Module 2 Types of Automation and Robotics in Industries

Content

Module overview (140 min)

- Boston Dynamics
- Industrial Robots
- Collaborative Robots (Cobots)
- Autonomous Guided Vehicles (AGVs)
- Autonomous Mobile Robots (AMRs)
- Mobile Manipulator
- AS/RS (Automated Storage and Retrieval Systems)
- Artificial Intelligence (AI) and Machine Learning (ML)
- Augmented Reality (AR)/ Virtual Reality (VR)

Group Discussion (15min)

- Any experience with Robots

Kahoot Quiz (15min)

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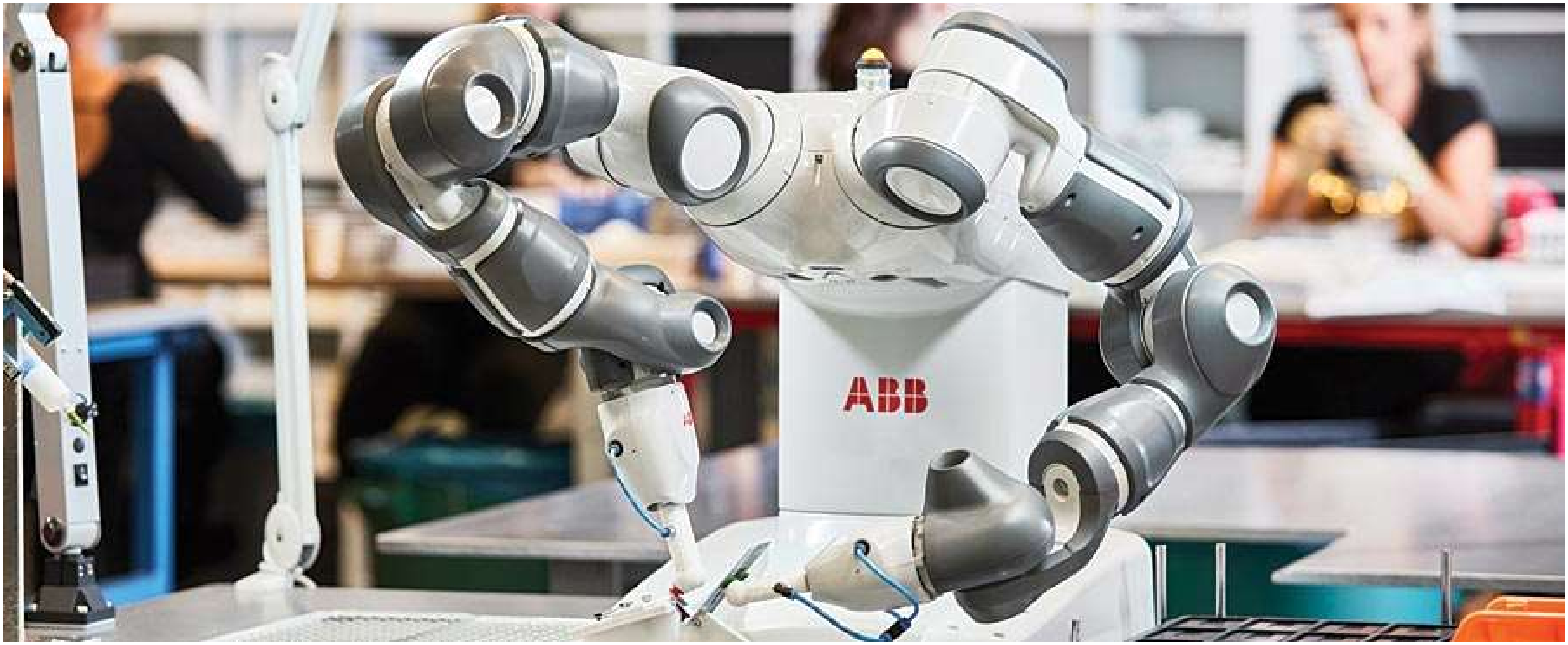
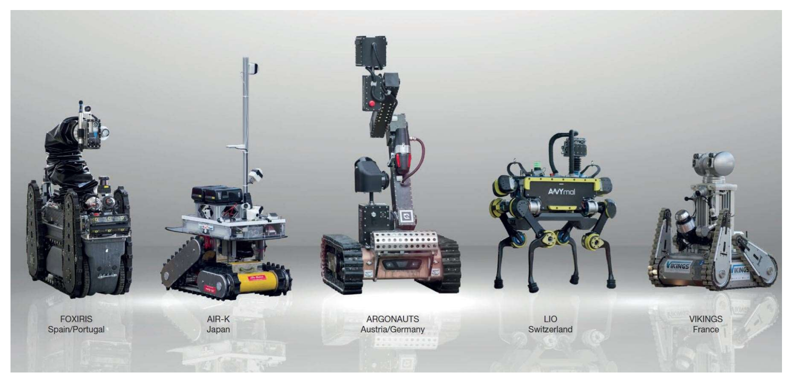
Part 1: Industrial Robots and Collaborative Robots (Cobots)



What is a Robot?

- A robot is a machine in a form of mechanically constructed system.
- Programmable by a computer to carry out complex series of actions automatically.
- Robots can be articulated, autonomous or semi-autonomous depending on the required applications.

Articulated Robots



Autonomous Robots

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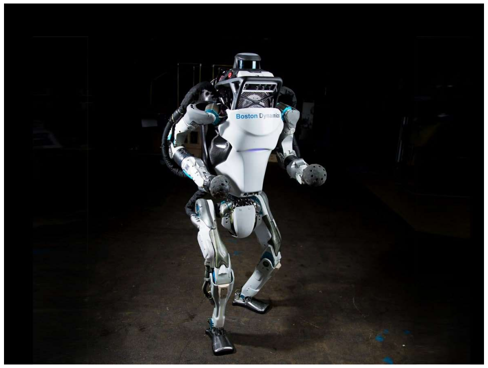
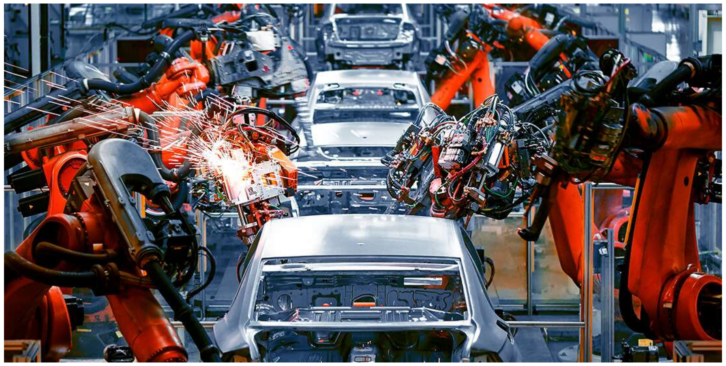
Why do we need robots?

- Robots were originally designed to automate monotonous tasks previously executed by human operators.
- Today, robots have evolved to expand their uses cases in many industries worldwide. (eg Healthcare, Military, Education, Space etc.)
- More processes can be automated using robots in order to increase productivity, efficiency and safety in complex environments today.





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Boston Dynamics

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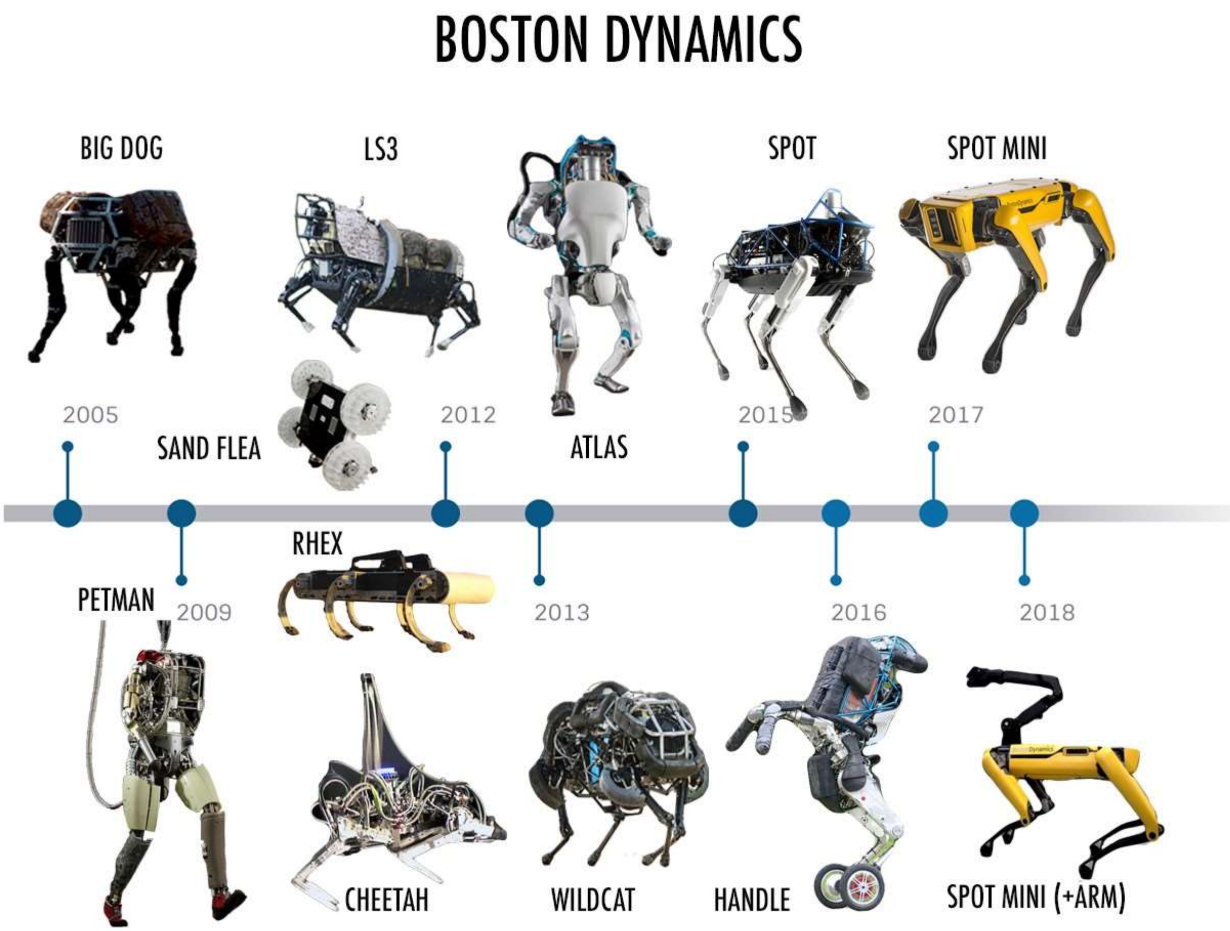
Boston Dynamics

In June 21, 2021, Hyundai Motor Group (the Group), Boston Dynamics, Inc. and SoftBank Group Corp. (SoftBank), today announced the completion of the Group's acquisition of a controlling interest in Boston Dynamics from SoftBank, The deal valued the mobile robot firm at US$1.1 billion. Now Hyundai owns 80%, the majority interest of Boston Dynamics.

HYUNDAI
MOTOR GROUP

Boston Dynamics



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State of The Art Robot - ATLAS

State of The Art Robot - ATLAS

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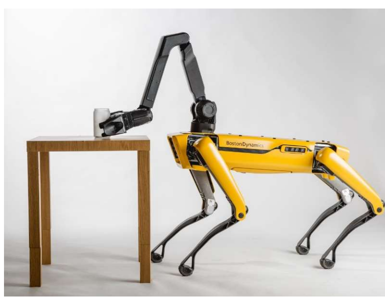
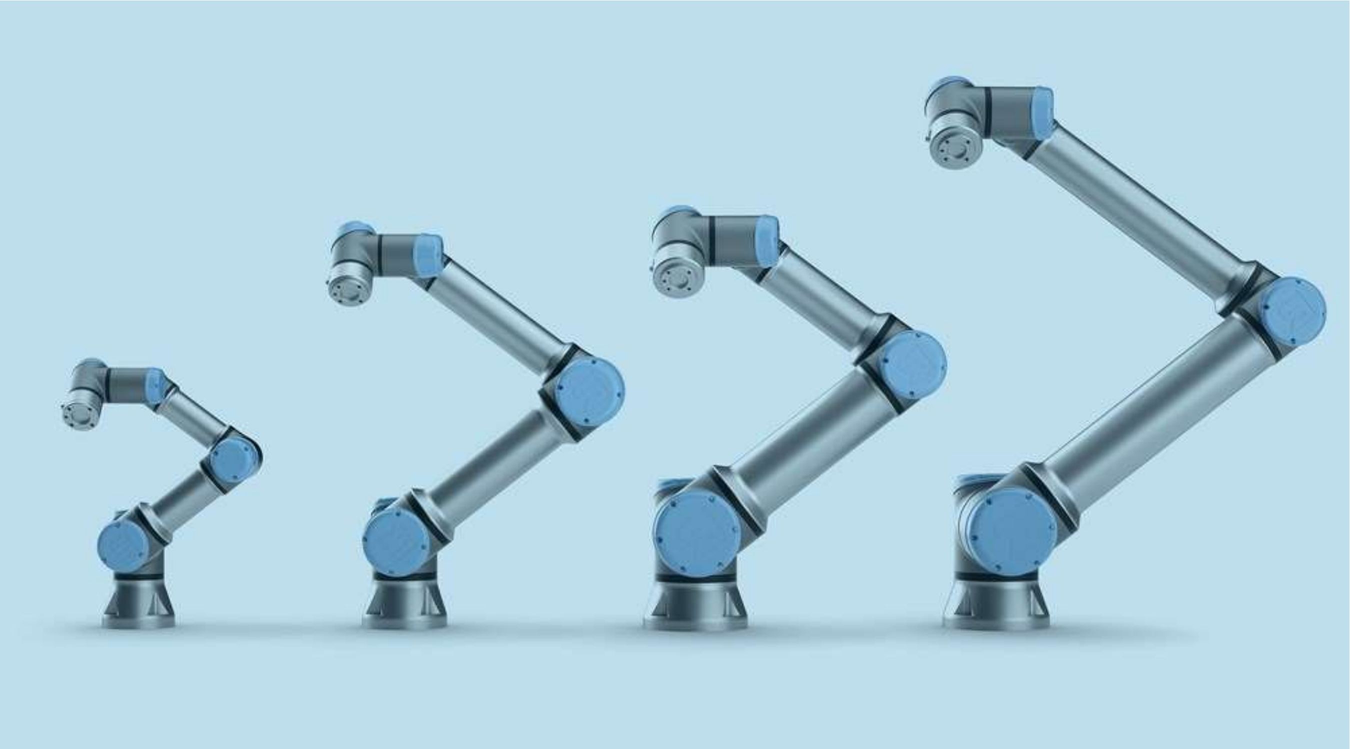
Characteristics of a Robot

- Even though there are so many different types of robots in the robotics field today, a robot will always have a few consistent characteristics:
  1. All robots are made up of a certain type of mechanical construction.
  2. Robots need electrical components to control and power itself.
  3. Robots require some level of computer programming in order know when and how to carry out a task.




Robotic Arm



Robotic Arms System and Definitions

Types of Robot Arm

- **What is a robot arm?**

Festo Cartesian Robot
- 3 degree of freedom
- Linear motion along axis

Cartesian

Hudson SciClops
- 1 rotary joint and 1-2 linear joint
- Cylindrical shape work envelope

Cylindrical

Polar

Kawasaki Unimate
- 2 rotary joints and 1 linear joint
- Spherical shape work envelop (AKA spherical robot)

ABB IRB 4400
- Mimics human arm
- 2-10 Rotary Joints (Axis)

Articulated Robot Arm

Scara

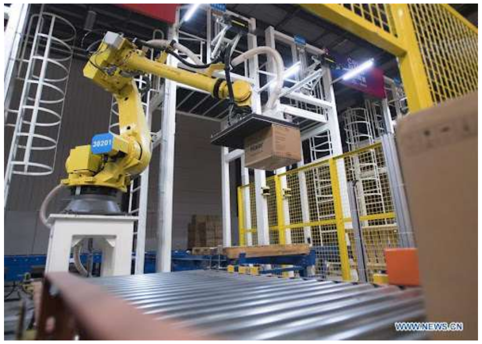
FANUC SCARA SR-6iA
- 2 parallel joints in 1 selected plane

Robot Arms System and Definitions
Use cases

- **Common use cases for Articulated Robot Arms**

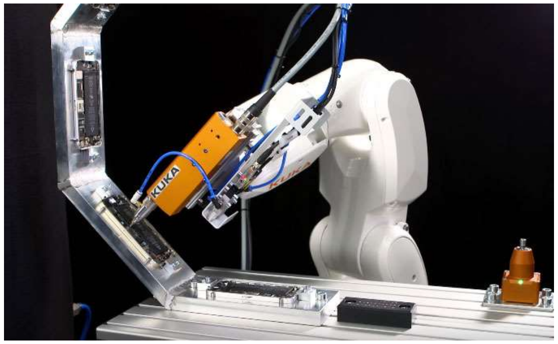

Welding


Automotive


Pick and Place, Warehouse Logistics

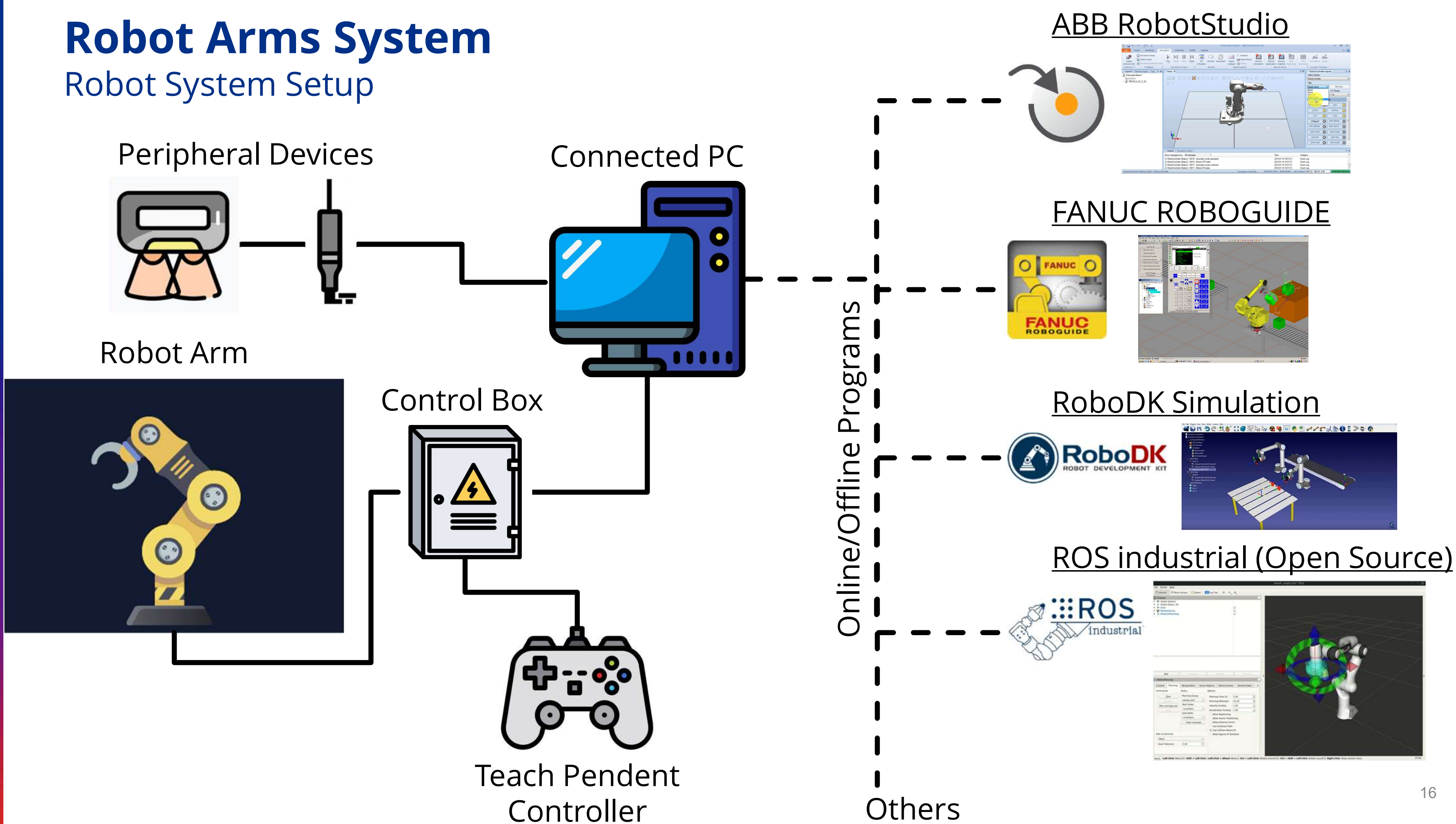

Spray Painting


Machine Tending, Injection Molding


Assembly, Screw Fastening

Robot Arms System

Robot System Setup



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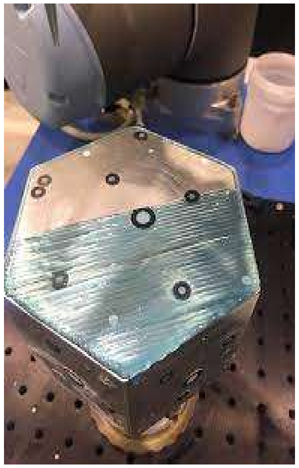
Robot Arms System

Robot Selection

- Application Specifics


  - No. of degree of freedom(DoF) required
  - Payload
  - Robot Reachability
  - Robot Functionality
  - Peripheral Devices
  - Footprint
  - Mounting

Features and benefits

- 15% smaller cells that have 10% shorter cycle times
- IP 40 protection as standard; IP 67 protection is also available as an option
- 4 air ducts, 10 customer signals and Ethernet routed internally from wrist flange to foot
- Two variants with 700 mm reach/7 kg payload and 900 mm reach/5 kg payload
- Mountable at any angle
- Large useable working area in a compact footprint

Specification

Robot Version	reach	payload	armload
IRB 1200-7/0.7	703mm	7kg	0.3kg
IRB 1200-5/0.9	901mm	5kg	0.3kg

Features

Integrated signal supply	10 signals on wrist
Integrated air supply	4 air on wrist(5 bar)
Integrated ethernet	one 100/10 Base-TX ethernet port
Position repeatability IRB 1200-7/0.7	0.02 mm
Position repeatability IRB 1200-5/0.9	0.025 mm
Robot mounting	Any angle
Degree of protection	IP40 / IP67
Controllers	IRC5 compact / IRC5 single cabinet

Movement

	IRB 1200-7/0.7		IRB 1200-5/0.9	
Axis movement	Working range	Maximum speed	Working range	Maximum speed
Axis 1 Rotation	+170° to -170°	288°/s	+170° to -170°	288 °/s
Axis 2 Arm	+135° to -100°	240°/s	+130° to -100°	240 °/s
Axis 3 Arm	+70° to -200°	300°/s	+70° to -200°	300 °/s
Axis 4 wrist	+270° to -270°	400°/s	+270° to -270°	400 °/s
Axis 5 Bend	+130° to -130°	405°/s	+130° to -130°	405 °/s
Axis 6 Turn	+360° to -360°	600°/s	+360° to -360°	600 °/s

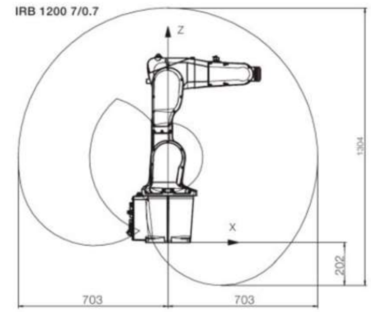
Performance	IRB 1200-7/0.7	IRB 1200-5/0.9
1 kg picking cycle		
25* 300 * 25 mm	0.42s	0.42s
Max TCP Velocity	7.3 m/s	8.9 m/s
Max TCP Acceleration	35 m/s*s	36 m/s*s
Acceleration time 0-1m/s	0.06s	0.06s

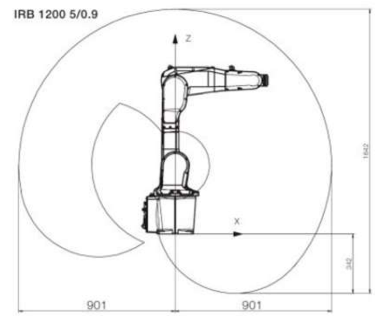
Electrical connections

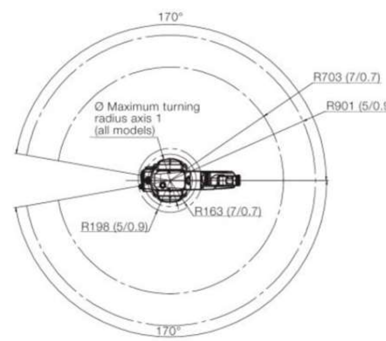
Supply voltage	200-600 V, 50-60 HZ	
Transformer rating	4.5 KVA	4.5 KVA
Power consumption	0.39 KW	0.38 KW

Physical

Dimension base	210mm*210 mm	210mm*210 mm
Weight	52 KG	54 KG







DoFs for robot arm

Definition: **Degree of freedom (DOF)** refers to the number of independent parameters or motions that characterize the configuration of a robot. Each degree of freedom represents a way in which a part of the robot can move. The more degrees of freedom a robot has, the more complex its motions can be. The movement can be such as linear or rotary.

For example, one robot arm might have four joints, where 3 joints allow for rotation. 2 joints allow for linear motion. This robot would be described as having 5 degrees of freedom, corresponding to the three independent joint rotations.

Joint type

Revolute Joint (Rotational): Allows rotation around an axis. Each revolute joint adds one degree of freedom.

Prismatic Joint (Translational): Allows linear motion along a particular axis. Each prismatic joint adds one degree of freedom.

Spherical Joint: Allows rotation around multiple axes simultaneously. Each spherical joint typically contributes three degrees of freedom.

Planar Joint: Constrains motion to a 2D plane. Each planar joint contributes two degrees of freedom.

Cylindrical Joint: Combination of a revolute joint and a prismatic joint. It contributes two degrees of freedom.

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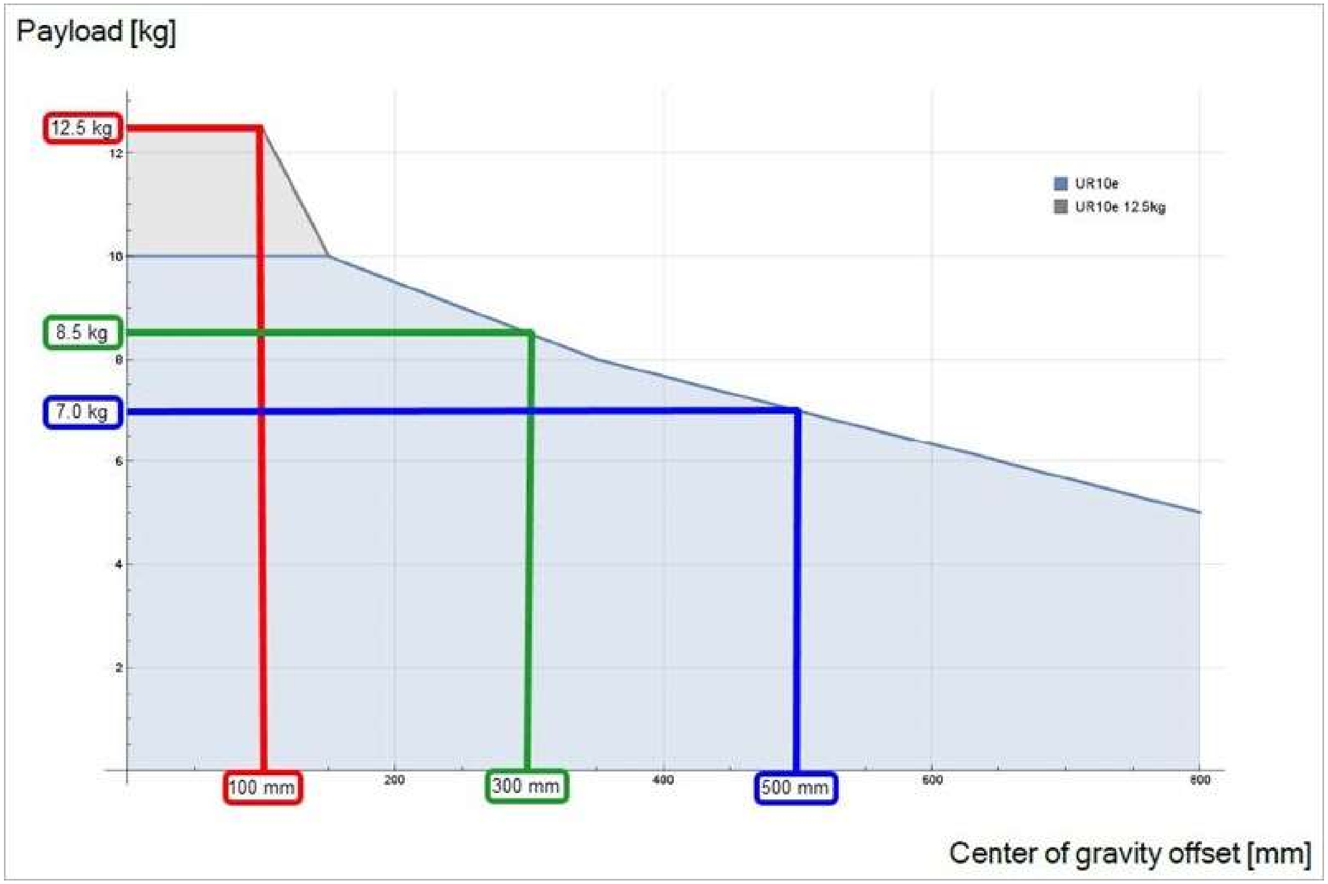
Payload

Definition: The **payload** of a robot refers to the maximum weight or load capacity that the robot can handle while maintaining its functionality and performance. It is a crucial specification in robotics, especially in industrial applications where robots are often used for tasks such as material handling, assembly, or welding.

Exceeding the specified payload capacity can lead to decreased accuracy, slower operation, increased wear and tear on components, and potential damage to the robot.

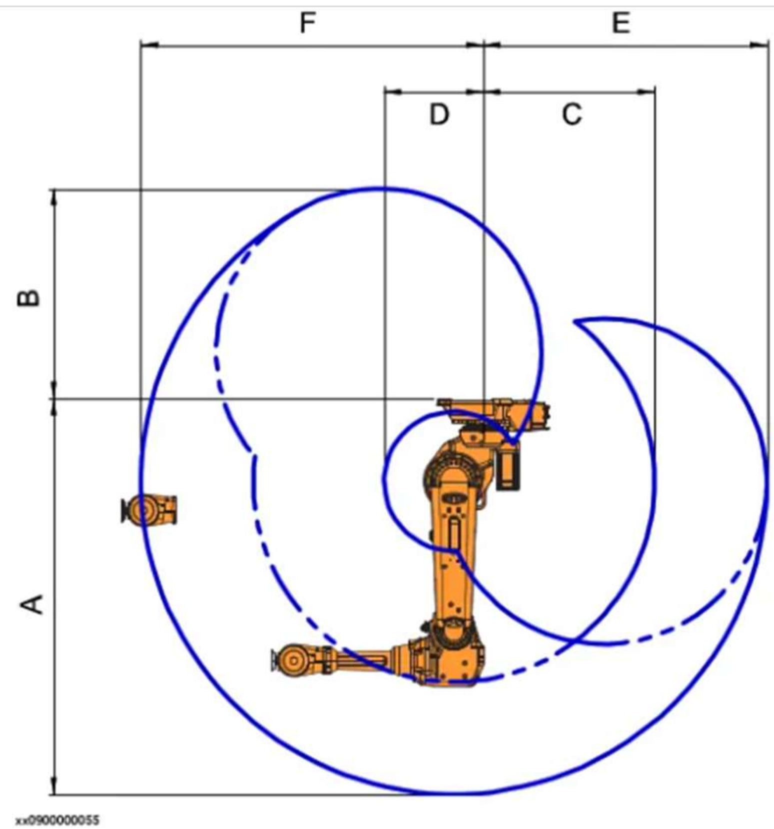
When evaluating the payload capacity of a robot, it's important to consider not only the weight of the object being manipulated but also factors like the reach of the robot (distance from the base to the end-effector), the speed of operation, and the desired precision of movement. Some robots may have a dynamic payload capacity specification.

Payload Profile



Reachability

Definition: The **reachability** of a robot arm refers to the set of positions and orientations in space that the end-effector (the tool or hand) of the robot can attain. It is essentially the workspace that the robot can cover. Reachability is a critical aspect of robot design and operation, as it determines the range of tasks the robot can perform.



Variant	Pos. A	Pos. B	Pos. C	Pos. D	Pos. E	Pos. F
IRB 4600 - 60/2.05	2371 mm	1260 mm	1028 mm	593 mm	1701 mm	2051 mm
IRB 4600 - 45/2.05	2371 mm	1260 mm	1028 mm	593 mm	1701 mm	2051 mm
IRB 4600 - 40/2.55	2872 mm	1735 mm	1393 mm	680 mm	2202 mm	2552 mm
IRB 4600 - 20/2.50	2833 mm	1696 mm	1361 mm	665 mm	2163 mm	2513 mm

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Factors Related to Reachability

1. **Joint Configuration:** The number and types of joints in the robot arm impact its range of motion. Different joint configurations provide different degrees of freedom, affecting the reachable space.

2. **Joint Limits:** Each joint of the robot arm has physical limits on its range of motion. These joint limits constrain the robot's ability to reach certain positions.

3. **Link Lengths:** The lengths of the robot arm's links (segments between joints) also affect reachability. Longer links can allow the robot to reach farther, but they might introduce mechanical challenges.

4. **End-Effector Design:** The design of the tool or end-effector at the end of the robot arm can influence its reachability. Some end-effectors may have specific constraints on their orientation or may limit the robot's ability to access certain positions.

5. **Workspace Analysis:** Engineers often perform a workspace analysis to determine the reachability of a robot. This involves mathematically modeling the robot's kinematics and analyzing the possible positions and orientations it can achieve.

6. **Obstacle Avoidance:** The presence of obstacles in the environment can also affect the robot's reachability. Advanced robotic systems incorporate obstacle avoidance algorithms to plan paths that allow the robot to avoid collisions and still reach its target positions.

7. **Redundancy:** Some robots have redundant degrees of freedom, meaning they have more joints than necessary to perform a specific task. This redundancy can be exploited to optimize reachability and avoid obstacles.

Industrial Robots

Definition

- An industrial robot is a robot system used for manufacturing. Industrial robots are automated, programmable and capable of movement on three or more axes.

- Typical applications of robots include welding, painting, assembly, disassembly, pick and place for printed circuit boards, packaging and labeling, palletizing, product inspection, and testing; all accomplished with high endurance, speed, and precision. They can assist in material handling.

Notable brands

ABB

KUKA

Yaskawa

Fanuc

Kawasaki

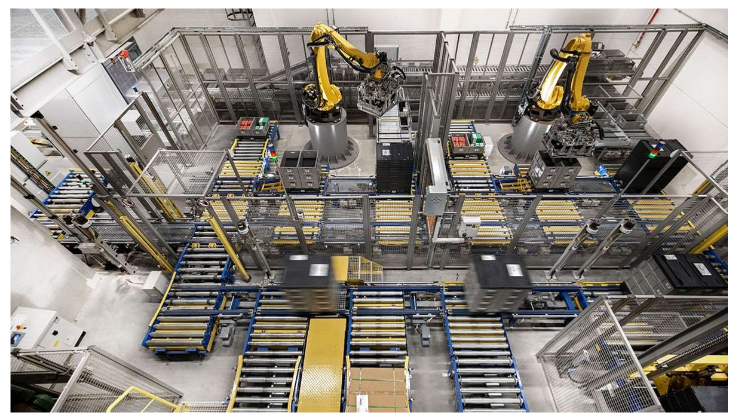
Industrial Robots Pros & Cons

Pros:

- Suitable for heavy, hazardous, monotonous manufacturing processes
- Able to handle large and heavy materials on the shop floor (Up to 2300kg)

Cons:

- Mandatory requirement of safety enclosures to keep humans out of the workspace
- Generally large footprint
- High cost of system (Scales with higher payload)



Industrial Robot

Source:
- https://www.youtube.com/watch?v=Cndodc3X50s

Collaborative Robots

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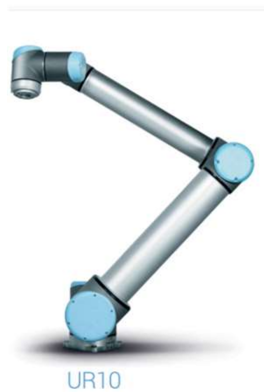
Definition

- Collaborative robots, or “cobots” are robots that are intended to work hand-in-hand with human beings. These machines focus on repetitive tasks, such as inspection and picking, to help workers focus more on tasks that require problem-solving skills.

Notable brands

ABB

KUKA



UR

Techman

Doosan

Fanuc

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Collaborative Robot Pros & Cons

Pros:

- Able to assist operators with work that may be too tedious, strenuous or dangerous for them to accomplish on their own.
- Lower cost to set up compared to industrial robots.
- Suitable for a large variation of processes within the robot's payload.

Cons:

- Not suitable for heavy lifting processes or heavy manufacturing.
- Generally low payload. (Up to 35 kg)

Collaborative Robot

Source:
https://youtu.be/pIcxOGo7ieU

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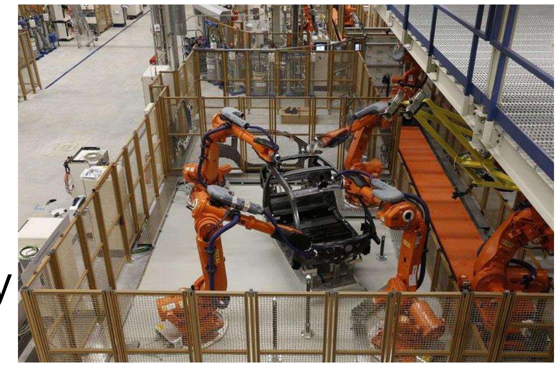
Key Differences Between Industrial Robots & Collaborative Robots

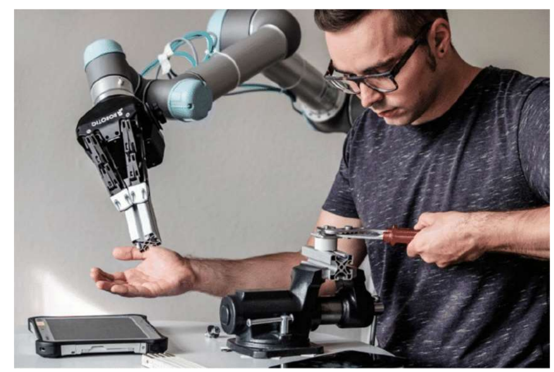
Industrial Robots:

- Industrial robots are designed to replace human when performing a job.
- Usually used to automate processes in heavy manufacturing environments.
- Requires a skilled operator /engineer to program the robot.
- Robot setup must be enclosed within a safety cage. Generally large footprint.



Cobots:

- Cobots are designed to work alongside humans to perform a job.
- Easier to program compared to industrial robots.
- Operator does not need to be specially trained to program a cobot.
- Cobot setup does not require safety cages. Generally small footprint.



Kahoot short Quiz

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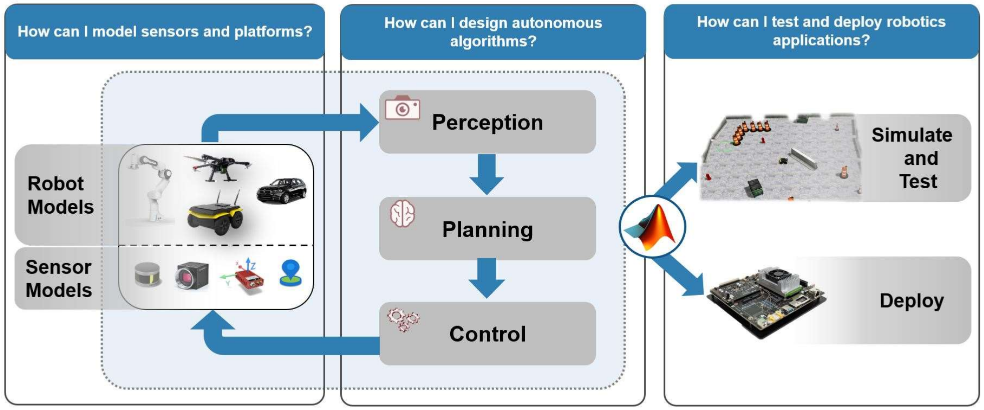
Part 2: Autonomous System

Autonomous System

Definition

- An autonomous system refers to a complex, self-contained entity or network of interconnected components that can operate, make decisions, and perform tasks without continuous human intervention. Autonomous systems leverage advanced technologies, such as artificial intelligence, machine learning, sensors, and actuators, to perceive their environment, analyze information, and execute actions based on predefined objectives.

- These systems are designed to function independently, adapting to changing conditions and making decisions in real-time. The level of autonomy can vary, and some autonomous systems may require occasional human oversight or intervention, while others operate entirely without human involvement.



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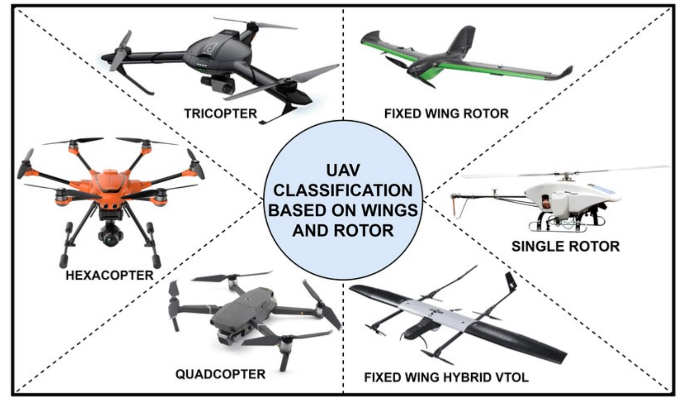
Categories of Autonomous System (Media)

1. **Land-Based Autonomous Systems:**
   - Autonomous Vehicles: Self-driving cars and autonomous buses.
   - Industrial Robots: Used in manufacturing and logistics.
   - Unmanned Ground Vehicles (UGVs): Robots designed for terrestrial exploration, surveillance, or military applications.
2. **Air-Based Autonomous Systems:**
   - Autonomous Drones: Unmanned aerial vehicles used for surveillance, photography, delivery, and other applications.
   - Unmanned Aerial Vehicles (UAVs): Used in military, reconnaissance, and exploration.
3. **Water-Based Autonomous Systems:**
   - Autonomous Underwater Vehicles (AUVs): Unmanned submarines used for underwater exploration, research, and surveillance.
   - Unmanned Surface Vehicles (USVs): Autonomous boats used for tasks such as data collection and monitoring.
4. **Space-Based Autonomous Systems:**
   - Autonomous Spacecraft: Unmanned vehicles used for space exploration, observation, and data collection.

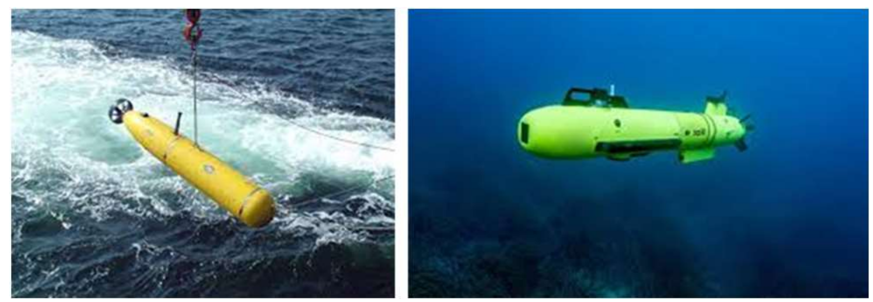
Categories of Autonomous System (Media)

Unmanned Ground Vehicles (UGVs)



Unmanned Aerial Vehicles (UAVs)

Unmanned Surface Vehicles (USVs)



Autonomous Underwater Vehicles (AUVs):

Unmanned Ground Vehicles (UGVs)

Definition

- **Unmannded Ground Vehicles (UGVs)** are vehicles equipped with advanced technologies that enable them to navigate, operate, and perform tasks without human intervention. These vehicles utilize a combination of sensors, actuators, and control systems to perceive their environment, make decisions, and execute actions, all without the need for direct human control.

Key Components

Sensors: UGVs are equipped with a variety of sensors, including cameras, lidar, radar, ultrasonic sensors, and inertial measurement units. These sensors collect real-time data about the vehicle's surroundings, allowing it to perceive obstacles, navigate through environments, and detect changes in its surroundings.

Control Systems: Advanced control algorithms and systems process the information gathered from sensors. These systems make decisions about vehicle movements, path planning, and response to dynamic environments.

Navigation: UGVs use autonomous navigation systems to determine their location and plan optimal paths to reach their destinations. This can involve mapping technologies, simultaneous localization and mapping (SLAM), and other techniques to ensure accurate and efficient navigation.

Communication: Some UGVs can communicate with each other and with central control systems to coordinate movements, share information, and optimize overall system performance. This is particularly important in scenarios involving multiple autonomous vehicles operating in the same environment.

Actuators: UGVs have mechanical actuators, such as motors or steering systems, that execute the decisions made by the control systems. These actuators allow the vehicle to accelerate, decelerate, turn, and perform other maneuvers autonomously.

Key UGV Application Scenarios

Application	Description
Material Handling	UGVs are widely used for transporting materials within warehouses, factories, and distribution centers. They can move goods between storage locations, production lines, and shipping areas.
Warehousing	UGVs play a crucial role in automating warehouse operations, including tasks such as picking, packing, and order fulfillment. They contribute to increased efficiency and accuracy in inventory management.
Automotive Manufacturing	UGVs are employed in automotive assembly lines to transport components, deliver parts to assembly stations, and move finished vehicles within the production facility.
Hospital Logistics	In healthcare settings, UGVs are used for the automated delivery of medical supplies, medications, and equipment, helping to streamline logistics and improve overall efficiency.
E-commerce Fulfillment	UGVs are utilized in e-commerce fulfillment centers to automate the movement of goods, ensuring timely order fulfillment and reducing manual labor requirements.
Food and Beverage Industry	UGVs are employed for transporting raw materials, finished products, and packaging within food and beverage processing plants. They help maintain hygiene standards and increase productivity.
Airport Cargo Handling	UGVs assist in the efficient movement of cargo within airport facilities, enhancing the speed and accuracy of cargo handling processes. They are particularly valuable in large cargo warehouses.
Cleanroom Environments	In environments with strict cleanliness requirements, such as semiconductor manufacturing, UGVs are used to transport materials without the risk of contamination from human contact.
Cross-Docking	UGVs facilitate the smooth flow of goods in cross-docking facilities by automatically transferring products from inbound to outbound docks, minimizing storage time.
Retail Distribution	UGVs are applied in retail distribution centers to automate the movement of products from storage areas to delivery zones, contributing to faster and more accurate order fulfillment.

Automated Guided Vehicles (AGVs)

Definition: Automated Guided Vehicles (AGVs) are mobile robots designed to perform material handling and transportation tasks within a controlled environment. These vehicles are guided along predetermined paths or routes using various guidance technologies and are used in industrial settings to automate the movement of goods and materials.

AGVs use different guidance systems to navigate, including:

Magnetic Tape: Magnetic tape is often placed on the floor to guide AGVs along specific paths.

Wire Guidance: A wire is embedded in the floor, and AGVs follow it for navigation.

Laser Guidance: Laser sensors help AGVs follow reflective targets for navigation.

Automated Guided Vehicles

Types of AGVs:

- **Unit Load AGVs:** Designed to transport a single load or item, such as a pallet or container.
- **Tow AGVs:** Pull other carts or trailers, allowing them to transport multiple loads.
- **Assembly Line AGVs:** Specifically designed for assembly line processes, moving items between workstations.

Communication:

AGVs can be integrated into larger systems, such as Warehouse Management Systems (WMS) or Manufacturing Execution Systems (MES), allowing them to receive instructions and communicate their status.

Drive Systems:

AGVs are equipped with **electric** or **hydraulic** drive systems. Electric AGVs are more common due to their flexibility, efficiency, and ease of control.

Autonomous Mobile Robots (AMR)

Definition: An Autonomous Mobile Robot (AMR) is a robotic system that is capable of navigating and operating in its environment without continuous human guidance. These robots are designed to move autonomously, avoiding obstacles and making decisions based on their sensory input. AMRs are used in a variety of applications across industries, such as logistics, manufacturing, healthcare, and more.

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Characteristics

Autonomous Navigation:

AMRs have the ability to navigate autonomously in their surroundings without the need for external guidance systems. They use onboard sensors and algorithms for mapping, localization, and path planning.

Sensors:

AMRs are equipped with various sensors to perceive their environment. Common sensors include LiDAR (Light Detection and Ranging), cameras, ultrasonic sensors, infrared sensors, and more. These sensors help the robot understand its surroundings and make informed decisions.

Mapping and Localization:

AMRs create maps of their environment and use localization algorithms to determine their position within those maps. This information is crucial for effective navigation and obstacle avoidance.

Obstacle Avoidance:

Autonomous mobile robots are programmed to detect and avoid obstacles in their path. They use sensors to identify obstacles and adjust their trajectory accordingly.

Path Planning:

AMRs use path planning algorithms to determine the optimal route from their current location to a specified destination. These algorithms take into account the environment, obstacles, and any dynamic changes in the surroundings.

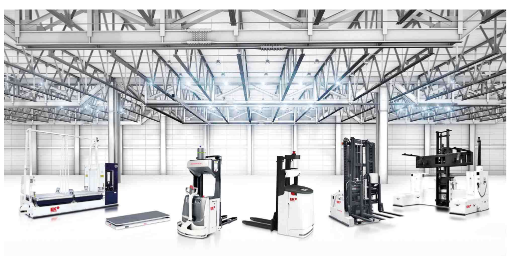
Major AGVs/AMRs Supplier

Clearpath Robotics

MIR

Fetch

Swisslog Holding AG



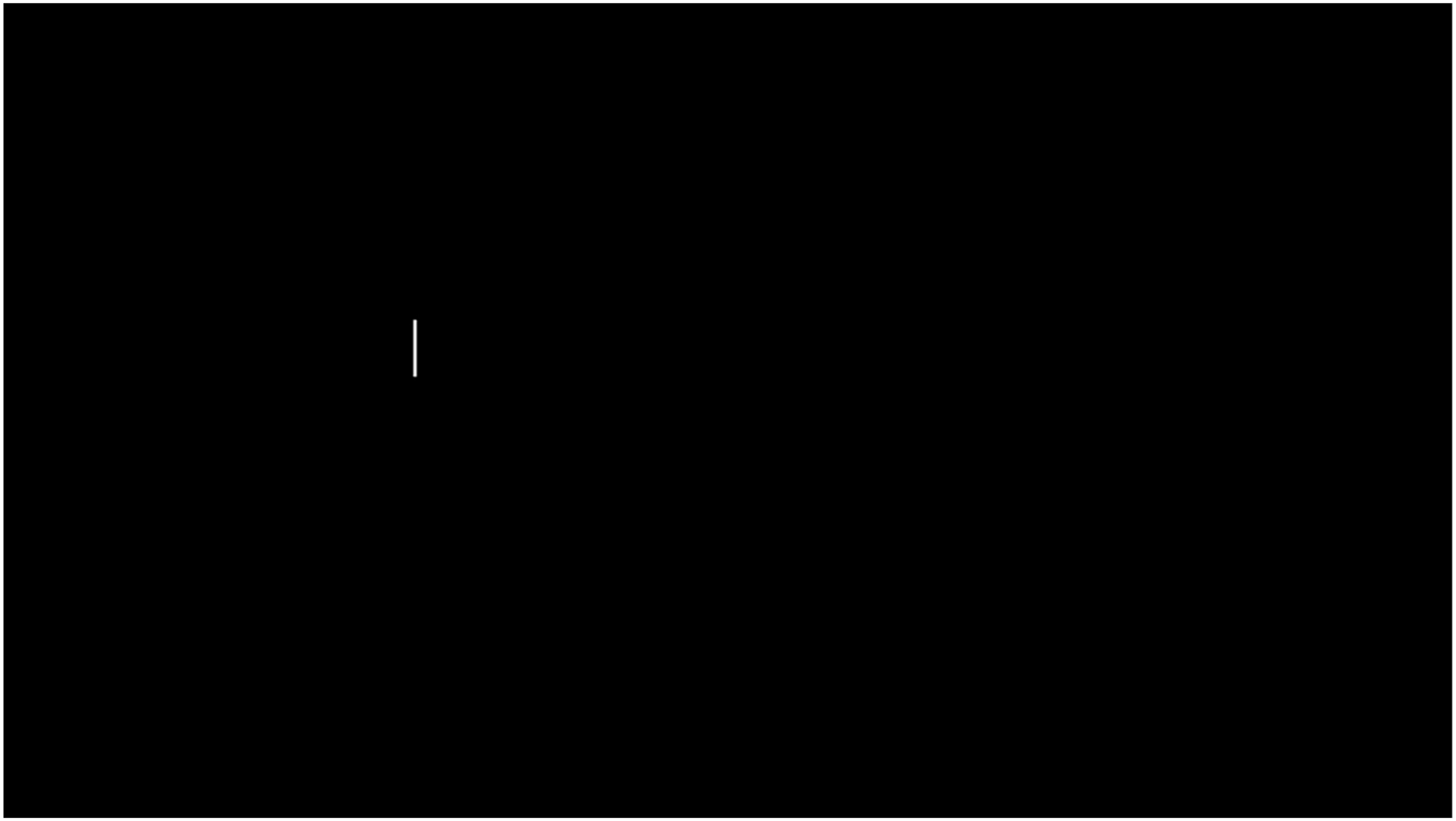
E&K Automation GmbH

Omron

JBT

Kollmorgen

AMRs vs AGVs



Mobile Manipulator

Definition

- A mobile manipulator is a robotic system that combines the capabilities of a mobile base (wheeled or tracked platform) with a manipulator (robotic arm) to perform various tasks. This type of robotic system is designed for mobility and manipulation, allowing it to navigate through its environment and interact with objects using its manipulative arm.

- Key Features of a Mobile Manipulator:

1) **Mobile Base:**

- The mobile base provides the robot with the ability to move in its environment. It can be equipped with wheels, tracks, or other mobility mechanisms. Mobility enables the robot to navigate, explore, and reach different locations, making it suitable for applications in diverse environments.

2) **Manipulator (Robotic Arm):**

- The manipulator, often mounted on the mobile base, consists of joints and links that allow it to manipulate objects in its surroundings. The arm can have various end-effectors, such as grippers, suction cups, or specialized tools, enabling the robot to perform a wide range of tasks.

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Mobile Manipulator

Applications:

Mobile manipulators find applications in various domains, including logistics, warehouse automation, manufacturing, service robotics, and research.

Examples of tasks include pick-and-place operations, inspection, material handling, and collaborative tasks in environments where mobility and manipulation are essential.

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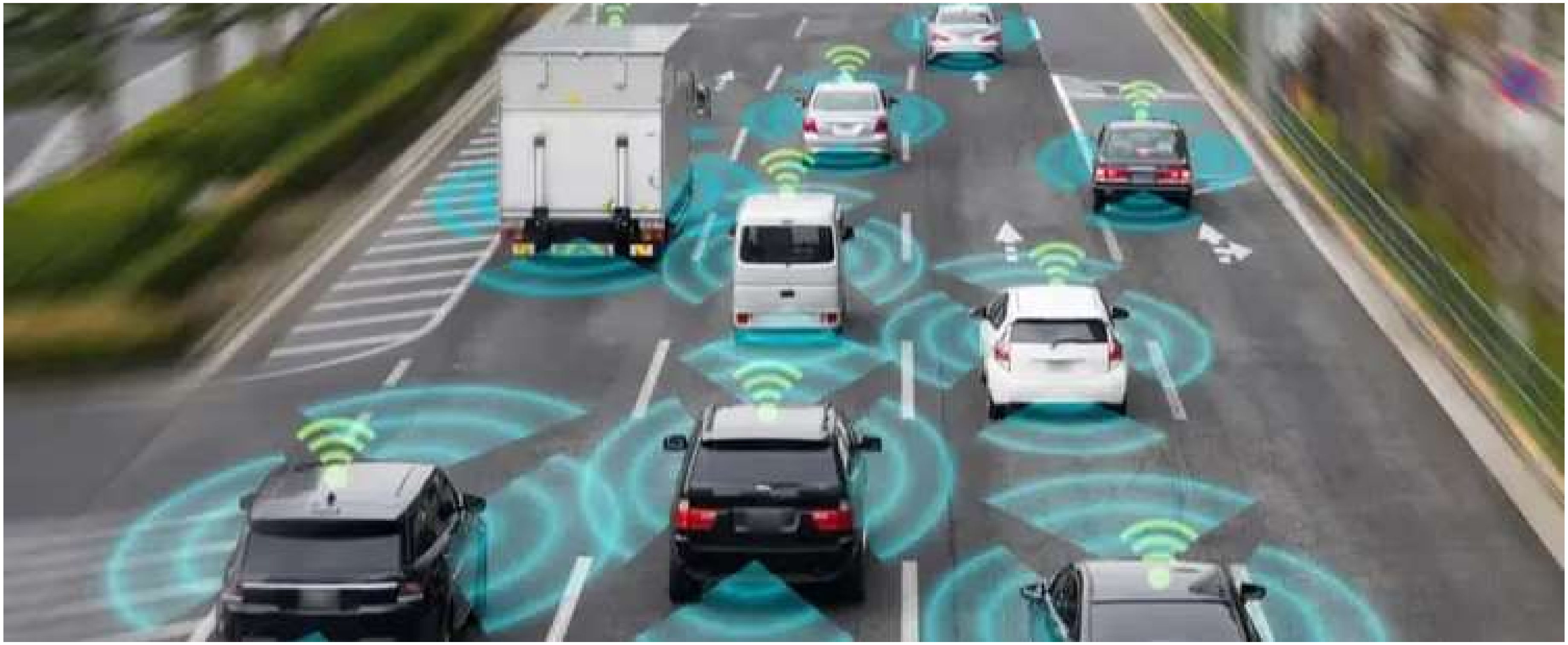
Autonomous Vehicles



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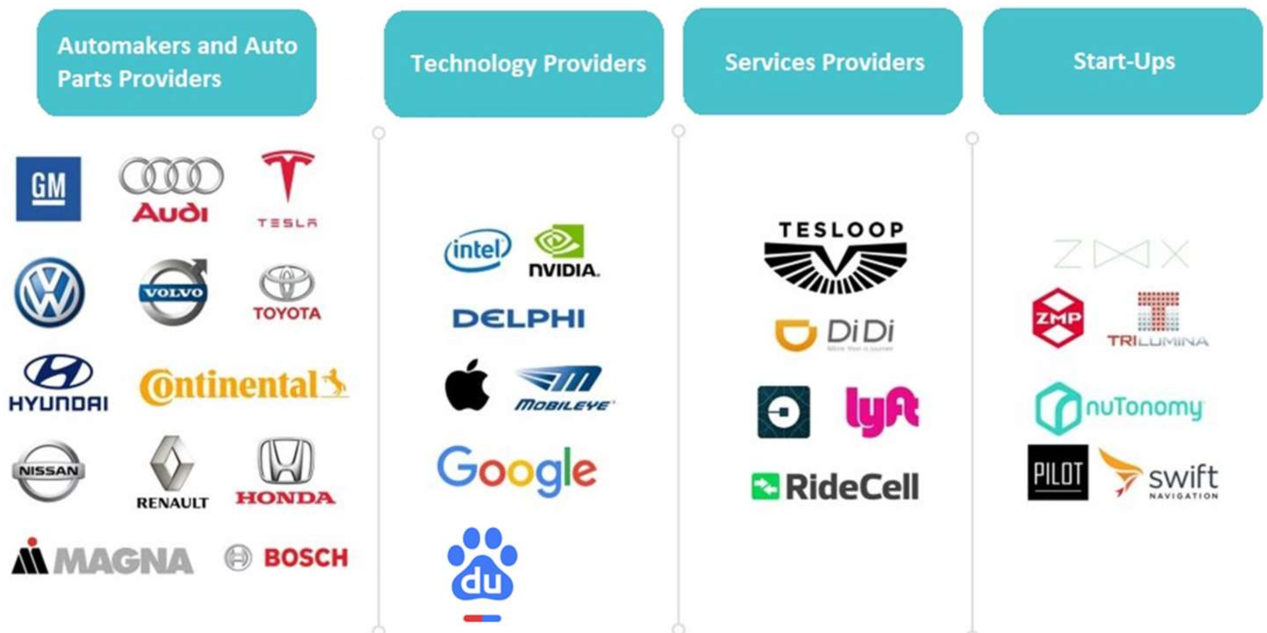
Autonomous Vehicles

Definition

- An autonomous vehicle, also known as a self-driving car or driverless car, is a vehicle capable of navigating and operating without human input. These vehicles use a combination of advanced technologies, such as sensors, cameras, radar, lidar, GPS, and artificial intelligence, to perceive their environment, make decisions, and control their movements.



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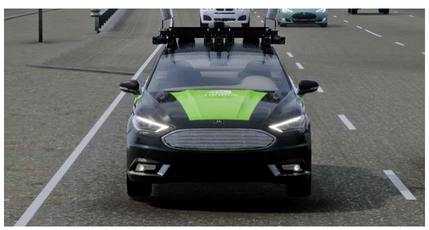
Autonomous Vehicles

Google Waymo

Baidu Apollo

Tesla



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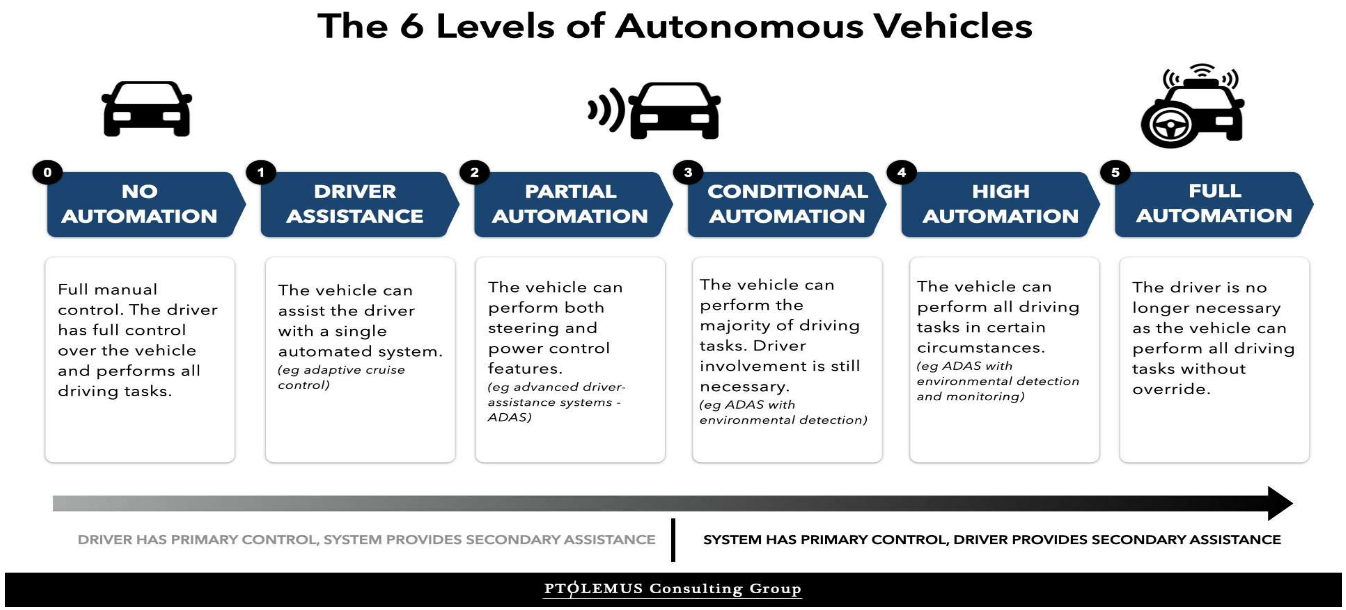
Types of Autonomous Vehicles

Definition

- Autonomous vehicles are designed to perform tasks traditionally carried out by a human driver, such as steering, accelerating, and braking. The goal of autonomous vehicles is to enhance safety, improve transportation efficiency, and provide greater convenience. They are typically classified into different levels of automation, ranging from Level 0 (no automation) to Level 5 (full automation), as defined by organizations such as the Society of Automotive Engineers (SAE).



L1-L6

The **autonomy level** of an autonomous vehicle is a measure of the vehicle's capability to perform various driving tasks without human intervention. The **Society of Automotive Engineers (SAE)** has established a widely accepted scale known as the **SAE J3016** standard, which defines **six** levels of driving automation, ranging from **Level 0** (no automation) to **Level 5** (full automation). Each level represents an increasing degree of automation and autonomy in the vehicle's operation.

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Autonomous Level

Level 0 - No Automation:

- The human driver is responsible for all aspects of driving.
- No automation features are present.

Level 1 - Driver Assistance:

- The vehicle can assist with either steering or acceleration/deceleration, but not both simultaneously.
- Examples include adaptive cruise control and lane-keeping assistance.

Level 2 - Partial Automation:

- The vehicle can control both steering and acceleration/deceleration simultaneously under certain conditions.
- The driver must remain engaged and monitor the environment.
- Examples include advanced adaptive cruise control and lane-keeping systems.

Level 3 - Conditional Automation:

- The vehicle can perform some driving tasks autonomously in specific conditions.
- The driver may disengage from active control but must be ready to take over when prompted by the system.
- Level 3 automation is limited to specific scenarios, such as highway driving.

Level 4 - High Automation:

- The vehicle can perform most driving tasks autonomously within defined operational domains or geofenced areas.
- The driver may not need to intervene in certain situations.
- Outside the predefined areas, the vehicle may require human control.

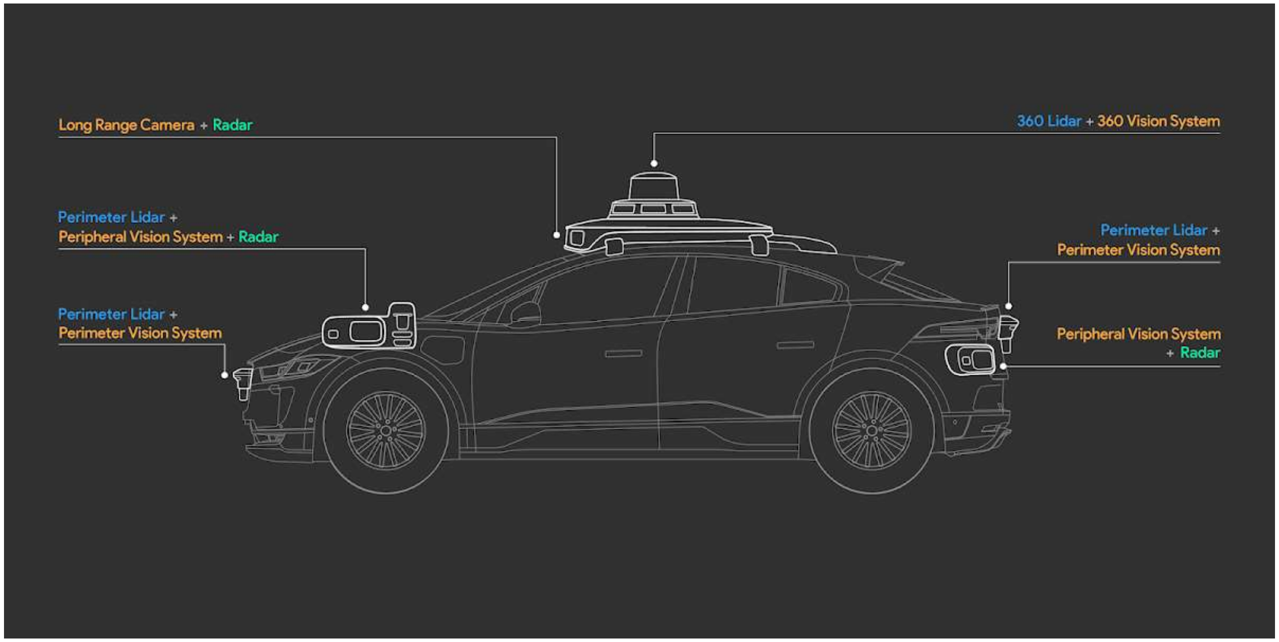
Level 5 - Full Automation:

- The vehicle is fully autonomous and capable of handling all driving tasks under all conditions without human intervention.
- No driver's seat or steering wheel is necessary.

Enabling Technology for Autonomous Vehicles

Definition

- An autonomous vehicle, also known as a self-driving vehicle or driverless vehicle, is a vehicle capable of navigating and operating without human input. These vehicles use a combination of advanced technologies, such as sensors, cameras, radar, lidar, GPS, and artificial intelligence, to perceive their environment, make decisions, and control their movements.



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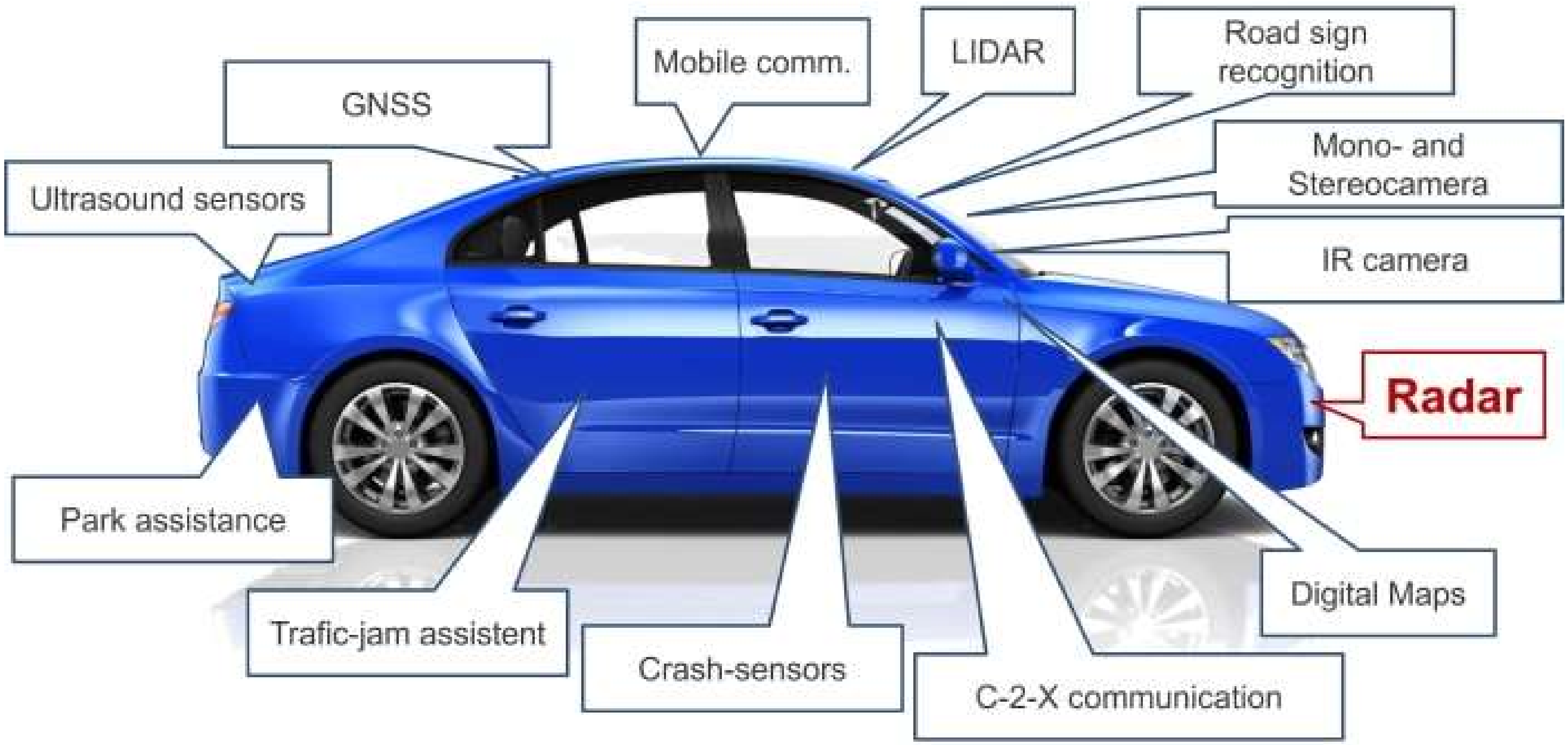

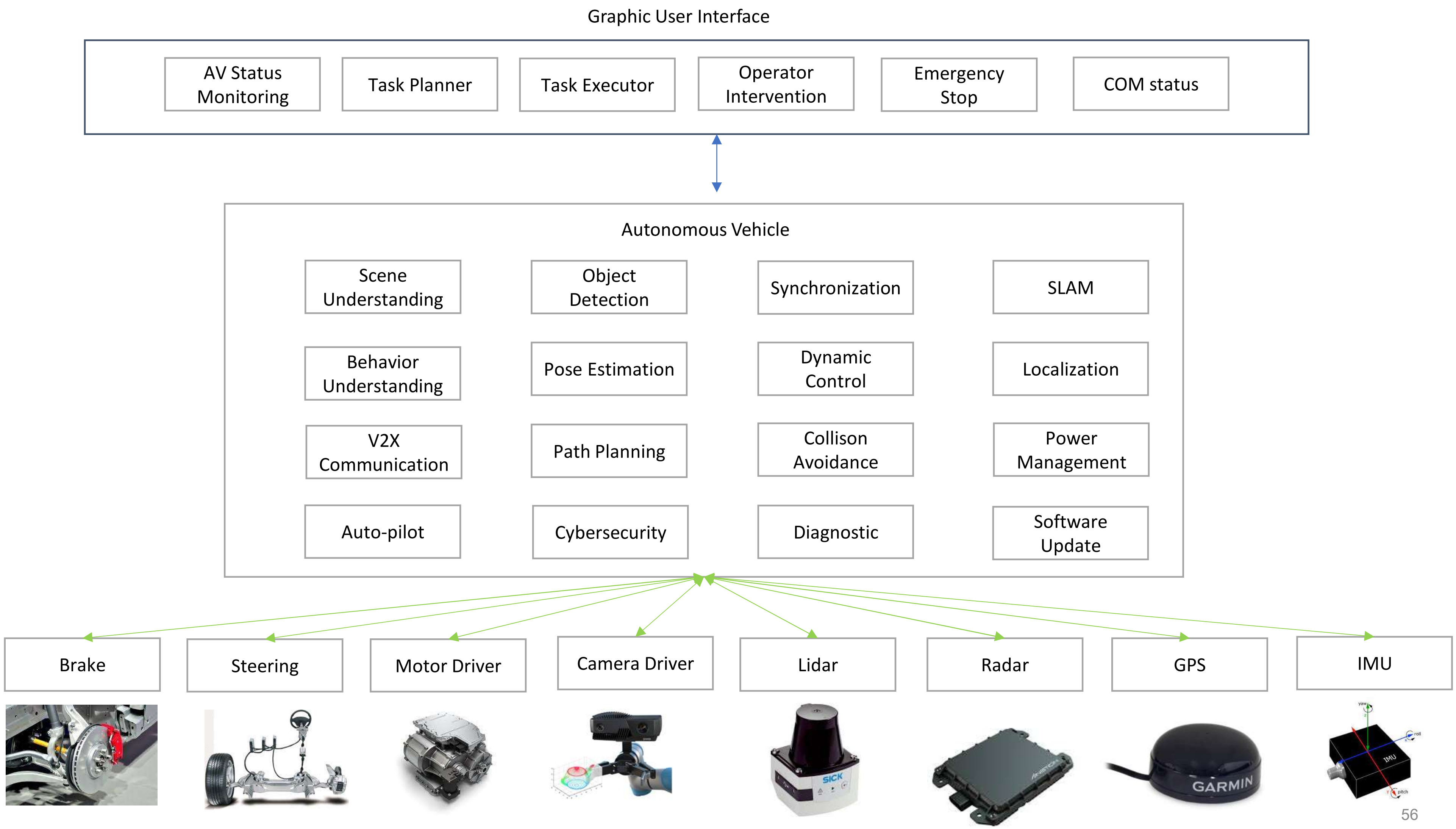

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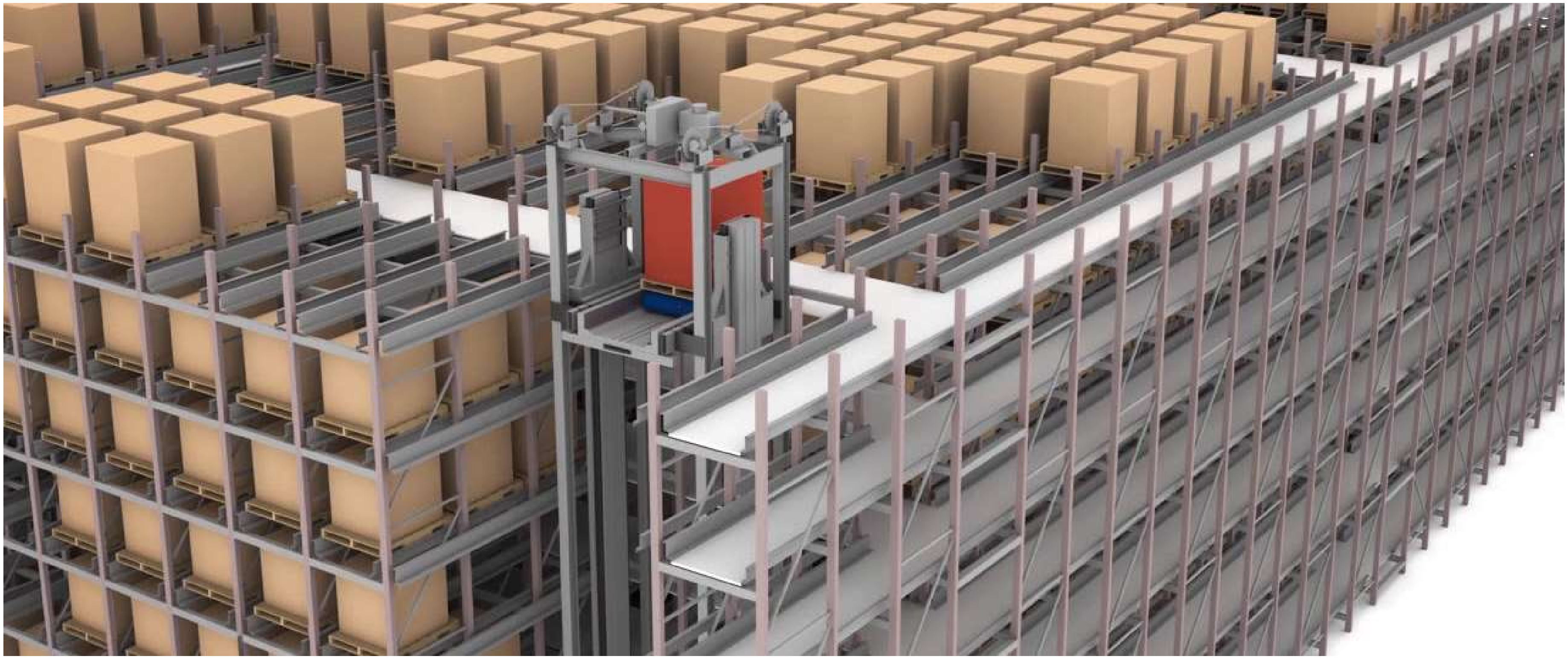
Part 2: Advanced Applications in Automation



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ASRS (Automated Storage and Retrieval Systems)

Definition

- **ASRS** stands for "Automated Storage and Retrieval System." It refers to a sophisticated automated system used in warehouses and distribution centers for the storage, organization, and retrieval of goods and materials. ASRS systems utilize a combination of computer-controlled equipment, such as conveyors, robots, and automated storage racks, to efficiently manage and handle inventory.

Key Components:

- **Storage Racks:** ASRS systems typically include high-density storage racks equipped with automated mechanisms for storing and retrieving items. These racks can be vertical or horizontal and are designed to maximize space utilization.
- **Automated Retrieval Devices:** These devices, often robotic or crane-like, move vertically or horizontally within the storage system to retrieve items based on computerized instructions. They are equipped with grippers, forks, or other tools to pick and place items.
- **Conveyors and Transport Systems:** ASRS systems incorporate conveyor belts and other transport mechanisms to move items efficiently within the warehouse or distribution center. This ensures a seamless flow of goods between different stages of the storage and retrieval process.
- **Control System:** The heart of an ASRS is its control system, which is computerized and manages the entire operation. It receives input from inventory management systems and translates this into commands for the automated equipment, optimizing the movement and storage of items.
- **Inventory Management Software:** ASRS is often integrated with advanced inventory management software. This software helps track the location and quantity of items in real-time, optimizing inventory levels and reducing errors.

ASRS (Automated Storage and Retrieval Systems)

Advantages	Details
Increased Efficiency	Rapid and automated storage and retrieval processes lead to higher operational efficiency.
Space Optimization	Utilizes vertical storage space and high-density racks, maximizing warehouse capacity.
Accuracy and Reliability	Automation reduces the risk of errors in storage and retrieval, ensuring high accuracy.
Labor Savings	Minimizes the need for manual labor in routine tasks, allowing human workers to focus on more complex activities.
Enhanced Safety	Automation reduces the physical demands on workers in high-rise storage areas, contributing to a safer work environment.
Faster Order Fulfillment	Automation accelerates the order fulfillment process, reducing lead times and improving customer satisfaction
Reduced Footprint	Maximizes space utilization, potentially reducing the overall footprint of the warehouse or distribution center
Dynamic Storage Configurations	ASRS can adapt to changes in inventory needs, allowing for dynamic storage configurations based on demand
Reduced Operating Costs	Over time, the efficiency gains, labor savings, and optimized processes contribute to reduced operating costs

ASRS

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Artificial Intelligence (AI)

Definition

- **Artificial Intelligence (AI)** refers to the development of computer systems that can perform tasks that typically require human intelligence. These tasks include learning from experience, reasoning, problem-solving, understanding natural language, and perceiving the environment. AI aims to create machines or systems capable of exhibiting intelligent behavior, enabling them to adapt and excel in various domains.

Key Components:

- **Machine Learning:** An integral part of AI, machine learning involves training algorithms to recognize patterns and make predictions or decisions based on data.
- **Natural Language Processing (NLP):** Enables machines to understand, interpret, and generate human language.
- **Computer Vision:** Allows machines to interpret and make decisions based on visual data, akin to human vision.
- **Expert Systems:** Utilizes rules and knowledge to solve specific problems, emulating the decision-making of a human expert.

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Machine Learning

Definition

- **Machine Learning (ML)** is a subset of AI that focuses on the development of algorithms and models that enable computers to learn from data and make predictions or decisions without explicit programming. ML algorithms learn patterns and relationships within the data, allowing them to generalize and make informed decisions on new, unseen data.

Key Components:

- **Supervised Learning**: Algorithms learn from labeled training data, making predictions or classifications based on input-output pairs.
- **Unsupervised Learning:** Algorithms identify patterns and relationships within unlabeled data without predefined outputs.
- **Reinforcement Learning:** Agents learn by interacting with an environment, receiving feedback in the form of rewards or penalties for their actions.
- **Semi-Supervised and Self-Supervised Learning:** Utilizes a combination of labeled and unlabeled data for training.

AI Applications in Industries

Industry	AI Applications
Manufacturing	- Predictive Maintenance - Quality Control- Supply Chain Optimization
Healthcare	- Diagnosis and Treatment - Drug Discovery - Virtual Health Assistants
Finance	- Fraud Detection - Algorithmic Trading - Customer Service
Retail	- Personalized Marketing - Inventory Management - Chatbots and Virtual Assistants
Automotive	- Autonomous Vehicles - Predictive Maintenance for Fleet Management - Smart Traffic Management
Energy	- Predictive Maintenance for Equipment - Energy Grid Optimization - Renewable Energy Forecasting
Agriculture	- Precision Farming - Crop Monitoring - Automated Harvesting
Telecommunications	- Network Optimization - Customer Service Automation - Fraud Detection and Security

YOUCAR

Artificial Intelligence in Production.
BMW Group Dingolfing Plant, Assembly.

Augmented Reality (AR)

Definition

- Augmented Reality (AR) is a technology that superimposes digital information, such as images, sounds, or text, onto the real-world environment in real-time. AR enhances the user's perception of the surrounding environment by adding digital content, allowing users to interact with both the physical and virtual worlds simultaneously.

Key Features:

- Real-Time Interaction: AR provides real-time interaction by overlaying digital information onto the user's view of the real world.
- Integration with Reality: Unlike VR, AR does not replace the real world but enhances it with additional information.
- Applications: AR is used in various applications, including gaming, navigation, education, healthcare, and industrial training.

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Virtual Reality (VR)

Definition

- **Virtual Reality (VR)** is a computer-generated simulation of an immersive, three-dimensional environment that users can interact with through specialized hardware, such as VR headsets. VR isolates users from the physical world, placing them in a synthetic environment where they can experience a sense of presence and engage with the virtual surroundings.

Key Features:

- **Immersive Experience:** VR provides a fully immersive experience, isolating users from the real world and transporting them to a virtual environment.
- **Head-Mounted Displays (HMDs):** VR typically involves the use of HMDs, which are specialized headsets that cover the user's eyes and ears.
- **Applications:** VR is utilized in gaming, simulations, training, education, healthcare, and various industries to create realistic and interactive virtual experiences.

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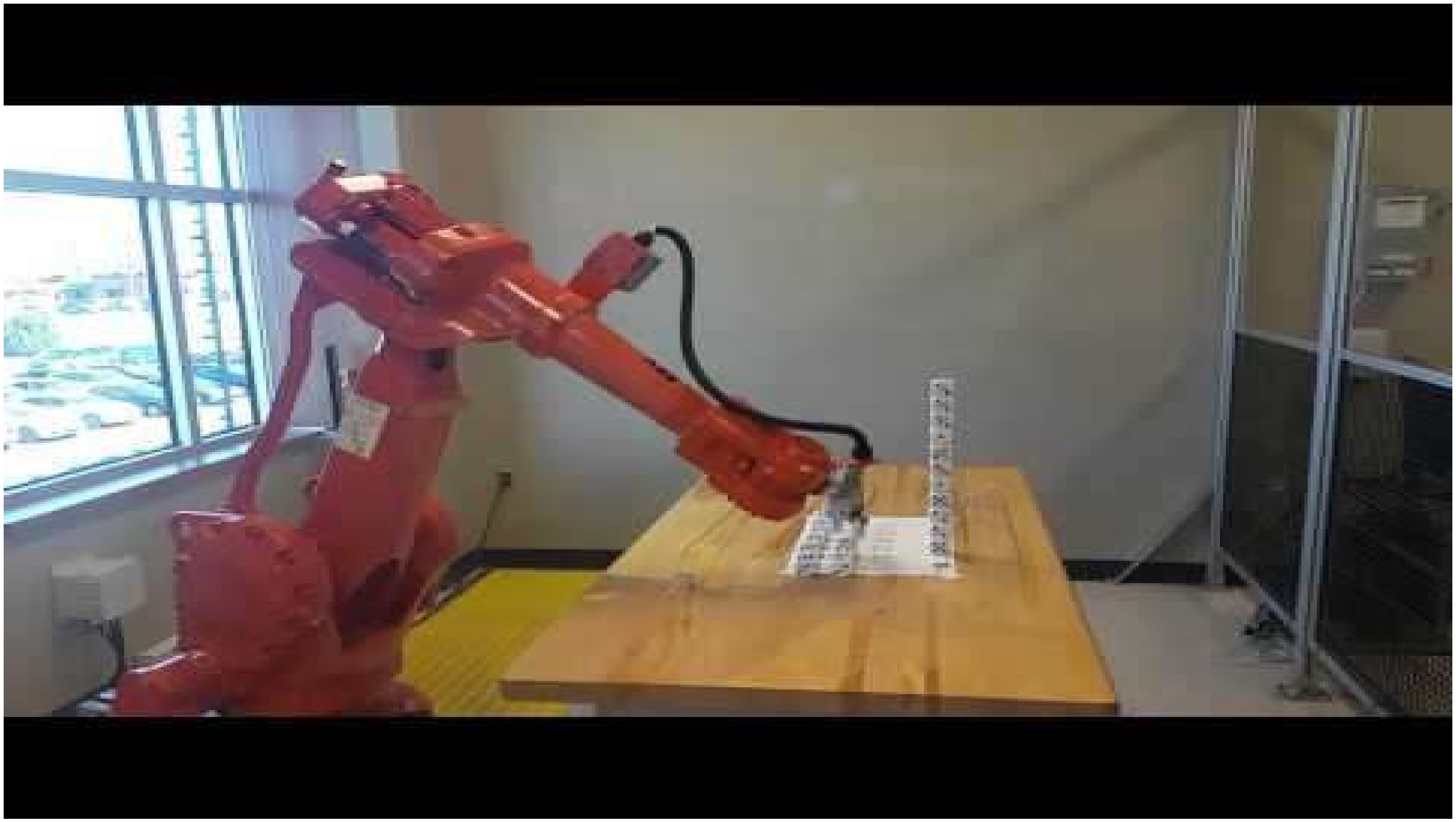
Differentiator for AR/VR

Aspect	Augmented Reality (AR)	Virtual Reality (VR)
Reality Interaction	Overlays digital information on the real-world environment.	Creates a fully immersive, computer-generated environment.
User Experience	Users see and interact with both the real and virtual worlds.	Users are fully immersed in a virtual environment.
Hardware	Uses devices like smartphones, tablets, AR glasses, or HUDs.	Requires specialized hardware, such as VR headsets.
Applications	Enhances real-world experiences by adding digital elements.	Applied in simulations, training, gaming, and virtual experiences.
Interaction Paradigm	Involves overlaying digital information onto physical objects.	Interaction is typically within the confines of the virtual space.

AR/VR Applications in Industries

Industry	AR Applications	VR Applications
Manufacturing/Industry	Assembly Assistance, Maintenance, and Repairs	Training Simulations for Machinery Operation and Complex Tasks
Healthcare	Surgical Navigation, Medical Training	Therapy and Rehabilitation, Training Simulations for Medical Staff
Education	Interactive Learning, Educational Apps	Virtual Field Trips, Immersive Learning Environments
Retail/E-Commerce	Virtual Try-On, In-Store Navigation	Virtual Shopping
Real Estate	Property Visualization, Interactive Property Tours	Virtual Property Tours
Automotive	Heads-Up Displays (HUD), Maintenance Assistance	Vehicle Design and Prototyping
Aviation/Aerospace	Maintenance and Training, Navigation Assistance	Flight Simulation

Example of Unforeseen Circumstances (Open Discussion)



Source: https://youtu.be/npItpe4U8KY

Group Discussion

As the environment gets more harsh and complex, robots are required to keep up in order to successfully automate processes in such environments.

- Reflect and share your experiences on Robotics and AI
- Are there any robots being adopted in your school, shopfloor or company?
- How have Robotics and AI transformed your company’s current process?
- Do you have any experience developing robotic solutions?
- What are the areas for improvement, or any lesson learned?

Kahoot