Robotics Merit Badge

Robotics - Requirements

Safety. Do each of the following:

- Explain to your counselor the most likely hazards you may encounter while working with robots and what you should do to anticipate, mitigate and prevent, and respond to these hazards. Describe the appropriate safety gear and clothing that should be used when working with robotics.
- Discuss first aid and prevention for the types of injuries that could occur while participating in robotics activities and competitions, including cuts, eye injuries, and burns (chemical or heat).

Robotics - Requirements

Robotics industry. Discuss the following with your counselor:

- The kinds of things robots can do and how robots are best used today.
- The similarities and differences between remote-control vehicles, telerobots, and autonomous robots.
- Three different methods robots can use to move themselves other than wheels or tracks. Describe when it would be appropriate to use each method.

Robotics - Requirements

General knowledge. Discuss with your counselor three of the five major fields of robotics (human-robot interface, mobility, manipulation, programming, sensors) and their importance to robotics development. Discuss either the three fields as they relate to a single robot system OR talk about each field in general. Find pictures or at least one video to aid your discussion.

Robotics - Requirements

Design, build, program, test. Do each of the following:

- With your counselor's approval, choose a task for the robot or robotic subsystem that you plan to build. Include sensor feedback and programming in the task. Document this information in your robot engineering notebook.
- Design your robot. The robot design should use sensors and programming and have at least 2 degrees of freedom. Document the design in your robot engineering notebook using drawings and a written description.
- Build a robot or robotic subsystem of your original design to accomplish the task you chose for requirement 4a.

Robotics - Requirements

Design, build, program, test. Do each of the following:

- Discuss with your counselor the programming options available for your robot. Then do either option 1 OR option 2.
  - Option 1. Program your robot to perform the task you chose for your robot in 4a. Include a sample of your program's source code in your robot engineering notebook.
  - Option 2. Prepare a flowchart of the desired steps to program your robot for accomplishing the task in 4a. Include procedures that show activities based on sensor inputs. Place this in your robot engineering notebook.
  - Test your robot and record the results in your robot engineering notebook. Include suggestions on how you could improve your robot, as well as pictures or sketches of your finished robot.

Robotics - Requirements

Demonstrate. Do the following:

- Demonstrate for your counselor the robot you built in requirement 4.
- Share your robot engineering notebook with your counselor. Talk about how well your robot accomplished the task, the improvements you would make in your next design, and what you learned about the design process.

Robotics - Requirements

Competitions. Do ONE of the following.

- Attend a robotics competition and report to your counselor what you saw and learned about the competition and how teams are organized and managed.
- Learn about three youth robotics competitions. Tell your counselor about these, including the type of competition, time commitment, age of the participants, and how many teams are involved.

Robotics - Requirements

Careers. Name three career opportunities in robotics. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

What is the most important thing in building a robot?

What is the most important thing in building a robot?

Safety!

Occupational Safety and Health Administration (OSHA)

Robotics

- Studies indicate that many robot accidents occur during non-routine operating conditions, such as programming, maintenance, testing, setup, or adjustment. During many of these operations the worker may temporarily be within the robot's working envelope where unintended operations could result in injuries.

Robotic Safety

Eye and Face Protection

There are several forms of eye/face protection available to provide protection from these hazards, including safety glasses with side shields, goggles, and face shields. Inspect equipment for damage each time it is worn. If you wear prescription glasses, and they are not approved safety glasses, you must wear approved safety goggles over them to achieve adequate protection.

- Eye and face protection is required when there is a risk of exposure to the following:
- Flying particles
- Chemical exposure (such as splashes, splatters, and sprays)

Robotic Safety

Hand Protection

Hand protection is designed to protect against heat, electrical, chemical and mechanical hazards. Use proper gloves and mechanical tool guards.

Gloves:

FRC participants should work with the team mentor to ensure the selected glove is the correct one to use for each project. For example, chemical-resistant gloves afford some measure of chemical protection. Wear them when handling chemicals.

Check your gloves for proper size, absence of cracks and holes, and good flexibility and grip before you wear them.

Robotic Safety

Mechanical Guards:

- Provide safety guards for power tools where required.
- Never use any equipment without safety guards in place.
- Notify your Safety captain and mentor of any broken or defective equipment, and take it out of service until repairs are made.

Hearing Protection

Make hearing protection devices available, such as earplugs and earmuffs, where there are objectionable/questionable sound levels. A team mentor can provide assistance in evaluating high-noise tasks and determining appropriate hearing protection devices.

Robotic Safety

Foot Protection

When engaged in *Robotic activities, all participants must wear shoes that* completely cover the entire foot. Shoes must have closed-toes and heels to protect against foot injuries, regardless of work location. Flip-Flops, Sandals, Mules, Crocs, etc. *are not acceptable when working on or near the robot*

In some cases, safety shoes or toe guards are appropriate for areas where heavy objects can fall on your foot.

Other Preventives

Ensure that team members or mentors are not wearing ties, loose clothing, jewelry, or hanging key chains when near or working on moving or rotating machinery. Tie hair back or cover it.

Robotic Safety

SOLDERING

Soldering can be dangerous because of the heat from the iron and the chemical fumes and vapors released from the solder and flux, respectively. When soldering, observe the following points:

- Wear eye and face protection.
- Solder in well-ventilated areas.
- Never touch the iron/gun. It heats to extreme temperatures that will cause severe burns. Wear cotton clothing that covers your arms and legs. Keep your soldering iron in its protective holder when not actually being used.
- Always wash your hands with soap and water after handling solder.
- Do not leave any hot tools, where someone can accidentally contact the hot element. ALWAYS ASSUME IT'S HOT!!!!

Robotic Safety

HAND TOOLS

Always use the proper tool for the job.

Example: DO NOT use a wrench for a hammer or a screwdriver as a chisel or a wrench for a hammer.

Tool Rules

- Before using any tool, check to see if it is in good condition. Don't use defective, dull, or broken tools. Don't put them back on the shelf; remove them from service.
- When using a screwdriver or other tools, place the work on the bench or hard surface rather than in the palm of your hand.
- When using knives/blades, direct your cutting strokes away from your hand and body, and be aware of those around you.

Robotic Safety

Tool Storage

- Store sharp-edged or pointed tools in a safe place. When carrying, cover the point or edges with shields. NEVER carry unshielded tools in your pocket.
- Don’t leave tools on overhead work surfaces. They may fall and strike someone below.
- Store equipment in a location where it will not create a safety hazard or get damaged.

Robotic Safety

STORED ENERGY

Plan out the required activities when servicing or making repairs to the robot. Make sure all teammates are aware that work is being done on the robot. Address the following:

- Ensure no one is working on the robot when it will be energized during repairs.
- **Electrical Energy: Disconnect the electric power source**
- Always de-energize the robot before working on it by unplugging batteries. Open the main circuit breaker ("re-set" lever is released).
- **Pneumatic Energy: Always vent any compressed air to the atmosphere.**
- Relieve any compressed or stretched springs or tubing and lower all raised components.

Robotic Safety

BATTERY SAFETY

CAUTION: Batteries contain acid. This substance, H_2SO_4, is a corrosive, colorless liquid that will burn your eyes, skin, and clothing.

Any battery that is visibly damaged in any way is dangerous and unusable, and should be set aside and handled accordingly.

Care must be taken when recharging batteries. Hydrogen can build up and explode.

First Aid: Neutralize it by pouring the sodium bicarbonate (baking soda) on all wetted surfaces.

Robotic Safety

All persons should lift at the same time using proper body mechanics. These include:

- Lift with the legs, keeping your back straight
- Do not twist your body. Use your feet if you need to turn.
- Use proper hand holds to grasp the robot and make sure you have a safe, secure lift point before starting the lift.
- Bend your knees to a comfortable degree and get a good handhold. Maintain normal spinal curves.
- Tighten your stomach muscles and commence lifting the robot, using your leg muscles if you are lifting the robot up from the floor. Keep the robot close to your body, and coordinate lift speed with the others.

Robotic Safety – First Aid

Injury	First Aid
Cuts - small	Wash – Neosporin - Bandage
Cuts - large	Apply pressure
Eye Injury - Foreign object or Chemical	Flush with water
Burn - Heat	Wash in cold water – Apply Ice – Apply Aloe
Burn - Chemical	Wash site thoroughly with soap and water

*** Call 911 or seek medical attention if injury is serious ***

Robotic Safety Video

http://www.youtube.com/watch?v=fivMiePNjCc

FIRST Lego League (FLL)

Ages 9-14

Elementary and middle-school students get to:

- Design, build, test and program robots using LEGO MINDSTORMS® technology
- Apply real-world math and science concepts
  Research challenges facing today's scientists
  Learn critical thinking, team-building and presentation skills
- Participate in tournaments and celebrations

FIRST Lego League (FLL)

Ages 9-14

- Made of Lego parts
- Operates autonomously (without human intervention) to complete specific tasks
- 3 - 10 Students
- Typically 6”-12”
- Competition Video http://www.youtube.com/watch?v=SvdTbTf4G0k

FIRST TECH Challenge (FTC)

Ages 14-18

Students get to:

- Design, build, and program robots
- Apply real-world math and science concepts
- Develop problem-solving, organizational, and team-building skills
- Compete and cooperate in alliances and tournaments and earn a place in the World Championship
- Qualify for nearly $9.7 million in college scholarships

FIRST TECH Challenge (FTC)

Ages 14-18

- Autonomous Operation
- Tele-operated
- Tetrix Components
- Lego / HiTechnic Sensors / NXT Controller
- 3 - 10 Students
- 18”
- Competition Video http://www.usfirst.org/sites/default/files/uploadedFiles/Robotics_Programs/FTC/FTC_Bowled_Over_Game_Animation.mp4

FIRST Robotics Competition (FRC)

Ages 14-18

Students get to:

- Learn from professional engineers
- Build and compete with a robot of their own design
- Learn and use sophisticated software and hardware
- Compete and cooperate in alliances and tournaments
- Qualify for more than $14.8 million in college scholarships

FIRST Robotics Competition (FRC)

Ages 14-18

- Autonomous Operation
- Tele-operated
- Industrial Components and Sensors
- NI cRIO Industrial Controller
- 5 feet high
- 4 – 100 Students
- Competition Video http://www.youtube.com/watch?v=cSc8FWfJQlU

Robotics - Requirements

General knowledge. Discuss with your counselor three of the five major fields of robotics (human-robot interface, mobility, manipulation, programming, sensors) and their importance to robotics development. Discuss either the three fields as they relate to a single robot system OR talk about each field in general. Find pictures or at least one video to aid your discussion.

Robotics

Recommended viewing for anyone entering a career in Robots

(the edited for broadcast TV version)

- ***Terminator***
- ***Terminator 2: Judgement Day***
- ***Terminator 3***: ***Rise Of The Machines***
- ***Westworld***
- ***WarGames***
- ***iRobot***
- ***2001: A Space Odyssey***

Recommended viewing for anyone entering a career in Robots

(the edited for broadcast TV version)

- ***Matrix***
- ***The Matrix Reloaded***
- ***The Matrix Revolutions***
- ***Battlestar Galactica***
- ***Star Trek The Motion Picture***
- ***Colossus***

* Warning Signs will appear at the bottom of the page in Red

What major systems are integrated to create a robot (referred to as major fields of robotics in the requirements ?

What major systems are integrated to create a robot (referred to as major fields of robotics in the requirements ?

- Human-Robot Interface (also known as Human Machine Interface – HMI)
- Mobility
- Manipulation
- Programming
- Sensors

Robots may have some or all of these systems
Robotic Teams are usually organized around these systems

What is a human-robot interface?

What is a human-robot interface?

A human-robot interface allows an operator to communicate or control the robot

* Warning Sign - Robot refers to it as a robot-human interface

Different types of human-robot interfaces

Keyboard and/or Mouse

Different types of human-robot interfaces

Touch Screen

Different types of human-robot interfaces

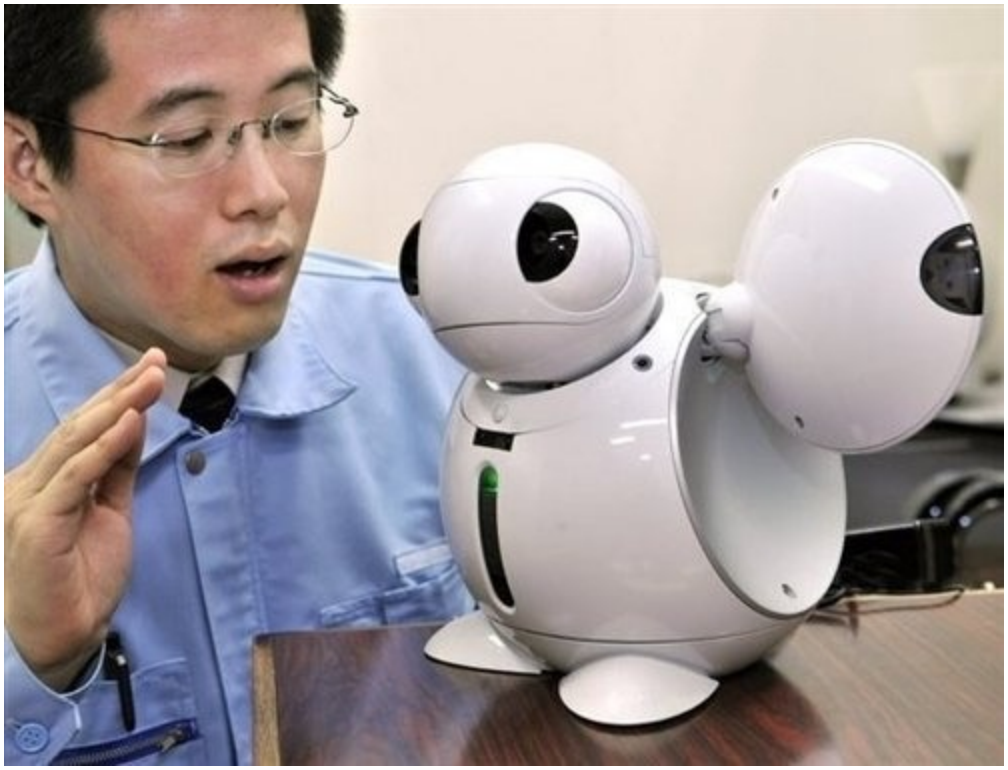
Joystick

Different types of human-robot interfaces

Game Pad

Different types of human-robot interfaces

Voice



Different types of human-robot interfaces

Inferred Remote

Different types of human-robot interfaces

Motion Control

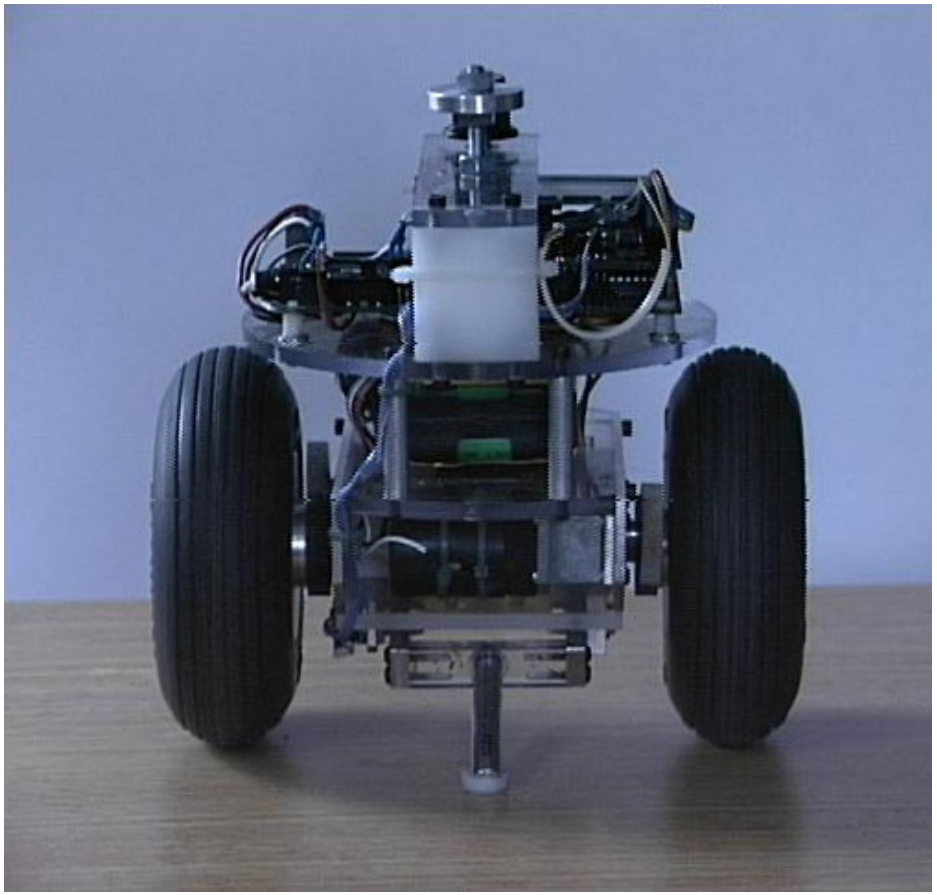
What is mobility?

What is mobility?

This is what allows the robot to move from one location to another

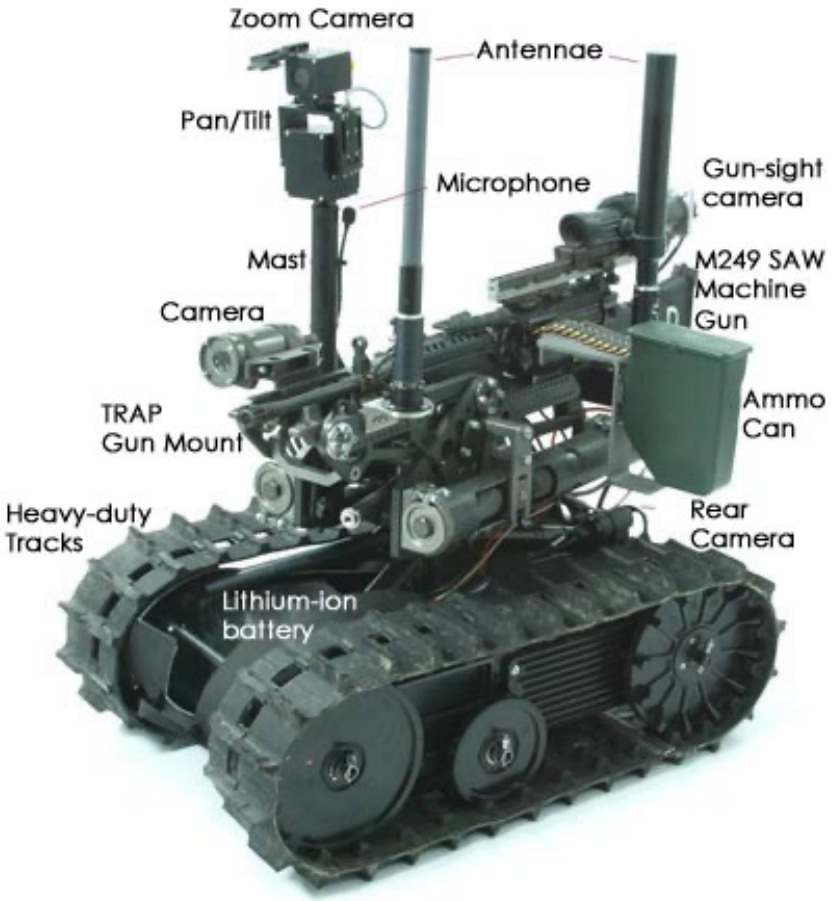
Different types of Mobility

Wheels



Different types of Mobility

Tracks



Different types of Mobility

Propellers
(Used for flight or in water)

Hovercraft

Plane

Helicopter

Different types of Mobility

Jet Propulsion

(Used for flight)

Different types of Mobility

“Legs”

Can mimic humans, animals or insects

Different types of Mobility

Crawl

(Small spaces)

What is Manipulation ?

What is Manipulation ?

Performing some function by the robot other than movement.

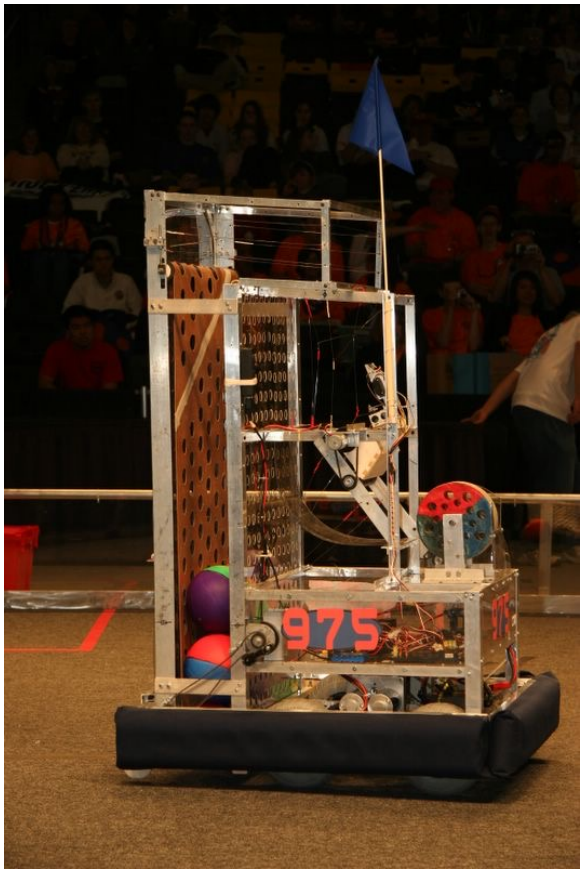
Different types of Manipulation

Arms or Claws

* Warning Sign - Robot wants to give you a ride

Different types of Manipulation

Collectors / Hoppers / Shooters



Different types of Manipulation

Lifters

What does programming do?

What does programming do?

***pro·gram·ming*/prōgramiNG/**

Noun: The action or process of writing computer programs.

Programming converts control functions to instructions that can be loaded or compiled and loaded into the robot. The controller and programming creates the “Brain” of the robot.

Compiler

The compiler changes code created by a programmer to binary or hexadecimal code that can be understood by the robot.

Programming Languages

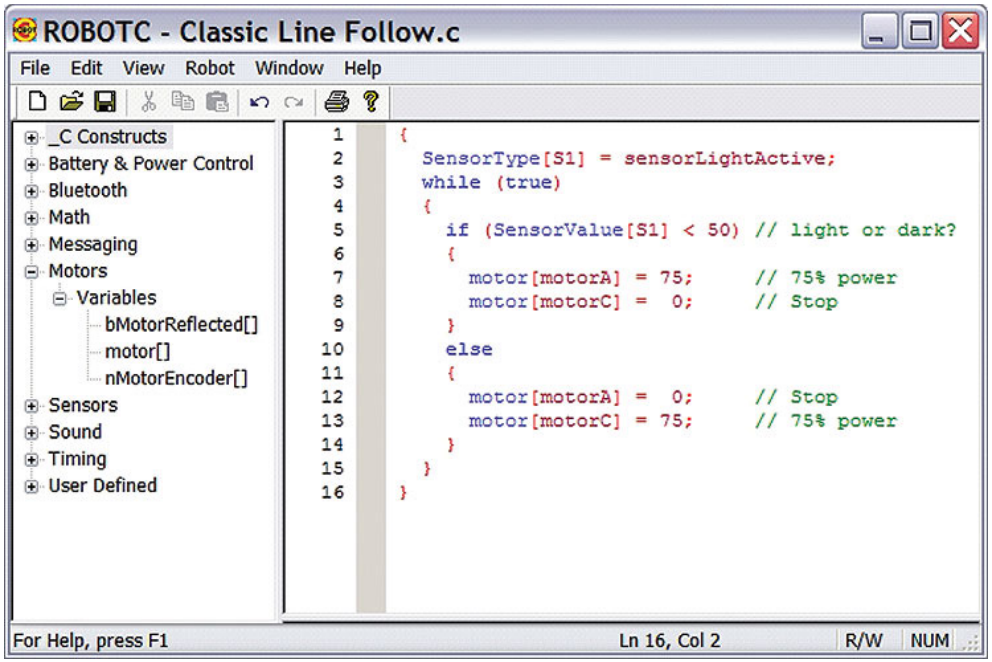
Robots can be programmed with text based programming languages or programming languages with graphical user interfaces.

* Warning Sign - Robot says “No”

Programming Languages

Examples of some TEXT based robot programming languages include:

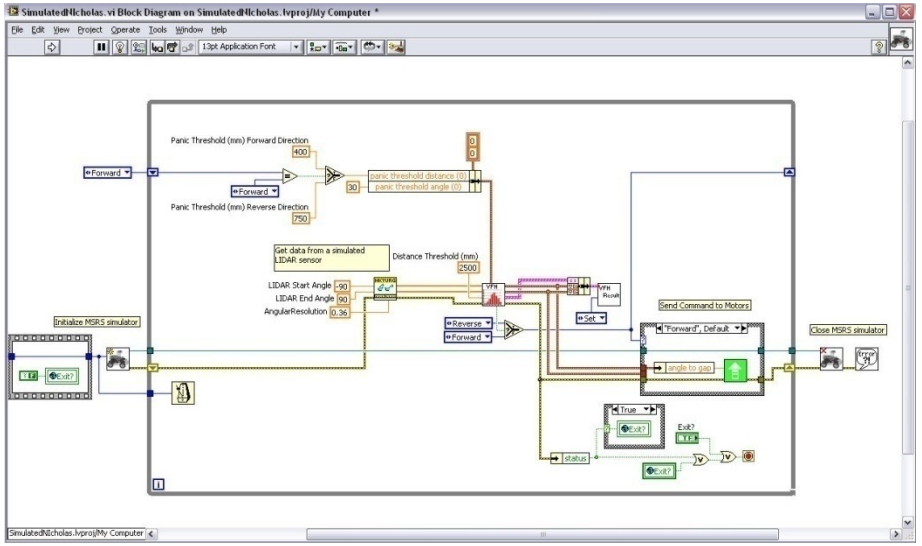
- Java
- C++
- C
- Robot C



Programming Languages

Some examples of graphical user interfaces used for robot programming include:

- Lab View
- WonderWare
- Cimplicity
- NXT-G



What are Sensors?

What are Sensors?

Sensor noun /’sensər/

A device that detects or measures a physical property and records, indicates, or otherwise responds to it.

These are the “eyes and ears” of the robot.

Different types of Sensors

Touch Sensor

The Touch Sensor gives your robot a sense of touch. The Touch Sensor detects when it is being pressed by something and when it is released again.

Suggestions for Use

You can use the touch Sensor to make your robot pick up things: a robotic arm equipped with a Touch Sensor lets the robot know whether or not there is something in its arm to grab. Or you can use a Touch Sensor to make your robot act on a command. For example, by pressing the Touch Sensor you can make your robot walk, talk, close a door, or turn on your TV.

Different types of Sensors

Sound Sensor

The Sound Sensor can detect both decibels [dB] and adjusted decibel [dBA]. A decibel is a measurement of sound pressure.

dBA: in detecting adjusted decibels, the sensitivity of the sensor is adapted to the sensitivity of the human ear. In other words, these are the sounds that your ears are able to hear.

dB: in detecting standard [unadjusted] decibels, all sounds are measured with equal sensitivity. Thus, these sounds may include some that are too high or too low for the human ear to hear.

Different types of Sensors

Light Sensor

The Light Sensor is one of the two sensors that give your robot vision [The Ultrasonic Sensor is the other]. The Light Sensor enables your robot to distinguish between light and dark. It can read the light intensity in a room and measure the light intensity of colored surfaces.

Suggestions for Use

You can use the Light Sensor to make a burglar alarm robot: when an intruder turns on the light in your room the robot can react to defend your property. You can also use the Light Sensor to make a line-following robot or a robot that can sort things by color.

Different types of Sensors

Ultrasonic Sensor

The Ultrasonic Sensor is one of the two sensors that give your robot vision [The Light Sensor is the other]. The Ultrasonic Sensor enables your robot to see and detect objects. You can also use it to make your robot avoid obstacles, sense and measure distance, and detect movement.

The Ultrasonic Sensor measures distance in centimeters and in inches. It is able to measure distances from 0 to 255 centimeters with a precision of +/- 3 cm.

The Ultrasonic Sensor uses the same scientific principle as bats: it measures distance by calculating the time it takes for a sound wave to hit an object and return – just like an echo.

Different types of Sensors

Acceleration / Tilt Sensor
Color Sensor
Compass Sensor
EOPD (Electro Optical Proximity Detector)
Gyro Sensor
IRSeeker V2

Discuss the following with your counselor:

- a. The kinds of things robots can do and how robots are best used today.
- b. The similarities and differences between remote-control vehicles, telerobots, and autonomous robots.

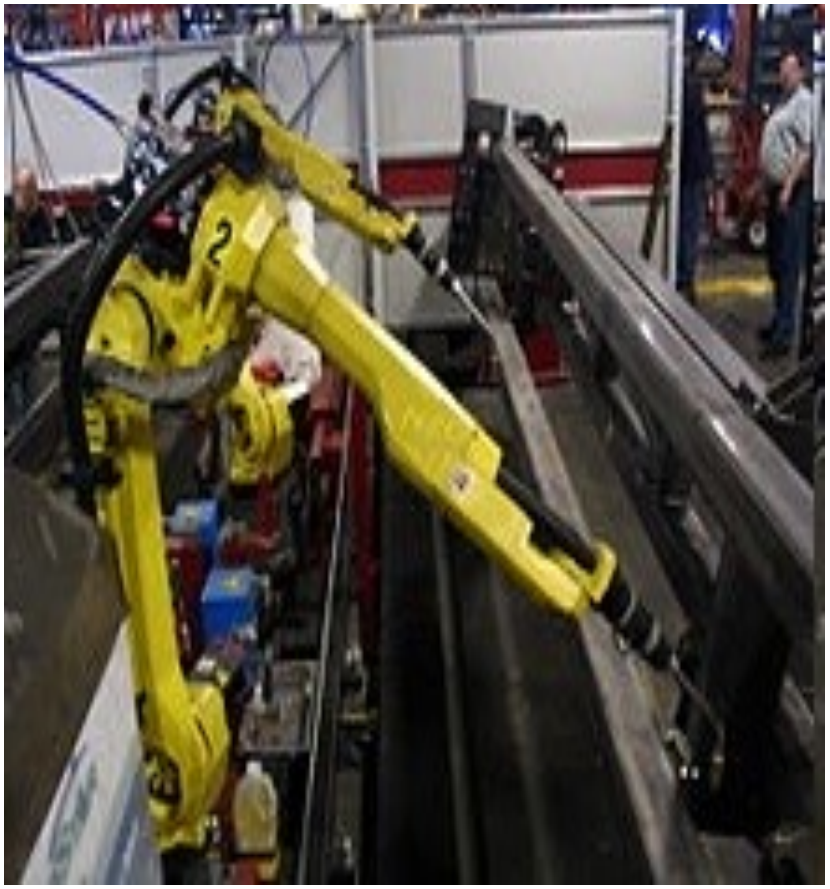
The kinds of things robots can do

Robots can be used for many things such as ….

- Defusing bombs
- Underwater exploration
- Planetary exploration
- Manufacturing
- Surgery
- And much more

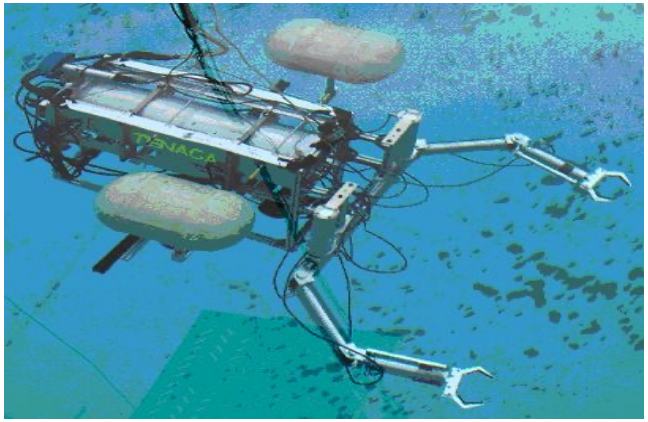
How robots are best used today

The most common place to find a robot is in industry working on an assembly line.



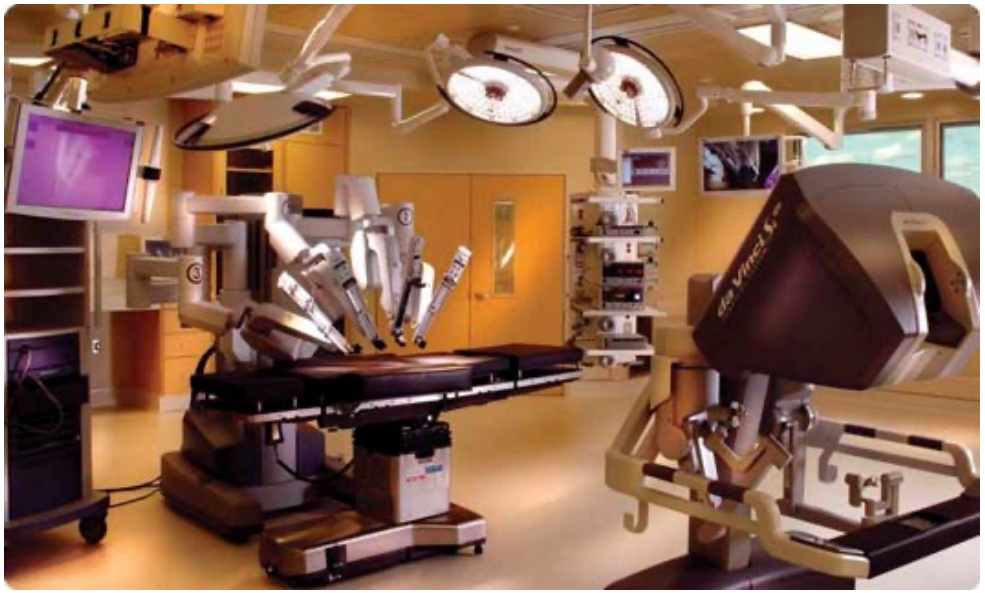
How robots are best used today

Robots are also used in hazardous environments



How robots are best used today

Robots are even being used in Surgery



daVinci surgical robot

Remote-control vehicles

- A remote-controlled vehicle is one where a direct connection to the object being controlled is needed such as a **Wire**.

Telerobots

- In a telerobots there is no physical connection to the remotely operated system by use of something such as **Radio waves** or **Wi-Fi.**

Autonomous

- Autonomous systems operate by making decisions based on programming and sensory feedback.
- **Not directly controlled by human** has to be previously programmed.

Careers in Robots

Careers in robotics include:

- Mechanical engineers
- Electrical engineers
- Computer scientists
- Control system designers
- Instrumentation engineers
- Experts in material sciences
- Biomedical Engineers
- Structural Engineers
- System integrators
- Control system engineers
- Information technology experts
- Technicians
- Electricians
- Operators

Education, Training, and Experience

A basic degree in a compatible engineering, science, or technology discipline is what is essentially required.

- **Associates Degree**
- **Bachelors Degree**
- **Masters Degree**

Apprentice Programs are available for Electricians, technicians and operators

Equipment Specific Training is also required.

Building Your Robot

Design, build, program, test. Do each of the following:

- With your counselor's approval, choose a task for the robot or robotic subsystem that you plan to build. Include sensor feedback and programming in the task. Document this information in your robot engineering notebook.
- Design your robot. The robot design should use sensors and programming and have at least 2 degrees of freedom. Document the design in your robot engineering notebook using drawings and a written description.
- Build a robot or robotic subsystem of your original design to accomplish the task you chose for requirement 4a.

Design, build, program, test. Do each of the following:

- Discuss with your counselor the programming options available for your robot. Then do either option 1 OR option 2.
  - Option 1. Program your robot to perform the task you chose for your robot listed above. Include a sample of your program's source code in your robot engineering notebook.
  - Option 2. Prepare a flowchart of the desired steps to program your robot for accomplishing the task in 4a. Include procedures that show activities based on sensor inputs. Place this in your robot engineering notebook.
  - Test your robot and record the results in your robot engineering notebook. Include suggestions on how you could improve your robot, as well as pictures or sketches of your finished robot.

Demonstrate. Do the following:

- Demonstrate for your counselor the robot you built in requirement above.
- Share your robot engineering notebook with your counselor. Talk about how well your robot accomplished the task, the improvements you would make in your next design, and what you learned about the design process.

Building Your Robot

Boy Scouts having their own robot equipment can get their robot project approved by the counselor.

For Boy Scouts not having their own robot equipment the FIRST robotic team will have build sessions using Lego components.

We use the tutorial for RobotC to teach programming.

Robot Engineering Notebook

Required Sections:

- Robot –Describe the type of robot that you want to build
- Task – Describe in detail the task the robot will accomplish
- Design Ideas – What you would like to build
- Tests –Describe the tests and designs which you tried in coming up with your final design
- Pseudo Code – A detailed flowchart of the step-by-step commands the robot must complete to accomplish the task

Robot Engineering Notebook

Required Sections (Cont'd):

- Software Code – Include the code
- Code Modifications – Include changes to code
- Final Robot Design – Include a picture or description of the final product
- Potential for improvement – Describe how you can improve your robot

Also see ➔

FTC Game Manual - Section 5 - The Engineering Notebook.pdf

Acknowledgements

Thanks to:

Boy Scouts of America for the requirements

FIRST for safety and competition information

FTC Team 975 & FRC Team 1541 for presentation