WAX–Next Generation Robot On The Web

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Alexander Ferworn
aferworn@scs.ryerson.ca

Wei Lu
wlu@ncart.scs.ryerson.ca

Network-Centric Applied Research Team
School of Computer Science
Ryerson University
350 Victoria St, Toronto, ON, M5B 2K3
Canada

(James) Elliott Coleshill
coleshill@look.ca

Wing Shiu
Wshiu@ncart.scs.ryerson.ca

Network-Centric Applied Research Team (N-CART)
Computing and Information Science
University of Guelph
Guelph, Ontario, N1G 2W1
Canada

Abstract

The Network-Centric Applied Research Team (N-CART) at Ryerson University has developed an improved WWW-based, wireless robot for telepresence applications. The mobile robot WAX [1] allows teleoperated control over the Internet using a standard web browser. WAX streams continuous video and audio through a wireless link from an on-board camera and microphone to video and audio servers associated with a generic web server. The system allows anyone with a connection to the Internet and a Java-Enabled web browser to control WAX. Employing WAX as a model to facilitate research in telepresence and teleoperation over the WWW, NCART has created on-line and printable manuals explaining how such a low-cost system can be recreated with limited resources and expertise.

Key Words

Internet Applications, Tele-Operation, Robotics

Introduction

In 1997 the N-CART lab at Ryerson University developed and deployed a wireless microcontroller-based robot on the Internet [2][3]. The robot MAX [4] can be controlled through any Java-Enabled Web browser communicating over an IP network. MAX streams video images continuously through an analog radio link from an on-board camera to a video server associated with an Apache web server.

The N-CART team has recently designed and developed an improved tele-operated robot WAX based on lessons learned from previous projects [5]. WAX is based on the original MAX design but has been improved in the following ways:

1. Better fine movement control
2. More efficient server-side resource utilization
3. Off-the-shelf component construction
4. Improved video quality
5. Audio, and
6. Improved security

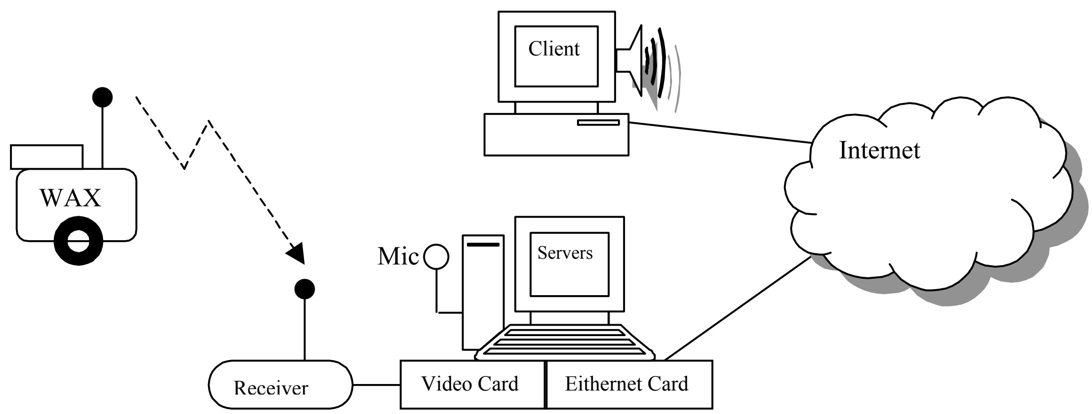
WAX, The Robot

WAX is fabricated from inexpensive and readily available components. Its chassis is machined from a solid piece of Medium Density Fiber (MDF) Board. Attached to the chassis are two commonly available gear-head motors to provide basic differential steering. An on-board MC68HC11 acts as a controller by interpreting received commands from the web server into motor control signals. Below is an early prototype of WAX.

Early Prototype of WAX

WAX is equipped with a standard off-the-shelf webcam which is used to provide video images to the client through the video server. The video stream is sent by a 2.4GHz transmitter from the robot to a receiver at the web server where JPEG images are streamed to a client Java applet.

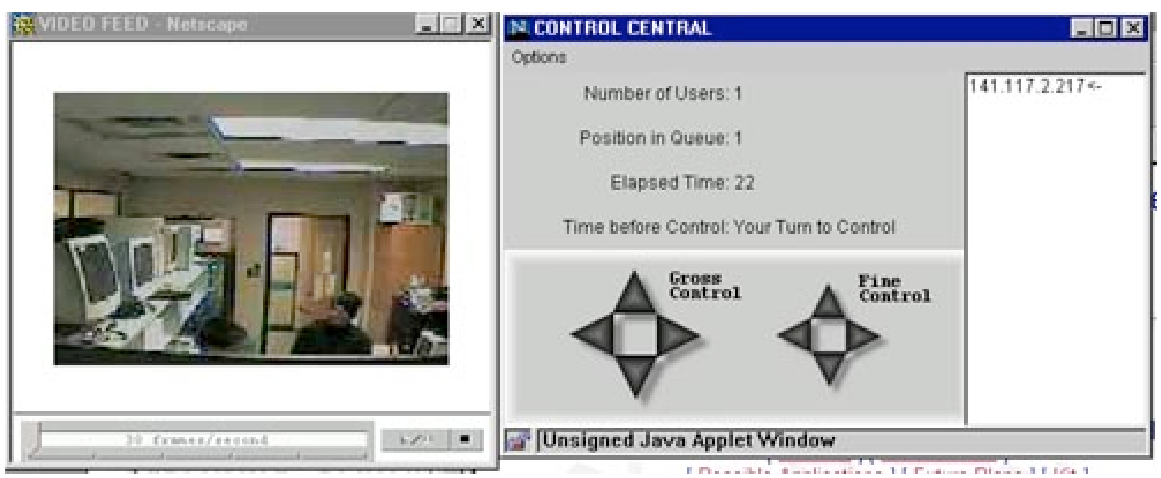
The diagram below illustrates the configuration of the WAX system.



Schematic of WAX's Configuration

Robot Controls

The server hardware is a Pentium-based PC running the RedHat Linux operating system and an Apache HTTP server. When a user visits WAX's web page they can load a Java Applet providing both gross and fine controls for the robot as well as a video applet allowing a robot-eye-view of the remote environment.



View of WAX's Client Interface

Through a series of software improvements over the original MAX controller, we have been able to achieve much finer control over the robot's movement. In addition, by reconfiguring and improving the drive train it has become possible to power both the drive train and the controller from a single on-board battery pack, significantly reducing the space used by non-payload components.

WAX’s streaming video system has been upgraded to use generic hardware and software. The streaming video server uses a standard off-the-self video capture card which can be configured using commonly available drivers to produce high-quality images.

We have improved upon server security as well. In the original MAX system every new client connection to the web server generated a new port to handle the streaming images. In the case of WAX, using the standard webcam drivers allows us to set up the streaming server to use only a single port. This allows us to more easily monitor the activity on the port and disallow certain activity if necessary.

An audio stream is provided with WAX. Using the same principles as the video server, the WAX web server is constantly writing to an audio file on its local disk. On the client’s machine another Java applet is running, collecting the audio file, and playing it through the local sound system.

With the experience we have gained through the MAX and WAX projects we have developed an effective means for producing extremely cost-effective, video and audio equipped, network-aware mobile robots. We have made these plans available on the web through the NCART web site[6]. We have concentrated on the control, video and audio services that are necessary for effective remote operation on the web.

Future Plans

Our short-term plans include providing certain semi-autonomous behaviours for WAX. We are using a form of constrained image recognition [7][8] in conjunction with a novel heuristic controller to perform tasks that are difficult to perform remotely. In addition we are planning obstacle avoidance behaviours to improve the robots mobility. A pan and tilt control for the on-board camera will increase WAX's field of view and allow for better interaction with humanity. We will also be providing better power consumption indicators to allow remote users to return to docking stations when recharging is necessary.

In the long-term, WAX will have sufficient processing and telecommunications capability to allow it to be connected to a wireless IP network. With this connection WAX will be able to move around the Ryerson campus using the network as a kind of extended backbone to communicate with its remote servers.

WAX will use the access facilities provided for disabled members of the Ryerson community in order to move between buildings. To accomplish this goal WAX will be outfitted with additional components to allow the robot to prod various “handicap access” buttons to open doors automatically.

Conclusion

We have demonstrated an effective wireless teleoperated robot which can be controlled over the Internet while providing sufficient video and audio feedback to a user to effectively interact with a remote location. In addition we have made the documentation available allowing anyone with only limited technical knowledge to implement a similar system. We envision that this may spur various related projects in groups that will now be equipped to experiment with this technology on their own.

References

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