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ROBOTICS

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TABLE OF CONTENT

01

CHAP # 1

INTRODUCTION TO ROBOTICS

Definition of Robotics

Robotics is an area of study concerned with the design, manufacture, execution, and use of machines. A robot is a self-contained or partial machine that can do activities of varied complexity, generally emulating human behaviors or even performing duties that would be hazardous or repetitious for people to complete. Robotics incorporates elements from various disciplines, including computer science, engineering, artificial intelligence, and control systems.

Here's a more in-depth look at the major features of robotics:

Design

Robotics entails the development of mechanical structures ranging from basic manipulators (robotic arms) to elaborate humanoid or animal-inspired designs. These buildings must be meticulously designed to carry out specific jobs effectively and securely.

Construction

After the design is finalized, the real robot is constructed. This entails choosing proper materials, fabricating components, and assembling them into a working robotic system.

Actuation

Robots move and manipulate using diverse systems such as wheels, tracks, legs, or specialized appendages. The mobility and dexterity of the robot are determined by the design of these actuation systems.

Sensing

Sensors are necessary for robots to sense their surroundings and communicate with them. Cameras, ultrasonic sensors, LIDAR, accelerometers, gyroscopes, and touch sensors are illustrations of common sensors. The robot may use the data collected from these sensors for a variety of purposes, including object identification and navigation.

Control

Robotics includes the creation of control algorithms that enable the robot to carry out predetermined actions in response to information from sensors and high-level commands. These algorithms could use machine learning methods, path planning, feedback loops, and collision avoidance.

Programming

Software is required for robots to function. This involves high-level programming to specify tasks and behaviors as well as low-level control code to handle hardware components. Machine learning in robotics refers to the ability of some robots to learn from their interactions and modify their behavior over time.

Autonomy

Many contemporary robots are built to function independently, allowing them to do jobs without constant human supervision. Complex algorithms are needed for decision-making, perception, and adaptation at this level of autonomy.

Applications

Robotics has practical uses across a range of industries, including manufacturing, healthcare, agriculture, space exploration, search and rescue, entertainment, and more. Robots are employed to boost productivity, lower risk, and increase the skills of human operators.

Ethics and Safety

As robotics technology improves, ethical questions such as privacy, security, employment displacement, and the possible abuse of autonomous robots become more important.

Nevertheless, robotics is a dynamic and fast-expanding technology that has the potential to revolutionize industries and transform how we interact with our surroundings.

BRIEF HISTORY AND EVOLUTION OF ROBOTICS

The background and development of robotics is an enthralling journey spanning decades, marked by enormous advances in engineering, technology, and artificial intelligence. Here's a more in-depth look:

Ancient and Medieval Periods

Ancient Automata

Automata, mechanical devices meant to replicate human or animal movements, have been around since ancient civilizations. Archytas, a Greek mathematician, built a mechanical bird propelled by steam in the 4th century BCE, while Hero of Alexandria designed many automata, including a steam-powered engine and a humanoid figure capable of pouring wine.

Medieval Clocks and Automata

In Europe during the Middle Ages, elaborate clocks and automata were made. The 13th-century astronomical clock in Prague, for example, had moving figures and numerous dynamic displays.

The Industrial Revolution and the Beginnings of Mechanization (18th–19th centuries)

The Industrial Revolution

The Industrial Revolution marked a significant development in mechanical engineering and manufacturing skills. Although not directly linked to robotics, these inventions provided a foundation for future breakthroughs in the field.

Automata Exhibitions

Automata displays were popular forms of entertainment in the 18th and 19th centuries. Inventors such as Jacques de Vaucanson constructed elaborate automata that accurately mimicked human behaviors.

Early Twentieth Century

Remote Control and Teleoperation

It's fascinating to learn about the origins of teleoperation and remote control technologies. Did you know that Nikola Tesla exhibited a remote-controlled boat in the late 1800s? The concept was then developed further in the early 1900s.

Robotics in Literature

In 1920, Czech playwright Karel Apek used the term "robot" in his play "R.U.R." (Rossum's Universal Robots). The drama delves into the subject of artificial creation and the consequences of constructing intelligent, labor-performing robots.

Mid-Twentieth Century

Cybernetics and Artificial Intelligence

Cybernetics arose in the mid-twentieth century as a branch of study that explored control systems and communication in biological creatures and machines. This set the groundwork for future AI and robotics research.

Unimate

Unimate, the first industrial robot, debuted in 1961. It was created by George Devol and Joseph Engelberger and was used in industrial plants for activities such as loading and unloading large goods.

Twenty-first century

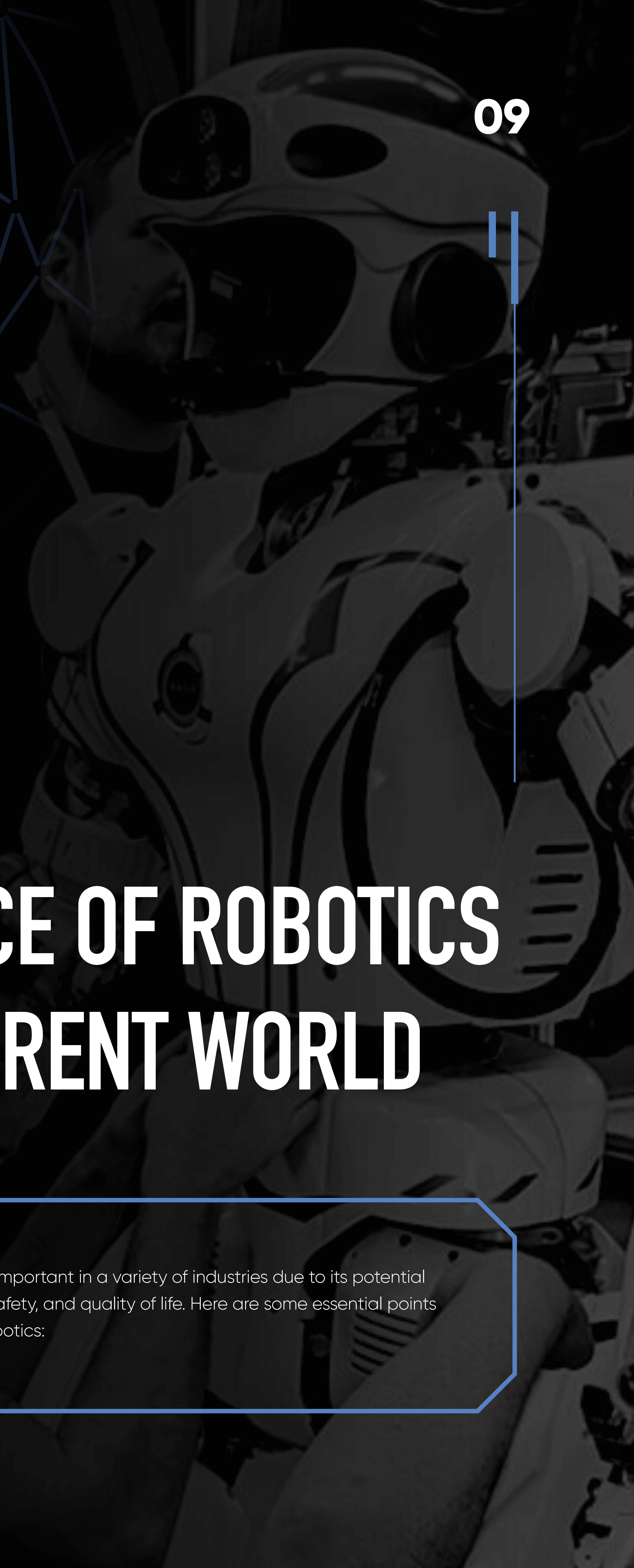
Sensing and perception improvements

Robots can now more correctly detect their surroundings because of developments in sensor technology made possible by the twenty-first century. Robotic perception has been enhanced with lidar, depth sensors, and sophisticated cameras.

Soft Robotics and Biomimicry

Researchers investigated soft robotics, which was influenced by biological systems and produced robots with more flexible and adaptive motions. The practice of "biomimicry," which includes imitating natural patterns, also rose to prominence.

#robotics



IMPORTANCE OF ROBOTICS IN THE CURRENT WORLD

Robotics is becoming increasingly important in a variety of industries due to its potential to improve production, efficiency, safety, and quality of life. Here are some essential points emphasizing the significance of robotics:

Automation in Industry

More Productivity

Robots are employed in manufacturing and industrial processes to perform repetitive operations with great accuracy, consistency, and speed, resulting in higher production rates and lower mistake rates.

Cost Effectiveness

Automated production lines frequently result in decreased operational costs and waste, boosting industry competitiveness.

Healthcare

Surgery and Medical Treatments

Surgical robots allow for minimally invasive treatments, which improve precision, reduce patient trauma, and decrease recovery periods.

Assistive Devices

Robotics assists persons with impairments by providing mobility, rehabilitation, and assistance with everyday tasks.

Warehousing and Logistics

Efficient Order Fulfillment

Robots in warehouses can swiftly identify, select, and pack things, increasing the efficiency of e-commerce order processing.

Inventory Control

Inventory inspections may be performed by autonomous robots and warehouse area utilization can be optimized.

Space Exploration

Exploration and Investigation

In space missions, robots are employed to investigate planets, asteroids, and other celestial entities, gaining vital data while minimizing the risk to human explorers.

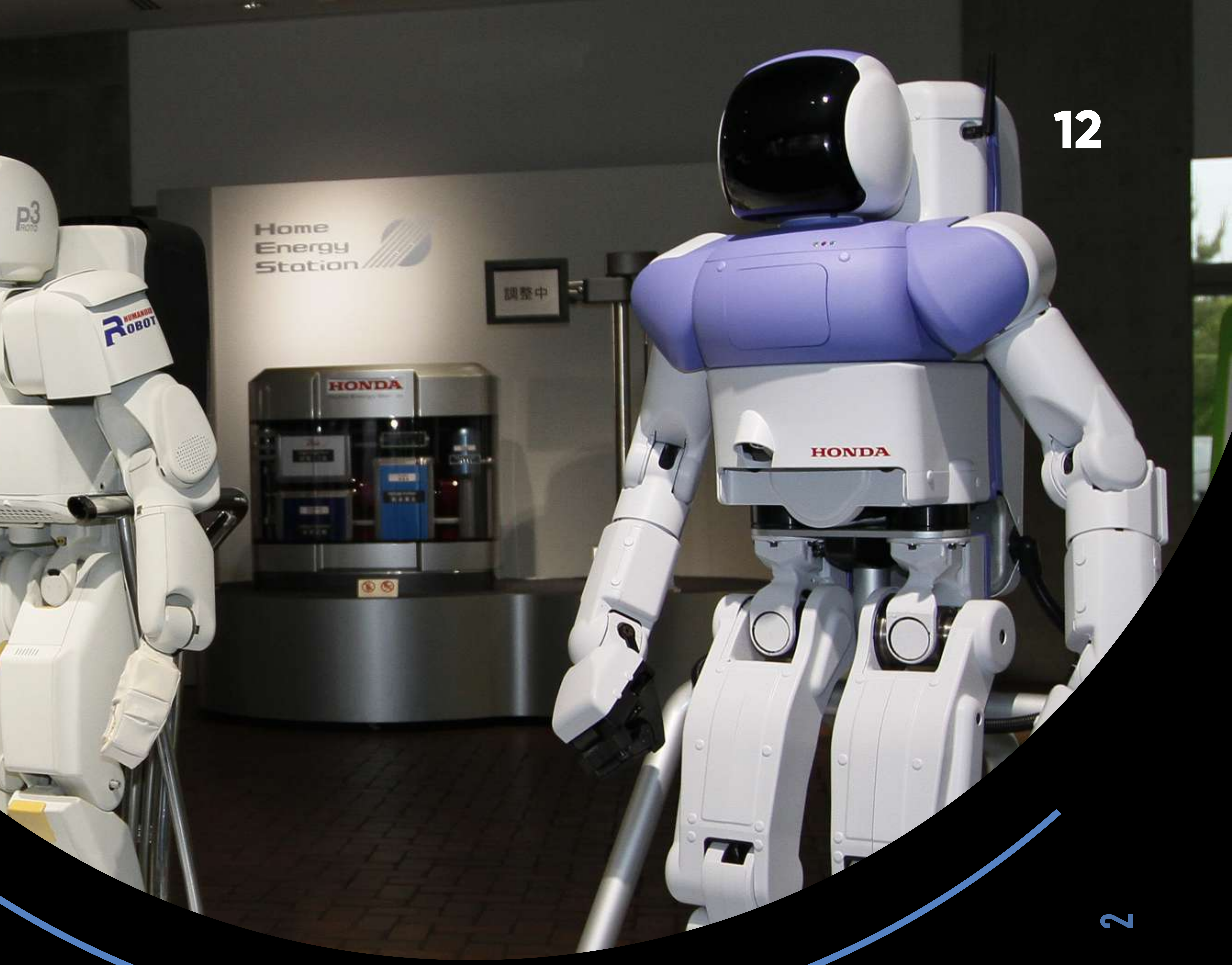
Education and Research

Learning Resources

Robotics allows kids to learn about science, technology, engineering, and mathematics (STEM) disciplines in a hands-on environment, encouraging innovation and creativity.

Scientific Exploration

Robots are utilized in a variety of scientific study domains, including oceanography, where they may access distant and deep-sea locales.



CHAP # 2

TYPES OF ROBOTS

Industrial Robots

Robots that are specially made for use in manufacturing and industrial operations are referred to as industrial robots. They are robotic devices that are capable of carrying out a variety of activities with accuracy, quickness, and consistency. By speeding production procedures, boosting productivity, and elevating product quality, industrial robots have completely transformed the manufacturing industry.

Here are some essential characteristics and uses for industrial robots:

Characteristics of Industrial Robots

Accuracy and Precision

Accuracy and exactness For operations like assembling, welding, and quality control, industrial robots are noted for their high levels of accuracy and precision.

Replicability

These machines can consistently complete jobs over time, which lowers mistakes and unpredictability in the production process.

Quickness and effectiveness

Due to their ability to operate at high speeds, industrial robots can enhance production rates and decrease cycle times.

Diversification

They are flexible to various production requirements because they may be configured to carry out a variety of jobs by altering their programming or tooling.

Security

To guarantee safe interaction with human employees, many industrial robots come with safety features like sensors and shielding.

Application of Industrial Robots

Assembly

Whether producing consumer products, automobiles, or electronics, robots are utilized in the product assembly process. They are competent at both complex and tedious assembly operations.

Welding

Industrial robots are frequently utilized in welding applications, delivering accurate and consistent welds in sectors including construction, automotive, and aerospace.

Painting and coating

Robots are utilized to evenly and precisely apply paints, coatings, and finishes, enhancing the beauty and longevity of the finished product.

Handling Materials

Robots are capable of moving objects between manufacturing steps, loading and unloading components, palletizing, and handling large goods.

Machine Tending

To minimize downtime and boost overall productivity, robots may tend to machines by supplying them with raw materials and removing finished goods.

Medical Robots

Modern technology devices called medical robots are intended to help medical practitioners with a range of operations, diagnoses, and treatments. They can accomplish complicated activities with accuracy, consistency, and ease, which can improve patient outcomes, lower the possibility of mistakes, and increase the effectiveness of medical procedures. Here are some typical medical robot types and their uses:

Surgical Robots

Surgeons are assisted by surgical robots during intricate surgeries. Compared to conventional surgical procedures, they provide more accuracy, stability, and dexterity. One such is the da Vinci Surgical System, which is frequently used for less invasive treatments like laparoscopic operations.

Rehabilitation Robots

These robots assist patients in their recovery and rehabilitation procedures. They can help people with mobility problems restore muscular strength, coordination, and range of motion. Rehabilitation robots are frequently utilized in physical therapy and neurological rehabilitation.

Telemedicine Robots

Patients and medical professionals can consult with one another remotely thanks to telemedicine robots. These robots allow physicians to engage with patients remotely, conduct diagnostic procedures, and offer medical advice since they are outfitted with cameras, microphones, and displays.

Diagnostic Robots

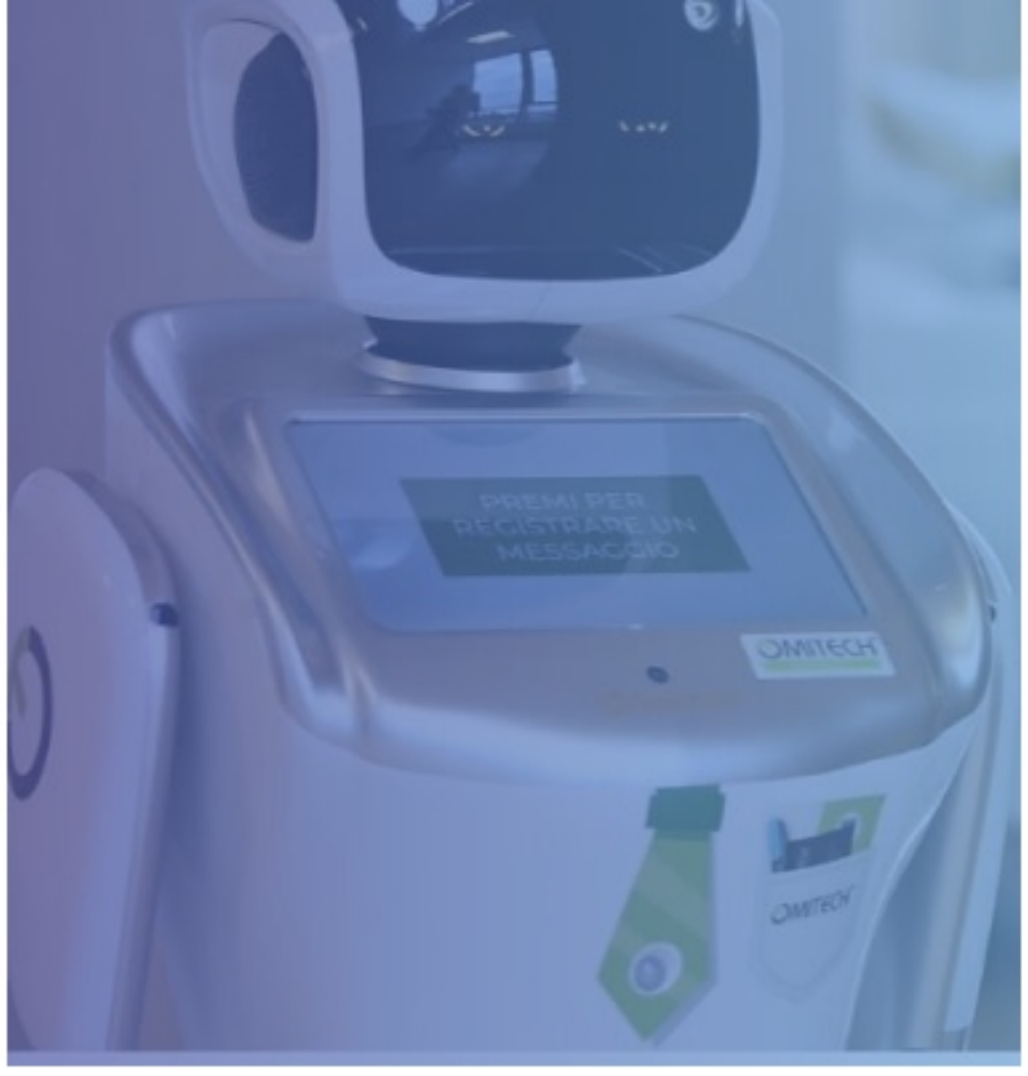
These robots are used for imaging and diagnostic procedures in medicine. They may operate independently to take X-rays, MRIs, CT scans, and ultrasounds, which lessens the burden on radiologists and increases the precision of diagnosis.

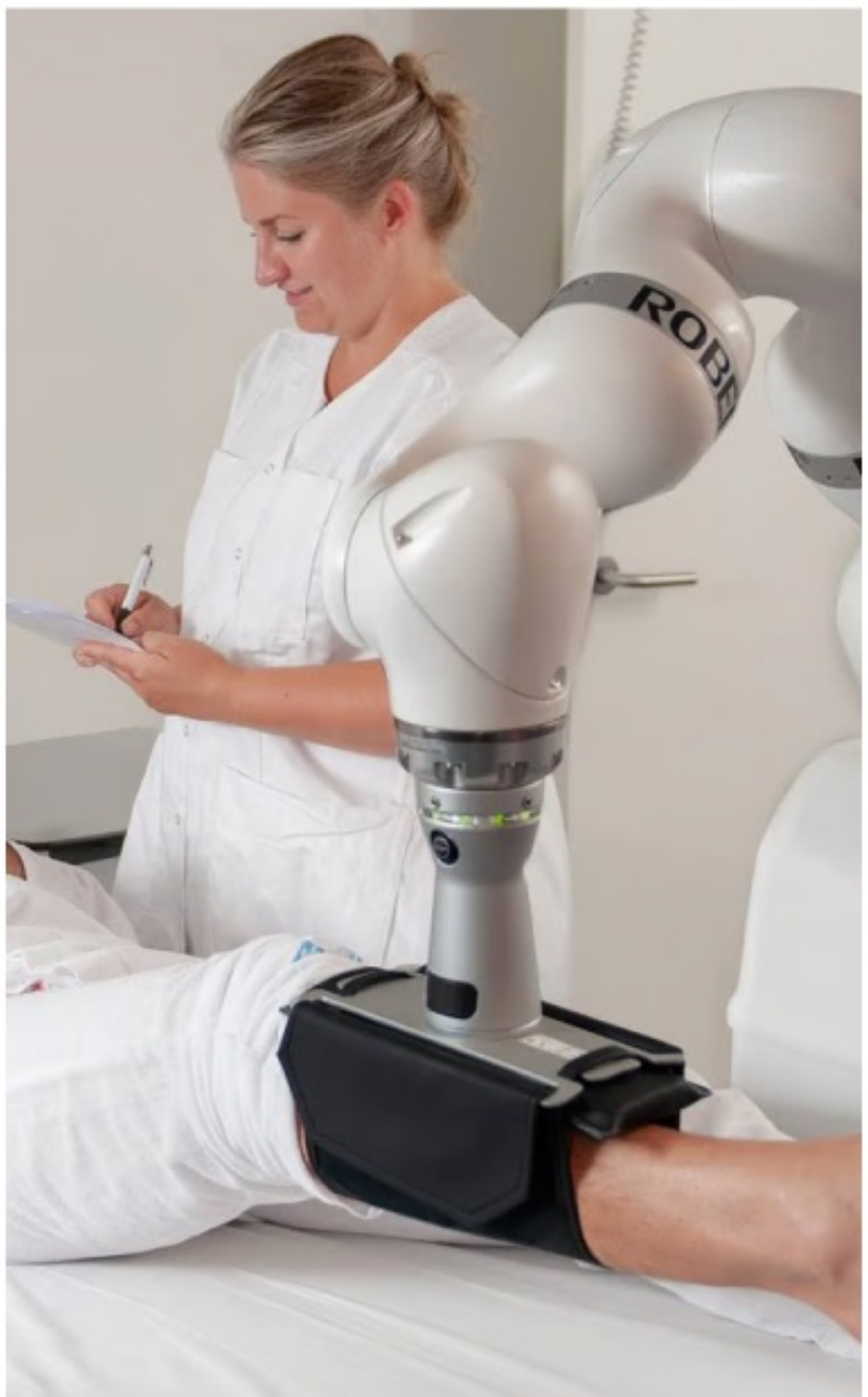
Pharmacy Robots

Pharmacy robots automate the management and distribution of drug activities. They are capable of precisely filling prescriptions, packaging drugs, and even delivering them to hospital patients.

Laboratory Robots

Utilized in research and diagnosis, laboratory robots automate processes including sample handling, testing, and analysis. They can make laboratory procedures more accurate and efficient.



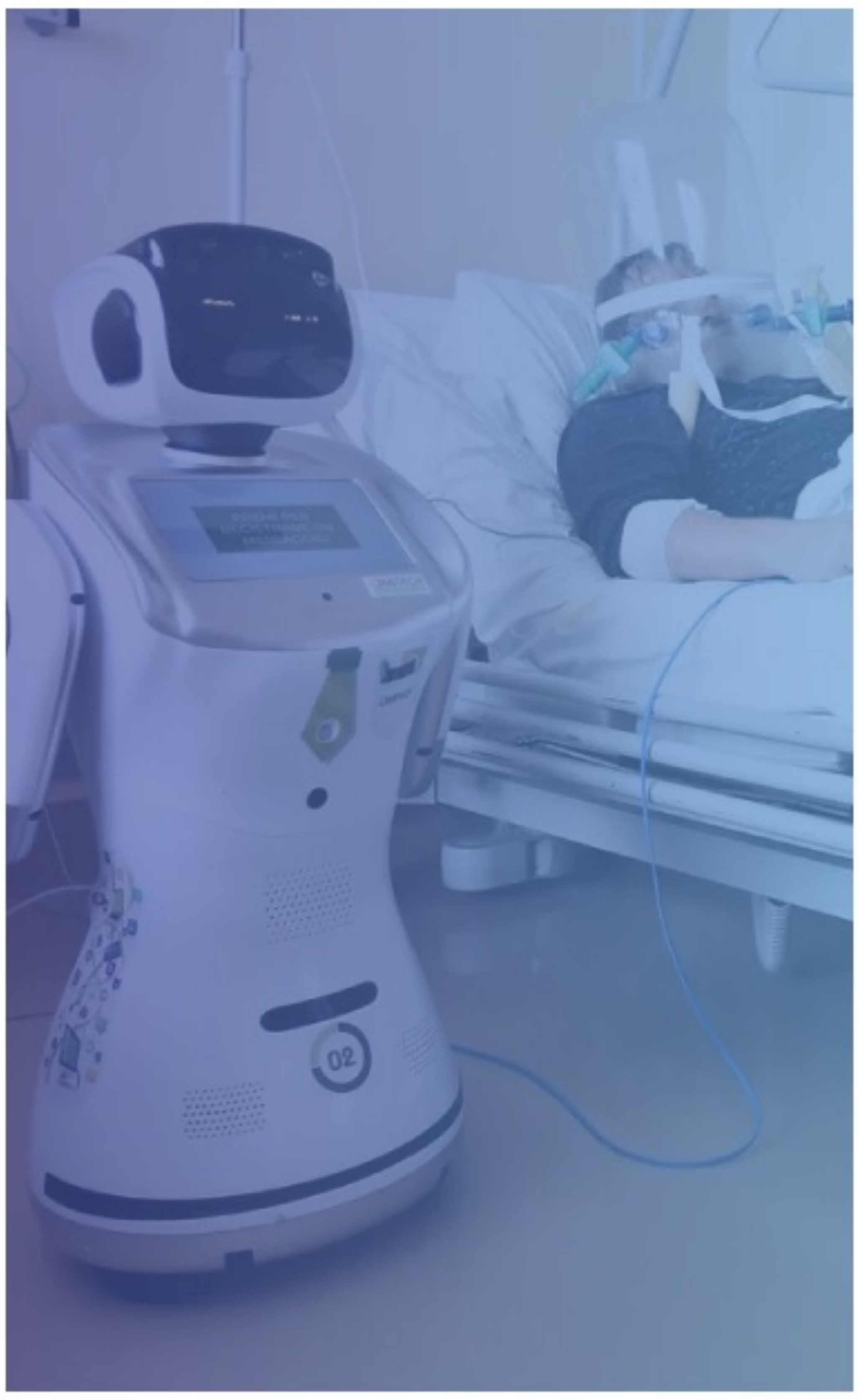


Robotic-assisted Rehabilitation

Robotic devices are utilized in physical therapy and rehabilitation in addition to exoskeletons to provide patients with specialized workouts and motions. These tools can adjust to the patient's development and hasten healing.

Nanorobots

While still in the early phases of development, nanorobots are incredibly small robots meant to function at the nanoscale. They might be used in targeted medicine administration, minimally invasive surgery, and even disease diagnosis at the cellular level.



Service Robots

Robots that can operate independently or in a semi-autonomous manner and aid people in a variety of settings are called service robots. They are outfitted with sensors, actuators, and, in many cases, powerful artificial intelligence algorithms that allow them to interact with and traverse their environment, as well as perform specialized jobs. These robots may be utilized in various locations and sectors to increase productivity, convenience, and safety.

Household Robots

These are intended for household usage and include robot Hoover cleaners, lawnmowers, window cleaners, and even companion robots that may give users entertainment and companionship.

Medical robots

Medical robots help in a range of healthcare duties, including patient monitoring, drug delivery, and surgical operations. They can increase surgical accuracy, lessen invasiveness, and raise the standard of healthcare services as a whole.

Robotic industrial systems

Production and manufacturing facilities employ industrial robots. They are capable of carrying out work such as assembling, welding, painting, and material handling, frequently enhancing the efficiency and precision of these operations.

Agriculture-related robots

These robots are employed in agriculture to carry out duties including planting, harvesting, crop health monitoring, and pesticide or fertilizer application. They can improve farming methods and lessen the demand for physical labor.

Robots for warehousing and logistics

These robots are used in warehouses and distribution centers for activities including selecting and packaging products, managing inventory, and moving products throughout a facility.

Robots for security and surveillance

In public areas like malls, airports, and museums, these robots are utilized for monitoring. They may patrol specific locations, keep an eye out for security lapses, and give human operators up-to-the-minute information.

Robots used in search and rescue

These robots are made to find individuals in dangerous or difficult-to-reach places during crises or disasters, and then to rescue them.

Robots for entertainment and hospitality

In hospitality environments like hotels and restaurants, some robots are built to engage with patrons by giving them information, delivering food and beverages, and even dancing or carrying out easy jobs for amusement.

Agricultural Robots

Agricultural robots are specialized robots meant to help in a variety of agricultural jobs and to increase production, efficiency, and sustainability in the farming business. These robots use modern technology including sensors, GPS, computer vision, and artificial intelligence to do activities that were previously done by humans.

Here are a few examples of typical agricultural robots and their applications:

Harvesting Robots

These robots are meant to gather crops such as fruits, vegetables, and grains on their own. They employ sensors and computer vision to identify ripe crops before picking them using robotic arms or other systems. During harvest seasons, harvesting robots may dramatically cut labor costs and boost efficiency.

Weeding Robots

Weeding is a time-consuming activity in agriculture. Weeding robots identify and eliminate weeds without harming crops by using cameras and image recognition software. This minimizes the need for chemical pesticides and human wedding, making farming less harmful to the environment.

Planting Robots

Planting robots are meant to automate the planting process by putting seeds or seedlings at precise intervals in the soil. They frequently employ GPS and other positioning technology to ensure correct planting and consistent crop development.

Data Collection and Monitoring Robots

These robots are outfitted with a variety of sensors to monitor the health, growth, and environmental conditions of crops. They may gather information on soil moisture, nutritional levels, and insect prevalence. This information assists farmers in making sound decisions about irrigation, fertilization, and pest management.

Spraying and Fertilizer Robots

Robots can give tailored applications based on real-time data instead of employing huge machines to spray pesticides or fertilizers. This cuts down on chemical use and minimizes overspray.

Autonomous Tractors

These are upgraded versions of regular tractors that can run on their own. They employ GPS and mapping technologies to precisely explore fields, till the soil, and do other activities.

Robots for Sorting and Packaging

Robots can sort and package products depending on size, shape, and quality after harvesting. This automation expedites the post-harvest process while maintaining uniform product quality.

#artificialintelligence

Military Robots

Military robots are devices created for a variety of uses in the context of military operations. These robots are created to support and improve human troops' ability in a variety of activities, from logistics and warfare to reconnaissance and surveillance. By carrying out duties that are too risky, complicated, or time-consuming for human workers, military robots might offer strategic benefits.

Here are some typical military robot types and their uses:

UGVs (unmanned ground vehicles)

These are on-land operating robotic vehicles. They can be utilized for activities including explosive ordnance disposal (EOD), reconnaissance, surveillance, supply transfer, and in some circumstances, even combat operations.

UUVs, or unmanned underwater vehicles

These robots are employed for oceanographic data collection, mine detection and removal, submarine tracking, and underwater exploration. They can be classified as remotely operated vehicles (ROVs) or autonomous underwater vehicles (AUVs), among other categories.

Counter-Drone Systems

These robots are made to find, follow, and destroy adversarial drones. They are employed to safeguard delicate locations from possible drone attacks.

Platforms for remotely controlled weapons

Some military robots have armaments that enable them to engage targets at a distance. These platforms might be ground-based robots with guns or other weapons, or they could be armed drones.

Robotic reconnaissance and surveillance

Robots with cameras, sensors, and communication devices may collect information in real time from dangerous or hostile locations, improving situational awareness for military troops.

Robots for search and rescue

Robots can be used to search for survivors in hazardous situations like fallen buildings or treacherous terrain in disaster-stricken or conflict-affected countries.

Robots for logistics and supply

Robots can help in the transportation of supplies, ammunition, and equipment in hazardous situations when it may be harmful or difficult for humans to do so.

Robotic deminers

These robots are intended to find and get rid of explosives like landmines so that human deminers are less at risk.

Robots that assist in combat

Some robots are made to serve soldiers in hostile environments by carrying equipment, offering cover, or helping with casualty evacuation.

COMPONENTS OF ROBOTICS

Actuators

Actuators are a vital component in robotics that provide robots the ability to move, interact with their surroundings, and carry out various activities. Robotic systems need physical motion to carry out their tasks provided by actuators. Using actuators in robotics looks like this

Joint Actuators

The many joints that make up robotic arms and legs need an actuator to move them. Depending on the design and planned use of the robot, these actuators may be electric motors, hydraulic cylinders, or pneumatic cylinders. Robots can move their limbs precisely and flexibly thanks to joint actuators.

Gripper Actuators

Gripper Actuators are devices that are used to grip and move items. Robot grippers are opened and closed by gripper actuators, enabling them to take up, hold, and release items of diverse sizes and forms.

Wheel and Leg Actuators

Actuators are employed in mobile robots to regulate the action of wheels, tracks, or legs. These actuators control how the robot moves through its surroundings, whether on wheels, crawling on legs, or utilizing other locomotion methods.

Head and Camera Actuators

To examine their environment, some robots feature moveable heads or cameras. In this instance, actuators allow the robot to pan, tilt, and rotate its sensors to receive visual input from various angles.

Manipulator Actuators

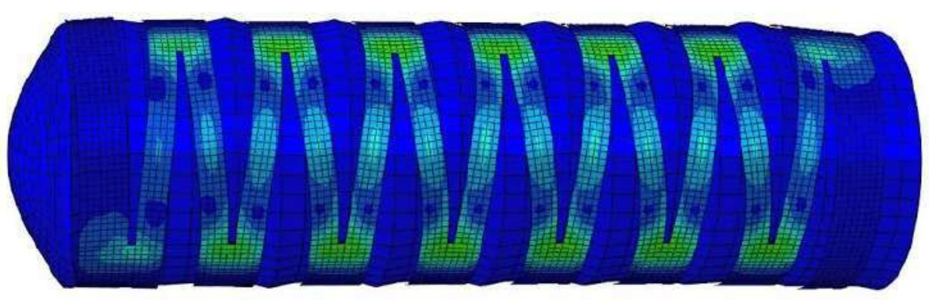
Actuators are used to control the numerous segments and joints of manipulator robots, such as those used in manufacturing or surgery. These actuators enable the manipulator to attain precise positions and orientations for executing tasks.

Actuated Sensors

Actuators are sometimes employed to physically manipulate sensors or probes. A robot with a touch sensor, for example, may utilize an actuator to push the sensor against an item to measure its qualities.

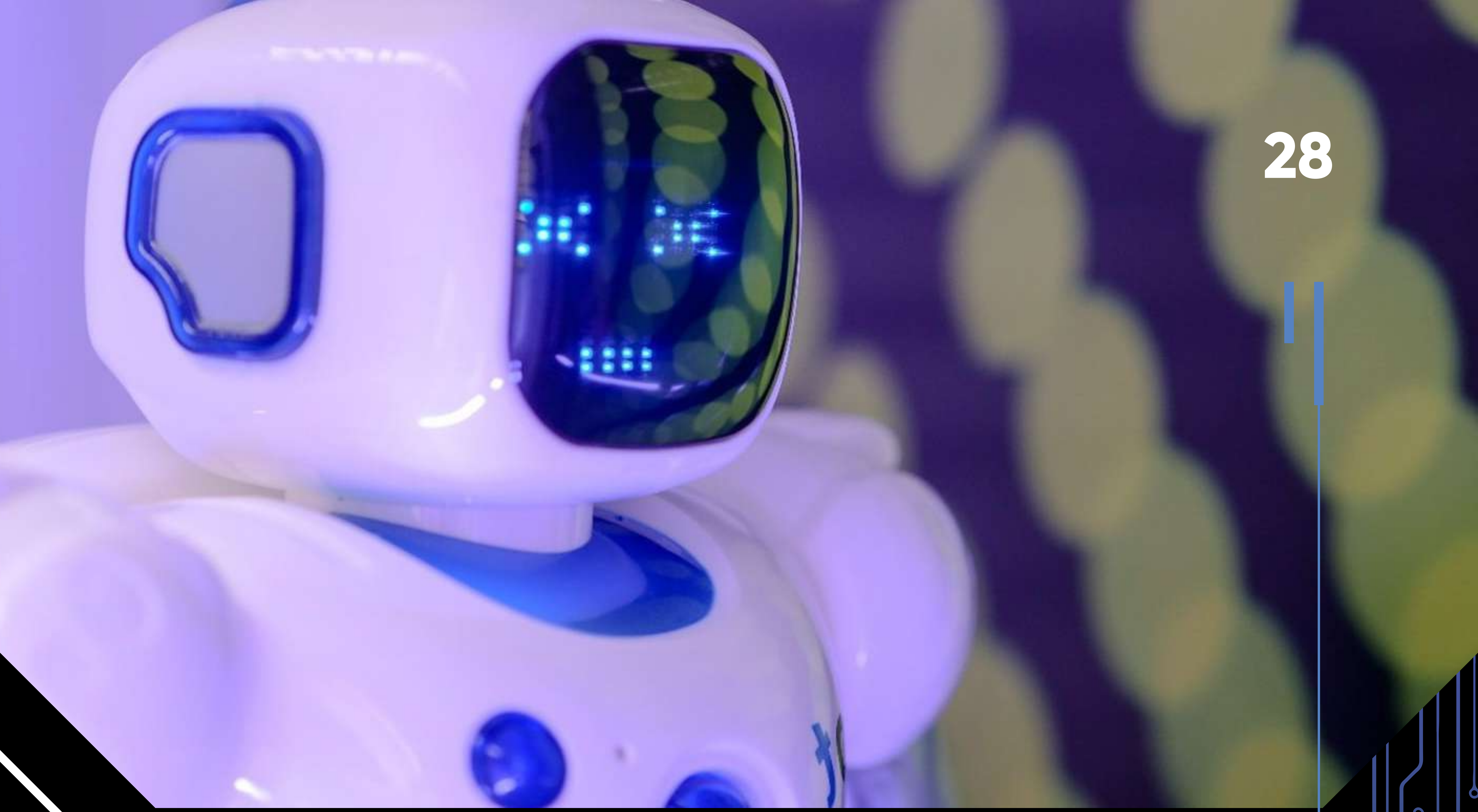
Artificial Muscle Actuators

In biomimetic robotics, artificial muscle actuators try to mimic natural muscle flexibility and movement. These actuators are constructed of materials that expand and contract in response to stimuli such as heat or electricity.



Actuation in Soft Robotics

To accomplish flexible and adaptive motions, soft robots frequently utilize fluidic or pneumatic actuators. Robots may interact securely with sensitive items and surroundings thanks to these actuators.



Sensors

Sensors are crucial parts of robotics and automation systems that provide robots the ability to detect and communicate with their surroundings. They offer information that robots may use as input to make decisions, traverse their environment, and carry out various activities.
Here are a few typical sensor types used in robotics:

Vision Sensors

Cameras and other vision sensors gather information about the environment's visual composition. Robots can recognize things, avoid obstacles, and carry out activities that call for visual awareness thanks to these sensors.

LiDAR (Light Detection and Ranging)

LiDAR (Light Detection and Ranging) sensors send out laser pulses and track how long it takes for the pulses to return after striking an object. By using this information, 3D maps of the robot's surroundings are produced, allowing for precise navigation and obstacle avoidance.

Ultrasonic Sensors

Ultrasonic sensors send out high-frequency sound waves and time how long it take for the waves to return after bouncing off things. These sensors are used for sensing closeness, detecting objects, and measuring distances.

Infrared Sensors

Infrared sensors pick up infrared light that things emit or reflect. They are employed for gesture recognition, heat source detection, and distance measuring.

Pressure Sensors

Pressure sensors, gauge the force exerted on a surface. To ensure effective grasp and control of items, they are included in robotic grippers and end effectors.

Temperature Sensors

Temperature sensors determine the temperature of an item or the air around it. They are utilized in operations like manufacturing or ecological surveillance where keeping track of temperature is crucial.

#robotics

Gas and Chemical Sensors

These devices are used to find certain gases or chemicals in the surroundings. They are utilized in procedures like ecological surveillance and gas leak monitoring.

Biochemical Sensors

In certain specialized applications, robots utilize biochemical sensors to identify biological markers, such as in surgical or diagnostic robots for the medical industry.

Touch Sensors

Touch sensors measure pressure or physical touch. Robots are given the capacity to perceive interactions with things or humans thanks to them.

#robotsensor

Control Systems

Robotics and automation are not complete without control systems, which are in charge of directing and controlling the actions of robots, devices, procedures, and other systems. These systems monitor inputs, make choices, and provide output commands to accomplish desired results using sensors, actuators, and algorithms. Different types of control systems exist, such as

Open-Loop Control Systems

In open-loop systems, control decisions are made by established directives without taking into account output feedback. Despite being straightforward, these systems cannot adapt to environmental changes or disruptions.

Closed-Loop (Feedback)

Closed-loop systems continually monitor the system's output and modify the control actions in response to the feedback from sensors. Despite interruptions or uncertainty, this enables more precise and reliable management.

PID (Proportional-Integral-Derivative)

The system error's proportional, integral, and derivative components—the discrepancy between the desired and actual values—are used to modify control actions in PID control, a typical feedback control approach. It is frequently employed for activities like regulating temperature and motor speed.

Model Predictive Control (MPC)

MPC makes use of a system's mathematical model to forecast its behavior and enhance control operations across a time horizon. Systems that are dynamic and complicated frequently employ this strategy.

Adaptive Control Systems

Adaptive control systems update their settings in response to changes in the system's behavior or surroundings. These systems can help you deal with uncertainties and fluctuations.

Hierarchical Control

Systems that use hierarchical control have numerous layers of control, from high-level decision-making to low-level motion control. Complex robotic systems often employ this strategy.

Distributed Control Systems

These systems provide for higher scalability and fault tolerance by distributing control responsibilities across several components or agents.

Motion Planning & Trajectory Generation

These systems create the courses and trajectories the robot should take to achieve a certain objective. They frequently consider things like kinematics, dynamics, and barriers.

Power Sources

Power sources are critical components that provide the energy needed to run robotic systems, electrical gadgets, equipment, and other technology. Selecting a suitable power source is critical in the context of robotics and automation to enable the dependable and efficient functioning of robotic systems. Here are some examples of frequent power sources used in robotics:

Power Grid

Robotic systems that are permanently installed can frequently be powered by the electrical power grid. This is typical in stationary robots and industrial automation.

Hydraulic Power

Hydraulic systems utilize pressurized fluid to create power for actuation in heavy-duty applications. Because of its tremendous force capabilities, hydraulic power is well-known in the construction and heavy machinery industries.

Pneumatic Systems

These systems employ compressed air to power actuators and generate motion. Despite being less popular than hydraulic power in robotics, pneumatic power is nevertheless employed in some applications because of its efficiency.

Fuel Cells

Using fuel cells, chemical energy from fuels like hydrogen may be converted into electrical energy. They provide longer operational times than conventional batteries and are frequently employed in

Solar Panels

Solar panels transform light from the sun into electricity, making them ideal for robotic systems that run outside or in isolated areas with limited access to power sources.

Tethered Power

Some robots can run constantly without the need for onboard batteries because they are tethered to a power source through a wire or other device. When prolonged operation is necessary, tethered power is frequently employed.

Kinetic Energy Harvesting

A few robotic systems are capable of producing electricity through movement. Robots can be powered by mechanical motion that is converted into electrical energy using kinetic energy harvesting devices.

CHAP # 4

ROBOT PROGRAMMING

Programming robots entails giving them instructions on how to carry out particular jobs. These directives direct robots to carry out a series of activities, motions, and choices to achieve different goals. Robot programming is essential for enabling robots to function autonomously in a variety of contexts. It can take the form of basic orders or complicated sequences of activities. Programmers can utilize techniques like offline programming, script-based coding, sensor-based control, pendant programming, and more to make robots do jobs precisely and effectively.

TYPES OF ROBOT PROGRAMMING

Lead-through Programming

Lead-through programming sometimes referred to as teach pendant programming or manual programming, is a technique for programming robots that involves instructing them physically to do the appropriate actions while holding a teach pendant in one hand. In this technique, the end effector or manipulator of the robot is manually moved through a series of actions, and the control system of the robot records and saves these movements as a program. The same set of motions may then be replicated automatically by saving and running this program
Lead-through programming often operates as follows:

Initial Teaching Phase

The operator moves the robot's arm, wrist, or end effector to the required positions and orientations by switching the robot into teaching mode. The operator can direct the robot's motions using the buttons, knobs, and joysticks that are normally found on the teach pendant.

Recording

The teach pendant records the locations, orientations, and motions of the robot's numerous joints or end effectors while the user maneuvers the machine. These noted locations produce a trajectory or path that the robot can afterward follow.

Editing and Monitoring

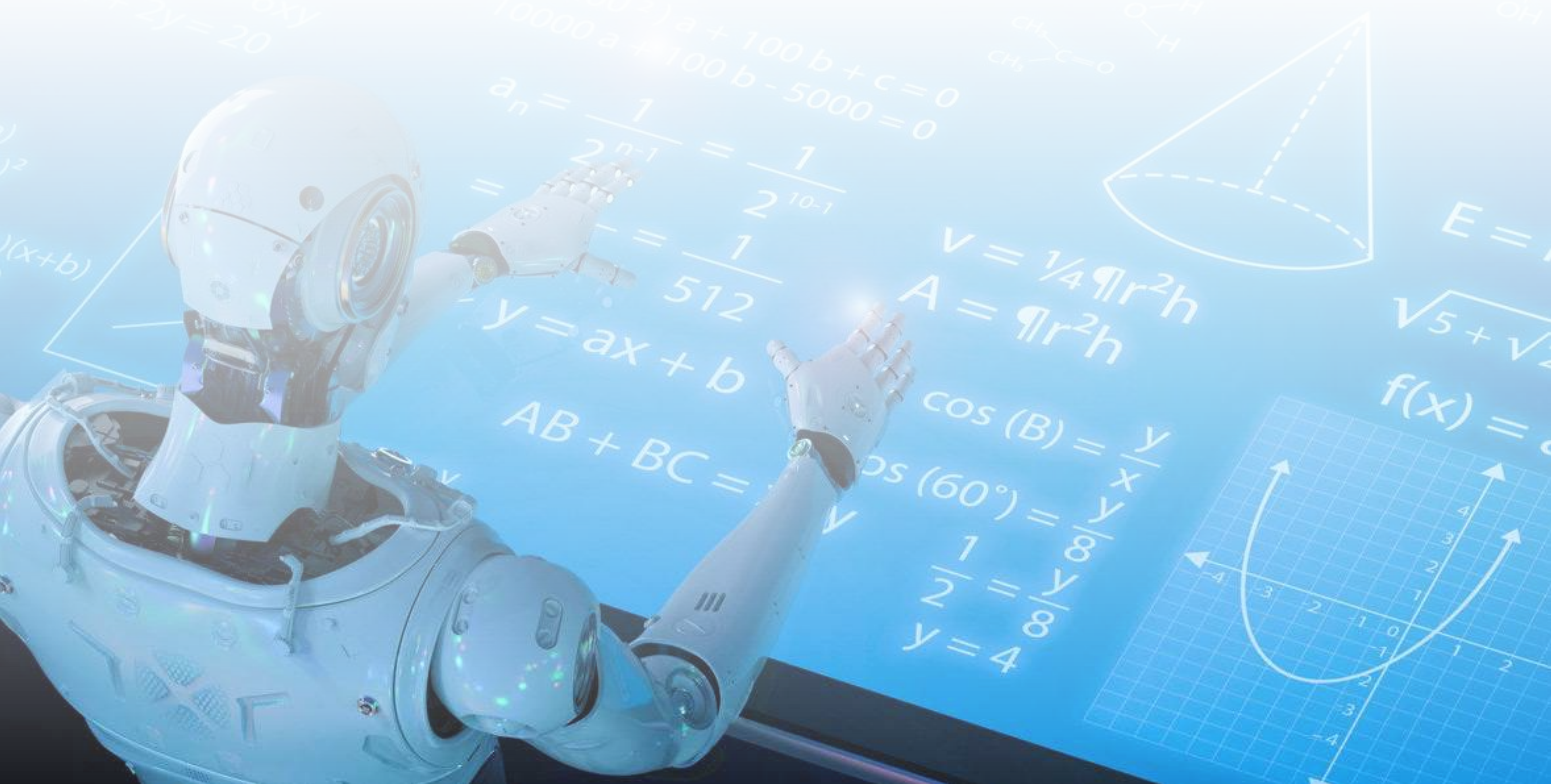
The recorded information is saved as a robot program once the operator has taught the robot the necessary motions. The movements in this program may be adjusted, the pace can be changed, and logic and decision-making processes can be added.

Playback

When necessary, the saved program can be run. The robot repeats the same actions on its own, following the same route or trajectory that was captured during the teaching phase.

For jobs that are challenging to directly program using code or where the environment and work circumstances might change, lead-through programming is frequently utilized. For early robot setup, prototype testing, and circumstances where real-time adaptation is crucial, it is very helpful.

Lead-through programming has the benefit of being simple, making it usable by people with little to no programming experience. For complicated jobs, it can take a while, and any program modifications can need reteaching the robot.



OFFLINE PROGRAMMING

Offline programming is a technique for programming robots that involves simulating robotic activities in a virtual environment, independent of the actual robot. Robot programs are created, tested, and optimized by programmers using specialized software rather than directly programming the robot itself while it is still in operation.
An overview of offline programming is provided below:

Virtual Environment

To generate a digital version of the real-world setup, programmers employ computer-aided design (CAD) models of the robot, its end effector, and the surrounding environment.

Simulation

In the virtual environment, the programmed actions are mimicked, allowing programmers to see how the robot would complete the job. Before running the program on the real robot, this simulation helps identify potential collisions, reachability concerns, and other faults.

Programming

Programmers specify the robot's motions, actions, and sequences in the virtual world using a user-friendly interface. This can include describing joint angles, pathways, trajectories, and object interaction.

Optimization

In the virtual environment, programmers may tweak parameters, pathways, and timings to improve the robot's performance, efficiency, and safety.

Verification

Programmers can use simulation to check if the robot's actions lead to the expected results. When the program is run on the actual robot, this minimizes downtime and the chance of mistakes.

Transfer of Program

The program may be transmitted to the actual robot for use after being tested in the virtual environment. This transfer might entail delivering commands to the robot's control system or exporting code.

INTRODUCTION TO POPULAR ROBOTICS PROGRAMMING LANGUAGES

Robotics programming languages are subsets of programming languages that are used to create, operate, and command robots. These languages are intended to make it easier to create robotic systems ranging from basic autonomous robots to sophisticated industrial automation operations.

ROS (Robotic Operating System)

ROS is a flexible framework for building robot software rather than a typical programming language. It offers libraries, tools, and conventions to assist developers in developing strong and flexible robotic applications. ROS supports a wide range of programming languages, including C++, Python, and others, enabling developers to construct components that communicate with one another in a distributed system.

Python

Python is a flexible and frequently used robotics programming language. Its ease of use and readability make it a popular choice for robotics beginners and researchers. Python packages like PyRobot and ROSpy, for example, provide interfaces for operating robots and interacting with ROS.

C++

C++ is well-known for its speed and is often used for programming industrial robots and real-time control systems. C++ is supported by several robotic systems and software frameworks, including ROS.

Java

Because of its platform neutrality and object-oriented programming skills, Java is utilized in robotics. The LeJOS framework, for example, enables Java programming of Lego Mindstorms robots.

Blockly

Blockly is a visual programming language that is frequently used to teach novices programming topics, including robotics. It employs a block-based interface in which users may develop programs by dragging and dropping code chunks.

LabVIEW

Particularly in industrial and research environments, LabVIEW is a graphical programming language used for creating and managing robotic systems. The dataflow programming model used by it is well-known.

URScript

Collaborative robots (cobots) from Universal Robots are programmed using URScript, a proprietary language. It is employed to design unique jobs and control patterns for these robots.

Scratch

Scratch is another visual programming language that is used to educate novices on how to code. It is used in robotics education to teach basic coding principles via a user-friendly interface.

ROBOTIC SYSTEMS

ROBOTIC ARM SYSTEMS

Components of Robotic Arm Systems

Joints

The joints that make up robotic arms each provide the arm's movement a degree of freedom (DOF). Revolute (rotational), prismatic (linear), and spherical (ball-and-socket) joints are examples of common joint types.

Links

Links are the sections separating joints; they control the arm's reach and flexibility. The type of link needed will depend on the application.

End-Effector

The tool or apparatus at the tip of the robotic arm that interacts with the outside world is known as an end-effector. It might be a camera, a gripper, a welding instrument, or any other tool required to carry out a particular operation.

Actuators

Actuators are in charge of causing each joint to move. Depending on the desired precision, speed, and payload capacity, they may be electric, hydraulic, pneumatic, or even a mix of these.

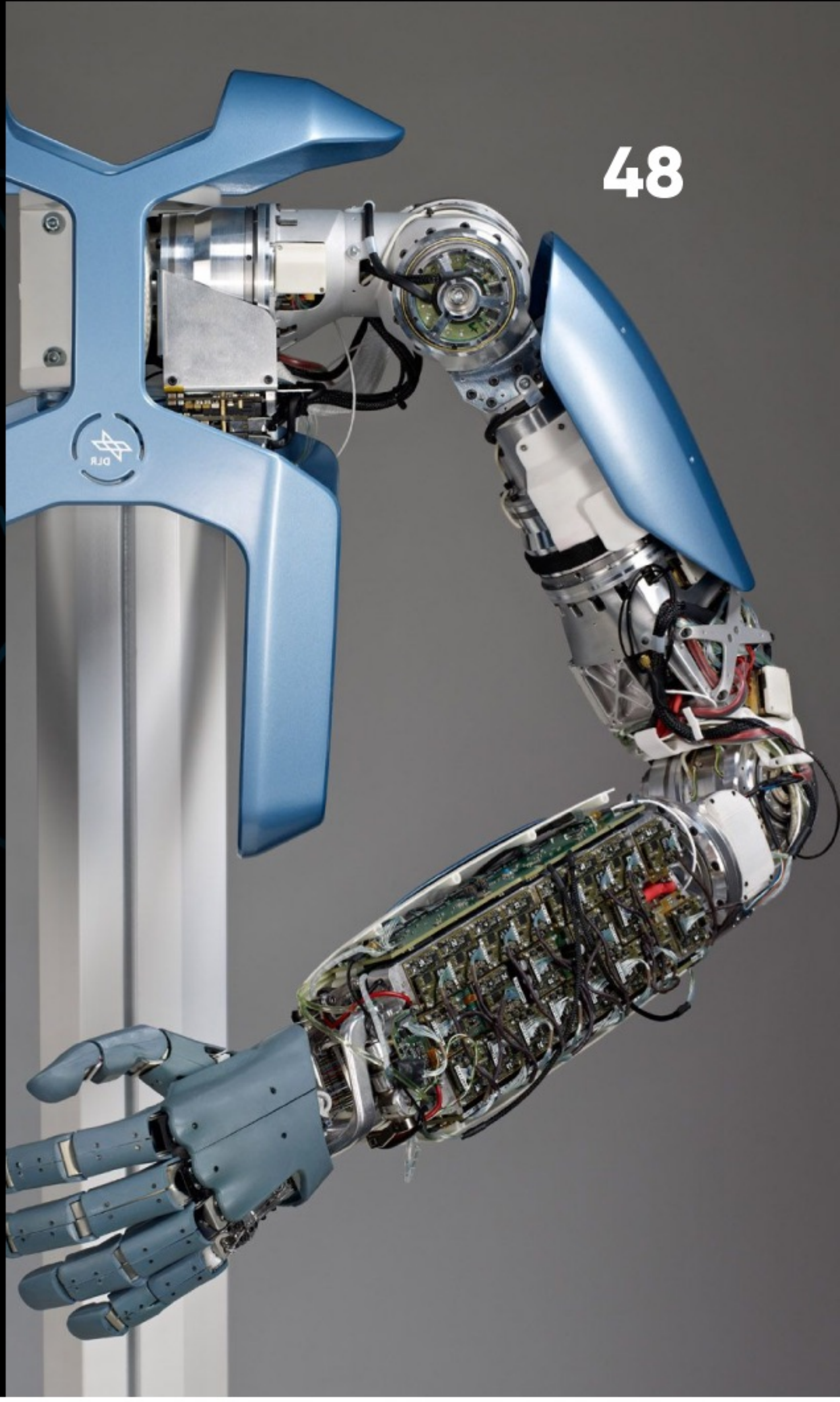
Sensors

By giving the robotic arm input, sensors help it detect its surroundings, alter its motions, and interact with objects. Cameras, force/torque sensors, encoders, and proximity sensors are examples of common sensors.

Controller

The robotic arm system's controller serves as its brain. To carry out precise motions and duties, it analyses sensor data and creates control signals for the actuators.

Applications of Robotic Arm Systems



Manufacturing

Manufacturing uses robotic arms extensively for jobs such as welding, painting, material handling, and assembling. They can do repeated jobs with great precision and speed, increasing manufacturing efficiency.

Pick and Place

In warehouses and distribution centers, robotic arms are used to automate the act of picking up products from one spot and depositing them in another. This is quite prevalent in e-commerce order fulfillment.

Surgery

In minimally invasive procedures, medical robotic arms are employed to give surgeons increased precision and dexterity, minimizing patient trauma and recovery time.

Laboratory Automation

Robotic arms are employed in research facilities to automate processes such as sample handling, pipetting, and experimentation.

Aerospace and Space Exploration

In space missions, robotic arms are used to carry cargo, deploy experiments, and perform maintenance on spacecraft and space stations.

Service Robots

Robotic arms are incorporated into service robots that are used for chores like cooking, cleaning the house, and helping disabled persons.

Entertainment and Arts

Robotic arms are utilized in entertainment programs, creative installations, and even special effects shots in motion pictures.

Autonomous Vehicles

Autonomous vehicles, also known as self-driving cars or driverless cars, are autos that can drive themselves and function without a driver. They are fitted with sophisticated sensors, artificial intelligence, and processing systems.

The following are some essential elements and technologies used in autonomous vehicles:

Sensors

Autonomous cars are fitted with a variety of sensors, including radar, cameras, ultrasonic sensors, lidar (light detection and ranging), and more. These sensors collect information about the immediate environment of the car, such as other cars, pedestrians, road conditions, and barriers.

AI and Machine Learning

AI algorithms analyze the sensor data to make judgments regarding vehicle control and navigation in real time. The car can learn from many scenarios and adjust to diverse driving circumstances thanks to machine learning technology.

Control Systems

To function safely and effectively, autonomous vehicles rely on control systems. Based on the AI's choices, these systems manage acceleration, braking, steering, and other vehicle operations.

Mapping and Localization

High-resolution maps are required for autonomous cars to determine their precise location on the road. Localization technology, which frequently employs GPS, sensor fusion, and map data, assists the vehicle in properly positioning itself.

Communication

Autonomous cars can interact with one another and with infrastructure (vehicle-to-vehicle or V2V communication). This improves safety and traffic flow by exchanging information about road conditions and other pertinent data.

Automation Levels

The Society of Automotive Engineers (SAE) has identified six levels of driving automation, ranging from Level 0 (no automation) to Level 5 (full automation). Each level denotes a varying level of human engagement in the driving process.

Regulations and Challenges

The deployment of self-driving cars creates legal, regulatory, and ethical issues. Governments and industry partners are collaborating to develop safety standards and rules for testing and deployment of these cars on public roads.

Drones

Unmanned aerial vehicles, or drones, are adaptable robotic aircraft that can fly without a human pilot on board. They can carry out a variety of duties thanks to their array of sensors, cameras, and communication systems.

#dronerobots

TYPES OF DRONES

Consumer Drones

These are readily accessible for use in leisure activities, aerial photography, and filming. Remote controls or mobile devices are frequently used to operate them.

Commercial Drones

Commercial drones are made for a variety of businesses, including filmmaking, surveying, agriculture, and construction. They have cutting-edge sensors and capabilities designed for specific uses.

Military Drones

Unmanned Combat Aerial Vehicles (UCAVs), sometimes referred to as military drones, are utilized in military situations for offensive activities such as reconnaissance and surveillance.

Drone Delivery

Businesses are looking into using drones to deliver products to consumers' doorsteps, particularly in rural areas.

Autonomous Drones

Drones that can travel and decide for themselves utilizing artificial intelligence and sophisticated algorithms are referred to as autonomous drones.

APPLICATIONS OF DRONES

Aerial Photography and Videography

Drones with high-end cameras are utilized for beautiful aerial photography and videography for use in cinema, advertising, and other applications.

Agriculture

Drones may be used to precisely apply fertilizer or pesticides, check crop health, and determine irrigation demands.

Search and Rescue

Drones that are equipped with infrared cameras and other sensors make it easier to find missing people or survivors in hard-to-reach places.

Infrastructure Inspection

Without endangering human inspectors, drones may examine bridges, electricity lines, pipelines, and other infrastructure to find problems.

Environmental Monitoring

Drones are used for environmental monitoring to keep an eye on ecosystems, animal populations, and the effects of natural disasters.

Scientific Research

Drones are used by scientists to gather data in challenging or remote locations for a variety of projects.

EXOSKELETONS

Exoskeletons are wearable robotic devices created to supplement or improve the wearer's physical capabilities. These accessories can offer aid with support, strength, and movement and are normally worn externally, much like a suit. Exoskeletons are used in a variety of professions, including medicine, business, the military, and rehabilitation.

Types of Exoskeletons

Powered Exoskeletons

Powered exoskeletons have motors and actuators to let the user move more easily. They can improve the wearer's mobility, enable heavy lifting, and increase strength.

Passive Exoskeletons

These exoskeletons employ mechanical structures and materials to disperse stresses and lessen the strain on the wearer's body rather than powered components.

Applications of Exoskeleton

Medical Rehabilitation

Exoskeletons are utilized in physical therapy and rehabilitation to assist patients in regaining movement after accidents or surgery. They can help with muscle building and relearning old walking patterns.

Industrial Use

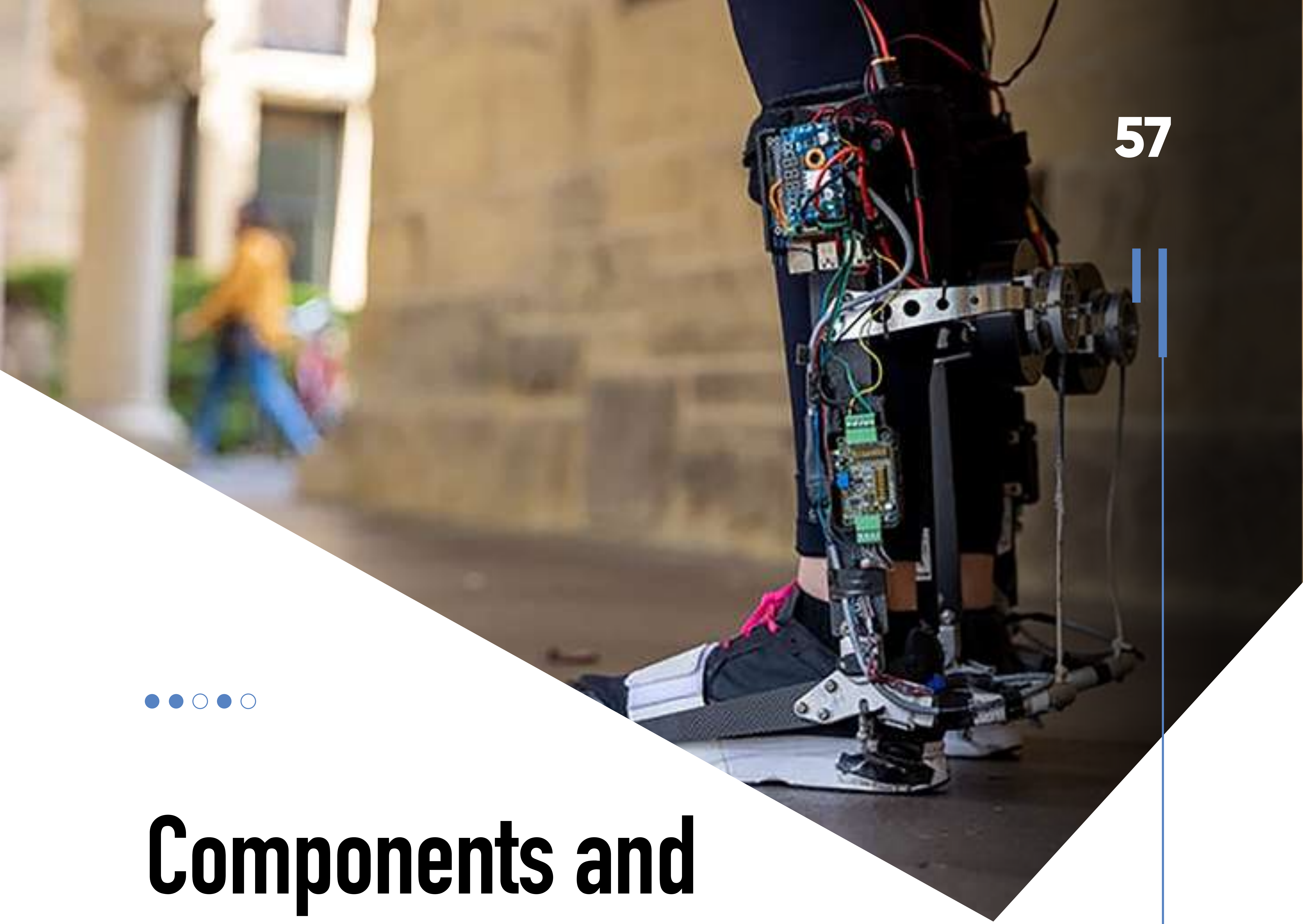
Exoskeletons can improve safety and productivity by reducing worker fatigue and strain in sectors like manufacturing and construction.

Military and Defense

Exoskeletons for the military can help soldiers carry huge loads more safely and effectively while also increasing their strength and endurance.

Agriculture and Logistics

Agriculture and logistics are two physically demanding professions that exoskeletons can assist with by easing the physical strain of repeated effort.



Components and Technologies

Actuators and Motors

Powered exoskeletons help with joint motions by using actuators and motors.

Sensors

The exoskeleton can monitor the wearer's motions and modify support using sensors like force sensors and accelerometers.

Control Systems

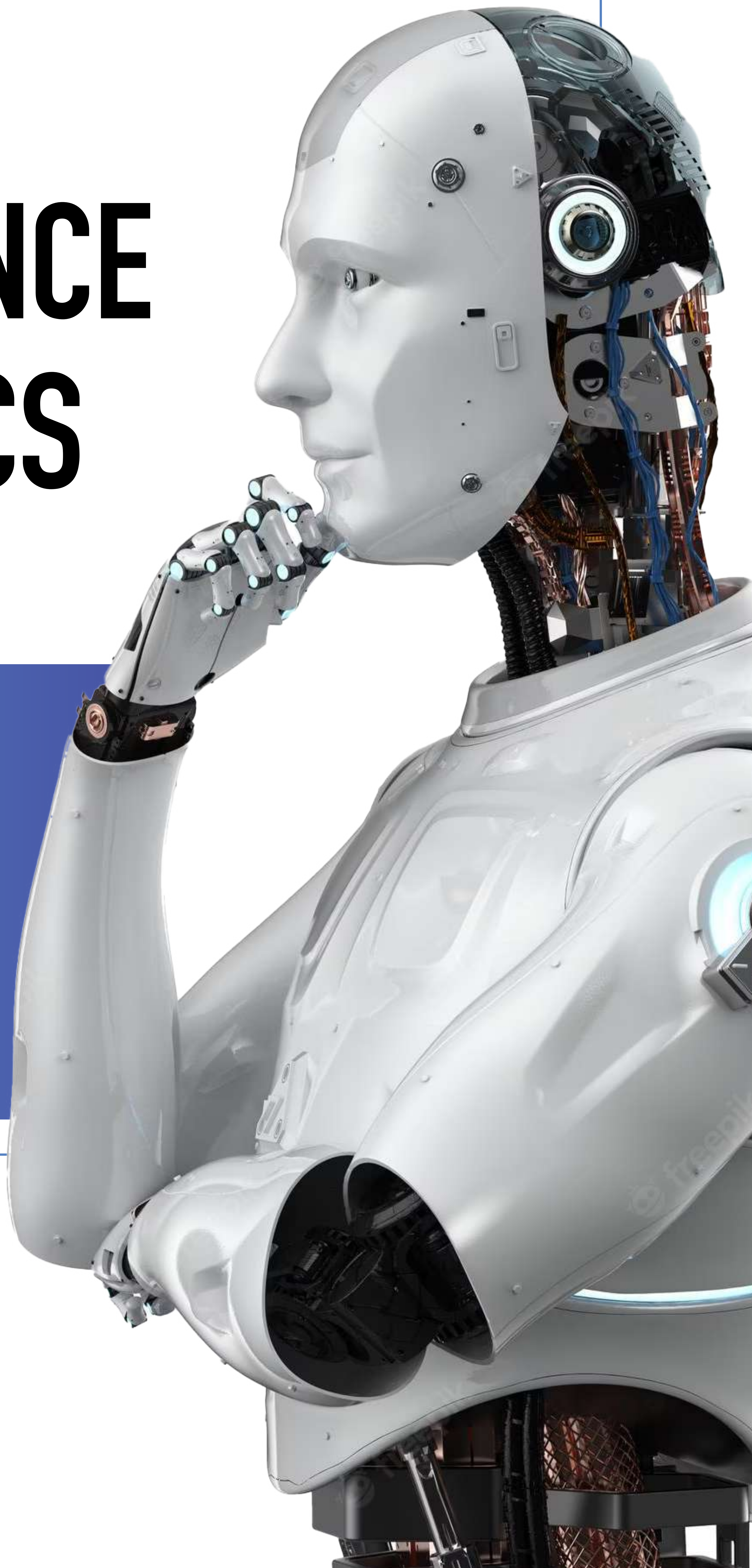
Control algorithms are used by exoskeletons to evaluate sensor data and deliver appropriate amounts of support.

Materials

Exoskeleton frames are made of lightweight and sturdy materials that provide the wearer's comfort and flexibility.

CHAP #6

ARTIFICIAL INTELLIGENCE IN ROBOTICS



Artificial intelligence (AI) is playing an increasingly important role in robotics, boosting the capabilities of robotic systems and allowing them to execute difficult tasks with greater autonomy, flexibility, and intelligence. Here are some of the important functions that AI plays in robotics:

#artificialintelligence

Perception and Sensing

To recognize and comprehend the robot's environment, AI-powered algorithms process data from multiple sensors. Computer vision techniques allow robots to recognize objects, people, barriers, and terrain characteristics, which is necessary for navigation and interaction.

Localization and Mapping

Artificial intelligence (AI) assists robots in creating accurate maps of their environment and estimating their position within these maps. This is critical for path planning and navigation. Simultaneous Localization and Mapping (SLAM) algorithms generate maps and establish the robot's location in real-time using sensor data.

Navigation and Path Planning

AI-powered navigation algorithms enable robots to design the best pathways to a destination while avoiding obstacles. These algorithms consider the kinematics of the robot, the surroundings, and dynamic barriers.

Machine Learning

Deep learning and other machine learning approaches enable robots to learn from data and improve their performance over time. By rewarding the right behaviors, reinforcement learning may be used to educate robots to execute tasks.

Human-Robot Interaction

AI improves robots' capacity to recognize and respond to human gestures, voices, and orders. Natural language processing (NLP) allows robots to comprehend and synthesize human language, making communication easier.

Predictive Maintenance

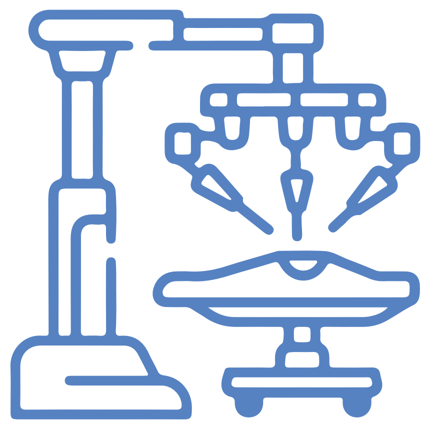
By analyzing sensor data, AI can forecast when a robot's components will fail, assisting in the prevention of failures and improving dependability.

Examples of AI-driven Robots

By analyzing sensor data, AI can forecast when a robot's components will fail, assisting in the prevention of failures and improving dependability.

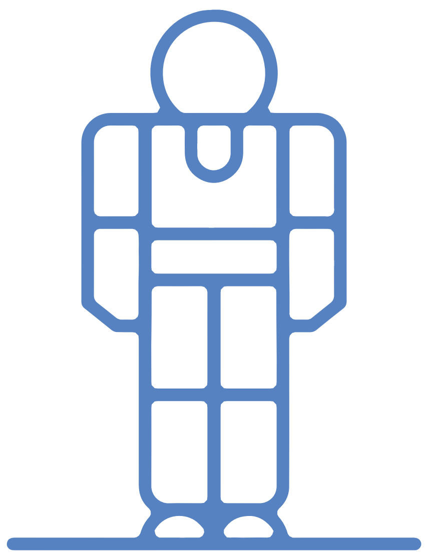
Boston Dynamics' Spot

A flexible quadruped robot with sophisticated sensors and cameras capable of inspection, data collecting, and remote operation. It is employed in a variety of industries, including construction, agriculture, and public safety.



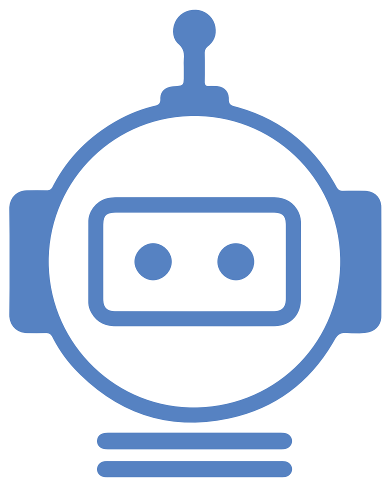
Robotic Surgical Systems

These systems aid surgeons in minimally invasive treatments with very accurate motions. They provide increased dexterity and visualization, resulting in better surgical results.



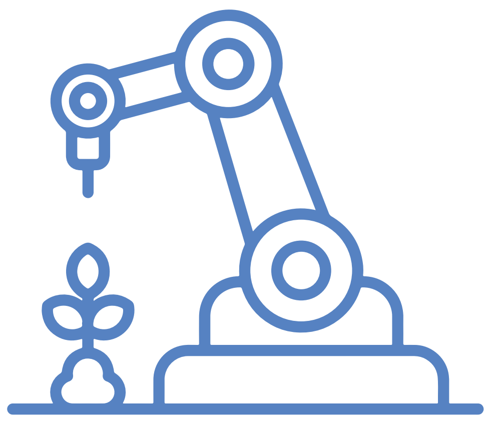
ASIMO by Honda

Although development was halted, ASIMO was a humanoid robot meant to communicate with humans, navigate complicated surroundings, and perform duties such as pouring beverages and carrying goods.



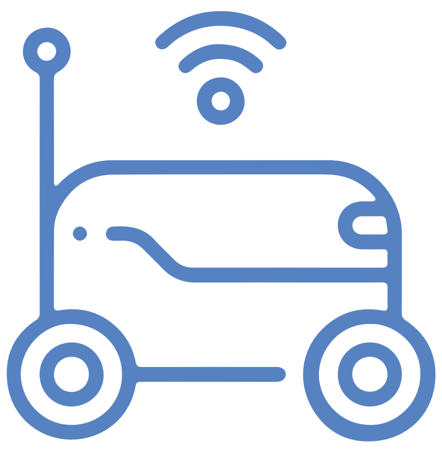
Amazon Robotics

These robots are employed in Amazon's warehouses to do duties such as sorting, inventory movement, and packing. They collaborate with human personnel to improve fulfillment efficiency.



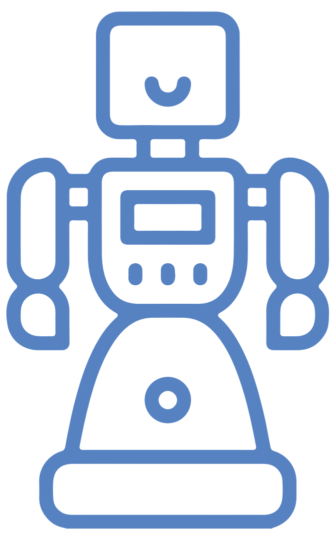
Agricultural Robots

A variety of robots are being developed to aid farmers with duties such as planting, harvesting, and crop monitoring. They utilize artificial intelligence and sensors to optimize resource utilization and crop productivity.



Delivery Robots

Some businesses are testing autonomous delivery robots that can convey products over short distances, minimizing the requirement for human delivery employees.



Social Companion Robots

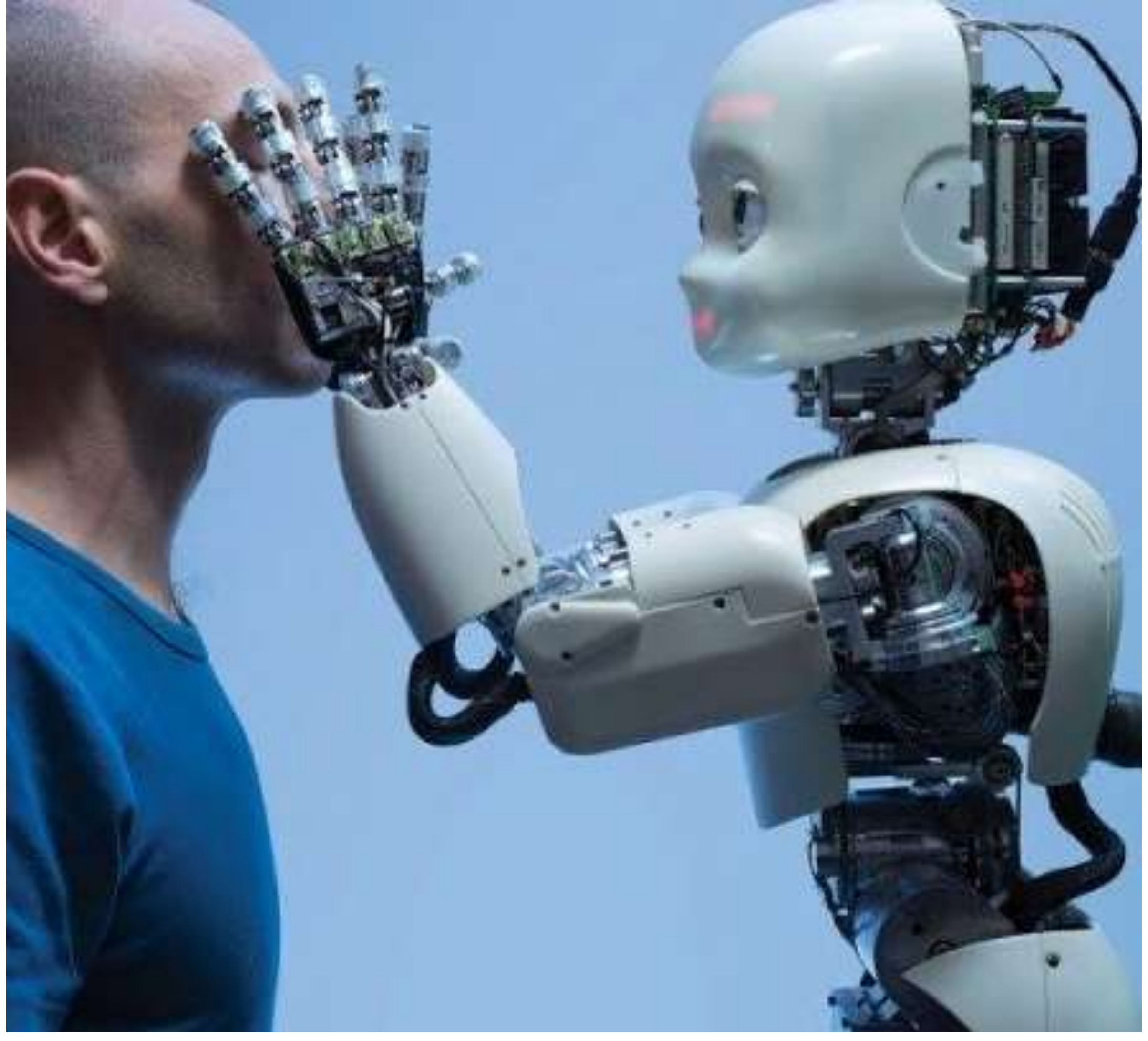
These robots are intended to give companionship and help to humans, notably the elderly or those with impairments. They may hold discussions, remind users to take their medicine and provide emotional support.

CHAP #7

ETHICS IN ROBOTICS

Ethical Considerations when Designing and Deploying Robots

Designing and deploying robots involves several ethical concerns that must be carefully considered. Consider the following crucial points.



Security

Human and environmental safety should be prioritized. Robots should be built to reduce the possibility of danger and injury to both users and bystanders.

Transparency

It is critical to be open about robot capabilities and limits. To minimize excessive expectations, users should have a clear grasp of what the robot can and cannot accomplish.

Accountability

Determine who will be held accountable if something goes wrong. This includes both legal and financial responsibility for any damages or problems produced by the robot.

Bias and Fairness

AI systems can pick up biases from their training data, which can lead to unfair or discriminating behavior. Robots should be carefully monitored to ensure that they do not propagate or magnify prejudices.

Private

Robots with cameras, sensors, and microphones have the potential to intrude on people's privacy. Privacy precautions and processes for gaining consent should be included in the design.

Job Displacement

In some industries, automation, and robots may result in employment loss. Mitigating the negative impact on workers should be considered while deploying robots.

Data Security

Robots can acquire and retain sensitive data. Ascertain that data is secured and safe and that user consent is sought before collecting data.

Human Control and Autonomy

Determine the amount of autonomy that is suitable for the robot. There should be a balance between human control and robot autonomy, especially when making ethical judgments.

Regulations and Standards

Speak up in support of ethical norms, regulations, and industry standards that encourage responsible robot design and deployment.

Job Displacement and the Role of Robots in Society

Job displacement and the role of robots in society are interrelated themes that have received a lot of attention as automation and robotics progress. Here's a more in-depth look at these topics:.

Job Displacement

Job displacement occurs when humans are displaced by machines, robots, or automation systems to do jobs that were previously performed by humans. It has both short-term and long-term consequences for the labor and the economy:

Short-term Disruption

When automation is implemented, there may be a short-term disruption when employees lose their jobs and must seek new ones.

Skills Mismatch

Automation may need a skill set that differs from that of many displaced workers, resulting in a mismatch between available positions and workers' credentials.

Industry-Specific Impact

Due to the repetitive and routine nature of their work, certain industries, such as manufacturing, shipping, and customer service, are especially vulnerable to job displacement.

Economic Impact

In the near term, job displacement might result in lower income levels, higher unemployment rates, and economic inequality.

Role of Robots in Society

Robots' impact on society is varied and extends beyond job loss. Robots can fulfill a variety of critical roles:

Improving Productivity

Robots can perform jobs with great accuracy and efficiency, resulting in higher overall productivity in industries.

New employment possibilities

While automation may result in employment losses, it may also result in new career possibilities in domains such as robotics development, maintenance, programming, and artificial intelligence (AI).

Economic Growth

The use of robots may drive economic growth by spurring innovation, improving manufacturing processes, and opening up new markets.

Complex and Dangerous Tasks

Robots may be deployed in dangerous or difficult-to-manage areas, such as disaster zones or deep-sea research.

Assistance and Companionship

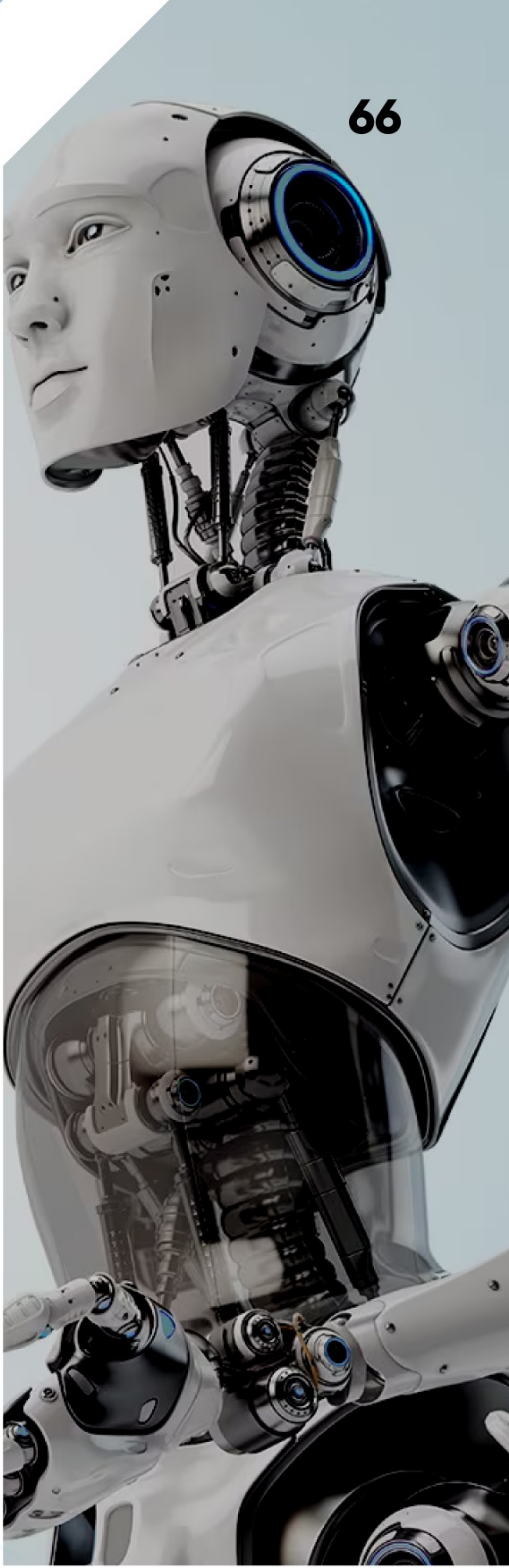
Robots can help the elderly and individuals with disabilities by improving their quality of life. They can also provide emotional support and company.

Education and Research

Robots may be used in education and research to help in learning, conduct experiments, and explore new scientific and technological boundaries.

C H A P # 8

FUTURE OF ROBOTICS



Predicted trends in Robotics

Predicting particular robotics trends can be difficult, but as of my most recent knowledge update in September 2021, there were numerous general trends and areas of development gaining traction in the field of robotics. Remember that progress in this subject is rapid and continuing, so these tendencies may have evolved further since then. Here are some predictions about future trends:

AI and Machine Learning Integration

To improve robot autonomy, adaptability, and decision-making skills, robotics is progressively incorporating AI and machine learning approaches. This includes enhanced motion planning, improved perceptual systems, and the capacity to pick up on and adapt to novel situations.

Collaborative and Soft Robotics

Robots created to collaborate with people are becoming increasingly commonplace. Robots may interact with their environment more securely and intuitively thanks to soft robotics, which uses flexible and malleable materials.

Industry 4.0 and Automation

The industrial industry keeps implementing robots to boost automation and productivity. This includes "cobots," or robots that collaborate with humans while working side by side.

Environmental and Disaster Response Robotics

Robots are utilized for jobs including monitoring the environment, responding to disasters, and handling dangerous materials. These machines can enter places that are too risky for people to enter.

Human-Robot Interaction

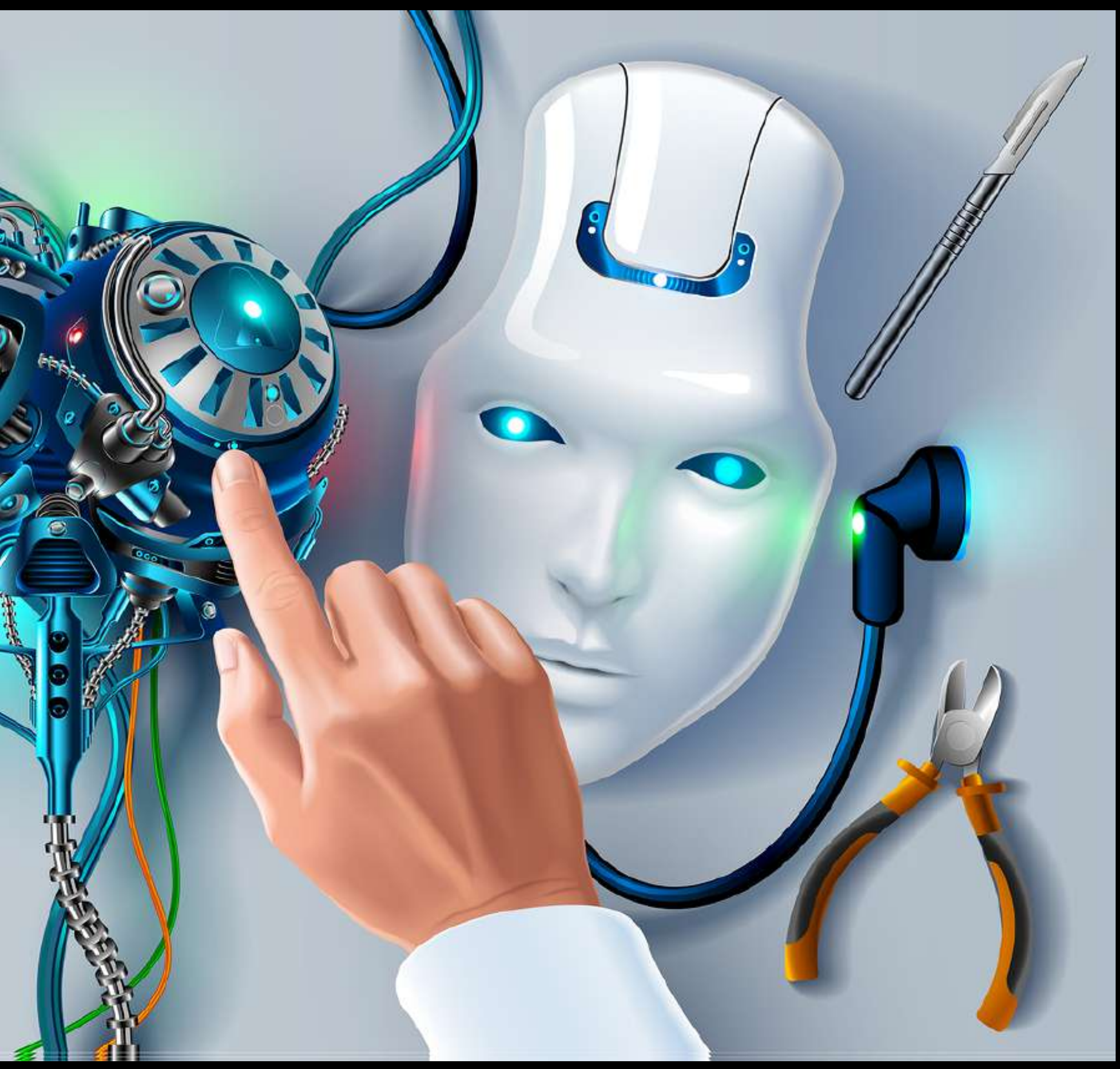
As robots grow more pervasive in our daily lives, so does our interaction. Interaction between humans and robots is still being developed in natural language processing, gesture recognition, and emotional comprehension.

Ethics and Rules

As robots grow more intelligent and autonomous, questions about ethics, safety, and rules are becoming more crucial. A crucial factor is ensuring that robots are created and used ethically.

Autonomous Vehicles and Drones

Self-driving automobiles, delivery drones, and autonomous aerial vehicles are all in the works. These technologies will have a tremendous influence on transportation, logistics, and possibly urban planning.



The Role of Robotics in Shaping the Future

Robotics is having a transformational impact on the future of many industries and elements of human existence. As technology advances, robots have a major impact on society, the economy, and our daily lives:

Automation and Workforce

Automation and robotics are transforming industries by simplifying operations, eliminating mistakes, and enhancing efficiency. While this may result in job displacement in some industries, it also opens up new potential for people to engage in more creative and high-value work. Workplaces are becoming more collaborative, with people and machines working together.

Healthcare and Medicine

Robotics are allowing for more accurate and minimally invasive surgical operations, resulting in shorter recovery periods and lower risks. Robots can help with duties including diagnostics, rehabilitation, and patient care. Telemedicine and remote surgery are becoming more possible because of advances in robotic technology.

Agriculture and Food Production

Precision farming techniques are being used by agricultural robots to improve crop productivity and resource utilization. They can also help to alleviate agricultural labor shortages and lessen the demand for toxic pesticides and herbicides.

Logistics and Supply Chain

By automating storage, sorting, packing, and delivery activities, robots are changing logistics. This has the potential to improve the efficiency and accessibility of e-commerce by lowering delivery times and costs.

Industry

Industry 4.0 entails the use of robots, the Internet of Things (IoT), and artificial intelligence in industrial operations. As a result, smart factories will be able to react to changing needs, optimize output, and decrease waste.

Exploration and Research

Robots are being utilized to investigate regions that people find too risky or inaccessible, such as undersea research, space missions, and disaster-stricken areas. They give useful information and insights while minimizing hazards.

Education and Skill Development

Robotics is becoming more integrated into the school curriculum to teach programming, problem-solving, and engineering abilities. Experience with robots can help students prepare for future employment in technology and innovation.

#robotics

PICTURES SOURCE LINKS

- https://www.istockphoto.com/photo/human-like-a-robot-in-a-pensive-posture-gm1354827837-429476357?phrase=robot
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