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INTRODUCTION TO ROBOTICS

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Contents

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Introduction

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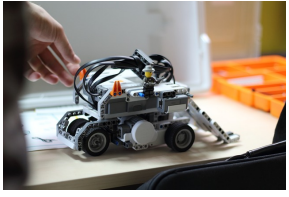
WALL-E
(zoomorphic)

C-3PO TT
(anthropomorphic)



Lego Robots
(technical)

What is a Robot?

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A Robot is...

- ... a machine able to extract information from its environment and use knowledge about its world to act safely in a meaningful and purposeful manner (Ron Arkin, 1998).

What is a Robot?

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A Robot is...

- ... a machine able to extract information from its environment and use knowledge about its world to act safely in a meaningful and purposeful manner (Ron Arkin, 1998).
- ... an autonomous system which exists in the **physical world**, can **sense** its environment and can **act** on it to achieve some goals (Maja J Mataric', 2007).

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Robotics

- The study of robots is known as Robotics, and it addresses **perception**, **interaction** and **action** in the physical world (loosely by Maja J Mataric', 2007).

Robots and Their Applications

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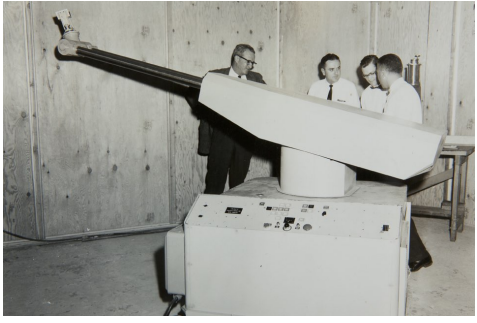
Unimate

- Created by George C. Devol in 1954 and deployed at the General Motors in 1961.
- First programmable manipulator for the manufacturing industry for specialized tasks.
- Video link: `https://www.youtube.com/watch?v=xyj6N-i6asQ`.



Unimate Robot
(a **stationary** robot)

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Shakey

- Created by Charles Rosen and team at Stanford Research Institute during 1966-1972.
- First AI-enabled **mobile** intelligent robot: **sense, reason, act**.
- Developments: A* search algorithm, STRIPS planner and Hough transform.
- IEEE Milestone Achievement Award!
- Video link: `https://www.youtube.com/watch?v=7bsEN8mwUB8`.

Shakey Robot and Charles Rosen

Robotics Application Domains

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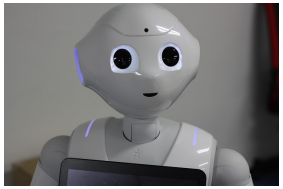
Based on purpose, we have robots for [1]:

- Healthcare and therapy
- Education
- Entertainment
- Search and rescue
- Telepresence
- Military and security
- Industry
- Public service
- Home and workplace
- Research



Pepper (SoftBank Robotics)

Autonomous Drone

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[1] Baraka, K., Alves-Oliveira, P., Ribeiro, T. (2020). An Extended Framework for Characterizing Social Robots. In: Jost, et al. (Eds.) Human Robot Interaction – Evaluation Methods and Their Standardization. Springer.

Robotics for UN Sustainable Development Goals (SDGs)

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A symbolic representation of the opportunities for robotics within the context of the UN SDGs. [1]

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[1] V. Mai et al., "The Role of Robotics in Achieving the United Nations Sustainable Development Goals"—The Experts' Meeting at the 2021 IEEE/RSJ IROS Workshop.

Robotics for UN Sustainable Development Goals (SDGs)

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Some examples of how robotics can contribute towards achieving the UN SDGs:

- SDG 3: Using socially assistive robots for autism therapy.
- SDG 7: Employing industrial robots to produce large stocks of **solar panels**.
- SDG 2: Developing robots with soft grippers to **harvest fruits and vegetables**.
- SDG 15: Sending **drones to monitor the air quality** and fight air pollution.
- SDG 14: Employing underwater robots to **monitor coral reefs**.
- SDG 13: Using aerial robots to **survey forest land**.
- ...

DFKI RIC and AG Robotik

More infos here: `https://robotik.dfki-bremen.de/en/research/teams/`

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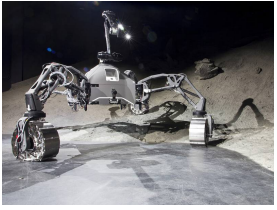
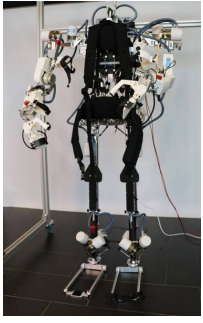
RH5 Manus
(Terrestrial)



Sherpa TT *(Space)*

DeepLeng *(Maritime)*



Full Body
Exoskeleton
(Healthcare)

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Learning Platform: TurtleBot3 Burger

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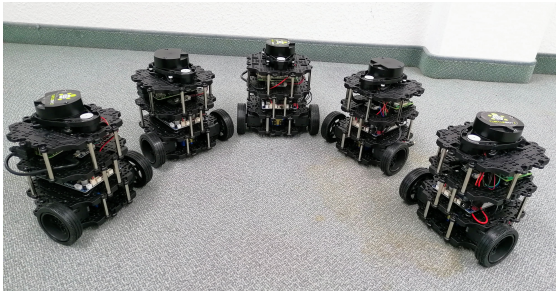

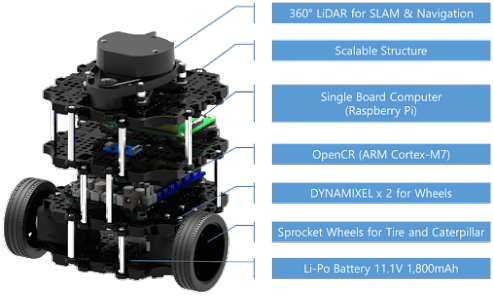

Documentation:
`https://emanual.robotis.com/docs/en/platform/turtlebot3/overview/`
`https://github.com/ROBOTIS-GIT/emanual`

Robots are made out of both hardware and software parts, for e.g.:

Hardware	**Software**
mechanical structure	operating system
sensors	drivers
actuators	data processing
processing units	algorithms
communication interfaces	software libraries

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How can robots be classified?

- Based on mobility: stationary or mobile
  - Stationary robots stay fixed at a specific location. E.g. robotic arms used in industry.
  - Mobile robots are capable of moving from one position to another in the environment. E.g. Mars Rovers.
- Based on appearance [1]:
  - Anthropomorphic (human-like); e.g. Pepper robot from SoftBank Robotics.
  - Zoomorphic (animal or insect-like); e.g. MiRo-E robot from Consequential Robotics Lab.
  - Technical (task-driven design); e.g. TurtleBot 3.

[1] Onnasch, L., Roesler, E. A Taxonomy to Structure and Analyze Human–Robot Interaction. Int J of Soc Robotics 13, 833–849 (2021).

Robot Autonomy

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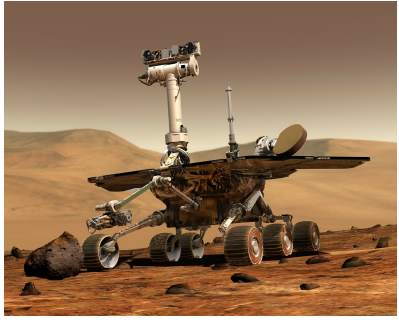
Traditionally, the focus has been on making robots **more autonomous**, i.e. to make them **less dependent on human** supervision or control to fulfill their tasks.

Teleoperation: Completely controlled by a human (not truly a robot).



Full autonomy: Makes decisions on its own and operates without any human control.

(Maja J. Matarić, The Robotics Primer, 2007)

Definition of Autonomy

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Autonomy:

"The extend to which a robot can operate in the tasks it was designed for (or that it creates for itself) without external intervention." [1]

[1] Baraka, K., Alves-Oliveira, P., Ribeiro, T. (2020). An Extended Framework for Characterizing Social Robots. In: Jost, et al.(Eds.) Human Robot Interaction – Evaluation Methods and Their Standardization. Springer, Cham.

Levels of Autonomy

Sheridan and Verplank (1978)[1] suggested 10 levels of autonomy summarized as follows by Parasuraman et al. (2000)[2]:

Level	Description (The computer...)
10 (High)	... **decides everything** and acts autonomously, **ignoring** the **human**.
9	... **informs** the human **only if it**, the computer, **decides to**.
8	... **informs** the human **only if asked**, or
7	... **executes automatically**, then **necessarily informs** the **human**, and
6	... **allows** the **human** a restricted **time to veto** before automatic execution, or

[1] Sheridan, T. B., and Verplank, W. L. (1978). Human and computer control of undersea teleoperators. Massachusetts Institute of Technology, Cambridge Man-Machine Systems Lab.
[2] Parasuraman, R., Sheridan, T. B., and Wickens, C. D. (2000). A model for types and levels of human interaction with automation. IEEE Transactions on Systems, Man and Cybernetics-Part A: Systems and Humans, 30(3), 286–297.

Levels of Autonomy

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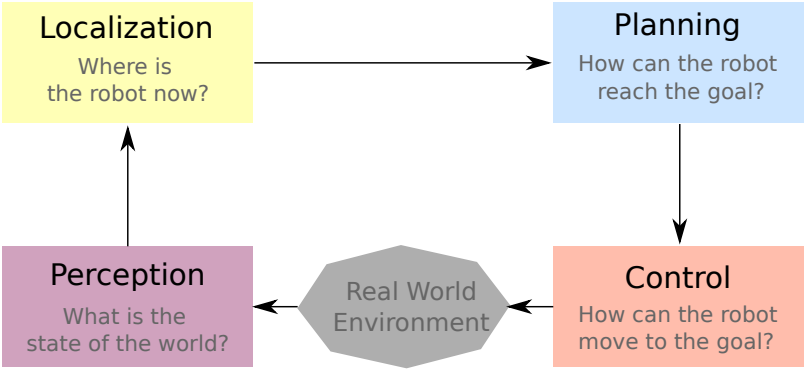
Sheridan and Verplank (1978)[1] suggested 10 levels of autonomy summarized as follows by Parasuraman et al. (2000)[2]:

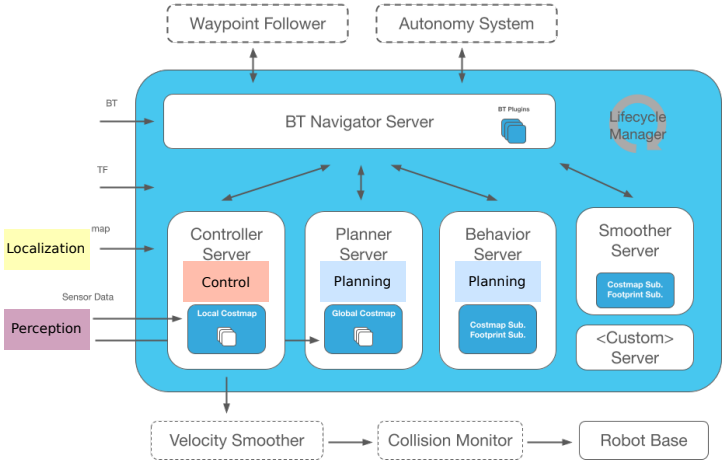
Level	Description (The computer...)
5	... **executes** that suggestion **if the human approves**, or
4	... **suggests** one **alternative**, or
3	... **narrows** the **selection** down to a few, or
2	... **offers** a complete set of decision/action **alternatives**, or
1(Low)	... offers no assistance; the **human** must **take all decisions** and **actions**

[1] Sheridan, T. B., and Verplank, W. L. (1978). Human and computer control of undersea teleoperators. Massachusetts Institute of Technology, Cambridge Man-Machine Systems Lab.
[2] Parasuraman, R., Sheridan, T. B., and Wickens, C. D. (2000). A model for types and levels of human interaction with automation. IEEE Transactions on Systems, Man and Cybernetics-Part A: Systems and Humans, 30(3), 286–297.

Autonomous Robot Navigation



Autonomous Navigation Stack in ROS2



Robot navigation stack in ROS2. `https://navigation.ros.org/`

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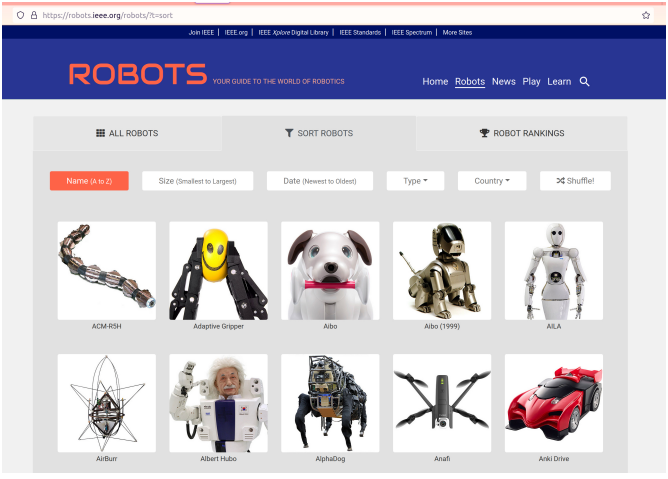
Institute of Electrical and Electronics Engineers



Source: `https://robots.ieee.org/learn/types-of-robots/`

Robotics Conferences and Journals

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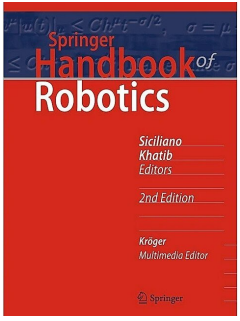
Follow some of the most important conferences and magazines to read more about the latest developments in robotics:

- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- IEEE Robotics and Automation Letters (RA-L)
- IEEE Transactions on Robotics
- Frontiers in Robotics and AI
- Springer Journal of Intelligent and Robotic Systems (JINT)
- MDPI Sensors
- ...

References

Learn more about Robotics



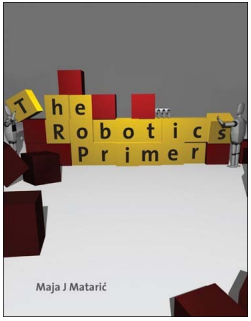
Springer Handbook of Robotics by Bruno Siciliano and Oussama Khatib. Springer (2008).

Source: `https://link.springer.com/referencework/10.1007%2F978-3-540-30301-5`

Mobile Roboter by Joachim Hertzberg, Kai Lingemann and Andreas Nüchter. Springer Vieweg (2012) (German).

Source: `https://link.springer.com/book/10.1007/978-3-642-01726-1`

References
Learn more about Robotics



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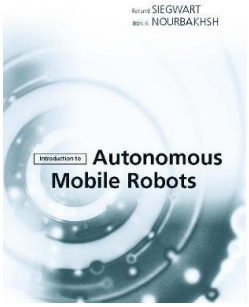
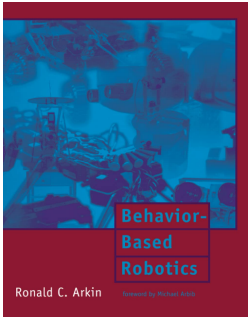


Introduction to Autonomous Mobile Robots by Roland Siegwart and Illah R. Nourbakhsh. The MIT Press (2004). Chapters 1, 4, 5, 6.



Behavior-Based Robotics by Ronald C. Arkin. The MIT Press (1998).

Next: Robot Programming