2025 Edition

Robotics

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	low	medium	high
Impact			▬
Complexity		●	

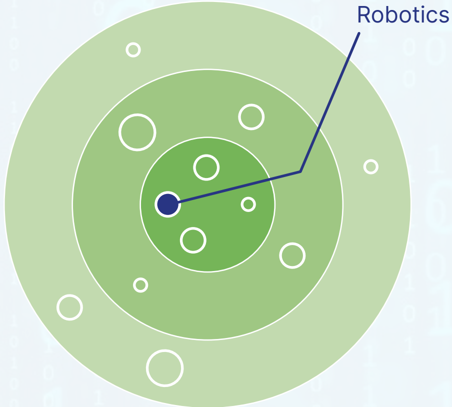
1 INTRODUCTION

Purpose

Robotics is the interdisciplinary field focused on designing and programming machines (robots) to perform tasks autonomously or semi-autonomously using components like sensors, actuators and AI-driven control systems. It spans applications from manufacturing and healthcare to exploration and personal assistance, with robots varying in autonomy, form and function.

Key benefits

Robots offer fundamental advantages such as the automation of processes and high precision in task execution, leading to increased efficiency and reduced error rates.



2 KEY CONCEPTS

Fundamental principles

The fundamental principles of robotics involve mechanics for structural design and movement, electronics for powering and connecting components, control systems for processing sensor data and directing actions, and software engineering for programming the robot's behaviour and decision making.

Terminology

In robotics terminology, actuators drive movement, sensors gather environmental data, end effectors perform specific tasks or manipulate objects, kinematics deals with the motion and positions of the robot's parts, and path planning determines the optimal route for the robot to achieve its goals.

The Three Laws of Robotics

1 A robot may not injure a human being or, through inaction, allow a human being to be harmed.
2 A robot must obey orders given to it by human beings except where such orders would conflict with the First Law.
3 A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

3 POPULAR TOOLS AND FRAMEWORKS

Primary tools

- ROS (Robot Operating System): an open-source framework for writing robot software.
- Gazebo: a simulation tool that integrates with ROS.
- Arduino: a cost-efficient hardware platform for building robots and control systems.

Comparison

- ROS vs Proprietary Systems: flexibility, community support, cost.
- Gazebo (free) vs V-REP simulation tool: simulation capabilities, ease of use, integration options.

4 APPLICATIONS

Industry use cases

- **Manufacturing:** automated assembly lines, precision welding.
  > Best Practice: Welding Robots.
- **Healthcare:** surgical robots, rehabilitation devices
  > Best Practice: Da Vinci Surgery.
- **Logistics:** autonomous guided vehicles (AGVs), warehouse automation.
  > Best Practice: Amazon.

Practical examples

- Panda: universal, low-cost, robotic automation tool.
- AnyMal: robust, autonomous, agile robot for inspection and exploration.
- RoboNaut: dexterous humanoid robot working side by side with humans in space.

Three Laws of Robotics

Source: www.researchgate.net
(Isaac Asimov's "Three Laws of Robotics", 1940)

5 IMPLEMENTATION INSIGHTS

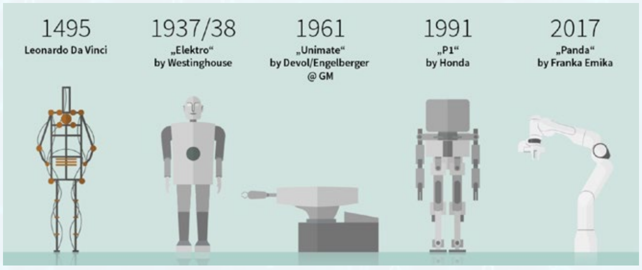
Best practices and tips

- **Modular Design:** ensuring components can be easily replaced or upgraded.
- **Robust Testing:** simulating and testing in various conditions.
- **Focus on Safety:** always integrating safety protocols to protect humans working alongside robots, especially in industrial environments. Using sensors, guards and emergency stop features to ensure safe operation.

Common challenges

- **Sensor Noise:** filtering and interpreting data accurately.
- **Power Management:** ensuring adequate power supply for all components.
- **Navigation and Localisation:** robots must accurately determine their position and navigate in complex, dynamic environments, especially in GPS-denied areas.

History of Robotics



Source: www.infineon.com

6 KEY TRENDS AND PREDICTIONS

Top milestones in Robotics

- **1961:** Unimate marked the first industrial robot used in manufacturing, revolutionising automation.
- **1991:** P1 (later ASIMO) by Honda showcased advanced humanoid robotics with complex mobility and interaction.
- **2017:** Panda by Franka Emika as first low-cost industrial robot.

Current trends

- **Collaborative Robots ('Cobots'):** robots working alongside humans.
- **AI integration:** enhancing robot intelligence and decision making.
- **Humanoid robots:** development of robots that mimic human movement and behaviour, such as Tesla's Optimus and Boston Dynamics' Atlas, aimed at assisting in complex tasks and human environments.

Future predictions

- **Swarm Robotics:** multiple robots coordinating as a single system.
- **Soft Robotics:** flexible robots mimicking natural organisms.
- **Human-Robot Collaboration:** collaborative robots (cobots) can safely interact with human workers.

7 KEY RESOURCES AND MOST HELPFUL LINKS

Websites and blogs

- **EEE Spectrum Robotics Blog:** latest news and advancements.
- **RobotShop Blog:** reviews and tutorials on various robotics components.
- **ROBOTICS:** engineering and automation of robots.

Online courses

- **RobotAcademy:** offers masterclasses, single lessons and online courses.
- **The Construct:** Python3 for Robotics.
- **FutureLearn:** Begin Robotics by the University of Reading.

Communities and forums

- **ROS Discourse:** discussions and support for ROS users.
- **Reddit:** r/robotics for general robotics discussions.
- **GitHub:** repositories and collaborative projects.

8 GLOSSARY

Common terms and definitions

- **Actuators:** components that cause movement in robots.
- **Sensors:** devices that detect changes in the environment.
- **End Effectors:** tools attached to the end of a robotic arm.
- **Kinematics:** study of motion without considering forces.
- **Path Planning:** algorithmic process to determine a path for the robot to follow.

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