Communications Robot System for Expressing Presence of Remote Participants

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An abundant number of remote communication tools that use networks are being developed. The background for such developments includes the decline in communication costs due to progress made in networking technologies, as people seek out methods to support a diverse range of employment in this aging society with declining birth rate and anticipate methods to conserve energy, which is necessary for activities such as commuting, out of consideration for environmental issues. Hardware and software systems to support teleconferencing are being developed in great quantities, as a means to remotely communicate with office environments[1)]. It is considered quite possible that the user population utilizing such systems will increase in the general population in the future, due also to the developments described in the abovementioned background.

Inadequate aspects remain however, for the aforementioned systems in comparison with face-to-face communications that are actually conducted in shared spaces. Needless to say the quality of image and voice media must be improved in order to raise the level of remote communications as these types of communications ordinarily employ images and voice. Improvements to these aspects, however, would not preclude successful resolution to all problems.

In order to resolve the problems described above, we focused on a robot technology as a factor that may potentially supplement the presence and corporality of participants in meetings, which are often lost in meetings when a common space is not shared. We are conducting research and development on this theme in order to achieve better remote communications.

This paper describes issues that arise from a lack of presence by participants, issues that became evident as we conducted teleconferencing activities within our own company, which explains the background that led us to consider the use of robots as a means to supplement such a lack of presence. Preceding research pertaining to remote communications using robots and physical media other than robots are introduced next, followed by descriptions of the features of a remote communication support system that uses the robots, which we are currently developing. Finally, a summary of the evaluation experiments for the system planned for the future will be described.

Background

Human Communication Laboratory is based at two locations, the Warabi Site (Saitama Prefecture) and the Kansai Site (Osaka Prefecture). Since direct communications involving all members of the laboratory are difficult, teleconferencing was conducted periodically. The status of the actual conferences that were held last year is described in **Table 1**.

Table 1 Status of teleconferencing at HCL

Connecting method:	Teleconferencing system using images and voice.
Number of participants:	13 persons (Warabi Site: 11 persons; Kansai Site: 2 persons).
Conference duration:	Two hours (held weekly).
Conference chair:	Present at the Warabi Site.
Descriptions:	Work related communications, as well as questions and answers relating to the activities of individuals, etc.

Particulars that require special mention include the fact that the number of participants at the Warabi Site and the Kansai Site was not balanced (11 to 2) and the meeting chair was present at the Warabi Site. Some problems were encountered as we actually conducted these conferences. Some of the main issues are described below:

- When discussions became intense at the Warabi Site, the conversation sometimes continued energetically with the two participants at the Kansai Site completely forgotten (lack of presence).
- Nonverbal reactions from the Kansai Site difficult to receive and were conveyed through means other than voice (same as above).
- A means for participants at the Kansai Site to intervene in discussions at the Warabi Site was limited to voice, creating an atmosphere that made intervention difficult (interruption was not easy).
- Cameras were fixed and participants at the Kansai Site could sometimes not see certain segments of interest (lack of freedom with images).

As described above, we believe that most of the problems that were encountered during the actual conferences could be ascribed to the fact that the actual space is not being shared and expressions that are unconsciously and physically conveyed by participants are lacking in remote communications.

When participants actually share a space, the presence of the participants is evident and unconscious postures, as well as the conscious angle of the body and line of sight can be read easily to estimate the extent of interest or concern. Furthermore, participants who wish to speak can appeal to other participants by raising their hand or by bending forward.

If the lack of a physical body creates problems, then thinking that something physical should be added to the system to supplement such a lacking presence, would certainly be a straightforward idea.

Real world oriented interaction

The concept of expanding the information world by assigning physical attributes to information, by utilizing the physical objects that actually exist in real three-dimensional space, is called the "Real World Oriented Interaction". For example, when a user grabs and relocates a three-dimensional object that exists in the real world, known as the Phycon (Physical Icon), then such changes are reflected on an element in the information space, which is moved accordingly.

Also, the most notable research in this field is a series of research collectively referred to, by Professor Hiroshi Ishii of the Massachusetts Institute of Technology, as "Tangible Bits"[2]. One outcome of the Tangible Bits research is inTouch[3], which offers numerous suggestions for considering physical communication media other than images and voice.

inTouch operates a pair of devices created by binding together three wooden cylindrical objects. These devices are connected via a network and when one user freely rotates these cylindrical objects, the rotating motion is reflected by the other set of cylindrical objects, which then rotate. Users who use inTouch communicate through rotations that are triggered by haptic input and output. Communications using inTouch have the following features:

- Haptic and kinesthetic senses are used as a new information communication channel, which is something other than image or voice.
- Sending and receiving information can be conducted bidirectionally at any time.
- Users create new avenues of communication with each other in the course of an ongoing communication, without following any specific protocol.

We determined that by applying the aforementioned concepts, which are the cornerstone of the development of inTouch, we could improve issues in remote communications as described earlier and therefore we decided to conduct research into communication media other than image or voice.

Preceding research of remote communication robot

We conceived the idea of using a robot as a physical substitute for a person remotely attending a teleconference, something that operates as an alternative, by applying the concept of the real world oriented interaction, which is intended to change the quality of communications by combining the attributes of physical entities and the benefits of information and communication technologies. In other words, we considered robots as a media for physically displaying bodily information. A number of preceding researches on robots that support communications based on such a concept already exist.

Research using robots as support for communications often involves autonomous robots with artificial intelligence and a lot of this type of research is conducted to deal with communications between people and robots. In our research, we focused on a robot to provide support for communications between people.

Case examples of highly related preceding research are introduced below. GestureMan[4, 5] is the subject of research and development as a robot system for remotely instructing work procedures in the Groupware Laboratory at the University of Tsukuba. This robot is used by specialists to instruct or to educate people at remote locations. It is equipped with a wheeled platform for free movement and elements that imitate a human head and arms for expressing a line of sight and the direction of interest referred to as the "orientation"[6] , a technical sociological term. It is a physical entity manipulated by a remote operator to express orientation as advance notice.

The Intelligent Robotics Laboratory at the Department of Adaptive Machine Systems in the Graduate School of Engineering of Osaka University is developing the Geminoid[7]. This is a state of the art humanoid robot, with a silicon mold of the body taken from the developer himself. It is capable of faithfully expressing human emotions and movements through remote control.

The following are characteristics of the existing research:

a) Direction of information is asymmetrical

The configuration is such that the sender of information operates a single robot to send information to a person receiving it at a remote location.

b) One person operates a robot

Ordinarily the sender of information is limited to a specific, single person.

c) Robots used are close to life size

Expressions of human factors are being attempted by experimenting with size and form.

Systems under development

Contrary to the robot research described above, robots currently under development have the following differences and features:

A) Direction of information is bidirectional and symmetrical

Multiple robots are present at remote locations to exchange bidirectional information.

B) Multiple people operate robots

All participants in a conference will be able to operate these robots.

C) Robots used are compact

Robots are designed in sizes that are suitable for movements at conference tables.

For of explaining the system, let us assume that a meeting is being held by several participants at two remote locations, with a teleconferencing situation that fits the scope of our system. This is a typical situation for teleconferencing in office environments.

It is desirable to allocate both of these locations the same number of robots as participants in the meeting to make bidirectional communications available through these robots for the system, which is intended to supplement the physical bodies of remote participants who are not physically at each location (features A and B). However, the number of participants present at such meetings is often undetermined and spatial limitations are also imposed on the rooms. Furthermore, a consideration for cost presents a limit on how many robots can be allocated.

Therefore, the number of robots and the number of participants at a meeting do not always correspond and multiple participants may share the control of a limited number of robots. Some means to express the identity of the person who is currently operating the robot must be made available.

Similarly, for the system and in order to justify costs, these robots do not have to faithfully reproduce the bodily features of human beings but they do need to be equipped with the simplified structure and size necessary to deliver the ability to express highly critical movements as “orientations” (feature C).

The operation of these robots must also be simple and easy, to ensure that it does not get in the way of participation at the meeting. For this reason, an interface for operation must be devised.

Details of the functions are explained below.

Robots have the fundamental abilities of moving functions and imaging functions using a camera. Operators using the system can “look” at objects of interest at the remote site using a robot, which is a physical entity, while people at that site can witness the act of “looking” and thereby create a situation where the robot is being “seen”. It is possible to offer a presence in a natural way and to express what the operator may be interested in, through this action to “look” and the accompanying action of moving. Participants can express their orientation using such a robot. Other participants at the remote location can perceive the orientation of the participant represented by the robot, based on the orientation of the robot in their presence.

This system was utilized at both of the two locations where a teleconference was conducted (**Fig. 1**) and shared by all participants at each location. The system overlays an ordinary teleconferencing system that uses

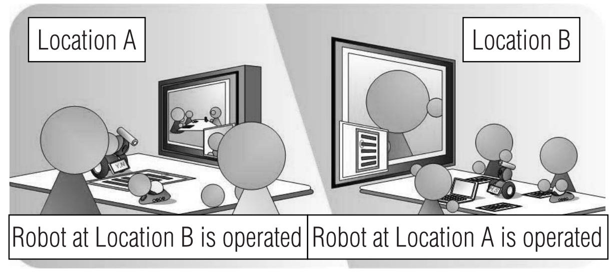

Fig. 1 Teleconferencing between two remote locations

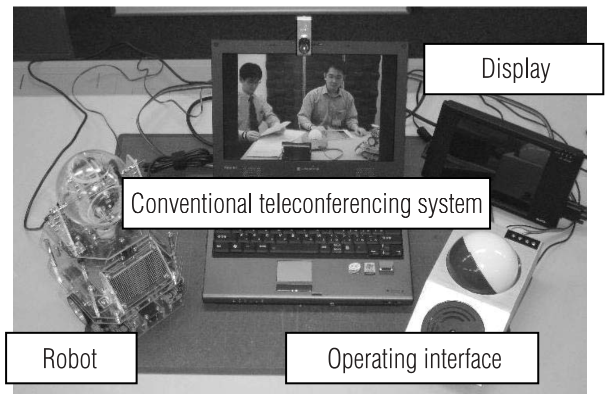

Fig. 2 System configuration diagram

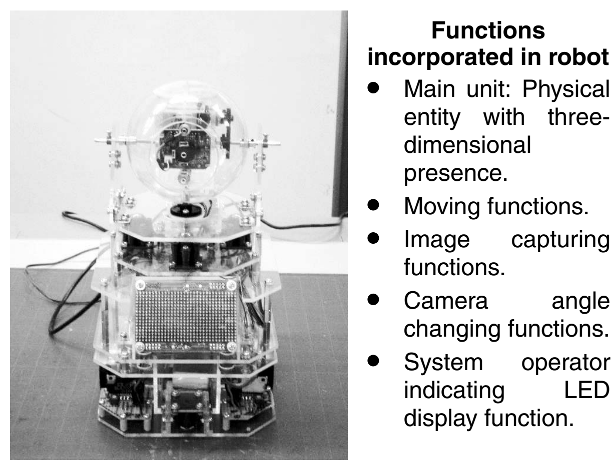

Fig. 3 Functional configuration of robot

images as well as voice which is configured with the “robot”, an “operating interface” (hereinafter referred to as the “operating IF”) and a “display” (**Fig. 2**).

The robot (**Fig. 3**) is a mobile vehicle mounted with a camera, which is capable of panning and tilting operations, as described earlier. It fulfills the role as a substitute of the participant at a remote location. A user can manipulate and freely move the robot to focus on arbitrary locations.

A three-dimensional presence is created by having a robot operating in a space. The camera simulates the shape of a face and performs expressions of orientation by panning and tilting the camera to represent the line of sight and orientation of the face of the operator.

Since multiple participants can share the operation of a single robot, it is necessary to identify the current operator. Several methods must be considered, but at the present time the current configuration of the robot under development incorporates an LED matrix to display the person's name or other identifying descriptions to distinguish the current operator, that means indicating whose intentions are represented by the motion of the robot.

Furthermore, an RFID is used for identifying the operator. Each participant of the conference is required to wear a wristband containing an RFID tag. This tag is scanned by the tag reader that is incorporated into the operating IF for identification. The result of identification is instantaneously reflected onto the details displayed on the LED matrix.

The ball-type operating method employed by the operating IF is used to operate the orientation of the camera. The ball operation is linked with the camera orientation, so that direct operating sensations are acquired when manipulating the robot.

Future developments

The developed robot in the future will be put to use under actual communicating and conferencing conditions held between the Warabi Site and the Kansai Site, for investigating changes that occur in communications due to such an implementation. To evaluate system, we intend to investigate qualitative methods, such as analyzing the interesting episodes observed over a long term under the conditions of use, as well as quantitative methods, involving for measuring the time required to complete a task when a test subject is required to undertake a specific assignment.

The evaluation results are used to extract important factors in order to achieve better remote communications, before they are fed back to create a the new system to acquire in the end the knowledge that can be applied to the development of highly efficient physical media, which will be necessary for the development of actual remote communication products.

Conclusion

The exchange of information through nonverbal and bodily expressions, conducted unconsciously in any face-to-face communication is lacking in remote communications, including teleconferencing. We introduced the development of a teleconferencing support system that uses robots as new communication media to resolve this issue.

The purpose of this research is not the development of a robot system to be sold as a product, but rather, in order to consider new media with a potential for resolving in some different ways various issues that arise in remote communications, which are conducted primarily with image and voice.

We intend to extract essential factors for remote communications in the future, through evaluation experiments conducted through the actual operation of the remote communication support system using the developed robot.

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