Challenges for Mobile Internet Appliances

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Abstract
We are conducting an on-going study designed to document the reality of movement and interaction of a Web-enabled mobile teleoperated device in a dynamic, unstructured indoor environment. Our goal is to document anomalies in the form of extensive recreation and annotated video. We have undertaken this task in order to develop strategies, tools and techniques for dealing with mobility issues likely to be encountered by actual teleoperated devices in their role as Internet Appliances (IAs). In this paper we outline our experimental design and describe some of the difficulties we have encountered.

Introduction
As the World Wide Web (WWW) has matured, attention has increasingly been drawn to its applicability as a medium supporting the so-called Internet Appliance (IA). Various academic [*0 find something at MIT from Wired magazine] and industrial [*1 JINI from Javasoft or Sun] organizations have announced various schemes to allow devices as diverse as washing machines [*2 Maytag], Air Conditioners [*3 Monitored for large buildings over the web…find reference] and others to communicate over the Internet. These devices share a major advantage in that, while creating appropriate network protocols and interfaces is difficult, they are immobile.

There is no shortage of Mobile, or partially mobile devices on the Internet. Teleoperation has taken many forms on the web, including Telepresence applications, such as [1], stationary control applications like [2] and [3], and innovative approaches to sharing limited resources such as the teleoperated telescope on the web [4]. N-CART has developed and deployed its own Tele-robot[5 note 6 is gone] that addresses some of the communication issues associated with the inherent unreliability of the communication link. MAX provides an intuitive user interface and streamed video to any Java-enabled web browser connected to the Internet. Unfortunately, there are many issues to be overcome before teleoperation over the WWW can become as innocuous as making a telephone call or using an automatic banking machine. We concentrate on issues related to the pragmatic details of moving around an unstructured environment, while perceiving it through a low-bandwidth, highly unreliable network.

The Study

We have devised two sets of experiments designed to collect sufficient data to allow us to develop strategies for dealing with the difficulties any mobile Tele-robot is likely to encounter in a similar indoor environment. We concentrated several scenarios as outlined below.

1. Locating and refueling using available power outlets.,
2. Finding and negotiating handicapped accessible facilities,
3. Dealing with elevator access, operation and egress, and
4. Autonomous operation in the event of communication loss.

Ryerson's campus was selected as an unstructured environment that would be traversed by our robot. Our initial experiments involved the creation of a capable tele-robot simulated by two research assistants (RAs) as shown in the figures below.

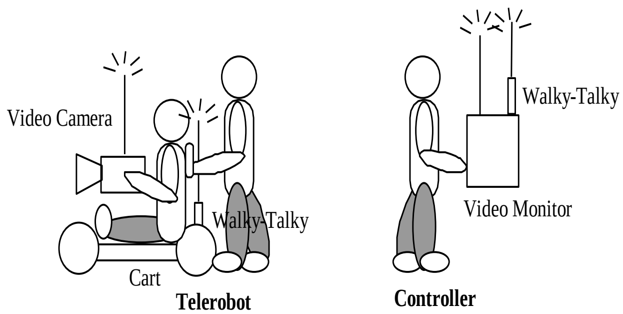

Figure 1 Conceptual Experimental Design


Figure 2 Actual Experimental Setup

One RA was responsible for providing the cart's mobility while the other RA controlled the camera. Our goal was to create the reality of a Tele-robot while providing the benefits of human observation. Another RA acted as the controller, equipped with a walky-talky, video receiver, and monitor. The cart's crew was instructed to respond only to a fixed set of commands issued by the controller. After each experiment the RAs were extensively debriefed to determine what they observed.

Experimental Design Set #1
[Explain what you did for set 1]

We recorded numerous anomalous situations that a similar device would also encounter, [explain what you mean by each point, possibly with a brief example]

- Degraded video due to environmental interference.
- Camera unable to view area of difficulty.
- Blind backward motion causes collisions.
- Ineffective camera zoom
- Obstructions stop vehicle motion and disorients user
- Gaining access and egress to and from passages problematic
- Tight corners very difficult
- Vehicles jostled by humans causing user disorientation
- Camera view obstructed
- Total loss of data communications
- Unseen obstructions (see figure 3)
- Inadvertent immobilization by obstruction or corner
- Turning into objects out of view

Figure 3 Example of undetected obstruction

Experimental Design Set #2

[Explain how this was different from 1 by contrasting it with 1]

Using the same building as in Set #1 we selected a room that acted as the unstructured remote environment. Two RAs were pressed into service to control and monitor a Pioneer II Robot (see figure 4). One RA was responsible for watching the robot and taking notes of events while the other RA equipped with a laptop, video receiver, and monitor (see figure 4) controlled the robot. After each experiment the RAs was extensively debriefed to determine what they observed.

Figure 4 Pioneer II Robot

Figure 5 Experimental Setup

Our team conducted a total of four scenarios and recorded the following issues:
[What were the scenarios and illustrate the points below as you will do for the list above]

- Fuzzy video communications
- Complete loss of video communications
- Blind backwards motion
- Managing tight corners very difficult
- Camera view obstructed
- Turning wrong directions
- Complete loss of data communications
- Turning into objects out of view
- Turning robot too far to left or right
- Getting caught on objects
- Immobilized by obstructions (see figure 6)
- Unseen obstructions (see figure 6)

Figure 6 Immobilized by unseen obstruction

Comparison

The following chart is a comparison study done on the two sets of experiments listed above.

Problem Description	**Experiment Set#1**	**Experiment Set#2**
Fuzzy video communications	ŏ	ŏ
Loss of video communications	ŏ	ŏ
Height of camera too high	ŏ	
Blind backwards motion	ŏ	ŏ
Zoom of camera	ŏ	
Robot stops when hitting objects	ŏ	
Opening doors very tricky	ŏ	
Managing tight corners very difficult	ŏ	ŏ
People push robot out of way	ŏ	
Camera view obstructed	ŏ	ŏ
Turning wrong directions	ŏ	ŏ

Loss of data communications	ŏ	ŏ
Getting caught in corners	ŏ	
Turning into objects out of view	ŏ	ŏ
Immobilized by obstructions	ŏ	ŏ
Unseen Obstructions	ŏ	ŏ
Turning robot too far left or right		ŏ
Getting caught on objects		ŏ
Robot turns when hitting objects		ŏ

[if you show a list like this you must explain why…is it because you are validating your findings from #1?)

Conclusion

Our findings will be used to drive the investigation and development of various potential solutions to the these and other problems uncovered in the study. Promising areas of investigation include the use of constrained image understanding to locate and position handicapped access buttons for activation, semi-autonomous behaviours used to aid the controller in avoiding collisions, and improved sensor and interface fusion in order to provide additional information to the controller. For more details of this study see [7]

References

[1] Ontario Telepresence Project at
http://www.dgp.toronto.edu/tp/tphp.html

[2] Australian teleoperated arm on the web located at
http://telerobot.mech.uwa.edu.au/

[3] Teleoperated garden on the web located at
http://telegarden.aec.at/html/spie.html

[4] Teleoperated telescope on the web located at
http://www.eia.brad.ac.uk/rti/index.html

[5] A. Ferworn, K. Plataniotis, "Effective Teleoperation Over the World Wide Web", Proc. of the IASTED International Conference for Robotics and Applications (RA'99), Santa Barbara, USA, October 28-30, 1999.

[7] *http://www.myna.com/~elliott/thesis*