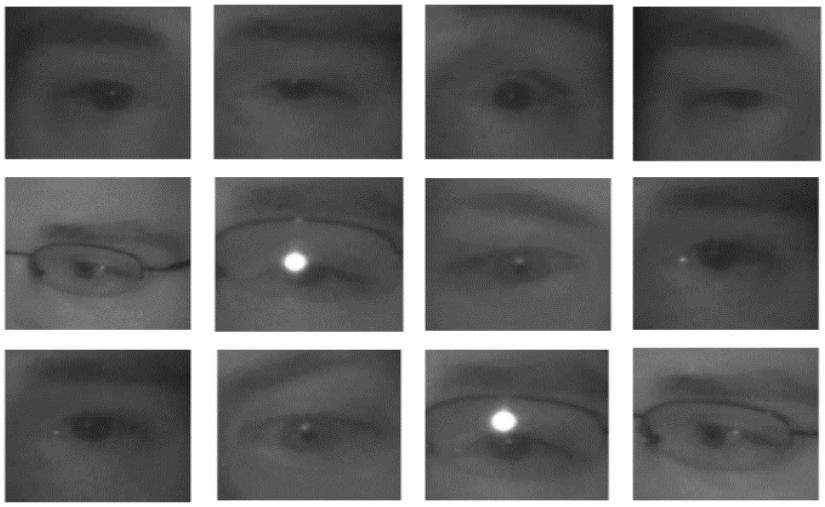

Figure 65 : *Open Eyes Dataset*

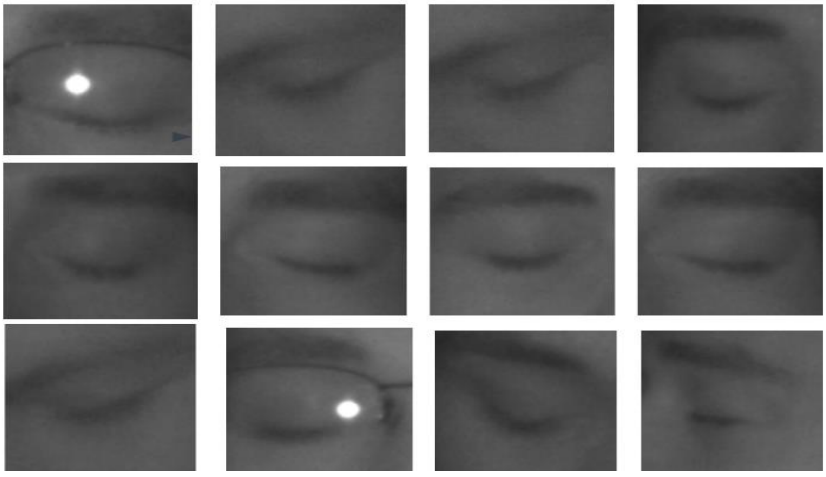

Figure 64 : *Closed Eyes Dataset*

We choose this Dataset for its quality, availability, reliability, and ease of access. It has allowed us to save time in progressing with our project.

a) Used Model:

In this system, the core of drowsiness detection is this model based on deep learning. The developed system should be placed on the driver's smartphone (a mobile application) or

inserted as a component on the vehicle's integrated system combined with GPS, maps, and other tools. The system detects sleep based on video analysis.

b) System Design:

For the design and the realization of our project, we have followed the following steps:

- Step 1: Introduce an image taken from a camera at the entrance of the system.
- Step 2: Detect the face from the input image, and create a region of interest "Region of Interest" (ROI).
- Step 3: Detect the eyes of the ROI and pass the result to the classifier.
- Step 4: The classifier will detect if the eyes are open or closed.
- Step 5: Calculate the score to check whether the person is in sleep state or not.

c) System Implementation:

After applying some preprocessing tasks to prepare image, we proceed to the development of our drowsiness detection model as follows:

- Importing necessary libraries from Python, including; Keras, Tensorflow, imitils, Pandas, dlib, seaborn, sklearn, matlibplot, etc.
- Loading the working dataset (1452 Closed_Eyes, 1452Open_Eyes)
- Loading the images and labels and Preprocessing the Dataset (Input Shape of Images for the CNN model (32, 32, 3)
- Splitting the input dataset into Train set and Test set with test set containing 20% of the total number of images (classes -> 1: Closed Eye, 0: Open Eye)
- Visualizing images of Closed Eye and Open Eye from the Dataset
- Visualizing the Dataset Distribution in Train and Test sets
- Defining the Model Architecture. “Table3” shows our Model architecture
- Training the Model with (Learning rate=0.0001, Optimazer = adam, Number of Epochs=200; batch_size=128
- Saving the model
- Plotting loss values and Accuracy against Number of Epochs for Train Set and Test Set (we will see that in The Obtained Results)
- Evaluating the built model on the test set (The obtained train accuracy: 99.66, the test set accuracy: **99.31**, the test_set_loss value: 0.00791)

d) Architecture of the Proposed CNN Model

Layer (Type)	Output Shape	Params#
Conv1 (Conv2D)	(None, 32, 32, 32)	896
batch_normalization(BatchNo	(None, 32, 32, 32)	128
conv2 (Conv2D)	(None, 32, 32, 32)	9248
batch_normalization_1 (Batch	(None, 32, 32, 32)	128
dropout (Dropout)	(None, 32, 32, 32)	0
max_pooling2d (MaxPooling2D)	(None, 16, 16, 32)	0
conv3 (Conv2D)	(None, 16, 16, 64)	18496
batch_normalization_2 (Batch	(None, 16, 16, 64)	256
max_pooling2d_1 (MaxPooling2	(None, 8, 8, 64)	0
conv4 (Conv2D)	(None, 8, 8, 64)	36928
batch_normalization_3 (Batch	(None, 8, 8, 64)	256
dropout_1 (Dropout)	(None, 8, 8, 64)	0
max_pooling2d_2 (MaxPooling2	(None, 4, 4, 64)	0
conv5 (Conv2D)	(None, 4, 4, 64)	36928
batch_normalization_4 (Batch	(None, 4, 4, 64)	256
conv6 (Conv2D)	(None, 4, 4, 64)	36928
batch_normalization_5 (Batch	(None, 4, 4, 64)	256
conv7 (Conv2D)	(None, 4, 4, 64)	36928
batch_normalization_6 (Batch	(None, 4, 4, 64)	256
dropout_2 (Dropout)	(None, 4, 4, 64)	0
max_pooling2d_3 (MaxPooling2	(None, 2, 2, 64)	0
flatten (Flatten)	(None, 256)	0
fc1 (Dense)	(None, 128)	32896
dropout_3 (Dropout)	(None, 128)	0
fc2 (Dense)	(None, 128)	16512
dropout_4 (Dropout)	(None, 128)	0
fc3 (Dense)	(None, 2)	258
Total params: 227,554 Trainable params: 226,786 Non-trainable params: 768		

Table 3 : *Architecture of the Proposed CNN Model*

e) Results obtained from the model:

In our system, we have achieved an accuracy of 99.31% for the test set. “Figure 66” clearly shows the obtained results. This is a very good result, and it demonstrates that our model can be used for real world applications.

```
10/10 [==============================] - 0s 30ms/step - loss: 0.0198 - accuracy: 0.9931
Test Set Accuracy: 0.993127167224884
Test Set Loss: 0.019795803353190422
```

Figure 66 : *The Obtained Results*

Now that we have proven the effectiveness of our model, let's take a look at some of the outcomes of our model and see how accurate it is.

The figures below show the accuracy and loss obtained by our model

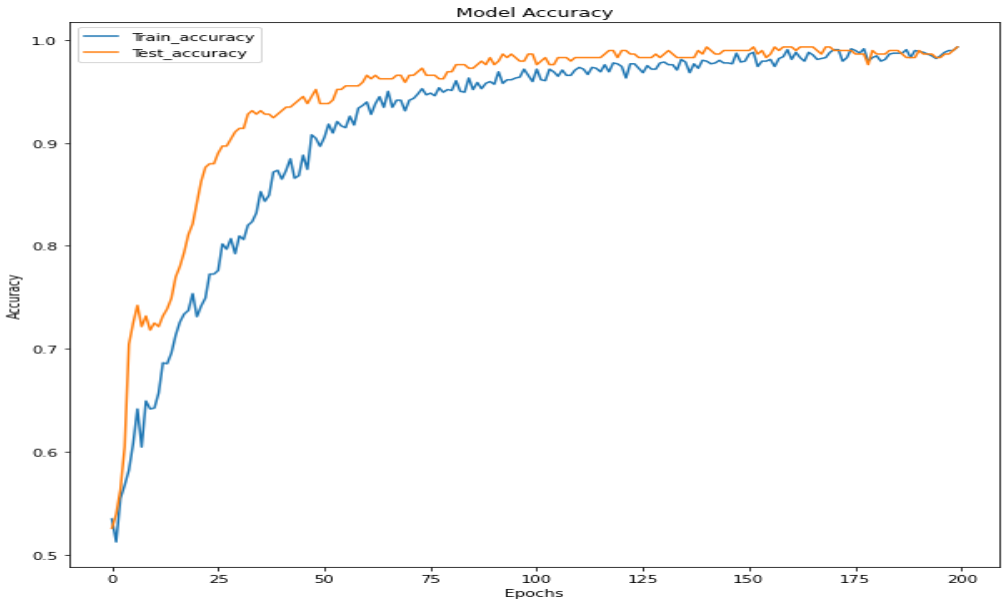

Figure 67*: Train and Test Set accuracy*

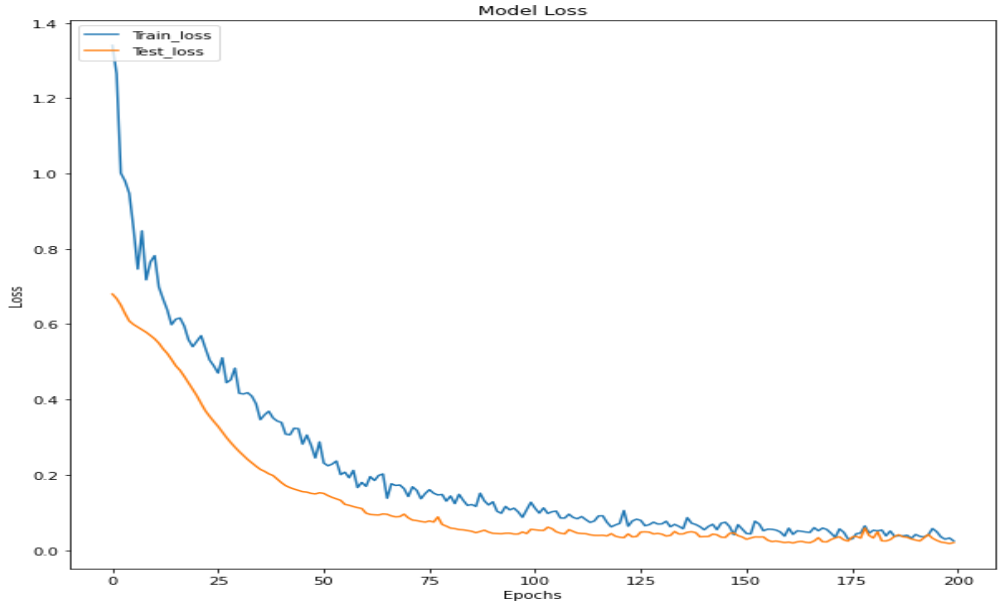

Figure 68: *Train and Test Set loss*

In the section below we will take a look at some comparisons of the most important existing models and see how accurate they are.

Comparison with Existing Models :

Sl. No / Paper Title	Comparison Parameters
Driver Fatigue Monitoring System Based On Eye StateAnalysis	**Techniques:** Face detection for eye state analysis **Algorithms** : Viola-Jones Face Cascade of **CLassifieirs**, Sup-port Vector Machine **Dataset** : 5 subjects **Accuracy**: 93.5%
Driver Drowsiness Monitoring Based On Yawn ing Detection	**Techniques: I.** Camera installed at front mirror: Face detection Mouth detection yawn detection **II.** Camera installed on the dash: Face detection Mouth detection yawn detection **Algorithms: Color** segmentation Active Counter **Model:** Viola-ones Method **Dataset**: 342 videos **Accuracy** : I. 85% ; II.95
Eye detection for a real-time vehicle driver fatigue monitoring system	**Techniques: Eye** detection using image processing **Algorithms**: ANN, SVM, AdaBoost **Dataset**: 1295 eye and 1363non eye images **Accuracy**: SVM: 98.1% ; AdaBoost: 95%
Real Time Drowsiness Detection Using Eye Blink Monitoring	**Techniques:** Face and eye detection for eye blink detection **Algorithms:** Viola Jones algorithm AdaBoost Haar classifier **Dataset**: Not Specified
Facial Features Monitoring for Real Time Drowsiness Detection	**Techniques:** Face detection and skin segmentation Eye Detection Yawn detection **Algorithms**: K-means algorithm, SVM **Dataset** : 100 templates **Accuracy**: 94%
Our Model	**Techniques :** Face Detection**,** Eye Detection **Algorithms** : CNN **Dataset** : 2904 images **Accuracy**: 99.31%

Table 4 : *Comparison with Existing Models*

As you can see, our model has a very high accuracy compared to the other models

The components used in our Arduino system:

Component	Quantity
Arduino Uno R3	1
Ultrasonic distance sensor HC-SR04	4
Gas sensor MQ6+MQ2	2
Temperature sensor DHT11	1
led	2
Buzzer	1
WiFi module ESP8266	1
Powerbank Cidea 8000mah	1
PlayStation Eye w640x480 pixels	1

Table 5: *Used Components*

Circuit diagram of our Arduino system:

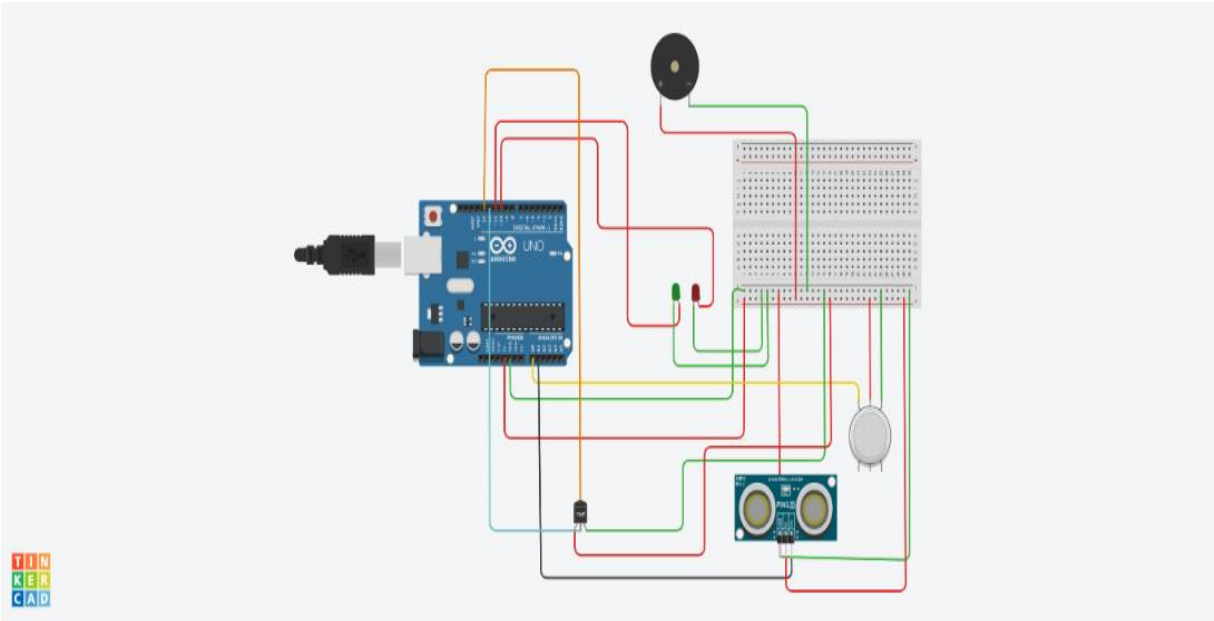

Figure 69: *The electrical schematic of our Arduino system*

Schematic view of our Arduino system:

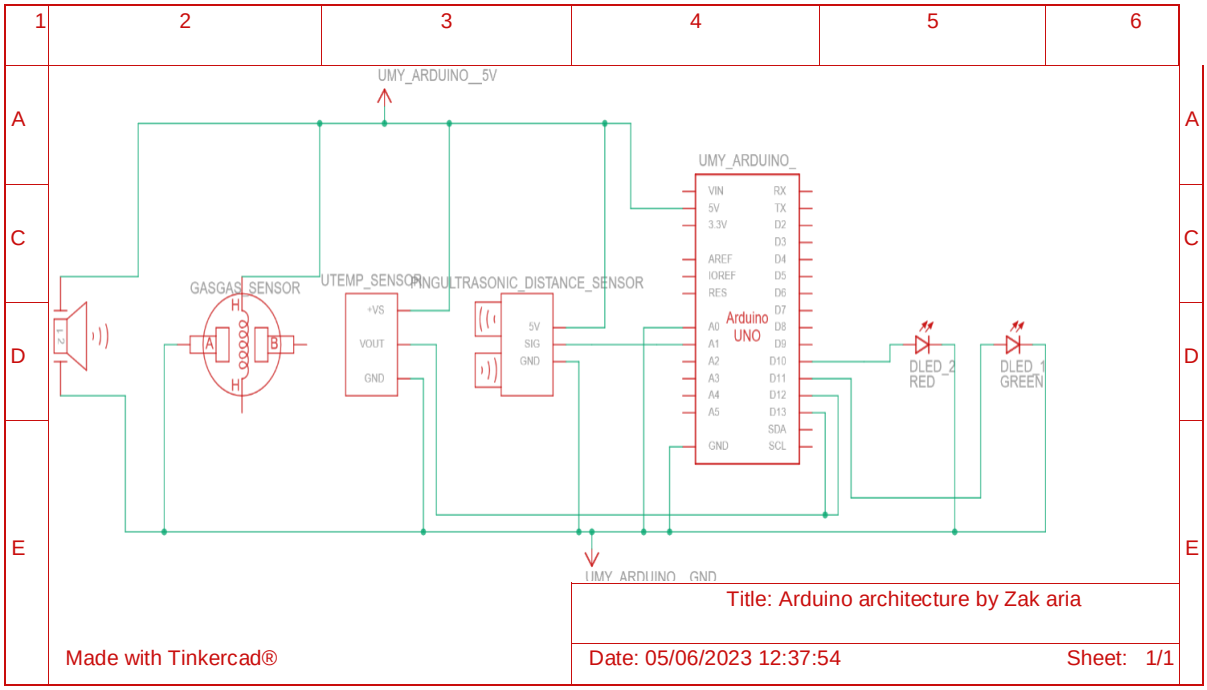

Figure 70: *Schematic view of our Arduino system*

Snippet of our Arduino code:

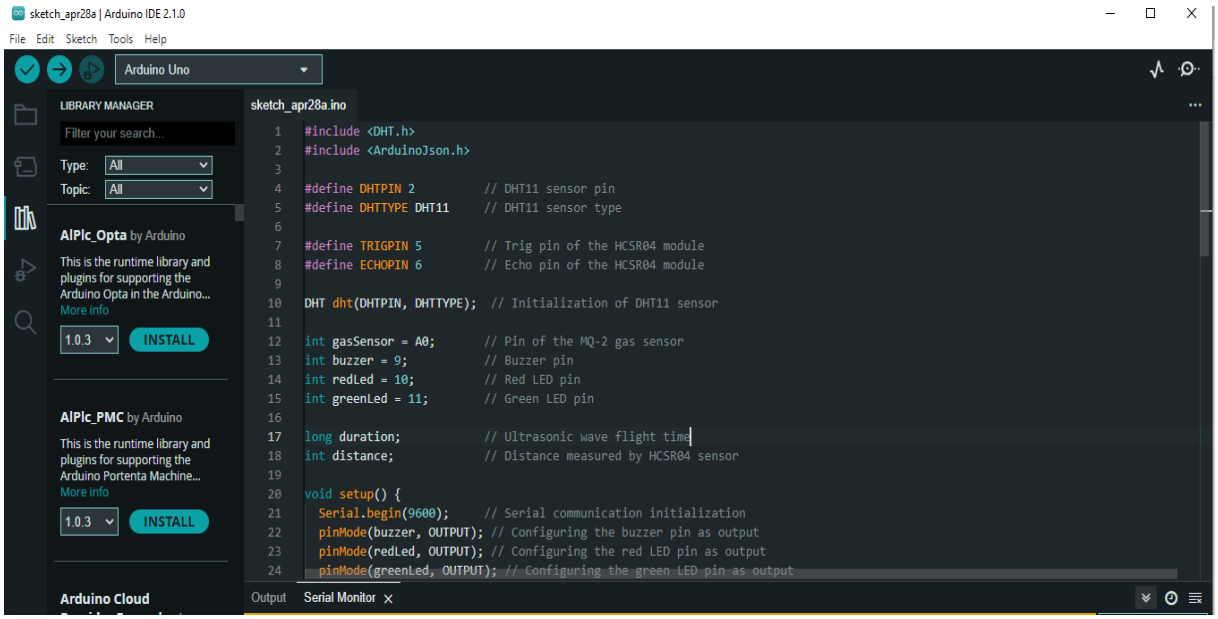

Figure 71: *Snippet Of Our Arduino IDE Code*

Real world application of our system circuit:

The sensors capture the data and send it to the Arduino. If the gas level exceeds the threshold or the distance is less than the limit, the Arduino triggers an audible alarm. Simultaneously, it sends the captured data either through the serial port or the ESP8266 module to the application, which displays the data to the user and triggers different alarms if the threshold of the captured data is exceeded. The application, on the other hand, continuously detects the driver's drowsiness in real time.

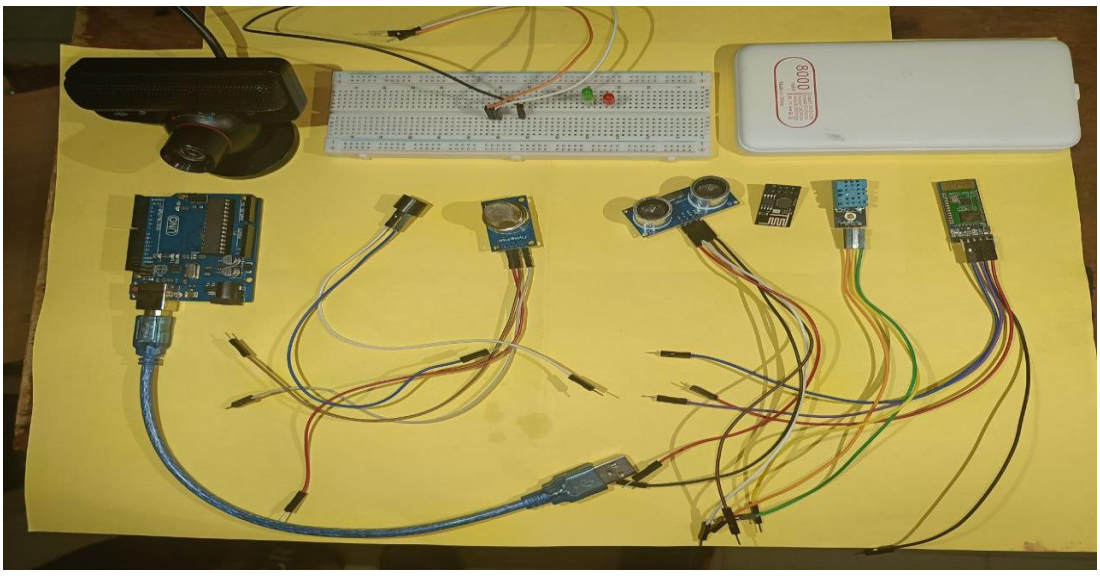

Figure 72 : *Real-world application of Our System*

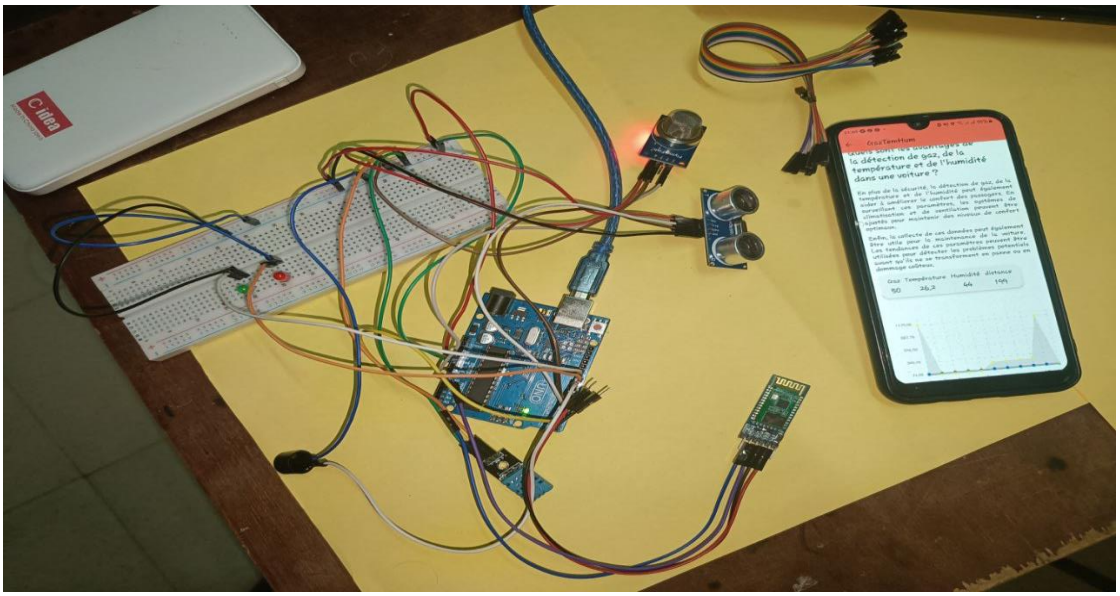

Figure 74 :*Real-world application of Our System*

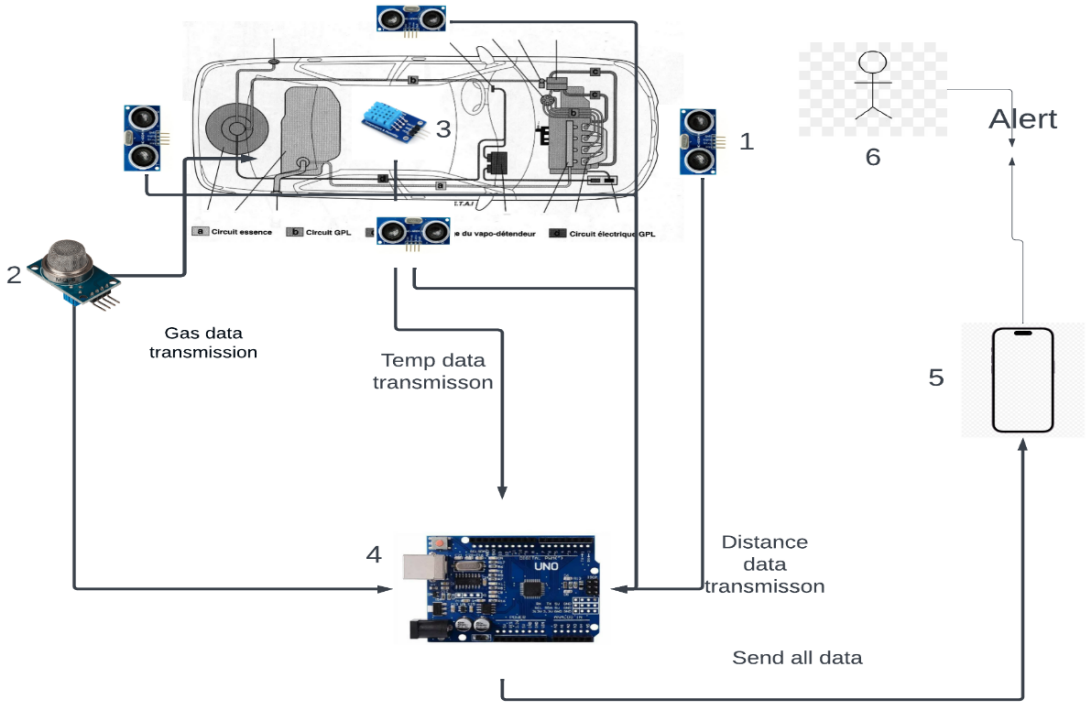

Figure 73: *Sketch of installing our system in a car*

1. Ultrasonic distance sensor
2. Gas detection sensor
3. Temperature and humidity detection sensor
4. Control and processing unit
5. Mobile application (Android/iOS)
6. Driver

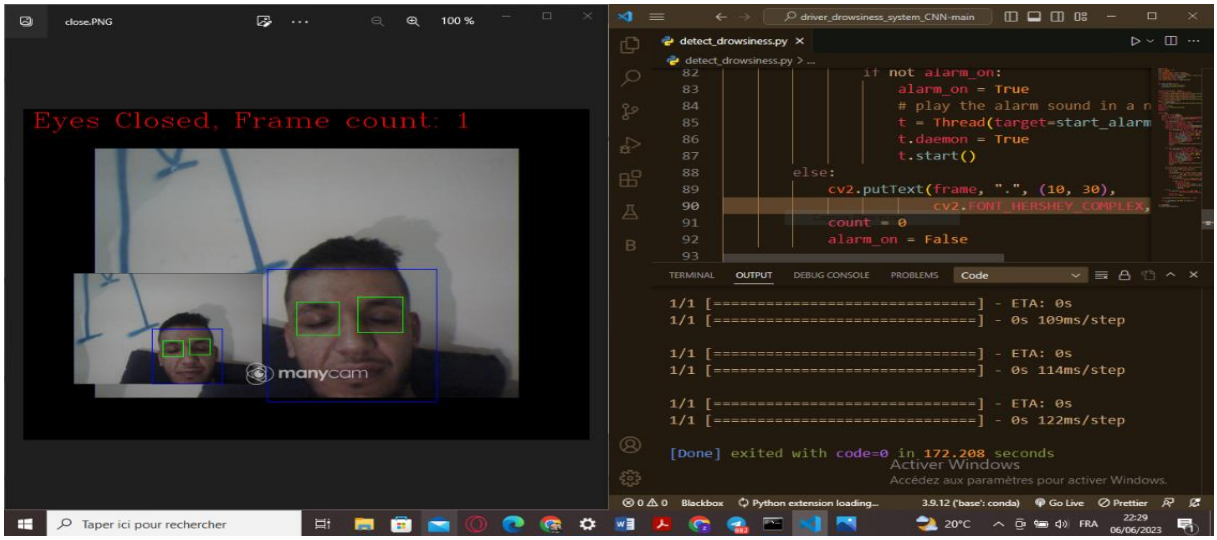

Figure 76 : *Screenshots of our drowsiness detection model when eyes are closed*

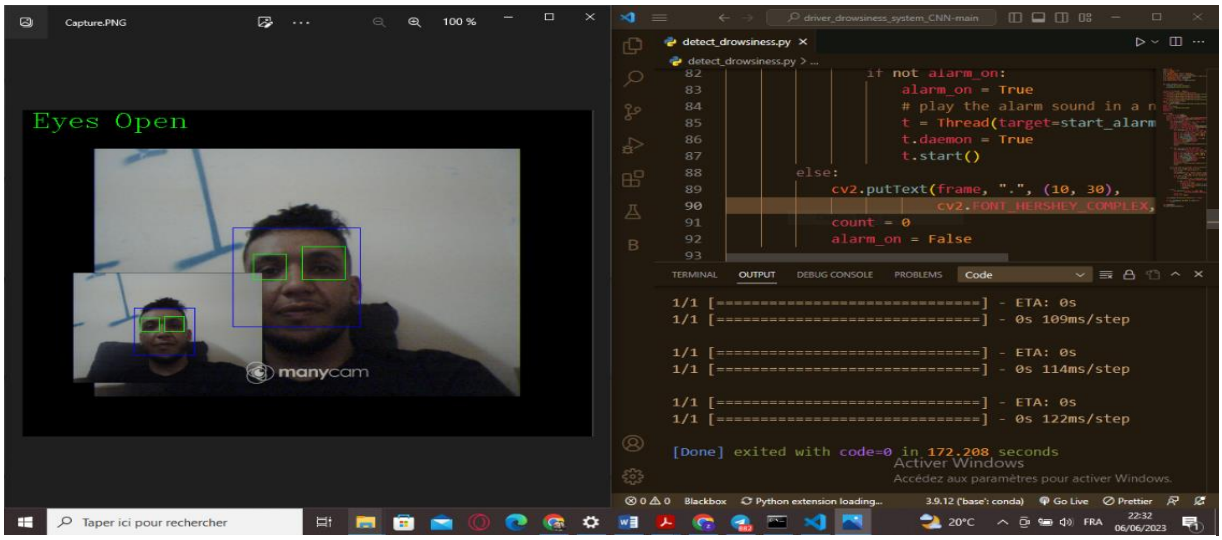

Figure 75: *Screenshots of our drowsiness detection model when eyes are open*

Mobile application interface:

We have chosen the name **SmartGuardian** for our system, and in this section, we will showcase some screens of our mobile application.

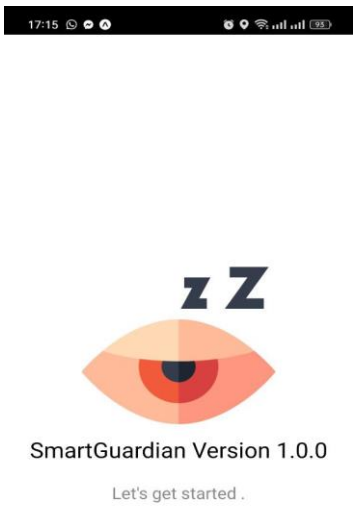

Figure 77 : *Start screen*

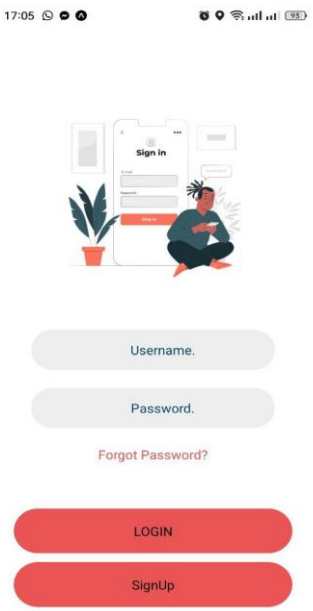

Figure 78 : *Login screen*

Figure 79 : *Home screen*

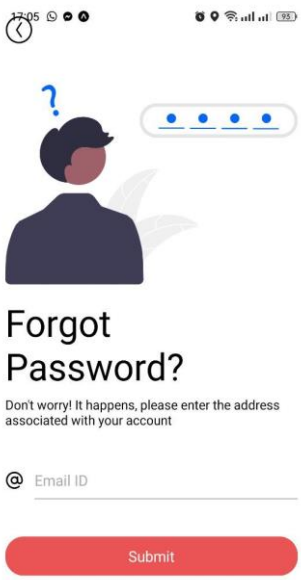

Figure 80 : *Forgot screen*

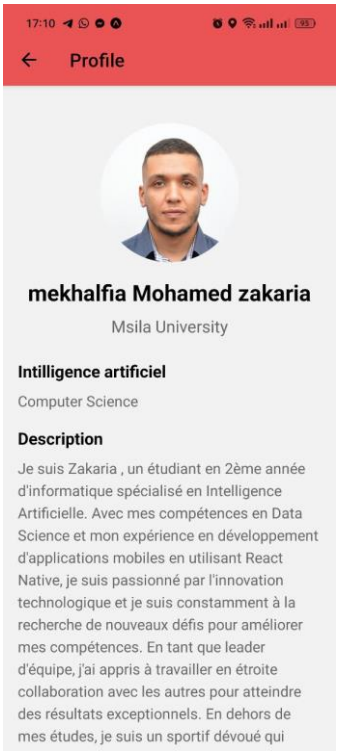

Figure 82 : *Profil screen*

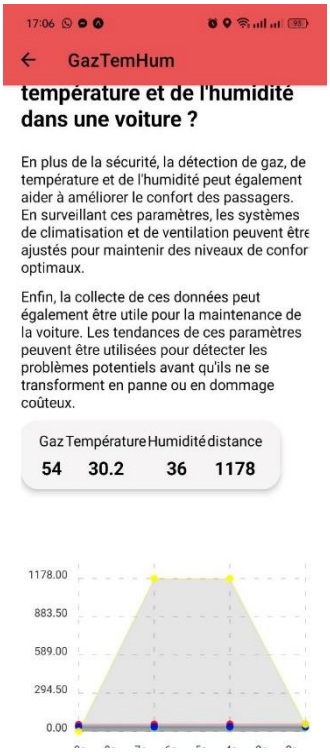

Figure81 :*Detection screen*

Speedometer:

Our mobile application also includes a speedometer feature that constantly monitors the vehicle's speed. This feature is essential to ensure the safety of both the driver and other road users, prevent potential accidents caused by excessive speed, and encourage safe driving practices.

Odometer:

In addition to the speedometer feature, our mobile application also utilizes an odometer to track the distance traveled by the vehicle. This feature is useful for alerting the driver to take a break when they have traveled a distance of 250 km successively in order to avoid fatigue and allow the driver to recover their energy.

4.6 Conclusion

This chapter presented the chosen tools and technologies used in the design and development of our system, including the architecture of our CNN model, the programming languages used, the databases, and the servers. We also showcased the features of our system, including the screens of the mobile application. From the results of our experiments, we can conclude that our SmartGuardian system is effective in detecting hazardous driving conditions such as drowsiness and high gas levels, and alerting drivers in a timely manner. and in the next section, we will discuss future perspectives for the development and improvement of our system.

General conclusion:

General conclusion:

The current project proposes an innovative and advanced system for the field of smart vehicles and transportation. The system utilizes cutting-edge AI-based techniques to detect the driver's state, the level of LPG, internal temperature, humidity, the safe distance from other vehicles, speeding, the distance traveled requiring rest, and other related options. The project's objectives are to ensure the safety of the driver, the vehicle, and other vehicles on the road, while minimizing human and material damage caused by road accidents.

The developed system is 100% operational, with all sensors installed, and the processing unit functioning correctly. The proposed DL model has achieved a very high accuracy rate of 99.31%. The detection of parameters such as LPG-C, temperature, humidity, and distances is achieved with 100% precision.

Although the SmartGuardian system is already operational and effective, there are still challenges and limitations to overcome to improve its performance. We plan to add a mobile phone detection model to trigger an alarm when the driver uses their phone while driving, a seatbelt detection model to detect when the driver is not wearing their seatbelt, and a camera to visualize the vehicle's blind spots. Additionally, we will work on improving the performance of the mobile application and the integrated system to provide a more user-friendly experience. Furthermore, integrating this system into commercial vehicles such as the MediaNav system offers promising prospects for the future. This integration can lead to a wider implementation of the SmartGuardian system, contributing to improving road safety for a larger number of people.

In conclusion, this innovative AI-based system for smart vehicles is a valuable addition to the transportation field. It ensures the safety of drivers and other road users while utilizing advanced technologies.

Appendices

4.7 Certificate of Participation in WMLDL 2023

Mohamed Zakaria Mekhalfia, Said Gadri. Drowsiness Detection System: Developing an Innovative Model Based on Deep Learning Approach. 1st International Workshop on Machine Learning and Deep Learning (WMLDL 2023), 07 March, Faculty of Mathematics and Informatics, Mohamed Boudiaf University of M'sila, Algeria


The First International Workshop on Machine Learning and Deep Learning
Mohamed Boudiaf University of M'sila, March 07, 2023

CERTIFICATE

OF PARTICIPATION AWARDED TO

Mekhalfia Zakaria

FOR CONTRIBUTING WITH AN ORAL PRESENTATION TITLED:

Drowsiness detection system: Developing an Innovative Model Based on Deep Learning Approaches

Co-authors: Said Gadri

WMLDL 2023 General Chair
Dr. Said Gadri

Head of the Computer Science Department
Mohamed Chatra

الدكتور سعيد قادري
Dr. Said GADRI

4.8 Certificate of Recognition: The 1st palce in the national competition for the best programmers.

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمي
جامعة محمد بوضياف – المسيلة

جامعة محمد بوضياف - المسيلة
Université Mohamed Boudiaf - M'sila

شهادة تقدير

يتشرف السيد مدير جامعة محمد بوضياف - المسيلة أن يمنح الطالب(ة): **مخالفية محمد زكرياء**، المولود(ة) بتاريخ: **1996-05-04** بـ: **برج بوعريريج**، هذه الشهادة نظير حصول فريق **Hodna Team** على **المرتبة الأولى** في المسابقة الوطنية لأفضل المبرمجين التي جرت بجامعة عمار ثليجي - الأغواط، متمنيا لهم مزيدا من النجاح والتفوق.

مدير الجامعة

4.9 Localization certificate for the innovative project Decision 1275:

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمي
جامعة محمد بوضياف بالمسيلة
حاضنة الأعمال

INCUBATEUR
UNIVERSITE DE M'SILA

الرقم:71/ الحاضنة/2023

شهادة توطين / تحضين" مشروع مبتكر ضمن القرار1275 "

أنا الممضي اسفله ,السيد : البروفيسور زاوش رضا.
مدير حاضنة الاعمال : لجامعة المسيلة .
المقر الاجتماعي /العنوان : جامعة المسيلة القطب الجامعي شمال
رقم علامة الحاضنة : 0804213017
تاريخ تسليم العلامة : 2021/04/12
اشهد ان الطالب / الطلبة التالية اسمائهم :

الاسم و اللقب	الطور الدراسي	التخصص	الكلية
مخالفية محمد زكريا	ماستر02	الذكاء اصطناعي	الرياضيات و الاعلام الالي

تحت اشراف الاستاذ/الاستاذة التالية اسمائهم

الاسم و اللقب	الرتبة	التخصص	الكلية
سعيد قادري	استاذ محاضر (أ)	الذكاء الاصطناعي	الرياضيات و الاعلام الالي

تم احتضانه على مستوى حاضنة الاعمال لجامعة المسيلة بمشروع تحت اسم :
Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile

خلال السنة الجامعية 2023/2022.
سلمت هذه الشهادة بطلب من المعني(ة) للإدلاء بها في حدود ما يسمح به القانون .
حرر في المسيلة بتاريخ: 2023/06/18

مدير الحاضنة
مدير حاضنة الاعمال
جامعة المسيلة
أ.د. رضا زاوش

4.10 Certificate of Deposit of Patent Application

الجمهورية الجزائرية الديمقراطية الشعبية
People's Democratic Republic of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research

Mohamed Boudiaf University - M'sila
جامعة محمد بوضياف بالمسيلة
BUSINESS INCUBATOR
حاضنة الأعمال

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JNIVERSITE DE M'SILA

جامعة محمد بوضياف - المسيلة
Université Mohamed Boudiaf - M'sila

الرقم: 2023/45 المسيلة في :2023/06/19

شهادة ايداع ملف براءة اختراع

يشهد مسؤول مركز الدعم التكنولوجي والابتكار، الدكتور **بريك يوسف**،

ان الباحث: **مخالفية محمد زكريا** باحث محتضن في حاضنة أعمال جامعة المسيلة،

قد أودع ملف براءة اختراع بعنوان

Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile

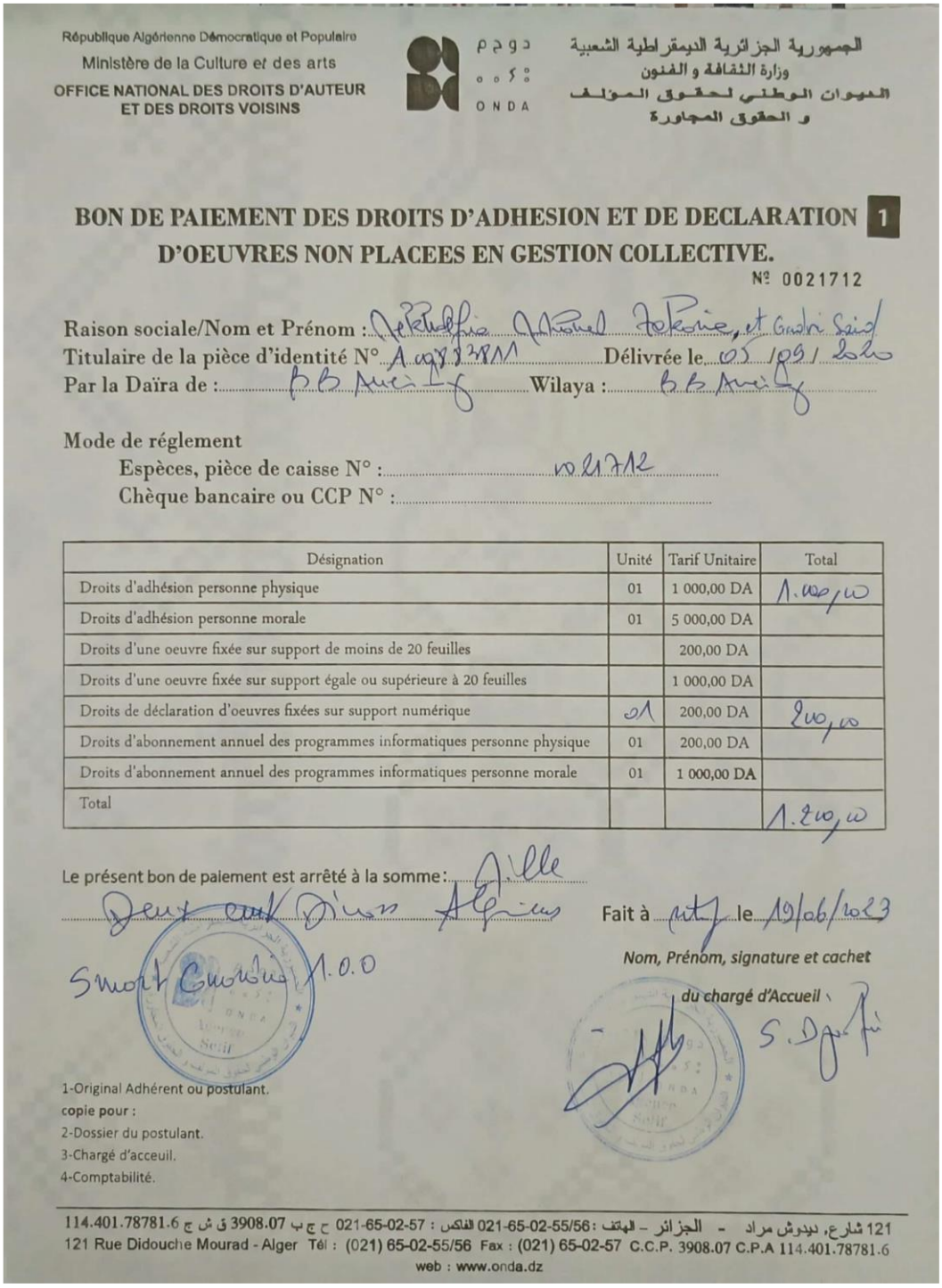
مسؤول مركز الدعم التكنولوجي والابتكار

بريك يوسف

وزارة التعليم العالي والبحث العلمي
مركز الدعم التكنولوجي والإبتكار
CATI
جامعة محمد بوضياف - المسيلة

ملاحظة: سلمت هذه الشهادة لاستعمالها في حدود ما يسمح به القانون

4.11 ONDA



République Algérienne Démocratique et Populaire
Ministère de la Culture et des arts
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ONDA

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة الثقافة و الفنون
الديوان الوطني لحقوق المؤلف و الحقوق المجاورة

BON DE PAIEMENT DES DROITS D'ADHESION ET DE DECLARATION D'OEUVRES NON PLACEES EN GESTION COLLECTIVE. 1

N° 0021712

Raison sociale/Nom et Prénom : Zekhnini Mohamed Zakaria, et Ouadi Said
Titulaire de la pièce d'identité N° A 09733811 Délivrée le 05/09/2016
Par la Daïra de : BB Amine Wilaya : BB Amine

Mode de réglement
Espèces, pièce de caisse N° : 0021712
Chèque bancaire ou CCP N° :

Désignation	Unité	Tarif Unitaire	Total
Droits d'adhésion personne physique	01	1 000,00 DA	1.000,00
Droits d'adhésion personne morale	01	5 000,00 DA	
Droits d'une oeuvre fixée sur support de moins de 20 feuilles		200,00 DA	
Droits d'une oeuvre fixée sur support égale ou supérieure à 20 feuilles		1 000,00 DA	
Droits de déclaration d'oeuvres fixées sur support numérique	01	200,00 DA	200,00
Droits d'abonnement annuel des programmes informatiques personne physique	01	200,00 DA	
Droits d'abonnement annuel des programmes informatiques personne morale	01	1 000,00 DA	
Total			1.200,00

Le présent bon de paiement est arrêté à la somme : Mille Deux cent Dinars Algériens

Fait à Alger le 19/06/2023

Nom, Prénom, signature et cachet du chargé d'Accueil

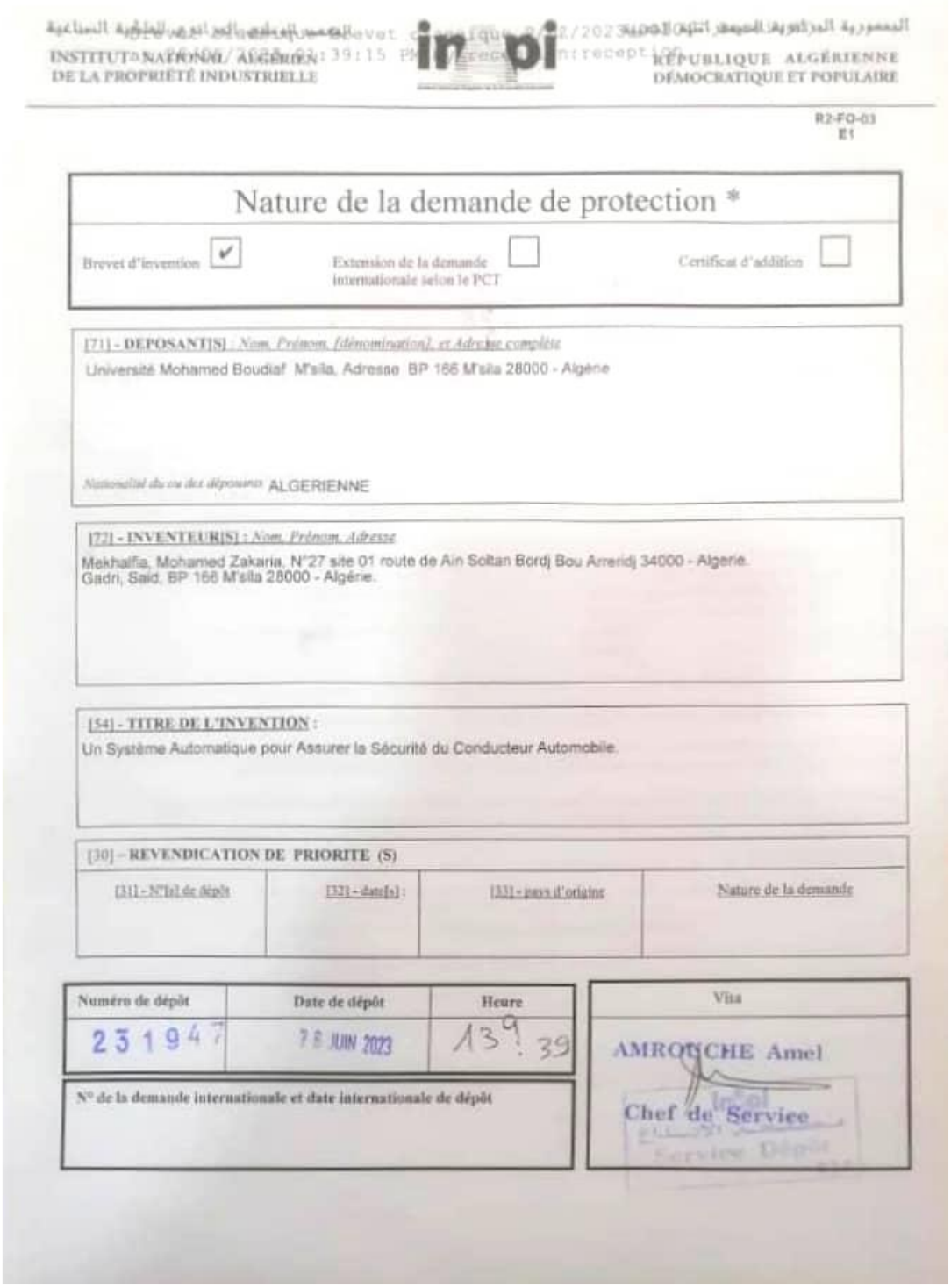
Smail Ghoubia 1.0.0

S. Djamila

1-Original Adhérent ou postulant.
copie pour :
2-Dossier du postulant.
3-Chargé d'acceuil.
4-Comptabilité.

121 شارع، ديدوش مراد - الجزائر – الهاتف : 021-65-02-55/56 الفاكس : 021-65-02-57 ح ج ب 3908.07 ق ش ج 114.401.78781.6
121 Rue Didouche Mourad - Alger Tél : (021) 65-02-55/56 Fax : (021) 65-02-57 C.C.P. 3908.07 C.P.A 114.401.78781.6
web : www.onda.dz

4.12 Inapi



INSTITUT NATIONAL ALGÉRIEN DE LA PROPRIÉTÉ INDUSTRIELLE

inapi

RÉPUBLIQUE ALGÉRIENNE DÉMOCRATIQUE ET POPULAIRE

R2-FO-03
E1

Nature de la demande de protection *

Brevet d'invention ✔ | Extension de la demande internationale selon le PCT ☐ | Certificat d'addition ☐

[71] - **DEPOSANT[S]** : *Nom, Prénom, [dénomination], et Adresse complète*

Université Mohamed Boudiaf M'sila, Adresse BP 166 M'sila 28000 - Algérie

Nationalité du ou des déposants ALGERIENNE

[72] - **INVENTEUR[S]** : *Nom, Prénom, Adresse*

Mekhalfia, Mohamed Zakaria, N°27 site 01 route de Ain Soltan Bordj Bou Arreridj 34000 - Algerie.
Gadri, Said, BP 166 M'sila 28000 - Algérie.

[54] - **TITRE DE L'INVENTION** :

Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile.

[30] – **REVENDICATION DE PRIORITE (S)**

[31] - N°[s] de dépôt	[32] - date[s] :	[33] - pays d'origine	Nature de la demande

Numéro de dépôt	Date de dépôt	Heure
231947	18 JUIN 2023	13:39

N° de la demande internationale et date internationale de dépôt

Visa

AMROUCHE Amel

Chef de Service

4.13 Internship Certificate from Naftal Bordj Bou Arreridj:

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REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIR
وزارة التعليم العالي و البحث العلمي
MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE SCIENTIFIQUE
جامعة محمد بوضياف بالمسيلة
UNIVERSITE MOHAMED BOUDIAFDE M'SILA
كلية الرياضيات و الإعلام الآلي
Faculté des Mathématiques et de l'Informatiques

رقم : 58/ ق.إ.إ/2023 المسيلة: 2023/05/21

إلى السيد : مدير مؤسسة نفطال ببرج بوعريريج

الموضوع:مساعدة الطلبة في إجراء تربص ميداني

في إطار ربط الصلة بين الجامعة والمحيط الإقتصادي يشرفنا أن نلتمس من سيادتكم اتخاذ الإجراءات اللازمة لتمكين االطالب المذكور أدناه من إجراء تربص ميداني بمؤسستكم.

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رئيس القسم

المؤسسة المستقبلة

A.BENZIANE

République Algérienne Démocratique et Populaire

Ministère de l'Enseignement Supérieur et de la Recherche Scientifique

Titre du projet

Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile.

Projet pour l'obtention du statut de startup conformément à la décision ministérielle 1275

Nom commercial

Smart Guardian

Version 1.0.0

Noms et Prénoms des inventeurs

Mekhalfia Mohamed Zakaria, Said GADRI

Fiche Technique :

À propos de l'équipe de supervision et de l'équipe de travail :

1. Équipe de supervision

Le superviseur du projet	
Superviseur principal : Gadri Said	Spécialité : Docteur en Sciences Informatiques

2. Équipe de travail

Équipe du projet	Spécialité	Faculté
Etudiant : Mekhalfia Mohamed Zakaria	Intelligence artificielle	Faculté des Mathématiques et de l'Informatique

1. Domaine technique auquel se rapporte l'invention

Notre invention « Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile » pourra avoir un apport très important sur le domaine de l'industrie des véhicules intelligents (Smart Cars, Self-Driving Cars), ainsi que le domaine du transport. Le système proposé dans le cadre de la présente invention utilise des techniques avancées issues de l'IA pour garantir un niveau très élevé de sécurité pour le chauffeur et le véhicule, en

contrôlant l'état du chauffeur (état du sommeil), le niveau du GPL dans la voiture (détecter toute fuite), la température interne (qui peut causer le sommeil), Humidité, état de la ceinture (installée/non installée), la distance de sécurité par rapport aux autres véhicules, l'excès de vitesse, la distance parcourue demandant un repos, et autres options.

2. Etat de la technique antérieure

Des millions de morts et de blessés autour du monde sont le résultat direct des accidents routiers. Plusieurs facteurs peuvent être cités ici, notamment : l'état du véhicule, l'état de la route, l'excès de vitesse, les conditions climatiques, consommation des produits alcooliques, et surtout le sommeil chez le conducteur qui représente l'un des facteurs les plus influençant selon les statistiques issues des centres spécialisés.

Plusieurs systèmes ont été développés pour remédier à ce problème, mais aucun de ces systèmes a traité tous les facteurs suscités ensemble. La majorité des réalisations ont concentré sur le problème du sommeil chez le chauffeur, avec un taux de détection relativement réduit. Alors l'avantage de notre système est qu'il traite tous les problèmes qui peuvent perturber la sécurité du chauffeur à la fois. En plus le taux de détection est presque 100%. Par exemple pour la détection du sommeil le taux dépasse le seuil de 99% même si le chauffeur utilise des lunettes noires, ou même dans le cas de l'existence d'obscurité autour du chauffeur. De même pour la détection des fuites du GPL dans la voiture, il s'agit ici d'un problème très critique qui demande des solutions innovantes et précises, notre système répond aux deux exigences, car il est basé sur une approche deep learning pour détecter en temps réel la fuite avec une grande précision (100%). Le système réalisé a été testé par les service de NAFTAL ou ils ont exprimé leur satisfaction totale.

Notre invention propose d'autres fonctionnalités qui n'existent pas dans ses prédécesseurs, à noter : la détection de la température et l'humidité, la détection des distances autour le véhicule (en avant, en arrière, à gauche, et à droite), un speedometer (compteur de vitesse) pour contrôler et un odomètre (compteur kilométrique) leur rôle est de contrôler la vitesse du conducteur et la distance parcourue par le conducteur et génère par conséquent des alertes pour indiquer au conducteur de diminuer la vitesse ou faire une pause s'il a parcouru plus de 250 km successivement.

3. But de l'invention

Notre invention a comme objectif global de garantir un niveau élevé de sécurité du conducteur dans les véhicules tradionnels, les véhicules semi-

automatiques, et les véhicules totalement automatiques (Self-Driving-Cars), et comme objectifs détaillés, on peut citer les suivants :

- Garder la vigilance du conducteur tout le temps et dans toutes les conditions.
- Assurer sa sécurité.
- Assurer la sécurité du véhicule, ainsi que les autres véhicules circulant sur la route.
- Minimiser les dégâts humains et matériels causés par les accidents routiers.
- Minimiser la facture des soins médicaux résultants des accidents routiers.
- Exploiter des technologies de pointe et des solutions innovantes basées sur l'IA dans le domaine du transport routier.

4. Équipe de travail :

En tant que groupe spécialisé en IA, notre but est de réduire et d'éviter les dégâts et les accidents routiers. Avec SmartGuardian, vous pouvez profiter de la route en toute confiance, sachant que notre technologie vous aide à prévenir les incidents et à assurer votre sécurité.

5. Roadmap développement technologique :

Année	**Fonctionnalités**	**État**
2023	Détection GPL ,Détection de somnolence	Marche avec succès
2024	Détection de température et d'humidité , Détection de ceinture de sécurité	Marche avec succès
2025	Détection de smartphone Vision des angles morts	Marche avec succès
Première installation	Les 4 premiers critères (GPL, somnolence, température/humidité, ceinture de sécurité)	Prêt

Année	Fonctionnalités	État
Mise à jour 1	Ajout de la détection de smartphone Ajout de la vision des angles morts	Prêt
Mise à jour 2	Tous les critères (GPL, somnolence, température/humidité, ceinture de sécurité, smartphone, angles morts)	Prêt à installer avec SmartGuardian V2.0

6. Présentation du secteur de marché :

Marché Probable : Tous les conducteurs effectuant de longs trajets.

Marché ciblé :

- Tous les véhicules fonctionnant au GPL
- Les véhicules de transport de gaz de NAFTAL et de SONATRACH, ainsi que les chauffeurs de camions et de taxis.

Notre projet de détection de somnolence, de fuites de gaz GPLC, de distance de sécurité routière, de température et d'humidité, d'excès de vitesse et de calcul de la distance parcourue cible plusieurs catégories de conducteurs, notamment les conducteurs de longs trajets, les conducteurs qui utilisent le gaz GPLC comme carburant et tous les chauffeurs. En outre, il est destiné aux grandes entreprises telles que NAFTAL et SONATRACH, qui utilisent des camions pour transporter du GPLC.

Le marché potentiel pour notre projet est très large, car il concerne tous les conducteurs qui souhaitent améliorer leur sécurité et réduire les risques sur la route. En ciblant les conducteurs de longs trajets, les conducteurs de véhicules GPLC et les entreprises de transport de gaz, nous espérons apporter une valeur ajoutée significative à ces secteurs et améliorer la sécurité sur les routes. De plus, notre solution est particulièrement pertinente pour les entreprises qui souhaitent améliorer la sécurité de leur flotte de véhicules et réduire les risques d'accidents de la route.

En résumé, notre projet vise à offrir une solution de sécurité complète pour tous les conducteurs qui souhaitent améliorer leur sécurité et réduire les risques sur la

route, ainsi qu'aux entreprises qui souhaitent améliorer la sécurité de leur flotte de véhicules.

7. Mesure de l'intensité de la concurrence

Plusieurs systèmes ont été développés pour remédier à ce problème, mais aucun de ces systèmes a traité tous les facteurs suscités ensemble. La majorité des réalisations ont concentré sur le problème du sommeil chez le chauffeur, avec un taux de détection relativement réduit. Alors l'avantage de notre système est qu'il traite tous les problèmes qui peuvent perturber la sécurité du chauffeur à la fois. En plus le taux de détection est presque 100%. Par exemple pour la détection du sommeil le taux dépasse le seuil de 99%

Le système réalisé a été testé par les service de NAFTAL ou ils ont exprimé leur satisfaction totale.

8. Coûts et charges

- Charges de personnel (expert en Media-Nav : 60 000 DA mensuel) (coûts variables)
- Développeur d'application : 60 000 DA mensuel). (Coûts variables)
- Coûts d'achat des capteurs et d'unités de traitement (5000 DA/unité)
- Coût du PC de bureau : 200 000 DA par unité. (Coûts fixes)
- Coût du PC portable : 200 000 DA par unité. (Coûts fixes)
- Carte graphique 150000DA par unité. (Coûts fixes)
- Coûts publicitaires : 20000 DA par mensuel. (Coûts variables)

9. Revenue :

- Coût mensuel de l'abonnement à l'application : 600 DA par utilisateur.
- Vente et installation de systèmes dans les voitures, 35 000 DA.
- Vente des statistiques routières à partir du tableau de bord et reporting de la plateforme.
- Les publicités sur l'application et sur le site.
- La maintenance du système qui est implémenté dans la voiture.

Titre du projet : **Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile.**

10. **Prototype :**

Figure 2:Start screen

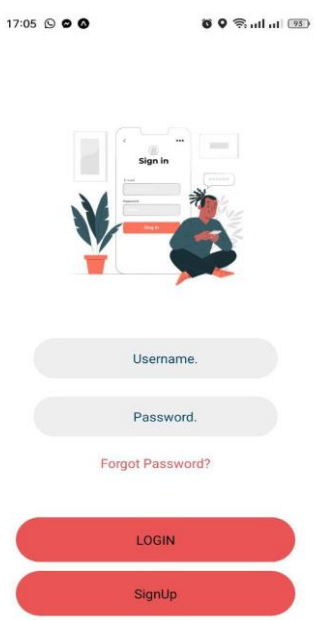

Figure 3:Login screen

Figure 1:Home screen

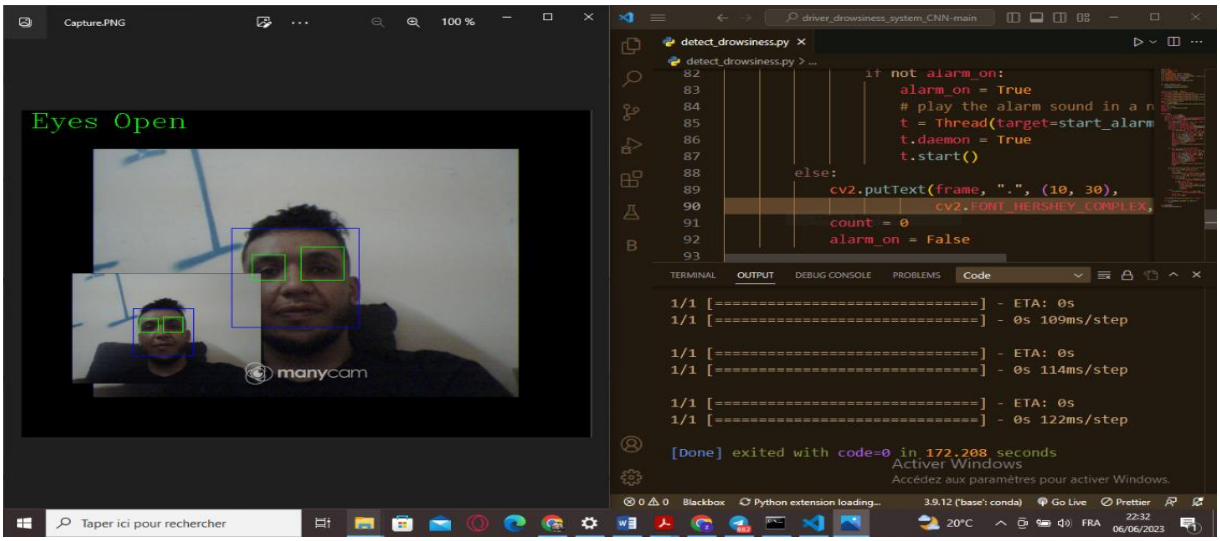

Figure 4 Screenshots of our drowsiness detection model when eyes are open

Titre du projet : **Un Système Automatique pour Assurer la Sécurité du Conducteur Automobile.**

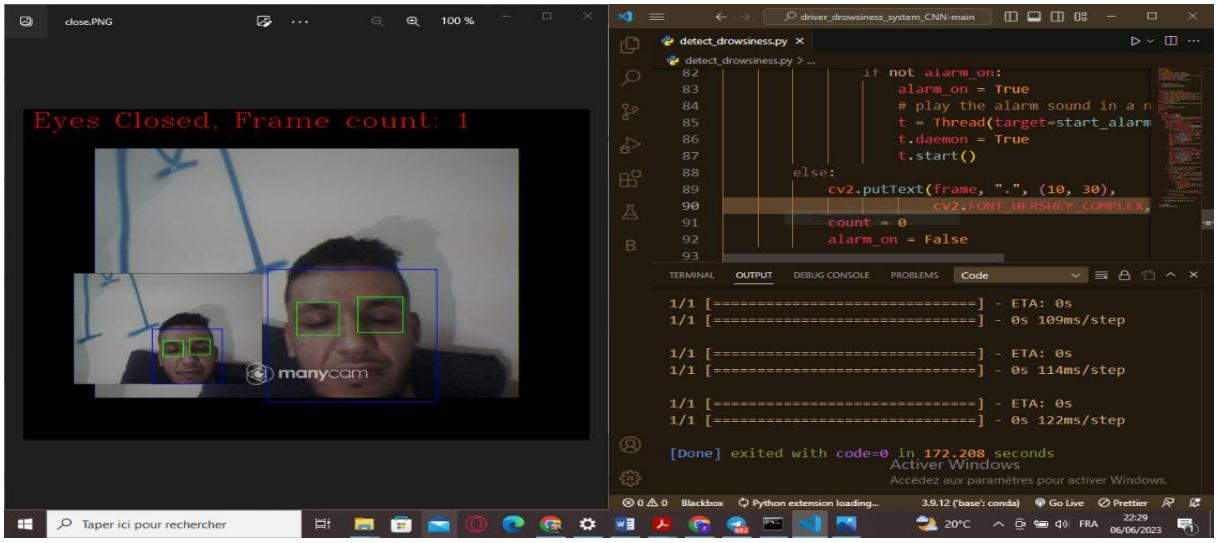

Figure 7:Screenshots of our drowsiness detection model when eyes are closed

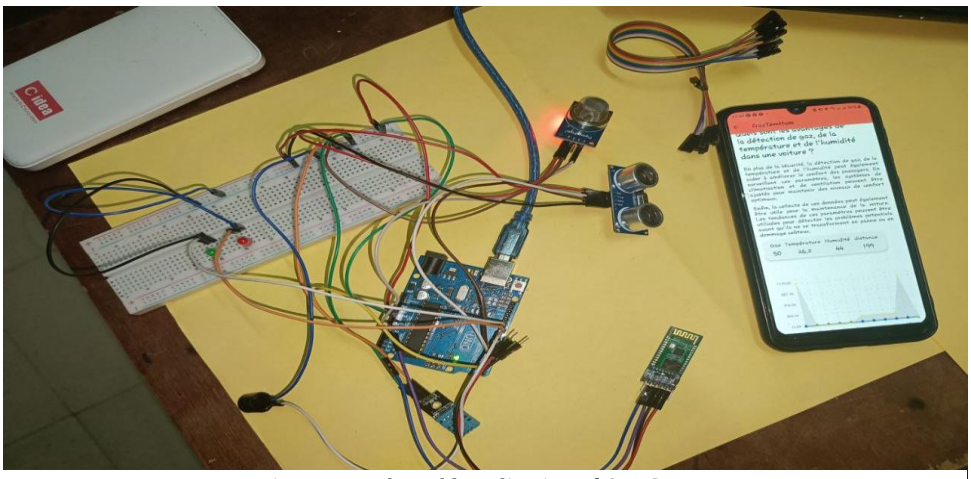

Figure 6:Real-world application of Our System

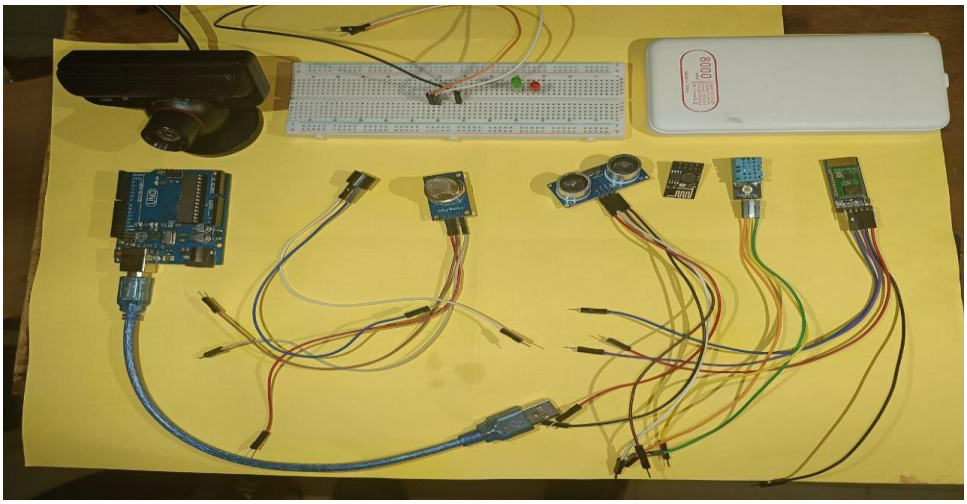

Figure 5:Real-world application of Our System

Partenaires clés	Activités clés	Proposition de valeur	Relation avec les clients	Segment de clientele
-ASF -Les usines de fabrication automobile en Algérie : SOVAC, Kia Motors. -Convention avec les constructeurs d'automobiles : Peugeot, Renault, Volkswagen... - Convention avec des concessionnaires automobiles en Algérie. -Fournisseurs de capteurs et d'unités de traitement. Convention avec NAFTAL,SONATRACH	-Détection de l'état de somnolence chez le chauffeur et avertissement en temps réel. -Détection des fuites de GPL dans la voiture et envoi de messages d'alerte au chauffeur. -Détection de la température interne de la voiture susceptible de causer la somnolence et avertissement au chauffeur (activation du climatiseur). -Détection de l'humidité à l'intérieur du véhicule et demande au chauffeur de prendre les précautions nécessaires pour éviter la somnolence (ouverture des vitres). -Détection et calcul des distances de sécurité autour de la voiture (avant, arrière, à droite, à gauche) pour une sécurité accrue des personnes et des biens.	-Garantie d'un niveau de sécurité très élevé pour le chauffeur et le véhicule. -Réduction des risques d'accidents routiers. -Contrôle de l'état du chauffeur, du niveau de GPL, de la température, de l'humidité, de l'état de la ceinture, de la distance de sécurité, de l'excès de vitesse, de la distance parcourue nécessitant une pause, et d'autres options. -Précision de détection de la somnolence à 99%. -Fourniture d'une version d'essai gratuite de l'application. -Assurance de la maintenance en cas de besoin. -Simplicité de conception de l'interface facilitant l'utilisation de l'application. -Simplicité de montage du système sur le tableau de bord de la voiture ou du camion.	-Support technique. -Assistance en ligne 24h/24 et 7j/7. -Site web donnant des statistiques et relié à l'application pour rester en contact avec les clients. -Réseaux sociaux. -Feedback sur l'application. Plateforme pour l'application et le système. -Satisfaction des besoins. -Simplicité de l'installation du système dans les voitures. -Maintenance (application et système).	-Marché probable : tous les conducteurs effectuant de longs trajets. -Marché ciblé : tous les véhicules fonctionnant au GPL -les véhicules de transport de gaz de NAFTAL et de SONATRACH, ainsi que les chauffeurs de camions et de taxis.

	Resources clés -Capteurs de détection de somnolence, de GPL, de température, d'humidité et de distance -Unité de traitement -Expertise dans les systèmes Media-nav -2 spécialistes dans la réalisation et la conception d'application mobiles -cameras sophistiquées -3 PC Bureau -2PC portables Local -camera : 7000da -1 carte graphique		Canaux de distribution Commercialisation de l'application et du système via Réseaux sociaux (e-marketing), vente en magasin de systèmes et de maintenance, vente de l'application sur App Store et Play Store, marketing direct.	

Structure de coûts	**Sources de revenus**
-Charges de personnel (expert en Media-Nav 60 000 DA mensuel -développeur d'application : 60 000 DA mensuel). -Coûts d'achat des capteurs et d'unités de traitement (19 000 DA/unité) -Coût du PC de bureau : 200 000 DA par unité. - carte graphique 150000DA par unité . -Coût du PC portable : 200 000 DA par unité. -Coûts publicitaires : 5000 DA par semaine.	-Coût mensuel de l'abonnement à l'application : 600 DA par utilisateur. -Vente et installation de systèmes dans les voitures, 35 000 DA. -Vente des statistiques routières à partir du tableau de bord et reporting de la plateforme. -Les publicités sur l'application et sur le site. -La maintenance du système qui est implémenté dans la voiture.

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ملخص

يقدم هذا المشروع نظامًا مبتكرًا ومتقدمًا لمجال السيارات الذكية والنقل. يستخدم النظام تقنيات متقدمة من الذكاء الاصطناعي لكشف حالة السائق ومستوى غاز البترول المسال، ودرجة الحرارة الداخلية، والرطوبة، والمسافة الآمنة من السيارات الأخرى، والسرعة الزائدة، والمسافة المقطوعة التي تتطلب استراحة، وغيرها من الخيارات. يهدف هذا المشروع إلى ضمان سلامة السائق والمركبة، بالإضافة إلى الحد من الأضرار البشرية والمادية الناجمة عن حوادث الطرق. يمكن اعتبار هذا المشروع خطوة هامة في البحث عن حلول أكثر فعالية وذكاءً للسلامة المرورية.

الكلمات المفتاحية: كشف النعاس، التعلّم العميق، الشبكة العصبية المتسلسلة المتبوعة بطبقات التصفية الثنائية، الرؤية الحاسوبية، السلامة الطرقية، كشف التسرب، السيارات الذكية

Abstract:

This project proposes an innovative and advanced system for the field of smart vehicles and transportation. The system uses advanced AI-based techniques to detect the driver's state, the level of LPG, internal temperature, humidity, the safe distance from other vehicles, speeding, the distance traveled requiring rest, and other options. The objectives of this project are to ensure the safety of the driver, the vehicle, and other vehicles on the road, while minimizing human and material damage caused by road accidents. This project can be considered as an important step in the search for more effective and intelligent road safety solutions.

Keywords: Drowsiness Detection, Deep Learning, CNN, Computer Vision. Road safety, Leak detection, Smart vehicles.

Résumé

Ce projet propose un système innovant et avancé pour le domaine des véhicules intelligents et du transport. Le système utilise des techniques de pointe issues de l'IA pour détecter l'état du chauffeur, le niveau de GPL, la température interne, l'humidité, la distance de sécurité par rapport aux autres véhicules, l'excès de vitesse, la distance parcourue demandant un repos, et autres options. Les objectifs de ce projet sont de garantir la sécurité du conducteur, du véhicule ainsi que des autres véhicules circulant sur la route, tout en minimisant les dégâts humains et matériels causés par les accidents routiers

Mots clés : Detection de Somnolence, Apprentissage profond, CNN, Vision par ordinateur, Sécurité routière, Détection de fuite, Véhicules intelligents