The
Robotics
Primer

The Robotics Primer

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1 *What is a Robot?*

What is a robot?

This is a good question to start with in learning about robotics, because there is a lot of misunderstanding about what robots are and are not, what they never were, and what they may become some time in the future. The definition of what a robot is has been evolving over time, as research has made strides and technology has advanced.

The word "robot" was popularized by the Czech playwright Karel Capek in his 1921 play Rossum's Universal Robots (R.U.R.). Most dictionaries list Karel as the inventor of the word "robot", but more informal sources (such as the Web) state that it was actually Karel's brother, Josef, that invented the word. In either case, the word "robot" results from combining the Czech words "rabota" meaning "obligatory work" and "robotnik" meaning "serf". Most robots today are indeed performing such obligatory work, in the form of repetitive and fixed tasks, such as automobile assembly and DNA sequencing. However, robotics is about much more than obligatory labor, as you will learn in this book.

The idea of a robot, or some type of a machine that can help people, is much older than the Capek brothers. It is not possible to pin-point where it originated, because it is likely that any clever engineer of the past thought of it in some form. The form changed over time, as science and technology advanced, and made many of the previously-unachievable dreams of robots become a reality or at least within the realm of possibility.

With the advancement of science and technology, the notion of a robot has become more sophisticated. In the past, the idea of a robot was one of a machine that was, basically, a clever mechanical device. Examples of such devices, ever extremely sophisticated ones, can be found throughout history.

Some examples include... But, as we will see, those are not robots, at least not by our current definition and understand of what a robot is.

While original notions of robots were those of clever mechanical automatons, as computational machinery developed (and in particular when it shrank in size sufficiently to be imaginable within a robot's body), the notions of robots started to include thought, reasoning, problem solving, and even emotion and consciousness. In short, robots started to look more and more like biological creatures, be they people or other animals.

These days we have (or should have) a very broad notion of what a robot can be, and do not need to limit ourselves by what is currently precisely possible mechanically or computationally. However, it is still hard to anticipate how our ideas of what a robot is and can be will evolve as science and technology advance.

So back to the question: what is a robot?

A robot is an autonomous system which exists in the physical world, can sense its environment, and can act on it to achieve some goals.

The above may seem like a very broad definition, but actually each of its parts is important and necessary. Let's take it apart to see why:

> A robot is an AUTONOMOUS system...

An autonomous robot acts based on its own decisions, and is not controlled by a human. It is certainly true that there are examples of machines that are externally controlled by humans; this is called tele-operation (tele means far in Greek, so tele-operation means operating a system from afar). These, however, are not true robots. True robots act autonomously. They may be able to take input and advice from humans, but are not controlled by them.

> A robot is an autonomous system which exists in the PHYSICAL WORLD...

Existing in the physical world, the same world that people and animals and weather and ... exist in is a fundamental property of robots. Having to deal with that physical world, and its unbendable physical laws and challenges, is what makes robotics what it is, a real challenge. Robots that exist on the computer are simulations; they do not really have to deal with true properties of the physical world, because simulations are never as complex as the real world. Therefore, although there are a lot of simulated robots in cyberspace, a true robot exists in the physical world.

> A robot is an autonomous system which exists in the physical world, can SENSE its environment...

Sensing the environment means the robot has sensors, i.e., some means of hearing and/or smelling and/or touching and/or seeing, and so on, in order to get information from the world. A simulated robot, in contrast, can just be given the information or knowledge as if by magic. A true robot can only sense its world through its sensors, just like people and other animals do. Thus, if a system does not sense but is magically given information, we do not consider it a true robot. Furthermore, if a system does not sense or get information, then it is not a robot, because it cannot respond to what goes on around it.

> A robot is an autonomous system which exists in the physical world, can sense its environment, and can ACT ON IT...

Taking actions to respond to sensory inputs and to achieve what is desired is a necessary part of being a robot. A machine that does not act (i.e., does not move, does not affect the world by doing/changing something) is not a robot. As we will see, action in the world comes in very different forms, and that is one reason why the field of robotics is so broad.

ROBOT

> A *robot* is an autonomous system which exists in the physical world, can sense its environment, and can act on it to ACHIEVE SOME GOALS.

Now we finally come to the intelligence or at least the usefulness of a robot. A system or machine that exists in the physical world and senses it, but acts randomly or uselessly is not much of a robot, because it does not use the sensed information and its ability to act in order to do something useful for itself and/or others. Thus, we expect a true robot to have one or more goals and act in order to reach those goals. Goals can be very simple, such as "don't get stuck" or quite complex, such as "do whatever it takes to keep your owner safe."

Having defined what a robot is, we can now define what robotics is.

ROBOTICS

Robotics is the study of robots, which means it is the study of autonomous and purposeful sensing and acting in the physical world.

Food for Thought:

- Are exo-skeletons (e.g., Ripley's in the movie Alien) robots?
- Is HAL, from the movie 2001 the Space Odisy, a robot?
- Is a thermostat a robot?

- Some intelligent Web agents are called "softbots". Are they robots?

Helpful additional materials:

- For more information and a summary of Karel Capek's play R.U.R., see...