ROVer Ranch: A 3-D Learning Environment for K-12

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Abstract

The ROVer Ranch is an online NASA project for K-12 students to learn about robotics engineering. The students assume a mission engineer's role to design, build and test a robot in a 3-D mission simulator. Students activities are structured along the lines of the scientific method as they discover the what, why and how of robotics. The activities are presented in a variety of ways so educators can use different teaching methods with their students.

The ROVer Ranch is sponsored by the NASA Learning Technologies Project (LTP), which is an Internet-based distance learning initiative that combines NASA research and advanced Internet technologies to create unique science learning environments. Technologies such as streaming media, real-time interactive gaming, 3-D simulations and remote manipulation of scientific instruments are some of the methods the LTP projects use to convey science lessons and NASA research.

Keywords: NASA, ROVer Ranch, Learning Technologies Project, LTP, 3-D, robotics, distance learning

1 ROVer Ranch Overview

Visualize a working ranch with a big house, stables, pastures and corrals. It's populated with animals and the people who tend them. But wait, those aren't horses in that corral. They're different types of remote operating vehicles. Robots. They've been planned and constructed on a workbench inside the barn and they're ready for testing. The ROVer Ranch is a blend of Tex meets tech where students experience building (or growing if you will) a robot, planning its activities and then testing it in a 3-D simulator.

The ROVer Ranch is a focused online web activity available at http://prime.jsc.nasa.gov/ROV. It is broadly scoped for K-12 grades based on the interest and skill levels of the students and teachers. While limited at the K-5 levels, a bright 2nd grader can use ROVer Ranch and teachers may select appropriate activities for these lower grades. The main targeted age group is 6-12th grade. There are currently hundreds of registered users and over 70 registered classes using ROVer Ranch to learn about robotics engineering. The program has a wide range of registrants from children with attention deficits to gifted and talented programs [Burns, 2001]. While the ROVer Ranch software is available at no cost, a user must have at least a 486 computer and an Internet connection. ROVer Ranch does not require broadband connectivity and is structured so that it runs without the visual VRML plug-in so it can be used by any socioeconomic group at school, home, the library or after school centers.

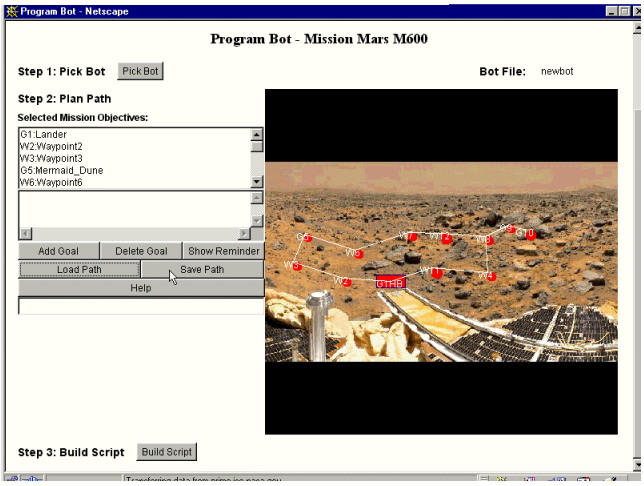
The main ROVer Ranch activities are: Robots 101, the Robotic Missions, Tools and Resources. Robots 101 sets the stage for the robotic missions with explanatory texts and background information that teach the student about cultural and historical aspects of robotics engineering, useful terminology and the components a robot may possess. Robots 101 includes suggested readings, vocabulary exercises, classroom activities, historical data and images of different types of robots. This section also includes information about the traits of robots, types of robots and subsystems that may be found on a robot or remote operating vehicle.

The Robotic Missions are presented as three activities that imitate a real-world engineering process. As a sequence, students are briefed on their mission requirements and must then build a robot and plan its movement and activities. After the robot is built and programmed, students test their designs by operating the robot in a 3-D simulated environment. For example, a mission might require the learner/mission engineer to photograph and perform experiments at several locations on the surface of Mars. The engineer must build a suitable robot from a parts inventory that contains several options within each robotic subsystem. The subsystems are tools, mobility, sensors, control and body. Each part in the inventory has a specification sheet that includes important data such as voltage and weight. The engineer must take care to select parts that match each other.

After all the parts are selected they must be hooked up to the correct power sources and run through a systems check to ensure compatibility. The route the robot will take is established by selecting a point-to-point path around the surface of Mars. The path is created by selecting multiple waypoints on a Mars map that correspond to the requirements in the Mission Briefing. Once the path is set the robot needs to know what actions to perform so the engineer is prompted to create a simple program that tells the robot, line by line, what to do as it moves along it's path around the Martian terrain. The engineer then places the robot in the 3-D simulation to run the mission. Mission data and scientific results of the mission are available in a summary log once the mission is concluded. Success or failure in the simulation depends on the design and planning of the robot. If all variables have been accounted for, the mission will run without interruption, however, it may be that the engineer has forgotten to account for some element and the robot or the script must be modified. This process of engineering and re-engineering involves the learner in a simple, interactive design and programming exercise.

The Tools support students and teachers by keeping track of their work activities and allowing them to talk with each other about their work in progress. There are tools for student file management, student work submission and viewing shared class work. Teachers can set up classes to monitor and evaluate student work. They can also create assignments and post them to the class assignment board. There is a separate Comm Center where classes of students and teachers can communicate with each other through journals and message boards. The Resources include a Teacher's Guide which provides an introduction to the ROVer Ranch software, suggestions on how to use the ROVer Ranch in the class, instructional goals, educational standards

information plus activities that are associated with the field of robotics, the International Space Station, Mars, physics and other topics.



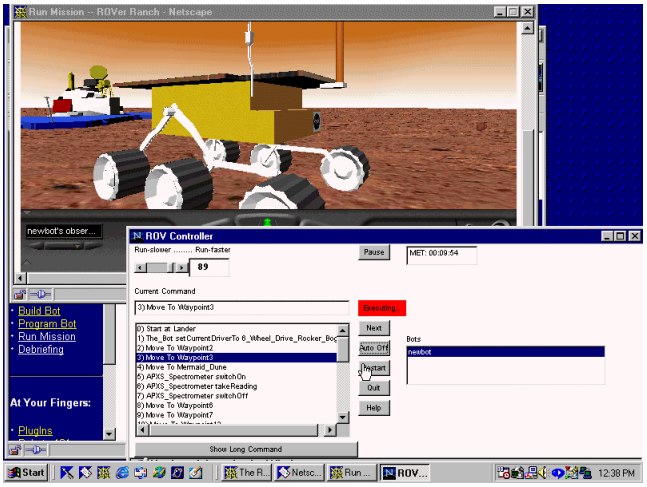
Example of a ROVer Ranch Path Planner activity

These core components provide a student with the essentials for assembling and instructing a software robot and a virtual 3-D mission simulator to test their robot. One set of simulated mission environments is centered on the International Space Station (ISS) and the mission goals are to navigate to various locations on the ISS and perform visual reconnaissance. These missions and prototype robot are based on the NASA Sprint AERCam, a small, spherical, free-flying camera platform used for outside inspection of spacecraft, which in this case is the ISS. Another set of simulated mission environments is based on the terrestrial exploration of Mars. The mission goals include photographic reconnaissance, taking spectrometer readings and other scientific measurements. These mission activities are similar to those conducted by the Mars Pathfinder robot that explored Mars in 1997 and other future robotic missions to Mars.

2 Instructional Technology with Multiple Teaching Modalities

The ROVer Ranch is K-12 instructional technology software structured as an interactive, Web-based robotics workshop with robotic reference material, Java building and planning tools and a 3-D simulation environment. It's an inquiry based learning project that uses a mix of cognitive and traditional methods of teaching. The rationale for using these different methods is based on the fact that there is no consensus in the education community regarding traditional fixed curriculum strategies or learning as a process as a best practice. [Becker 1999] The types of teaching practices a learner might encounter during their school day can range from traditional drill and practice to more complex, project-based environments where the learner is the active generator of knowledge. It has been noted that the development of successful instructional technology materials is dependent on the availability of "several options for teachers to use materials given the realities of the classroom environment, content and teaching practice." [Grabowski 1998]

Additionally, student-initiated projects, inquiries and problem-solving activities must incorporate fundamental elements from traditional behavioral teaching styles to obtain measurable goals and objectives required by standards-based curriculum and academic testing. Educational technology has the potential to support fundamental change in education by focusing on activities that promote the acquisition of higher-order thinking and problem-solving skills. However, complete reliance on project-based learning may pose a risk to reform and a partial alternative is to incorporate some of the structure of current textbooks in a manner that engages students in a far more effective way. [Rand 1996] For these reasons, ROVer Ranch offers a variety of teaching methods to accommodate the very wide variety of teachers and their academic requirements.



Example of a ROVer Ranch simulation

3 Science Education at the ROVer Ranch

ROVer Ranch has a number of applications to science and technology education. The nature of its online structure compels the student to use basic computer technology skills and learn the software tools that are contained within the site. More abstractly, it teaches technology literacy in a number of ways. Examples of technology literacy skills exercised at the ROVer Ranch, which are a part of the International Technology Education Association Standards for Technological Literacy, [ITEA 2002] include the following:

- Students develop an understanding of the attributes of design and learn that design is a creative planning process that leads to useful products and systems.
- Students learn that the requirements for a design are made of distinct criteria and constraints. If and when their robots fail they learn that there is no perfect design.
- In the course of getting a robot to run properly students learn the concepts of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Science learning opportunities are embedded throughout the ROVer Ranch software. The background material is richly detailed with robotic examples and photographs. Students learn how robots are designed and used in real world applications such as industry, hazardous environments and space exploration. The

actual missions are a forum for the student to assume the role of a robotic engineer where they design and run a virtual robot. During the mission process students learn fundamental elements of the scientific method. This includes established activities such as brainstorming, defining a problem, research, identifying criteria and constraints, exploring possibilities, selecting an approach, making a prototype, testing and evaluating the design, refining the design, creating the robot, and communicating the processes and results. Additionally, students are encouraged to explore other disciplines such as literature, art and history as they relate to robotics and robotics engineering.

4 Conclusion

The ROVer Ranch is an interactive tool to instruct students in the field of robotics engineering and science. It contains the essential elements to plan, build and test a simulated robot in an online environment. It provides feedback to the student on the status of their robot mission such that they can re-engineer their robot for different scenarios and different outcomes. The supporting materials provide background information and activities that supplement the simulations. The software also includes tools for communication, file manipulation and teacher project management.

The ROVer Ranch is a part of the NASA's Learning Technologies Project, which provides K-12 students access to NASA research using advanced Internet technology. The purpose of the ROVer Ranch robotics workshop is to involve students in a simplified design and programming task that exercises skills in mathematics and science using tools that can be explored interactively. The ROVer Ranch gives students an opportunity to learn and apply basic science concepts and to observe the behavior of a system they design while learning about NASA research and robots.

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