Tele-Direction: A New Framework for Collaborative Telepresence

The Tele-Actors Guild

UC Berkeley and MIT Media Laboratory

teleactor@media.mit.edu

ABSTRACT

We propose a new framework for Internet-based telepresence, in which the participants collaboratively experience and effect events at a remote site.. The system combines a remote agent (the "Tele-Actor") with distributed audience control (the "Tele-Directors"). This framework allows the remote group of Tele-Directors not only to view but to vote on commands and thereby to *participate* in the Tele-Actor's environment. In this technical sketch we describe the Tele-Direction framework and some of the key human interface issues.

Keywords

Telepresence, Teleconferencing, collaborative control, telerobotics, Tele-Actor, Tele-Director.

INTRODUCTION

There has recently been a great deal of interest in real-time conferencing and telepresence. The rise of "reality" TV, featuring unscripted filming of ongoing events and (limited) audience participation, demonstrates that such programming attracts a sizeable audience. The Web, with its myriad web-cams and occasional tele-robots, has awakened interest in active participation in distant lives and events. However, very few current systems support multiple users simultaneously sharing one mobile telepresence resource.

FRAMEWORK

We propose a new framework that combines the components illustrated in Figure 1: the "Tele-Actor" agent receives instructions and moves in the remote environment, capturing video and audio as it moves. On the other end are the users, the remote group of "Tele-Directors" who watch from individual computer screens and collaboratively direct the actions of the Actor through a centralized server.

The Tele-Direction framework is independent of specific implementations. The environment can either be real, as in the examples above, or virtual, as in a game such as *Riven*. The Actor, too, can take a variety of forms. It can be a tele-robot in a real environment or a software program in a virtual space. It can also be a human being, instrumented to receive commands and transmit back images and audio.

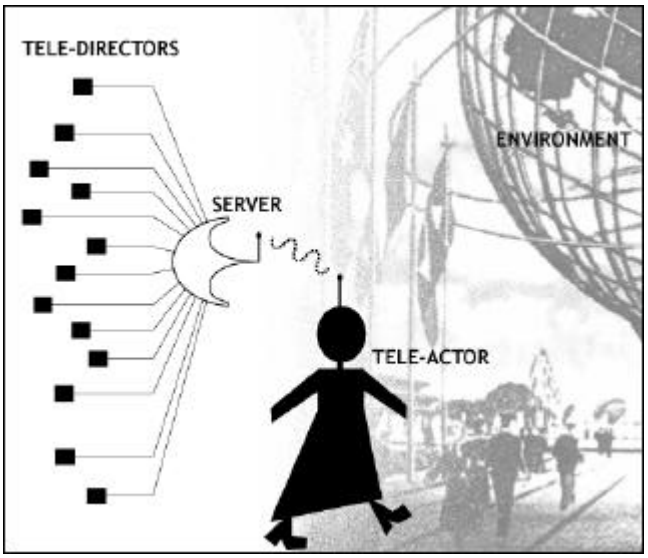

Figure 1 The Tele-Direction Framework

Several of us have had considerable experience building tele-robots[3]. However, existing robots are complex, expensive, limited in mobility, and insufficiently reliable for sustained performance in demanding environments [2]. In our current studies we are exploring a tele-directing alternative, replacing the robot with a human actor.

A human can improvise to avoid obstacles, add commentary and interact with people. By using a human actor, we can navigate complex situations that are far beyond the capabilities of any extant robot. Furthermore, working with a remotely directed human actor will provide useful insights for further tele-robot development.

While the environment and the Actor may be either real or virtual, the Directors are always human. They are a geographically distributed audience who receive the live audio and video stream originating from the remote Actor and who send instructions to the Actor via a collaborative interface. Exploring a range of designs for this interface

and evaluating their effects on the behavior of and interactions among the audience members is a key area of this work.

RELATED WORK

The Tele-Direction system builds upon work from two fields: remote human interaction and collaborative control.

Tele-robotic systems allow a single human operator to view and manipulate a robot in a remote environment. With the advent of the Web, a number of publicly accessible Internet-based tele-robots have been created [4]. Most early tele-robots were made for exploring hostile environments such as Mars or the ocean floor; more recently, systems such as Paulos and Canny's *ProPs* [6] have been designed to enable remote social interaction. A similar communication model, but with a human rather than robotic subject, has been explored by the "wearable" research community [5]. To our knowledge, none of these systems permit a group of users to simultaneously control the remote agent.

There is a substantial body of research on collaborative interfaces, e.g. [2] and on interfaces for social interaction, e.g. [7]. Particularly relevant is work addressing real-time collaborative control. *Cinematrix* [1] allows an audience to control motion projected on a screen by holding up color-coded paddles; large groups of untrained users are quickly able to coordinate aggregate motion, e.g. to move a cursor through a complex maze. *Ouija2000* [3] allows a distributed audience to collectively tele-operate an industrial robot arm via the Internet. Users receive visual feedback from the remote site; their actions (mouse-clicks) are aggregated at the server to produce a single robot control stream.

CURRENT IMPLEMENTATIONS

In our initial Tele-Direction interface, the Directors propose and vote on actions to be taken by the Actor. Votes can be taken quite frequently and only the winning action is communicated to the Actor. This interface is best suited for a human actor; we have implemented it for both virtual and real environments.

In the virtual environment, the Actor is directed via on screen commands through the game *Riven*. The Directors see screen shots and vote on actions. We have been using this implementation as a test bed for experimenting with different Director interfaces.

We have also built a system in which an instrumented Actor moves in a real environment. A camera and microphone transmit the Actor's environment to the server; the Actor receives audio instructions for movement, actions, and general advice. This implementation presents a number of technical challenges (e.g. wireless video transmission) and interface questions. The design of the Tele-Actor's equipment (e.g. the mounting and visibility of the camera) affects how people react to the Actor and how the Directors see the Actor.

Finally, we are developing scenarios. Initially these are explorations of our lab and simple tasks. When the system is complete, we plan to use it to allow people to remotely experience more exotic situations, from secluded wildlife refuges to exclusive nightclub parties.

RESEARCH QUESTIONS

We will be using the Tele-Direction framework to explore a number of human-interface design problems. For instance, what medium is best suited for remote direction giving? We now use audio but will compare it with head-mounted displays that may prove better in a complex environment. We are also investigating the influence of the Directors' interface on how they collaborate or compete to achieve their individual goals. We are designing a number of different interfaces and will be evaluating them both quantitatively (e.g. how quickly can the Directors direct the Actor to a particular place) and qualitatively (e.g. did the remote Director's feel as though they were part of a crowd—and was this was a positive or negative sensation). And we are interested in gathering insights about remote directing that can be applied to the design of future tele-robots.

More information on the Tele-Direction project can be found at http://smg.media.mit.edu/Projects/TeleDirection.

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