Session 1320

Remote Sensing and Tele-robotics for elementary and middle school via the Internet

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Abstract

The Science, Engineering, NASA Site Of Remote Sensing (SENSORS) project aims to help bring remote sensing and tele-robotics to upper elementary and middle school audiences. By creating a network of simulated environments, ranging from the Moon to Mars to Antarctica to a working city-scape, SENSORS gives student opportunities to explore and automate remote environments via the web. The main SENSORS site (www.ceeo.tufts.edu/sensors) serves as portal to access each of the seven different environments (3 are currently operational, 4 more will be operational by mid – late 2003). The sites each feature curriculum related to their environment that can be done in a classroom without a computer. Curriculum ideas encompass a broad range of activities from keeping a journal on your observations about an environment to designing an instrument to investigate the attributes of the environment. As a culminating project, each environment has different challenges that need to be solved in a physical miniature replica of their environment. Via the web, users remotely control LEGO RCX based rovers in these environments by submitting programs that instruct the creation to complete a maneuver or collect data. For example, a mission on the Moon site is to drive the lunar rover between two points on the surface. Users submit various trial programs (via a Flash interface) to the site to get data about how far the rover travels at different amounts of time before submitting their final mission to accomplish the challenge. This paper will detail this unique collection of sites as well as discuss the opportunities and learning available to students in this new environment. In addition the design, implementation, and programming present in creating a robust interface for remote exploration powered by Robolab, LabVIEW, Macromedia Flash, and ASP will be addressed.

Introduction

Humans explore the earth and the solar system in their quest for knowledge. The scientists and engineers who make this exploration possible step through a process of viewing from afar, sending probes, and finally designing, building, and launching a spacecraft or rover to the location. This process involves a high level of understanding of math, science, and engineering and the ability to apply it to probe, rover, and spacecraft design, construction, and programming. NASA employs the best and the brightest to do this and their results, more often than not, are spectacular feats that garner the interest and attention of the public.

Tufts University's Center For Engineering Educational Outreach created SENSORS, the Science, Engineering NASA Site Of Remote Sensing (www.ceeo.tufts.edu/sensors) with the aim of capitalizing on the concept of an exploration mission to make K-12 learning of math, science, and engineering engaging. This project, funded by NASA's Learning Technology Project, supports a network of locations that host information, curriculum, and model terrains. The culminating activity at each site is the submitting of a mission, ranging from data collection to retrieval of an object, for a LEGO based ROV to complete on the model terrain.

Establishing a site model

Prior to establishing a network of sites, a model site needed to be established and the software for remote missions needed to be created. As the lead institution, this development was done at Tufts and served to create Tufts' own Moon site. The site was organized according to how students would approach understanding the moon: Viewing from Afar, Probing the Surface, and finally Driving the Rover.

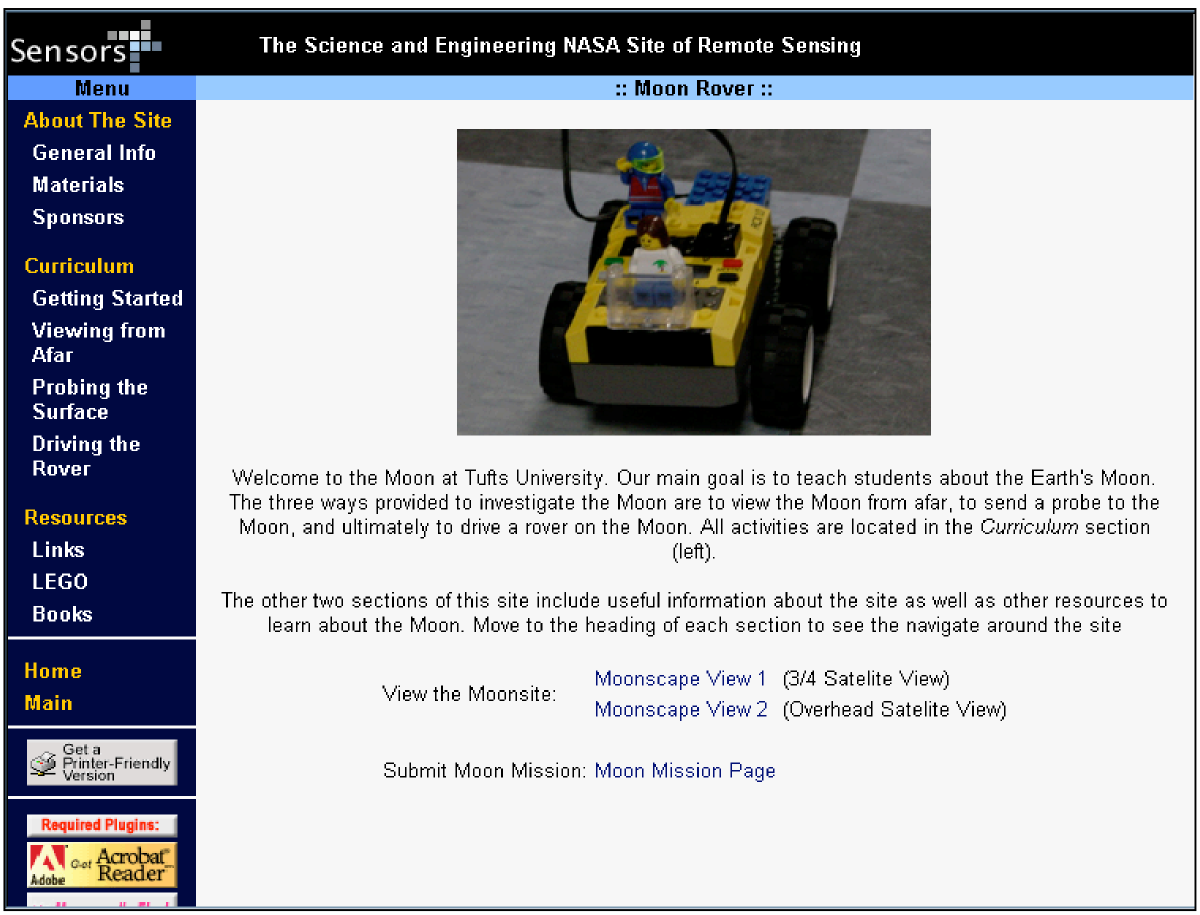

Figure 1: Tufts Moon Site (http://www.ceeo.tufts.edu/sensors/moon)

By working with teachers curriculum was created that would allow students to follow a process similar to the NASA scientists and engineers while incorporating math and science skills they needed to learn. In the Viewing From Afar section the activities have observe the moon to see what they can deduce about its movement and size. For example students try to establish the distance from the earth to the moon by punching a hole in a piece of paper and moving the paper until the moon exactly fills the hole (The ratio of the distance from your eye to the hole and your eye to the Moon will be equal to the ratio of the two diameters, the hole's and the Moon's.)

VIEWING FROM AFAR: ACTIVITIES

Keep a Moon Journal

Balls and Lamps
- Modeling Day and Night
- Modeling the Phases of the Moon
- Explaining Solar Eclipses
- Explaining Lunar Eclipses
- Does the Moon Rotate?
  - On the Moon

Size and Distance
- The Scale of Things
- Pizza Payoff
- Marble-sized Moon
- Distance from Earth to Moon
- How Big is the Moon, Really?

Figure 2: Activities at Tufts' Moon Site For Viewing the Moon From Afar

Students move on to activities in the Probing the Surface section. Several of these activities employ the LEGO RCX to collect data and illustrate data collection principals. The activities focus on how would you establish what the surface of a location is like so that you could design and appropriate spacecraft or ROV as well as establishing understandings of phenomenon that happen there (gravity etc…)

The final section "Driving on the surface" lets students program a mission to run on the remote site. The moon site has several mission challenges including finding a hidden pattern, calibrating the car to go specific distances, and collecting temperature data. Classrooms with access to the LEGO RCX technology are encouraged to practice the challenges in their classroom before submitting a solution via the web to give more students access.

Driving the Rover

The most technologically intense part of creating the model site was creating a method by which via the web students could control an ROV. This involved creating a web interface that could be used by both those with LEGO RCX hardware and software and those without (so as to reach as broad an audience as possible). While the ability to program the LEGO RCX already existed, this also had to be modified to accept input generated via the web and multiple requests.

As Tufts' is one of the developers of ROBOLAB, the Labview based software package for programming the RCX, this was the method of communicating with the RCX. A rover was designed with the IR interface oriented upwards so that a tower could be mounted in the center of the moon-scape to communicate with the RCX throughout the terrain.

Figure 3 : A picture of the Tufts moon-scape.

A web interface was designed that allowed users to login and submit mission to try and accomplish one of the challenges. Each user signs up for a block of time in which to run their missions. This was put in place to prevent multiple submissions to the ROV at the same time which would result in confusion. A Flash interface was designed to allow users to program the RCX (movements and data collection) as seen in Figure 4.

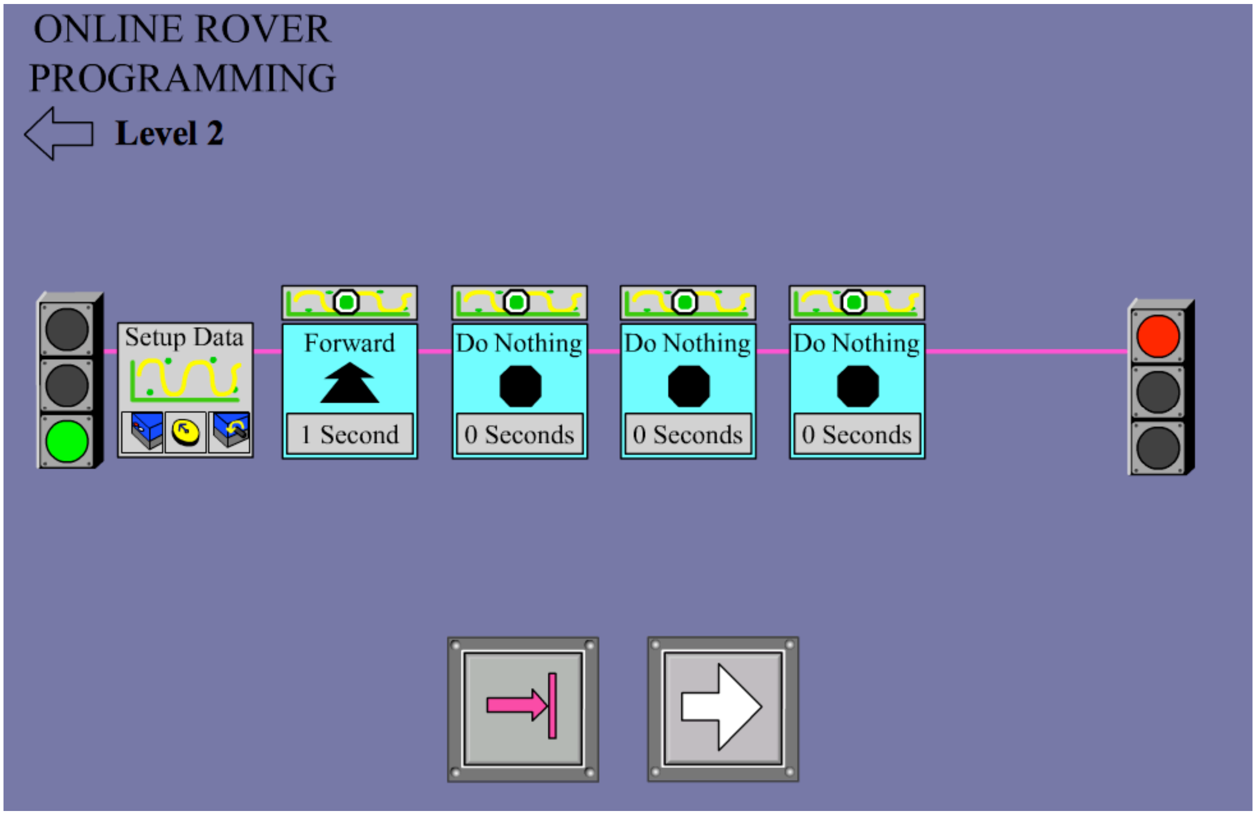

Figure 4: The Flash interface allows anyone to create a program for the moon-scape ROV.

The Flash interface stores LASM (Lego Assembly Language) that it stores on the web server. The machine connected to the moon-scape running ROBOLAB (with SENSORS server enhancements) continually checks a queue on the web server for new missions. Once it finds a mission it imports the LASM and runs the mission.

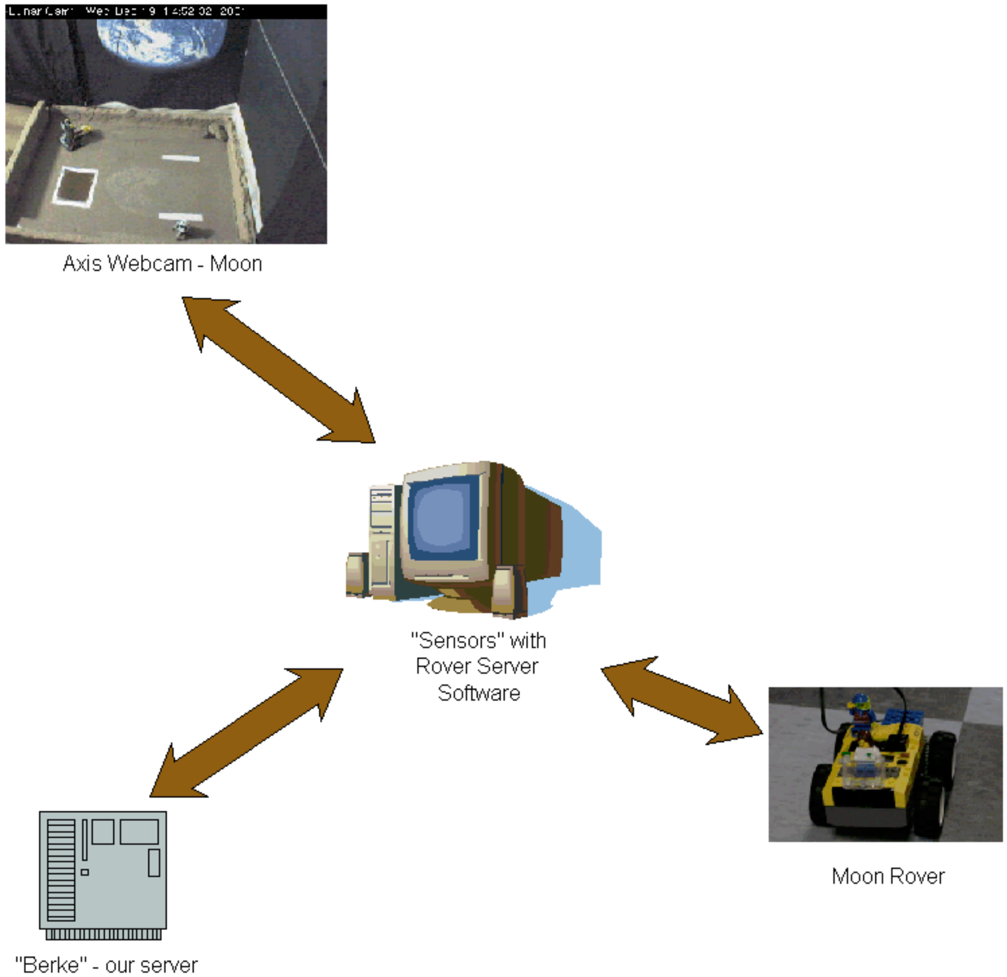

Figure 5: Flow of information of SENSORS Rover portion

Missions can be watched in real-time via web cams or Quicktime movies can be downloaded (a feature in alpha testing). Once a mission has been run users can also retrieve the data they have collected.

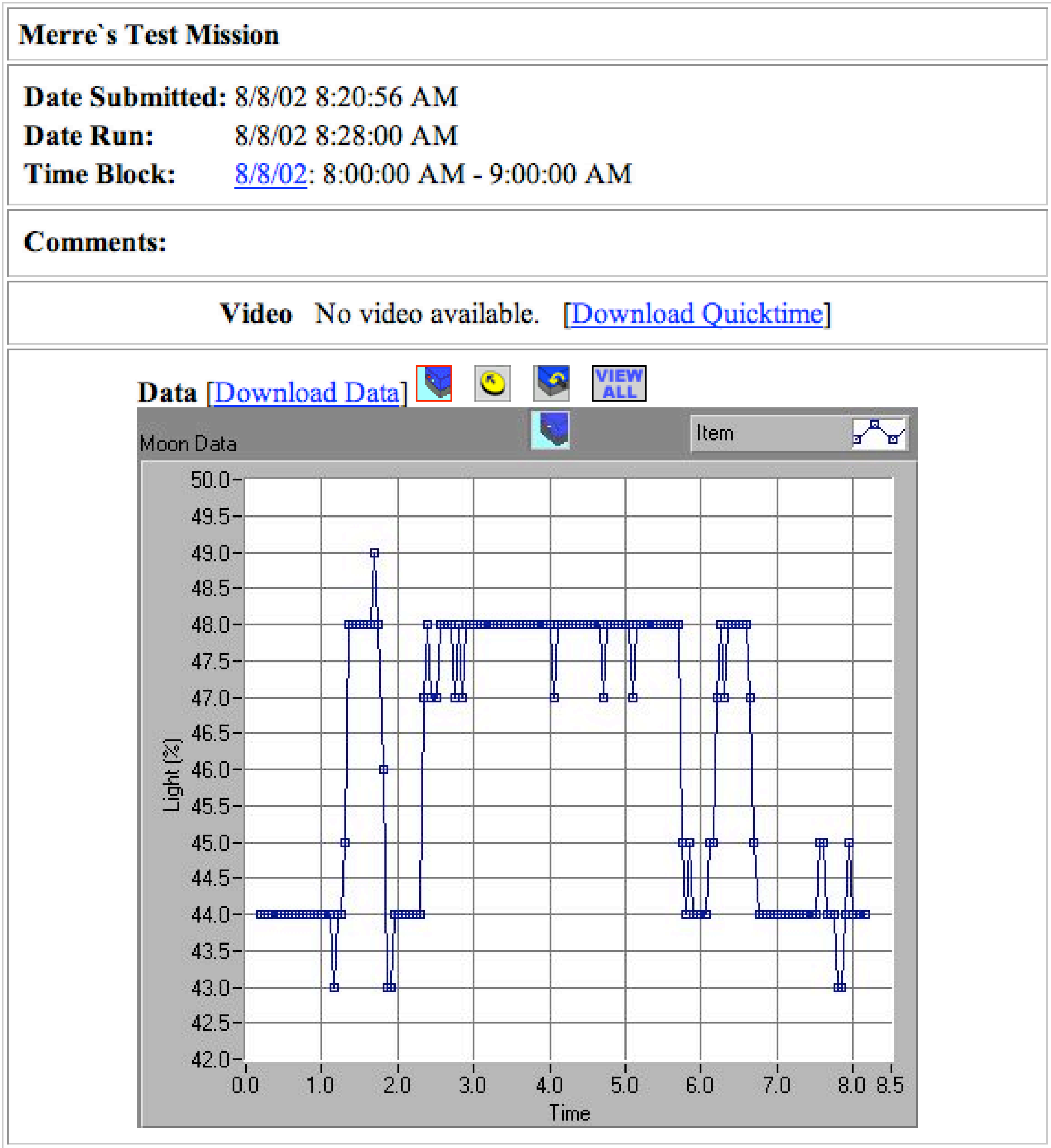

Figure 6: Sample Light Sensor Data Collected on the moon-scape

The data can be analyzed on-screen or exported in spreadsheet format. Users have the ability to re-run missions and to remove un-successful missions.

Network of Sites

Figure 7 illustrates the locations of the institutions currently slated to host sites in the U.S. Australia's Technology School of the Future is also slated to host a site.

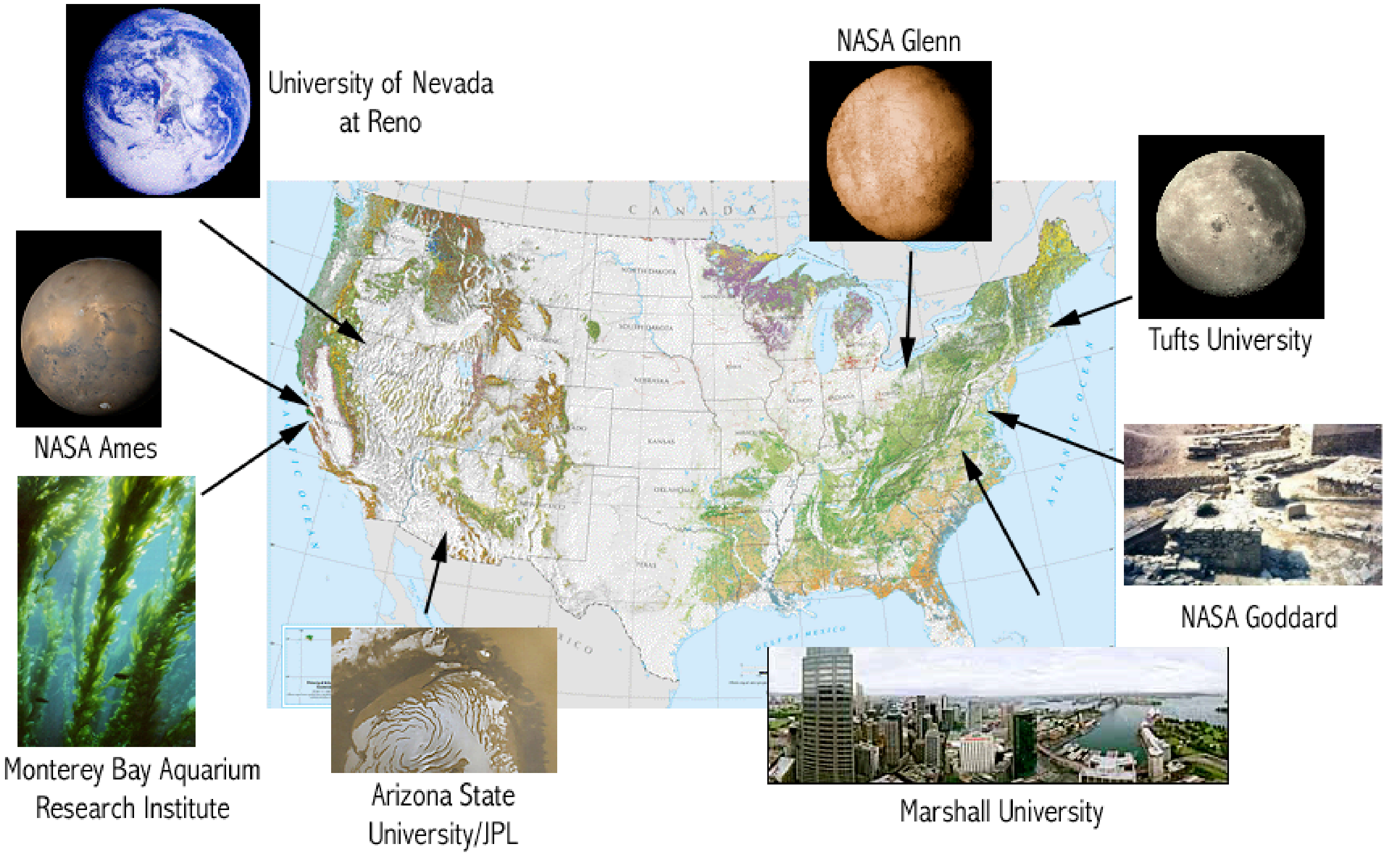

Figure 7: U.S Sensors Sites

Each of the sites is developing a location similar to Tufts' lunar site but rooted in their own expertise and mission. NASA Glenn, for example is developing a site based around Jupiter's moon of Europa where missions surround the quest to determine if there is water there while Arizona State University/JPL are working on a Mars site where missions are based on dust issues. Sites that are operational are linked from the main SENSORS portal (http://www.ceeo.tufts.edu/sensors). Aside from Tufts 3 are currently in beta mode schedule to be complete this year with the rest coming into beta mode in the next few months.

Difficulties and Future Directions

The difficulties in getting this project off the ground were mostly technological. Getting the rover system to be as robust as possible involved some significant hurdles. While the benefit of the RCX is that it doesn't need to be plugged in (as it runs on AA batteries) to have the system ready at any hour and to get consistent motor output it was necessary to plug the RCX in. Several methods of returning the RCX to a "home" were explored but most (camera based) were too time or resource intensive. We worked around this difficulty by giving users a virtual joystick to position the ROV with before they ran their mission.

In the classroom students have been very excited about the prospect of controlling remote ROVs. However, it is difficult to keep 20 students engaged with 1 computer controlling 1 ROV.

In classrooms with LEGO technology this was easy to work around by having students build their own models. In other situations, it was necessary to restructure the activity to be an extra or something students accomplished during free time.

Overall, the project has been met with great enthusiasm and the establishment of a network of sites has led to great collaboration and a greater outreach than if all the sites were hosted by one institution. We look forward to increasing the quality of the sites and looking for ways outside of a classroom setting such as museums and visitors centers to use the SENSORS sites.

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