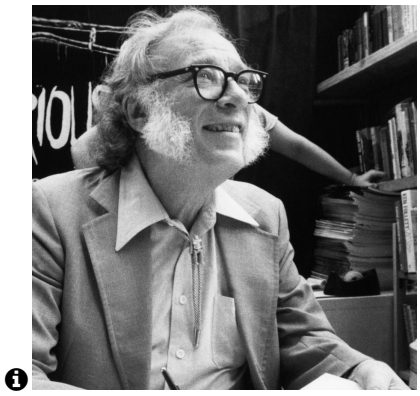
# Chapter 1

# What is Robotics?

**Reading**

1. Computing machinery and intelligence, Turing (2009)
2. Thrun Chapter 1
3. Barfoot Chapter 1

The word *robotics* was essentially coined by Issac Asimov in one of his short stories named Liar!. This is about a *robot* named RB-34 which, through a manufacturing fault, happens to be able to read the minds of humans around it. Around 1942, Isaac Asimov started using the word robot in his writings, is among its first references. This is also when he introduced the Three Laws of Robotics as the theme for how robots would interact with others in his stories/books. These are as follows.



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

Asimov would go on to base his stories on the counter-intuitive ways in which robots could apply these laws. In this case, RB-34 adheres to the First Law and in order to not hurt the feelings of humans and make them happy, it deliberately lies to them. It tells the *robopsychologist* Susan Colins that one of her co-workers is infatuated with her. However, when she confronts RB-34 later by pointing out that lying to people can end up hurting them, the robot experiences a logical conflict within its laws and becomes unresponsive.

This is, after all, science fiction but these laws give us insight into what robots are. Let's see what modern *roboticists* have to say.

> "Robotics is the science of perceiving and manipulating the physical world through computer-controlled mechanical devices." — Sebastian Thrun in Probabilistic Robotics

> "EVERYTHING comes together in the field of robotics. The design of an autonomous robots involves: the choice of the mechanical platform, the choice of actuators, the choice of sensors, the choice of the energy source, the choices of algorithms (perception, planning, and control). Each of these subproblems corresponds to a discipline in itself, with its design trade-offs of achievable performance vs limited resources." — Andrea Censi in Censi (2016).

I find the Third Law really insightful to understand intelligence as well. Let us define intelligence as the ability of an organism to survive[1]. We will all agree that trees are less intelligent than animals, an ant is less than intelligent than a dog, which is less intelligent than a human. A program like AlphaGo is not very intelligent, you can disable it by simply switching it off. A key indicator of intelligence is the ability to move around in the physical environment, to sense possible harm and take actions to change the outcome.

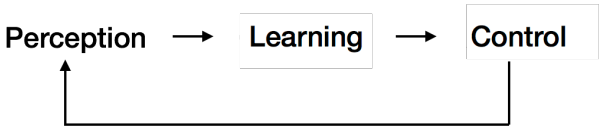
Robotics is Embodied Artificial Intelligence.

> A robot is a machine that senses its environment using sensors, interacts with this environment using actuators to perform a given task and does so efficiently using previous experience of performing similar tasks.

We will cover the fundamentals of these three aspects of robotics: perception, planning and learning.

## 1.1 Perception-Learning-Control

Perception refers to the sensory mechanisms to gain information about the environment (eyes, ears, tactile input etc.). Action refers to your hands, legs, or motors/engines in machines that help you move on the basis of this information. Learning is kind of the glue in between. It helps crunch information of your sensors quickly, compare it with past data, guesses what future data may look like and computes actions that are likely to succeed. The three facets of intelligence are not sequential and robotics is not merely a feed-forward process. Your sensory inputs depend on the previous action you took.




[1] feel free to come up with another definition

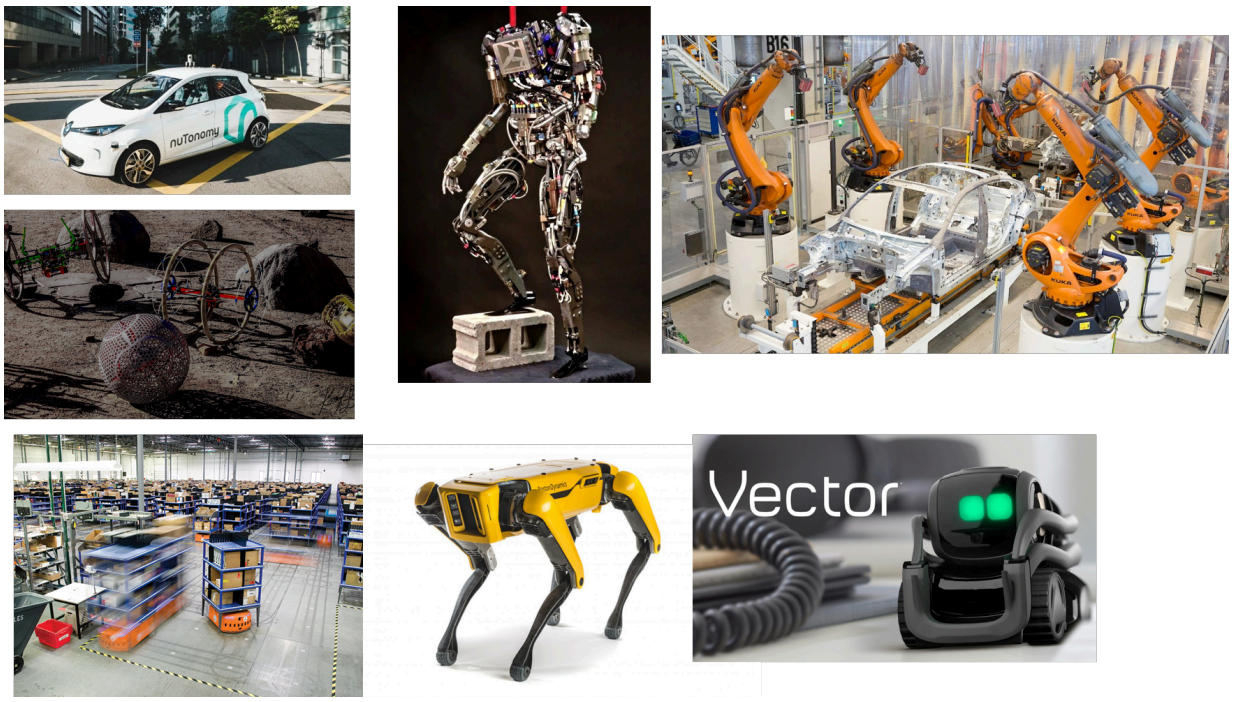
## 1.2 Goals of this course

The goals of this course is to develop the main ideas in robotic perception, learning and control. Robotics *is* everything, so we will focus on understanding how they are *combined together* to build a typical robot. After this course, we expect you to be able to choose one among the different robotics algorithms to perform a particular task, think critically about these algorithms and build new ones.

**Other courses** Some examples of other courses at Penn that address various aspects of this picture above are

- Perception: CIS 580, CIS 581, CIS 680
- Learning: CIS 520, CIS 521, CIS 522, CIS 620, CIS 700, ESE 545, ESE 546
- Control: ESE 650, MEAM 520, MEAM 620, ESE 500, ESE 505, ESE 619

## 1.3 Some of my favorite robots




These videos should give you an idea of how the everyday life of a roboticist looks like: Kiva's robots, Waymo's 360 experience, Boston Dynamics' Spot, JPL-MIT team at the DARPA Sub-T Challenge, Romeo and Juliet at Ferrari's factory, Anki's Vector, and the DARPA Humanoid Challenge.

# Bibliography

Censi, A. (2016). A class of co-design problems with cyclic constraints and their solution. *IEEE Robotics and Automation Letters*, 2(1):96–103.

Turing, A. M. (2009). Computing machinery and intelligence. In *Parsing the Turing Test*, pages 23–65. Springer.