# INSPIRING FUTURE IT PROFESSIONALS WITH MARS ROVERS

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*Isaac Rieksts and **Glenn Blank
Computer Science & Engineering Department
Lehigh University
19 Packard Lab
Bethlehem, PA 18015
Telephone (610)-758-4867
Fax: (610)-758-6279
(*)Email: ivr307@lehigh.edu
(**)Email: glennblank@gmail.com

**ABSTRACT**

With the goal of inspiring at-risk middle school students, we have developed an innovative curriculum using one sixth replicas of the rovers currently on Mars. Each student receives hands-on experience by performing missions in a simulation program. These missions allow students to relate to the process of controlling the actual rovers. Furthermore, students have an opportunity to remotely program and control the replicas in a realistic Martian landscape created in the basement of a middle school. Programming robots in this landscape is the centerpiece of a Technology curriculum in all four middle schools in the Allentown School District as well as a summer and Saturday program at Lehigh University.

## 1. INTRODUCTION

In 2003 alone, the number of newly declared computer science and computer engineering majors declined by 23% [1], in spite of the growing demand for IT professionals. This decline can be traced to declining interest in computing and IT in high schools, where programming courses are small and do not reflect the ethnic or gender diversity of the general population. Due to the national decline in computer science majors, more exciting ways teach computer science are needed to meet the growing need for IT.

Robotics— especially autonomous or remotely-controlled robots—is one such exciting and rapidly growing field. Autonomous vacuum cleaners and lawn mowers are available for sale. Young people see the potential of autonomous robots is prominent in movies and video games. The DARPA-sponsored Urban Challenge for autonomous vehicles (Lehigh jointly developed the fourth-placing vehicle) has attracted the attention of national media. The Spirit and Opportunity rovers have generated an ongoing stream of images from the surface of Mars.

This paper focuses on an innovative curriculum for teaching robotics at the middle school level. Students learn how to design missions which become programs for replicas of the Mars rovers. A local middle school has converted a basement storeroom into a realistic model of a Martian landscape, on which the rovers perform their missions. This hands-on experience generates excitement as students learn about space, engineering, and computer science. Through exciting missions, the students gain experience by using a realistic model of the NASA control room.

The remainder of the paper is organized as follows. Section 2 introduces two outreach programs, designed to interest in STEM and IT, which have developed the new curriculum. Section 3 describes the replica rovers and their environment, including a student friendly interface and a simulation program that lets students try out rover programs. Section 4 discusses early results and finally section 5 concludes with plans for dissemination and future work.

## 2. LV STEM and Launch-IT

LV STEM (Lehigh Valley Science, Technology, Engineering, and Mathematics) is an NSF GK-12 project which sends graduate students to help develop innovative research-curricula in local schools (see www.lehigh.edu/stem). The first author is one of eight NSF Graduate Fellows for this project and the second author is the Principal Investigator. LV STEM seeks to widen the pipeline of PhDs who are advocates for K-12 education and of K-12 students who can communicate complex concepts of STEM disciplines through writing and multimedia. Graduate Fellows, Lehigh faculty, STEM school teachers, and volunteers from local corporations work together on teams to develop novel curricula in Lehigh Valley schools with substantial majorities of students from under-represented minorities. The LV STEM project began developing the Martian landscape project and curriculum at a middle school in the Allentown School District with 76% minority and 86% low income students. These efforts have generated tremendous enthusiasm within the school, the district and beyond—Harrison-Morton Middle School (HMMS) is now a NASA Explorer school and the Mars Yard has been featured in the March 10, 2006 edition of *The Chronicle of Higher Education*.

Launch-IT is an NSF ITEST project whose vision is to "launch at-risk middle and high school students in the greater Lehigh Valley toward college and careers in Information Technology (IT)" (see www.lehigh.edu/launchit). These students are bussed to the campus of Lehigh University once a month during the school year and for three weeks during the summer. Sixth and seventh graders are working on the robotics team, learning how to conduct science, math and technology 'missions' using remotely controlled robots in the Martian landscape at HMMS.

Until the fall of 2006, the LV STEM program at HMMS had used ER1 robots developed by Evolution Robotics. Each robot required a laptop computer on top of it, which controlled all robot operations. Students wrote small programs for the ER1, employing a relatively simple interface of If-Then rules. Thus students learned how to program with a simple, high-end environment, checking inputs from sensors and creating outcomes with actuators. Recently, the LV STEM HMMS team decided to move away from the ER1s, because Evolution Robotics is no longer supporting the low-priced educational model, the ER1s have limitations with respect to durability and battery life, and because the lead HMMS teacher advocated more faithful realism to the Mars rovers.

Several new developments have recently enhanced the Martian landscape program. With additional support from the Pennsylvania Infrastructure Technology Alliance (PITA) and GEARS Educational Systems, LLC, more realistic rovers have been developed and a technology class room has been remodeled to look like the NASA control center for Spirit and Opportunity. A more realistic environment leads to more realistic scientific missions and increases interest among the students. Launch-IT is incorporating these new technologies into their program as well. The vision of the Allentown School district is to expand to use of the new curriculum under development to all four Allentown middle schools.

## 3. METHODOLOGY

The new technology being introduced is creating excitement for the students. These new technologies consist of replica rovers, an interface to control them, and a simulation of their operation.

### 3.1 Replica Rovers

As a teaching tool, the program uses a replica of the Mars rovers. Since arriving in 2004, Spirit and Opportunity have been sending images, temperatures, and other measurements back to Earth; students can view exciting images on the NASA web site. The rovers have outlasted their expected operational time by years, making them one of the most successful science and engineering projects of our time. Although only expected to travel one kilometer, Spirit has traveled 7 kilometers and Opportunity has traveled 12 kilometers. The rovers are programmed via commands sent from Earth.

The replica that GEARS Robotics developed specifically for this project is one sixth the size of the actual rovers. Figure 1 shows the replica with six wheels. These wheels can be controlled individually or simultaneously. For the interface, the wheels are control simultaneously. Each wheel has a motor mounted inside of it, along with motors to rotate wheels for turning. For sensing, the replica has a camera and a science probe. Although the replica moves slowly, it still moves faster than the full scale rover. The replica has the same suspension design as the full scale rover, allowing for travel over rough terrain. To connect to the replica, a wireless connection is used to transmit commands.

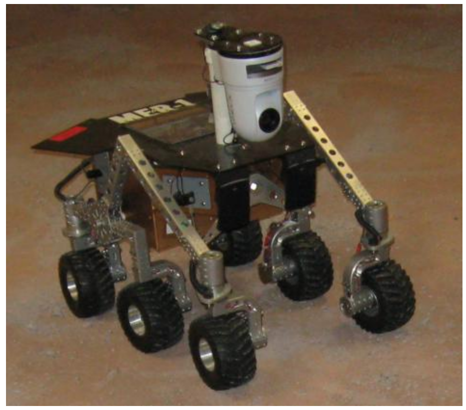

Figure 1: One sixth replica of Mars rover

For a more realistic experience, an environment for replica called the Mars Yard was built. An unused storage room in the basement of a school building was converted into a Martian landscape. Several features provide a realistic environment. For example, a canvas painting of Martian terrain decorates the walls create to a panoramic view (figure 2 shows the Martian landscape in the background). For the 800 square foot floor, red concert and gravel imitating the surface of Mars also adds to the experience. When entering the room, you pass through an air lock style door. To allow remote access to the room, a camera is mounted on the ceiling. Together, these features create a unique experience.

**3.2 Interface**

The replica rover's original interface was complex and difficult for students to use. In the summer of 2007, the first author designed and implemented a simpler interface for the river was designed and built in Java. This interface was designed with two modes for communicating with the replica. First, commands may be sent separately so control decisions can be made in real time. Secondly, a more advanced control allows for users to drag-and-drop commands into a queue for the entire queue to be executed in sequence. This advanced control is the standard way of communication. The advanced controller (shown in Figure 2) has to be simple enough for the students to use, but must also be complex enough for the students not to lose interest. To create a visually pleasing interface, graphics were produced. Along with the graphics, the skill levels of the students must be taken into account. Since the students vary between sixth and eighth grade, they have varying levels of skill. To meet the needs of every student, the interface must have different levels of difficulty. The control system is simple enough to only require the four basic controls. These controls are forward, back, left, and right. However, an advanced student can be more efficient if he/she uses additional controls that are a combination of the basic controls. Students may also adjust the speed and length of time for executing a command.

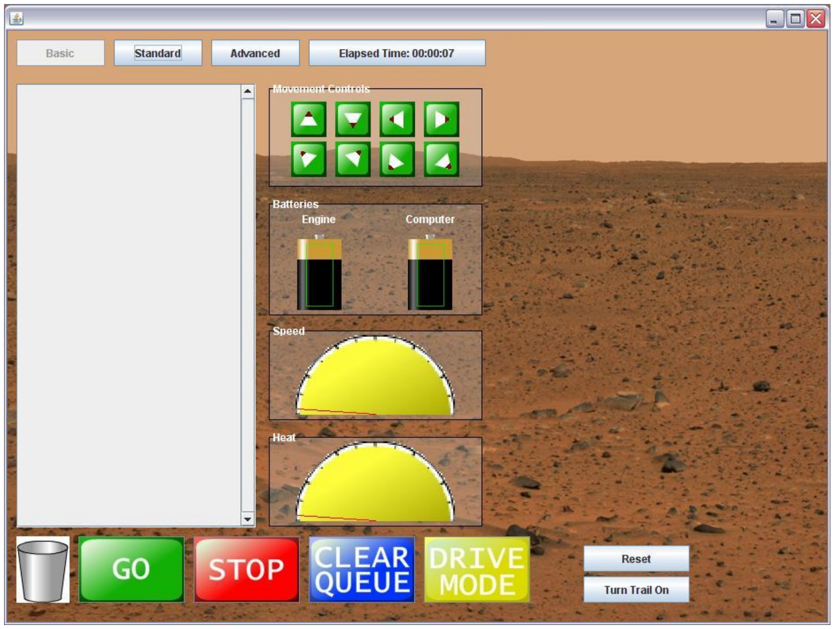


Figure 2. Control interface for replica of Mars rover

Another feature for teachers is the time elapsed. This feature allows a teacher to monitor how fast a student is working. The ability to time the process also creates a competition between students to push them harder. In future work, the interface will allow a student to create and execute a series of commands in the form of the code that the replica rover actually receives.

### 3.3 Simulation

Since there are only three robots in the Mars Yard, the student-to-robot ratio creates a problem. To solve this problem, a simulator was developed. This allows students to each work on their own simulator to test their ideas before running them on the actual replica rover. Figure 3 illustrates the simulation display screen. As Figure 3 shows, actual pictures of the Mars Yard and replica rover are used in the simulation.

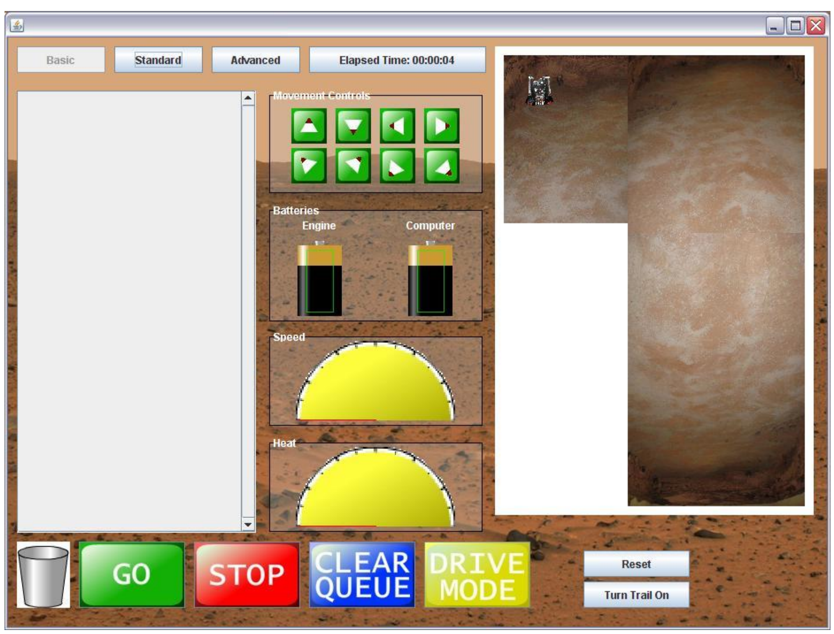


Figure 3. Simulation of a replica rover in the Mars Yard

The simulator has some features that focus on helping teachers monitor students. Due to the large class sizes (one teacher to 20-30 students), it is difficult to monitor the controls a student is using. To address this problem, the multiple screen have a different colors making it easy to see when a student is on a screen designed for a different project than the teacher is currently conducting.

If the tracking feature is turned on, the robot leaves a trail. This feature allows easy tracking of where the robot has gone during the simulation. The teacher then does not have to observe the entire simulation run in order to know what the student has accomplished. Once the run is completed, the teacher just looks at the trail for the results of a student's simulation.

There are eight commands for controlling the rover (forward, backward, right, left, forward and right, forward and left, backward and right, backward and left). These commands are dragged and dropped from the Movement Controls box (under the Elapsed Time indicator) to the queue of commands on the left (which currently contains seven commands). To execute these commands, one would click on the GO button. In the simulation, the rover leaves a trail from the starting position to its current location—the blue line behind the rover in figure 1. This output is used for quick grading or to teach shapes using the simulator. The DRIVE MODE button sends one command at a time, rather than a queue, so students can observe the result of each step safely. To send commands down to an actual rover in the Martian landscape via an Internet link one selects a "connect to robot" button at the startup of the program. The student will then be able to watch the rover execute the commands, via a web camera mounted on the rover and a "sky" web camera mounted on the ceiling of the landscape room.

## 4. PRELIMINARY RESULTS

The Launch-IT students were the first to work with the replica rover and its interface during the summer session of 2007. After building one of the rovers from a kit (two over rovers were already assembled), the students drove the replica rover in a hallway at Lehigh University. To control the replica rover, students sent single commands between each of the replica rover's actions.

The simulator has been used by Launch-IT students in both the summer and fall program of 2007. Students were given several missions to complete on the simulator. These missions ranged from simple missions such as moving to a point in the room to more complex missions such as creating an equilateral triangle in the room.

Assessment showed that Launch-IT students on the robotics team developed a high level of excitement about "working with computers" (3.5 on a 1-4 Likert Scale) and all students successfully constructed rover simulation programs. The only complaint the students had was the slow speed of both the replica rover and the simulator. However, this feature was intentional, providing an opportunity to teach students about reasons why the real Mars rover moves at even slower speeds. The students were excited to use both the simulation and the replica rover. They found linking a sequence of commands together to complete a mission to be a challenging but fun task.

## CONCLUSION

The new rovers and simulation give the students a bridge between their science classes and current technology used by NASA. Both the rover and its simulation have grabbed the attention of students. These results show potential to achieve the goals of both programs to increase the enrollment of students in technology areas and prepare them for the next level of education.

In future work, improvements will be made to the interface and simulation to create a more realistic experience. The simulation will be enhanced to provide a virtual view from the rover's perspective. The web camera for the replica rover will be integrated with the interface as well. Allentown School District plans to work with the LV STEM team at HMMS to expand the scope of the Martian rover curriculum to all four of its middle schools.

Allentown School District plans to work with the LV STEM team at HMMS to expand the scope of the Martian rover curriculum to all four of its middle schools. This simulation program can be used as is or it could be adapted for use with different robots at other schools that might be interested in applying similar technology. The program is designed for a robot that uses telnet to receive commands through a network. One module (a Java class) of the program can be modified without much difficulty to reflect the differences in the commands used to control the robot. If a school wishes to use this replica rover or the program, please contact one of the authors.

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