Integrating Education and Real Research

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Abstract

Popular media has spawned a recent interest in teaching robotics in the classroom. Many different approaches have been attempted, with many that focus on robot competitions. However, following the competition, students often do not know where to turn to keep their curiosity in robotics alive. This paper discusses a collaborative approach that shows students a clear path from early robot competitions through to careers in the field. The approach relies on student participation in real research and a ladder of mentorship through their academic journey.

Introduction

There has recently been a surge in robotics interest in the popular media. Students from kindergarten through graduate school have caught the fever and are studying robotics in many different ways. One of the most popular has been through robot competitions that have ranged in style from Lego robot leagues, like Botball and First Lego League, to complex mechanical leagues, like the First Robotics Competition, to simulation only leagues such as the RoboCup Simulation league. For many students these competitions are an eye opening and life changing experience; for the first time, many may see a practical and exciting application of math and science, and may wish to pursue robotics. But how, whats the next step? The Remote Exploration Program (REP) is an attempt at bridging the gaps that exist between these early experiences and the next steps that can lead to a career in science, engineering and even robotics.

REP is a collaborative effort between Washington University in St. Louis (WUSTL), the Idaho National Engineering and Environmental Laboratory (INEEL), the St. Louis Science Center, and St. Louis area schools. The goal is to create an inclusive outreach program of science, engineering and original research that in turn fosters a clearer path for students to pursue careers in the fields of science, engineering, and robotics. The program consists of ongoing outreach activities that culminate in the remote exploration of an unknown site using robots.

The Remote Exploration Program

The Remote Exploration Program (REP) is structured with ongoing science and engineering outreach programs throughout the academic year. However, the keystone event is the remote exploration of an unknown site. For this exploration, students will come to the St. Louis Science Center and teleoperate a robot that is physically a great distance away (in another state), to explore an unknown environment.

The vision for REP is that this remote environment will show mountains and other geologic features that students from the Midwest are unfamiliar with to engender a real sense of being somewhere else. The mis-

sion will then be for the students to simply explore this foreign remote environment theyve been placed in. The other concept is for students to complete a real world mission similar to tasks that the INEEL group is interested in. Two of INEEL's current interests are remote characterization of high radiation environments and urban search and rescue operations.

For the pilot program in the spring of 2004, the remote environment will be housed at the St. Louis Science Center and the exploration will be similar to a real world robotic task. We believe that it will add value to both the human factors research and to the students experience if the teleoperation activity simulates a real world robotic mission such as exploring a simulated hazardous material contamination or exploring a mock collapsed building. Starting in the spring of 2005, the remote environment will be outdoors near the INEEL facility in Idaho Falls, ID. For this outdoor environment we are still considering several exploration tasks. We would like to simulate an environmental cleanup and monitoring task, but have not worked out how to simulate this with contaminants that can effectively be sensed.

Program Goals

It's important to keep in mind that the remote exploration is only a vehicle to accomplish our goals. REPs true focus is its two main goals: to involve young students in real research, and to delineate a clear path from early childhood interest in robotics through to careers in the field. Science and engineering outreach are merely added benefits necessary to fulfill the main goals.

Real Research

Recently, introducing students to real research has become a hot topic in academia; but it really hasn't reached the level that REP is targeting. The National Science Foundation's programs such as Research Experience for Undergraduates (REU) and the St. Louis area Students and Teachers as Research Scientists (STARS) programs often introduce undergraduates and high school students to research, but REP will offer students as young as Kindergarten an opportunity to participate in real research, albeit in a limited way.

The most significant portion of the real research will be human-robot interaction studies which will focus on improving the performance of the Graphical User Interface (GUI) developed by INEEL for their real world robot missions. As part of their on going human-robot interaction and long-term robot autonomy research, K-12 students will be intertwined with the research as both participants and reviewers.

For the spring remote exploration, one of the variables we want to study is user performance based on prior experience with the GUI. To accomplish this, student participants will be divided into several groups, based on the level of experience the students have with the GUI. Some will have no experience, others some experience and the remainder extensive experience. The student operator will then be allowed to teleoperate the robot to accomplish the task, while the rest of the class assists the operator by performing data analysis on the environment. For the more advanced students, following the remote exploration they will have an opportunity to meet with the human factors researchers who will give an introduction to human-robot interaction studies. The students will then get to contribute as researcher as they participate in reviewing the video of their interaction, guided by the professional researchers.

Career Path

The significance of using real world applications for the purpose of the simulation is multifaceted. One of the most important reasons is that these real world activities ground the human-robot interaction research because it evaluates the GUI being used for its original intention. But even more importantly, using a real world application is an essential link in REP's chain that leads interested students to careers in science, engineering and robotics. It's a subtle point, but many students that participate in robot competitions have very little exposure to robots outside the competition. When asked for a real world application their only examples may be factory robot workers or Mars rovers. Factory robots aren't sexy, and NASA isn't about to let a kindergartener drive Sprit or Opportunity. REP offers students an opportunity to see first hand what robots and roboticists do in the real world and to meet potential future role models.

But then REP builds on this experience. For those students that are interested they can participate at the next level. They can participate in voluntary supplemental programs such as the Saturday Science Seminars or the Saturday Engineering Events or even one of the summer opportunities. REP has a mentorship ladder for interested students built into these activities. It uses students that excel at one grade level to assist students in lower levels. In this interaction the higher grade students also have the opportunity to share with the younger students their current projects. Both students take away from this experience. The older student sees the enthusiasm and the respect the younger pays them, and the younger student gains from advice and guidance of the older.

The mentorship ladder is already being established. The first rung was establishing a summer mentorship program for aspiring high school students. These students had the opportunity to come to WUSTL during the summer months and study robotics. A second rung was established when an undergraduate who had gotten excited about FIRST robotics continued her interest and continued the work of others on a prototype planetary rover at WUSTL under the mentorship of a graduate student. And the ladder continues to develop; this fall students at Gateway Middle School, a St. Louis Public School that WUSTL works with, worked on creating an outdoor robot to be deployed at the remote site. Those students that excelled have been asked back

to help mentor new students in a similar project. And the ladder will continue to develop as undergraduate students will be given the opportunity to continue their interest at real labs such as INEEL during the summer, and people in industry are given the opportunity to return to graduate school to complete advanced degrees.

Science Outreach

A side product of REP are the Scientific Outreach opportunities it produces. There are three major components to REP's scientific outreach: Saturday Science Seminars, St. Louis Science Center Exhibits, and classroom tie-ins. Saturday Science Seminars will offer insight into the science of robotics. Taking a higher level look at the components of a robot, students will spend significant time learning how to teleoperate the robots using the interface and may learn about the science of search and rescue or hazardous material clean up.

In addition to Mission Control and the robot training area, the St. Louis Science Center will have exhibit space open for the general public to learn about robot technologies. They will have displays explaining robot and sensor technologies and will offer models for hands on learning about different sensors. The St. Louis Science Center will also play a crucial role in scientific outreach with how Mission Control itself is organized. Because there will only be one primary robot at the remote site, the mission itself will be structured such that a single class participates on different levels. While one student teleoperates the robot, the rest of the class will act as a data analysis group to help the operator complete the mission. This may mean the rest of the class must plot the concentration of hazardous material at different areas or they may try to integrate data from other sources, such as fixed sensors or cameras, to try to find survivors in a mock collapsed building. Whatever the mission may be, the St. Louis Science Center's Mission Control exhibition space and pre-exploration preparation will play a critical role in the success of each class at successfully completing the mission.

The third component to REP's scientific outreach are the classroom tie-ins accentuated by an exploration that is coupled with a real world application. These tie-ins by far are the best way REP can reach students because teachers can intertwine them with their curriculum. Example tie-ins could be as simple as teaching latitude and longitude so they can interpret GPS data, or teaching about volcanic activity and mountain formation as part of the geology they might find in the Western United States. Other examples could include teaching about urban search and rescue techniques and traditional methods for finding survivors in collapsed buildings or teaching math to help students understand how to pinpoint the source of a hazardous material spill based on a concentration gradient. The list of tie-ins is nearly endless, but by giving significance to a topic, teachers often find that it entices the students to concentrate just a little harder. Ideally some of these tie-ins would be taught before coming to the remote exploration at the St. Louis Science Center so the entire class would be prepared when they arrived.

Engineering Outreach

The engineering outreach activities offer students an intensive hands-on engineering series. Broken up into two segments, the engineering series will offer Saturday Engineering Experiences and after school engineering projects.

The Saturday Engineering Experiences are designed to be single Saturday introductions to engineering principles. They will concentrate on small hands on projects that teach engineering principles. Some of these small projects may be to design and construct a simple manipulator arm, or a pan-tilt camera mount.

The after school engineering program will be much more intensive with students expected to build an outdoor robotic vehicle from a kit of off-the-shelf components. A pilot program was tried in the fall at Gateway Middle school and the pilot program is being revisited and retargeted toward high schools this spring.

The pilot program at Gateway was structured such that a select group of 7th and 8th grade students worked with a graduate student from Washington University to design and build a scout robot to assist the primary robots with the exploration of the remote site. After a brief introduction to robots and existing technologies, the students were given a box of components and an explanation of how each worked. These components included a Kyosho Blizzard Radio Controlled tracked vehicle; a GPS receiver; a Javelin Stamp microcontroller; an 802.11b wireless radio to serial bridge; an 802.11b wireless camera; and temperature, pressure, light, and humidity sensors, etc.

The students were then guided through the integration phase but while the students were highly interested by the components displayed and robotic examples, their interest began to wane when they started programming the Javelin Stamp microcontroller. While they were capable of simple programming tasks they had difficulty generalizing their experiences and combining them into a workable architecture. Based on this experience, the pilot program is being restructured to target high school students. The high school students are being targeted with the approach that given the problem of designing a robot to assist the exploration of an unknown environment, a box of off-the-shelf components and an engineering student for guidance and advice when called upon, they are to engineer an outdoor robot to be deployed at the remote site.

One of the hardest components of these K-12 student engineered projects is the front end graphical user interface. This will be handled by WUSTL, with a Java enabled GUI that can be run on virtually any machine.

Conclusions

From the students prospective REP goes beyond the fun and games of these robot competitions and shows students the real world applications of robots and a

path to a viable career in robotics. It shows them the way that Lego style robotics can lead to careers in the field by simply taking it one step at a time and following in the footsteps of their mentors. But in the short term and for students not interested in robotics, it offers a concrete example for science skills they have learned and it encourages them to work as a team.