Basic Robotics

Learning Objectives:

Upon completion of this lesson you will be able to describe the history of robots, identify examples of common robots, identify the main parts of a robot, and explain how robots help humans.

Mission Team Leader Note This Mission may be conducted with (or without) the accompanying slide show.

Discussion

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Introduction to Robotics

The robots of the movies, such as C-3PO and the Terminator are portrayed as fantastic, intelligent, even dangerous forms of artificial life. However, robots of today are not exactly the walking, talking intelligent machines of movies, stories and our dreams. Today, we find most robots working for people in factories, warehouses, and laboratories. In the future, robots may show up in other places: our schools, our homes, even our bodies.

Robots have the potential to change our economy, our health, our standard of living, our knowledge and the world in which we live. As the technology progresses, we are finding new ways to use robots. Each new use brings new hope and possibilities, but also potential dangers and risks.

Continue lesson with NASA video "Let's Talk Robotics".

Continue with discussion sub-topics.

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History of Robots

When did the first *robot* appear?

In the 1920's, Karl Capek from Czechoslovakia introduced the world's first *robot* on stage. His play was entitled "Rossum's Universal Robots." The theme of the play was *robots* controlling

humans in society. Although he introduced the idea of *robots*, Karl Capek was skeptical about how much of an impact *robots* could have. He rejected all suggestions that a *robot* could ever replace a human being, or have feelings such as love or rebellion.

Where did the word *robot* come from?

The word "*robot*," a Czech term for forced labor or serf, was also introduced by a Capek. Karl was wondering what to call the "artificial workers" in his play, and he thought they should be called "labori." His brother didn't like that idea, and muttered that they should be called "*robots*." Then, the term "*robot*" was born.

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What is a Robot?

Simply, a robot is any machine that does work on its own, after being programmed by a human. Some examples of common robots are an alarm clock and a photocopier. (Ask the Mission Team members how an alarm clock and a photocopier could be considered robots. Ask them to come up with other examples of robots.) Ninety percent of robots in use today are industrial robots. That means they are used to assemble products; handle dangerous material; spray finishes on products; and even inspect parts, produce, and livestock. Robots can be found in factories, warehouses, laboratories, energy plants, hospitals, and even on the space shuttle.

What is the hardest thing for a *robot* to do?

The hardest thing for a *robot* to do is to walk. This is hard for the creators of the *robot* as well, since the act of walking involves hundreds of specific motions. Also, a large part of walking time is spent on one leg, so it is important for the *robot* to have good balance, just like a child learning to walk! Some real *robots* must walk on uneven surfaces, like the surface of Mars, so these *robots* need sensors in their legs to find good footholds!

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Why Use Robots?

There are many benefits to using *robots* instead of humans. Can you imagine working in a factory all day, every day, doing the exact same thing over and over again? The good thing about *robots* is that they will never get bored, and they will do things more efficiently than people. Also, *robots* never get sick, or need to rest. This means they can work for 24 hours a day, 7 days a week. They will never need time off, or lunch breaks. Sometimes, when a task is too dangerous or difficult for a human, a *robot* will be able to do it without any risks or problems. Some interesting places *robots* have travelled include space, the depths of the ocean, inside volcanoes, into buildings containing bombs, and others. *Robots* are sent out when the "mission" may be too dangerous for a human. *Robots* are regularly used by police forces around the world to disarm bombs, and by scientists to venture inside volcanoes to gather important data. A *robot*-camera named Jason was also involved in the discovery and exploration of the Titanic shipwreck in

1986. Jason was attached to a mini-submarine, and the crew up above directed the mini-submarine throughout the wreck, obtaining some great pictures!

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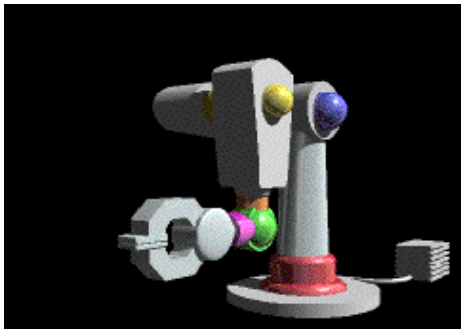
Robot Building Blocks

Robots consist of five main parts: controller, arm, drive, end effector, and sensor



Mission Team Leader Note (This part of the lesson can also be done online using http://www.paly.net/%7Edbertain/eng-ed/Robotics/robo/griponrobotics/index.html)

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CONTROLLER - Every robot is connected to a computer, which keeps the pieces of the arm working together. This computer is known as the controller. The controller functions as the "brain" of the robot. The controller also allows the robot to be networked to other systems, so that it may work together with other machines, processes, or robots.

Robots today have controllers that are run by programs - sets of instructions written in code. Almost all robots of today are entirely pre-programmed by people; they can do only what they are programmed to do at the time, and nothing else. In the future, controllers with artificial intelligence, or AI could allow robots to think on their own, even program themselves. This could make robots more self-reliant and independent.

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ARM - Robot arms come in all shapes and sizes. The arm is the part of the robot that positions the end-effector and sensors to do their pre-programmed business.
Many (but not all) resemble human arms, and have shoulders, elbows, wrists, even fingers. This gives the robot a lot of ways to position itself in its environment. Each joint is said to give the robot 1 degree of freedom.

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DRIVE **- The drive is the "engine" that drives the links (the sections between the joints into their desired position. Without a drive, a robot would just sit there, which is not often helpful. Most drives are powered by air, water pressure, or electricity.**

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END- EFFECTOR - The end-effector is the "hand" connected to the robot's arm. It is often different from a human hand - it could be a tool such as a gripper, a vacuum pump, tweezers, scalpel, blowtorch - just about anything that helps it do its job. Some robots can change end-effectors, and be reprogrammed for a different set of tasks**.**

If the robot has more than one arm, there can be more than one end-effector on the same robot, each suited for a specific task

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SENSOR - Most robots of today are nearly deaf and blind. Sensors can provide some limited feedback to the robot so it can do its job. Compared to the senses and abilities of even the simplest living things, robots have a very long way to go.

Humans and Robots – The Space Shuttle Remote Manipulator System (RMS)

Following the remarkable successes of the Apollo Moon landings and the Skylab space station program, many space experts began reconsidering the role of humans in space exploration. In a healthy debate on exploration strategies, some experts concluded the goals the future would be best served by robotic spacecraft. Human space travelers require extensive life support systems. With current propulsive technologies, it would just take too long to reach any destination beyond the Moon. Robots could survive long space voyages and accomplish exploration goals just as well as humans. Other space experts disagreed. Humans have an important place in space exploration, they contended. Robots and humans are not interchangeable. Humans are far more adaptable than robots and can react better to the unexpected.

When things go wrong, humans can make repairs. This, they pointed out, was demonstrated conclusively during Skylab, when space walkers made repairs that saved the mission. Today, new exploration strategies are at work. The goal is no longer humans or robots. It is humans and robots working together. Each brings important complimentary capabilities to the exploration of space. This has been demonstrated time and again with the Space Shuttle Remote Manipulator System (RMS) robot arm. The arm, also called Canadarm because it was designed and constructed by Canada, has been instrumental to the success of numerous space missions. The 15-meter-long arm is mounted near the forward end the port side of the orbiter's payload bay. It has seven *degrees of freedom* (DOF). In robot terms, this means that the arm can bend and rotate in seven different directions to accomplish its tasks. Like a human arm, it has a shoulder joint that can move in two directions (2DOF); an elbow joint (1 DOF); a wrist joint that can roll, pitch, and yaw (3 DOF); and a gripping device (1 DOF). The gripping device is called an *end effector*. That means it is located at the end of the arm and it has an effect (such as grasping) on objects within its reach.

The RMS's end effector is a snare device that closes around special posts, called *grapple fixtures*. The grapple fixtures are attached to the objects the RMS is trying to grasp.
On several occasions, the RMS was used to grasp the *Hubble Space Telescope* and bring the spacecraft into the orbiter's payload bay. After the spacecraft was locked into position, the RMS helped spacewalking astronauts repair the telescope and replace some of its instruments. During operations, the RMS is controlled by an astronaut inside the orbiter. The RMS actually becomes an extension of the operator's own arm. Television cameras spaced along the RMS permit the operator to see what the arm is doing and precisely target its end effector. At times, during the

Hubble servicing, one of the space walkers hitched a ride on the end effector to gain access to parts of the telescope that were difficult to reach. The arm became a space version of the terrestrial cherry picker.

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Activity

Have Mission Team members do basic robotics activity one which emphasizes the dexterity and fine senses of the human body.

Basic Robotics Activity One

Begin the lesson by asking Mission Team members to imagine they are robots in Earth's orbit with a simple task to perform: Tie the safety tether of an astronaut to a metal ring in the open cargo bay of the space shuttle. Easy for a hightech robot, right?

Have Mission Team members put on blindfolds and tie their shoes. Ask them to try it again, this time wearing the blindfolds and heavy gloves. Repeat the task a third time, but this time tape Popsicle sticks or tongue depressors to the fingers of the gloves.

Ask Mission Team members the following questions: Why is it so hard to tie your shoes? What are the many different kinds of signals your brain receives from your body to do this seemingly simple task? What would be involved in building a machine to tie your shoes.

Sometime during your life, maybe about 20 years from now, you will see the first images of a human walking on Mars. You may even be the first one to walk on Mars Long before a human undertakes the dangerous task of going to Mars, however, the planet will be explored by an army of large and small robots.

A robot is an electronically controlled device programmed to conduct tasks that could normally be done by human workers. In hostile environments everywhere, particularly in space, modern explorers are turning to robots to undertake dangerous missions that cannot yet be undertaken by humans. In July 1997, a small robotic rover called Sojourner drove around on the cold surface of Mars, the first of many robots being designed by NASA to explore other planets. On Earth, smart robots are being developed to venture into active volcanoes, dive deep into the oceans, search for land mines left from wars, and help police disarm terrorist bombs.

Much robot development is spurred by NASA. The space agency plans to use robots in three basic ways: on-orbit assembly, science payload tending, and planetary surface exploration. Assembly robots will help build Space Station Alpha during the next few years. The robots will be the eyes and hands of human controllers who will use something called virtual reality telepresence to see what the robot sees.

Science payload robots will help astronauts inside the space station and will run science experiments when people aren't around. Exploration robots will land on and survey distant planets, moons, and asteroids. These robots must be able to "think" for themselves. If a robot comes to a cliff on Mars, for example, it has to stop without a controller back on Earth telling it to do so. Thinking robots are important because it takes many minutes to communicate between

Earth and other planets, so human controllers can't respond fast enough to help a robot avoid a dangerous situation.

Earthbound industries are adapting much of NASA's robotic technology for everything from tiny microsurgery tools to giant steam shovels. While a robot may never actually tie your shoes, the machines are increasingly becoming creatures not just of science fiction, but of the real world.

1. Robots have been used in manufacturing for more than a decade. What products do you use that were made with the help of a robot? How and why was a robot used?

2. Do you think a smart robot could be your friend? How would that be different from having a human friend or even a pet? What responsibilities would you have toward the robot?

3. What activities or problems can you think of that a robot could solve or at least help with?

PROGRAM YOUR PARTNER

Try your hand at guiding a robot to do a simple task.

Until robots become true "thinking" machines, able to understand their environment and make decisions about what to do to accomplish their mission, they will depend on controllers to guide them. In this activity you will work with a partner to find out how hard it is to accurately guide a robot through even simple tasks.

Materials

1. blindfold
2. notebook
3. shoe box (or some other container that size.
4. baseba1.or tennisball

1 Working with a partner, one of you will take on the role of a robot, the other the controller. The person playing the robot should be securely blindfolded and given the ball.

2. The robot, following verbal instructions from the controller, must move along a prescribed course (down an aisle and around a desk, for example) and then deposit the ball in the container. The robot can't talk during the first attempt and must follow the directions given to it exactly ("turn right" doesn't necessarily mean all parts of the body or 90° right). After the robot has successfully put the ball in the container, the robot and controller should switch roles and try it again.

3. When you have both completed the task, figure out what the most difficult part in communicating instructions was, then develop a written glossary of commands to make maneuvering easier. Define a specific length for a step (the length of a piece of notebook paper, for example) and instead of saying "turn right" or "turn left," work out specific angles for the size of turns ("turn 20 degrees to the right," for example).

4. Repeat the mission again using a different route, taking a turn in each role. Did the glossary make things easier for both the robot and the controller? Was there less misunderstanding?

5. Try it again, but this time draw a map of the route the robot is supposed to take. The controller must sit facing away from the course the robot must follow, but this time the controller will use the robot's eyes (which in a real robot would be a TV camera). The controller must use the map to keep track of the robot's location and is allowed to ask "yes" and "no" questions so the robot can give feedback about its surroundings. The robot must still await the controller's instructions before moving.

Questions

1. What problems might you face if the robot wasn't as smart as you or your partner?

2. The minimum round-time for a signal between Earth and Mars is 8.8 minutes; the maximum time is 41.9 minutes. How would you change your commands if they took 20 or 30 minutes to reach your robot? What dangers would that delay cause?

3. What sensory devices could you add to the robot to make controlling it more precise?