Hoang-Long Cao

English for Robotics

Tiếng Anh chuyên ngành Robot và Cơ điện tử

Contents

Preface

The book is under development. (2021-01-17)

This book is for students who majored in Robotics or Mechatronics. It aims at helping students (especially Vietnamese students) learn both technical English and knowledge in robotics (and mechatronics).

The book is regularly updated with research in robotics, mechatronics and AI since these fields are closely connected. The latest PDF version can be downloaded from here:

`https://hoanglongcao.github.io/E4R/english-for-robotics-hoanglongcao.pdf`

There might be some mistakes in this book since I am not an English native speaker. Please let me know so I can correct them.

Hoang-Long Cao

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About the author

I am Hoang-Long Cao (http://hoanglongcao.github.io). I am currently a postdoc researcher at the Vrije Universiteit Brussel, Belgium and a lecturer at Can Tho University, Vietnam. My research topics are social robotics, human-robot interaction, and human-robot collaboration.

Resourses

This book has been created using the **Rmarkdown** (Allaire et al., 2020) and **bookdown** (Xie, 2020) packages within the RStudio (RStudio Team, 2018) environment.

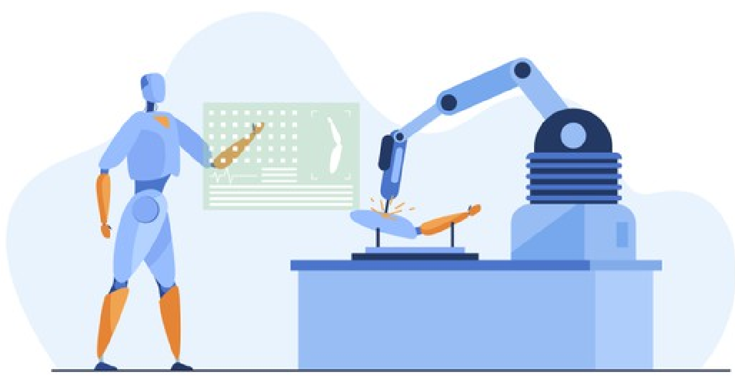
English definitions are from Cambridge Dictionary[3], and Dictionary.com[4].

Pictures are mostly from Freepik[5] and Unplash[6]. Icons are from Flaticon[7]. See Credits.

[3] https://dictionary.cambridge.org
[4] https://dictionany.com
[5] http://freepik.com
[6] https://unsplash.com
[7] https://www.flaticon.com

1

Robotics and Engineering



Robotics is an interdisciplinary research area at the interface of computer science and engineering. The goal of robotics is to design intelligent machines that can help and assist humans. Robotics draws on the fields of information engineering, computer engineering, mechanical engineering, electronic engineering, artificial intelligence, and others.

Source: Adapted from the Wikipedia article "Robotics" (Wikipedia contributors, 2021e), which is released under the Creative Commons Attribution-Share-Alike License 3.0.

1.1 Reading: What Is Robotics?

Robotics develops machines that can substitute for humans and replicate human actions. Robots can be used in many situations and for many purposes, but today many are used in dangerous environments, manufacturing processes, or where humans cannot survive. Robots appear in various forms. Some are made to resemble humans in appearance. This is said to help in the acceptance of a robot in certain replicative behaviors usually performed by people. Such robots attempt to replicate walking, lifting, speech, cognition, or any other human activity. Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics.

The concept of creating robots that can operate autonomously started in the past but has only grown rapidly since the 20th century. Throughout history, it has been frequently assumed by various scholars, inventors, engineers, and technicians that robots will one day be able to mimic human behavior and manage tasks in a human-like fashion. Today, people research, design, and build robots for various purposes, whether domestically, commercially, or militarily. Many robots are built to do jobs that are hazardous to people, such as defusing bombs, finding survivors, and exploring mines. Robotics is also used in STEM (science, technology, engineering, and mathematics) as a teaching aid.

Robotics is a branch of engineering that involves the conception, design, manufacture, and operation of robots. This field overlaps with computer engineering, computer science especially artificial intelligence (AI), electronics, mechatronics, mechanical, nanotechnology, and bioengineering.

Source: Adapted from the Wikipedia article "Robotics" (Wikipedia contributors, 2021e), which is released under the Creative Commons Attribution-Share-Alike License 3.0.

Read the text above and and answer the following questions.

1. The field of robotics inspired by nature: . . . .
2. The fields that overlap with robotics: *computer engineering*, *computer science*, *electronics*, ..., *mechanical*, *nanotechnology*, *bioengineering*.

Solution is in the footnote.[1]

Match the words below with their definitions.

Words

1. robotics . . . . .
2. inventors . . . . .
3. engineers . . . . .
4. STEM . . . . .
5. AI . . . . .
6. mechatronics . . . . .

Definitions

a. the science of making and using robots
b. the combination of mechanical engineering, computing, and electronics, as used in the design and development of new manufacturing techniques.
c. the study of how to produce computers that have some of the qualities of the human mind, such as the ability to understand language, recognize pictures, solve problems, and learn
d. someone who has invented something or whose job is to invent things
e. science, technology, engineering, and mathematics
f. a person specially trained to design and build machines, structures, and other things, including bridges, roads, vehicles, and buildings

Solution is in the footnote.[2]

[1] 1.bio-inspired robotics; 2.mechatronics.

[2] 1a - 2d - 3f - 4e - 5c - 6b

1.2 Writing: What Can Robotics Do?

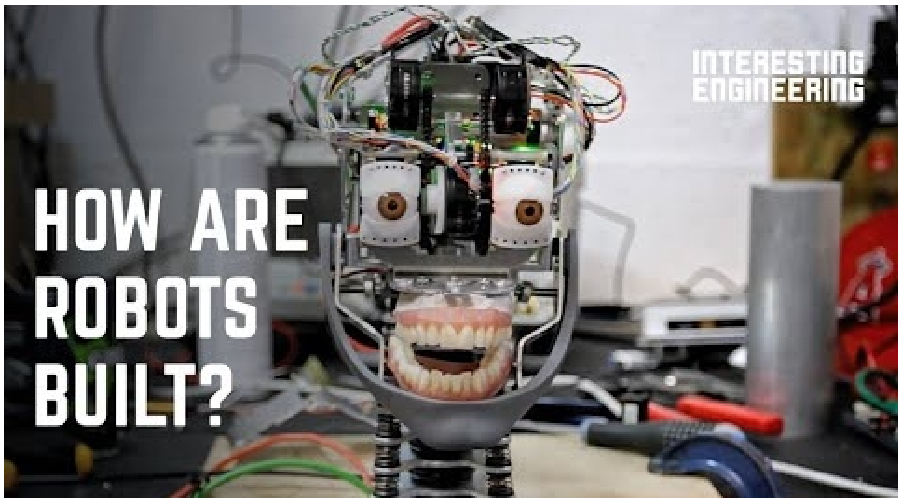
Write a paragraph about what robotics can do for a better world. An example is shown below.

> Industrial robots are mechanical devices which, to a certain degree, replicate human motions. They are used whenever there is a need to reduce the danger to a human, provide more strength or accuracy than a human, or when continuous operation is required. Most robots are stationary, but some move throughout the workplace delivering materials and supplies.
>
> — "Industrial Robot". (encyclopedia.com, 2020)

1.3 Speaking: Robots Help People

Discuss with your classmates about how robotics can help people.

1.4 Listening: How Are Robots Built?



Source: "How are robots built?". Youtube. https://youtu.be/oHKCwyUa2rg (Interesting Engineering, 2020).

Listen to the video and fill in the blanks.

Robots have jumped from the screen and .... pages into our reality disrupting almost every modern industry.

Agriculture, space, travel, medicine, and .... are just a couple of places robots have begun to appear.

You could argue that they have already started to take over our world.

Just in the past few decades, robots have reached new heights.

The continual and rapid progress of .... paired with readily available large datasets, lower prices for .... , and a steady demand for efficiency has created the perfect storm for engineered . . . .

Yet you should not be intimidated by robots.

Though robots are certainly complicated pieces of machinery, they are also delightfully simple to understand.

In a lot of cases, robots are based on us humans.

You can even build your own simple robot at home.

Solution is in the footnote.[3]

1.5 My Glossary

Translate these terms into your language.

robotics . . . .

artificial intelligence . . . .

mechatronics . . . .

engineer . . . .

manufacturing . . . .

technology . . . .

innovation . . . .

electronics . . . .

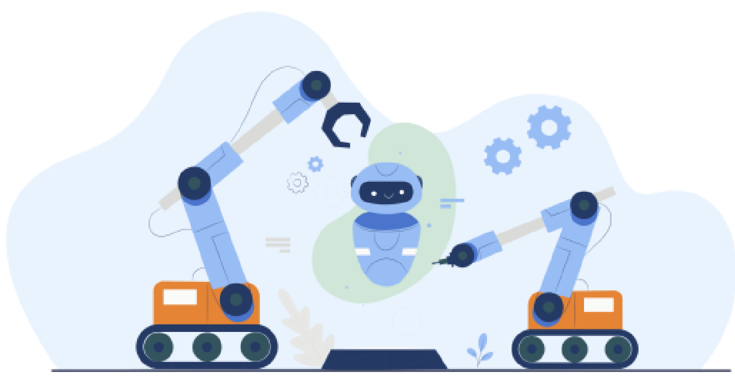
sensors . . . .

motors . . . .

[3] science fiction; manufacturing; artificial intelligence; sensors and electronics; innovation.

2

Robots and Their Applications



Robots are found everywhere in factories, homes, hospitals, and even in outer space. Several categories of robotic applications are industrial robots, autonomous mobile robots, humanoid robots, and educational robots. In the past, robots mainly worked alone in isolated areas. Nowadays, people research and develop robots that interact with humans directly.

Source: Adapted from the chapter "Robots and their applications" (Ben-Ari and Mondada, 2018).

2.1 Reading: Classification of Robots

Robots can be classified according to the environment in which they operate. The most common distinction is between fixed and mobile robots. These two types of robots have very different working environments and therefore require very different capabilities. Fixed robots are mostly industrial robotic manipulators that work in well-defined environments adapted for robots. By contrast, mobile robots are expected to move around and perform tasks in large, ill-defined, and uncertain environments that are not designed specifically for robots.

There are three main environments for mobile robots that require significantly different design principles because they differ in the mechanism of motion: aquatic (underwater exploration), terrestrial (cars), and aerial (drones). Robots for these three environments can be further divided into subclasses: terrestrial robots can have legs or wheels or tracks, and aerial robots can be lighter-than-air balloons or heavier-than-air aircraft.

Robots can be classified by the intended application field and the tasks they perform. The first robots were industrial robots because the well-defined environment simplified their design. Service robots, on the other hand, assist humans in their tasks. These include home robots like vacuum cleaners, transportation like self-driving cars, and defense applications such as drones. Medicine, too, has seen the increasing use of robots in surgery, rehabilitation, and training. These are recent applications that require improved sensors and closer interaction with the user.

Source: Adapted from the chapter "Robots and their applications" (Ben-Ari and Mondada, 2018).

Read the text above and complete the diagrams below.

Classification of robots by environment and mechanism of interaction

1. fixed
2. . . . .
   a) . . . .
   b) terrestrial
      i) . . . .
      ii) . . . .
   c) . . . .

Solution is in the footnote.[1]

Classification of robots by application field

1. industrial
   a) . . . .
   b) . . . .
2. . . . .
   a) home
   b) . . . .
   c) . . . .
   d) . . . .

Solution is in the footnote.[2]

---

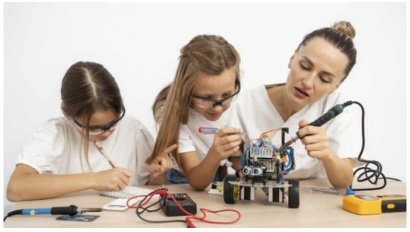
[1] 1.fixed; 2.mobile; aquatic; terrestrial; i.wheeled; ii.legged; airborne

[2] 1.industrial; logistics; manufacturing; 2.service; home; transportation; defense; medicine

2.2 Writing: Categorizing Robots

Describe these robots using two types of classification learned in the Reading section

This is a robot arm. It is a fixed industrial robot for logistics.



. . . .
. . . .
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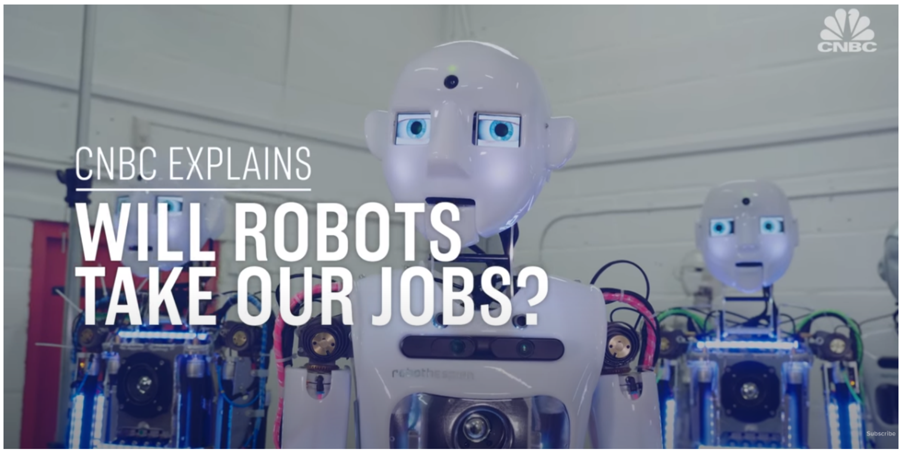
. . . .

2.3 Speaking: Robots in Your Country

Discuss with your classmates about robotics research and development in your country.

2.4 Listening: Will Robots Take Our Jobs?



Source: "Will robots take our jobs? | CNBC Explains". Youtube. https://youtu.be/a-7Azih0D98 (CNBC International, 2018).

Listen to the video and fill in the blanks.

This is a . . . . robot, which means it looks, it talks, and it even acts, well, like a human.

There's no denying robots and . . . . are increasingly part of our daily lives.

Occupations that require repetitive and predictable tasks in . . . ., ... and administrative support were especially high-risk.

A survey of 20,000 employers from 42 countries found that the IT, customer service and advanced . . . . industries will add workers over the next two years as a result of automation.

This is particularly a problem for .... workers who aren't able to retrain for new jobs.

Solution is in the footnote.[3]

2.5 My Glossary

Translate these terms into your language.

application ....

classification ....

industrial ....

logistics ....

transportation ....

automation ....

humanoid ....

drone ....

mobile ....

fixed ....

[3] humanoid; automation; transportation; logistics; manufacturing; low-skilled

3

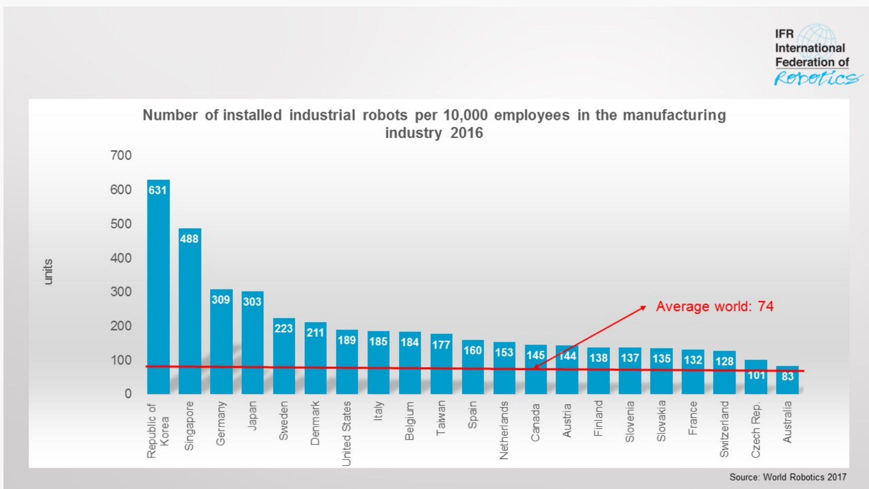
Robotics around the World

In 2017, nearly 2 million industrial robots were in use around the world, up nearly 280% since 1993. The use of robots has more than doubled in the last 20 years in most advanced economies. The top users of industrial robots in 2017 were China, Japan and South Korea, using nearly 50% of the world's stock of robots. European nations were also significant users of industrial robots in 2017, with Germany employing around 200,000 robots.

Source: Adapted from the article "Which Countries and Industries Use the Most Robots?" (Federal Reserve Bank of St. Louis, 2019).

3.1 Reading: Robot Density Rises Globally

The automation of production is accelerating around the world. 74 robot units per 10,000 employees is the new average of global robot density in the manufacturing industries (2015: 66 units). By regions, the average robot density in Europe is 99 units, in the Americas 84 and in Asia 63 units.



The 2017 World Robot Statistics, issued by the International Federation of Robotics (IFR)

"Robot density is an excellent standard for comparison in order to take into account the differences in the automation degree of the manufacturing industry in various countries," says Junji Tsuda, President of the International Federation of Robotics. "As a result of the high volume of robot installations in Asia in recent years, the region has the highest growth rate. Between 2010 and 2016, the average annual growth rate of robot density in Asia was 9 percent, in the Americas 7 percent and in Europe 5 percent."

Source: Adapted from the article "Robot density rises globally" (IFR, 2018).

Read the text above and answer the following questions.

1. In 2017, what is the average of global robot density in the manufacturing industries? ....
2. Is it higher or lower that that of 2015? ....
3. Which continent has the highest average robot density? ......
4. Accoriding to the 2017 World Robot Statistics, what is the most automated country in the world? ....
5. Between 2010 and 2016, was the average annual growth rate of robot density in Asia 7 percent? ....

Solution is in the footnote.[1]

Complete the list of the top 10 most automated countries and territories in the world

1. *Republic of Korea*
2. ....
3. ....
4. ....
5. ....

Solution is in the footnote.[2]

6. ....
7. ....
8. ....
9. ....
10. ....

Solution is in the footnote.[3]

[1] 1. 74 per 10,000 employees; 2. Higher; 3. Europe; 4. Republic of Korea; 5. No, 9 percent.

[2] 1.Republic of Korea 2.Singapore 3.Germany 4.Japan 5.Sweden

[3] 6.Denmark 7.USA 8.Italy 9.Belgium 10.Taiwan

3.2 Writing: What is Your Favorite Robot Company?

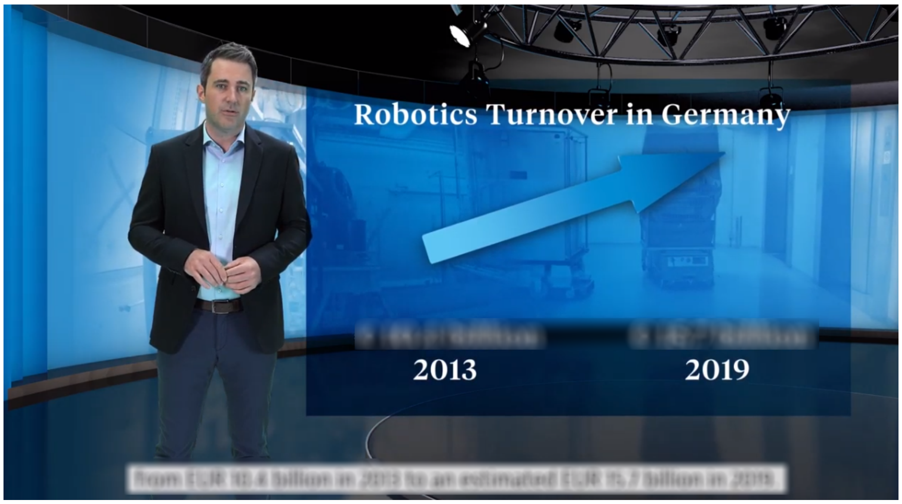
Write a paragraph about your favorite robot company. An example is shown below.

> KUKA is a German manufacturer of industrial robots and solutions for factory automation. The company was founded in 1898 in Augsburg, Germany, by Johann Josef Keller and Jacob Knappich. While previously emphasizing customers in the automotive industry, the company has since expanded to other industries. The KUKA Robotics Corporation has 25 subsidiaries worldwide, mostly sales and service subsidiaries, including in the United States, Australia, Canada, Mexico, Brazil, China, Japan, South Korea, Taiwan, India, Russia and most European countries.
>
> — "KUKA — Wikipedia". (Wikipedia contributors, 2021a)

3.3 Speaking: Should Robots Be Different in Your Country?

Discuss with your classmates how robots in your country should be designed and controlled differently. For example, think about the economy and culture.

3.4 Listening: Robotics in Germany



Source: "Robotics in Germany". Youtube. https://youtu.be/7t6pt7JTeoY (Germany Trade & Invest, 2020).

Listen to the video and fill in the blanks.

With their love of mechanical engineering, ... are particularly fascinated by robots.

Germany is among the world's .... users of them.

And German turnover in robotics and automation has grown by ....% in recent years from .... billion euros in 2013 to an estimated .... billion euros in 2019.

What's more, industry experts predict annual growth of ....% in the years to come.

What are some of the current trends?

One is that robots and human beings are working together.

This can take the form of .... which allow man and machine to cooperate and which could render elaborate safety precautions such as kill switches obsolete.

Another form of man-plus-machine are .... like the "Cray X" by German Bionic.

It helps workers do heavy and repetitive lifting and won its parent company the prestigious German .... award in 2019.

Traditional industrial robots were built to carry out one task or set of tasks ad infinitum. But that too is changing.

The next generation of robots will be adaptable to a multitude of jobs.

Case in point: the Panda power tool from Munich company Franka Emika which is billed as the fastest selling industry suited robot in the world.

Solution is in the footnote.[4]

3.5 My Glossary

Translate these terms into your language.

robot density ....

economy ....

culture ....

cobot ....

exoskeleton ....

entrepreneur ....

[4] Germans; top five; 50; 10.4; 15.7; 12; cobots; exoskeletons; entrepreneur

4

Robot Control

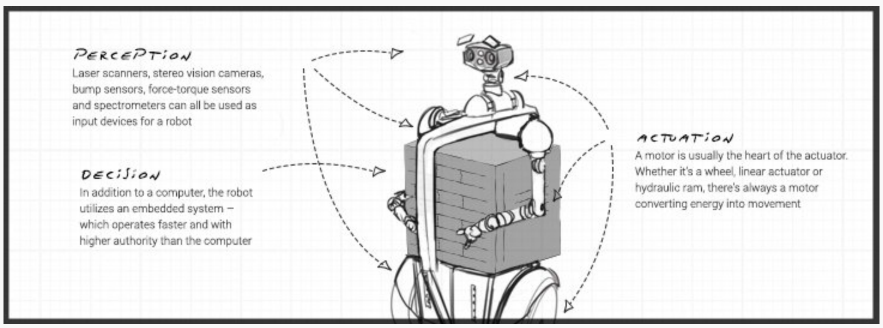
All robots have three types of components: sensors, a control system, and actuators. If we compare robots to human beings, the sensors would be our senses. They send information to the control system (the brain) and we modify our behavior and affect our surroundings through actuators (parts of the body). A robot also needs a source of power in order to function and a physical structure to sustain the elements it is made up of.

Source: Adapted from the article "What is a robot? Getting to know sensors and actuators" (DIWO, 2015).

4.1 Reading: How is a Robot Controlled?

Robotic control is a system that contributes to the movement of robots. This involves the mechanical aspects and program systems that make possible to control robots. Robotics could be controlled in various ways, which includes using manual control, wireless control, semi-autonomous, and fully autonomous. In the present day, as technological advancements progress, robots and their methods of control continue to develop and advance.

What is autonomy? Autonomy is the ability to make your own decisions. In humans, autonomy allows us to do the most meaningful, not to mention meaningless, tasks. This includes things like walking, talking, waving, opening doors, pushing buttons, and changing light bulbs. In robots, autonomy is really no different.



Autonomous robots, just like humans, also have the ability to make their own decisions and then perform an action accordingly. A truly autonomous robot is one that can perceive its environment, make decisions based on what it perceives and/or has been programmed to recognize and then actuate a movement or manipulation within that environment. With respect to mobility, for example, these decision-based actions include but are not limited to the following basics: starting, stopping, and maneuvering around obstacles that are in their way.

Source: Adapted from the Wikipedia article “Robot control” (Wikipedia contributors, 2021b), which is released under the Creative Commons Attribution-Share-Alike License 3.0; and “What Are Autonomous Robots?” (Walker, 2017).

Read the text above and answer the following questions.

1. List several ways of controlling a robot.

   . . . .

Solution is in the footnote.[1]

2. What are the 3 main actions of a truly autonomous robot?

   . . . .

Solution is in the footnote.[2]

3. Is this robot a truly autonomous robot? . . . .

Solution is in the footnote.[3]

---

[1] manual control, wireless control, semi-autonomous, and fully autonomous

[2] perceive its environment, make decisions, actuate a movement or manipulation

[3] Yes if it performs all 3 actions: perception, decision, and actuation

4.2 Writing: Manually Control a Robot

Write a paragraph about a manual control method. For example: direct wired control, wireless remote control (e.g. wifi, bluetooth, infrared).

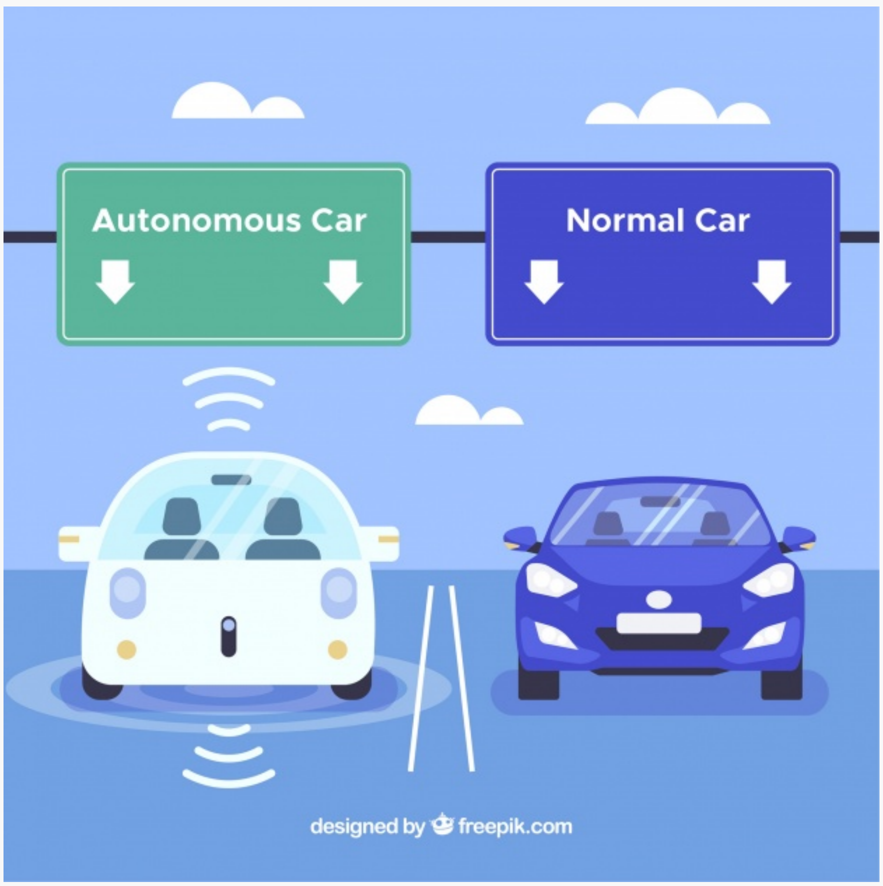
> The easiest way to control a vehicle is with a handheld controller physically connected to the vehicle using a cable (i.e. a tether). Toggle switches, knobs, levers, joysticks and buttons on this controller allow the user to control the vehicle without the need to incorporate complex electronics. In this situation, the motors and a power source can be connected directly with a switch in order to control its forward/backwards rotation. Such vehicles usually have no intelligence and are considered to be more "remote controlled machines" than "robots".
>
> — "Controlling Your Robot". (Cbenson, 2019)

Check the Robotshop website[4] for more examples.

[4] https://www.robotshop.com/community/tutorials/show/how-to-make-a-robot-lesson-6-controlling-your-robot

4.3 Speaking: How can an Autonomous Car Navigate?

Discuss with your classmates the differences between an autonomous car and a normal car. How can the autonomous car navigate and perceive the world?



4.4 Listening: TUG Autonomous mobile Robot in Hospitals

Source: "TUG autonomous mobile robot in hospitals, Aethon Inc.". Youtube. https://youtu.be/WafkcuhTtMc (Igor Gabrielan, 2016).

Listen to the video and fill in the blanks.

TUG by Aethon transports materials and supplies through hospitals.

TUG reduces costs and frees clinical staff to focus on what's important: serving patients.

It can easily be used in existing as well as new construction since it requires no new infrastructure.

It integrates two building systems through . . . . and this allows TUG to open doors and call and ride elevators.

Its array of . . . . detect people and objects.

TUG can make on-demand or pre-scheduled . . . .

The exchange platform will carry a wide variety of interchangeable carts and halls up to 1,000 ....

TUG can be used by the pharmacy or lab to securely deliver medications and specimens using biometrically controlled access and pin codes.

It transports sterile operating room supplies, delivers meals, hall's clean or dirty linen, removes trash or regulated medical waste.

TUG are .... A command center in Pittsburgh is watching over them 24/7 365.

TUG can be controlled from a wide variety of .... including mobile devices or call boxes.

TUG with over 450 installed in hospitals. This is a proven reliable and cost-effective solution for automating internal logistics.

Solution is in the footnote.[5]

4.5 My Glossary

Translate these terms into your language.

control system ....

manual control ....

autonomous control ....

navigation ....

deliveries ....

reliable ....

interface ....

[5] Wi-Fi; sensors and lasers; deliveries; pounds; reliable; interfaces

5

Sensors

Robotic sensors are used to estimate a robot's condition and environment. These signals are passed to a controller to enable appropriate behavior. Sensors in robots are based on the functions of human sensory organs. Robots require extensive information about their environment in order to function effectively.

Source: Adapted from the Wikipedia article "Robotic Sensors" (Wikipedia contributors, 2021d), which is released under the Creative Commons Attribution-Share-Alike License 3.0.

5.1 Reading: Types of Robot Sensors

There are hundreds of sensors made today to sense virtually anything you can think of, and it is almost impossible to list all available sensors.

A light sensor is used to detect light and create a voltage difference.

A sound sensor (generally a microphone) detects sound and returns a voltage proportional to the sound level.

Temperature sensors are ICs providing voltage difference for a temperature change.

Contact sensors are those which require physical contact against other objects to trigger.

A proximity sensor can detect the presence of a nearby object within a given distance, without any physical contact.

Tactile pressure sensors are useful in robotics as they are sensitive to touch, force, and pressure.

Positioning sensors are used to approximate the position of a robot, some for indoor positioning and a few others for outdoor positioning.

An accelerometer is a device that measures acceleration and tilt.

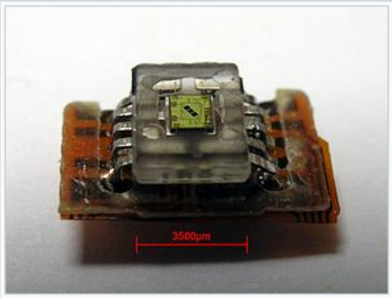
A gyroscope or simply Gyro is a device that measures and helps maintain orientation using the principle of angular momentum.

Voltage sensors typically convert lower voltages to higher voltages or vice versa.

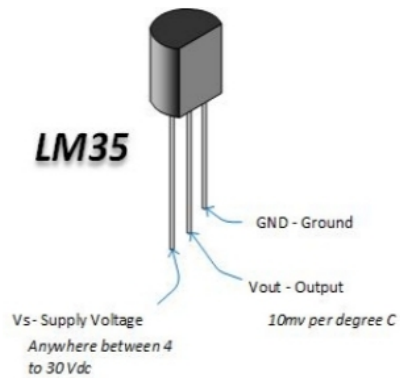
Current sensors are electronic circuits that monitor the current flow in a circuit and output either a proportional voltage or a current.

Source: Adapted from the article "Types of Robot Sensors" (robotplatform.com, 2021b).

Read the text above and classify the sensors below.



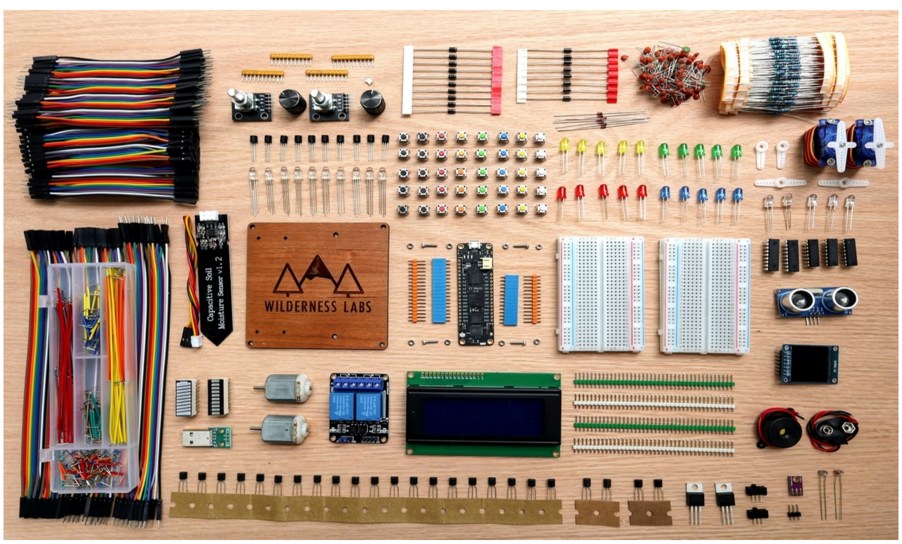
A photodetector salvaged from a CD-ROM drive. The photodetector contains three photodiodes, visible in the photo (in center).



1. . . . .   2. . . . .

Solution is in the footnote.[1]

What are the components in this photo that can be used as sensors?



. . . .

Solution is in the footnote.[2]

[1] 1.light sensor; 2.temperature sensor

[2] positioning sensor, contact sensors, light sensor, proximity sensor, voltage sensor

5.2 Writing: Force Sensitive Resistor

Read the description of this sensor and write a paragraph about how this sensor can be used in robots.

> Size: 1/2” (12.5mm) diameter active area by 0.02” thick (Interlink does have some that are as large as 1.5“x1.5”)
>
> Price $7.00 from the Adafruit shop
>
> Resistance range: Infinite/open circuit (no pressure), 100KΩ (light pressure) to 200Ω (max. pressure)
>
> Force range: 0 to 20 lb. (0 to 100 Newtons) applied evenly over the 0.125 sq in surface area
>
> Power supply: Any! Uses less than 1mA of current (depends on any pullup/down resistors used and supply voltage)
>
> — “Force Sensitive Resistor (FSR)”. (Adafruit, 2012)

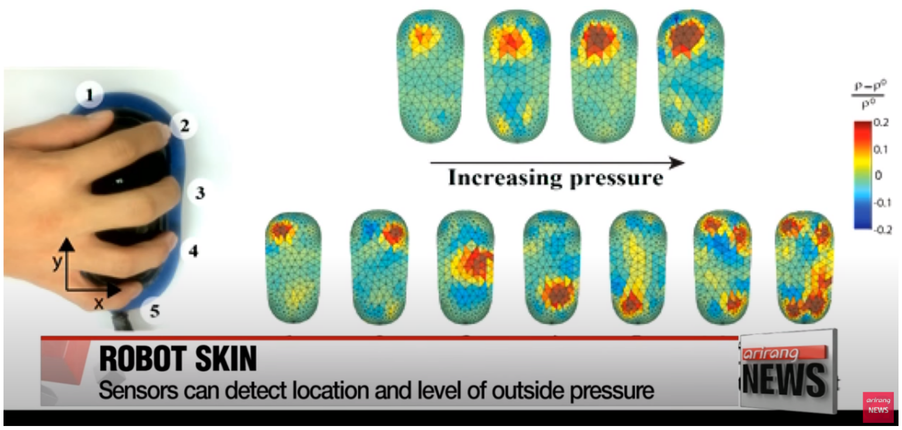
Check the Adafruit website[3] for more information.

[3] https://learn.adafruit.com/force-sensitive-resistor-fsr

5.3 Speaking: Making Decisions with Sensor Inputs

Discuss with your classmates about different types of sensors that this industrial robot is probably equipped with. What does the robot do with those sensor inputs?

5.4 Listening: Researchers Develop "Robot Skin" Sensor



Source: "Researchers develop 'robot skin' sensor". Youtube. https://youtu.be/TsN0ytwCkzk (Arirang News, 2017).

Listen to the video and fill in the blanks.

The latest is this: a .... sensor that can play the role of a skin for AIs. Kim Mok-yeon sheds light on this discovery.

Researchers from the Korea Advanced Institute of Science and Technology have developed a tactile sensor that can measure not only the amount of pressure applied on contact but also pinpoint the .... its been touched.

When the sensor is pressed, different colors appear on a screen, depending on the ....

The sensor also locates the exact spot where pressure is exerted through the computer screen.

"The sensor can act as the skin of a robot because it uses .... rubber to measure electrical resistance."

The team attached electrodes on the surface of sensors and let . . . . flow through them.

The sensors are made with 'piezoresistive composite' which is a combination of . . . . and carbon nanotube.

This composite has the property to change the value of electric . . . . on corresponding parts when pressure is exerted from outside.

Researchers say manufacturing these sensors is relatively easy and cost-efficient.

"The sensors can be used widely in the robot industry, and they are particularly promising for rehabilitation purposes."

The research team expects the technology to be applied in a variety of fields such as robotic skin, 3D computer interface, and wearable medical devices.

Solution is in the footnote.[4]

5.5 My Glossary

Translate these terms into your language.

tactile . . . .

accelerometer . . . .

gyroscope . . . .

resistance . . . .

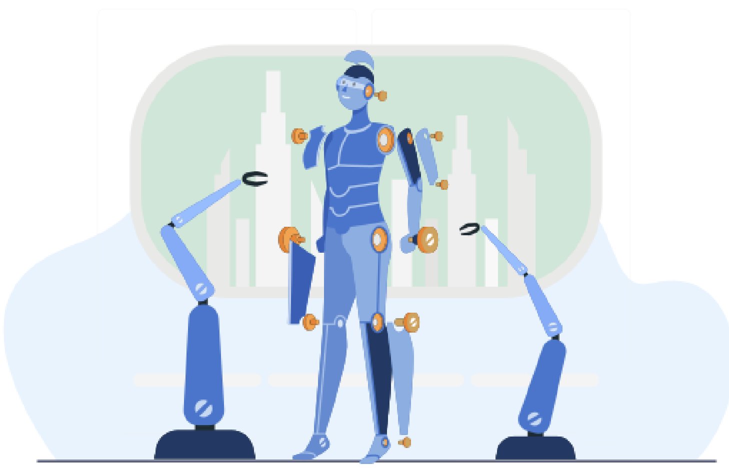
diameter . . . .

proximity . . . .

[4] tactile; location; level of pressure; conductive; current; silicon; resistance

6

Actuators



Actuators are the "muscles" of a robot, the parts which convert stored energy into movement. By far the most popular actuators are electric motors that rotate a wheel or gear, and linear actuators that control industrial robots in factories. There are some recent advances in alternative types of actuators, powered by electricity, chemicals, or compressed air.

Source: Adapted from the Wikipedia article "Robotics" (Wikipedia contributors, 2021e), which is released under the Creative Commons Attribution-Share-Alike License 3.0.

6.1 Reading: Robot Actuators

An actuator is an electromechanical device that converts energy into mechanical work or motion. For robots, actuators are like muscles that perform work. The work can be either to induce motion or to object motion. That is either to start a movement or to stop it. There are different types of actuators available and most of them either create rotational motion or linear motion.

Linear actuator creates linear motion. It creates to and fro motion (forward and backward). These actuators can be driven by either linear or rotational motion.

To simplify things, let us take an example of a bicycle. When the cyclist pushes the pedal, it rotates the bottom bracket in a cycle which is connected to a roller chain. Now the rotational motion from the bracket creates a linear motion in the roller chain.

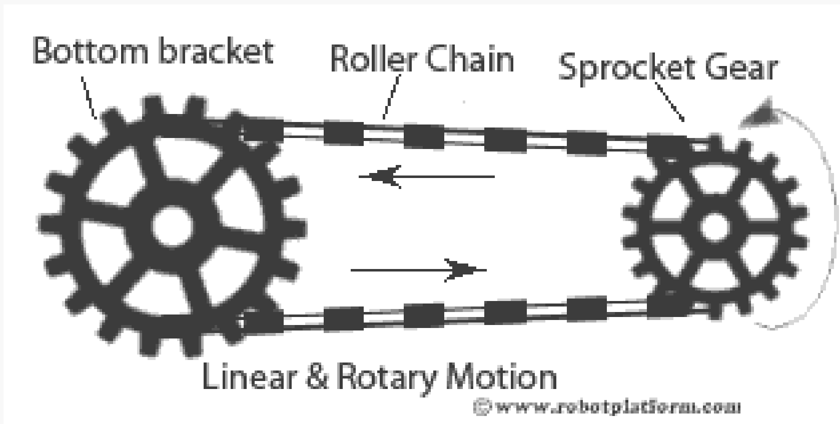
Rotational actuator induces rotary or rotational motion. A simple DC motor is an example of a rotational actuator. Similar to a linear actuator, rotation actuators can be driven by either linear motion or rotational motion.

Let us continue with our bicycle example to understand how linear motion can be used to create rotary motion. The roller chain in a bicycle is connected to the sprocket gear of the driving wheel. When a cyclist pedals, the roller chain (remember that roller chain is an example of linear motion) rotates the sprocket gear creating a rotational motion that further rotates the wheel.

Most actuators can be mechanically designed to induce rotary motion or linear motion. A simple nut attached to a linear member can create a rotary motion. On the other hand, attaching a screw to a rotary actuator creates linear motion.

The below animations shows both linear motion and rotary motion. The bottom bracket rotates creating a linear motion in the roller chain.

Further, the same linear motion of the chain creates rotary motion in sprocket gear.



Actuators require energy to create motion and the source of energy is usually electric current, pneumatic pressure, or hydraulic fluid.

Source: Adapted from the article "Actuators" (robotplatform.com, 2021a).

Read the text above and answer the following questions

1. What are the main types of actuators?

   . . . .

2. What is "to and fro" motion?

   . . . .

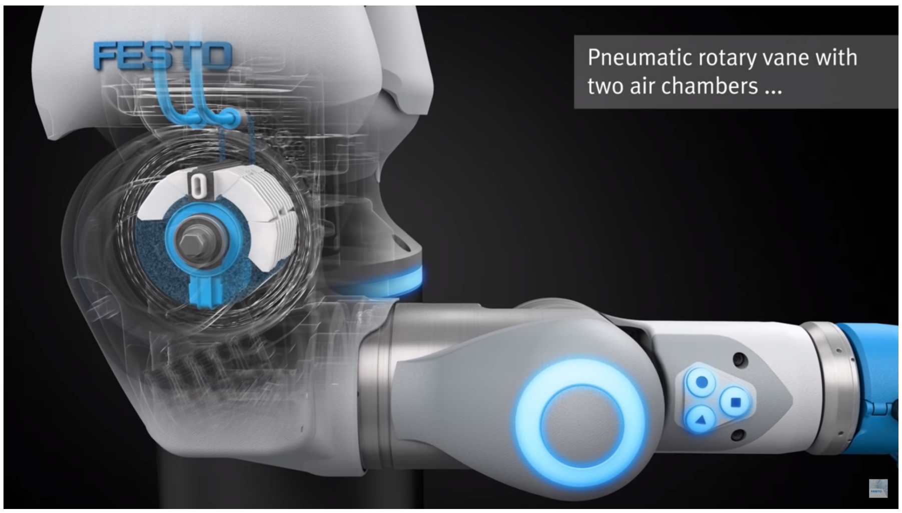
3. Is a DC motor a linear actuator?

   . . . .

Solution is in the footnote.[1]

[1] 1.linear and rotational; 2.forward and backward; 3.No, it is a rotational actuator.

6.2 Writing: Festo – BionicCobot



Source: "Festo – BionicCobot (English)". Youtube. https://youtu.be/54u3H69tcgM (Festo, 2017).

Watch the video and describe the robot and its actuators.

. . . .

. . . .

. . . .

. . . .

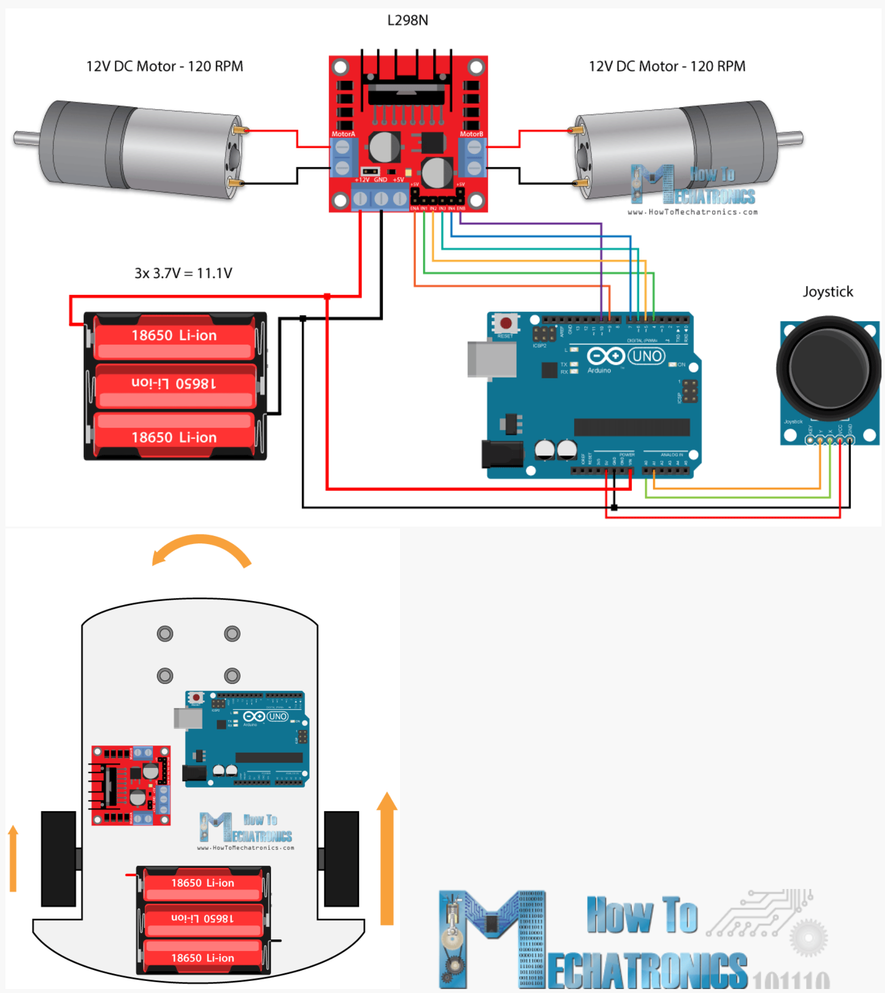
. . . .

. . . .

. . . .

6.3 Speaking: Arduino DC Motor Control

Discuss with your classmates how to use Arduino board to control DC motors of a mobile robot. Talk about the components in the schematic and their functions.



6.4 Listening: Modular Desktop Collaborative Robotic Arm

Source: "GLUON Modular Desktop Collaborative Robotic Arm by SCA". Youtube. https://youtu.be/ZVXztAk8ruw (Best Crowdfunding Campaigns, 2019).

Listen to the video and fill in the blanks.

In particle physics, gluon is the elementary particle for .... a strong force between two quarks.

So what is the INNFOS robotic arm GLUEON?

GLUON is a completely new INNFOS educational six-axis robotic arm that's based on the INNFOS SCA technology and can be easily assembled.

What is INNFOS SCA?

SCA is a Smart .... Actuator independently developed by INNFOS.

It integrates high-performance servo drive, servo motor, high-precision .... and speed reducer.

But it is only .... the size of the conventional servo system.

The six joints of the info .... robotic arm are all powered by the QDD Lite NE-30 actuator.

Based on infos SCA technology, GLUON has a variety of functions including low resistance torque control, gravity compensation, impact resistance, ... , impedance control, torque, velocity and position control to ensure the safety of human machine ....

Solution is in the footnote.[2]

6.5 My Glossary

Translate these terms into your language.

linear ....

rotational ....

chain ....

gear ....

pneumatic ....

hydraulic ....

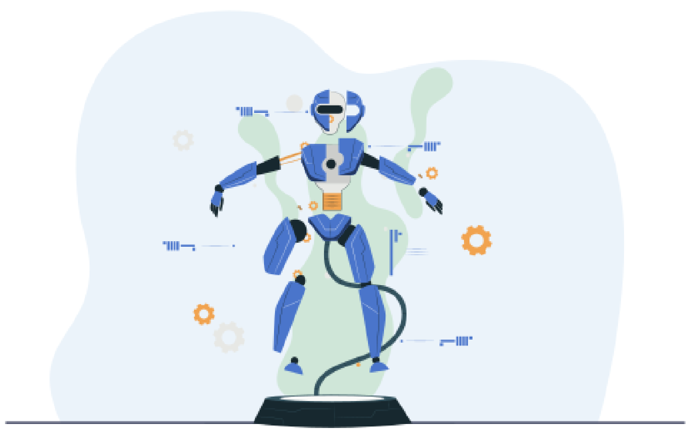
degree of freedom ....

gripper ....

[2] transmitting; Compliant; encoder; one-tenth; six axis; collision detection; interaction

7

Materials



Robots operate in the physical world. Various engineering materials are used in robots to provide shape, strength and durability. Metals, plastics, and composites tend to dominate the structural elements, but other materials are occasionally used.

Source: Adapted from the article "Structural Materials for Robots" (Nelson, 2020).

7.1 Reading: Robot Materials

Here are some of the materials to keep in mind when designing and building robots.

Steel is one of the materials used most often by robot builders. This sturdy metal is a smart choice if you're building a robot that needs to stand up to harsh conditions. It's possible to harden the steel to between 100,000 and 300,000 pound-force per square inch (psi) in many cases.

Demand is growing for commercial robots with flexible exteriors, such as human-like “skin.” Moreover, it's advantageous for cobots that work alongside humans to have soft surfaces. Rubber and soft plastics can meet that goal.

Although aluminum has a higher price point than steel, it's easier to shape and is lighter. Aluminum is also a good material if you're worried about a robot's exterior becoming rusty over time because aluminum does not rust. However, because it can corrode in some wet environments, you might consider treating the surface to give it more protection against possible corrosion.

Kevlar is a synthetic fiber frequently used for bulletproof vests. Some of its characteristics make it worth evaluating for robot exteriors, too. You could use it as a covering on robots that require safeguarding from extreme temperatures. Many heat-resistant gloves feature Kevlar because the material does not melt or drip when exposed to hot environments.

Investors and developers have become increasingly aware of the need for eco-conscious and sustainable robotics development. Recycled materials and biodegradable plastics would go a long way to helping them achieve that goal.

This is just an introductory list to some of the most commonly used materials for robot exteriors. Of course, the material a robot uses will depend primarily on its purpose. For instance, materials used in robot-assisted surgery must be able to withstand rigorous sterilization techniques. In this case, a polymer like acrylonitrile butadiene styrene (ABS) would fare far better than a material that can't stand up to medical requirements and regulations.

Some soft robotics materials can even "feel" pain and heal themselves.

Source: Adapted from the article "5 materials to evaluate for designing, building robust robots" (robotplatform.com, 2021a).

Read the text above and answer the following questions

1. What are the materials mentioned in the text?

   . . . .

2. Why are recycled materials and biodegradable plastics used in robots?

   . . . .

3. What is the field of robotics using materials that can "feel" pain and heal themselves?

   . . . .

Solution is in the footnote.[1] [2] [3]

[1] steel, rubber, aluminum, kavlar, recycled materials, biodegradable plastics, polymer

[2] the need for eco-conscious and sustainable robotics development

[3] soft robotics

7.2 Writing: Properties of Materials

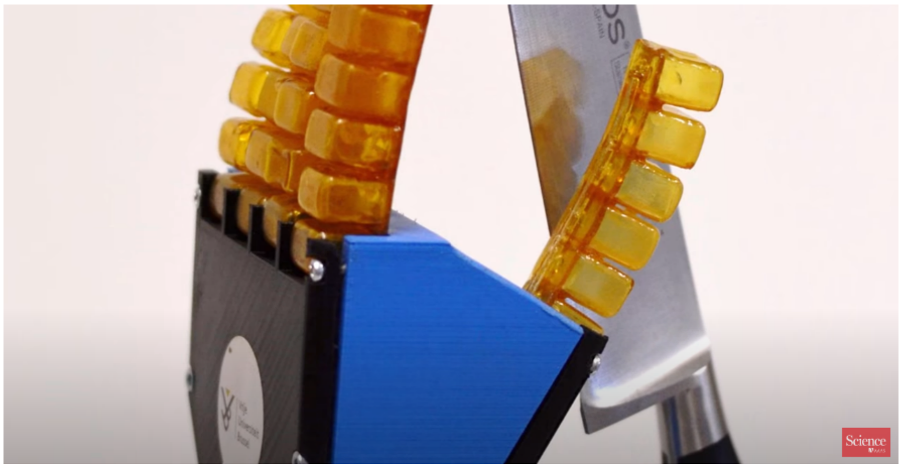
Write a paragraph about the properties of a material used in robotics. An example is shown below.

> Steel is the most common and least expensive metal, and also one of the strongest. Unhardened mild steel yields at 30,000-50,00 psi. For structural purposes, it can be hardened easily to 100,000 psi, and for tooling, can be strengthened to nearly 300,000 psi. It has a density of approximately 8 times the density of water (7.9 gm/cc), and a melting point around 1400 degrees C (pure iron 1530 C), which looks white hot.
>
> — "Structural Materials for Robots". (Nelson, 2020)

7.3 Speaking: What is This Robot Made of?

Discuss with your classmates about different materials that are probably used to make this mobile robot.

7.4 Listening: Self-healing Robot



Source: “A robot that heals a little like WolverineA”. Youtube. https://youtu.be/X5CvLQ9fULs (Science Magazine, 2017).

Listen to the video and fill in the blanks.

. . . . might be the next big thing, but right now, they're very delicate.

Any small rips or punctures could render these devices unusable.

To combat this, researchers have built soft robots with a material that, with a little heat, can reassemble itself after some types of damage.

The robots get this . . . . factor from their construction.

They are made entirely of a synthetic material called an elastomer, short for “elastic . . . .”

When heated, the molecular bonds that keep the elastomer together loosen, and begin to reform back to their original cube-like ....

A little over an hour after being damaged, the material was almost completely healed, and 24 hours after cooling, the only evidence was a small scar. In testing, this material was adapted to a robotic hand, a gripping claw, and an artificial muscle. Each one represents a standard use for a soft robot, and each one was successfully able to heal when heated.

The robots could withstand cuts and stabs, and achieved nearly-full .... once healed.

Even after two healing ...., the robots could still perform well.

The researchers say that these .... elastomers could make soft robots more commonplace, now that their weakness for pointy objects has been eliminated.

Solution is in the footnote.[4]

7.5 My Glossary

Translate these terms into your language.

aluminum ....

recycled materials ....

biodegradable plastics ....

sustainable ....

self-healing ....

4 Soft robots; healing; polymer; shape; performance; cycles; self-healing

8

Robot Safety

Today robots are used in many different areas and applications, and their safety-related problems have increased significantly. Each new area and application may call for specific precautions for operators, maintenance workers, robot systems, and so on. In the past, robot safety did not receive as much attention as it deserved from both manufacturers and users. This scenario is changing in recent years, and robot-related accidents could be one of the factors behind this change.

Source: Adapted from the chapter "Fundamentals of Robot Safety" (Dhillon, 1991).

8.1 Reading: Workplace Robotics Safety

Many hazards and injuries can result from the use of robots in the workplace. Some robots, notably those in a traditional industrial environment, are fast and powerful. This increases the potential for injury as one swing from a robotic arm, for example, could cause serious bodily harm. There are additional risks when a robot malfunctions or is in need of maintenance. A worker who is working on the robot may be injured because a malfunctioning robot is typically unpredictable.

There are four types of accidents that can occur with robots. Impact or collision accidents occur generally from malfunctions and unpredicted changes. Crushing and trapping accidents occur when a part of a worker's body becomes trapped or caught on robotic equipment. Mechanical part accidents can occur when a robot malfunctions and starts to “break down”, where the ejection of parts or exposed wire can cause serious injury. Other accidents at just general accidents that occur from working with robots.

There are seven sources of hazards that are associated with human interaction with robots and machines. Human errors could be anything from one line of incorrect code to a loose bolt on a robotic arm. Many hazards can stem from human-based error. Control errors are intrinsic and are usually not controllable nor predictable. Unauthorized access hazards occur when a person who is not familiar with the area enters the domain of a robot. Mechanical failures can happen at any time, and a faulty unit is usually unpredictable. Environmental sources are things such as electromagnetic or radio interference in the environment that can cause a robot to malfunction. Power systems are pneumatic, hydraulic, or electrical power sources; these power sources can malfunction and cause fires, leaks, or electrical shocks. Improper installation is fairly self-explanatory; a loose bolt or an exposed wire can lead to inherent hazards.

Emerging robotic technologies can reduce hazards to workers, but can also introduce new hazards. For example, robotic exoskeletons can be used in construction to reduce load to the spine, improve posture, and reduce fatigue; however, they can also increase chest pressure, limit mobility when moving out of the way of a falling object, and cause balance problems. For collaborative robots, isolation is not possible. Possible hazard controls include collision avoidance systems, and making the robot less stiff to lessen the impact force.

Source: Adapted from the Wikipedia article "Workplace robotics safety" (Wikipedia contributors, 2021f), which is released under the Creative Commons Attribution-Share-Alike License 3.0.

Read the text above and complete the lists below.

Four types of accidents

1. . . . .
2. . . . .
3. . . . .
4. *other accidents*

Seven sources of hazards

1. *human errors*
2. *control errors*
3. . . . .
4. . . . .
5. . . . .
6. . . . .
7. *improper installation*

What are the possible hazards when using robotic exoskeletons?

. . . .

Solution is in the footnote.[1] [2] [3]

---

[1] 1.impact or collision; 2.crushing and trapping 3.mechanical part

[2] 3.unauthorized access; 4.mechanical failures; 5.environmental sources; 6.power systems

[3] chest pressure, limit mobility, balance problems

8.2 Writing: What is a Robot Safety Standard?

Use the following words to fill in the blanks.

international; safe operations; organizations; safety standard; global market

---

Source: Adapted from the article "Robot Safety Standards: A Brief Overview" (Robotics Online, 2017).

A robot . . . . is a collection of guidelines for robot specifications and . . . . in which all involved in the manufacture, sales and use of robots must follow. Often, standards are created by a diverse group of industry interests to ensure the standards benefit everyone.

Some common standards . . . . include:

- American National Standards Institute (ANSI)
- U.S. Standards Body including CSA, BSI, DIN, AFNOR, JISC and more
- International Organization for Standardization (ISO)
- International Standards Body
- International Electrotechnical Commission (IEC)
- International Standards Body

Much of the work of robot safety standards organizations is involved in making . . . . robot standards. This is where robot safety standards begin to have a much larger impact on the . . . .

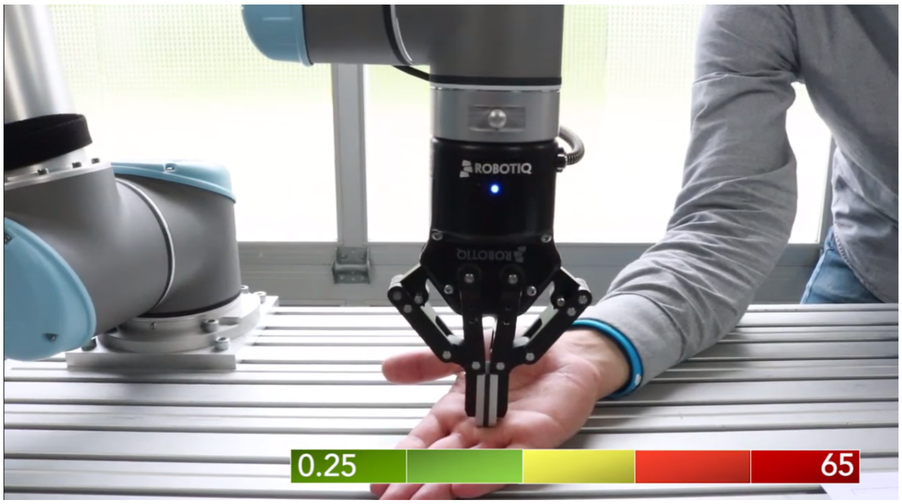
Solution is in the footnote.[4]

[4] safety standard; safe operations; organizations; international; global market

8.3 Speaking: Who Is At Fault? Who is Liable?

Discuss with your classmates who is responsible if there occurs an accident with a self-driving car: the car company, the car designers (engineers), the car owner, the car itself, others.

8.4 Listening: Collaborative Robot - Risk Assessment



Source: “Evaluate a Risk for a Collaborative Robot - Risk Assessment”. Youtube. https://youtu.be/itHzlfuUa5k (Robotiq, 2016).

Listen to the video and fill in the blanks.

In a . . . . process, it is important to identify the different risk involving the use of a collaborative robot.

Evaluating a risk correctly can be a game-changer in your risk assessment process.

The risk is usually evaluated using four different criteria: severity of injury, possibility of occurrence, possibility of avoidance, and . . . .

Let's take the simple example of a gripper hitting my hand against the table.

The severity of injury is rated from 0.25 to 0.65. The lowest being a scratch or a bruise. The highest being .... In this case, the pain level is not even reached when the robot stops. So a rating of 0.25 is accorded to this risk.

The second .... is the possibility of occurrence of the hazard. It is rated from 0.05 being almost impossible to 6 being certain. In this case, we consider that this risk is possible.

The third criterion is possibility of avoidance rated from possible being 0.75 to impossible being 5. In this case the robot is not moving fast enough to .... me instantly. So it is possible to avoid the impact.

Finally, the frequency of exposure is rated from 0.5 being annually to 5 being constantly. In this case, the worker is exposed daily to the answer.

Then all these criteria are multiplied together to give a certain rate. In this case 1.4 which is considered as being ....

Once all your risks are evaluated. You can do a risk reduction process starting with the most dangerous one.

Solution is in the footnote.[5]

8.5 My Glossary

Translate these terms into your language.

safety standard ....

liable, liability ....

risk assessment ....

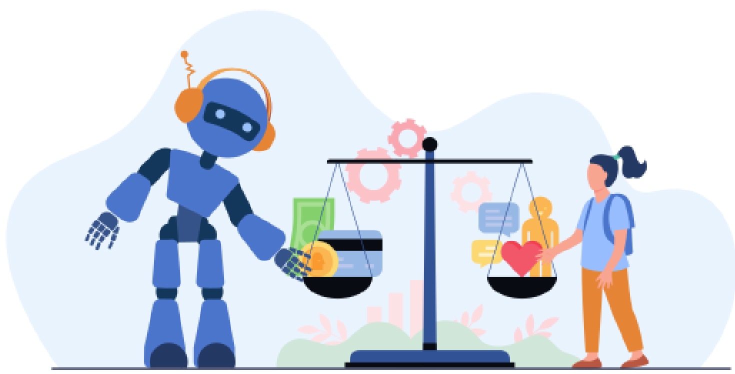
exposure ....

avoidance ....

[5] risk assessment; frequency of exposure; catastrophic; criterion; crush; neglectable

9

Robot Ethics



Robot ethics (or roboethics) concerns ethical problems that occur with robots, such as whether robots pose a threat to humans, whether some uses of robots are problematic, and how robots should be designed such that they act 'ethically'. Researchers from diverse areas are beginning to tackle ethical questions about creating robotic technology and implementing it in societies, in a way that will still ensure the safety of the human race.

Source: Adapted from the Wikipedia article "Robot ethics" (Wikipedia contributors, 2021c), which is released under the Creative Commons Attribution-Share-Alike License 3.0.

9.1 Reading: The Ethical and Social Implications of Robotics

Book overview: Robot Ethics – The Ethical and Social Implications of Robotics

Edited by Patrick Lin, Keith Abney and George A. Bekey

Robots today serve in many roles, from entertainer to educator to executioner. As robotics technology advances, ethical concerns become more pressing: Should robots be programmed to follow a code of ethics, if this is even possible? Are there risks in forming emotional bonds with robots? How might society—and ethics—change with robotics? This volume is the first book to bring together prominent scholars and experts from both science and the humanities to explore these and other questions in this emerging field.

Starting with an overview of the issues and relevant ethical theories, the topics flow naturally from the possibility of programming robot ethics to the ethical use of military robots in war to legal and policy questions, including liability and privacy concerns. The contributors then turn to human-robot emotional relationships, examining the ethical implications of robots as sexual partners, caregivers, and servants. Finally, they explore the possibility that robots, whether biological-computational hybrids or pure machines, should be given rights or moral consideration.

Ethics is often slow to catch up with technological developments. This authoritative and accessible volume fills a gap in both scholarly literature and policy discussion, offering an impressive collection of expert analyses of the most crucial topics in this increasingly important field.

Source: Adapted from the overview of the book "Robot Ethics" (Lin et al., 2012) at `https://mitpress.mit.edu/books/robot-ethics`.

Read the text above and answer the following questions.

1. Why do ethical concerns become more pressing?

. . . .

2. Who is involved in this book?

. . . .

3. What are the roles of robots in human-robot emotional relationships that this book examines?

. . . .

4. Is research on robot ethics fast enough?

. . . .

Solution is in the footnote.[1] [2] [3] [4]

[1] because robotics technology advances

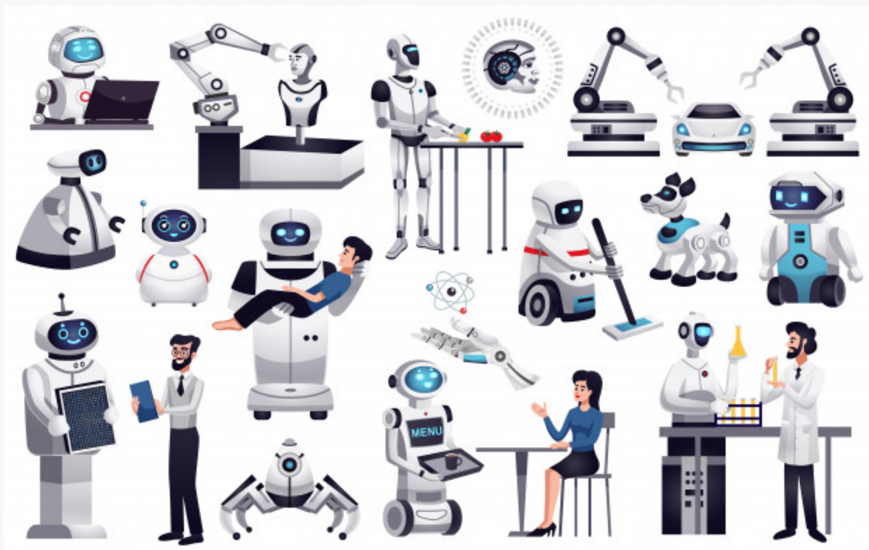
[2] scholars and experts from both science and the humanities

[3] sexual partners, caregivers, and servants

[4] ethics is often slow to catch up with technological developments

9.2 Writing: Can Robots Replace Human?

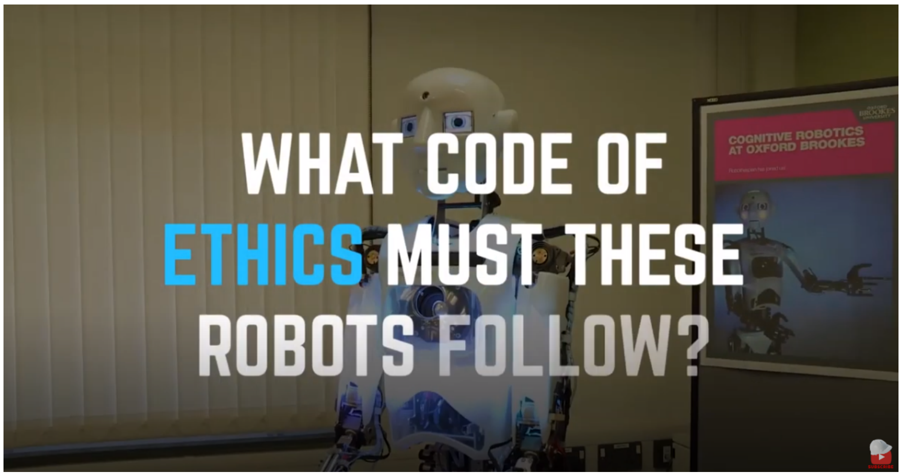
Write a paragraph about a job that can be performed by robots and the relevant ethical or legal issues.



9.3 Speaking: Android

Discuss with your classmates whether or not robots should look like a human. How much should robots look like us?

9.4 Listening: Can We Apply Human Ethics to Robots?



Source: "Can we apply human ethics to robots? (Roboethics)". Youtube. https://youtu.be/dWshtB0gCvs (Interesting Engineering, 2019).

Listen to the video and fill in the blanks.

[From 2:37] How can we create robots that never harm humans?

When robots can finally think for themselves, who or what is going to be held responsible, when or if an autonomous system . . . . or willfully harms a human.

Currently researchers are following a trend that aims at promoting the design and implementation of artificial systems with embedded . . . . acceptable behavior. This is all good and well for service robots. They are designed to live peacefully among humans.

But what do we do about . . . . robots? How do we apply robot ethics to robots that are meant to harm and perhaps even kill humans?

Author of The AEhical Landscape of Robotics Noel Sharkey argues that the cognitive capabilities of robots do not match that of humans and thus lethal robots are .... as they may make mistakes more easily than humans.

Indeed Asimov's laws cannot be theoretically applied to robots that are designed to kill humans. There is also the theory that engineers and designers of robots must assume .... regarding the ethical consequences of their creations. In other words, engineers and designers of robots must be morally accountable for what they design and bring out into the world.

If this is the case then creators of lethal robots take responsibility for the harm those robots do. This is a tricky area to navigate as military robots are a big industry and will continue to become more so.

In the end robot ethics seem to leave us with more .... questions. Only time will tell how the field evolves with the advent of more and more robots. But since the age of robotics is upon us, it might serve us well to explore robot ethics at a ....

Solution is in the footnote.[5]

9.5 My Glossary

Translate these terms into your language.

ethics ....

humanities ....

morally ....

lethal ....

[5] malfunctions; morally; lethal; unethical; responsibility; unanswered; faster pace

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30. Android. Photo from http://www.geminoid.jp/en/index.html

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