MERBoard Satellites: Tools to Augment Knowledge Sharing and Access

ABSTRACT

This paper outlines the conceptual design and prototype of knowledge capture devices that augment the large public display platforms of science teams working on the Mars Exploration Rover (MER) mission. The MERBoard Satellites allow NASA scientists to create richer knowledge artifacts by taking pictures and recording voice annotations during science team meetings. The digital image and sound files are automatically collected, processed, organized and made accessible on the shared display so that scientists can focus on time-critical decision making. A context-specific interface was created to allow scientists to easily re-access captured data for immediate, near-term and long-term reuse. We describe and evaluate the user-centric design of the Satellites, and the associated browser, Telescope.

Author Keywords

Design, MER, collaboration, knowledge sharing

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

The MERBoard Satellites improve the large public display platform used by teams of NASA scientists by providing simple instruments to enrich the data record from mission meetings. The Satellites also enable the sharing of visual and audible artifacts to remote participants. Although the conceptual design and working prototype of these knowledge capture devices were developed specifically for the needs of mission scientists, these tools may improve any meetings where the knowledge artifacts are ephemeral or distributed among many meeting participants.

BACKGROUND

The Mars Exploration Rover (MER) Project uses two Rovers equipped with imaging and sensor instruments to provide information about the mysterious red planet. This data is sent back to Earth once each sol (Martian day). Teams of scientists then analyze this downlinked data, discuss implications and form theories to determine what avenues for exploration would prove to be most fruitful for the next day. These decisions are converted into specific instructions by engineers who then build, validate and uplink the next day's plans to the Rovers.

The critical timing between the data downlink and the programming sequencing uplink make the MER science team meetings high-stakes affairs. Delays could cost a whole day's explorations, while hasty analysis could circumvent opportunities to make key discoveries. The historic nature of the project elevates the need for clear records of decisions and processes. [9] The MER science team meetings are therefore an opportune test bed for enhancements to the team-meeting environment.

These needs fueled NASA's Human-Centered Computing Group's development of the MERBoard [8]. The NASA MERBoard consists of a large-screen interface to a series of mission-specific tools to help scientists map out data readings, schedule Rover actions, and track each sol's activities. Screen captures of these environments may be mailed to individual team members or placed in the whiteboard space for annotation or editing by the science team. [10]

ETHNOGRAPHY

To understand the needs and context of the mission scientists, attended milestone mission review meetings at JPL, viewed numerous videotapes of field tests of the MER mission and interviewed mission scientists to refine our observations and ideas. Of these, the field test tapes, which show simulated science team meetings where a toy rover is piloted about a sandbox, gave us the clearest indications of what the science operation working group meetings might be like in terms of number of people, organization of teams, physical layout of space, available tools, and operational procedure.

Among other things, we observed that:

1) Despite the plethora of computing and display resources in the meeting room, there was paper everywhere. Scientists were taking notes on notepads, large sheets of paper were used for flipchart drawings, and stacks of large color plots of the Mars surface blanketed many flat surfaces. Though these artifacts seemed to be very useful for the science members in the thick of their meeting, the wide and disparate array of paper information would likely be a challenge for future scientists to collect, unravel and decipher.

2) Many scientists used their own laptops during the course of the science team meetings. They mostly used the laptops for notetaking, but would occasionally pass the laptops around to show something. This sharing method will not scale well to a distributed setting, and makes unifying the mission data record harder.

3) Teams would commonly interact with other teams by leaning over the back of their chairs and speaking to them. Such inter-group communication will be hard to replicate on the actual MER mission when the science teams are situated in different rooms and different floors, or in the future MER mission in 2008 when the science teams will be distributed across the country or perhaps even the world.

In addition, scientists communicated in interviews that there was not enough time during the frenzy of the meetings to organize and record things, or even to figure out how to use new tools that might automate that process. We were repeatedly told that tools needed to be "effortless, transparent and seamless."

DESIGN

Scientists have an existing work practice that revolves around physical display, personal ownership and local sharing of information, which serves their immediate goals but gives short shrift to longer-term goals for distributed collaboration and unified data collection. Our system design focuses on bridging the gap between the physical and digital information environments by providing each team of scientists two media capture devices to use in conjunction with their public display platform: a digital camera and a digital microphone. These devices are battery operated, and convey information wirelessly to a group server, which then presents the captured data for immediate discussion or manipulation on the MERBoard itself.

MERBoard Satellites

The MERBoard Satellites are used for active capture, and explicitly encourage users to record messages or to photograph key documents. This explicit capture [5] also allows users to make immediate use of captured data; you can snap a sketched plan and, seconds later, show it to the group and mark it up on the digital whiteboard.

Our research indicated that the Satellite system needs to be grounded in device metaphors that the scientists are already familiar with, and that the moving, processing and storing of data need to occur invisibly. These goals led us to opt to integrate existing devices that the scientists should be familiar with. To capture images, sketches, charts, and physical artifacts, we employ a Ricoh i700 digital camera [7] augmented with a compact flash wireless networking card. To capture audio annotations, we use a Compaq iPaq H3600 [3] augmented with a wireless Ethernet card.

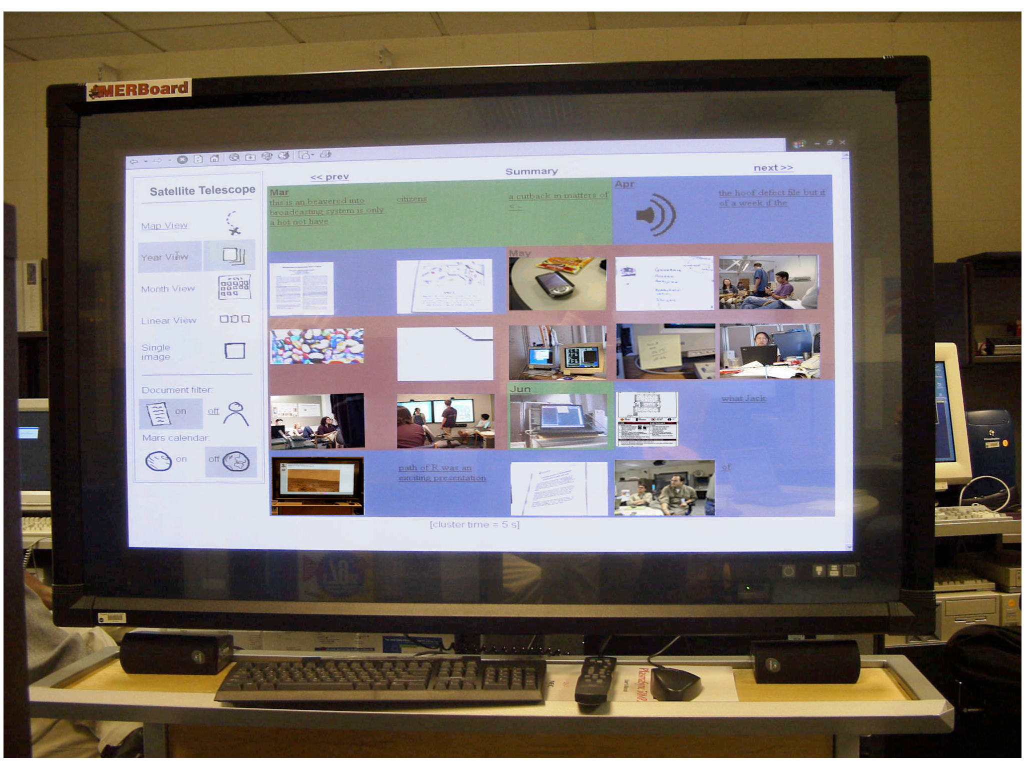

Figure 1. Telescope on the MERBoard, showing data captured with Satellites

Both devices are configured automatically to upload automatically wirelessly a dedicated local server. The files are processed to enhance their general utility: Audio files are converted to text using speech-to-text software to enable visual scan and search of captured data. Image files are document-filtered to produce clean images of drawn sketches or text documents. The processed images are subsequently run through OCR to distinguish written documents from pictures of objects or people.

Telescope

The capture of large amounts of data is only useful if it is easy to find relevant information afterwards. The fact that the data pool is jointly-owned presented special challenges, since the organizational whims of individual scientists may not suit the whole team. For this reason, we developed a specialized interface to navigate the data from the Satellite system, named Telescope.

Telescope features different "views" into the data pool, so that users can utilize spatial, temporal and associative mnemonic cues, as well as search, to retrieve relevant information. Telescope is a html-based interface, which made use of the MERBoard's web browser to allow scientists to navigate collected sound clips and images by reference. A navigation tool bar allows scientists to switch between the following views:

The Map View allows users to view all the files associated with the physical location on Mars. The goal was to allow scientists to access data from meetings based on the Mars Rover's temporal and spatial contexts. This view was not fully functional in our working prototype, as it relies on images of the Martian surface that we did not have access to. However, this view could be critical for mission scientist to differentiate fairly homogenous images.

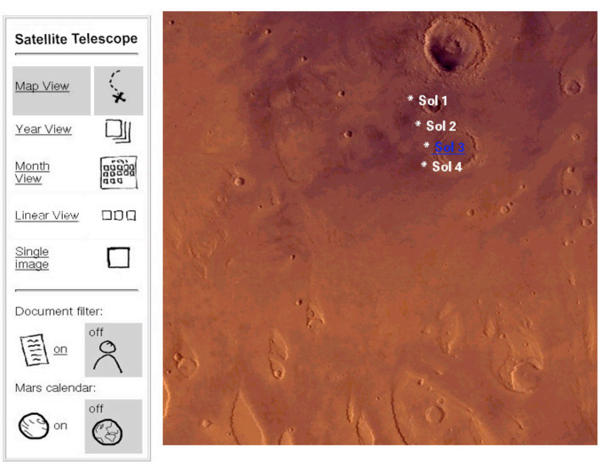

Figure 2: Satellite Telescope with Map View

Year View and *Month View* are both time-clustered views of captured Satellite data. Time-clustering is based on the observation that images tend to be generated in clumps; clusters of images are hence grouped and represented by an iconic image to allow the quick perusal of images [4]. allowing scanning of data clusters with different levels of granularity. The sounds are represented by "textbits" that contain truncated speech-to-text translations of the audio file to enable data scanning of these multi-modal files. These images or text tidbits help the users locate the relevant set of images.

Linear View and *Single Image View* represent the traditional timeline metaphor. Linear view shows thumbnails or textbits for all the files in the data pool, while Single Image View shows a single large image flanked by thumbnails of adjacent images.

Beneath the view navigation buttons are toggle switches for various modes:

Document Filter on/off The document filter toggle changes the thumbnails or images in view to filtered or unfiltered versions of each file. The document filter is meant to make images of documents more legible.

Mars Calendar on/off One interesting feature of the MER project is that the scientist operate on Mars sols, which are 24.66 hours; over the course of the MER mission, the earth days and Mars days become unaligned. We offer the option of categorizing meetings by Mars days and Earth days because people might associate relevant data to events in either time frame.

DISCUSSION

Ideally, we would have liked to test the Satellite system in the environment it was designed for: the Mars Exploration Rover Mission. Unfortunately, the same high-stakes conditions that drew us to the MER project also made it a poor place for an empirical test of prototype technology. Instead, we piloted the Satellite system in several research group meetings, and solicited feedback from the MERBoard design team.

Satellite feedback

The automatic uploading of digital photos was universally well-received. Everyone appreciated the near-instantaneous access to captured data; moreover, many people mentioned how much they enjoyed just watching snapped images "magically" appear on the MERBoard. The document-processing generated a similar giddy response. However, while most people liked wirelessness of the camera and microphone, the MERBoard team expressed concern that people might inadvertently walk off with them, or misplace them. Such concerns might be alleviated by a system with a fixed camera or microphone such as Xerox PARC's ZombieBoard [1], wherein users can place paper drawings documents or charts in the field of view of a whiteboard camera to scan them in.

The audio capture device garnered more skepticism; many people were unsure about the utility of voice annotations. We felt that voice annotations would be made more attractive by the speech-to-text processing; even with several mistakes, it was easy for meeting participants to distinguish the gist of each clip. Nonetheless, we found that people did not trust the recognition to work, and hence were less enamored of recording audio clips than of taking pictures.

People suggested other input devices that could be added to the system, for example, digital video cameras or scanners. While the existing camera could clearly fulfill these functions, these comments suggested that users were more interested in having multiple dedicated devices than having one or two all-purpose devices. The architecture underlying the Satellite system allows additional devices to be integrated so long as they are network-enabled.

Many people asked us about attaching a person's name to the Satellite audio clips and pictures, to indicate authorship or ownership. The MERBoard team was interested in using some form of "badging in" like that used in the IBM Blueboard system [8] or Georgia Tech's DUMMBO [2], and suggested that data could be annotated with meta about who is near the board at the time of artifact generation. Garnering the specific ID of author "seamlessly" would probably require voice identification or biometric sensors to be integrated into the Satellites.

Part of interest in identification stems from an attachment to a personal ownership model for the data, wherein data always belongs to someone. [9] The MERBoard team indicated that scientists like having data on their laptop, and being able to organize data on their own. We feel there is some room for the interleaving of the shared and personal data management models, and would like to experiment with using something like Sony's Pick-and-Drop system [6], to allow people to easily copy objects from the shared space to their individual laptops.

Telescope feedback

Everyone we showed the Telescope interface to liked the concept of multiple views into the information. We received many suggestions of other types of filtering that could be done to help people find things—sorts by data type, by author, etc.—based on how they remember things. People were really interested in the Mars-specific views, the Map view and the Mars calendar view, even though it was hard to evaluate how useful those would be in a non-mission environment.

The data clustering proved to be hard for people to comprehend, even when we iterated graphical elements to indicate that there were "stacks" of images behind the iconic image. We found that the clustering makes mores sense to people when there is a large body of data being navigated, and that the most recently captured objects should not be clustered at all, since their relevance is augmented by their recentness.

FUTURE WORK

The next step for the MERBoard Satellites is experimentation to determine which views prove to be the most useful for data navigation and ease of retrieval.

However, the critical component to the success of the Satellite system is adoption; if people do not actively capture data, the possibility of future access is precluded. For this reason, we feel that real-world deployment of the Satellite tools might tell us more about their usefulness than experimentation would. While the Satellite system was designed with the needs and practices of mission scientists in mind, many aspects of the system could be tested in any collaborative work setting.

Finally, we think that augmenting user-captured data with implicitly captured data [5] may help to motivate the use and adoption of the Satellite system and its browser.

ACKNOWLEDGMENTS

[removed for purposes of anonymity.]

REFERENCES

1. Black, M., Bérard, F., Jepson, A., Newman, W., Saund, E., Socher, G. and Taylor, M. The Digital Office: Overview. In *Proc. AAAI 1998 Spring Symposium on Intelligent Environments*. March 1998, 1-6.
2. Brotherton, J., Abowd, G., Truong, K. Supporting Capture and Access Interfaces for Informal and Opportunistic Meetings. *Georgia Institute of Technology Tech. Report GIT-GVU-99-06*, Dec. 1998.
3. Graham, A., Garcia-Molina, H., Paepcke, A., Winograd, T. Time as Essence for Photo Browsing Through Personal Digital Libraries. In *Proc. JCDL 2002,* ACM Press (2002), 326-335.
4. Hewlett-Packard. *Compaq iPaq H3600 PDA.* http://www.compaq.com
5. Ju, W., Ionescu, A., Neeley, W., Winograd, T. Where the Wild Things Work: Capturing Shared Physical Design Workspaces. In *Proc. CSCW 2004.* ACM Press (2004), 217-225.
6. Rekimoto, J. A Multiple Device Approach for Supporting Whiteboard-based Interactions. *Proc. CHI 1998*, ACM Press (1998), 344-351.
7. Ricoh Corporation. *RDC-i700 Digital Camera.* http://www.ricohzone.com/Product_RCDi700.html
8. Russell, D.M., Trimble, J., Wales, R. Two paths from the same place: Task driven and human-centered evolution of a group information surface. *Make IT Easy Conference*, San Jose, CA, USA. June 2002.
9. Tollinger, I., McCurdy, M., Vera, A. H., Tollinger, P. Collaborative Knowledge Management Supporting Mars Mission Scientists. In *Proc. CSCW 2004.*ACM Press (2004), 29-38.