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EventScope: a telescience interface for Internet-based education — Source link

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EventScope: A Telescience Interface for Internet-Based Education

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Abstract

The goal of exploration through telerobotics is to broaden our understanding of the universe. Towards this goal, the EventScope project at Carnegie Mellon University merges educational software and a telescience / telerobotics mission interface for use within classroom settings to provide more direct connections to new information. Answering scientific questions requires mission interaction on a first-person level—for instance, a student can glean a wealth of information by remotely exploring the contours of a rock formation. Traditionally this interaction is limited to only a single user because a robot can be in only one place at one time. EventScope addresses this scalability problem by enabling dynamic interaction with mission information through tools that allow users to navigate independently of the spatio-temporal nature of a robotic expedition. Further, interface elements such as annotations and hotspots allow science educators and scientists to annotate representations of remote sites to convey their expert knowledge to students on a mass scale.

1. Introduction

The EventScope Project (www.eventscope.org) is a NASA and foundation funded project between the STUDIO for Creative Inquiry and the Robotics Institute at Carnegie Mellon University that develops software and educational curriculum using a 3-D virtual environment to enable exploration, education and discussion. EventScope aims to provide an educational telepresent experience by instilling an individual feeling of exploration and providing ubiquitous access for educational purposes across a variety of classroom scenarios and computing platforms.

2. Goals of EventScope

EventScope extends telepresence into a medium for scientific inquiry. More so, EventScope provides *guided* scientific inquiry to support education. We set the following goals for EventScope's design:

- **Applying remote experience to education.** Meeting this goal requires a framework allowing specialists and educators to enhance a user's telepresent experience with their expert knowledge of a site or topic. On the most basic level, such a framework provides tools for the creation of an educational curriculum. On another level, it offers tools to enable students to formulate and express their viewpoints with peers or mentors.

  The best-known use of telepresence / telerobotics in education is the Jason Project created by Bob Ballard [2]. At Carnegie Mellon University, the BigSignal interface represented the first entirely web-based telerobotic interface for education. BigSignal gave over 1500 students the opportunity to explore the remote Antarctic environment [4]. The LAPIS project uses the Jet Propulsion Laboratory's (JPL) WITS interface to enable high school students to interact with the FIDO rover at JPL [11].

- **Providing a personal feeling of exploration to many users.** A core challenge is to make telepresence interesting even with fewer robots than people. This requires techniques that amplify a single, geographically oriented remote experience captured by one or more robots and seamlessly relay that experience to society at large.

  Prior work that addresses this issue includes certain NASA interfaces that connected large groups of people with data archives representing remote sites. MarsMap [19] and WITS [1] were virtual environments that enabled Pathfinder scientists to virtually explore the surface of Mars through a computer-based environment constructed from Mars site data. These virtual environments effectively created a personal feeling of exploration because the data archives resembled the actual sites. Similarly, during the 1998-2000 NASA/Carnegie Mellon University Robotic Search for Antarctic Meteorites, The BigSignal Project provided over 1500 students with spatial- and temporally-based interfaces that allowed them to explore the remote Antarctic environment [4] when the robot was both in and out of communication.

- **Providing ubiquitous access.** Telepresence for education also requires interfaces and interaction technologies that run on consumer-level computers such as those found in homes and schools. These computers rarely have high-end CPUs and ample memory available. Interface devices often used for telepresence such as VR goggles, special projectors and 3-D mice are inappropriate for widespread access to telepresence.

  Prior work includes Telegarden, which allowed the public to remotely care for real plants and interact with a virtual community via the Internet [7]. In the PROP project, participants visited and interacted with people in far away urban environments by controlling small blimps and carts [14]. With its touch-tone telephone interface and interactive television shows, RoverTV allowed thousands of people to explore the Atacama Desert by controlling Nomad, a planetary rover prototype built at Carnegie Mellon [16]. RoverTV collected votes from viewers requesting that the rover turn left, go straight or turn right. The most popular command was sent directly to Nomad. Each of these prior works featured interaction paradigms that used affordable computers and standard I/O devices.

3. Creating Virtual Communities in Educational Settings

The underlying collaborative structure of EventScope is similar to state-of-the-art collaborative educational software researched and developed in the new electronic media age. The structure of this software generally falls into one of two categories:

Peer to Peer: Knowledge Forum is an example of a virtual space with rich multimedia capabilities that enables students to share ideas [17, 18]. Results indicate that students using this software in classrooms exhibited greater improvement on standardized tests and in the quality of their work, as compared to students instructed using traditional face-to-face teaching methods. Building on the success of this approach, EventScope allows students to virtually "step" into the analyzed and processed 3-D world of others, or superimpose their own analyzed world onto that of others.

Peer to Expert: Globe Lab is a popular WAN-based educational software that forms both student-student and student-scientist partnerships [3]. This design removes the complexity of understanding the local data and collection method, and instead focuses the collaboration on analysis of the data. By applying this educational approach to EventScope, the traditional paradigm of scientists serving as masters to the cognitive apprenticeship of students changes to one of true collaboration.

4. The EventScope Interface

The EventScope interface uses a 3-D virtual environment based on archives of data from planetary exploration missions to create a personal feeling of exploration. Users download virtual worlds and use interfaces to explore these data archives. Users gain a feeling similar to the thrill of controlling a robot by navigating these intuitive virtual environments.

As shown in Figure 1, the EventScope interface includes:

A. Curriculum / Instructional Text Window: This region contains curriculum and classroom lessons created by scientists and educators.
B. Virtual Environment: This is constructed by fusing Mars Global Surveyor MOLA data and Viking Orbiter images. Other views contain 3D representations of the Mars Pathfinder landing site constructed from stereo camera imagery and high-resolution images from the MGS Mars Orbital Camera.
C. Annotations: This allows educators to mark regions of relevance within the virtual environment that pertain to the curriculum and lessons. Students also may complete homework assignments by marking answers to specific questions posed by educators within the virtual environment.
D. Tool Bar: This contains tools to navigate and to activate/deactivate annotation overlays. It also has buttons to change from photorealistic to topographic views; annotation tools to mark the surface; and undo/redo, load and save buttons.
E. Backwards and Forward Buttons: These control a guided tour created by educators. Guided tours are accompanied by lessons and annotations to demonstrate certain concepts and raise scientific questions.

The EventScope software has been designed and optimized to minimize its demands on hardware platforms so that it is widely accessible to users on consumer-level computers. This development sets the stage for ubiquitous access. The software is written entirely in Java, using the Java 3D API for 3-D graphics. Java technologies enable easy portability across platforms. To date, the EventScope team has successfully tested the software on the PC platform with Windows 95, 98, NT and 2000, and plans to port the software to the Sun Solaris platform. Once Apple makes the Java 3D API available on Mac OS X, EventScope will be ported the software to the Macintosh platform.

The software has been extensively optimized so that the user has a satisfying experience even on computers with limited memory, storage and performance. Data for 3-D models are compressed to reduce memory and storage requirements. The 3-D display is optimized dynamically at run time, based on the software's own measurements of the hardware's performance. This optimization allows the software to scale to a wide range of hardware. For example, when the user moves a 3-D model on screen on a slow computer, the model is replaced with an optimized, less detailed version that can be quickly animated. As soon as the user stops moving the model, the original, full-detailed version is displayed. On faster computers, the full-detailed model is always shown.

EventScope requires no special visualization or interface hardware. Computers running EventScope use standard mice as pointing devices, although more specialized devices could be integrated if necessary.

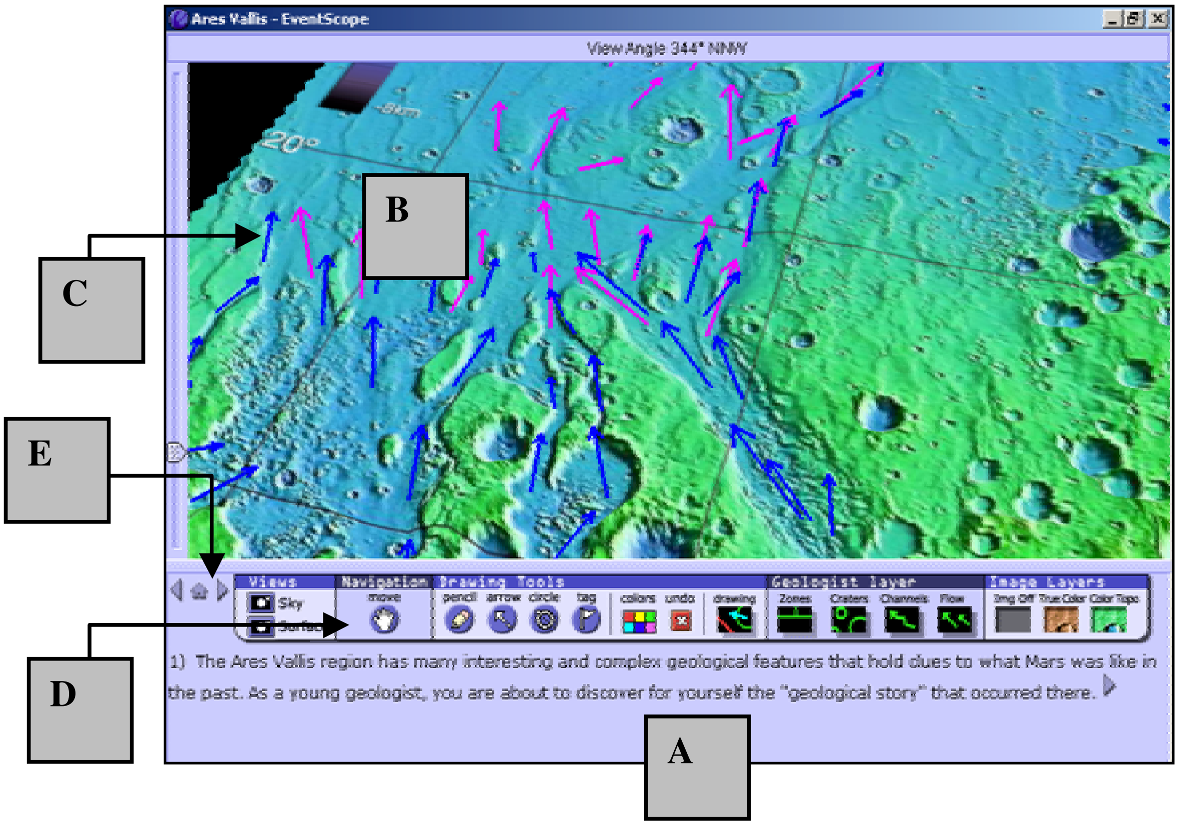

Figure 1. The EventScope interface

In classic scenarios in which one user controls one robot at one time, there is a personal feeling of exploration because every view from the robot is based on subjective input. However, in telerobotics scenarios involving more than one user, such as Mars Pathfinder [19], the experience involves many passive participants. Other techniques require participants to wait in a queue to control a rover [16], or even to vote [8] for control. These scenarios are less than optimal for public planetary exploration, because answering individual scientific questions requires the ability to interact with the mission on a first-person level—for instance, a geologist can glean important data by remotely exploring the contours of a particular rock formation.

EventScope imparts a sense of being in direct control of a spacecraft or robot by integrating many types of information into a rich virtual environment. By doing this, EventScope enables the user to navigate the archive from a spatial point of view and to hyperlink from one virtual model to another.

This capability is a prime strength of the EventScope interface. In the case of Mars exploration, Viking Orbiter images relay a view of the entire planet, the Mars Global Surveyor MOC images [10] provide high-resolution images of specific areas and data from Viking Landers and Mars Pathfinder [19] allow for human-scale, first-person exploration. On the surface it is important to go from first-person rover views to spectral or high-resolution close-ups of samples. By using "flags" as spatial hyperlinks to zoom from one scale of resolution to the next, newcomers and non-mission specialists may see where a mission fits within a larger body of knowledge.

EventScope uses a global view to familiarize students with the entire planet. Hyperlinks on the surface then connect users with higher resolutions views of the surface. Hyperlinks on these models connect users with a first person perspective, such as the views from Mars Pathfinder or Viking missions.

5. A Framework for Educational Telepresence

Educational telepresence enhances raw data from a remote site by incorporating curriculum, communication and discussion. EventScope adds immense value by providing tools that allow people to archive experiences of a remote site in a local representation, thereby enabling individual exploration and research that enriches and is enriched by a collective construction of knowledge.

EventScope's design aligns with two socio-cognitive principles:

1. Knowledge is acquired during both inter- (individual) and intra-mental processes (between individuals) [20].

2. The advancement and improvement of scientific knowledge is through the collective construction of a community rather than the isolated pursuit of individuals [15].

The current EventScope interface facilitates education by allowing users to draw / mark on representations of remote sites with arrows, markers, and areas to present Web curriculum, as demonstrated in Figure 1. In this way, non-specialists such as students, as well as educators and scientists outside the primary discipline of the remote experience view the remote site through the lens of their respective experiences. Students, in turn, draw their own scientific conclusions, ask questions, post reports, or directly query the scientists. Ultimately, non-specialists and specialists can access each other's comments.

The challenges for educational telepresence arise from the creation of an electronic community and the construction of scientific knowledge. These challenges are:

- To utilize electronic communication to bring together a diverse population and to form work groups free of geographical limitations.

- To creatively use the appropriate communication method and information-sharing strategy to avoid the pitfalls of unproductive group dynamics [13, 22].

- To enhance group performance in terms of speed, creativity, innovation and depth of processing [13].

By virtue of its structure, EventScope builds a mosaic of diverse groups in several ways. First, it caters to a diverse demographic by being readily accessible to both well-served and under-served school populations. Secondly, it is suitable for a wide range of student abilities, from low to high achievers. And finally, people with diverse interests and expertise (students, educators, scientists or the general public) can use EventScope to experience a remote environment.

6. Status of EventScope

Since 1999, the EventScope interface and software have undergone two iterations of pilot testing. The first iteration, conducted in fall 2000, was in three schools that represented a cross-section of urban and suburban environments. The second pilot test in spring 2000 took place in nine schools located in urban, suburban and rural settings.

Now in its final year, the current EventScope program is focused on specific needs that surfaced during formative evaluation: to make the interface more responsive, with multiple kinds of information feedback; and to rely less on traditional (paper-based) curricula by providing more information within the interface. Technical and curriculum developments will be evaluated when EventScope is deployed into 36 schools in and near Pennsylvania.

7. Areas for Future Work

The EventScope team has identified the following areas as critical to realizing the full potential of educational telepresence:

- **Remote Collaboration**. A structure is needed for peer-to-peer interaction so that students and teachers may easily collaborate over distance.

- **Automated Updating**. An infrastructure is needed to automate the updating process of the virtual environment using incoming data from a mission. This will require a specialized technology back-end, as well as political action in order to gain access to information in a timely fashion.

- **Close the Loop**. Systems are needed that facilitate the flow of public feedback during a mission. Such systems would need to organize a group of requests into robotic search patterns [6]. Taking a different tact, Tele-Actor allows participants to observe and "vote" on the goals of a human moving through and interacting with a virtual environment [9].

- **Authoring Tool**. A structure is needed that allows more educators to author additional remote experiences. See related work at www.plartformdigital.com.

8. Summary

EventScope creates a collaborative framework that allows specialists, educators and students to add and archive their own experiences of a remote geographical site for science education and discourse.

Built into this framework are techniques for creating a personal feeling of exploration while providing access to society at large. Techniques for ubiquitous access focus these capabilities into standard classroom computing scenarios in which mouse and keyboard interaction and constrained processor speeds are the norm.

Current work is in the form of online educational curricula presented through a virtual reality interface. This work extensively addresses issues inherent in development of educational Remote Experience.

Future work in the arena of a telescience interface for Internet-based education will explore group interaction dynamics by facilitating peer-to-peer collaboration; furthering automated updating of virtual environments by using incoming data; closing the loop with robotic missions by using feedback from users; and developing authoring tools so that educators may create a diverse telepresence curricula.

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