MAX: Teleoperated Dog on the Web

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Summary of Main Contributions

- New control metaphor based on a dog's leash
- Examination of "Adequate" feedback vs. "Optimal" feedback
- Wireless teleoperated control over the web
- Streamed video allowing real-time control of device

INTRODUCTION

The N-CART team has developed and deployed a wireless microcontroller-based robot allowing teleoperated control via a web browser communicating over an IP network. The robot--MAX streams video images continuously via analog radio link from an on-board camera to a web server. Anyone having made a connection via a Java-enabled Netscape web browser can control Max.

THE DOG LEASH AS A METAPHOR FOR CONTROL

The traditional model for teleoperated control is shown in the figure below.

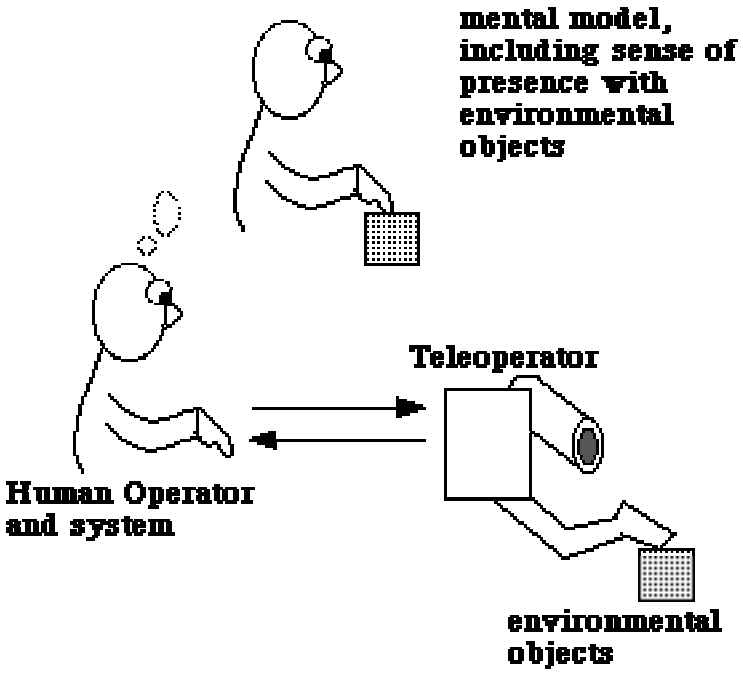

Figure 1 Classic Teleoperation

There are many applications for a tight control loop. This is generally desirable where the outcome of a particular action must be assured. Telesurgery, for example, is one such application where momentary loss of control could result in disastrous consequences.

There is however another class of application where tight control is not the critical measure of success and might even be undesirable. For example, remote security cameras in locals like bus terminals or train stations typically provide very noisy images and allow only intermittent control (if any), yet still provide sufficient information for a human operator to feel confident in their function and make use of their information.

The Dog Project

N-CART wished to explore this other class of application. The Dog project was initiated in 1997. The goal of the project was to put a robot on the web. It quickly became apparent that by the nature of the WWW and TCP/IP it would be very difficult to achieve the level of control and feedback necessary to achieve the classic teleoperation model. Given this fact we began musing about why it was necessary to have this level of control at all.

We selected a dog's leash as a metaphor for loose control of a remote device much in the same way that one maintains loose control of a dog while it is being walked. The dog is controlled through tugs on its leash yet the dog is free to do what it wishes within the restrictions imposed by its tether. Controlled by a leash dogs are used as aids for the blind, as a means for detecting illicit narcotics and a myriad of other applications--short of surgery.

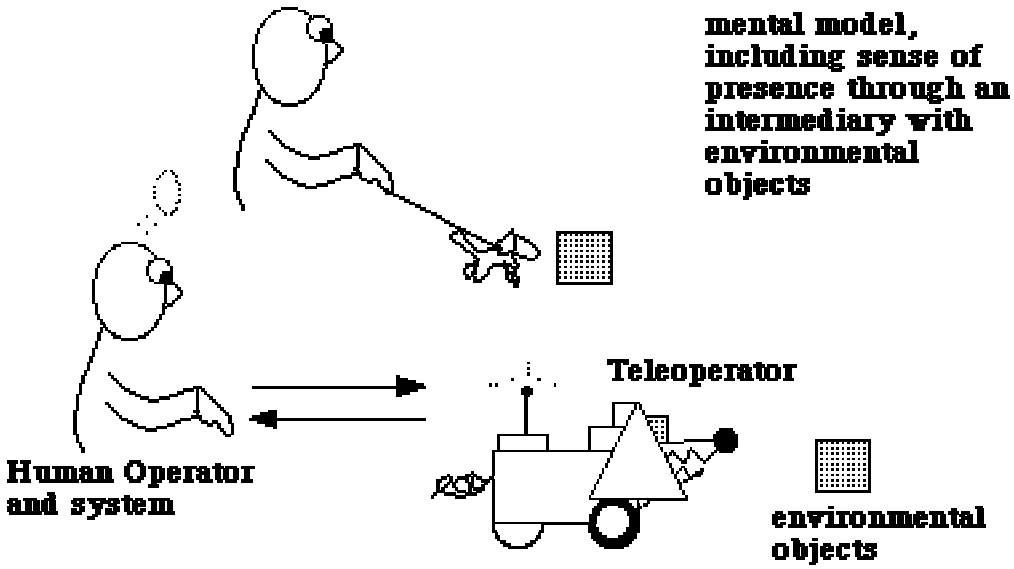

Figure 2 The dog leash metaphor

We adopted this metaphor because of the way a communication media such as the WWW work. Our device would be controlled through a somewhat noisy analog signal which would eventually be sent over the inherently unreliable WWW. Spurious commands would occasionally be received by the device making it behave in unintended ways. Occasional network delay or even randomly generated "noise" could abruptly change a command or otherwise change the movements of the dog as if it had a will of its own. The dog leash metaphor allowed us to safely ignore these spurious signals and actions--because we fully expected them.

THE TECHNOLOGY OF MAX

Max was purposely fabricated from inexpensive and readily available components. Max's aluminium body employs twin differential drive wheels for steering and propulsion. Control is provided by an on-board micro-controller.

Max is equipped with a fixed B/W CCD camera. The analog video stream is transmitted via a bidirectional radio transceiver which also provides a back channel for control signals. Essentially the dog broadcasts on channel 52. The video signal is received by another transceiver and fed into the cable TV port of a VCR which provides video-out to a video capture board located on a server. The transceivers have a range of several meters thus allowing control away from fixed network components. This configuration is shown in the figure below.

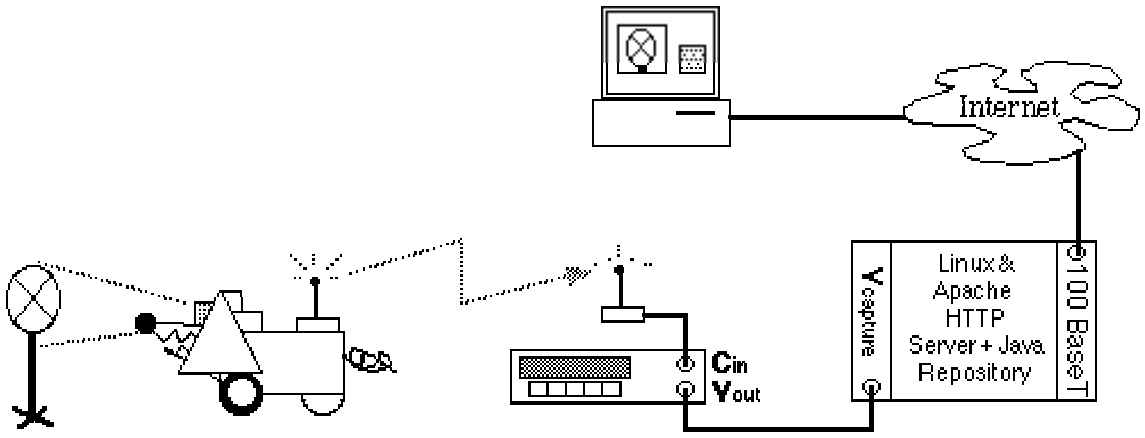

Figure 3 Schematic of Max's configuration

The server hardware is a Pentium-based PC running the Linux operating system and an Apache hypertext transport protocol (http) server. The server is connected to the internet via a 100 Megabit twisted pair Ethernet card. The streaming video software is provided through a custom Java application. Visitors to Max's home page are presented with a configurable "dog's eye view" of the environment and a Java applet providing both gross and fine controls for Max. Multiple users are accommodated through circular Queuing--allowing each user one minute of active control but unlimited passive viewing.

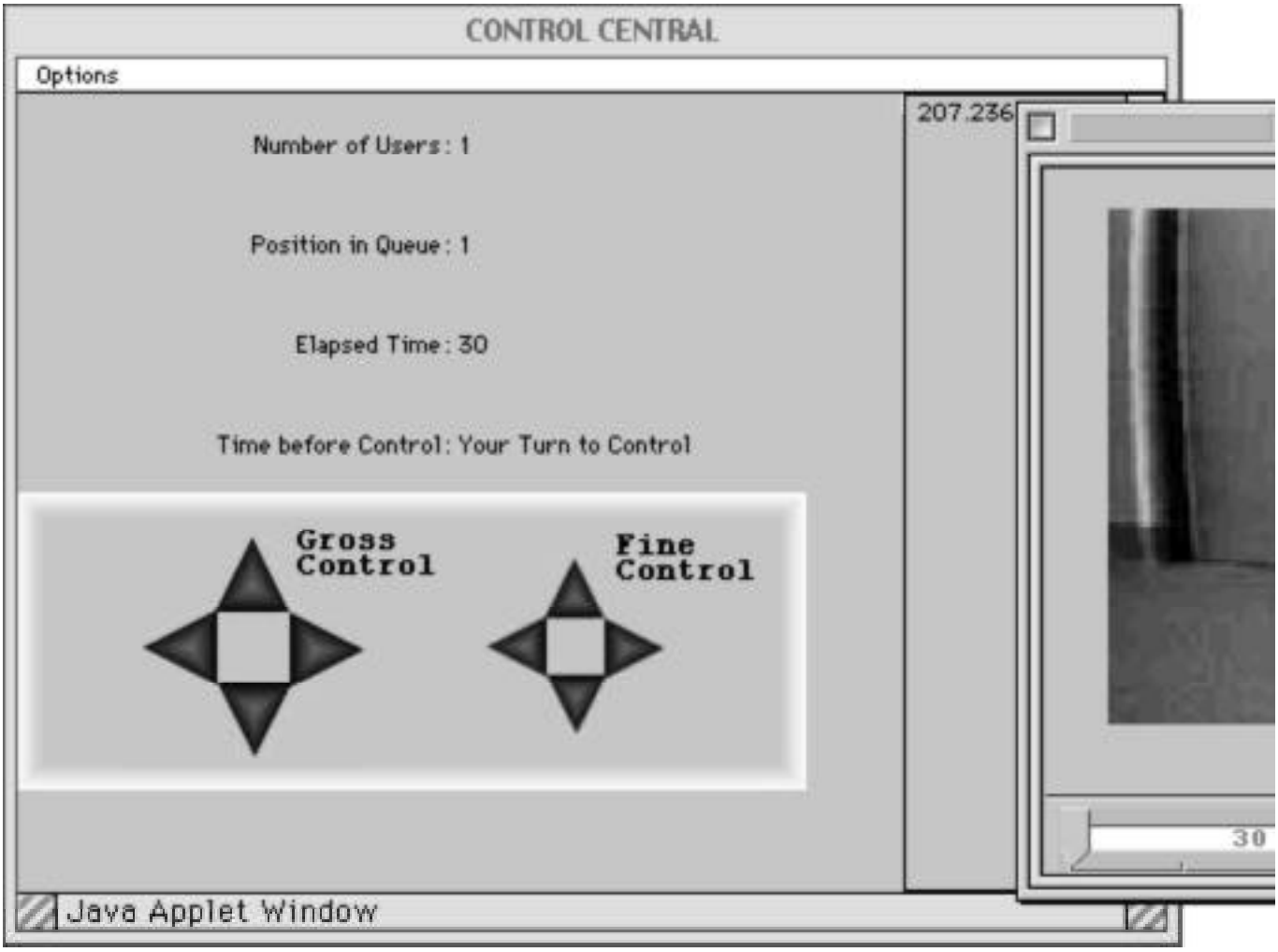

Figure 4 Max's control interface (left) and video image at 14.4 KBPS

EARLY RESULTS

Max was first publicly demonstrated at the Ryerson Polytechnic University Open House on October 24, 1998 and can be found under the projects link at http://max.scs.ryerson.ca. Max was found to function adequately over extended periods of time and can be very easily controlled using the simple interface provided. Max has been "walked" from as far away as several hundred kilometres with a transmission rate as low as 14.4 KBPS while still providing a usable video interface.

Figure 5 Max as a stylized dog

Our initial target audience consisted of young children. We believed that they would be more accepting of the role playing necessary in order to justify the quirky nature of Max. To facilitate this understanding we dressed Max to appear as a stylized dog and built an enclosed arena which allowed an operator to see Max before they attempted to control him. The enclosure was built around a public bench so that Max could interact in a limited way with people who were not involved with Max but just happen to be there. Dozens of children were attracted throughout the day. Inevitably each child caught on to the metaphor and within minutes was skilfully urging Max around the enclosure. To date, children as young as three years old have successfully taken Max for a walk.

CONCLUSION

We have demonstrated a working, mobile wireless robot which can unreliably be controlled over vast distances providing sufficient feedback to a remote controller to allow intelligent decision making to take place. By discounting reliable control through our metaphor we have gained a measure of independence from the need for it. If you aren't controlling a device which is pretending to be a human at the remote end you don't expect human reactions. After all, its just a dog!