Hoang-Long Cao

English for Robotics

Tiếng Anh chuyên ngành Robot và Cơ điện tử

Contents

Preface

The book is under development. (2021-01-08)

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 to state-of-the-art knowledge in robotics and partially mechatronics and AI since these fields are closely connected.

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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[2] http://creativecommons.org/licenses/by-nc-sa/4.0/

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.

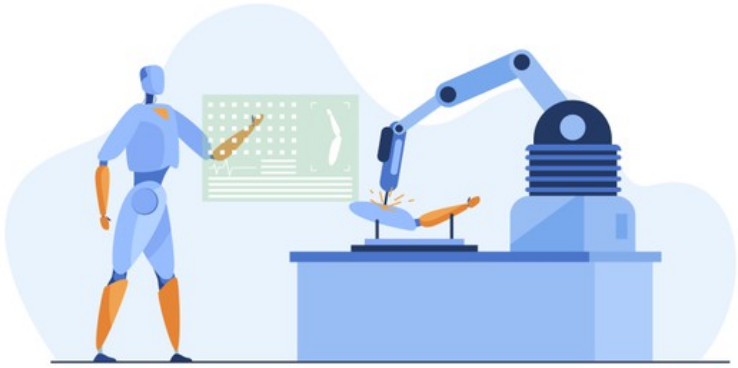
English definitions are from Cambridge Dictionary[3], and Dictionary.com[4].

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

[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, 2021d), 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, 2021d), 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]

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[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)

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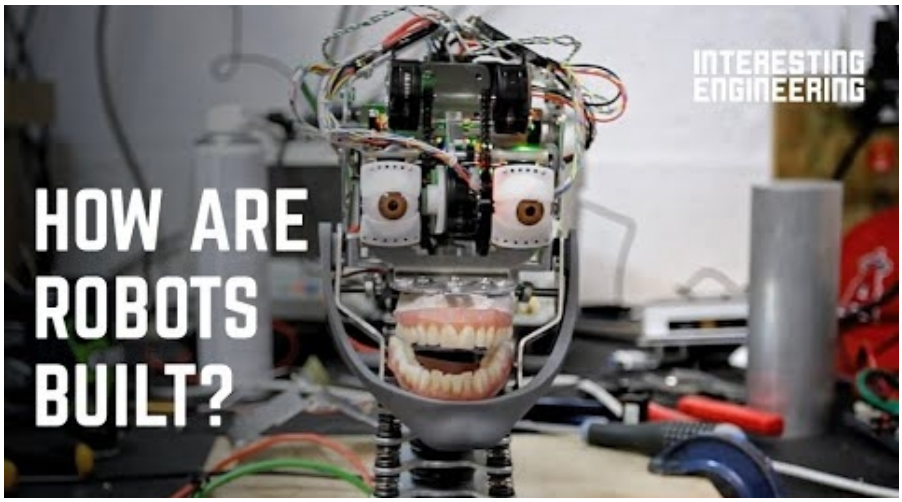
1.3 Speaking: Robots Help People

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 .....

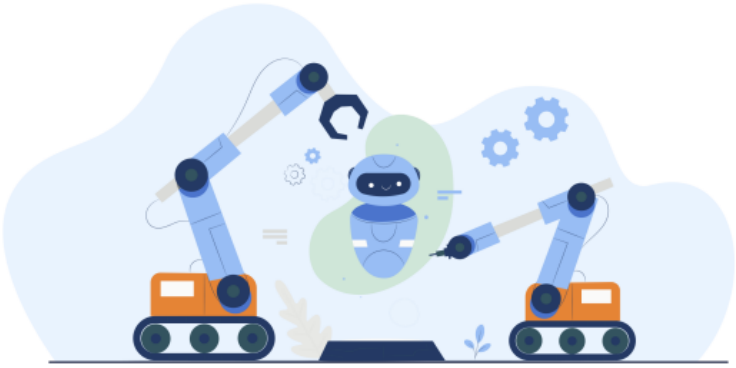
sensors .....

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]

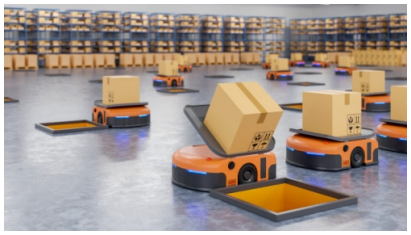
[1] 1.fixed; 2.mobile; aquatic; terrestrial; i.wheeled; ii.legged; airborne

[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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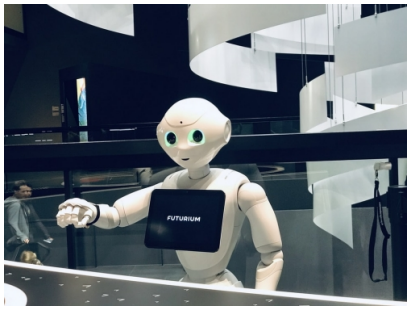

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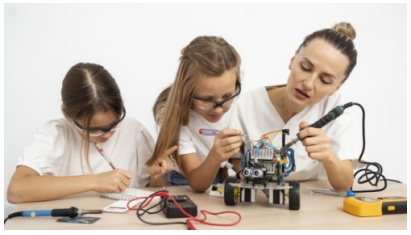
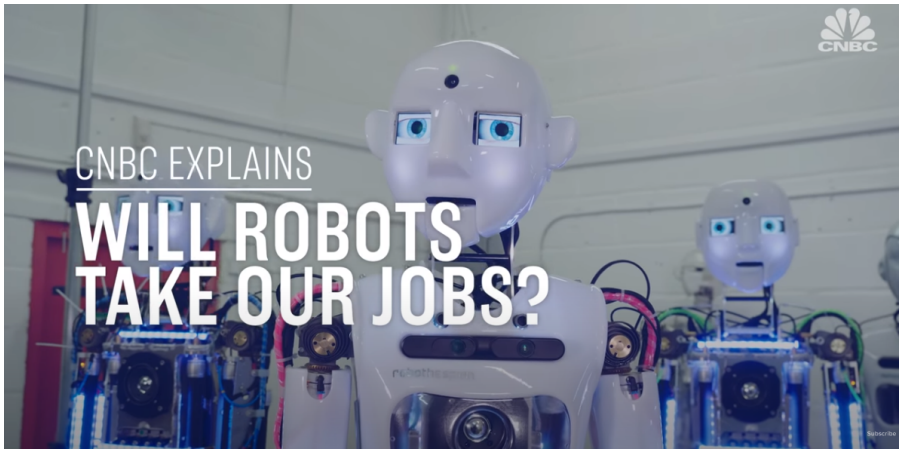


2.3 Speaking: Robots in Your Country

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

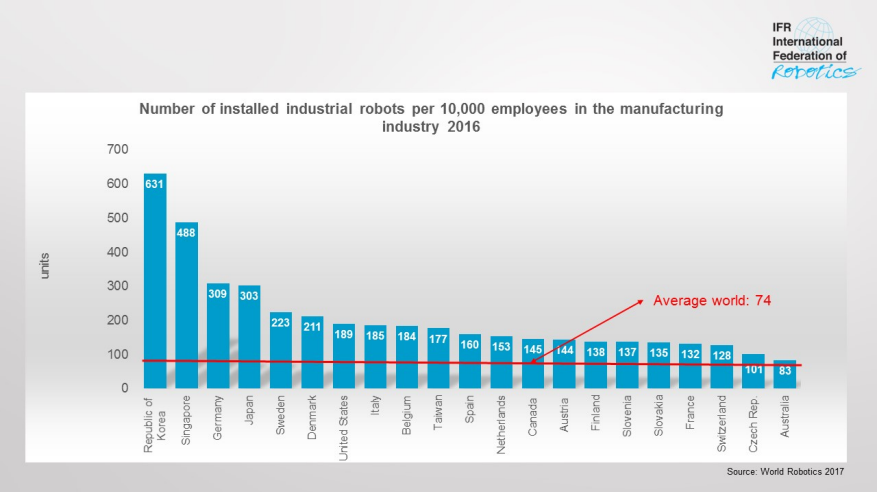
Robotics around the World

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]

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

2. 6.Denmark 7.USA 8.Italy 9.Belgium 10.Taiwan

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

3.2 Writing: What is Your Favorite Robot Company?

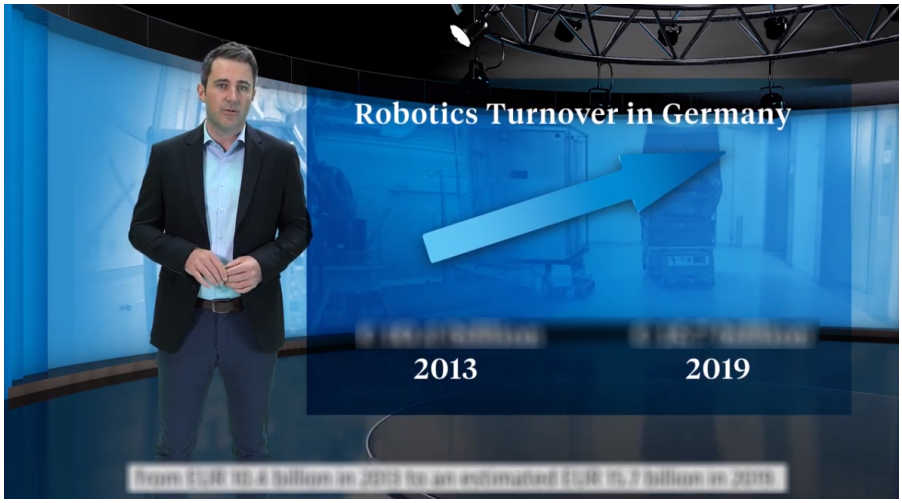
Write a paragraph about your favorite robot company. An example is shown below.

> 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 about 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 . . . . . .

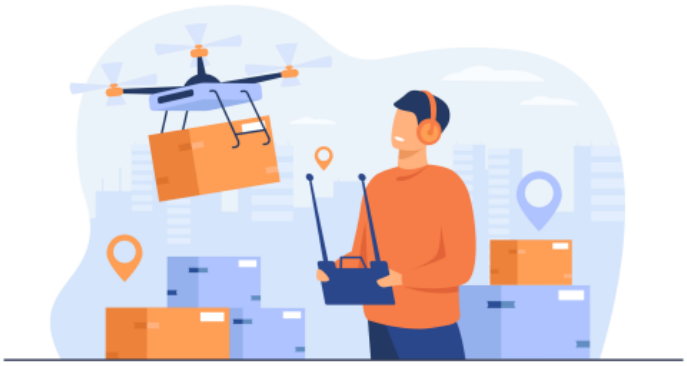
exoskeleton . . . . . .

entrepreneur . . . . . .

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

4

Robot Control



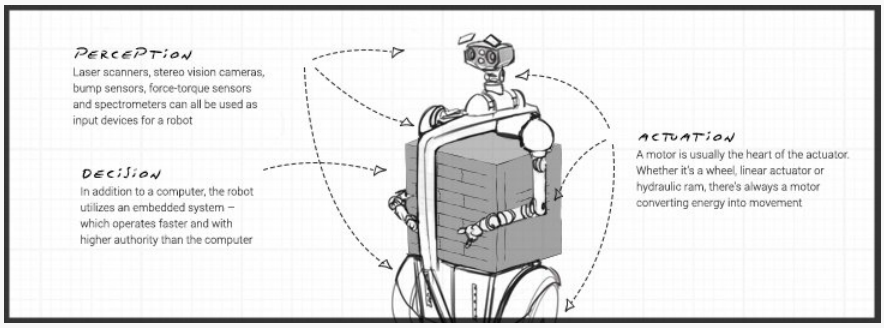
All robots have three types of components: sensors, a control system, and actuators. If we compare robots to human beings, the sensors would be our senses. They send information to the control system (the brain) and we modify our behaviour and effect our surroundings through actuators (parts of the body). 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 the system that contributes to the movement of robots. This involves the mechanical aspects and program systems that makes 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, the robots and its 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.

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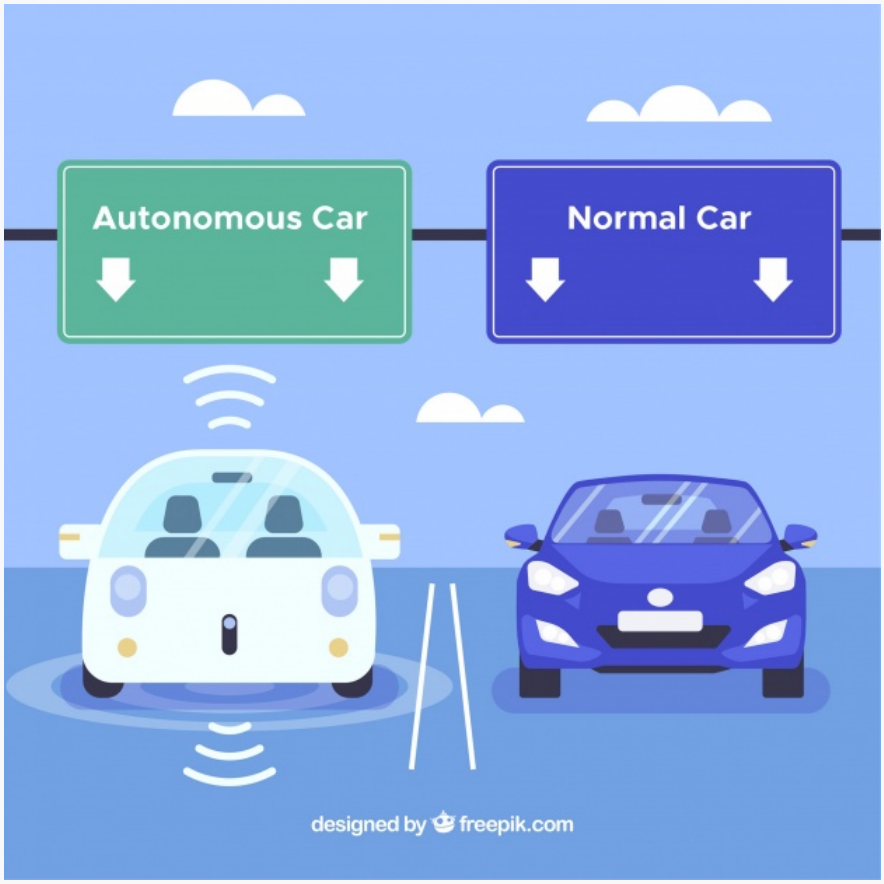
[4] https://www.robotshop.com/community/tutorials/show/how-to-make-a-robot-lesson-6-controlling-your-robot

4.3 Speaking: How can an Autonomous Car Navigate?

Discuss with your classmates about 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, 2021c), 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.

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

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 change in temperature.

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

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 few others for outdoor positioning.

An accelerometer is a device which measures acceleration and tilt.

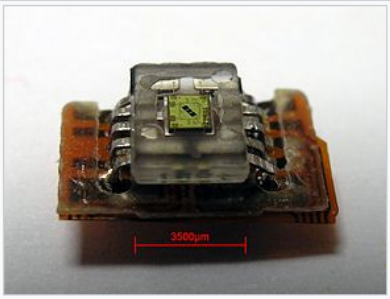
A gyroscope or simply Gyro is a device which measures and helps maintain orientation using the principle of angular momentum.

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

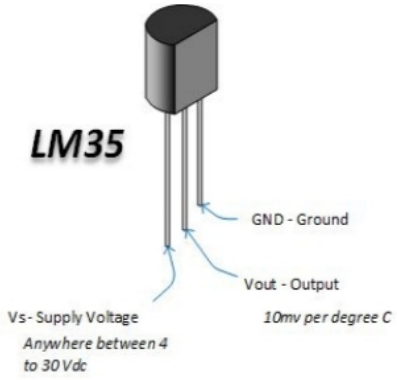
Current sensors are electronic circuits which monitor the current flow in a circuit and output either a proportional voltage or a current.

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

Read the text above and classify the sensors below.



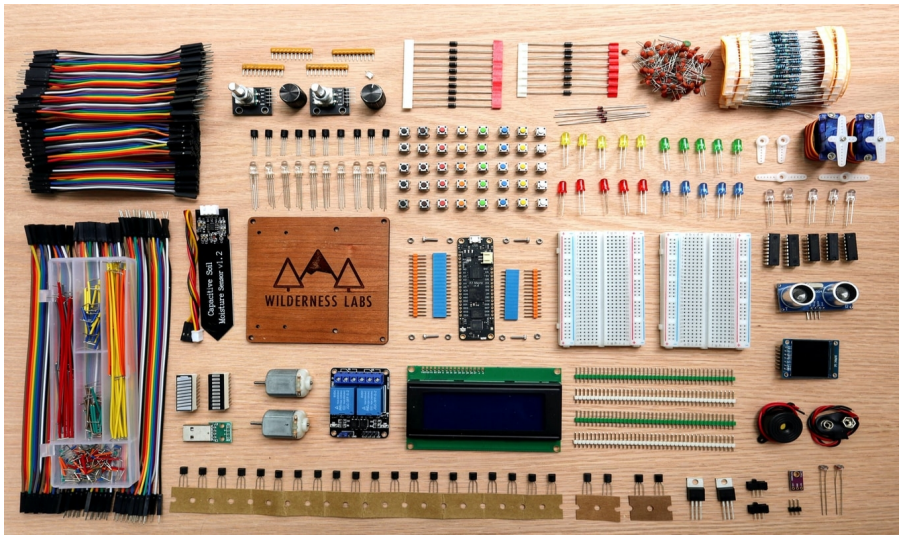
A photodetector salvaged from a CD-ROM drive. The photodetector contains three photodiodes, visible in the photo (in center).



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]

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

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

5.2 Writing: Manually Control a Robot

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.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

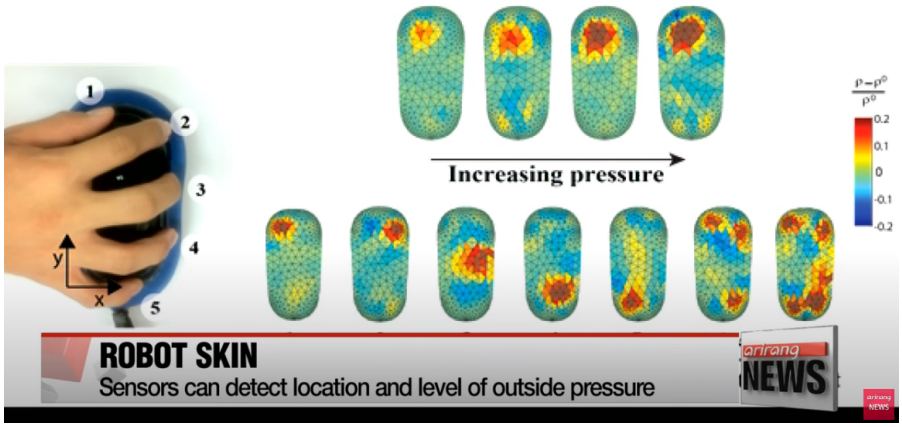
. . . . . .

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

5.3 Speaking: Making Decisions with Sensor Inputs

Discuss with your classmates different types of sensors that this industrial robot is probably equipped. 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/TsNOytwCkzk (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

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22. Photo of LM35 from https://www.eeeshopbd.com/
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