Teleportation Through Communications

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Abstract—A stereoscopic, stereophonic, user-controllable communications system is described. This system might allow the user to feel physically present at some remote location and thus might be considered to be an approximation through communications to teleportation. While admittedly somewhat futuristic, such a teleportation-through-communications system might be realistic in the bandwidth-rich future.

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In the interim, the system might be useful for experimental explorations of the feeling of physical presence in interpersonal communications.

I. Introduction

A. Communications—A Substitute for Travel

The physical transportation of people seems to be a significant contributor to the cause of many of the crises in such areas as energy and urban congestion presently afflicting the United States. The use of communications as a replacement for the physical transportation of people might help to solve such transportation-related crises.

To a considerable extent, the conventional telephone probably already substitutes for much travel, although the increased interpersonal interaction resulting from the telephone has possibly increased travel to some extent also. It is possible that a richer communications system using not only audio communications but also video communications might allow communications to substitute for even more travel situations. On the other hand, the telephone and its audio-only relatives might already have substituted for those situations in which a communications substitute were possible. These are interesting and significant issues worthy of further future research.

B. Video Teleconferencing

Communications systems have already been designed to enable two groups of people to hold a conference between two physically separate locations through the use of interactive video communications. A British system called Confravision, a system at use at Bell Laboratories between Murray Hill and Holmdel, NJ, and the intercity PICTUREPHONE ® Meeting Service presently being offered by the American Telephone and Telegraph Company are somewhat similar in that these three systems use many television cameras and monitors with automatic voice-controlled video switching so that the person speaking can be seen by all at the remote location [1]–[3].

C. Factors Affecting Teleconferencing Usage

A number of other teleconferencing systems also exist, some using sophisticated video technology and others using simple audio-only technology [4]. Some of these systems experience good usage while others do not. The factors affecting usage might be related to the off-premises nature of some of these systems, the nature of the meetings, the relationship between the participants, the economic tradeoff against travel, or some aspect of the teleconferencing technology itself. This paper addresses the technology factor by suggesting an "ultimate" communications system that would be applicable to teleconferencing.

D. Physical Presence

When using the telephone or some visual communications device, the user usually does not feel physically present at the remote location. However, when one person visits another person, they are each able to sense physical presence through various acoustic and visual stimuli. Quite possibly, people travel to visit and meet with other people because of some human need to sense this physical presence.

The nature of the sensation of physical presence needs definition and exploration so that its importance in face-to-face communications can be ascertained. Whether "physical presence" can be "felt" remotely through the use of communications technology needs to be determined along with the technological requirements for transmitting such "physical presence," if indeed it can be transmitted.

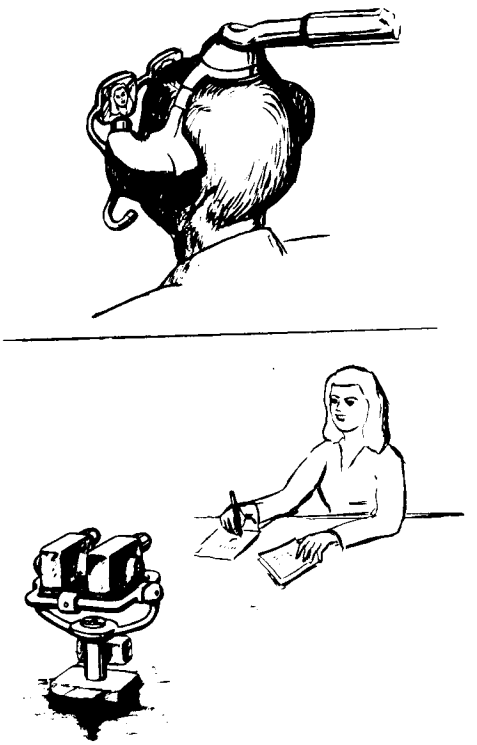

Fig. 1. Pictorial depiction of teleportation-through-communications system showing head-piece worn by the user and equipment located at the remote location.

E. Teleportation Through Communications

The acoustic and visual stimuli that a person senses when visiting another person should probably be retained as closely as possible in any communications system intended to convey a feeling of physical presence. Thus both stereophonic audio and stereoscopic video would seem to be required for a communications system intended to "convey" a person from one location to another. Also required would be an ability for the users to determine themselves where the remote equipment looks and listens.

The features of stereophonic audio, stereoscopic video, and user control are essential ingredients in the communications system proposed in this paper to allow a person to feel physically present at a remote meeting with one or more other people. This system, through communications, would approximate teleportation!

II. A Teleportation-Through-Communications System

A. System Description

The teleportation-through-communications system proposed in this paper consists of equipment used by the user and equipment located at the remote location. As is depicted in Fig. 1, the user wears a stereophonic headset that is equipped with a boom microphone. Attached to the headset is a spectacle-like device that presents a separate image to each eye. Suitable optics are used so that the images seem to be located about 6 m from the user.

The images presented to the user come from the faces of two cathode ray tubes. Small cathode ray tubes might be located on each side of the headphone-spectacle device, or alternatively, fiber optics might be used to transmit the images to the spectacle device.

The headphone band is attached to a gimbal device that senses any movement of the user's head. Alternatively, coils

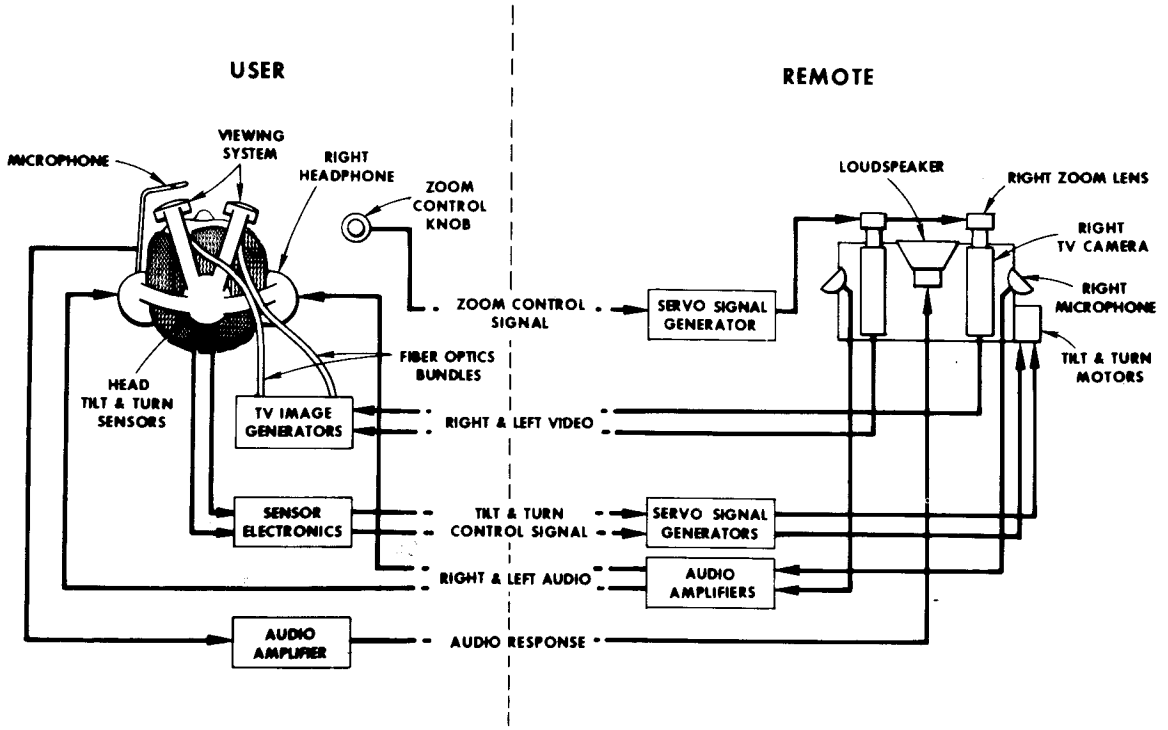

Fig. 2. Signal paths required for teleportation-through-communications system.

or some form of radio transmission might be used to sense movement of the user's head.

The remote system consists of two small television cameras that are positioned about 6 cm apart to correspond to the distance between the two eyes of a person. Two microphones are mounted with the cameras to approximate the distance between two human ears. All this equipment, including a small loudspeaker, is mounted on a platform that can be automatically turned and tilted by an appropriate mechanism.

The images picked up by the two television cameras are transmitted to the two television cathode ray tubes which then present the two images separately to each eye of the user as shown in Fig. 2. The acoustic signals picked up by the two microphones are transmitted to the two separate earphones which present a separate acoustic signal to each ear of the user. The physical position of the user's head is sensed by the gimbal mechanism, and this position information is transmitted to motors which control the position of the platform to correspond to the position of the user's head. Any speech spoken by the user is picked up by the boom microphone and is transmitted to the loudspeaker located on the platform.

With this system, the user is able to turn his head and see stereoscopically and hear stereophonically what is happening at the remote location. Any speech spoken by the user will be heard by those present at the remote location, and any conversation that occurs at the remote location will be heard stereophonically by the user.

B. Technological Options

Stereoscopic information is conveyed by the horizontal shifts of images relative to their backgrounds. Hence, the two images picked up by the two cameras would be quite similar. Thus differential coding of one image relative to the other would seem appropriate in order to reduce the bandwidth required to transmit the left and right visual information.

Rather than physically moving the cameras, mirrors might be used in front of the lenses to change the viewing direction. Electronic steering of a microphone array might be used rather than physical movement of two microphones.

Zoom lenses might be added to the two cameras so that the user could zoom in on some picture or scene of interest. In this way, the user could substitute for the usual ability of moving closer to see something of particular interest.

The bandwidth required to transmit two video signals might be reduced by using a device to track the movement of the user's eyes [5]. Since the human visual system sees high resolution only within a very small field, the resolution of the television image outside this field could be greatly reduced and the user would not know that any degradation had occurred.

A stereophonic headset for which the sound images are not localized within the listener's head but are localized externally has recently been demonstrated [6]. This has been accomplished by the use of microphones which closely approximate the acoustic properties of the human ear and head and by the use of earphones which are tightly coupled to the listener's ears with proper acoustic impedance matching. The use of this stereophonic system in the teleportation-through-communications system would probably enhance significantly the realism of the feeling of acoustic presence at the remote location.

The stereoscopic television should probably be in color to enhance the feeling of realism and presence. At the present, however, color television cameras are quite large and bulky, and hence two cameras could probably not be mounted easily on the remote platform. One possible solution would be the use of flexible fiber-optics bundles to carry two images from the platform to the stationary color cameras. Alternatively, recent research has demonstrated the feasibility of solid-state charge-coupled color cameras that are lightweight and small sized [7].

C. User Surrogate

The remote system would in effect be a surrogate for the user. For example, if someone at the remote location spoke the user's name, then the user would stereophonically locate the direction of the speaker and would turn his head in that direction. This

action would be sensed by the gimbal mechanism which would then cause the platform to turn in the same direction, and the user would be able to see the person who spoke his name. The people at the remote location would see the platform turn and would therefore know that the user was looking at them. The directional characteristics of the loudspeaker mounted on the platform would also serve as a clue to the remote people as to the direction in which the user was speaking. As they became accustomed to the remote device and its responses, people at the remote location would probably come to accept the device as a surrogate for the user. However, the people at the remote location would be somewhat at a disadvantage since they would be unable to see the facial expressions of the user.

The platform device might be equipped with a handle so that it could be transported easily to any room or other location where the user wished to be "present" for some conference or meeting. The "surrogate" might be placed on a table, chair, or other suitable resting place. The headphone device worn by the user would also be portable.

Thus both the platform device and the headphone device could be used at different times by different people to "attend" different meetings at different locations. Neither the user nor the people at the remote location would have to go to a special site—the user's office and a regular conference room would be sufficient. The only requirement would be a broadband transmission facility between the user's office and the remote location.

III. Discussion

A. Market Prospects

The teleportation-through-communications system described in this paper probably is not a marketable product in the near future. The hardware is quite elaborate and would undoubtedly be quite expensive. The user must wear a cumbersome headphone-spectacle device. Also, a large amount of bandwidth is needed for transmitting two television images.

B. Technical Feasibility

The teleportation-through-communications system described in this paper is admittedly quite futuristic. However, such a system is definitely within the capabilities of present technology, although widespread commercial exploitation is not reasonable for the present.

The Bell Helicopter Company has constructed a user-controlled stereoscopic device for use by helicopter pilots [8], [9]. A photograph of the helmet-spectacle device worn by the pilot is shown in Fig. 3. Two servo-controlled television cameras are mounted on struts with a wide physical separation to create an exaggerated sensation of depth. The head-mounted stereoscopic display was later adapted for use in computer graphics research at the University of Utah [10].

C. Research Tool

For the present, a teleportation-through-communications system would be an interesting demonstration of communications technology that some day in the future might form the basis for a communications service. A teleportation-through-communications system would be a useful vehicle for studying and understanding the importance and role of such factors as stereophonic sound, stereoscopic vision, and user control in face-to-face interpersonal communications. Evaluations of the effects of acoustic and visual distortions on interpersonal communications might also be studied using the system. Thus, for the present, a teleportation-through-communications system would be primarily a research tool and technology demonstration.

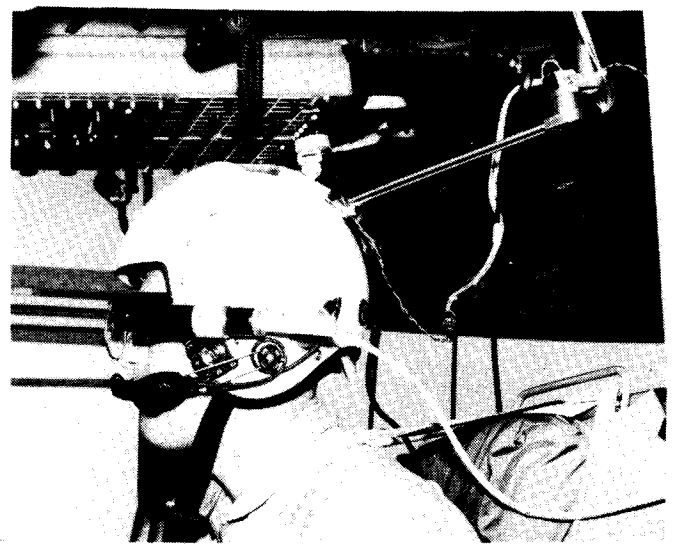

Fig. 3 Stereoscopic head-mounted display used by helicopter pilots. Miniature CRT's are mounted on the sides of the pilot's helmet. The display optics, consisting of a spherical-mirror reflector and a pellicle beam-splitter, present a collimated image to the user. (Photograph courtesy of H. W. Upton, Bell Helicopter Company.)

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