ENGINEERING INSIDE: ROBOTICS

2014, Issue 3

Extreme Exploration

September, 2014

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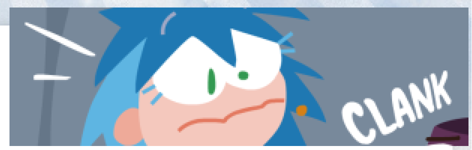

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About IEEE Spark

IEEE Spark is an online publication intended to inspire students ages 14-18 to learn more about engineering, technology, and computing, and raise excitement about careers in these disciplines. *IEEE Spark* features articles on technological innovation, university preparation tips, professional career profiles, at-home activities, comics, and more! *IEEE Spark* is brought to you by IEEE with generous funding from the IEEE New Initiatives Committee.

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Extreme Exploration

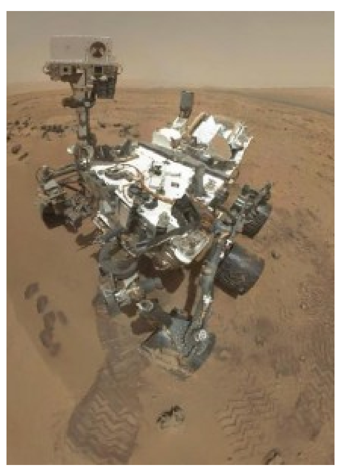
September, 2014
by Robin Hegg

Humans have always dreamed of exploring the unknown, whether it was what lay beyond the horizon or what lay beyond the stars. While humans have achieved incredible feats in exploration—mapping the world and sending people to the moon—there is still unexplored terrain tugging on the human imagination, but potentially still out of our reach. Extreme environments—those with extreme temperatures, pressure, wind, or distance from earth—pose a challenge to the human body. Many of these environments are simply too dangerous for humans to explore on their own. Others are too far away for humans to explore in one lifetime. This is where robot explorers come into play. Robots are helping us to explore in space, under the water, and in the Antarctic.

NASA's Mars rovers are exploring an extreme environment humans are not yet ready to explore themselves. Mars is one of the most interesting places to explore right now—it is the most Earth-like planet in our solar system and it has water, which means there is the possibility that life once existed or may still exist there.

Mars' environment poses serious challenges, even to robot explorers. The temperature changes dramatically, dropping from as high as 20 degrees Celsius down to -120 degrees Celsius. The terrain is rough and rocky, we have no global positioning system (GPS), communications back to Earth are delayed, and huge dust storms can block visibility and clog up instruments.

The *Curiosity* rover, which landed in Gale Crater on Mars on August 6, 2012 is investigating the Martian environment, evaluating the field site inside Gale Crater to see if it may have offered favorable conditions for microbial life.



Curiosity Rover's Self Portrait at 'John Klein' Drilling Site, Cropped Image Credit:NASA/JPL-Caltech/MSSS

Curiosity has six 20-inch (50 cm) wheels in a rocker-bogie suspension. The wheels are designed for climbing in soft sand and scaling rocks. The rover's wheels have cleats and move independently. *Curiosity* is able to climb over obstacles as high as 26 inches (65 cm). The rover is also able to self-monitor itself constantly to keep itself operational despite the extreme temperatures and dust storms. *Curiosity* has heating and cooling systems that work to keep the rover's tools at optimal temperatures. It has two computers, one of which can take over if there are problems with the main computer. The rover's communications also have lots of built-in redundancies, so that if one system fails, there are others that can take over.

Curiosity is equipped with 17 cameras that help it to avoid obstacles, navigate, search for points of interest, and examine and analyze Mars' environment. With the help of an infrared laser, *Curiosity* can vaporize an interesting surface and then examine its composition. If it needs to examine the surface further, *Curiosity* can swing its robotic arm over and use its microscope and X-ray spectrometer to get a closer look. *Curiosity* can also collect a specimen using a drill, then move the sample into one of its laboratories. *Curiosity* also has a dust removal tool to help keep itself clean and functioning properly.

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Curiosity is also investigating the habitability of Mars in preparation for possible future human exploration, including measuring radiation exposure inside the spacecraft during the trip to Mars. In the future, robots could act as aides for human explorers to other planets, scouting, recording, carrying gear, and serving as a rescuer if needed. Engineers plan to use *Curiosity's* design as the basis for a Mars rover mission planned for 2020. You can keep track of *Curiosity*'s latest adventures by **following *Curiosity* on Twitter**.

The undersea world still holds mysteries we've yet to explore. Lack of oxygen and light, strong currents, and intense pressure can make exploring parts of the underwater world extremely challenging. Remotely operated vehicles (ROVs) stay attached to the ship by a long cable, which allows scientists to manipulate it. ROVs are able to reach great depths and can stay deep underwater for extended periods of time. Autonomous underwater vehicles (AUVs) are programmed explore the deep ocean and collect data. Scientists are able to conduct other research on board the ship while the AUVs explore on their own. Hybrid vehicles can operate attached or unattached. A hybrid vehicle called ***Nereus*** explored the Mariana Trench, the deepest part of the ocean.

A new robot from the Korea Institute of Ocean Science and Technology has been designed to explore areas with rough waters and strong currents that aren't safe for divers and where propeller-driven ROVs and AUVs don't work well and stir up debris. The robot, called *CR200* or ***Crabster***, was designed to resemble a giant crab with the hopes that it will be able to walk along the sea floor and endure strong underwater currents just like a real crustacean. Most crustaceans are aquatic animals. They have segmented bodies, a hard exoskeleton, legs, and antennae. While the robot is still in the testing phase, researchers hope to soon be able to send it to help archaeologists explore twelfth-century shipwrecks in the Yellow Sea, located between China and the Korean peninsula, that have been untouched for centuries.

Crabster
Photo credit: KRISO

Crabster's bio-inspired design has six legs (unlike a crab's eight) moving with 30 joints and a glass fibre shell designed to stand up to strong currents. It can also change its position depending on different pressure conditions. Its front legs may be given grippers, allowing it to pick up objects and store them inside a compartment. *Crabster* is connected to an external power source by a long tether, meaning it can stay underwater for days at a time. It has 11 cameras, including one sound based camera that can allow the robot to "see" in cloudy water. It will be able to make 3D maps of its surroundings using sonar.

In the future, *Crabster* may be able to help map the seafloor, survey and inspect shipwrecks and pipelines, respond to oil spills, and assist divers.

Another extreme environment robots are helping us to explore is the Antarctic. Robots like Yeti, a rover, explore the ice's surface, helping to search for dangerous cracks, explore ice caves, and find things buried under the polar ice.

The robot **ENDURANCE** (Environmentally Non-Disturbing Under-Ice Robotic Antarctic Explorer) is mapping out the geochemistry and biology of the water in the Antarctic. ENDURANCE is an autonomous underwater vehicle (AUV) configured to the specific challenges of the Antarctic environment. ENDURANCE is designed to be deployed through a hole melted through a 3-meter thick ice cap, travel as far as 700 meters from the hole, and return safely through the hole following each mission. It seeks to examine the chemical makeup of the water, create a high-resolution 3D map of the underwater area, and, if possible, to form an image of the underwater glacier face.

ENDURANCE has four navigation systems, one of which helps the robot find the ice melt hole and return to the surface. ENDURANCE moves using thrusters and is able to hover within 5cm horizontally and 1cm vertically. It can also return to pre-defined locations.

ENDURANCE also includes 96 sensors to help it avoid obstacles, make maps, sense its speed and depth, and collect information. It has 16 different water chemistry sensors and four real-time cameras. ENDURANCE also has a science payload that sends a set of instruments into the water to examine the water's chemistry and other interesting things below the robot where it may not be safe to travel. ENDURANCE is able to autonomously collect water samples while holding itself steady against the ice ceiling above it using "ice picks," making sure not to disturb the area it's testing.

NASA hopes that knowledge gained from testing ENDURANCE can help to explore objects in our solar system containing water, such as Jupiter's moon, Europa.

Robots have already expanded the places we’re able to explore, allowing us to learn more about the world and universe around us. As robotic technology continues to move forward, humans and robots will continue to work together to learn and explore in new and exciting ways.

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Meet Maciej J. Zawodniok!

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Maciej J. Zawodniok is Associate Professor of Computer Engineering at the Missouri University of Science and Technology (former UMR) and Assistant Director of NSF I/UCRC on Intelligent Maintenance Systems. Dr. Zawodniok's research focuses on adaptive and energy-efficient protocols for wireless networks, network-centric systems, network security, cyber-physical and embedded systems with applications to manufacturing and maintenance. In addition, Dr Zawodniok is advising IEEE Student Branch and undergraduate students in IEEE Robotics, IEEE Black Box, and other competitions. For his work, he has received the Outstanding New Advisor of the Year award by Student Life at Missouri S&T (2012), and Outstanding Branch Counselor at both IEEE St Louis Section (2013) and Region 5 (2013).

How are robotics involved in the work you do?

I teach about embedded system design, and robotics is the most natural and enticing way for students to understand many challenges and relate the "boring" curriculum to real issues.

What is your educational background and how did this prepare you for your work with robotics?

I had received my undergraduate and MS degree in computer science and PhD in Computer Engineering. Both are an excellent combination for a robotics-related career since you need the understanding of the hardware and physical components, as well as how to write software that makes the robots look smart.

What do you love about working with robots?

I like the feeling of accomplishing something real that moves and does something in the real world. But what I love is having the robot or device behave in a new, unexpected way. You program it to follow a set of well-defined rules, then you let it operate in a real environment. As it encounters obstacles or interacts with humans, it starts to adapt to the situation. Perhaps, the robot does something new that you have not anticipated based on the set of rules; almost as if it has become a little intelligent. This is not trivial to achieve, but gives me thrills and sometimes nightmares 😉

Is there anything you don't like about working with robotics?

Only when "Murphy's Law" starts to "mess" with my project and nothing works as it is supposed to.

How do the fields of robotics and engineering blend in the work that you do?

In many projects I work with companies on automation. Such work could easily become focused on the robotics side only, but understanding the context of the application is very important. I may need to work with process engineers and mechanical engineers to understand what the robot has to do and what it cannot do. Also, it is important to remember that there are people with whom the robots will interact, who will have impact on how well the robot will perform in a real environment. All of these engineering disciplines have to come together to succeed.

Please describe a favorite project you have worked on that involved robotics?

USEFUL LINKS:

Missouri University of Science and Technology
NSF I/UCRC on Intelligent Maintenance Systems

EDUCATIONAL BACKGROUND:

Computer Engineering (Ph.D.) University of Missouri-Rolla, 2006

Computer Science (MS) Silesian University of Technology, 1999

ADVICE TO STUDENTS:

Dream big! The potential of a robotics revolution is here and now - and you can lead and shape it. You could be the Steve Job or Bill Gates of the robotics industry.

I love to work with student design teams on IEEE robotics competitions. While I'm not directly involved in the technical aspects, design work, or programming, it feels very rewarding to guide the students and help them figure out solutions. They take the basic knowledge from various courses and employ it in a large, multidisciplinary project. They learn, grow, and their robotics careers take off.

Whom do you admire and why?

I admire Isaac Asimov, the science fiction author, for giving us dreams filled with robots. In the age when robots were barely invented, he dreamed about the future with countless robots and how they can help humanity. Most of the ideas in his books and novels are yet to be achieved, but it gives inspiration to engineer the robots of the future.

How has the potential of robotics changed since you began your career?

Fortunately, I'm not too old to remember life without robots. However, when I was a young undergraduate student, robots were typically associated with simple industrial automation. They were distant, almost non-existent to most people. Today, there are robots present in our lives, schools, and homes. For example, I have an iRobot vacuuming my house, thus relieving me from the dreaded chore. Kids in school learn robotics by playing with Lego Mindstorms.

How do you think robotics applications will change in the next 10 years?

I believe we are on the verge of the next revolution – robotics revelation – with young minds ready to realize the dreams of Issac Asimov's books. Robots will become a bigger and bigger part of our lives. In medicine, robots will improve the standard of living for the elderly and robotic prosthetics such as arms or legs with full sensory capabilities will enable amputees to live normal lives.

What's the most important thing you've learned in the field?

Working in robotics is a multi-disciplinary effort. You need expertise in multiple fields from mechanics, electronics, and controls, to programming, human factors, and social engineering. You also need to understand the application and application specific domain, e.g. chemistry in process automation, or medicine and human physiology in healthcare.

What advice would you give to recent graduates entering the field?

Dream big! The potential of a robotics revolution is here and now – and you can lead and shape it. You could be the Steve Job or Bill Gates of the robotics industry.

If you weren't working with robotics, what would you be doing?

Right at this moment … piloting a spaceship on the way to Mars.

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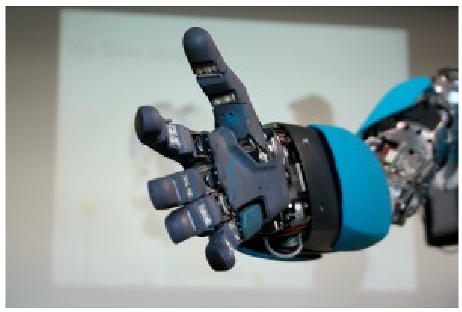
Design a Robot Arm

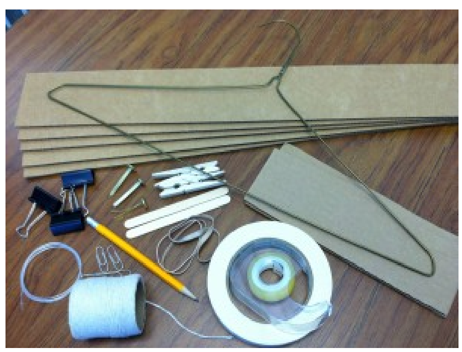
September, 2014

When engineers design a robot, they usually have a specific problem or task in mind. They have to select the materials, design, and construction that suit their robot's needs best. In this activity, you will design a robot arm that needs to be able to pick up a Styrofoam cup. You'll have a variety of materials to choose from. You'll select your materials, sketch out your design, then build and test your robot arm. If it doesn't work, go back to the drawing board and try again!



Scroll down to the bottom of this activity for a list of more advanced robotics activities you can try at home.

Materials



- 3-inch wide and approximately 22-inch long strips of cardboard, 5 or so
- Binder clips (different sizes), 8 or more
- Brads (aka paper/brass fasteners), about 10
- Clothespins, 6
- Craft sticks, 10 to 15
- Fishing line, 3 to 4 feet
- Hangers, 1 or 2
- Paper clips (different sizes), 10 to 15
- Pencils, 3 to 4
- Rubber bands (different sizes), 15
- Tape, clear and masking
- Twine, 3 to 4 feet
- Cardboard scraps of various sizes, 10

Steps

Your goal is to design a robot arm that can pick up a Styrofoam cup. The arm must be built using materials from the list above and must be at least 18 inches long.

1. Examine the available materials. Think of a design for your robot arm, keeping in mind that it needs to be able to pick up a Styrofoam cup. Decide which items from the list above you will be using.
2. Draw a sketch of your design before beginning construction.
3. Build your robot arm.
4. Once your arm has been built, test it out. Is it able to pick up the Styrofoam cup?
5. If your robot arm didn't work, think about what why it didn't work and what changes need to be made. Develop a new and improved design and try again!

Questions

1. Did you use all the possible materials? Why or why not?
2. Which material is the most critical to your robot arm design?

DID YOU KNOW?

1. A typical robotic arm is made up of seven metal segments joined by six joints.
2. In 2013, researchers at the University of Pittsburgh pulled off a remarkable feat: the operation of a robotic arm with mind control alone.
3. Just this year, a team of Italian and Swiss researchers developed the LifeHand 2, the first artificial hand that can restore a sense of touch to patients with a missing limb.

FIND OUT MORE:

You can also visit **TryEngineering.org** to explore other engineering activities and resources. Additional activities and lessons can be found **here**.

3. If you had to make multiple designs before your robot arm worked, what did you learn in developing subsequent designs? What made your final design work?

Additional Advanced At-Home Robotics Activities

Want to try to build your own robot at home? Here are three more advanced activities you try:

How to Build a Robot: The BeetleBot v2 (Revisited)

http://www.instructables.com/id/How-to-Build-a-Robot-The-BeetleBot-v2-Revisite/

Popsicle Stick Arduino Hexapods

http://mad-science.wonderhowto.com/how-to/create-swarm-robot-minions-with-these-popsicle-stick-arduino-hexapods-0134022/

Simple Arduino Robot Arm from 9 gram servos

http://projectsfromtech.blogspot.com/2013/09/simple-arduino-robot-arm-from-9-gram.html

ENGINEERING INSIDE:
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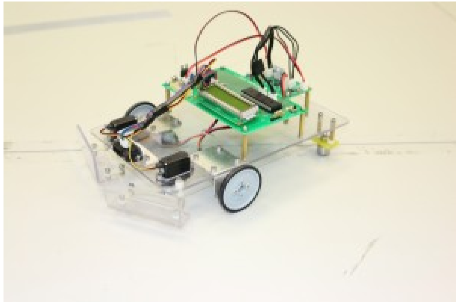
Explore Robotics with Competitions and Camps!

September, 2014
by Robin Hegg

You can learn more about robotics and start building your own robots with competitions and summer camps.



There are a number of local and national robotics competitions with which you can get involved. The **BEST** (Boosting Engineering, Science, and Technology) robotics competitions take place each fall, with over 850 middle and high schools participating. Students are challenged to build a functioning machine in six weeks that can perform specific tasks in three minutes. **FIRST** (For Inspiration and Recognition of Science and Technology) robotics competitions have programs and competitions for grades K-12. Student teams all receive a common kit of parts and are given six weeks to construct their robot. The **VEX Robotics Competitions** challenges middle and high school students, along with their teachers and mentors, to build innovative robots that can earn them points in an annual game. Some student chapters of IEEE also sponsor robotics competitions. **Penn State's IEEE chapter** hosts an annual robotics competition that is open to students in grades K-12 across the state of Pennsylvania.

A more advanced type of robotics competition is the **DARPA Robotics Challenge (DRC)**. DARPA is the United States Department of Defense's Defense Advanced Research Projects Agency, which works to develop new technologies for the military. The DARPA Robotics Challenge aims to develop robotic technology that can aid in disaster relief where human relief workers may not be able to help. Competitors work to develop ground robots that can execute complex tasks and use standard tools and equipment in a dangerous environment. The DARPA Robotics Challenge runs for approximately 27 months, with three separate competitions.

In addition to competitions, there are also robotics summer camps throughout the country. **Digital Media Academy** camps offer courses in robotics and engineering, as well as game design, programming, and more. **RoboTech Center** offers summer camps and after school programs in New Hampshire and Massachusetts. **CyberCamp Robotics Academy** hosts summer robotics camps in Ontario, Canada. A number of museums, like the **American Museum of Natural History** and the **Tech Museum of Innovation** also frequently offer summer robotics programs.

Want to learn more about robots at home? IEEE's free **Robots iPad app** is a great way to learn more about robots and robotics. The app features 158 robots from 19 countries and allows you to examine them with 360-degree views, interact with them, watch videos of the robots in action, and learn how they work.

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IEEE Robotics and Automation Society

September, 2014
by Robin Hegg

Since 1987, the **IEEE Robotics and Automation Society** (RAS) has been working to advance innovation, education, and research in robotics and automation. It also works to promote cooperation and the sharing of information among its members. The IEEE RAS is made up more than 20 local and regional chapters that sponsor talks, student competitions, and continuing education workshops.

The IEEE RAS sponsors three annual conferences: **IEEE International Conference on Robotics and Automation (ICRA)**, **IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)**, and **IEEE International Conference on Automation Science and Engineering (CASE)**, which looks at. It also co-sponsors the biannual **IEEE/RAS-EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)** with the IEEE Engineering in Medicine and Biology Society.

The IEEE Robotics and Automation Society also includes a **Student Activities Commit tee (SAC)**. The SAC is made up of students from around the world and works to represent students in robotics. They organize and manage activities, recruit students, put on competitions, and provide students with opportunities to network with robotics professionals and gain professional experience. You can learn more about what the RAS SAC is up to by checking out their **news and announcements**, **upcoming events**, and **volunteer opportunities**.

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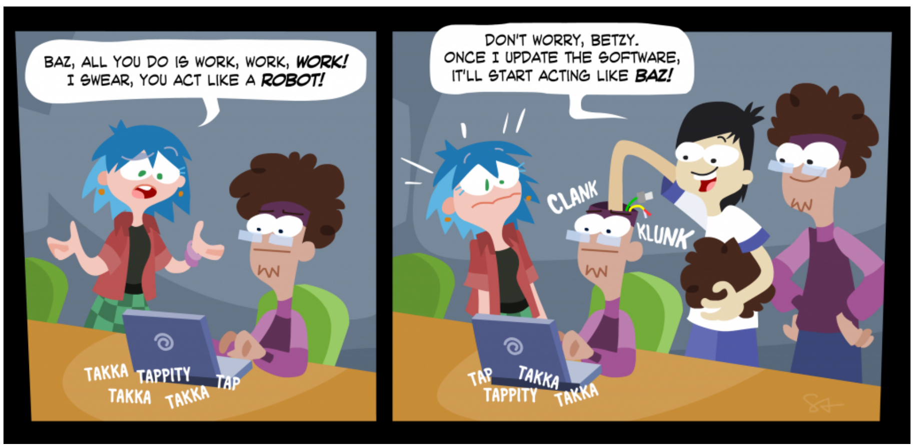
September, 2014



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1) The term Robot comes from the Czech word “robota” meaning:
   a) Forced Labor
   b) Man Made
   c) Shiny Metal
   d) See

2) What is a Robot?
   a) A machine that does work on its own
   b) A device that gathers information from the environment
   c) A machine capable of performing or extending human tasks
   d) All of the above

3) Robots cannot be like humans because they lack:
   a) Logic
   b) Strength
   c) Creativity
   d) Memory

4) What do we call the Robot’s brain?
   a) The Wiz Bang
   b) CPU/Controller
   c) The A.I. Unit
   d) All of the above

5) The most common Robot in our society today is the Robotic
   a) Pipe cleaner
   b) Wheelchair
   c) Arm
   d) Vehicle

6) What is one of the most difficult tasks for a Robot to perform?
   a) Talk
   b) See
   c) Climb
   d) Walk

7) What are the names of the first two robots sent to Mars?
   a) C-3P0 and R2D2
   b) Spirit and Opportunity
   c) Rosie and Data
   d) Bender and Optimus

8) Which energy source is NOT used to power Robots
   a) Electricity
   b) Solar
   c) Battery
   d) Propane

9) Human life is affected every day by Robots
   a) True
   b) False

10) What popular appliance is considered to be a robot and a non-robot at the same time?
   a) Television
   b) Computer
   c) VCR
   d) Video game systems

IEEE Spark Challenge: Robotics Answer Key

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