RobotPHONE: RUI for Interpersonal Communication

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ABSTRACT
RobotPHONE is a Robotic User Interface (RUI) that uses robots as physical avatars for interpersonal communication. Using RobotPHONE, users in remote locations can communicate shapes and motion with each other. In this paper we present the concept of RobotPHONE, and describe implementations of two prototypes.

Keywords
Robot, Interface, Interpersonal communication, Physical avatar, Bilateral Servo, RUI

INTRODUCTION
For a long time, robots have chiefly been considered as machines that perform work in the place of human beings, such as industrial robots. However, considering the characteristic of their physical embodiment, robots can also be recognized as interfaces for human beings. The concept of using a robot as an interface between the real world and the information world can be referred to as a Robotic User Interface (RUI). An intelligent robot as a physical entity for an Artificial Intelligence agent or a haptic feedback robot arm used in VR systems are good examples of an RUI.

In this paper, we propose RobotPHONE. RobotPHONE is a RUI system for interpersonal exchange that uses robots as agents for physical communication.

ROBOTPHONE
The RobotPHONE system employs robots as devices that are called *shape-sharing*. The shape and motion of remote shape-sharing devices are always synchronized. Operations to the robot, such as the modification of posture, or the input of motion, are reflected to the remote end in real-time. Therefore, users of RobotPHONE can communicate and interact with each other by exchanging the shape and motion of the robot.

It can be said that RobotPHONE is a system that makes it possible to have an object exist virtually in a remote place on behalf of user. RobotPHONE transfers the existence of the user not by attempting to transmit the user itself but to transmit the user's substitute.

Consider a mother giving her daughter a stuffed doll to keep her company at night. This is a form of communication aided by a physical entity. RobotPHONE can allow this kind of communication to become possible.

Initial prototype
As an initial prototype based on the RobotPHONE concept, we implemented an experimental system which has two snake-like robots for a shape-sharing device. Each snake-like robot has six parallel axes, and these axes make a right angle with the long side of the snake's body. Therefore, the range of body movement is limited to the two-dimensional plane, but the body itself represents a shape that can be easily modified by hand.

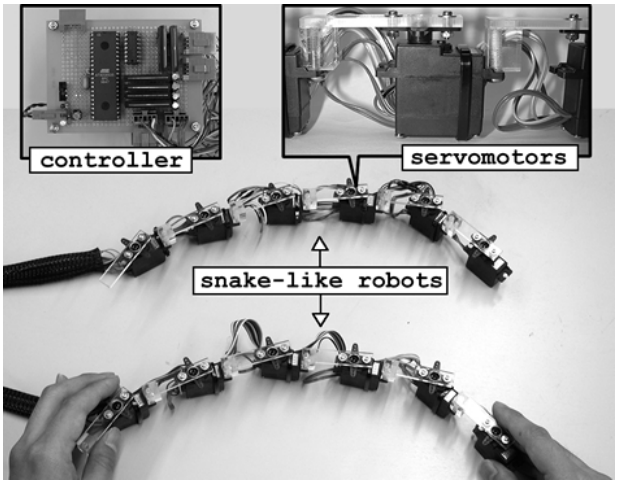

Figure 1: Snake-like robots and controller

The system consists of two snake-like robots and the controller unit (Figure 1). A noteworthy point in system design is that it is very simple and consists of general and inexpensive parts. Servomotors of snake-like robots were converted from commercial servo units for a radio-controlled model. The controller was made by a one-chip microcontroller.

The servomotors are controlled by a symmetric bilateral control method, in which servomotors are always controlled to minimize the position difference of each pair. The symmetric bilateral control method is not so suitable for transferring precise force information, but it has the highly desirable merit of simplicity in implementation.

At first, we checked whether the shape-sharing device could be handled when bilateral control is performed. The torque necessary for bending a joint of the shape-sharing device was 0.45[kgf·cm]. Although gear reduction ratio of the servomotor was relatively high (319:1), by choosing appropriate servo gain, the torque could be kept easily manageable by a single hand.

When one of two robots is manipulated, the other robot follows the operation of user without delay. Hence the user is able to form the shape of the remote robot freely.

Since completely symmetrical bilateral control is performed, it is possible to mutually control the system without distinction of a master or slave device. Moreover, if one robot is restrained by hand, the restrained state can be transferred to the other, and the user can feel the existence of a person on the remote end.

Second prototype

When we designed the second prototype, we tried to make the system friendlier to everyone. To meet this requirement, we integrated the second RobotPHONE system with a voice communication system, and gave it the appearance of a teddy bear. By using the teddy bear-like robot as a shape-sharing device, we also intended to refine the essence of a communication device. When a user communicates with this system, the teddy bear acts as his/her physical avatar. Therefore it was very important to give the teddy bear-like robot similar shape and placement of degrees of freedom to a human being.

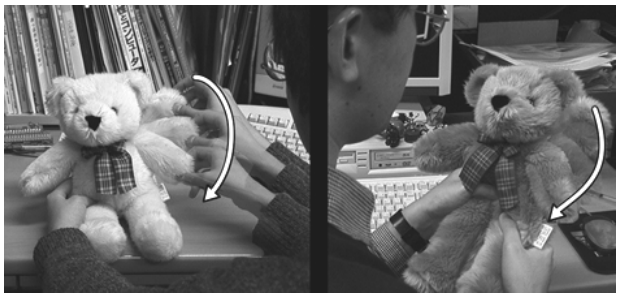

Figure 2: Teddy bear-like robots

The servomotors and the controller used in the second prototype were the same as the initial prototype. Hence, as described before, each joint can be moved easily by one hand, and synchronization of the pose and motion is maintained in real-time.

Since a user can treat the teddy bear-like robot just like an ordinary teddy bear, this system is very easy to use. If the user moves the teddy bear's head, hands or legs, these movements will be transmitted to the opposite side. Just as the teddy bear placed in front of the user is an input device, it is also a display device that displays the status of the remote robot. In other words, while each teddy bear acts as an avatar of the user who sits in front of it, it also acts as an avatar of the user at remote side seamlessly.

With traditional communication methods such as telephones and videoconferencing systems, a user can only feel the existence of the person behind the veil of the machine. In contrast, a user of RobotPHONE can feel the existence of the person as if he was directly in front of her.

RELATED WORK

There are several works that share haptic sensation or the position of the object for interpersonal communication. Ishii's inTouch [1] synchronizes the rotation of rollers under the hand. Fogg's HandJive [2] synchronizes the movement of a balloon and a stick gripped in the user's hand. PsyBech(Physically Synchronized Bench) by Ishii [3] synchronizes the position of an object on the workbench. These works synchronize only the motion or position of the object. We think that the combination of the shape and motion is especially important and this combination leads to embodiment of the communication as a result.

CONCLUSION

In this paper we proposed the concept of RobotPHONE, and discussed the implementation of two prototypes. Through the development of these prototypes, we demonstrated the feasibility of implementation and the potential of the RobotPHONE concept. We will refine the system design to adapt for practical use, such as support for long distance communication. Current plans include using modems to exchange data for bilateral control.

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