Topic 1: Introduction to Robotics and Internet of Things

Fig. 1: Asimo, robokind ambassador (HONDA).

Learning Objectives:

After completing this topic, you will be able to define the main characteristics of robotics and the Internet of Things (IoT), give an overview of the application areas of these technologies, reflect on their benefits and challenges and know the historical background.

Table of Content:

Student activities before starting

Create an experience report about IoT and Robotics in your personal environment: Investigate the importance of Internet of Things and Robotics in your environment. For example, observe where these technologies are used in studies, at work, at home, in public spaces etc. Examine what purpose it is used for and what benefits are generated. Which of these areas of application did affect you directly? What advantages and disadvantages do you see personally and in general?

Lesson 1.1 Robotics: Definition, Benefits and Challenges

What is a robot?

Robots are mechanical or virtual systems capable of performing tasks autonomously or semi-autonomously. This is a very broad definition. In fact, Robots are very diverse. They ride on wheels, walk on two, four or even six legs. Some can swim, dive or take to the skies. Some robots assemble sensitive microchips in high-tech facilities. Others work in dusty car factories. Still others help diagnose and treat diseases. Robots range in size from a thumbnail to a refrigerator. Some robots can make pancakes. Others can land on Mars.

This diversity in size, design and capabilities makes it difficult to come up with a definition for the term "robot." The images 1 – 6 show just a few examples from the wide range of areas in which robots can be used.

Fig. 2: SmartBird flies like a bird (FESTO).

Fig. 3: Aibo wants to play: a consumer Robot with entertainment Functions (SONY).

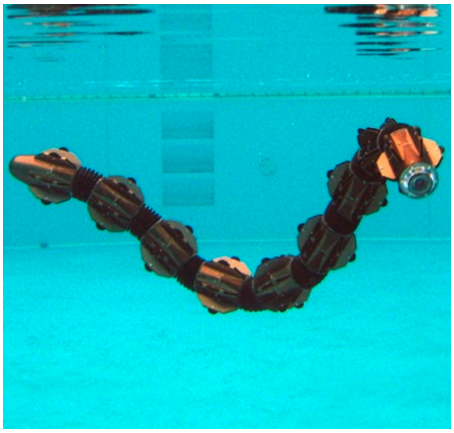

Fig. 4: ACM-R5H snakebot goes swimming (TOKYO INSTITUTE OF TECHNOLOGY).

Fig. 5: YuMi, human-machine collaboration robot (AB)

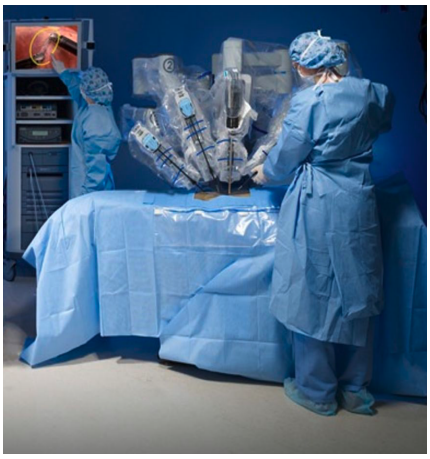

Fig. 6: Da Vinci Diagnostic: This robot assists doctors with complex examinations and surgical procedures (INTUITIVE SURGICAL).

Where does the name "robot" come from?

The term robot is derived from the Czech/Slavic word robota, which means work or drudgery. The Czech writer Karel Čapek first referred to machine people as robots in the play "R.U.R. - Rossum's Universal Robots," published in 1920. The term "robot" means different things to different people. And even roboticists themselves have different ideas about what a robot is and what it is not. We mostly know what a robot should look like and what it should be able to do from science fiction movies.

Robotics as a Discipline

Robotics is an interdisciplinary field that deals with the development, design, and application of robots. Robotics combines various fields such as mechanics, electronics, computer science, and artificial intelligence to develop systems capable of performing human-like tasks. This can range from simple tasks such as grasping objects to complex tasks such as autonomous navigation in unknown terrain.

Two Definitions of a robot

So what makes a robot? Here are two definition that's neither too general nor too specific:

Definition 1 (Robot Institute of America, 1979):

"A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks".

Definition 2 (Erico Guizzo, 2023):

“A robot is an autonomous machine capable of sensing its environment, carrying out computations to make decisions, and performing actions in the real world”.

Roboter versus Automate

An **automate** is a machine that can perform a specific task automatically, but only this task. For example, a coffee machine can brew coffee, but nothing else. And a CNC milling machine can be programmed, but in the end it can only mill. If this operation is no longer needed, an automatic machine is useless. A **robot**, on the other hand, can be programmed and retooled and can thus be used for many tasks. The special feature of a robot is its **flexibility**. Where a vending machine can only repeat the predefined operation, a robot can be reprogrammed to grip or assemble.

Benefits of robotics

The benefits of robotics are diverse, just as the fields of their application. They range from industrial automation, where robots are used in factories to perform repetitive tasks, to medicine, where robots are used in surgery to perform precise procedures. Applications of robotics can also be found in aerospace, logistics, and the home. Additionally, they're used in education for teaching and research to name just a few.

The following overview shows the most important application areas that benefit from robotics:

- Industrial robotics: industrial robots are used in factories to automate repetitive tasks such as assembly, welding, painting, and packaging.
- Medical robotics: in medical robotics, robots are used in surgery to perform precise and minimally invasive procedures. They can also help with patient rehabilitation and care.
- Agricultural robotics: in agriculture, robots are used to automate tasks such as planting, harvesting, and weeding. They can also help monitor crops and animals.
- Logistics robotics: in logistics, robots are used to transport, sort and store goods. They can also help with picking and packing products.
- Service robotics: service robots are used in a variety of settings, including hotels, restaurants and hospitals, to perform tasks such as cleaning, delivering food and drinks, and receiving and entertaining guests.
- Military and security robotics: robots are used in military applications to perform tasks such as reconnaissance, defusing bombs and rescuing people in dangerous situations. They can also help monitor borders and public places.
- Educational and research robotics: robots are used in schools and universities to teach students about programming and robotics. They are also used in research to develop new technologies and applications.

Challenges of robotics

Robotics impacts all areas of life raising a variety of social, technical and ethical issues.
For example, there is the question of the impact of robots on the labor market and what responsibility this implies for decisions in economics. There are also discussions about privacy and security in the context of autonomous robots. The following overview shows the multitude of risks that are often associated with each other:

Socio-economic Risks

- Job Displacement: Risk of unemployment due to automation.
- Inequality: Uneven distribution of access to and benefits from robotics.

Technical and Security Risks

- Privacy and Security: Potential for hacking leading to privacy breaches or malicious use.
- Safety: Risk of accidents due to malfunctions or programming errors.
- Dependence on technology: Over-reliance leading to diminished human skills and vulnerability if systems fail.

Ethical and Environmental Risks

- Ethics and Dehumanization: Risk of emotional detachment and dehumanization of personal relationships.
- Environmental Impact: Pollution and resource depletion from production and disposal of robots.

Lesson 1.2. Internet of Things Definition, Benefits and Challenges

What is the Internet of Things (IoT)?

The Internet of Things (IoT) describes the network of physical objects ("things"), that are embedded with sensors, software, and other technologies for connecting and exchanging data with other devices and systems over the internet. For this purpose, sensors and actuators embedded in physical objects are linked through wired and wireless networks as the diagram below (fig. 7) shows:

Fig. 7: Internet of Things (Jacob, 2019)

Benefits of the Internet of Things

The IoT enables greater automation and control in many areas, from home automation to health monitoring to industrial automation. Here's an overview of different application areas:

- Connected Cars: IoT in cars allows for real-time data collection and sharing, improving navigation, maintenance, safety, and enhancing driver experience.
- Smart Appliances: IoT-enabled appliances automate tasks, manage energy use, provide convenience through remote control and enhance household efficiency.
- Connected Security Systems: IoT integrates cameras, sensors, alarms, providing real-time monitoring, instant alerts, and enhancing safety and security at home or work.
- Smart Agriculture Equipment: IoT devices monitor soil, weather, crop health, automate irrigation and fertilization, boosting productivity and sustainability in agriculture.
- Connected Retail: IoT in retail enhances customer experience with personalized recommendations, inventory management, and streamlined checkouts, driving business growth.
- Connected Healthcare Monitors: IoT in healthcare enables real-time patient monitoring, preventive care, personalized treatment, improving patient outcomes significantly.
- Connected Manufacturing Equipment: IoT enhances manufacturing efficiency with real-time monitoring of machines, predictive maintenance, reducing downtime and optimizing production.
- Connected Cities: IoT transforms cities into smart cities, optimizing utilities, improving transportation, enhancing public safety, and promoting sustainable living.

Challenges of Internet of things (IoT)

The Internet of Things (IoT) offers many benefits, but there are also some challenges. Not everyone has the same access to IoT technologies. This can lead to a widening of the digital divide between those who have access and those who do not. In addition, the automation of jobs through IoT could cause some people to lose their jobs.

There are also security-related challenges. IoT devices collect a lot of data, and that can cause privacy issues. These devices can also be vulnerable to hacking, which poses risks to data security and our physical security. Many IoT devices also don't have very strong security standards, which makes them even more vulnerable.

There are also ethical challenges. It is often not clear what data IoT devices collect and how it is used. This can cause issues with transparency and consent. And if we become too dependent on IoT devices, it could limit our human autonomy.

To address these challenges, we need clear rules and guidelines, both at the technological and policy levels.

Lesson 1.3 Historical Background and evolution of Robotics and Internet of Things

Evolution of the Internet of Things

Let's talk about the evolution of the Internet of Things (IoT). An older term that goes with it is "machine-to-machine" or M2M for short. This refers to devices talking directly to each other and doing things without humans having to help. This can happen over wires or wirelessly.

A well-known example of this is telemetry. It has been used to transmit data since the beginning of the last century. The first to do it used telephone lines and later radio waves to send measurement data. M2M communication is an important part of the IoT and is often used for remote monitoring, control and automation.

The idea of networked devices has been around since the 1970s. Back then, people often talked about "embedded Internet" or "ubiquitous computing." But the term IoT wasn't invented until 1999 by Kevin Ashton, when he was working at Procter&Gamble and promoting RFID technology. The term IoT then became really well known in early 2014.

The difference between M2M and IoT lies primarily in the type of network. With M2M, the devices communicate directly with each other via various connections. With IoT, they exchange their data via a data cloud. This enables even more complex networked solutions than M2M.

Activity: Read the article “machine-to-machine M2M” at https://www.techtarget.com/iotagenda/definition/machine-to-machine-M2M (TechTarget). This page provides a comprehensive definition of M2M, with information on the applications and technologies that enable this type of communication.

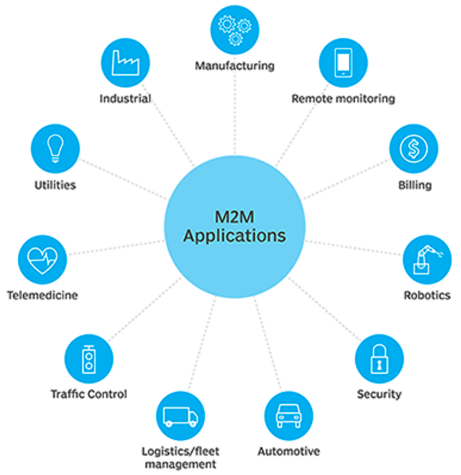

Fig. 8: M2M applications (TechTarget).

Evolution of Robotics

Robotics has a long history, ranging from simple automated machines to complex, intelligent robots. The first beginnings of robotics can be traced back to ancient Greece. People in the ancient Greece already built machines that performed simple tasks. But modern robotics began in the 20th century. In 1961, Unimate, the first industrial robot, was installed on a General Motors assembly line to handle die-casting and welding (fig. 9). The Unimate robot, invented by George Devol and Joseph Engelberger, played a significant role in the development of industrial automation.

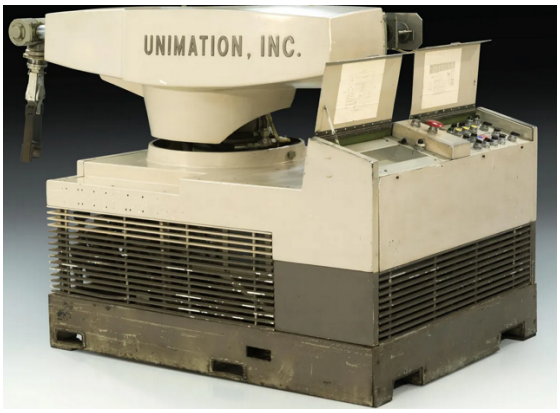

Fig. 9: Unimate, the first industrial robot (IEEE Spectrum).

Learn more about Unimate at https://spectrum.ieee.org/unimation-robot.

The Stanford Arm

The 1970s and 1980s were a time of great progress. During this time, the first robotic arms were developed and used in manufacturing and laboratories. An important name from this time is Victor Scheinman, who invented the "Stanford Arm," one of the first versatile robotic arms (fig. 10).

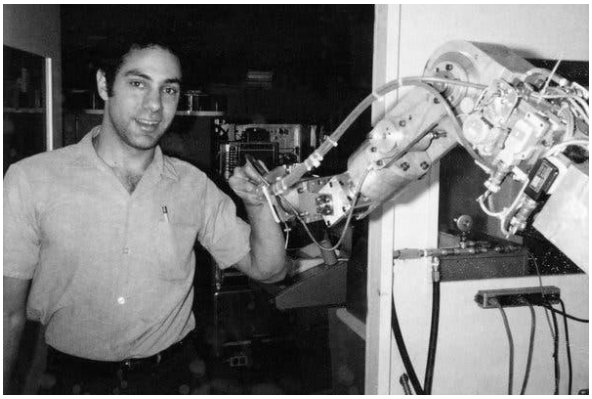

Fig. 10: the Stanford Arm, a programmable six-jointed robot (Bruce Baumgart/Stanford University Archives, Stanford School of Engineering).

Learn more about the Stanford Arm at https://www.nytimes.com/2016/09/22/technology/victor-scheinman-dead.html.

NASA Mars Rover "Sojourner"

In the 1990s and beyond, robotics evolved greatly. Robots became more intelligent and were able to perform more complex tasks. One example is the Mars Rover "Sojourner" which NASA sent to Mars in 1997 (fig. 11).

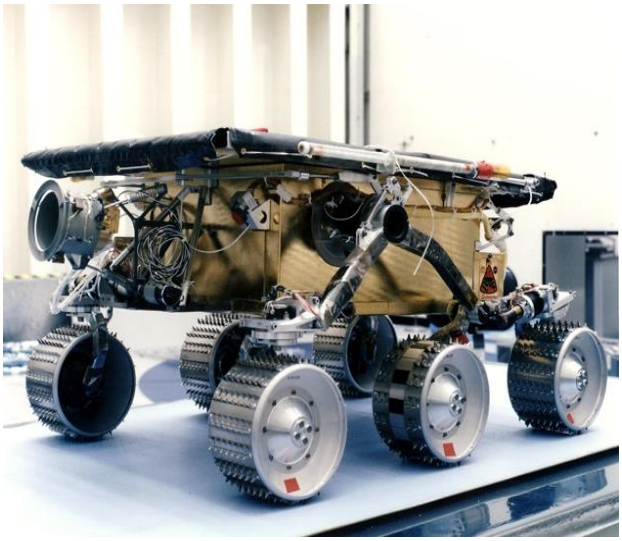

Fig. 11: Mars Pathfinder Rover Sojourner (NASA, 1996).

Humanoid robots

In the 21st century, we see even more progress. Today there are robots working in homes, in hospitals, in factories and even in our space. One well-known robot is Honda's "ASIMO" humanoid robot, which can walk, run and even climb stairs (fig. 12 – 13).

Fig. 12: ASIMO shows the sole of the left foot which is part of the Floor Reaction Control (Wikipedia).

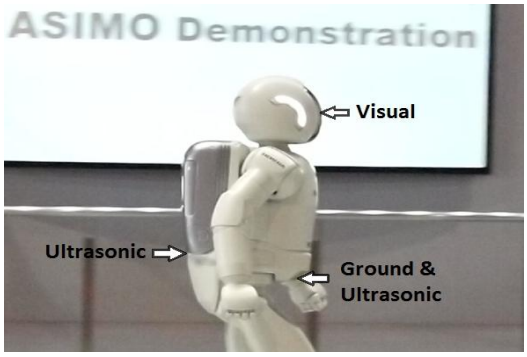

Fig. 13: ASIMO environment identifying sensors which include visual, ground, and ultrasonic sensors (Wikipedia).

Consumer Robots

Rodney Brooks, a well-known robotics expert, has done much to make robotics what it is today for consumers. He co-founded iRobot, a company that makes the Roomba, the popular robot vacuum cleaner (fig. 14). Overall, robotics has evolved tremendously throughout history. And there's still plenty of room for progress and innovation.

Fig. 14: Roomba Combo™ j7+ Robot Vacuum and Mop (iRobot).

Final note:

As you have seen, the Internet of Things and robotics are fascinating technologies that can impact our lives in many ways. As with all technologies, they bring both benefits and challenges. It is up to us how we use them and what direction we give them. In the following chapters, we will take a closer look at the application issues and how robots and the Internet of Things work. So stay curious and open to new things, and also cultivate your critical thinking!

Sources

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