

Introduction to AI in Automation Transforming Industries Through Intelligence

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Abstract:

In today's rapidly evolving technological landscape, the synergy between artificial intelligence (AI) and automation has emerged as a powerhouse of innovation, revolutionizing industries across the globe. AI, often referred to as the "brain" of automation, brings a new level of intelligence, adaptability, and efficiency to various processes that were once limited by human capabilities. This seminar delves into the dynamic world of AI in automation, exploring how this transformative duo is reshaping industries, enhancing productivity, and paving the way for a smarter future.

As the world becomes increasingly interconnected and data-driven, AI has emerged as a driving force behind the next industrial revolution. It encompasses a range of technologies that enable machines to learn, reason, and make decisions, mimicking human intelligence to varying degrees. On the other hand, automation involves the use of technology to perform tasks with minimal human intervention, resulting in increased accuracy, speed, and consistency. The marriage of AI and automation combines the cognitive abilities of AI with the precision of automated systems, resulting in a paradigm shift in how industries operate.

Keywords: AI in automation, Artificial Superintelligence, Sensor Technology

History of Automobile Industry:

- 1. 1769:** The First Self-Propelled Vehicle In 1769, Nicolas-Joseph Cugnot, a French engineer, built the first self-propelled vehicle, a steam-powered tricycle. This vehicle is considered one of the earliest ancestors of the modern automobile.
- 2. 1885:** The First Gasoline-Powered Automobile Karl Benz, a German engineer, is credited with inventing the first gasoline-powered automobile. In 1885, he completed the Benz Patent-Motorwagen, a three-wheeled vehicle powered by an internal combustion engine.
- 3. 1886:** Birth of the Automobile Industry On January 29, 1886, Karl Benz received a patent for his motor vehicle, and this date is often considered the birth of the automobile industry.

4. **1893:** First Mass-Produced Car The Duryea Motor Wagon Company, founded by brothers Charles and Frank Duryea in the United States, started producing the first commercially successful gasoline-powered automobile in 1893.
5. **1908:** Ford Model T On October 1, 1908, Henry Ford introduced the Ford Model T, an affordable, mass-produced automobile that revolutionized the industry. It became immensely popular and is considered one of the most influential cars in automotive history.
6. **1913:** Assembly Line Production Henry Ford's introduction of the moving assembly line in 1913 further revolutionized automobile manufacturing, drastically reducing production time and costs. This innovation allowed for even greater mass production of automobiles.
7. **1920s:** The Rise of Automobile Ownership During the 1920s, automobile ownership became more widespread as cars became more affordable. The automobile transformed transportation and had a significant impact on society, commerce, and urban development.
8. **1930s:** Streamlined Designs and Innovations In the 1930s, automotive design evolved, and streamlined features were incorporated into cars. Innovations such as automatic transmissions and hydraulic brakes also emerged during this period.
9. **1940s-1950s:** Post-WWII Boom and Modernization After World War II, the automobile industry experienced a boom as the economy recovered and consumer demand increased. Car designs became more modern, and improvements in safety and technology were introduced.
10. **1970s:** Oil Crisis and Environmental Concerns The 1970s brought about an oil crisis, prompting the automotive industry to focus on fuel efficiency and emission reduction. This period marked a shift towards more environmentally friendly cars.
11. **1980s-1990s:** Technological Advancements The 1980s and 1990s saw significant advancements in automotive technology, including the introduction of electronic fuel injection, computerized engine control systems, and safety features like airbags and anti-lock brakes.
12. **2000s-Present:** Hybrid and Electric Vehicles In the 21st century, there has been a growing emphasis on sustainability and environmental concerns. This led to the rise of hybrid and electric vehicles, with major automakers producing electric cars to reduce greenhouse gas emissions. The history of the automobile is a fascinating journey of innovation, technology, and societal impact, and it continues to evolve as new technologies and trends shape the automotive industry.

Versions Of AI

Artificial Intelligence (AI) can be broadly categorized into different versions based on its capabilities and approaches. Here are the main versions of AI

Narrow AI (Weak AI OR AI-1.0):

Narrow AI, also known as Weak AI, refers to AI systems that are designed and programmed to perform specific tasks or solve particular problems. These systems are specialized and excel in the defined domain but lack general intelligence. Examples of narrow AI include virtual personal assistants (e.g., Siri, Alexa), image recognition systems, and recommendation algorithms used by streaming services.

General AI (Strong AI OR AI-2.0):

General AI, also known as Strong AI, refers to AI systems that possess human-like intelligence, including the ability to understand, learn, and apply knowledge across a wide range of tasks. These AI systems would

have cognitive abilities similar to human beings and would be capable of reasoning, self-awareness, and consciousness. General AI remains a theoretical concept and has not been achieved as of my last update in September 2021.

Artificial Superintelligence (AI-3.0):

Artificial Superintelligence (ASI) goes beyond human-level intelligence. ASI would surpass the cognitive abilities of the most intelligent human beings in every possible aspect. This level of AI is still speculative and hypothetical, and there are various discussions and debates about its potential implications and ethical concerns.

Autonomous Driving Vehicle:

- **Introduction to Autonomous Driving**
- **Sensor Technology**
- **Perception and Environment Understanding**
- **Localization and Mapping**
- **Machine Learning and AI**
- **Control Systems**
- **Challenges and Future Trends**
- **Cybersecurity and Privacy**



Fig.1 Autonomous Driving Vehicle [4]

**Introduction to Autonomous Driving:
Levels of Autonomy (SAE Levels 0-5):**



Fig.2 Introduction to Autonomous Driving [5]

Level 0 - No Automation: At this level, the human driver is responsible for all aspects of driving, including control, monitoring, and responding to the environment. There might be some driver assistance features, like warnings or momentary interventions, but the driver remains fully in control.

Level 1 - Driver Assistance:

Level 1 vehicles introduce certain automation features. These systems can assist the driver with either steering or acceleration/deceleration, but not both simultaneously. An example is adaptive cruise control, which can maintain a set speed and following distance from the vehicle ahead.

Level 2 - Partial Automation:

Level 2 vehicles can simultaneously control both steering and acceleration/deceleration under certain conditions. However, the driver must remain engaged and ready to take over at any moment. Examples include Tesla's Autopilot and some advanced driver-assistance systems.

Level 3 - Conditional Automation:

At this level, the vehicle can handle most driving tasks in certain conditions or environments. The driver is allowed to disengage from active control, but must be available to take over when the system requests. Level 3 vehicles can manage themselves in specific scenarios, such as highway driving.

Level 4 - High Automation:

Level 4 vehicles can perform all driving tasks autonomously within specific operational domains, such as predefined geographic areas or controlled environments. Human intervention might be needed only in exceptional situations outside the operational domain.

Level 5 - Full Automation:

Level 5 represents full automation, where the vehicle is capable of completely autonomous operation without any human intervention. There is no need for a steering wheel or pedals, as the vehicle is designed to operate independently in all conditions and environments where a human driver could operate.

Sensor Technology:

LiDAR (Light Detection and Ranging):

LiDAR sensors emit laser beams and measure the time it takes for these beams to reflect off objects and return to the sensor. This data is used to create a detailed 3D map of the environment, enabling the vehicle to accurately detect and localize objects. LiDAR provides precise distance and depth information, making it crucial for obstacle detection and navigation.

Radar (Radio Detection and Ranging):

Radar sensors use radio waves to detect objects by measuring the time it takes for radio waves to bounce back after hitting an object. Radar is effective in various weather conditions and provides information about an object's distance, speed, and size. It's commonly used for adaptive cruise control and collision avoidance.

Cameras:

Cameras capture images and videos of the environment. Computer vision algorithms analyse these images to identify objects, read road signs, detect lane markings, and recognize pedestrians and other vehicles.

Cameras are crucial for understanding the visual aspects of driving and can provide detailed contextual information.

IMU (Inertial Measurement Unit):

An IMU combines accelerometers and gyroscopes to measure the vehicle's linear and rotational movements. IMUs provide data about the vehicle's acceleration, velocity, and orientation, which is essential for maintaining stability and accurate positioning.

Perception and Environment Understanding:



Fig.3 Perception and Environment Understanding [6]

Object Detection:

AI-powered object detection algorithms enable automated systems to identify and locate objects within images or sensor data. Computer vision techniques, such as convolutional neural networks (CNNs), are used to analyse visual data and identify the presence of various objects, such as pedestrians, vehicles, or obstacles. Object detection is fundamental in applications ranging from autonomous driving to manufacturing quality control, where accurate identification of objects is crucial for safe and efficient operation.

Object Classification:

Object classification goes a step further by not only detecting objects but also assigning them to specific categories. AI models are trained on labelled data to distinguish between different types of objects, such as distinguishing between different types of vehicles or identifying specific items in a scene. This classification capability enhances automation systems' understanding of their environment, enabling them to make context-aware decisions based on the recognized objects.

Integration and Decision-Making:

The integration of AI-driven perception with decision-making processes is a key aspect of automation. As AI systems perceive and understand their environment, they contribute vital information to the decision-making layer. AI algorithms process sensor data, recognize objects, and assess the context of the surroundings, feeding this information into decision-making models.

Localization and Mapping:

Localization is the process of determining a vehicle's precise position and orientation within a known environment. Mapping involves creating a detailed representation of the environment, including road

layouts, lane markings, traffic signs, and other relevant features. Together, localization and mapping form the foundation for accurate and safe autonomous navigation.

Using High-Definition Maps for Precise Localization:

High-definition maps provide a reference point for precise vehicle localization. This is achieved through a process known as simultaneous localization and mapping (SLAM):

Localization: The vehicle uses its onboard sensors to match the real-time data it receives with the pre-existing map. By identifying recognizable landmarks or features in the environment, the vehicle can estimate its position and orientation relative to the map.

Mapping: As the vehicle navigates, it updates the map by incorporating new sensor data. This is crucial for maintaining an accurate representation of the environment, accounting for changes like construction zones, lane closures, or temporary obstacles.

Machine Learning and AI:



Fig.4 AI in Vehicles [7]

Data Collection: Diverse and representative data is collected from sensors installed on the autonomous vehicle. This data includes images, LiDAR point clouds, radar measurements, and more. It covers various driving scenarios, weather conditions, and environments.

Data Annotation: Human annotators label the collected data with relevant information, such as bounding boxes around objects, semantic labels for segmentation, and trajectories for tracking. These annotations serve as ground truth for training and evaluation.

Model Selection and Architecture: The appropriate machine learning model architecture is selected based on the task. For object recognition, CNNs are commonly used. For path planning and decision-making, reinforcement learning models or neural networks with specific architectures are designed.

Training: The model is trained using the annotated data. During training, the model learns to recognize patterns and make predictions based on input data. Optimization techniques adjust the model's parameters to minimize the difference between its predictions and the ground truth labels.

Validation and Testing: The trained model is validated on a separate dataset to ensure it generalizes well to new data. Extensive testing is conducted using simulation environments and real-world scenarios to evaluate the model's performance.

Control Systems:

Control algorithms in autonomous vehicles are responsible for converting high-level decisions, such as route planning and object avoidance, into specific control inputs to the vehicle's actuators (e.g., steering, throttle, brakes). These algorithms ensure the vehicle operates smoothly, safely, and accurately. Here are key control aspects

Real-Time Adjustments: Control systems continuously adjust vehicle inputs based on real-time sensor data and feedback. For example, if a pedestrian suddenly enters the road, the control system might apply emergency braking.

Adaptive Cruise Control (ACC): ACC systems maintain a safe following distance from the vehicle ahead. These systems use radar or LiDAR to monitor the distance and speed of the lead vehicle, and adjust the vehicle's speed and braking accordingly.

Challenges and Future Trends:

Inclement Weather: Adverse weather conditions like rain, snow, fog, and glare can hinder the performance of sensors and affect the accuracy of perception algorithms. Dealing with these conditions requires advanced sensor technologies, data fusion techniques, and robust algorithms.

Shared Mobility: Autonomous driving technology could drive a shift from individual car ownership to shared mobility services. Ride-sharing and autonomous taxis may become prevalent, reducing traffic congestion and improving resource utilization.

Cybersecurity and Privacy:

Secure Software Development: Ensuring secure coding practices during software development and implementing rigorous testing processes can reduce vulnerabilities. Regular software updates can also patch known vulnerabilities.

Over-the-Air (OTA) Updates: OTA updates should be designed with security in mind to prevent malicious code injection during updates.

In-car Virtual Assistants

An in-car virtual assistant is an AI-powered technology that provides voice based interaction and assistance to drivers and passengers inside a vehicle. It leverages natural language processing (NLP) and machine learning to understand spoken commands and queries, allowing occupants to control various vehicle functions, access information, and perform tasks without needing to use physical controls or take their hands off the steering wheel.

FEATURES:

Voice Interaction: Users can initiate conversations with the virtual assistant by using a wake word or a button press. They can ask questions, issue commands, or request assistance using natural language.

Navigation: Users can ask for directions, search for points of interest, and receive real-time traffic updates. The virtual assistant can provide turn-by-turn navigation instructions.

Media and Entertainment: The assistant can control the vehicle's infotainment system, allowing users to play music, change radio stations, access podcasts, and even control smart home devices.

Calling and Messaging: Users can make hands-free phone calls, send text messages, and manage their contacts using voice commands.

Vehicle Controls: In-car virtual assistants can adjust settings like climate control, lighting, and seat adjustments based on user preferences.

Information Retrieval: The assistant can provide answers to general knowledge questions, weather updates, news, and more.

Safety Alerts: Virtual assistants can alert drivers to potential hazards, upcoming road conditions, and other safety-related information.

Vehicle-to-everything (V2X) communication. AI-powered V2X communication enables vehicles to interact with other vehicles, infrastructure, and pedestrians, providing real-time information and improving overall traffic safety and efficiency.

Examples : AI in Car Virtual Assistants:

Amazon Alexa Auto: Integrates Amazon's Alexa voice assistant into vehicles, allowing users to perform tasks, control smart home devices, and access Amazon services.

Apple CarPlay with Siri: Allows users to access their iPhone apps, including Siri, through the vehicle's infotainment system.

Recent Development in Automobile Industry:

Smart Manufacturing:

Smart Manufacturing in the automotive industry leverages artificial intelligence to revolutionize production processes. AI-driven predictive maintenance ensures equipment reliability, computer vision systems enhance quality control, and process optimization minimizes inefficiencies, while supply chain management employs AI for accurate demand forecasting and efficient inventory management. AI also plays a key role in the development of autonomous vehicles and the personalization of vehicles to customer preferences. It optimizes energy usage, enhances worker safety through collaborative robots, and improves testing and validation processes, ultimately making automotive manufacturing more efficient, adaptable, and environmentally responsible.

Blockchain, most likened technology in the internet generation:

Blockchain has enabled the information more secure and safe to change, hack or cheat the system. It transforms the organization's processes. It enables to share the vehicle data over a secure network for connectivity and shared mobility solutions such as urban transportation, ride-hailing and deliveries. It is also used in the verification process to improve efficiency across back-office works and supply chain. The disruption of blockchain in auto sector is anticipated to increase in the future.

Connected Cars: Today, cars are also getting connected via the internet giving rise to the connected car technology. It has become the new norm in the automobile industry. Connected cars provide a host of smart and convenient features like continuous internet connectivity, app2car connectivity and geo-fencing among others.

Advantages of Integrating AI Technology:

The integration of AI technology in automobiles brings numerous benefits including increased safety, efficiency, and improved driver experience.

Safety: With accurate sensing technologies and decision-making skills, AI helps detect and avoid accidents.

Efficiency: AI systems can optimize fuel consumption and route-planning resulting in reduced travel time and expenses.

Driver Experience: Voice-activated in-car assistants help drivers stay connected while minimizing driver distraction.

Cost Reduction: Automated manufacturing of automobile components using AI results in reduced production costs.

Final Thoughts on the Impact of AI in the Automobile Industry:

The integration of AI technology is necessary for the automobile industry's growth and development. It will lead to better driver safety, lower maintenance costs, and improved energy usage efficiency. It's a journey, not a destination.

Pros

- Enhanced driver experience
- Improved efficiency
- Better safety
- Cost reduction
- Data privacy concerns
- Cybersecurity risks
- Reliability of AI systems
- Liability-related issues

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