Artificial Intelligence & Machine Learning Unit 1: Introduction to AI-ML Question bank and its solution

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Unit 1: Introduction to AI-ML

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Question bank and its solution

by

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Unit 1: Introduction to AI & ML

Syllabus:

Content	Theory	Mathematics	Numerical
• **Need**			
History of AI	✓	✗	✗
Comparison of AI with Data Science	✓	✗	✗
Need of AI in Mechanical Engineering	✓	✗	✗
• **Introduction to Machine Learning**			
Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation.	✓	✗	✗
• **Approaches to AI**			
Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical	✓	✗	✗
• **Approaches to ML**			
Supervised learning, Unsupervised learning, Reinforcement learning	✓	✗	✗

Type of question and marks:

Type	Theory	Mathematics	Numerical
Marks	2 or 4 or 6	-	-

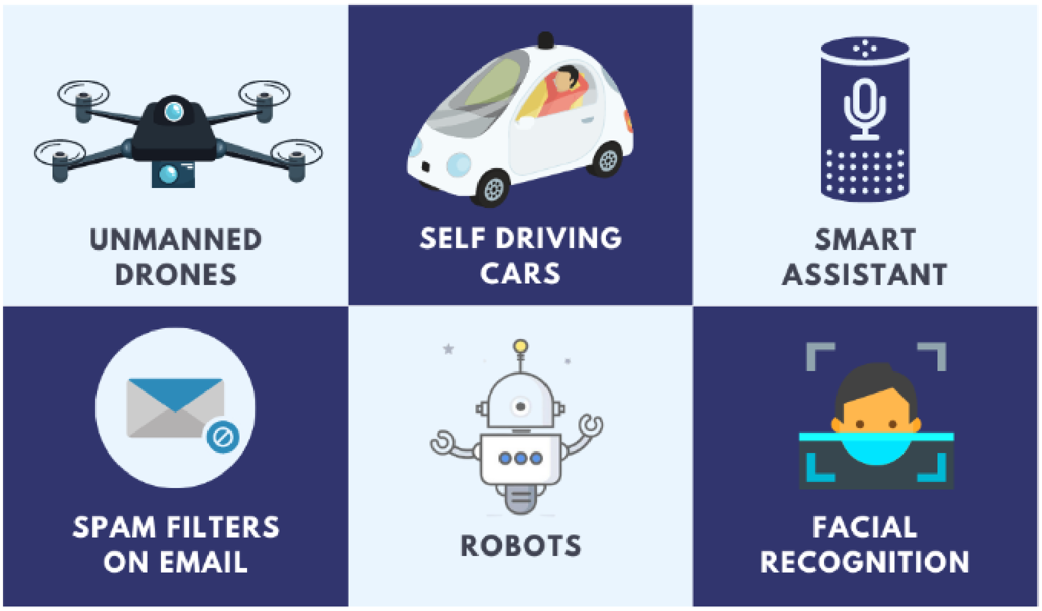
Topic: Feature extraction	Theory	Mathematics	Numerical
	✓	✗	✗

Theory questions

1. What is the motivation behind AI approach? What is its history?

The motivation behind AI (Artificial Intelligence) is to create machines or computer systems that can perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and natural language processing.

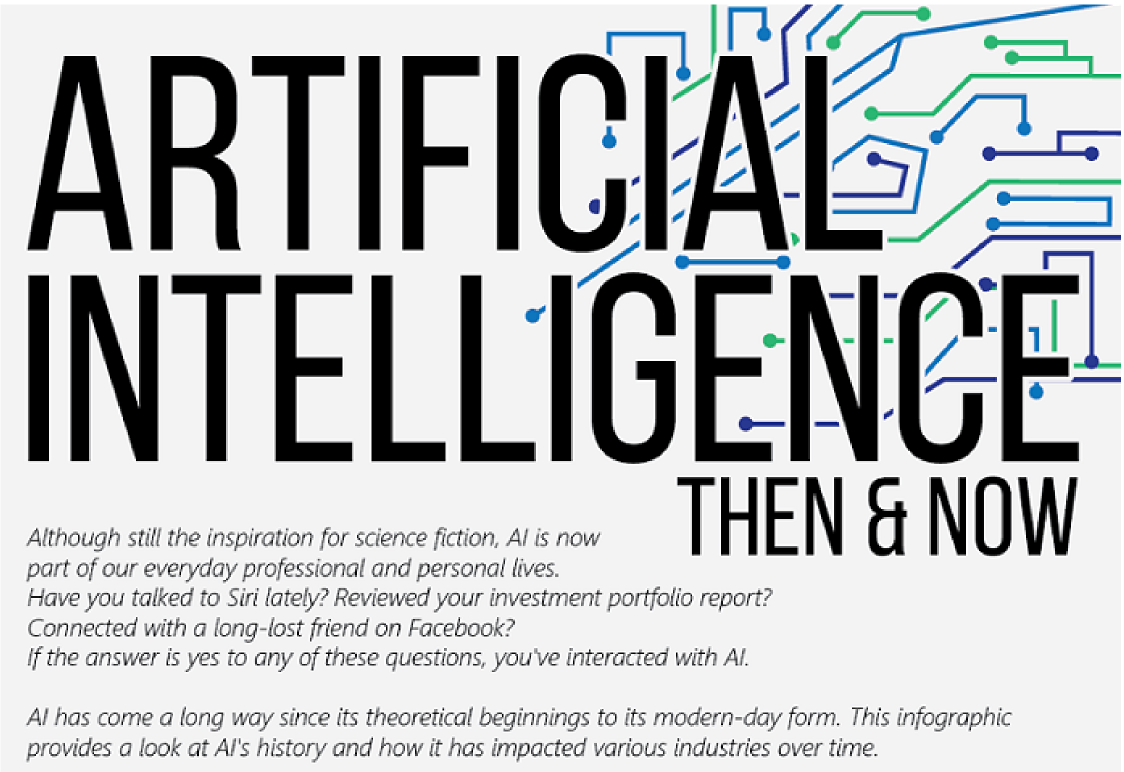
- The idea behind AI is to develop intelligent machines that can automate tasks, reduce human effort, and improve efficiency. By creating machines that can perform complex tasks, we can free up human resources to focus on more creative and innovative endeavors.
- Another motivation behind AI is to create machines that can learn and adapt to new situations. This ability to learn and adapt is what sets AI apart from traditional computer programs, which are designed to follow a predetermined set of rules.
- AI also has the potential to transform many industries, from healthcare to finance to manufacturing. For example, in healthcare, AI can be used to analyze medical data to identify patterns and trends that can help doctors make more accurate diagnoses and develop more effective treatments. In finance, AI can be used to analyze market trends and make predictions about future market movements.
- Overall, the motivation behind AI is to create intelligent machines that can automate tasks, learn and adapt to new situations, and transform industries by unlocking new levels of efficiency and productivity.

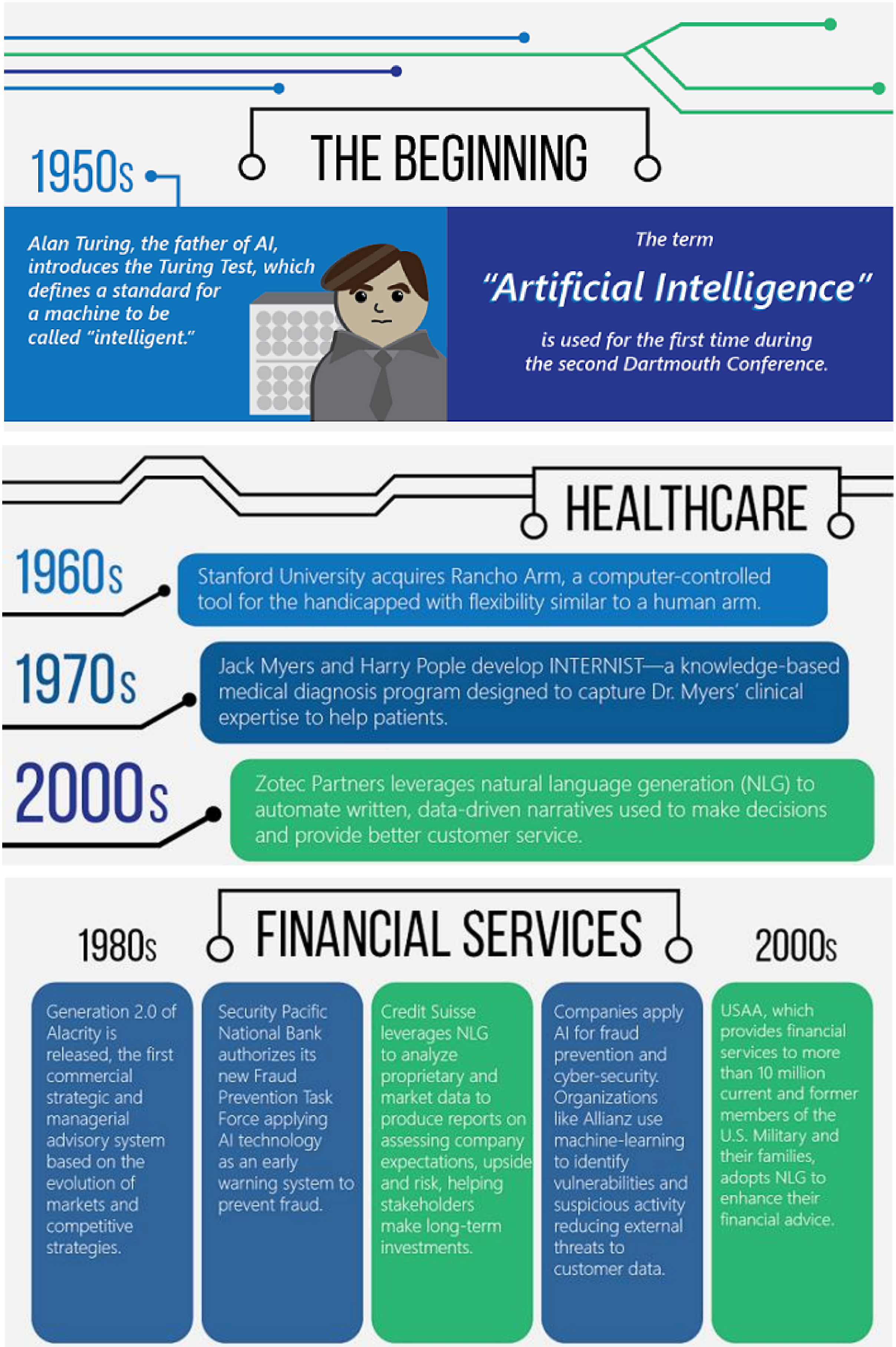


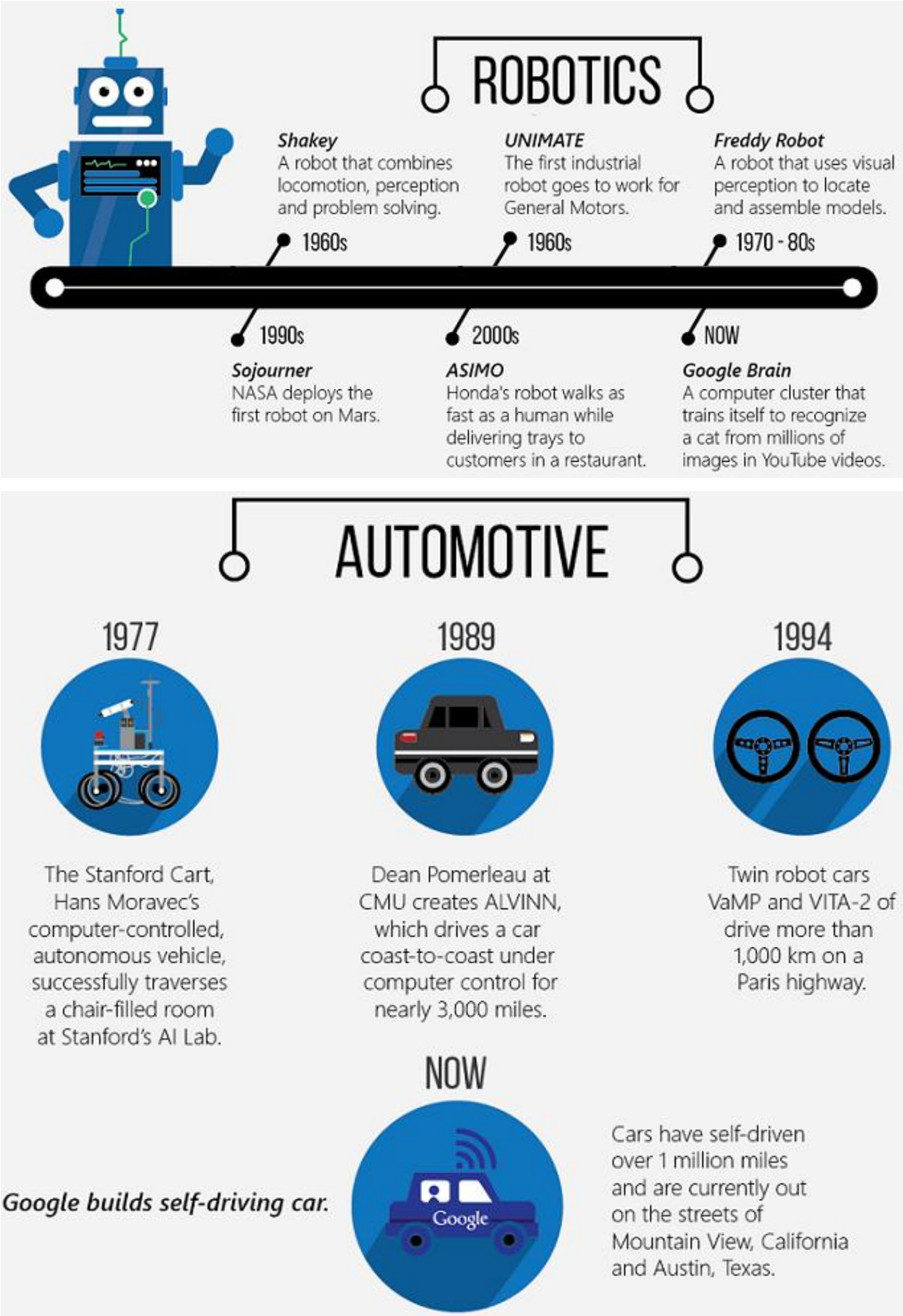
The history of AI (Artificial Intelligence) can be traced back to the 1950s, when researchers first started exploring the possibility of creating intelligent machines. The term "artificial intelligence" was first coined by John McCarthy, who is considered one of the pioneers of the field.

- During the 1950s and 1960s, researchers developed a number of early AI systems, including rule-based expert systems and the first machine learning algorithms. However, progress in AI was slow and many researchers became disillusioned with the field, leading to what was known as the "AI winter" in the 1970s and 1980s.
- In the 1980s and 1990s, there was renewed interest in AI, and researchers began to develop more sophisticated algorithms and techniques, such as neural networks and genetic algorithms. This led to significant progress in areas such as computer vision, speech recognition, and natural language processing.
- In the 2000s and 2010s, the rise of big data and the availability of powerful computing resources led to a new wave of progress in AI, particularly in the area of machine learning. This has led to the development of advanced AI systems, such as deep learning algorithms, that have achieved breakthroughs in areas such as image and speech recognition, natural language processing, and game playing.

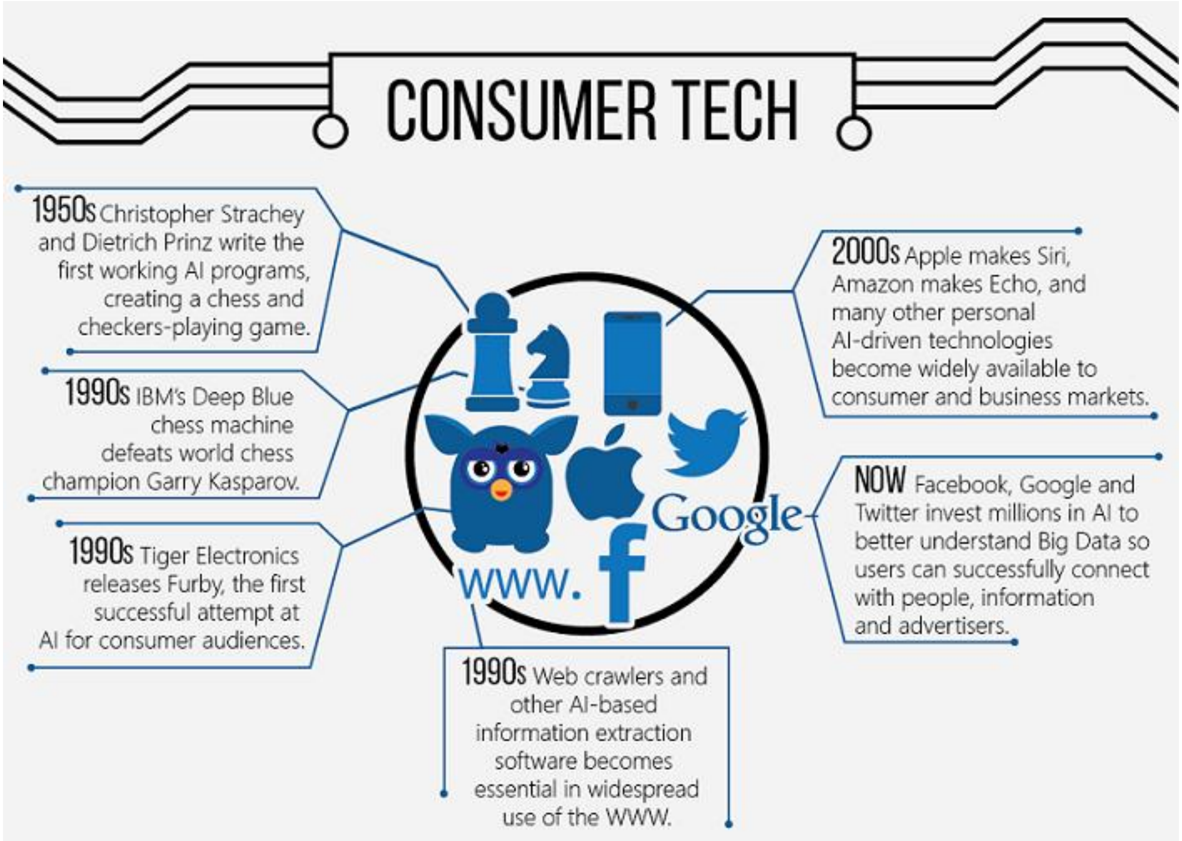
Today, AI is a rapidly growing field that is driving innovation in a wide range of areas, from autonomous vehicles and robotics to healthcare and finance. As computing power continues to increase and new AI algorithms are developed, the potential applications of AI are likely to continue to expand.

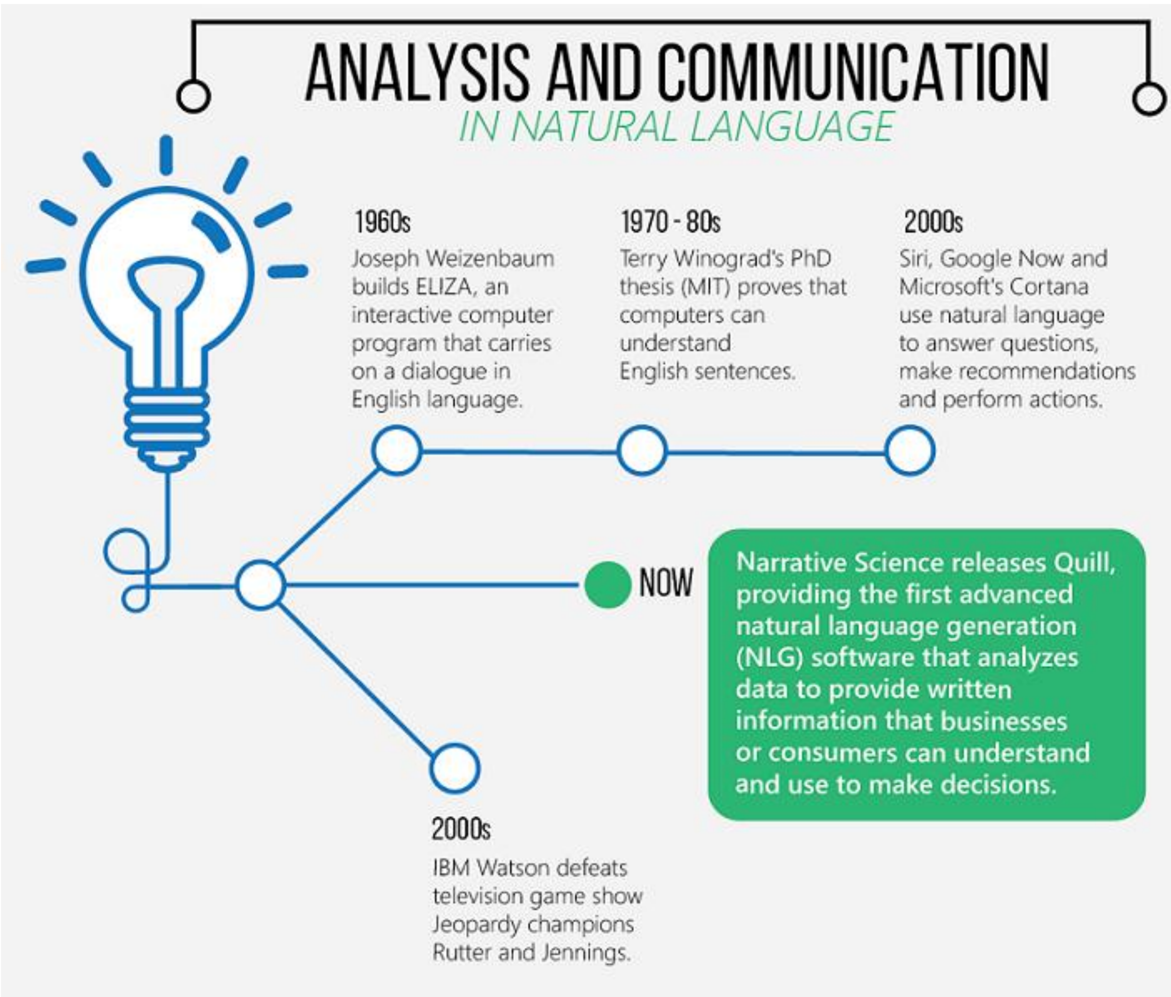



THE BEGINNING
1950s
Alan Turing, the father of AI, introduces the Turing Test, which defines a standard for a machine to be called "intelligent."
The term "Artificial Intelligence" is used for the first time during the second Dartmouth Conference.
HEALTHCARE
1960s
Stanford University acquires Rancho Arm, a computer-controlled tool for the handicapped with flexibility similar to a human arm.
1970s
Jack Myers and Harry Pople develop INTERNIST—a knowledge-based medical diagnosis program designed to capture Dr. Myers' clinical expertise to help patients.
2000s
Zotec Partners leverages natural language generation (NLG) to automate written, data-driven narratives used to make decisions and provide better customer service.
FINANCIAL SERVICES
1980s
2000s
Generation 2.0 of Alacrity is released, the first commercial strategic and managerial advisory system based on the evolution of markets and competitive strategies.
Security Pacific National Bank authorizes its new Fraud Prevention Task Force applying AI technology as an early warning system to prevent fraud.
Credit Suisse leverages NLG to analyze proprietary and market data to produce reports on assessing company expectations, upside and risk, helping stakeholders make long-term investments.
Companies apply AI for fraud prevention and cyber-security. Organizations like Allianz use machine-learning to identify vulnerabilities and suspicious activity reducing external threats to customer data.
USAA, which provides financial services to more than 10 million current and former members of the U.S. Military and their families, adopts NLG to enhance their financial advice.



Source: Artificial Intelligence Then and Now https://insidebigdata.com/2015/10/03/artificial-intelligence-then-and-now/


CONSUMER TECH
1950s Christopher Strachey and Dietrich Prinz write the first working AI programs, creating a chess and checkers-playing game.
1990s IBM's Deep Blue chess machine defeats world chess champion Garry Kasparov.
1990s Tiger Electronics releases Furby, the first successful attempt at AI for consumer audiences.
1990s Web crawlers and other AI-based information extraction software becomes essential in widespread use of the WWW.
2000s Apple makes Siri, Amazon makes Echo, and many other personal AI-driven technologies become widely available to consumer and business markets.
NOW Facebook, Google and Twitter invest millions in AI to better understand Big Data so users can successfully connect with people, information and advertisers.
Google
www.

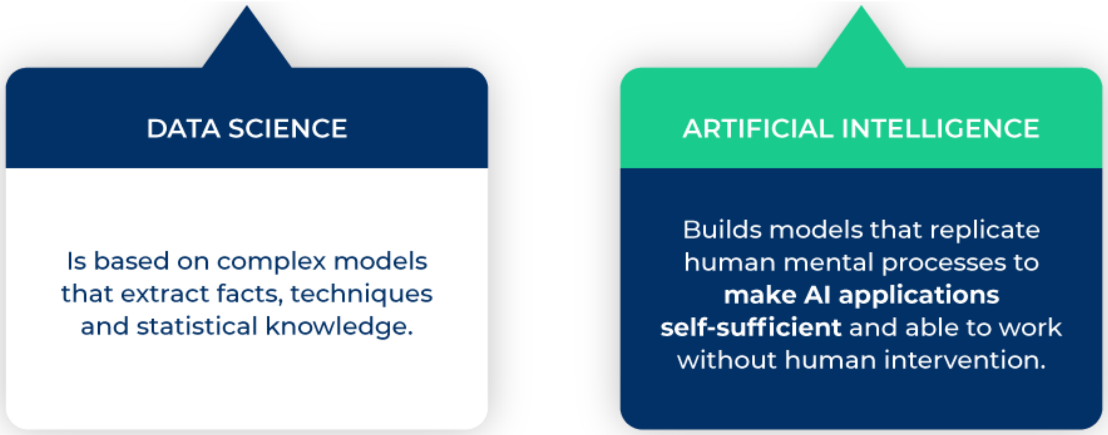

ANALYSIS AND COMMUNICATION
IN NATURAL LANGUAGE
1960s
Joseph Weizenbaum builds ELIZA, an interactive computer program that carries on a dialogue in English language.
1970 - 80s
Terry Winograd's PhD thesis (MIT) proves that computers can understand English sentences.
2000s
Siri, Google Now and Microsoft's Cortana use natural language to answer questions, make recommendations and perform actions.
NOW
Narrative Science releases Quill, providing the first advanced natural language generation (NLG) software that analyzes data to provide written information that businesses or consumers can understand and use to make decisions.
2000s
IBM Watson defeats television game show Jeopardy champions Rutter and Jennings.

2. Compare the scope of AI and data science. OR differentiate AI and data science with respect to their scope.

AI (Artificial Intelligence) and Data Science are two related but distinct fields in computer science.

- AI is a broad field that focuses on creating machines or computer systems that can perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and natural language processing. AI involves the development of algorithms and models that enable machines to learn and reason about the world, make predictions, and make decisions.
- Data Science, on the other hand, is a more specific field that focuses on the extraction of insights and knowledge from data. Data Science involves the use of statistical models, algorithms, and visualization tools to analyze large and complex data sets, identify patterns and trends, and make predictions.
- While there is some overlap between AI and Data Science, the two fields differ in their goals and approaches. AI is focused on creating intelligent machines that can learn and reason about the world, while Data Science is focused on extracting insights and knowledge from data.
- Another key difference between AI and Data Science is the types of data they work with. AI often deals with complex and unstructured data, such as images, video, and text, while Data Science typically deals with structured data, such as numerical or categorical data in tables or databases.

In summary, AI and Data Science are related but distinct fields in computer science. While AI is focused on creating intelligent machines that can learn and reason about the world, Data Science is focused on extracting insights and knowledge from data. Exclusive highlights are given below. Source: https://www.algotive.ai/blog/what-is-data-science-and-how-does-it-work-with-artificial-intelligence



DATA SCIENCE

Consists of analyzing and visualizing data to find hidden patterns for decision making.

It is based on different statistical, design and development methods, working with structured and unstructured data.

Total human control: a data scientist extracts and then analyzes the information, processes and uses it.

We use it to perform predictive analysis in situations that require fast mathematical reasoning.

ARTIFICIAL INTELLIGENCE

Involves implementing predictive tools and models to determine results in fields such as safety, sales, processes, etc.

It relies on algorithms and database updating to operate.

Partial human control: a person programs software and machinery, but they then AI handles the data independently.

We use it for risk analysis, to make decisions in a short time and without emotional influence, as for repetitive tasks.

DATA SCIENCE

Encompasses multiple analytical, descriptive, predictive and prescriptive applications.

Mainly implemented at:
- Internet Search Engines
- Advertising
- Marketing

Example:
Analyzes data collected from call centers to understand customer rotations and create strategies to retain them.

ARTIFICIAL INTELLIGENCE

Relies on computer applications that simulate human cognition and intelligence.

Mainly implemented at:
- Transport
- Healthcare
- Manufacturing
- Robotics
- Automation
- Security

Example:
Uses facial recognition and databases to detect suspicious subjects and activities.

ITS MAIN TOOLS, **LIBRARIES** AND **PLATFORMS** ARE:

DATA SCIENCE

- Python
- R
- Jupyter
- Zeppelin
- RStudio

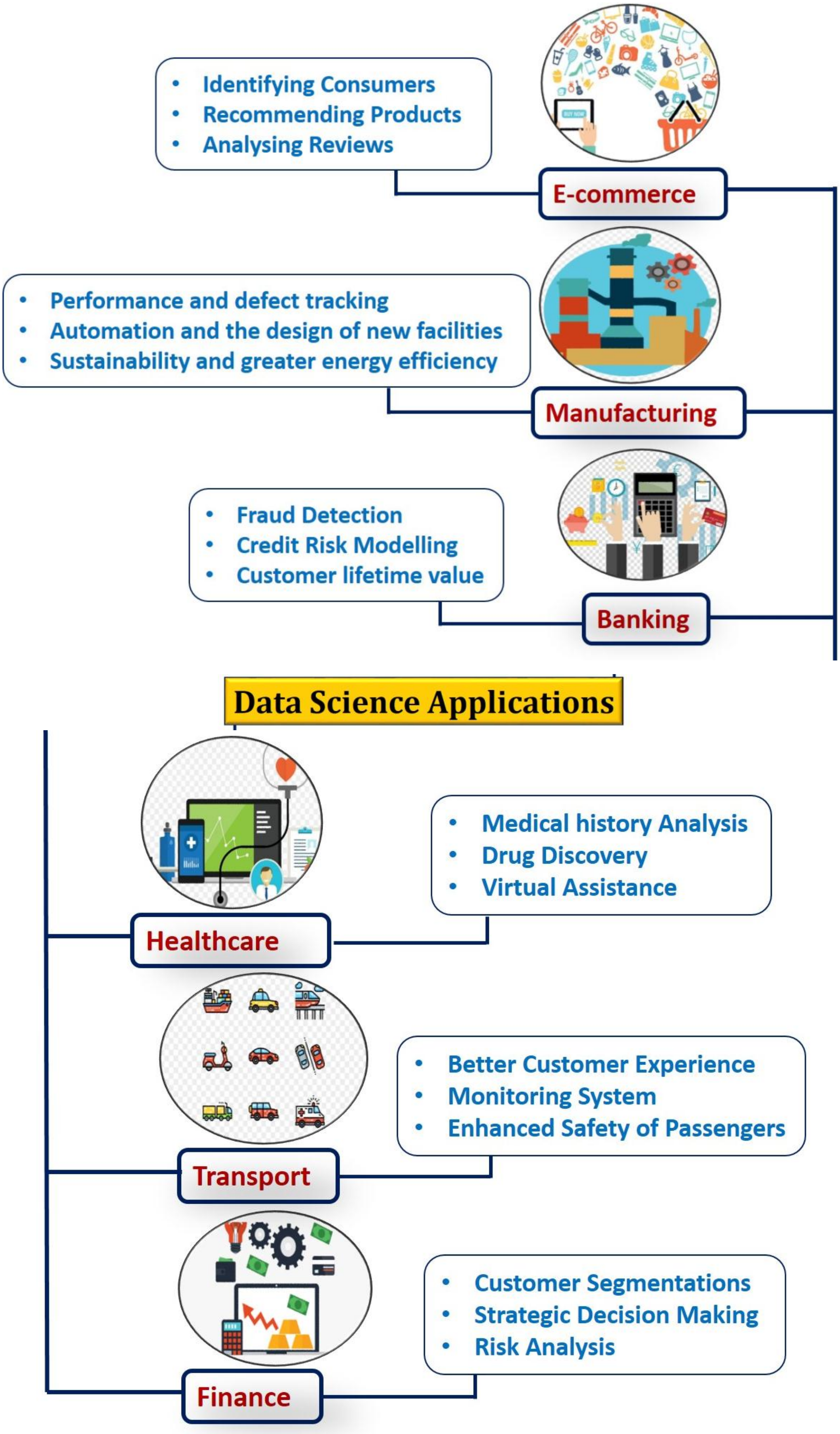
*It is worth noting that data science uses a larger number of programs because its analysis processes are more time-consuming and consist of several steps.

ARTIFICIAL INTELLIGENCE

- TensorFlow
- Kaffee
- scikit-learn

	Data Science	Artificial Intelligence
1	Requires pre-processing, analysis, visualization, and build predictive models	Use pretrained models for classification, predictions and pattern recognition
2	Primarily uses statistical techniques and ML Models	Implements ML and Deep Learning algorithms
3	Finds hidden patterns in data	Gives autonomy to data models
4	Builds ML and data models using statistical insights	Used for building models that surpass or match human cognition and understanding capabilities
5	Does not involve high scientific processing	Involves high scientific processing
6	It is a data analytics and statistical technique	Mainly machine learning and deep learning technique
7	Data is controlled with data science techniques	Involves robotic control with AI and machine learning techniques

Source: https://www.analytixlabs.co.in/blog/data-scientist-vs-ai-artificial-intelligence-engineer-what-is-the-difference/



Source: https://www.shiksha.com/it-software/articles/data-science-career-and-future-scope-blogId-26453

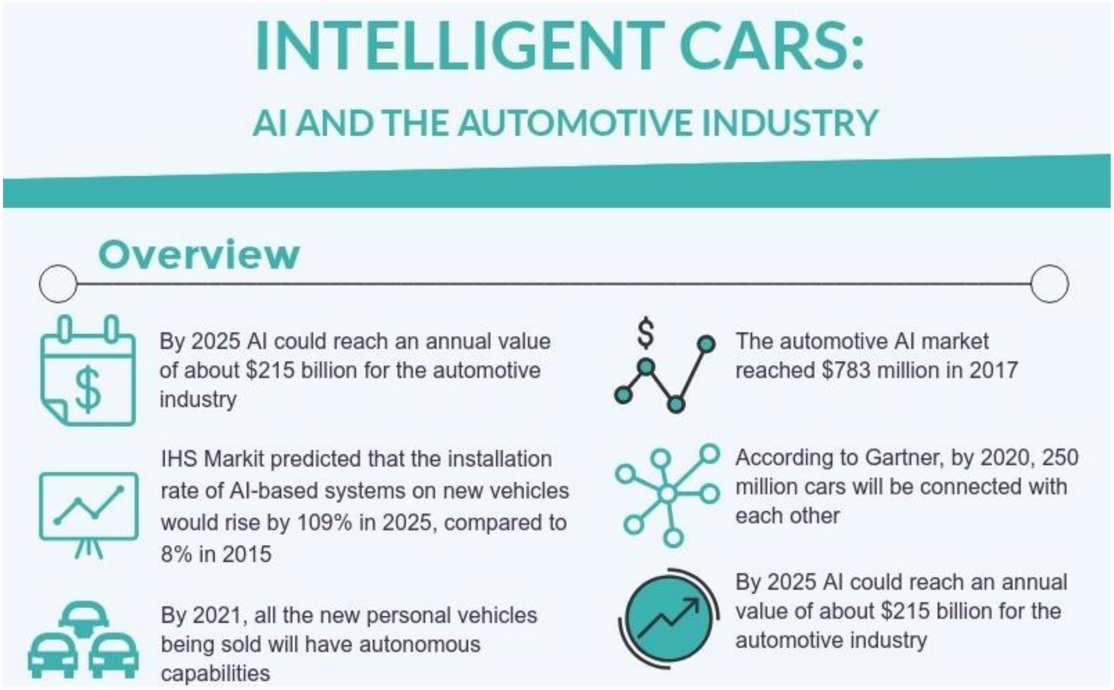
3. Enlist applications of AI-ML in mechanical engineering domain.

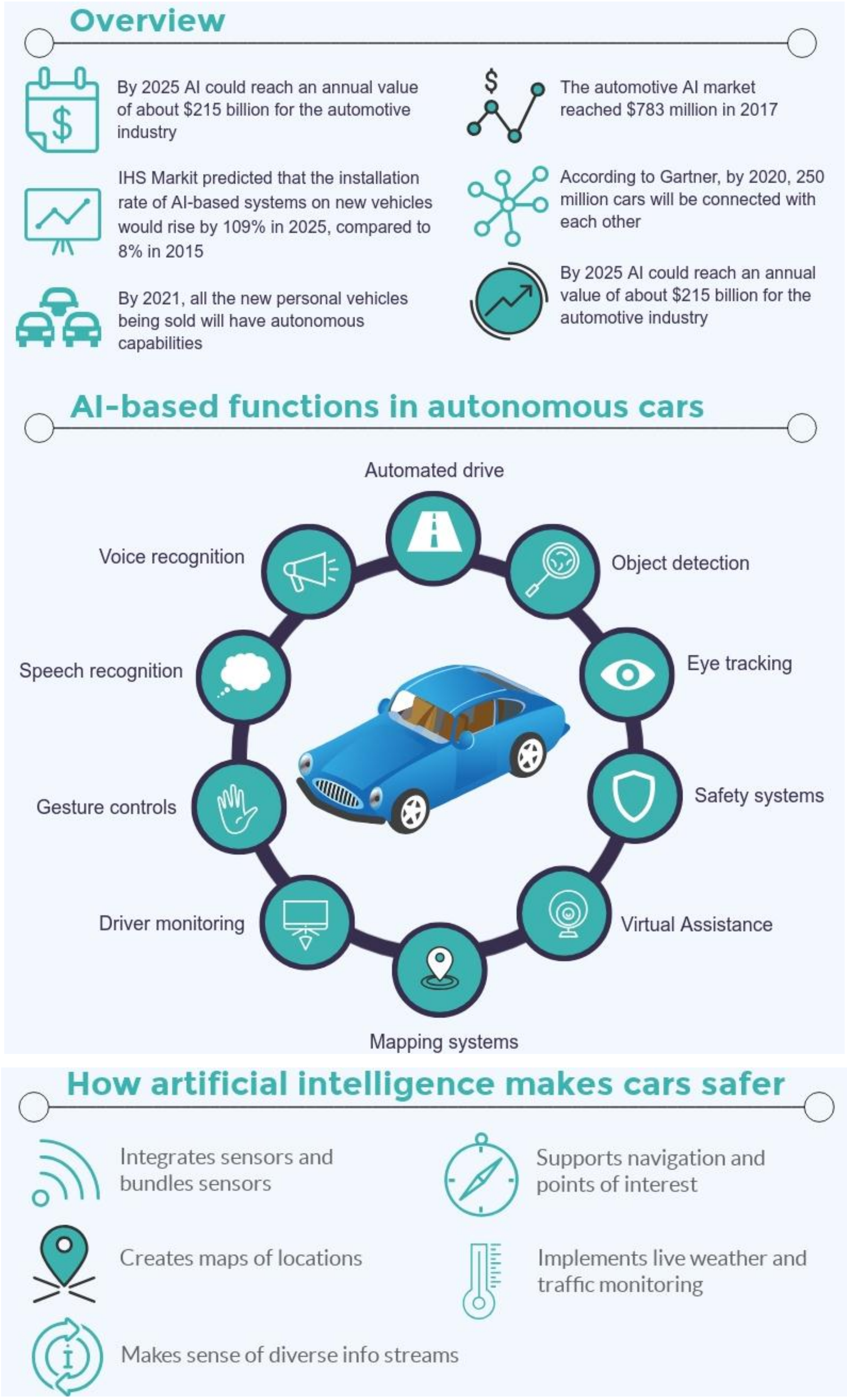
Artificial intelligence is playing an increasingly important role in mechanical engineering and various applications are summarised here.

Automobile industry

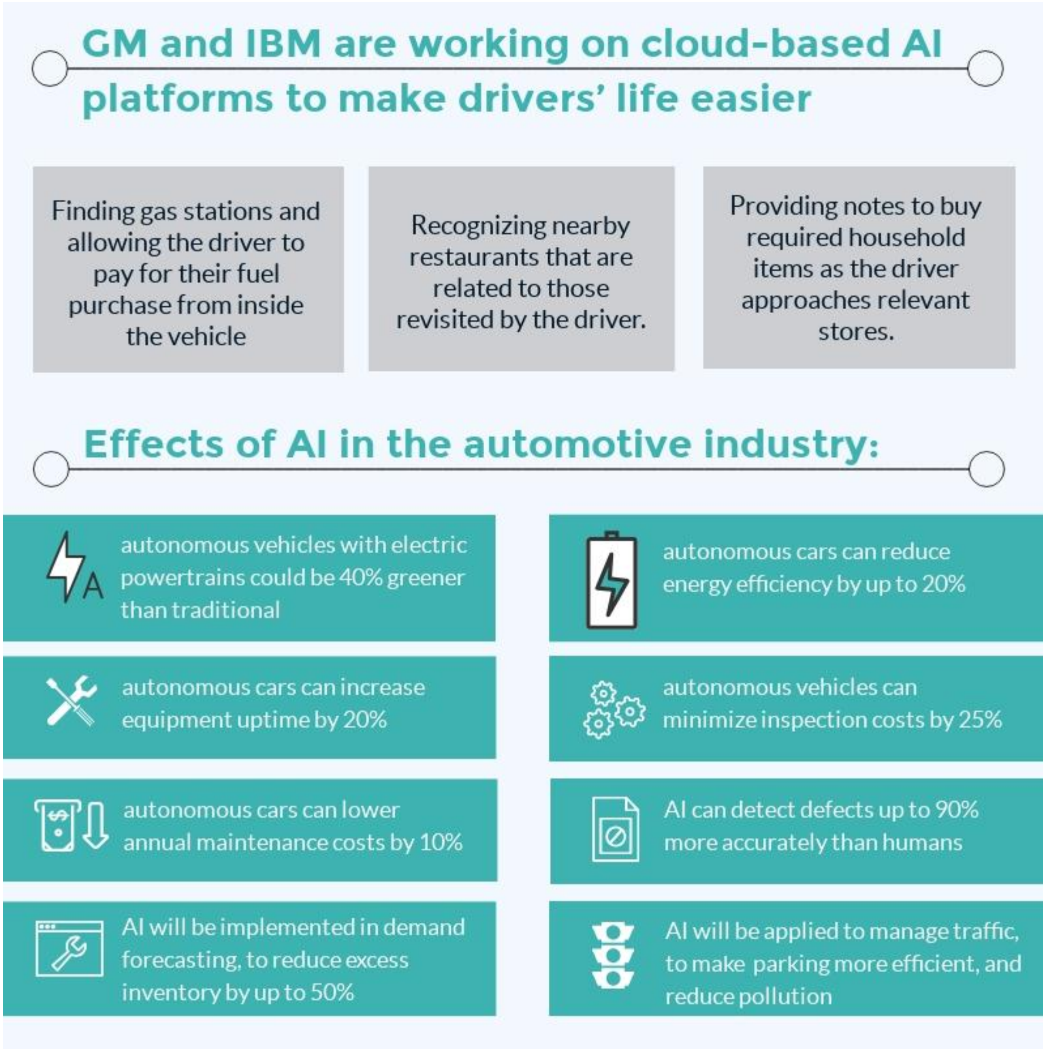
AI in the automobile industry, with many applications being developed to enhance vehicle performance, safety, and efficiency. Here are a few examples:

- **Autonomous driving:** AI is essential for the development of self-driving cars. Autonomous vehicles use sensors such as lidar, radar, and cameras to perceive the environment and make decisions. Machine learning algorithms are used to train the AI system to recognize objects, predict their movements, and make decisions on how to navigate the vehicle safely.
- **Predictive maintenance:** AI can help predict when a vehicle needs maintenance by analyzing data from sensors and other sources. This can help prevent breakdowns and reduce downtime.
- **Personalized driving experience:** AI can analyze driver behavior and preferences to create a personalized driving experience. For example, the AI system can adjust the seat, temperature, and music based on the driver's preferences.
- **Enhanced safety features:** AI is being used to develop advanced safety features such as collision detection and avoidance, lane departure warnings, and adaptive cruise control.
- **Connected cars:** AI can enable vehicles to communicate with each other and with infrastructure, creating a network of connected cars that can share information and coordinate movements.

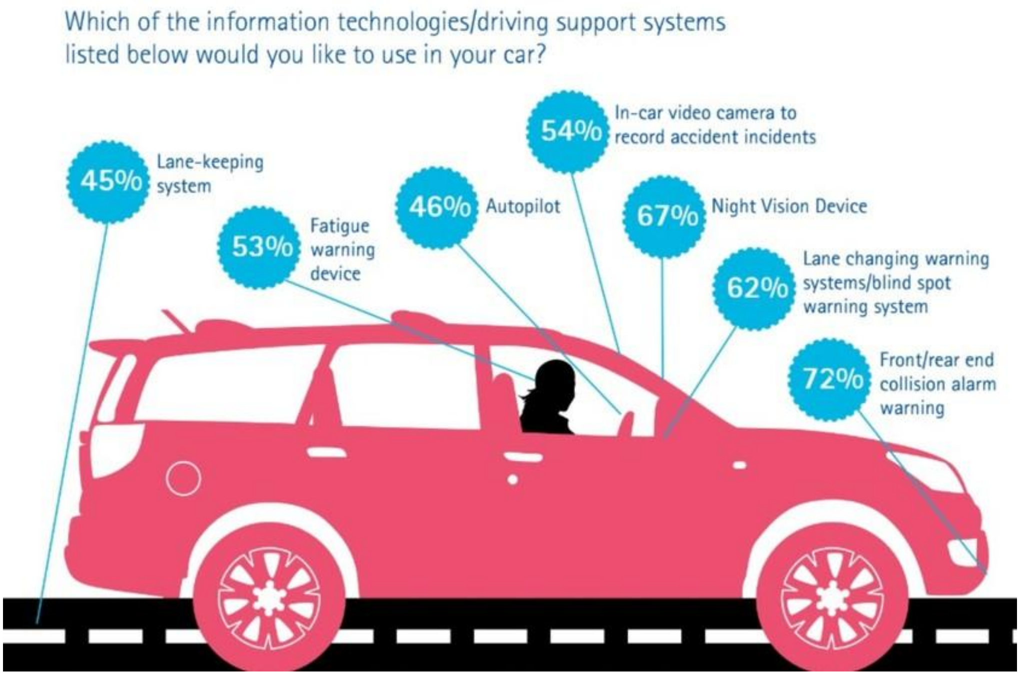




Source: https://rickscloud.com/intelligent-cars-ai-and-the-automotive-industry/



Source: https://www.linkedin.com/pulse/how-artificial-intelligence-machine-learning-auto-models-mishanin/



Detect and classify objects in radar signal and get their distance
Using combination of CNN and LSTM
Radar Perception
Lidar Perception
Detection for lane markers, drivable space vehicles, etc.
Annotation for Deep Learning
Detect and classify lane markers, drivable space, traffic sign, other vehicles, blinkers, etc.
Using multiple CNN and LSTM-like (TAGM) networks on multiple cameras
Camera Perception
Behavior planning
Reinforcement learning for safe and human-like driving behavior
Prediction based on LSTM and convolutional networks

Digital Cockpit - Scalable heterogeneous compute architecture
Mirror replacement display
AR/HUD display
Passenger display
Reconfigurable cluster display
Center display
Rear-seat display
Mirror replacement vision system
Foundational technologies
Artificial intelligence
Heterogeneous computing
Computer vision
Audio
Multimedia
Location
Security
Connectivity

RSU with AI-based camera
Traffic hazard warning
AI-based camera detects a hazard on the right lane and alert other cars on the road; via precise positioning other cars avoid the lane with the hazard
RSU with AI-based camera
Pedestrian alert
Traffic light detects a pedestrian crossing the street and alert oncoming cars via I2V;
Also, possible via direct V2P communication
Road Safety
V2V/V2I: Intersection management assist
I2V
Send updated 3D HD map with the hazard via 5G NR C-v2X
V2P
Subway
Defining connected urban transport
Edge AI
E.g. for detecting pedestrians or hazards
C-V2X (I2V)
E.g. send 3D HD map updates or hazard warning
Localization
E.g. for lane-level warning, and navigation

Source: https://venturebeat.com/ai/how-ai-is-impacting-the-automotive-world/

Manufacturing industry

AI is transforming the manufacturing industry in a number of ways. Here are some examples:

- **Quality control:** AI can be used to monitor production lines and identify defects or quality issues in real-time. Machine learning algorithms can analyze large amounts of data and identify patterns that indicate potential problems before they become major.
- **Predictive maintenance:** AI can predict when machines and equipment will require maintenance or repairs, reducing downtime and increasing efficiency.
- **Supply chain optimization:** AI can be used to optimize the supply chain by analyzing data on inventory levels, production schedules, and shipping times. This can help manufacturers reduce costs and improve delivery times.
- **Robotic automation:** AI can be used to control robots and other automation systems, allowing for more efficient and flexible manufacturing processes.
- **Smart factories:** AI can enable factories to become more connected and intelligent, with machines and equipment communicating with each other and with human operators. This can lead to more efficient and effective production processes.
- **Demand Planning:** AI allows the industry to optimize product availability by reducing out of stocks and waste or spoilage. AI can also assist with obtaining a more reliable perception of sales patterns.
- **Inventory Management:** AI can be utilized to acquire a stabler knowledge of inventory levels permitting companies to plan for the future and withdraw stock-outs.

Source: https://www.vlcsolutions.com/blog/artificial-intelligence-in-manufacturing/

Demand planning

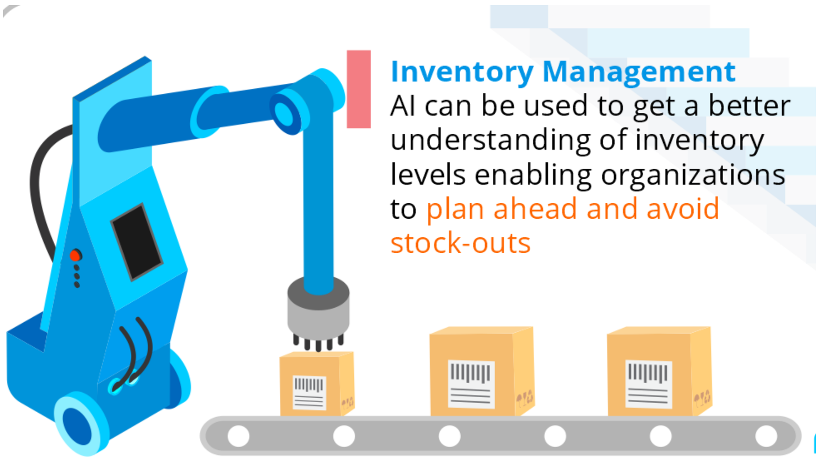
AI enables organization to optimize product availability by decreasing out of stocks and spoilage. AI can also help with getting a better understanding of sales patterns.

Company uses AI algorithms to predict demand based on a wide variety of data gathered from social media, weather, and financial markets.[4]

Product development/R&D

AI enables organizations to expediate product development and R&D by reducing the test times and driving more concrete insights from customer data and demands

Icompany is using big data and AI platforms to create tests for hard to validate functionalities improving the targeted coverage by 230x compared to standard regression tests[5]



Inventory Management

AI can be used to get a better understanding of inventory levels enabling organizations to plan ahead and avoid stock-outs

Production

TAKT can be reduced by using AI to streamline manufacturing processes, improving throughput

Company uses AI to automatically adjust rate, speed, acceleration, etc. of the industrial robots leading to the time reduction to 1/10th of conventional method[6]

Process control

AI can help organizations optimize processes to achieve production levels with enhanced consistency, economy and safety

Company uses AI to influence operations by predicting outcomes and improving efficiency levels to optimise output.[7]

Quality control

Product quality inspections bring uniformity and efficiency in quality control, using image-based and sensor-based processes.

Company uses AI to promote high-level of precision in tire manufacturing, resulting in an improvement of more than 15% over traditional methods

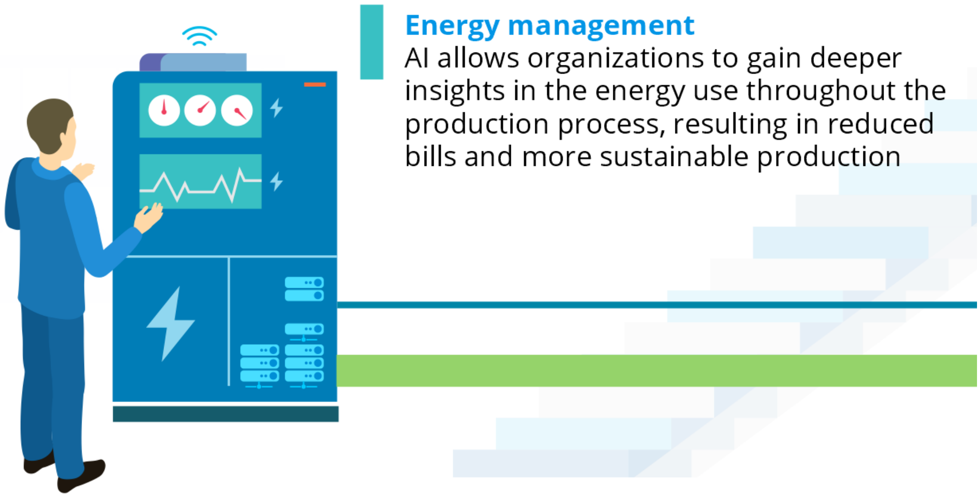
Maintenance

Using AI, organizations can predict and prepare for asset failure, reducing (or even avoiding) downtime.

company uses computer vision to analyse images from robot mounted cameras to spot early signs of failing robotic part [8]

Safety

AI is used to get a better understanding of risk factors within the shop floor and can help safer operations



Energy management

AI allows organizations to gain deeper insights in the energy use throughout the production process, resulting in reduced bills and more sustainable production

Mechanical Design

Here are some examples of how AI is being used in mechanical design.

- **Generative design:** AI can be used to generate designs based on specified parameters, such as weight, strength, and material usage. By using machine learning algorithms to analyze vast amounts of data, AI can produce innovative designs that are optimized for performance and cost-effectiveness.
- **Simulation and analysis:** AI can be used to simulate the behavior of mechanical systems and analyze the results. This can help mechanical engineers identify potential issues and optimize designs before they are manufactured, reducing costs and improving quality.
- **Design optimization:** AI can be used to optimize existing designs by analyzing data and identifying areas for improvement. This can lead to products that are lighter, stronger, and more efficient.
- **Design validation:** AI can be used to validate designs by comparing them to known data and identifying potential issues. This can help ensure that designs are safe and effective before they are manufactured.
- **Collaboration and knowledge management:** AI can be used to facilitate collaboration among designers and engineers by providing tools for sharing data and knowledge. This can help ensure that everyone is working on the most up-to-date information and can lead to more effective design processes.

Thermal / Heat Transfer / HVAC / Fluid Mechanics / Fluid Power

Here are some examples of how AI is being applied in various ways.

- **Optimization of thermal systems:** AI can be used to optimize the design of thermal systems such as engines, heat exchangers, and refrigeration systems. By analyzing large amounts of data and using machine learning algorithms, AI can identify areas for improvement and optimize the design for performance and efficiency.
- **Predictive maintenance:** AI can be used to predict when HVAC and fluid power systems will require maintenance or repairs. By analyzing data from sensors and other sources, AI can identify potential issues before they become major problems.
- **Smart control systems:** AI can be used to control HVAC and fluid power systems, allowing for more efficient and flexible operation. This can help reduce energy costs and improve performance.
- **Simulation and modeling:** AI can be used to simulate and model the behavior of fluid systems, such as airflow or fluid flow through a pipe. This can help engineers identify potential issues and optimize designs before they are manufactured.

- **Optimization of fluid dynamics:** AI can be used to optimize the design of fluid systems such as pumps and turbines, improving performance and reducing energy consumption.

Materials and Metallurgy

Here are some examples of how AI is being applied in various ways.

- **Materials discovery:** AI can be used to predict the properties of new materials before they are synthesized, reducing the need for trial-and-error experimentation. By using machine learning algorithms to analyze large amounts of data on the properties of existing materials, AI can identify promising candidates for new materials with specific properties.
- **Image recognition:** AI can be used to recognize materials based on images or visual data. Machine learning algorithms can be trained on large datasets of images of different materials, allowing the AI to recognize and identify materials in new images.
- **Spectral analysis:** AI can be used to analyze the spectra of materials, such as their reflectance or absorption spectra. By training machine learning algorithms on spectral data, AI can identify and recognize materials based on their unique spectral fingerprints.
- **X-ray diffraction analysis:** AI can be used to analyze X-ray diffraction patterns of materials. By training machine learning algorithms on patterns from known materials, AI can identify and recognize new materials based on their diffraction patterns.
- **Sensing technologies:** AI can be used with various sensing technologies, such as spectroscopy or magnetometry, to recognize and identify materials based on their physical properties.

Energy Conservation and Management

Here are some examples of how AI is being applied in various ways.

- **Smart Grids:** AI can be used to optimize the operation of smart grids, which are modern electrical grids that use sensors and other technologies to manage energy more efficiently. By analyzing data from sensors and other sources, AI can identify patterns in energy usage and predict future demand, helping to optimize the distribution and consumption of energy.
- **Building Energy Management:** AI can be used to optimize the energy consumption of buildings. Machine learning algorithms can analyze data from sensors and other sources to identify patterns in energy usage and predict future demand, allowing building managers to optimize heating, ventilation, and air conditioning (HVAC) systems and lighting to save energy.

- **Renewable Energy Optimization:** AI can be used to optimize the operation of renewable energy sources such as wind turbines and solar panels. By analyzing data from sensors and other sources, AI can predict energy output and optimize the operation of renewable energy sources to maximize energy production.
- **Energy Efficiency:** AI can be used to identify opportunities for energy efficiency improvements in industrial and commercial settings. Machine learning algorithms can analyze data from sensors and other sources to identify inefficiencies in energy usage, allowing organizations to take steps to reduce energy waste and save money on energy costs.
- **Energy Storage Optimization:** AI can be used to optimize the operation of energy storage systems such as batteries. By analyzing data from sensors and other sources, AI can predict energy demand and optimize the operation of energy storage systems to maximize energy availability.

4. Explain role of reasoning in machine learning.

- Reasoning in machine learning refers to the ability of a machine learning system to make logical deductions and draw inferences based on the input data it receives. This involves using algorithms and statistical models to analyze and interpret data, and then applying logic and reasoning to make decisions or predictions based on that analysis.
- In machine learning, reasoning can be both deductive and inductive. Deductive reasoning involves drawing conclusions based on a set of premises or assumptions, while inductive reasoning involves making generalizations based on specific observations.
- Imagine a mechanical system that needs to make a decision based on a set of inputs. For example, a robot arm that needs to grasp an object and move it to a specific location. To make this decision, the robot arm needs to analyze the data from its sensors (such as cameras or pressure sensors), and then use this data to reason and make a decision about how to move.
- In a similar way, machine learning algorithms use data as input to make decisions or predictions. They use mathematical models and algorithms to analyze the data and find patterns, and then use reasoning to make predictions or decisions based on those patterns.
- For example, a machine learning system used in predictive maintenance of machines might analyze data from sensors on the machines to detect patterns of wear and tear. Based on these patterns, the system can reason that certain components are likely to fail soon, and trigger maintenance alerts or take action to prevent a breakdown.

- By incorporating reasoning capabilities into machine learning systems, they can make more accurate predictions and decisions, just like a well-designed mechanical system. This analogy can help mechanical students to understand the concept of reasoning in machine learning in a more relatable way.

5. Explain problem solving strategies in AI.

Reasoning in machine learning refers to the ability of a machine learning system to make logical deductions and draw inferences based on the input data it receives. This involves using algorithms and statistical models to analyze and interpret data, and then applying logic and reasoning to make decisions or predictions based on that analysis.

- Problem solving in AI involves developing algorithms and techniques to enable machines to find solutions to complex problems in a way that mimics human problem solving. There are several techniques used in AI to solve problems, including search algorithms, heuristics, and optimization algorithms.
- Search algorithms are used to explore a problem space and find a solution by evaluating different possible paths or states. For example, the A* algorithm is used in pathfinding, where it searches through a graph of possible paths to find the shortest path between two points.
- Heuristics are rules or strategies that simplify a problem by reducing the number of possible solutions. They can be used to guide search algorithms, making them more efficient. For example, in chess, a heuristic called "minimax" is used to search for the best move by exploring possible moves and their consequences.
- Optimization algorithms are used to find the best solution among a set of possible solutions. They can be used for tasks such as feature selection or parameter tuning in machine learning. For example, gradient descent is an optimization algorithm used to minimize the loss function in training a neural network.
- In addition to these techniques, AI problem solving often involves combining multiple techniques and incorporating feedback from the environment to improve the solution over time. Reinforcement learning, for example, is a type of AI problem solving that involves learning from rewards or punishments given by an environment in response to actions taken by an agent.
- Overall, problem solving in AI involves developing algorithms and techniques to enable machines to find solutions to complex problems in a way that mimics human problem solving, but with the advantage of being able to explore a much larger search space and optimize solutions more efficiently.

6. How is Knowledge represented in AI?

Knowledge representation in AI refers to the process of storing and organizing information in a way that allows machines to reason about and use that information to make decisions. It involves designing formal systems for representing knowledge in a way that is understandable to machines, and developing algorithms and techniques for manipulating and using that knowledge. There are several ways to represent knowledge in AI, including:

- Logic-based representation: This involves representing knowledge in the form of logical statements, such as "If A then B". This allows machines to perform logical inference and deduce new information based on existing knowledge.
- Semantic networks: This involves representing knowledge in the form of nodes and edges, where nodes represent concepts or objects and edges represent relationships between them. This allows machines to reason about relationships between objects and infer new knowledge.
- Frames: This involves representing knowledge in the form of structured objects, called frames, which contain attributes and relationships between objects. This allows machines to reason about complex objects and their relationships.
- Rule-based systems: This involves representing knowledge in the form of rules that specify how to reason about certain situations. This allows machines to make decisions based on a set of predefined rules.

In addition to these methods, there are also hybrid approaches that combine multiple methods to represent knowledge.

7. Explain Planning, Learning, Perception, Motion and manipulation in AI.

Planning, Learning, Perception, Motion, and Manipulation are all important areas of AI that enable machines to perform complex tasks.

- Planning: Planning involves developing algorithms and techniques to enable machines to make decisions and take actions based on a set of goals or objectives. This involves modeling the environment, predicting the consequences of actions, and selecting the best course of action to achieve a desired outcome.
- Learning: Learning involves developing algorithms and techniques that enable machines to learn from experience and improve their performance over time. This can be done through supervised learning, unsupervised learning, or reinforcement learning, where the machine is given feedback in the form of rewards or punishments.
- Perception: Perception involves developing algorithms and techniques to enable machines to interpret sensory input, such as images or sound. This can involve tasks such as object recognition, speech recognition, or natural language processing.

- Motion: Motion involves developing algorithms and techniques to enable machines to move in a controlled and coordinated way. This can involve tasks such as pathfinding, obstacle avoidance, and motion planning.
- Manipulation: Manipulation involves developing algorithms and techniques to enable machines to manipulate objects in their environment. This can involve tasks such as grasping, lifting, and moving objects.

8. Explain "Cybernetics and brain simulation" approach of AI.

The Cybernetics and Brain Simulation approach to AI involves studying the principles of cybernetics and attempting to simulate the workings of the human brain in order to create intelligent machines. This approach draws heavily from the fields of neuroscience and cognitive psychology to understand how the brain processes information and makes decisions.

- The basic premise of cybernetics is the idea that complex systems can be studied and controlled by using feedback mechanisms. In AI, this involves developing algorithms and techniques that allow machines to receive feedback from their environment and adjust their behavior accordingly. For example, a machine learning algorithm may receive feedback in the form of rewards or punishments and adjust its behavior to maximize its rewards.
- The brain simulation approach to AI takes this one step further by attempting to simulate the workings of the human brain. This involves modeling the neurons, synapses, and other structures in the brain and using this model to create intelligent machines. This approach has led to the development of neural networks, which are a type of machine learning algorithm inspired by the structure of the brain.
- The goal of the Cybernetics and Brain Simulation approach to AI is to create machines that are not only intelligent, but also have the ability to learn and adapt to new situations. By simulating the workings of the human brain, researchers hope to create machines that can reason, make decisions, and learn in the same way that humans do.
- Development of neural networks, which are a type of machine learning algorithm that is inspired by the structure of the brain. Neural networks are made up of layers of artificial neurons connected to each other & trained to recognize patterns and make decisions.

9. Explain "Symbolic" approach of AI.

Symbolic AI (rule-based AI) involves the use of logic & symbols to represent and reason about knowledge. It is based on the idea that intelligence can be simulated by representing knowledge using symbols and rules, and manipulating those symbols to draw conclusions and solve problems.

- In Symbolic AI, knowledge is represented using logical expressions or symbols, such as predicates, propositions, and rules. These symbols can be combined and manipulated using logical operations, such as deduction, induction, and abduction, to derive new knowledge and solve problems.
- One of the key advantages of Symbolic AI is that it is transparent and explainable. Since knowledge is represented using symbols and rules, it is possible to understand how the system arrived at a particular conclusion or decision. This makes Symbolic AI useful in applications where transparency and interpretability are important, such as in legal or financial decision making.
- However, Symbolic AI has limitations in dealing with uncertainty and handling large amounts of data. It is not well-suited for applications where knowledge is uncertain or incomplete, such as in natural language processing or image recognition. This has led to the development of other subfields of AI, such as Machine Learning, which are better suited for these types of applications.

Here's an example of Symbolic AI from mechanical domain:

Suppose you want to build an expert system that can diagnose car engine problems. The expert system would take in symptoms of a car engine malfunction and output a diagnosis and recommended solution.

To do this, you could represent knowledge using symbols and rules. For instance, you might represent the symptom "engine won't start" using the symbol "engine_wont_start". You might also represent possible causes of this symptom using rules, such as:

- If the battery is dead, then the engine won't start
- If the fuel pump is not working, then the engine won't start
- If the spark plugs are faulty, then the engine won't start

These rules can be combined using logical operations such as deduction, induction, and abduction to derive new knowledge and solve problems.

For example, suppose the expert system receives the symptom "engine_wont_start". It can use the rules above to deduce that the problem might be a dead battery, faulty fuel pump, or faulty spark plugs. The expert system can then ask additional questions or run tests to further narrow down the diagnosis and recommend a solution.

10. Explain "Sub-Symbolic" approach of AI.

Subsymbolic AI, also known as connectionist AI or neural network AI, is a subfield of artificial intelligence that focuses on creating intelligent systems that can learn from data through a process called training. It is based on the idea that intelligence can be simulated by modeling the way neurons in the brain process information.

In subsymbolic AI, knowledge is represented using interconnected nodes or neurons, which are organized into layers. Each neuron receives input from other neurons, processes that input using an activation function, and outputs a result to other neurons. By adjusting the strength of the connections between neurons, subsymbolic AI systems can learn to recognize patterns, make predictions, and classify data.

One of the key advantages of subsymbolic AI is its ability to learn from data without being explicitly programmed. This makes it well-suited for applications where the rules or logic that govern the problem domain are complex or difficult to specify, such as in natural language processing, image recognition, and speech recognition.

However, subsymbolic AI is often criticized for being a black box, meaning that it is difficult to understand how the system arrived at a particular conclusion or decision. This lack of transparency and interpretability can make it challenging to apply subsymbolic AI in certain contexts, such as in legal or medical decision making.

Here's an example of Sub-Symbolic AI from mechanical domain:

- Subsymbolic AI can also be used to develop an expert system for diagnosing car engine problems. Here's an example of how this might work:
- First, a large dataset of car engine symptoms, causes, and solutions would be collected. Each symptom and cause would be represented as an input vector, and each solution would be represented as an output vector.
- A neural network would then be trained on this dataset using backpropagation, a subsymbolic learning algorithm. The neural network would have several layers of interconnected nodes, or neurons, that learn to recognize patterns in the data.
- When a user inputs a set of symptoms into the system, the neural network would process the input and produce a set of possible causes and solutions. The neural network would adjust its weights and connections based on feedback from users and real-world data, continually improving its accuracy over time.
- As the system is trained on more data, it would become increasingly accurate at diagnosing engine problems and recommending solutions. Additionally, the system could also be combined with a rule-based system, such as Symbolic AI, to provide a more complete diagnosis.

11. Compare Symbolic and Sub-Symbolic AI w.r.t. one practical example.

Both symbolic and subsymbolic AI approaches can be used for diagnosing car engine problems.

- Symbolic AI, which uses a rule-based approach, involves encoding expert knowledge and rules into the system in the form of if-then statements. For example, if the engine is making a knocking sound, then it could be a sign of a bad bearing or worn-out piston rings.

- Subsymbolic AI, which uses a neural network approach, involves training the system on a large dataset of car engine symptoms, causes, and solutions. For example, the system could be trained on data from thousands of car engines with known problems, and it would learn to recognize patterns in the data to predict what's causing the problem.

In the context of diagnosing car engine problems, both symbolic and subsymbolic AI approaches could be used together to provide a more complete diagnosis. Symbolic AI could be used to encode expert knowledge and rules into the system, while subsymbolic AI could be used to train the system on a large dataset of engine symptoms and solutions.

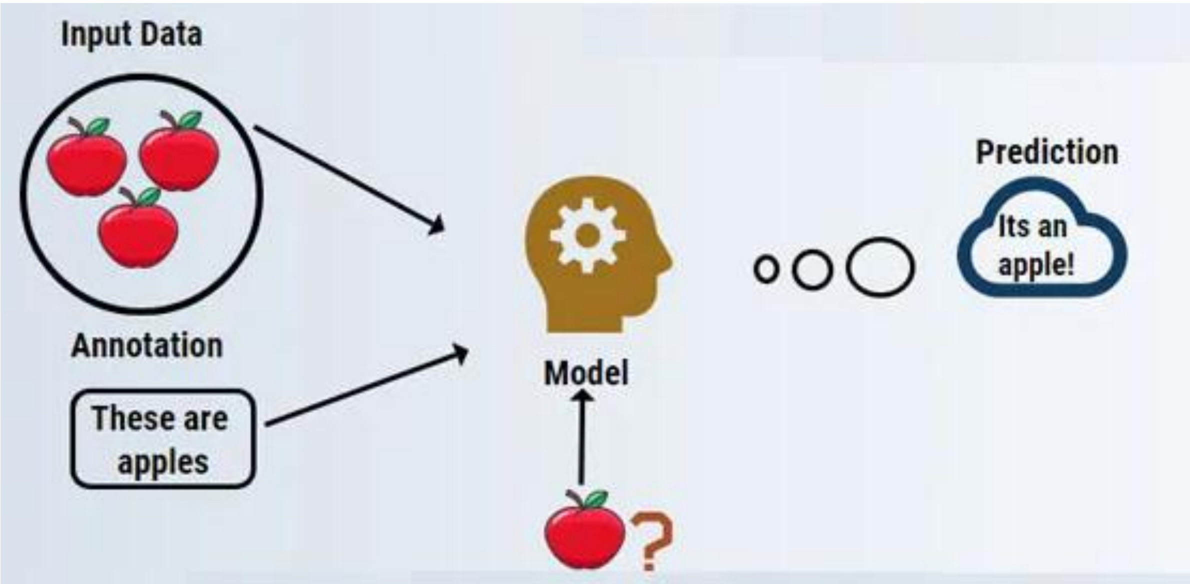
12. Explain supervised learning w.r.t. one practical example.

Supervised learning is a type of machine learning algorithm that involves training a model to make predictions based on labeled examples.

- In supervised learning, the algorithm is provided with a dataset that includes input data, or features, and corresponding output data, or labels.
- The goal of the algorithm is to learn the mapping function between the input data and the output data, so that it can make accurate predictions on new, unseen data.

Let's understand supervised machine learning with the help of an example.

- Let's say we have a fruit basket that is filled up with different species of fruits.
- Our job is to categorize fruits based on their category. In our case, we have considered four types of fruits: Apple, Banana, Grapes, and Oranges.



Now we will try to mention some of the unique characteristics of these fruits which make them unique.

Sr. No.	Size	Color	Shape	First Name
1	Small	Green	Round to oval, Bunch shape cylindrical	Grape
2	Big	Red	Rounded shape with a depression at the top	Apple
3	Big	Yellow	Long curving cylinder	Banana
4	Big	Orange	Rounded shape	Orange

Now let us say that you have picked up a fruit from the fruit basket, you looked at its features, e.g., its shape, size, and color, for instance, and then you deduce that the color of this fruit is red, the size if big, the shape is rounded shape with a depression at the top; hence it is an apple.

- Likewise, you do the same for all other remaining fruits as well.
- The rightmost column ("Fruit Name") is known as the response variable.
- This is how we formulate a supervised learning model; now, it will be quite easy for anybody new (Let's say a robot or an alien) with given properties to easily group the same type of fruits together.

13. Explain unsupervised learning w.r.t. one practical example.

Contrary to Supervised learning, Unsupervised Learning involves presenting the model with unlabelled data. This means that the data does not have any labels, or categories and there is no training involved. This type of learning can be considered as learning without any guidance. The model is left open to learn on its own by detecting the co-relations between the features, without any expected output.

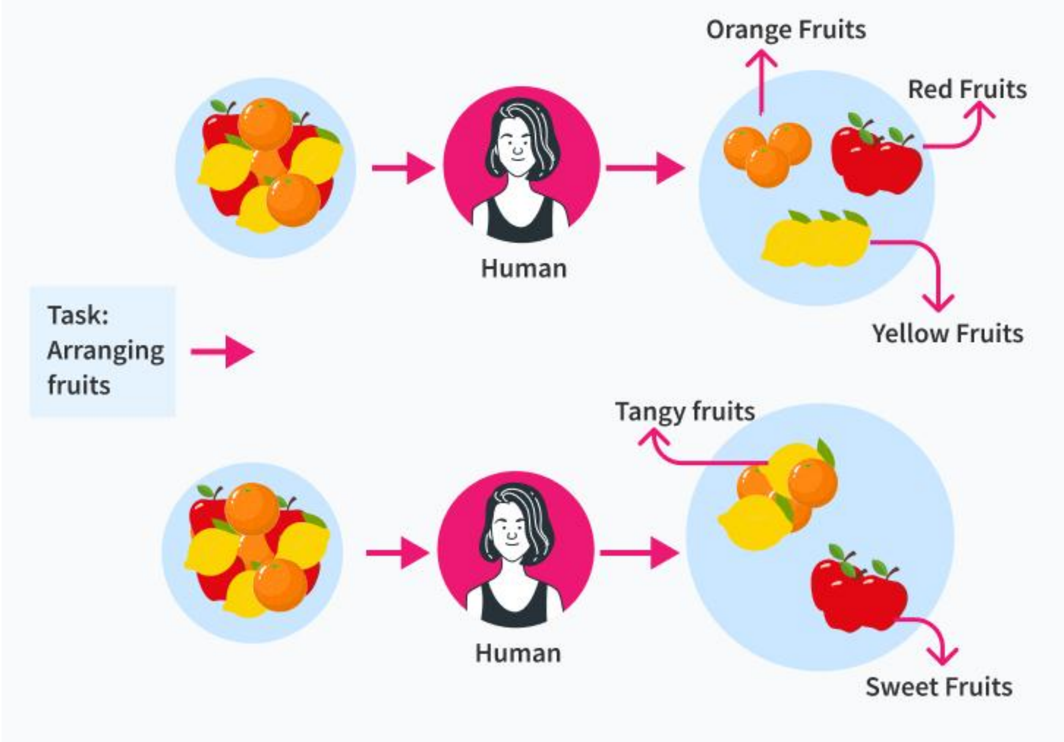
The basic principle of unsupervised learning is to learn in the absence of any ground truth to compare our model with. The idea is to use the underlying patterns in the data to generate a reconstruction of the input data, in a useful format. By 'underlying patterns in the data' we mean that the data is then explained on the basis of similarities, hidden patterns, etc, all without any human intervention.

Let us understand the working of unsupervised Machine Learning with the help of an example:

Suppose we give our model unlabeled images of red colored fruits, such as pomegranate, apples and plums. Our model hasn't seen or known any kind of fruits before and will now try to categorize the images on the basis of similarity and differences in the structure and appearance only. We will let the model to discover the hidden patterns in the data itself.

Combine these two according to the first picture with fruits example.

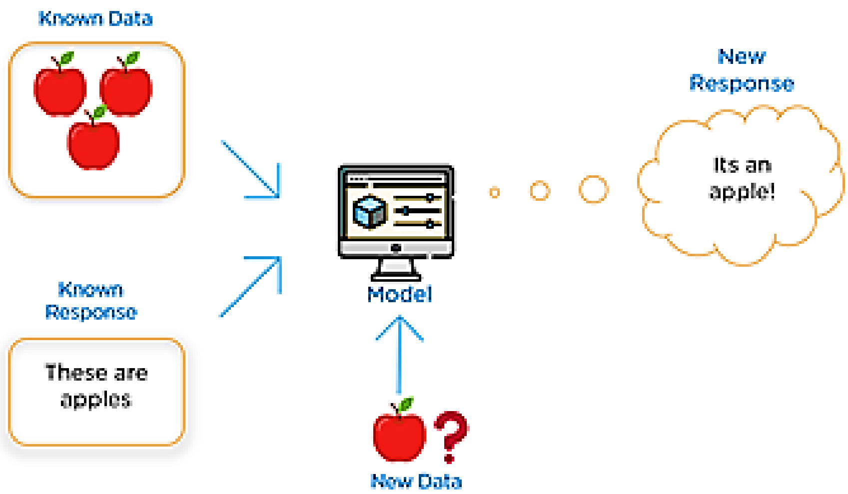
Same way, in recommendation systems, unsupervised learning algorithms help cluster commodities that are frequently bought together. This further helps the sellers to provide recommendations to the buyers, many of which we have seen quite a lot of times on online selling platforms such as "Frequently bought together" and "customers who bought this, also bought this".



14. *Compare supervised & unsupervised learning w.r.t. one practical example.*

Supervised Learning - Remember the time when you used to go to school? The time when you first learnt what an apple looked like? The teacher probably showed a picture of an apple and told you what it was, right? And you could identify the particular fruit ever since then. That's exactly how supervised learning works.

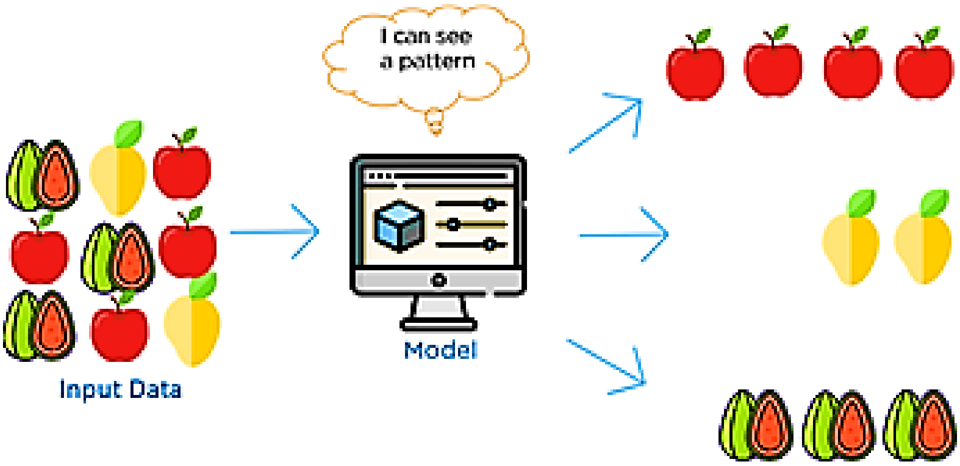
As you can see in the image below



- Step1 -You provide the system with data that contains photos of apples and let it know that these are apples. This is called labeled data.

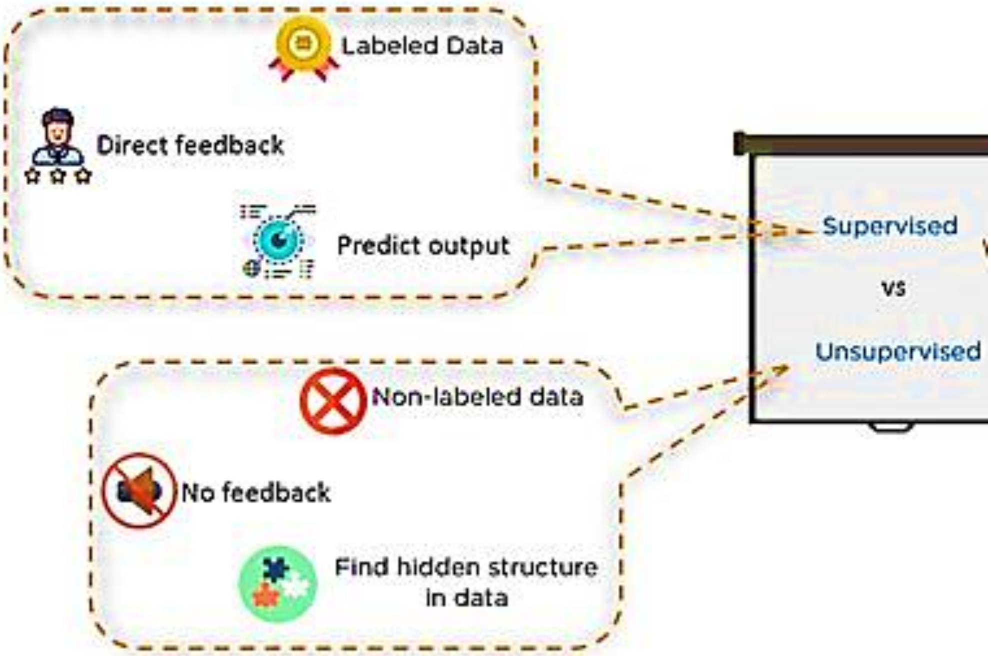
- Step2 -The model learns from the labeled data and the next time you ask it to identify an apple, it can do it easily.

Unsupervised Learning – If somebody gives you a basket full of different fruits and asks you to separate them, you will probably do it based on their colors, shape and size, right? Unsupervised learning works in the same way. As you can see in the image



- Step1-You provide the system with a data that contains photos of different kinds of fruits and ask it to segregate it. Remember, in case of unsupervised learning you don't need to provide labeled data.
- Step 2-The system will look for patterns in the data. Patterns like shape, color and size and group the fruits based on those attributes.

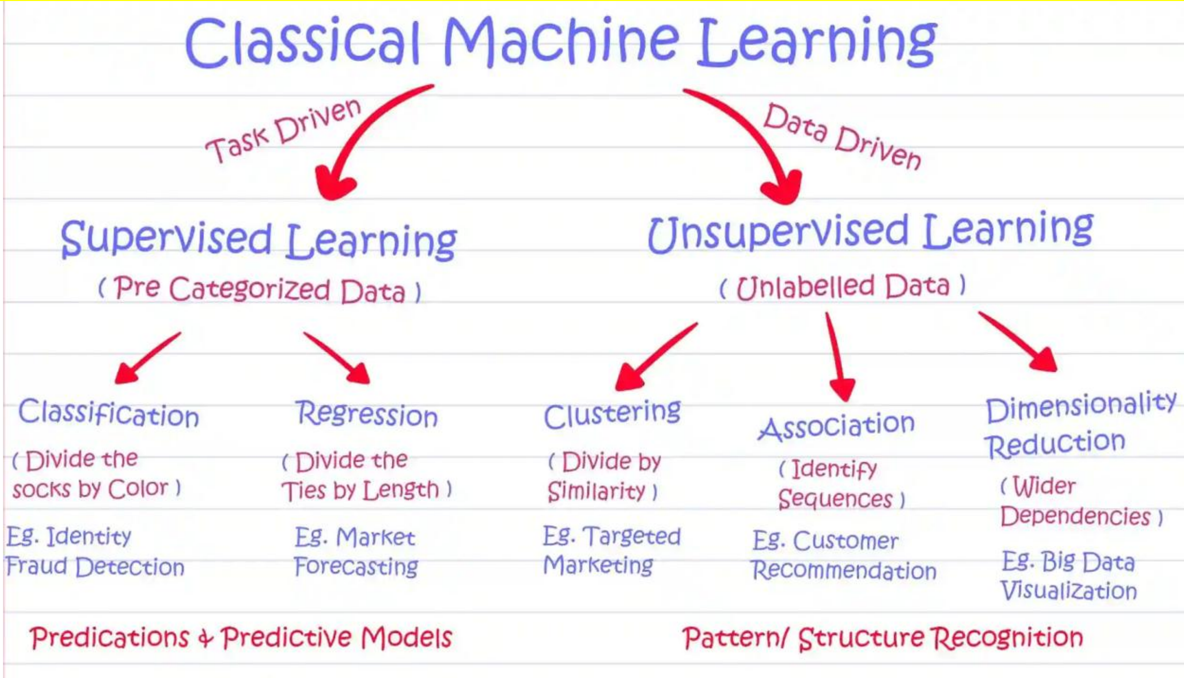
So let's sum up the differences between supervised and unsupervised learning-

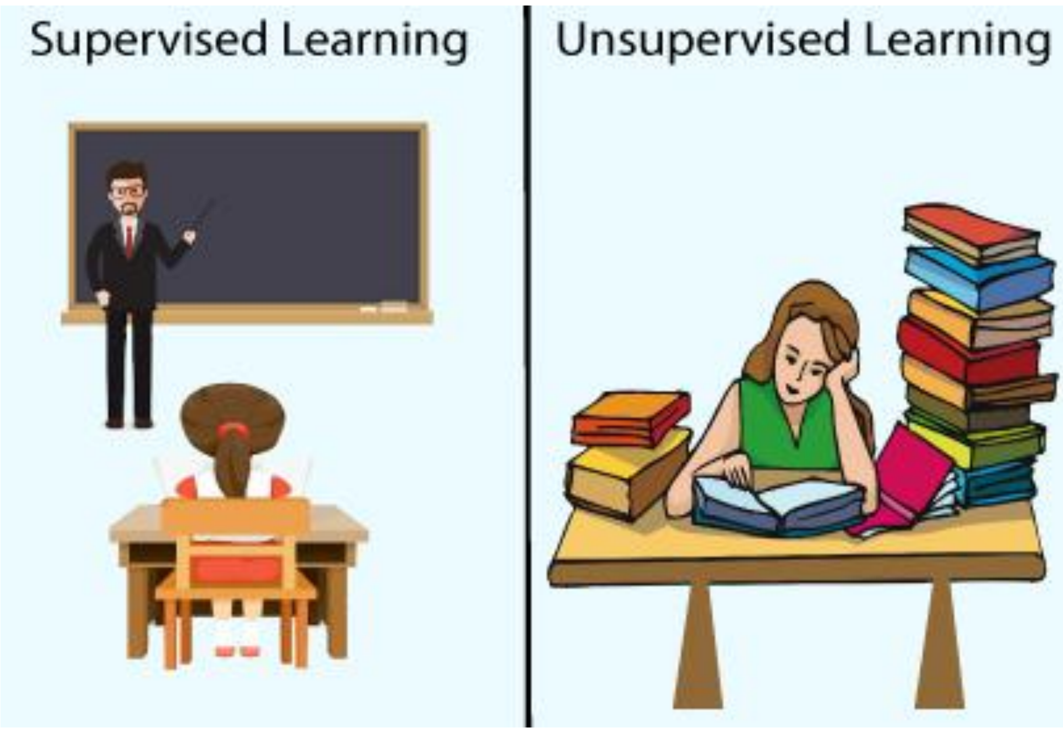


- **Type of input data –** In case of Supervised Learning, the input data is labeled and in case of Unsupervised Learning, the input data is not labeled.

- **Feedback –** In case of Supervised Learning, the system learns from the output and keeps it in mind while in case of unsupervised learning, there is no feedback involved.
- **Function –** Supervised Learning is generally used to predict data whereas, Unsupervised Learning is used to find hidden structure in the data.

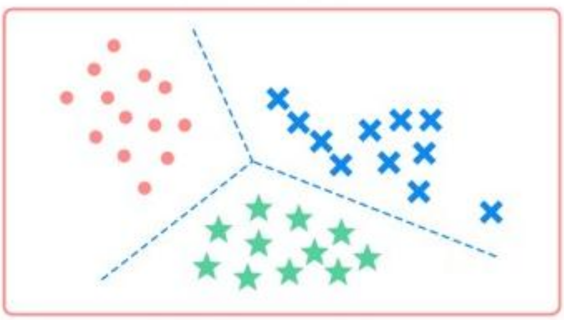
15. Compare supervised & unsupervised learning w.r.t. one practical example.





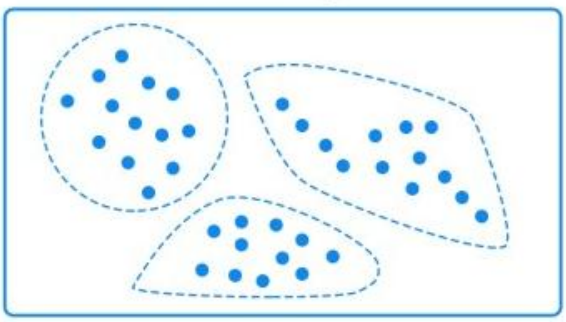
Supervised learning	Unsupervised learning
Input data is labeled	Input data is unlabeled
Has a feedback mechanism	Has no feedback mechanism
Data is classified based on the training dataset	Assigns properties of given data to classify it
Divided into Regression & Classification	Divided into Clustering & Association
Used for prediction	Used for analysis
Algorithms include: decision trees, logistic regressions, support vector machine	Algorithms include: k-means clustering, hierarchical clustering, apriori algorithm
A known number of classes	A unknown number of classes

Classification



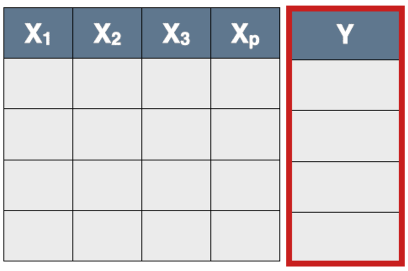
Supervised learning

Clustering



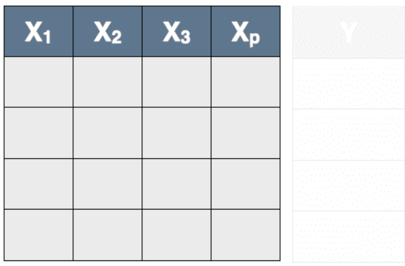
Unsupervised learning

Supervised Learning

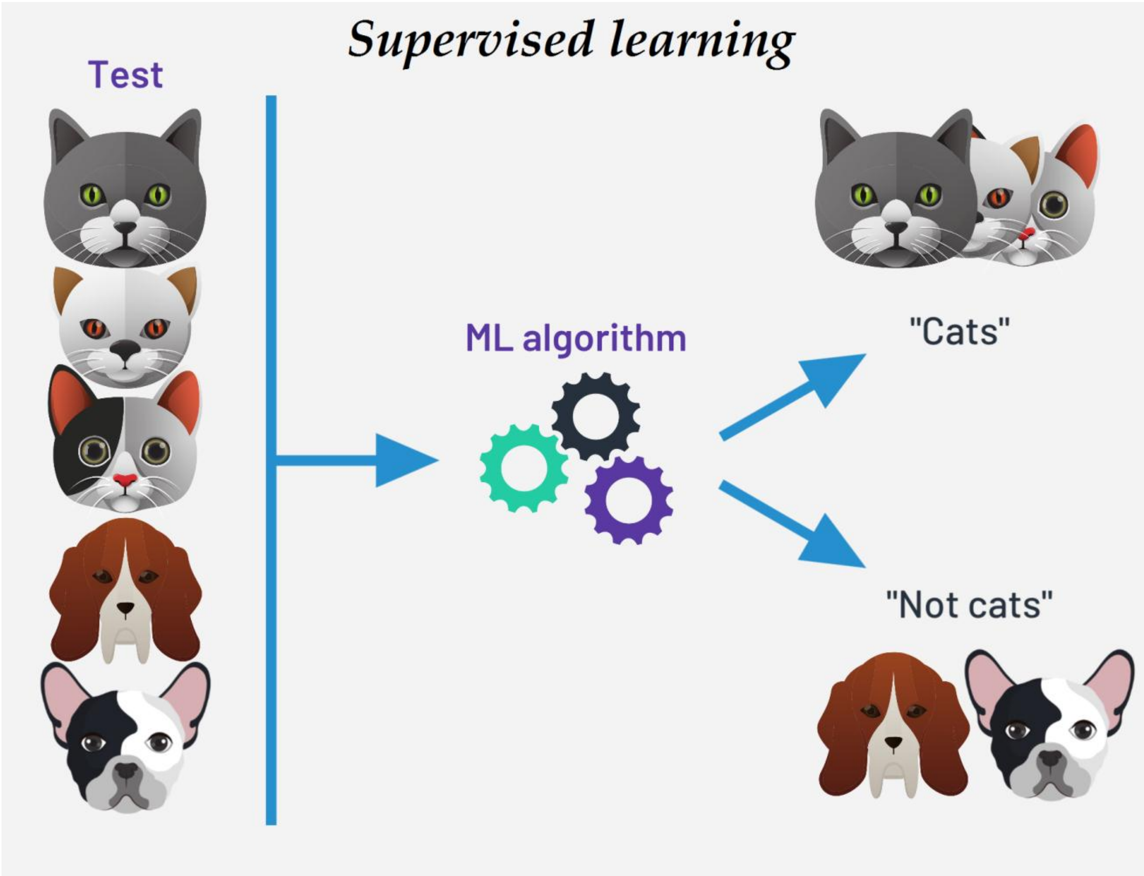


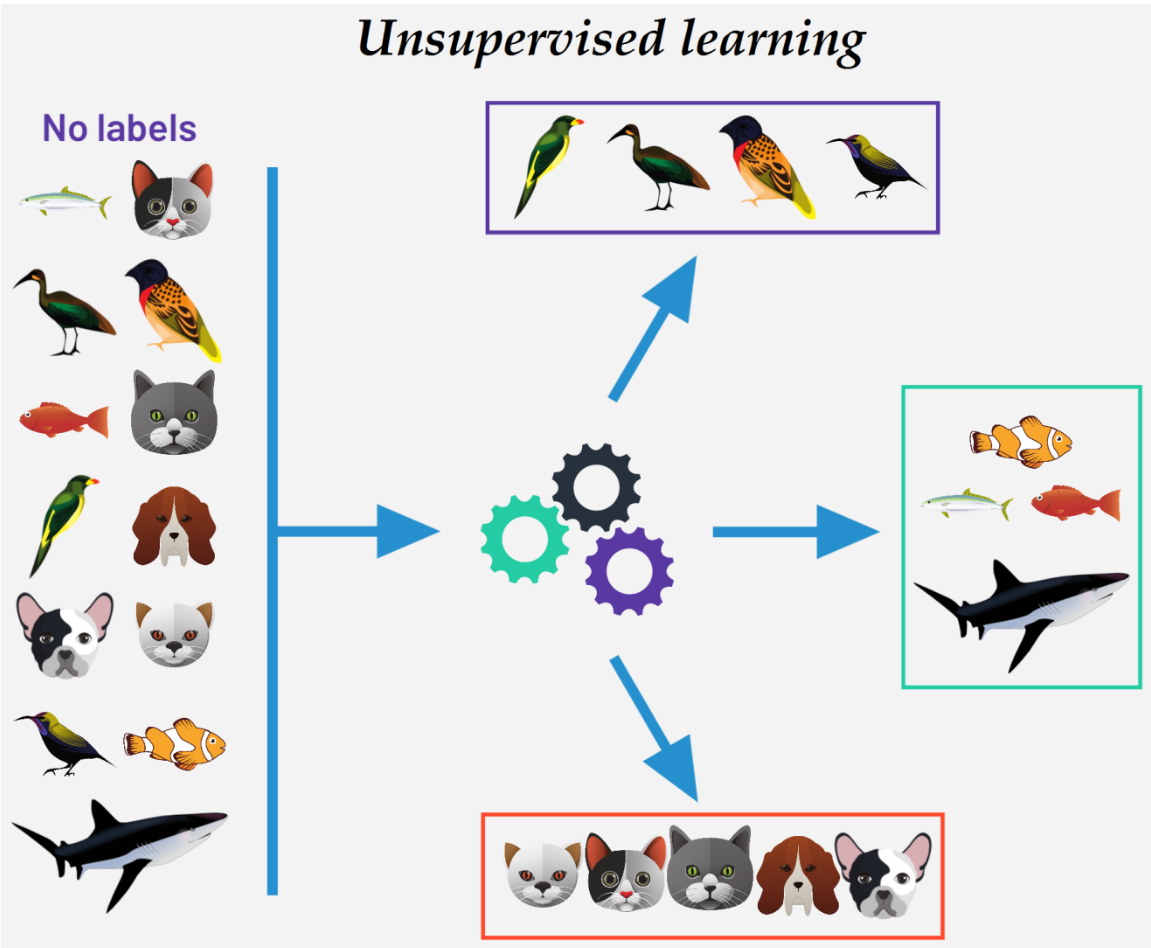
Target

Un-Supervised Learning



No Target


Supervised learning
Test
ML algorithm
"Cats"
"Not cats"


Unsupervised learning
No labels

16. Explain reinforcement learning w.r.t. one practical example.

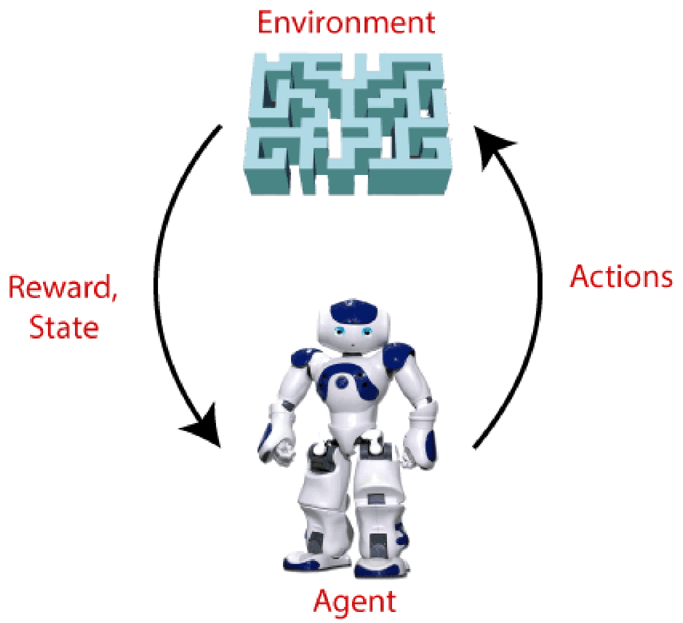
Reinforcement Learning is a feedback-based Machine learning technique in which an agent learns to behave in an environment by performing the actions and seeing the results of actions. For each good action, the agent gets positive feedback, and for each bad action, the agent gets negative feedback or penalty.

- In Reinforcement Learning, the agent learns automatically using feedbacks without any labeled data, unlike supervised learning.
- Since there is no labeled data, so the agent is bound to learn by its experience only.
- RL solves a specific type of problem where decision making is sequential, and the goal is long-term, such as **game-playing, robotics**, etc.
- The agent interacts with the environment and explores it by itself. The primary goal of an agent in reinforcement learning is to improve the performance by getting the maximum positive rewards.
- The agent learns with the process of hit and trial, and based on the experience, it learns to perform the task in a better way. Hence, we can say that ***"Reinforcement learning is a type of machine learning method where an intelligent agent (computer program) interacts with the environment and learns to act within that."*** How a Robotic dog learns the movement of his arms is an example of Reinforcement learning.
- It is a core part of Artificial intelligence, and all AI agent works on the concept of reinforcement learning. Here we do not need to pre-program the agent, as it learns from its own experience without any human intervention.
- **Example:** Suppose there is an AI agent present within a maze environment, and his goal is to find the diamond. The agent interacts with the environment by performing some actions, and based on those actions, the state of the agent gets changed, and it also receives a reward or penalty as feedback.
- The agent continues doing these three things (**take action, change state/remain in the same state, and get feedback**), and by doing these actions, he learns and explores the environment.
- The agent learns that what actions lead to positive feedback or rewards and what actions lead to negative feedback penalty. As a positive reward, the agent gets a positive point, and as a penalty, it gets a negative point.

Terms used in Reinforcement Learning

- **Agent():** An entity that can perceive/explore the environment and act upon it.
- **Environment():** A situation in which an agent is present or surrounded by. In RL, we assume the stochastic environment, which means it is random in nature.

- **Action():** Actions are the moves taken by an agent within the environment.
- **State():** State is a situation returned by the environment after each action taken by the agent.
- **Reward():** A feedback returned to the agent from the environment to evaluate the action of the agent.
- **Policy():** Policy is a strategy applied by the agent for the next action based on the current state.
- **Value():** It is expected long-term retuned with the discount factor and opposite to the short-term reward.
- **Q-value():** It is mostly similar to the value, but it takes one additional parameter as a current action (a).



Approaches to implement Reinforcement Learning

There are mainly three ways to implement reinforcement-learning in ML, which are:

1. **Value-based:**

   The value-based approach is about to find the optimal value function, which is the maximum value at a state under any policy. Therefore, the agent expects the long-term return at any state(s) under policy π.

2. **Policy-based:**

   Policy-based approach is to find the optimal policy for the maximum future rewards without using the value function. In this approach, the agent tries to apply such a policy that the action performed in each step helps to maximize the future reward. The policy-based approach has mainly two types of policy:

   - **Deterministic:** The same action is produced by the policy (π) at any state.

   - **Stochastic:** In this policy, probability determines the produced action.

3. **Model-based:** In the model-based approach, a virtual model is created for the environment, and the agent explores that environment to learn it. There is no particular solution or algorithm for this approach because the model representation is different for each environment.

Applications:

In mechanical systems, reinforcement learning can be used to optimize control strategies for various tasks such as motion planning, trajectory optimization, and fault detection. For example, RL can be used to train a robotic arm to grasp objects more effectively or to learn how to walk on uneven terrain.

- Training an autonomous vehicle to navigate a road is another example of reinforcement learning. The agent interacts with the environment and receives rewards based on its actions. The goal is to learn a policy that safely and efficiently navigates the vehicle to its destination. In this example, the rewards could be defined based on the distance travelled towards the destination, the speed of the vehicle, and the number of traffic violations or accidents that occur. The agent would use trial and error to learn a policy that maximizes the rewards over time, while also taking into account the safety constraints.
- Other examples of reinforcement learning include training a robot to grasp objects, teaching a virtual assistant to understand natural language commands, and optimizing energy consumption in a smart home. Reinforcement learning can be applied in a wide range of domains where decision-making is required, and where a clear objective can be defined.

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