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Mechanisms for Implementing Artificial Intelligence to Achieve Road Safety in Algeria

An analytical study

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Abstract

This study aims to highlight the importance of artificial intelligence systems in achieving traffic safety in Algeria by analyzing the situation of traffic accidents over the period from 2010 to 2023. It also aims to showcase the efforts and measures taken to implement artificial intelligence systems to reduce these accidents and propose suitable solutions to achieve economic performance. The study found that, in the field of traffic safety in Algeria, many regulatory measures and efforts have been taken; however, these laws have not succeeded in reducing traffic accidents. Regarding the application of artificial intelligence systems, their use is limited to security services only, such as radars and cameras.

Keywords: Artificial Intelligence, Traffic Safety, health economics, Economic Performance.

JEL Classification Codes: H51, I11, J28,K32, R41.

Introduction

Road safety is currently one of the most critical issues facing countries around the world at all levels, especially after the significant increase in population and vehicles. Regrettably, despite this issue affecting all segments of society, road safety has not yet received sufficient attention at both the international and national levels. According to the latest report from the World Health Organization in 2023, the number of fatalities due to traffic accidents is estimated at 1.19 million people, with more than two deaths per minute and over 3,200 deaths per day. These accidents result in injury and disability for between 20 and 50 million individuals globally. Traffic-related injuries are the leading cause of death for people aged between 5 and 29 years, not to mention the economic, social, and environmental losses, which represent 3% of the Gross Domestic Product (World Health Organization).

According to Ministry of transport (2019) Algeria also suffers from the problem of traffic accidents and their severe impacts on the economic, social, and environmental levels. Each year, Algeria records over 3,000 deaths and approximately 40,000 injuries. In 2018, statistics showed that every 2 hours, one Algerian dies in a traffic accident, and another is injured every 10 minutes. This highlights the urgent need for effective measures to address road safety issues in Algeria. (p. 27)

Most traffic accidents result from the increasing number of vehicles combined with the improper behaviors of road users. In this field, many regulatory measures and organizational efforts have been taken to change these behaviors and prevent such accidents, such as regulating traffic flow and promoting proper use of public roads through specific laws. However, these laws have not met expectations in terms of reducing the rate of traffic accidents and minimizing human and material losses from this phenomenon.

To address these issues, there are many technologies and methods that rely on the application of artificial intelligence principles. Using these technologies leads to better vehicle control and monitoring which reduce road accidents. This involves

utilizing advanced detection, data processing, communication, and control techniques aimed at minimizing traffic accidents.

By applying artificial intelligence systems, efficiency can be achieved in reducing resource use and costs associated with road accidents and traffic congestion. These systems also enable the improvement of traffic flow, reducing travel time and fuel consumption, which positively impacts economic productivity, economic performance, energy efficiency, and time savings. Moreover, these systems assist in improving road infrastructure planning and design, leading to reduced long-term maintenance costs. Thus, the use of artificial intelligence systems in traffic safety not only ensures road safety but also enhances overall economic performance comprehensively.

The statement of the problem

From this perspective, the statement the of problem revolves around the following central question: **How can artificial intelligence systems contribute to achieving road safety in Algeria?**

To answer this question, the study will focus on the following points:

Firstly: Fundamentals of artificial intelligence and road safety;

Secondly: Application of artificial intelligence systems to achieve road safety based on some recent international experiences;

Thirdly: Analysis of the current situation of road safety in Algeria and the application of artificial intelligence to enhance it.

Importance and Objectives of the Study: This study aims to:

- Highlight the importance of artificial intelligence systems in achieving road safety.

- Identify the success factors of some recent global experiments in reducing road accidents through the use of artificial intelligence systems.

- Determine Algerian efforts in achieving road safety and the extent of application of artificial intelligence systems within it.

Firstly: Basics of Artificial Intelligence and Road Safety

1. Concepts Related to Road Safety

1.1 Definition of Road Safety

Al-Kasasbeh (2016) defined Road safety as: "A set of measures aimed at ensuring the safety of road users, resulting in reducing the number of traffic accidents and minimizing the risks or consequences associated with them." (p. 251)

Aiming to adopt all plans, programs, and traffic regulations to ensure the safety of individuals and their property, maintaining security in the country, and preserving its human and economic components. Road safety encompasses three elements: the vehicle, the road, and the human factor." as defined by Boufroukh (2019, p.64)

Based on the definitions mentioned above, road safety can be defined as "taking all necessary measures to reduce accidents and fatalities on the road, thereby ensuring complete safety for all road users, both in terms of material and human aspects. It is considered a critical issue for all countries due to its social and economic consequences."

1.2. Road Safety Objectives: There is no disagreement that the noble and humanitarian goal of road safety is to preserve human life and minimize the financial costs resulting from traffic accidents, regardless of their severity or frequency. According to Samira&Laamria (2018, p. 105-106) the objectives of road safety include:

- √ **Reducing the Number of Accidents:** This is achieved by enforcing traffic regulations on road users through imposing penalties on offenders, as well as intensifying traffic awareness campaigns.
- √ **Minimizing the Hazards of Traffic Accidents:** Meaning reducing the numbers of fatalities, injuries, and losses resulting from such accidents, by applying scientific solutions in road engineering and construction, and vehicle design to meet traffic safety requirements. This includes covering road bridge pillars and metal barriers with shock-absorbing materials on the sides of roads to mitigate

the impact of accidents when vehicles collide with these objects, and ensuring medical emergency services, etc.

√ **Decreasing the Probability of Traffic Accidents:** This is done by implementing preventive safety measures to prevent the recurrence of accidents that have occurred previously at specific locations, such as dangerous curves or hidden slopes where the likelihood of accidents recurring is high. This requires continuous and field studies of accident statistics, their locations, and direct causes to find suitable solutions that eliminate the underlying causes of repeated accidents (preventive measures).

1.3. Traffic Safety Elements: the elements suggested by Najmi (2017) consist of:

- **Vehicle:** It is one of the causes of traffic accidents and constitutes an important element of traffic safety due to the increase in the vehicle fleet and inadequate maintenance. Several safety measures should be available in the vehicle, including:

- Headlights in terms of clarity, colour, and brightness.

- Tires in terms of type, size, load capacity, speed rating, production year, and storage conditions.

- Reflective mirrors to aid driver visibility, along with rain wiper areas.

- Seat belts, headrests, and airbags.

- Brakes and parking brakes that control vehicle movement, as well as door locks.

- Visual and audible warning signals;

- Spare wheels with tools for removal and installation;

- Fire extinguishers and a first aid kit;

- Door closing systems in case of overturning.

- **Roads:** play a crucial role in traffic accidents, whether due to their increase or decrease, which is why it is essential to ensure road safety measures and

construct a network of high-quality roads meeting international standards through:

- Engineering design and planning of roads and their lighting;

- Road durability and traffic safety measures, such as removing debris and shifting sand;

- Availability of traffic control tools like road signals, signs (including advisory, warning, informative, and ground signs). Fadila (2017)

The human element includes:

- **The driver:** The primary and most responsible factor in traffic accidents, being the active and driving force behind all traffic operations. Therefore, drivers must possess several qualities, including:

  - Sensory alertness and a sense of responsibility;

  - Knowledge of traffic regulations and adherence to them;

  - Focus while driving;

  - Familiarity with the mechanics of the vehicle and its continuous maintenance.

- **Pedestrians:** They are individuals who walk on foot, including injured children in strollers or those with special needs. In other words, pedestrians are individuals on foot or those pushing or pulling strollers for children, patients, or the disabled, or those using self-propelled vehicles at speed. Among the most important mistakes pedestrians make are:

  - Not using designated pedestrian crossings

  - Failing to walk on sidewalks and not using pedestrian staircases

  - Pedestrians' ignorance of the meanings of traffic lights, road markings, and traffic signs.

- **Passengers:** They are individuals inside a vehicle other than the driver or their assistant and can contribute to traffic accidents by distracting the driver, such as engaging in conversation with them.

2. Concepts related to artificial intelligence:

According to Shanabi (2017) The term intelligence includes many mental abilities related to analysis, planning, problem-solving, mental simulation speed, as well as abstract thinking, idea collection and coordination, language comprehension, and learning speed. Generally, human intelligence cannot be defined, but some criteria can be mentioned to judge it, including the ability to generalize and abstract, recognize similarities between different situations, adapt to new situations, and discover and correct errors to improve performance in the future.

2.1. Definition of Artificial Intelligence:

Shanabi (2017, p. 153**)** stated that Artificial Intelligence (AI) is a branch of computer science that involves the operation of computer systems to perform tasks similar to human intelligence processes such as learning, inference, and decision-making. Several other definitions of artificial intelligence have been proposed, including:

Artificial intelligence is a term used in one of the disciplines of computer science, belonging to the modern generation of computer generations, aimed at simulating the intelligence processes that occur within the human mind, so that the computer becomes capable of problem-solving and decision-making in a logical, structured manner, using the same thinking processes as the human mind. These processes include:

- Learning: Acquiring information and the rules that use this information;

- Reasoning: Using previous rules to reach approximate or definite conclusions;

- Automatic or self-correction: Therefore, artificial intelligence in this context requires:

- Data system: Used to represent information and knowledge;

- Algorithms: Needed to outline how to use this information;

- Programming language: Used to represent both information and algorithms.

From here, artificial intelligence can be considered one of the modern branches of computer science that seeks sophisticated methods to program it in order to perform inferences and tasks similar to human intelligence methods. Therefore, it is a science that explores defining human intelligence and specifying its dimensions, then simulating some of its properties. However, this does not mean comparing the human mind, created by Almighty God, with the machine created by creatures.

2.2. Importance of Artificial Intelligence:

• It is expected that artificial intelligence will contribute to preserving accumulated human expertise by transferring it to intelligent machines.

• Humans will be able to interact with machines using human language instead of computer programming languages, making machine usage accessible to all segments of society, including individuals with special needs, whereas advanced machine interactions were previously restricted to specialists and experienced individuals.

• Artificial intelligence plays a crucial role in many sensitive fields such as aiding in disease diagnosis and prescription, providing legal and professional consultations, interactive education, security and military domains, and various other areas.

• Intelligent systems contribute significantly in decision-making domains, as they possess independence, precision, and objectivity. Therefore, their decisions are far from error, bias, racism, prejudice, external interference, or personal judgments.

• Smart machines alleviate many risks and psychological pressures from humans, allowing them to focus on more important and humane matters. By employing these machines to perform strenuous and dangerous tasks, explore unknown places, and participate in rescue operations during natural disasters, they also play an effective role in fields involving complex details that require intense mental concentration, continuous presence of mind, and swift, sensitive decisions that cannot tolerate delay or error (Shanabi 2017, p. 154)

2.3. Artificial Intelligence Technologies Related to Traffic Safety:

2.3.1. Traffic control devices and violations to reduce traffic accidents.

A. **Traffic Control Device Between Two Points on the Road:** This system captures images of all vehicles passing between points A and B on the road. The device reads license plates, determines vehicle speed and passage time at these points. This system can calculate traffic volume between the two points and operates either through electrical power or using motion-sensitive radar.

B. **Traffic Control System:** This system is installed on tall poles along the road and consists of cameras mounted on electric-powered poles, or using laser or motion-sensitive radar. The system comprises three units: the first unit is a camera that captures images of all passing vehicles, the second is a motion sensor that identifies vehicles, calculates their speed, and the third unit collects and stores information obtained from the first two units, then transmits this information to the control center to take action against vehicles violating traffic rules.

C. **Traffic Signal Violation Monitoring System:** This system captures simultaneous images of the violating vehicle and the traffic signal as evidence of running a red light, using advanced cameras. Moreover, the device captures images of vehicles crossing pedestrian crossings at traffic lights or even vehicles traveling against the direction of traffic.

D. **Pedestrian Crosswalk Violation Control System:** This device captures images of vehicles that stop at a red traffic light positioned at pedestrian crosswalks marked with designated lines on the road. This action constitutes a violation of pedestrians' rights to safely cross the road without interfering with vehicles in their lanes, and without vehicles obstructing them at designated pedestrian crossing areas indicated by ground markings.

E. **Violation Detection System for Wrong-Way Driving:** This device is deployed at traffic lights and intersections on main streets. It is capable of capturing images of all vehicles passing in front of it and cross-referencing their data with the

control center. This device can be used to monitor vehicles running red lights at intersections or report vehicles listed in the blacklist database passing by. Additionally, it can detect vehicles violating directional rules by turning right or left, or those traveling in the opposite direction of traffic flow.

F. **Speed and Load Limit Violation Control System:** The components of this system capture images of all vehicles passing in front of the device, read and record the license plate numbers of these vehicles, verify their speed, load, and vehicle condition, and check if they are listed in the police blacklist. Any vehicle violating traffic rules will have all its data recorded by the device and automatically sent quickly to another unit installed at the nearest inspection point that the violating vehicle will pass through, displaying this information on a small screen at the inspection point.

G. **Traffic Accident Recording Device:** This device is installed at hazardous intersections, locations with a history of frequent traffic accidents, or even places where such incidents are anticipated to occur. (Bolqwas & Bolqwas, 2019, p. 419)

2.3.2. Driver support systems to reduce traffic accidents.

Among these devices, we mention, for example, but not limited to, the following:

a) **Variable Message Signs (VMS):** These are signs that provide drivers with changing information about the road they are using (such as heavy traffic, accidents, road closures, etc.). They also inform drivers about weather conditions and the appropriate speed in case of heavy rain or dense fog, with all messages displayed automatically on the sign board.

b) **In-car Emergency Alert System:** This system allows road users to request assistance, ambulance services, or car repairs, or to obtain road information without leaving their vehicle. It consists of a call box containing three buttons: a red button for emergencies, a green button for requesting technical assistance or intervention, and an orange button for inquiry services. When the driver presses any of these buttons, the request is sent to a telematics center that directly

identifies the vehicle's location through GPS. On the other hand, in the event of a traffic accident, the system reacts to the impact and alerts that an accident has occurred.

c) **Automatic Accident Detection System:** This system detects accidents after receiving a signal indicating an incident, relying on a system typically found on highways behind safety barriers. When a vehicle collides with the safety barrier, the system alerts the central computer about the impact. The data is then analyzed to determine the location, enabling rapid intervention by emergency services and company authorities.

d) **RDS-TMC (Radio Data System - Traffic Message Channel):** This system allows road users to access information about traffic conditions and road conditions via audio and visual updates. It is a system installed in vehicles that transmits this information via radio waves to a dedicated center, which then relays the information to drivers in a language they understand while driving their vehicles.

e) **Collision Avoidance Systems:** These are among the most advanced intelligent transportation systems that contribute to improving road safety. Many drivers may become distracted while driving due to activities like using a phone or changing music CDs, which can lead to lane departure and consequently traffic accidents. These systems use radar and various sensors to detect nearby vehicles and potential road hazards. This allows the driver to be prepared to take corrective actions and preventive measures to avoid or mitigate the severity of collisions. Some of these systems, upon sensing danger, issue warnings on the car's windshield to alert the driver and may even activate automatic braking.

f) **Driver Drowsiness Alert Systems:** These systems utilize video technology to detect signs of fatigue in drivers and alert them when necessary to prevent hazardous driving.

g) **Speed Reduction Devices:** Measures related to vehicle design have been developed to mitigate injuries, aiming to equip vehicles with preventive safety devices and enhance them to reduce the severity of injuries. Among the most impactful devices for speed reduction, monitoring, and analysis of their use are speed limiters (Retort speed) and tachographs. These devices are installed only on vehicles such as medium-sized passenger cars with more than 15 passengers, buses, and trucks carrying loads exceeding 8 tons.

Secondly: Application of Artificial Intelligence Systems for Achieving Traffic Safety According to Some Recent Global Experiments

1. **The United States' experience in using artificial intelligence to achieve traffic safety**

According to (Ezell, 2010) The United States of America relies on artificial intelligence in its system, as these intelligent systems increase the absorptive capacity of base facilities, reducing the need for new road construction, for example, when the instant information transmission system for traffic signals was implemented in the United States of America, the flow of traffic improved significantly as follows:

- √ Traffic signal stops decreased by 40%.
- √ Travel time reductions by 25%.
- √ Fuel consumption efficiency improved by 10%, resulting in a 22% reduction in emissions.

Smart transportation systems have also helped reduce traffic congestion, which costs the United States in other statistics 4.2 million hours and 2.8 million gallons of fuel, approximately $200 billion annually. In practice, smart transportation systems reduce traffic congestion by 20% or more.

To further illustrate the importance of smart transportation systems, we will present some data prepared in the United States that demonstrates the expected benefits of implementing these systems in reducing environmental impacts as follows:

- √ The application of advanced traffic monitoring and signal control systems has shortened travel times by 8% to 25%.
- √ The use of highway systems in cities and urban areas has resulted in a decrease in traffic accident rates ranging from 24% to 50%, while traffic volume has increased by 8% to 22% at speeds ranging from 13% to 48% faster than prevailing speeds during congestion.
- √ Accident management programs can reduce delay associated with traffic congestion caused by accidents by 10% to 45%.
- √ Estimates the indication that using commercial vehicles equipped with safety systems, compliant with electronic procedures, and subject to automated road inspections will reduce the fatality rate from accidents by 14% to 32%.
- √ Productivity in freight transport has increased by over 25% per truck per day in the private sector.
- √ Widely deploying emergency accident reporting devices can significantly shorten the time it takes to detect an accident in a rural area by almost 90%.
- √ In rural areas, adhering to lanes and utilizing modern collision avoidance technologies can prevent a significant number of accidents caused by vehicles veering off the road.
- √ It is expected that using in-vehicle technology devices specialized in lane departure prevention will prevent over a million rear-end and side collisions each year. (Qusti, n.d., pp. 13-27)

The indirect benefits resulting from the implementation of smart transportation systems include cost savings in medical care and treatment for victims of traffic accidents, as well as reducing the societal costs associated with loss of life. These benefits also encompass improving safety and security levels, facilitating access to unfamiliar locations, and easing access to information about recreational places, travel, and services.

Therefore, these systems require traffic monitoring and sensing mechanisms, advanced traffic management centers, and sophisticated wired and wireless communication means that can serve as the link between drivers and traffic management centers.

2. South Korea's Experience in Using Artificial Intelligence for Road Safety

Moufaq & Boubakour (2017) stated that the external costs of the transportation system in South Korea in the year 2000 were estimated as follows:

- **Traffic Congestion Costs:** The costs of traffic congestion in South Korea have steadily increased since the early 1990s at an average rate of 18% per year. The estimated cost of traffic congestion reached 19 trillion won, equivalent to $17 billion, representing about 4% of the gross national income.
- **Traffic Accidents:** Traffic accidents in South Korea result in 300,000 incidents annually, with 12,000 fatalities and 350,000 injuries. These statistics place South Korea among the highest globally in terms of traffic accidents. The estimated cost of traffic accidents in 1998 was 6.7 trillion won, equivalent to $5.8 billion.

Therefore, South Korea will invest $3.2 billion in smart transportation systems during the period spanning from 2008 to 2020, averaging $230 million annually. South Korea has also developed its infrastructure using smart transportation systems in a city-by-city manner, where this system is constructed in a specific city and upon completion, operations shift to another city. This system has been implemented in 4 cities considered as key models for smart transportation systems. These models include:

- √ Adaptive Trafic signal Control
- √ Real-time Trafic information
- √ public transportation management
- √ speed violation Enforcement

South Korea uses what is known as T-money for transportation, providing 30 million transactions daily, with 44 cities having smart transportation systems, 9300

buses, and 300 bus stops equipped with real-time information and location systems, as well as bus status displays. Additionally, the smart transportation system in South Korea covers 100% of highways.

3. Japan's Experience in Using Artificial Intelligence for Traffic Safety: According to Moufaq, & Boubakour (2017) Japan is considered a leading country in the world when it comes to smart transportation systems, driven by its increasing focus on them, in addition to the high percentage of beneficiaries from these systems. The first appearance of smart transportation systems in Japan was under the name of Vehicle Information and Communication Systems (VICS), providing information on traffic conditions on most highways in Japan. It offers real-time information using extensive data collection to generate information about traffic conditions, displayed inside the vehicle on the information panel. This type of system was launched in 1996 and became nationwide by 2003 through the Vehicle Information and Communication System Center, which will reduce travel time for long trips by an average of 20%. (pp. 28-29)

Japan launched an enhanced version of this system under the name of Intelligent Transportation System Version 2, which allows the utilization of vehicle location system information regarding traffic flow. Some functions of this modern system include voice warnings to the driver ("Please slow down, you are approaching a congested traffic curve ahead"). This system was developed from 2004 to 2007 and was nationally implemented and disseminated in 2010, marking a very rapid advancement.

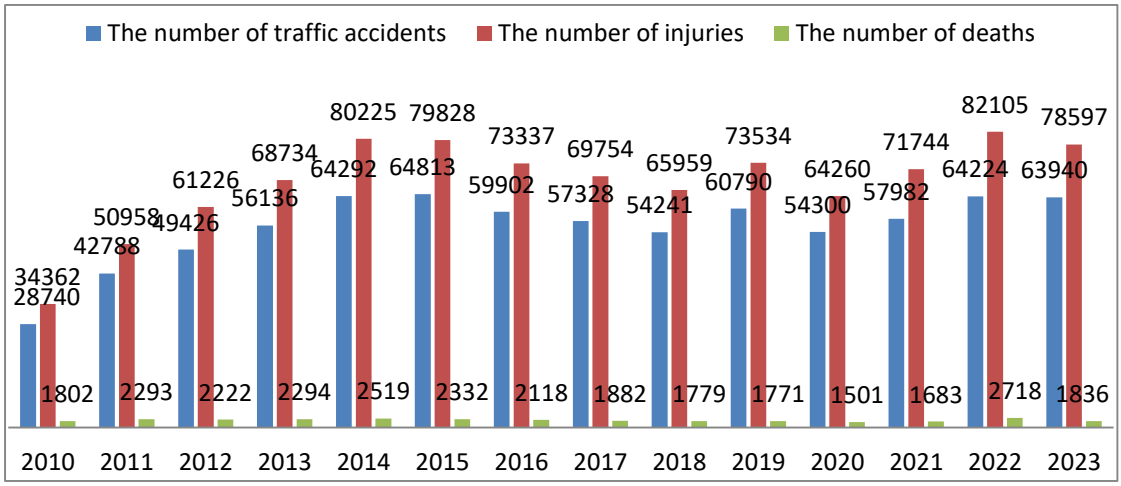
At least 34 million vehicles in Japan are equipped with real-time information, allowing access to this information in vehicles or at home via the internet in real-time format. Artificial intelligence systems in Japan are based on a unified national system, with 68% of vehicles using automatic payment systems. Japan also invests a total of $700 million in artificial intelligence systems.

Thirdly: Analysis of the current situation of traffic safety in Algeria and the application of artificial intelligence to achieve it.

First: Traffic safety in Algeria: according to the Ministry of Transport, Planning and Development Directorate (2019), the data presented in the sector statistical yearbook indicates that traffic accidents in Algeria represent a public health problem, with more than 3,000 deaths and around 40,000 injuries recorded each year. In 2018, an Algerian died every two hours and another was injured every ten minutes. Most traffic accidents result from the increasing number of vehicles on the road, coupled with the reckless behavior of road users. Various regulatory measures and efforts have been taken to change these behaviors and prevent such accidents. These measures include traffic regulation and promoting proper road use through the enforcement of Law 87-09 enacted on February 10, 1987, along with applicable regulations outlining traffic rules. However, this law has not met expectations in terms of reducing the rate of traffic accidents and minimizing human and material losses resulting from this phenomenon.

Figure 01: Number of traffic accidents in Algeria for the period.

(2023-2010)



Source: Compiled by us based on: Civil Protection: Summary of traffic accidents in Algeria, accessed on 15/04/2024, at 16:23, from the following website: https://www.protectioncivile.dz/arabe/?controller=article&action=contenu&ida=3972&idr=43

From the figure above, it's noticeable that the rate of traffic accidents has witnessed a continuous increase over these years, from 2010 to 2023. In 2010, the rate

was recorded at 67%, which saw a rise of 108% in 2015, equivalent to 64,813 traffic accidents, the highest number during this period. Similarly, in 2022, the highest number of traffic accidents was recorded at 100%, totalling 64,224 accidents, followed by 63,940 accidents in 2023 nationwide.

As for the number of injuries, it has also seen an increase during these years. There was a 67% increase from 2010, totalling 34,362 injuries, and a 100% increase in 2014, with 80,225 injuries. The highest percentage was recorded in 2022 with 82,105 injuries, followed by 78,597 injuries in 2023.

Regarding the number of fatalities, according to the data provided in the figure above, 2022 recorded the highest number of deaths at 2,718, equivalent to 7 deaths per day. In 2023, there were 1,836 deaths, which is about 5 deaths per day. This can be attributed to several reasons, including non-compliance with traffic laws, speeding, mobile phone usage, and failure to use seat belts while driving.

2- Applications of Artificial Intelligence Systems to Reduce Traffic Accidents in Algeria:

In light of the current circumstances surrounding traffic safety in Algeria, the Algerian state, through its research centers, has adopted several initiatives in the field of these systems and their updates. Here's a summary of the most significant ones:

- The Advanced Technology Development Center in Algeria, as a public scientific and technological institution affiliated with the Ministry of Higher Education and Scientific Research, has undertaken several projects. The first project focuses on the development of electric smart car systems, aimed at enhancing real-world environments based on decisions that approach human decision-making capabilities. The objective is to create advanced functions for electric cars to utilize them for automated urban transportation. The second project involves the automatic monitoring of moving vehicles, aiming to develop systems to adapt control systems with all dynamic muscle systems by improving their performance. This relies on achieving control systems for the structure of muscle systems that allow for greater autonomy for mobile robots, granting them real-time processing capabilities. The third project concerns robot systems for production, aiming to develop an independent smart robot capable of intervening remotely in communications.

-The establishment of a national system for collecting data on traffic accidents aims to create a comprehensive database connected to a central bank. This bank will store all data related to traffic accidents using the latest global technologies and connect it to relevant stakeholders to prevent traffic accidents effectively.

The National Organization for Technical Inspection of Public Works relies on the use of advanced devices based on smart systems for conducting studies and monitoring road construction. These include:

- A road curvature measurement device aimed at monitoring road networks, studying the evolution of congestion and traffic density, as well as detecting curved areas on the road surface and monitoring performance effectiveness, and a device for data analysis (RSP Mark IV) used to measure the undulations experienced by vehicles on the road to ensure traffic safety and comfort for travelers, reduce noise, as well as a device (HWD) for inspecting road networks to measure cracks and irregularities in construction in order to identify the negative effects resulting from congestion.

- Providing the metro and tram systems in Algeria with control systems, including coordination equipment responsible for managing all systems through a central control room equipped with audiovisual means connected to all stations, available on a modern rail signalling network, in addition to automatic equipment for sales and monitoring of transportation revenues through magnetic tickets. Also, signalling and warning systems for the CBTC system that provide the driver with all warnings about restricting train movement, such as immediate stopping or malfunction, temporary speed limit.

- Equipping the East-West highway with management and monitoring systems to alleviate traffic congestion and ensure traffic safety. Examples include 1269 video surveillance cameras for monitoring traffic density, as well as 20 cameras for real-time fire detection and alerting to mitigate accident and fire hazards, and protect toll booths and other associated stations. The monitoring center is available at each maintenance and operation center, equipped with the latest technological facilities and connected via optical fibers to transmit data and information. Emergency response centers, totalling 1412 centers approximately every 2 kilometers along the highway, are equipped to report any accidents, breakdowns, or fires. There are also 81 variable message signs controlled by the monitoring center to provide information related to traffic safety, such as congestion, traffic density, and guidance for highway users. Maintenance and operation centers, numbering 22 centers distributed along the highway, aim to provide the best services.

-Equipping the tunnels on the East-West highway with advanced systems including: surveillance camera system, automatic accident detection system, emergency communication and service system, and fire detection system aimed at ensuring traffic safety.

-Advanced systems are used in monitoring and controlling railway operations, including: signals, represented by messages responsible for informing relevant personnel of road conditions to control train movement hazards and related accidents. There are also disablement systems based on safe automatic control and monitoring of equipment on tracks to reduce accident risks, increase capacity, and decrease train waiting times. The control and monitoring center is responsible for ensuring optimal and safe line utilization through centralized train control, maintenance operations, and more. The automatic train protection system ensures a safe distance between trains when traveling on the line. The unified train control system monitors speed, provides signals, and delivers real-time information to the driver, assisting them in their duties and stopping the train in case of human error.

-Security services utilize advanced systems for road monitoring, including the use of radar in urban and rural areas to detect traffic violations and take necessary actions. Radar devices allow for video recording captured by cameras to stop drivers who commit violations (La'almi et al., 2017).

Conclusion

Through this study, it can be said that many countries have achieved significant success in enhancing traffic safety by implementing artificial intelligence systems to reduce traffic accidents and mitigate their severity. These countries have provided substantial safety margins through vehicle control and safety systems, leading to better management of funds allocated to road construction and maintenance. Additionally, information systems assist road users in minimizing time wasted in traffic congestion, as well as exerting more control over vehicles and reducing accidents caused by vehicles, human factors, or the environment. Regarding the application of artificial intelligence systems in Algeria, it is observed that their use is limited to security services such as radars and cameras. The railway devices are managed by the operating company of the metro. Moreover, other advanced systems utilizing wired and wireless communications and computerized electronics are not yet adopted in Algeria. Therefore, the following suggestions are proposed:

- Raising awareness about traffic safety and promoting traffic education to reduce traffic accidents and decrease the associated costs, thereby achieving economic performance;

- Increase traffic surveillance to enforce traffic laws and promote the use of traffic monitoring technologies like radars and cameras on roads, especially in areas with high accident rates.

- Develop traffic surveillance methods using artificial intelligence tools that can be used across all regions, including rural areas.

- Implement advanced systems to control and monitor vehicle speed, such as speed control devices and alertness systems, among other smart systems.

- Use electronic boards with variable messages to convey awareness messages.

- Establish advanced information centers about road networks, site maps, and traffic flow patterns.

- Enhance traffic control centers and operational rooms to meet the requirements of artificial intelligence systems.

- Train and qualify traffic personnel in the field of artificial intelligence technologies by sending them to countries already implementing these systems to attend seminars and workshops, enabling them to handle artificial intelligence technologies effectively.

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