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Artificial Intelligence in Industry 4.0: The future that comes true: AI

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AI Solutions for Sustainable, Safety and Resilient Transport and Mobility

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Abstract: *Logistic, transport and mobility is an important human need. To meet these mobility needs, our driving and movements must be safe, i.e. without consequences and injuries. Traffic safety can result in significant human and economic losses. As road traffic fatalities remain a global societal problem, finding effective solutions has become a top priority. Leveraging artificial intelligence (AI) presents a promising avenue for improving traffic safety through innovative approaches and applications. Improving traffic safety using artificial intelligence involves various applications and strategies aimed at enhancing road safety through advanced technological means. Improving traffic safety using artificial intelligence can be through next approaches: Intelligent traffic management systems; Predictive maintenance; Autonomous vehicles; Accident prediction and prevention; Driver assistance systems. By integrating artificial intelligence into traffic safety measures,we make transportation safer for everyone.*

Keywords*: Artificial intelligence, road traffic, autonomous vehicles, safety, predictive maintenance*

1. Introduction

Mobility isn't just about having access to one mode of transportation but having the ability to access these services and the quality of those options. Mobility helps us move around effortlessly, with a sense of stability and control, so us can feel free and empowered in all that we do. That's especially true when it's coupled with added flexibility, strength, balance, and full range of motion with your joints. Sustainable mobility encompasses fundamental pillars of clean mobility, safe mobility, and inclusive mobility and which contributes economically. The greater partenvironmentally friendly modes of transport, such as rail or river transport, are usually more efficient over long distances. However, when transporting goods over short distances, trucks are still the best alternative.Sustainable Safety implies that the traffic environment is designed to rule out serious crashes and to mitigate the severity of the crashes that do happen. The road environment, vehicles and technology are to offer support and protection to make the safety of the traffic system as little dependent on individual actions as possible. Sustainable Safety is an optimal approach to

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improve road safety. A sustainably safe road traffic system prevents road deaths, serious road injuries and permanent injury by systematically reducing the underlying risks of the entire traffic system. Human factors are the primary focus: by starting from the demands, competencies, limitations and vulnerabilities of people, the traffic system can be realistically adapted to achieve maximum safety. [1]. Traffic Safety Resilience is about ensuring all road users have the skills and strategies required when using the road. Resilience is the ability of a road network to withstand not only the impacts of extreme weather (snow, ice or flooding) but also industrial action, major incidents and other local risks.

2. Sustainable Transport and AI

Building sustainable cities is an imperative step towards a greener and more liveable future. Prioritizing walkability and cycling, implementing smart energy management systems, embracing compact urban planning, enhancing public transportation, promoting green building practices, and engaging community participation, cities can become thriving and sustainable hubs that prioritize the well-being of both people and the planet. [22]- "*The provision of services and infrastructure for the mobility of people and goods— advancing economic and social development to benefit today's and future generations—in a manner that is safe, affordable, accessible, efficient, and resilient, while minimising carbon and other emissions and environmental impact*." (United Nations definition for sustainable transport).Competitive and sustainable road transport is a vital component of our everyday lives. It forms the backbone of the modern economy and facilitates the mobility, logistics, and delivery needs within and around the European Union (EU). Ensuring the safety and security of the road transport system is therefore of paramount importance.[22]. Artificial Intelligence (AI) can change the mobility landscape, shattering long-held assumptions about the limitations of computer systems in tackling complex problems. The notion that machines lack these essential faculties is being debunked by the advancements in AI technology. AI will play a main role in minimizing the environmental impact of traffic andwill enable a more sustainable approach to traffic engineering.

2.1. AI Solutions for Sustainable Transport and Mobility

AI-driven solutions can significantly contribute to the development of sustainable transport systems by optimizing the use of resources, enhancing efficiency, and reducing environmental impacts. Some AI solutions for sustainable transport is:

1. Smart Traffic Management implies: Traffic Signal Optimization and Traffic Flow Prediction.
2. Enhanced Public Transportation includes two types of AI solutions: Dynamic Route Planning and Passenger Flow Management. AI can forecast passenger volumes and optimize the deployment of vehicles to match demand, minimizing energy waste and improving service efficiency.
3. Electric Vehicle (EV) Optimization implies Battery Management Systems and Smart Charging Networks. AI can optimize battery usage and charging cycles in electric vehicles, extending battery life and enhancing energy efficiency. AI can manage and distribute the load across charging stations, optimizing charging times based on energy demand and grid capacity, reducing peak loads, and promoting the use of renewable energy.
4. Autonomous Vehicles (AVs) include two types of AI solutions for sustainable transport and mobility: Energy-Efficient Routing and Fleet Management. AI-driven autonomous vehicles can choose the most energy-efficient routes, minimize unnecessary acceleration or braking, and optimize overall fuel or electricity usage. For fleets of autonomous vehicles, AI can manage dispatching, routing, and maintenance scheduling, maximizing efficiency and reducing the environmental impact.
5. Sustainable Urban Mobility Planning includes two types of AI solutions for sustainable transport and mobility: Mobility as a Service (MaaS) and Urban Planning Simulations. AI can integrate various transport modes into a single, cohesive service. AI can simulate different urban mobility scenarios, helping planners design cities that minimize travel distances, encourage sustainable transport options, and reduce emissions.
6. Eco-Friendly Logistics implies two AI activities: Route Optimization for Freight and Predictive Maintenance.AI can optimize delivery routes for freight, reducing travel distance, fuel consumption, and emissions. AI can predict when maintenance is needed for transport vehicles, ensuring they operate at peak efficiency and reducing the likelihood of breakdowns that could lead to inefficiencies.
7. Shared Mobility Solutions include next AI activities: Ride-Sharing Optimization and Bike and Scooter Sharing.AI can match passengers with similar routes, optimizing carpooling services. AI can optimize the distribution and availability of shared bikes and scooters, ensuring they are available where demand is highest, encouraging their use of cars for short trips.
8. Environmental Impact Monitoring include next AI activities: Emission Tracking and Reduction and Air Quality Management. AI can monitor emissions from various transport modes in real-time, identify sources of excessive emissions, and suggest mitigation strategies. AI can suggest measures to mitigate pollution, such as temporary traffic restrictions or promoting alternative transport modes during peak pollution periods.

9. Smart Infrastructure include next AI activities: Adaptive Traffic Systems and Green Corridor Development. AI can that adjust to real-time conditions, including changing weather patterns, to maintain efficiency and safety. AI can assist in designing and maintaining "green corridors" for freight and public transport, prioritizing routes that minimize environmental impact.

These AI-driven solutions collectively contribute to creating a more sustainable, efficient, and environmentally friendly transport ecosystem.

3. Traffic Safety and AI

"Vision Zero" is the EU's strategy for reaching reduction 50 % fatality in the road accidents till 2030. As road traffic fatalities remain a global societal problem, finding effective solutions has become a top priority for every country. UN's Sustainable Development Goal Target 3.6 by 2030, halve the number of deaths and injuries from road accidents globally. It is necessary for the project to develop AI solutions to enhance road safety. [23]. Leveraging artificial intelligence (AI) presents a promising avenue for improving road safety through innovative approaches and applications. Improving traffic safety using artificial intelligence involves various applications and strategies aimed at enhancing traffic safety through advanced technological means. Leveraging artificial intelligence (AI) presents a promising avenue for improving traffic safety through innovative approaches and applications. AI optimizes traffic signal timings, lane management, and road design to improve traffic flow and reduce congestion, which in turn enhances safety by reducing the likelihood of accidents caused by congestion-related factors.

3.1 AI Solutions for Traffic Safety

Artificial intelligence (AI) is transforming traffic and transportation especially in the following areas:

- road safety data and regulatory frameworks,
- safer vehicles,
- road infrastructure,
- post-crash response.

The AI for Road Safety initiative is in line with the UN General Assembly Resolution (UN A/RES/74/299) on Improving global Road Safety, which highlights the role of innovative automotive and digital technologies, as well as in line with the UN Secretary General's roadmap on digital cooperation. The new initiative will support achieving the UN SDG target 3.6 to halve by 2030 the number of global deaths and injuries from road traffic accidents, and the

SDG Goal 11.2 to provide access to safe, affordable, accessible and sustainable transport systems for all by 2030. [23].The seven areas in which AI solutions for traffic safety are currently being used the most are:
1. Intelligent Traffic Management Systems (ITMS)
2. Predictive Maintenance.
3. Autonomous Vehicles.
4. Accident Prediction and Prevention.
5. Driver Assistance Systems.
6. Emergency response optimization of a traffic accident.
7. Simulation and training for road safety.

3.1.1. Enhancing traffic safety through ITMS

AI-powered TMS utilize real-time data to optimize traffic flow, detect congestion, and predict potential hazards. By analyzing this data, AI algorithms can dynamically adjust traffic signals, reroute vehicles, and implement proactive measures to prevent accidents. [19]. ITMS play a main role in enhancing road safety through a variety of functionalities and features. Enhancing traffic safety by using intelligent traffic management systems contributes through the following activities:
Real-time Monitoring: ITMS use data collection devices to monitor traffic conditions in real-time. ITMS can identify potential safety hazards promptly. ITMS can quickly respond to accidents, congestion, or road hazards, minimizing their impact on road safety.
Traffic Flow Optimization: ITMS use algorithms to optimize traffic flow and minimize congestion. By adjusting signal timings, lane assignments, and speed limits based on current traffic conditions.
Incident Detection and Management: ITMS can quickly detect incidents such as accidents, vehicle breakdowns, or hazardous road conditions. Once detected, ITMS can automatically alert authorities and provide guidance to drivers, helping to mitigate the impact of incidents and prevent secondary accidents.
Adaptive Signal Control: ITMS utilizes adaptive signal control algorithms to prioritizing traffic movements and reducing unnecessary delays. Using technology ASC improves intersection safety and reduces the risk of accidents.
Pedestrian Safety: ITMS includes features such as pedestrian detection and crossing assistance to enhance pedestrian safety. By providing clear signals, designated crossing times, and safe crossing points, ITMS helps reduce pedestrian-related accidents.
Speed Management: ITMS employs speed monitoring and enforcement measures to encourage compliance with speed limits. By alerting drivers to speed violations and enforcing speed limits through automated enforcement systems, ITMS reduces the likelihood of accidents caused by speeding.

Emergency Vehicle Pre-emption: ITMS includes provisions for prioritizing emergency vehicles during emergencies. By pre-empting traffic signals and providing clear pathways for emergency vehicles, ITMS improves emergency response times and reduces the risk of accidents involving emergency vehicles. ITMS by continuously monitoring traffic conditions, optimizing traffic flow, detecting incidents, and implementing proactive measures to mitigate safety hazards. By leveraging advanced technologies and data-driven approaches. [3] [4]

3.1.2. Enhancing traffic safety through predictive maintenance

AI-driven predictive maintenance systems can schedule maintenance activities efficiently, ensuring the reliability and safety of road networks. Predictive maintenance contributes significantly to road safety by ensuring that road infrastructure, such as signs, signals, pavement, and bridges, remains in optimal condition, thereby reducing the risk of accidents caused by infrastructure failures. Enhancing traffic safety by using predictive maintenance contributes through the following activities:

Early Detection of Infrastructure Issues: Predictive maintenance systems utilize various sensors and monitoring devices to continuously assess the condition of road infrastructure.

Proactive Maintenance Planning: By using proactively scheduling maintenance tasks based on predictive models, authorities can address potential safety concerns before they impact road safety.

Prevention of Infrastructure Failures: By identifying and addressing maintenance needs proactively, predictive maintenance helps prevent infrastructure failures that could pose safety risks to road users. Whether it's repairing potholes, replacing damaged signs, or reinforcing bridges, timely maintenance interventions reduce the likelihood of accidents caused by infrastructure deficiencies.

Improved Infrastructure Resilience: Predictive maintenance allows authorities to prioritize maintenance efforts based on the condition and criticality of infrastructure assets. By allocating resources more effectively and addressing high-risk areas promptly, predictive maintenance enhances the resilience of road infrastructure to withstand various weather conditions and traffic loads, thus enhancing road safety.

Cost Savings: By implementing predictive maintenance strategies, authorities can reduce the overall cost of maintaining road infrastructure. By addressing maintenance needs before they escalate into costly repairs or emergencies, predictive maintenance helps minimize expenses associated with infrastructure failures and the subsequent impacts on road safety.

Enhanced Public Trust and Confidence: Proactive maintenance efforts demonstrate a commitment to ensuring the safety and reliability of road infrastructure. By maintaining roads in optimal condition and minimizing the risk of accidents caused by infrastructure failures, predictive maintenance systems contribute to building public trust and confidence in the transportation network.

Predictive maintenance plays a crucial role in enhancing road safety by detecting infrastructure issues early, proactively addressing maintenance needs, preventing failures, improving infrastructure resilience, reducing costs, and fostering public trust. By investing in predictive maintenance technologies and strategies, authorities can create resilient transportation networks. [2] [3]

3.1.3. Enhancing traffic safety through autonomous vehicles

Through computer vision technologies, threats thereby reducing risk of accidents caused by human error. [6]. Artificial Intelligence is significant for road safety, particularly autonomous vehicles which through various applications and technologiescontribute increase traffic safety. AI-powered autonomous vehicles can perceive their surroundings, make driving decisions, and navigate safely, thereby reducing accidents caused by human error. AI plays a crucial role in autonomous vehicles (AVs). AVs use AI algorithms for perception, decision-making, and control to navigate safely on roads. These vehicles can analyse their surroundings using sensors like LiDAR to detect objects, pedestrians, and other vehicles, making real-time decisions to avoid accidents. Next activities AI contributes to increase road safety in the realm of autonomous vehicles:
Perception and Detection: AI algorithms, such as computer vision and LiDAR processing, enable autonomous vehicles to perceive and detect objects, pedestrians, cyclists, and other vehicles on the road with high accuracy and reliability. This allows vehicles to react quickly to potential hazards and avoid collisions.
Predictive Analytics: Analysing real-time traffic conditions, weather forecasts, and historical accident data, can help for potential risks and hazards on the road. By predicting dangerous situations before they occur, autonomous vehicles can safety.
Decision-Making: AI algorithms enable autonomous vehicles to make complex decisions in real-time, such as lane changing, merging, and navigating through intersections.
Adaptive Control Systems: AI-based ACS continuously adjust vehicle speed, acceleration, and steering in response to changing road conditions, traffic patterns, and environmental factors. This helps optimize vehicle performance while ensuring safety and comfort for passengers and other road users.

Emergency Response: In the event of an emergency or unexpected situation, AI algorithms enable autonomous vehicles to react quickly and appropriately, such as applying emergency braking or maneuvering to avoid obstacles. These systems can help prevent accidents and minimize the severity of collisions.
Cybersecurity: AI-powered cybersecurity solutions protect autonomous vehicles from cyber threats, such as hacking and malware attacks, which could compromise their safety and functionality. By detecting and mitigating security vulnerabilities, AI helps ensure the integrity and safety of autonomous driving systems.
Regulatory Compliance: AI algorithms assist autonomous vehicle manufacturers and operators in ensuring compliance with regulatory standards and safety guidelines. By continuously monitoring and analyzing vehicle performance and behavior, AI helps identify and address potential safety issues and regulatory violations.

AI very important forroad safety in the futuredevelopment of autonomous vehicles by enabling advanced perception, decision-making, control, and emergency response capabilities. As autonomous driving technology continues to evolve, AI will remain instrumental in ensuring safe and reliable transportation for all road users. [6]

3.1.4. Enhancing traffic safety through accident prediction and prevention

By proactively targeting these areas with targeted interventions such as increased enforcement, infrastructure improvements, and public awareness campaigns, authorities can prevent accidents and save lives. AI algorithms are usedto predict and prevent accidents by identifying high-risk areas and implementing targeted interventions. Accident prediction and prevention analytics involve techniques, statistical modelling, forecast potential traffic accidents and implement strategies to prevent them. [9] [10]. Next activities AI contributes to increase road safety through accident prediction and prevention:
Data Collection: Relevant data is collected accident, traffic flow data, weather conditions, road infrastructure data, and demographic information.
Data Preprocessing: The collected data involve handling missing values, removing outliers, and standardizing the data format.
Feature Engineering: Relevant features or variables are selected or engineered from the dataset to capture important factors that contribute to accidents, such as road conditions, time of day, traffic volume, and driver behavior.
Model Development: ML models, are used to predict the likelihood of accidents occurring in specific locations or under certain conditions.

Evaluation: The trained models are evaluated using metrics such as accuracy, precision, recall, and F1-score to assess their performance in predicting accidents.
Monitoring and Iteration: The deployed model is continuously monitored, and feedback from its predictions is used to improve its performance over time. This may refining its algorithms based on new insights.

By leveraging accident prediction and prevention analytics, transportation agencies and authorities can proactively identify high-risk areas and implement targeted interventions to reduce the occurrence of traffic accidents and improve road safety. [9]

3.1.5. Enhancing traffic safety through driver assistance systems

By monitoring driver behavior and road conditions in real-time, these systems can provide timely alerts and interventions to prevent accidents caused by distractions, fatigue, or reckless driving. AI can analyze driver behavior vehicle sensors, smartphones, and cameras. By monitoring factors like speed, distraction, fatigue, and adherence to traffic rules, AI systems can provide feedback to drivers and help them adopt safer driving habits. [8].AI-based alerts and interventions to help avoid accidents, such as lane departure warnings, adaptive cruise control, and automatic emergency braking. AI Driver Assistance Systems (ADAS) are advanced technologies integrated into vehicles to enhance safety, convenience, and comfort for drivers and passengers. These systems utilize artificial intelligence (AI), machine learning, and sensor technologies to provide various functionalities aimed at assisting drivers in different aspects of driving. Key components and functionalities of AI Driver Assistance Systems enhancing traffic safety are:
Collision Avoidance Systems: ADAS includes features such as forward collision warning (FCW) and automatic emergency braking (AEB) that use sensors (such as radar, lidar, and cameras) to detect potential collisions with vehicles, pedestrians, or obstacles. The system can alert the driver and, in some cases, automatically apply brakes to mitigate or prevent collisions.
Lane Departure Warning and Lane Keeping Assist: These systems use cameras to monitor lane markings and alert the driver if the vehicle unintentionally drifts out of its lane. Lane Keeping Assist goes a step further by gently steering the vehicle back into its lane to help prevent accidents caused by unintended lane departures.
Adaptive Cruise Control (ACC): ACC uses sensors to maintain a set distance from the vehicle in front, automatically adjusting the vehicle's speed to match the flow of traffic. It can accelerate, decelerate, and even bring the vehicle to a complete stop if necessary, enhancing both safety and driver convenience.

Blind Spot Monitoring: Uses sensors to detect vehicles in the driver's blind spots and alerts them through visual or auditory warnings. Some systems also provide active intervention by applying corrective steering or braking.
Parking Assistance: ADAS includes features such as parking sensors, surround-view cameras, and automated parking systems that assist drivers in maneuvering into and out of parking spaces. These systems can detect obstacles and provide guidance to help drivers park safely and accurately.
Traffic Sign Recognition: Using cameras and image processing algorithms, ADAS can recognize and interpret traffic signs such as speed limits, stop signs, and road markings. This information is then displayed to the driver, helping them stay informed and compliant with traffic regulations.
Driver Monitoring Systems: Some advanced ADAS include driver monitoring systems that use cameras and sensors to monitor the driver's attention, drowsiness, and fatigue levels. These systems can issue alerts if they detect signs of driver distraction or fatigue, helping prevent accidents caused by driver inattention.
AI Driver Assistance Systems: As technology continues to advance, these systems are expected to become even more sophisticated and effective in enhancing both safety and convenience on the roads. [8]

3.1.6. Enhancing traffic safety through emergency response optimization of a traffic accident

AI Emergency Response Optimization for road safety involves leveraging AI technologies to enhance the efficiency and effectiveness of emergency response systems in addressing road accidents and other emergencies. AI can optimize emergency response systems by predicting accident locations, estimating severity, and suggesting the most efficient routes for emergency vehicles. [11]. [12]. This is key aspects of how AI can optimize emergency response for road safety:
Real-time Incident Detection: AI algorithms analyze data from various sources such as traffic cameras, sensors, and emergency calls to detect road accidents and incidents in real-time. This enables prompt notification and dispatching of emergency services to the scene of the incident.
Route Optimization: AI can optimize the routing of emergency vehicles by considering factors closures, and the location of the incident. By identifying the fastest and most efficient routes, AI helps reduce response times and improve the chances of saving lives.
Resource Allocation: AI algorithms analyze the severity and nature of incidents, as well as the availability of emergency resources, to optimize resource allocation. This includes dispatching appropriate types and quantities of

emergency vehicles, personnel, and equipment to effectively address the situation.
Predictive Analytics: By anticipating future incidents, emergency services can pre-position resources and be better prepared to respond promptly.
Communication and Coordination: AI facilitates seamless communication and coordination among emergency responders, including police, fire departments, and medical services. Integrated AI platforms enable real-time sharing of information, coordination of response efforts, and effective collaboration to address complex emergencies.
AI algorithms assess risks associated with emergency response activities, such as traffic congestion, safety hazards, and environmental factors. By identifying potential risks, AI helps emergency services them the safety of responders and the public.
Continuous Improvement: AI systems continuously learn and adapt from past emergency response data to improve future operations. By analyzing response times, outcomes, and feedback, AI helps identify areas for improvement and optimize emergency response strategies over time.

By harnessing the power of AI for emergency response optimization, can be significantly enhance road safety by reducing response times, improving resource allocation, and mitigating risks associated with road accidents and other emergencies. [8]

3.1.7. Enhancing traffic safety through simulation and training for road safety

AI simulation and training involve use artificial intelligence (AI) technologies to create realistic virtual environments where drivers, pedestrians, and other road users can improve skills in controlled setting. [20] [22]. Next activities AI can be applied to simulation and training for road safety:
Virtual Driving Simulators: AI-powered driving simulators replicate real-world driving scenarios, allowing users to practice various driving maneuvers and encounter different road conditions without the risk of accidents. These simulators use AI algorithms to generate realistic traffic behavior, weather conditions, and road hazards, providing users with immersive and challenging training experiences.
Scenario-based Training: AI simulation platforms can generate a wide range of driving scenarios, including highway driving, city navigation, parking challenges, and emergency maneuvers. By presenting users with diverse scenarios, AI training systems help develop essential driving skills such as hazard perception, decision-making, and situational awareness.
Pedestrian and Cyclist Interaction: AI simulation environments can simulate, helping drivers understand their behavior and learn how to anticipate and

respond to their movements. This type of training enhances drivers' awareness of their surroundings and reduces the risk of accidents involving pedestrians and cyclists.
Adaptive Training Programs: AI-driven training systems can adapt to users' skill levels and learning styles, providing personalized feedback and guidance based on their performance. By analyzing users' actions and responses in real-time, AI algorithms can identify areas for improvement and tailor training programs to address individual needs effectively.
Emergency Response Training: AI simulations can recreate emergency scenarios such as tire blowouts, brake failures, and sudden obstacles in the roadway, allowing drivers to practice emergency maneuvers and decision-making under pressure. By simulating realistic emergencies, AI training platforms help drivers develop the skills and confidence needed to handle unexpected situations safely.
Driver Behavior Analysis: AI algorithms can analyze users' behavior and performance in simulated driving scenarios, identifying areas of concern such as aggressive driving, distracted driving, or poor decision-making.
Continuous Learning and Assessment: AI simulation platforms can track users' progress over time, recording their performance metrics, and identifying trends in their driving behavior. This data-driven approach enables continuous learning and assessment, allowing users to track their improvement and focus on areas where further practice is needed.
Integration with Vehicle Technology: AI training systems can be integrated withallowing users to practice interacting with these systems in simulated environments. This integration helps drivers familiarize themselves with new technologies and understand their capabilities and limitations before encountering them on the road.
By leveraging AI simulation and training for road safety, drivers, pedestrians, and other road users can improve their skills, develop safer behaviors, and ultimately contribute to reducing accidents and saving lives on the road. [22]

4. AI for Resilient Transport and Mobility

Transportation resilience is defined as the ability of a transportation system to move people around in the face of one or more major obstacles to normal function. These obstacles can include extreme weather events, major accidents, and equipment or infrastructure failures. The concept of transport mobility includes 5 aspects, namely:

- For individuals.
- For communities.
- On a design level.
- On an economics level.
- On a strategy level.

Transportation resilience is of paramount importance to individuals and communities. This is something that businesses and travelers alike need to think about, as the availability of transportation is critical to the function of both of these aspects. [23]

4.1. AI Solutions for Resilient Transport and Mobility

AI can enhance the resilience of transport systems by making them more adaptable, responsive, and robust against disruptions, whether caused by natural disasters, infrastructure failures, or other unexpected events. Next AI solutions designed to improve the resilience of transport:

1. Predictive Analytics and Risk Assessment include next activities for resilient transport and mobility: Disaster Prediction and Infrastructure Health Monitoring. AI models can analyze historical data and real-time information to predict natural disasters(e.g., floods, landslides, storms) that could disrupt transportation networks, allowing for pre-emptive action. AI-driven sensors and analytics can continuously monitor the condition of bridges, roads, tunnels, and other critical infrastructure, predicting potential failures and enabling timely maintenance before issues escalate.
2. Adaptive Traffic Management Systems include next activities for resilient transport and mobility: Real-Time Traffic Adaptation and Incident Detection and Response. AI systems can reroute traffic dynamically in response to accidents, road closures, or other disruptions, minimizing delays and maintaining flow even during crises. AI can quickly detect traffic incidents or emergencies using data from cameras, sensors, and social media, enabling faster response times and reducing the impact of disruptions.
3. Resilient Public Transportation Networks include next activities for resilient transport and mobility: Dynamic Routing for Public Transport and Crowd Management. AI can reroute buses, trains, and other public transport vehicles in real-time during disruptions, ensuring continuity of service and minimizing inconvenience to passengers. AI can predict and manage passenger flow in response to disruptions, such as service interruptions or unexpected surges in demand, optimizing vehicle deployment and reducing overcrowding.
4. Supply Chain and Logistics Resilience include next activities for resilient transport and mobility: Supply Chain Optimization and Inventory Management. AI can help logistics companies identify alternative routes and modes of transport in the event of disruptions, ensuring that goods continue to move efficiently through the supply chain. AI-driven inventory systems can predict supply chain disruptions and adjust inventory levels, accordingly, ensuring that critical supplies are available even during transport network disruptions.

5. Autonomous and Connected Vehicles include next activities for resilient transport and mobility: Resilient Autonomous Fleets and Vehicle-to-Infrastructure (V2I) Communication. AI can manage fleets to adapt routes operations in real-time based on road conditions, traffic, and other disruptions. AI can facilitate communication between vehicles and infrastructure, enabling real-time adjustments to traffic lights, road signs, and other systems to maintain transport resilience.
6. Emergency Response and Recovery include next activities for resilient transport and mobility: AI-Driven Emergency Planning and Post-Disaster Recovery. AI can simulate various disaster scenarios to help authorities plan effective response strategies, ensuring that transport networks can quickly recover after an event. AI can assist in prioritizing and coordinating recovery efforts, such as repairing critical infrastructure, rerouting traffic, and restoring public transport services.
7. Climate Resilience include next activities for resilient transport and mobility: Climate Impact Prediction and Green Infrastructure Development. AI can model the long-term impacts of climate change on transport networks, helping planners design infrastructure that can withstand extreme weather conditions and rising sea levels. AI can optimize the design and placement of green infrastructure, such as permeable pavements and urban green spaces, to reduce the impact of climate-related disruptions on transport systems.
8. Cybersecurity for Transport Networks include next activities for resilient transport and mobility: AI-Enhanced Security and Threat Prediction and Prevention. AI can cybersecurity transport infrastructure from cyberattacks that could disrupt operations. AI can analyze patterns of cyberattacks to predict and prevent future threats, ensuring the resilience of transport systems in an increasingly digital world.
9. Resilient Mobility-as-a-Service (MaaS) include next activities for resilient transport and mobility: Flexible MaaS Platforms and User Communication. AI can enable MaaS platforms to dynamically adapt to disruptions by offering alternative routes, modes of transport, or even postponing trips, ensuring continuity of service for users. AI can enhance communication with users during disruptions, providing real-time updates and alternative travel options to ensure they reach their destinations safely.
10. Integrated Urban Planning includes next activities for resilient transport and mobility: AI-Driven Scenario Planning and Resilient Network Design. AI can assist various disaster scenarios transport systems, helping cities design more resilient infrastructures. AI can optimize the design of transport networks to ensure redundancy, meaning if one part of the system fails, others can compensate to maintain overall functionality.

These AI-driven solutions enhance the ability of transport systems to withstand, respond to, and recover from disruptions, ensuring that mobility remains reliable and efficient even in the face of challenges. [23]

4. Model for Predicting the Location of a Traffic Accident

Building a prediction model for forecasting the location of a traffic accident involves several steps (Figure 1).

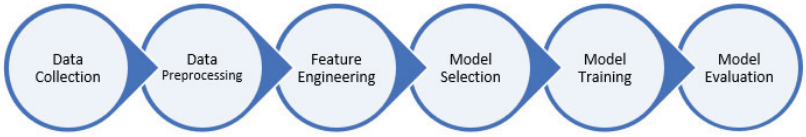


Figure 1. Predictive model for location traffic accident

By building predictive model for location a traffic accident, created in five activities:
Data Collection: It is necessary to collect historical data on traffic accidents, including details such as accident locations (latitude and longitude), time of day, weather conditions, road type, traffic volume, and any other relevant factors. This data is obtained from local transportation departments, law enforcement agencies, or publicly available datasets.
Data Preprocessing: It is necessary to "clean" the collected data, handle convert categorical variables into a suitable format for analysis. Additionally, it needs to normalize or scale numerical features.
Feature Engineering: It is necessary could be predictive of accident locations. This could include spatial features such as proximity to intersections, road curvature, and presence of traffic signals, temporal features.
Model Selection: It is necessary to choose a suitable machine learning model for predicting accident locations. Common models for spatial prediction tasks include decision trees. It is necessary consider the complexity of the model and its ability to handle spatial data effectively.
Model Training: Train selected model on the training data, using techniques such as cross-validation to tune hyperparameters and avoid overfitting.
Model Evaluation: It is necessary evaluate the trained model using the testing data to assess its performance.

Proposal model for predicting the location of a traffic accident presented is in figure 2.

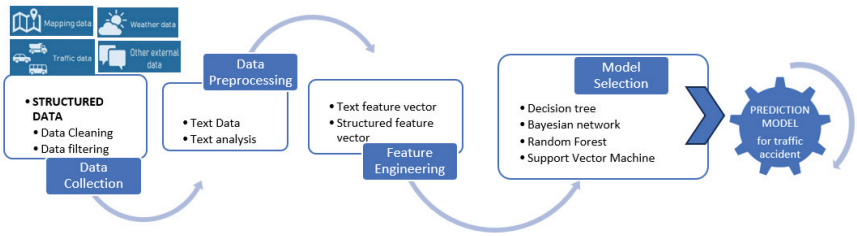


Figure 2. Model for predicting the location of a traffic accident

After establishing a model for predicting the location of a traffic accident, if it shows good performance, it is necessary, deploy it in a production environment where it can make real-time predictions. This might involve integrating the model into a web application or backend service that can receive input data (e.g., current traffic conditions) and output predicted accident locations. It is necessary to continuously monitor and maintenance a model for predicting the location of a traffic accident. Continuously monitoring and maintenance a model implies inspection the performance of the deployed model and update it as needed with new data or retraining periodically to ensure its accuracy and reliability over time. Building an effective prediction model requires careful consideration of selection, maintenance its effectiveness in real-world scenarios. Additionally, ethical considerations should be considered, particularly regarding data privacy and fairness in algorithmic decision-making. [14]

5. Conclusion

The use of AI technologies and solutions for proactive infrastructure safety management improves traffic safety. Artificial intelligence offers unprecedented opportunities to enhance traffic safety through innovative technologies and applications. While AI holds great promise for improving road safety, it's essential to address challenges such as data privacy, ethical considerations, and regulatory frameworks to ensure its responsible and effective deployment. Additionally, ongoing research and collaboration between stakeholders are necessary to maximize the benefits of AI in enhancing road safety for all road users. Artificial intelligence offers unprecedented opportunities to enhance traffic safety through innovative technologies and applications. By leveraging AI-driven solutions across various domains, from intelligent traffic management to autonomous vehicles and predictive analytics, we reduce significantly, making our roads safer for all users. With Artificial Intelligence (AI) at the lead, the transportation sector is poised for a transformative era of unmatched efficiency and safety. The integration of AI technologies in transportation promises to revolutionise the sector by enhancing vehicle automation, optimising logistics and supply chain management and improving traffic

management systems. Key terms such as “AI-driven transportation solutions”, “autonomous vehicles” and “intelligent traffic systems” are pivotal elements that highlight the industry’s trajectory towards a more interconnected and automated future. These innovations are poised to reduce human error, streamline operations and facilitate a smoother flow of goods and people, aligning with the global push towards sustainability and reduced carbon footprints. The mix of AI and ML with road safety is starting a new era. This era offers better driving safety and smarter traffic control. They aim to prevent accidents by analyzing data and predicting risks in real time. Smart roads and new tech trends point to a bright future for road safety. By combining smart algorithms with app development, traffic control will improve. It will also help making our communities safer. By adopting AI and ML technologies, we are all working towards a safer future. AI and ML technologies don’t just improve safety; they change how we think about transportation. This isn’t just about avoiding accidents. It’s about creating a safer world for everyone. In digital era, the push for safer roads is driven by innovation and the desire to protect lives.

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