WithYou - A Communication System to Provide Out Together Feeling

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ABSTRACT

In this paper, we present a video-based communication system that provides an Out Together Feeling. In other words, it makes a pair of users, one outdoors and the other indoors, feel as if they are going outside together. To achieve this, it is important that both users (1) can freely peruse the outdoor user's surroundings, (2) can see what the outdoor user is looking at, and (3) can focus together on the same point. To realize these features, we have designed and implemented a system called WithYou. It consists of two subsystems: a wearable system for the outdoor user and an immersive space for the indoor user. The indoor user wears an HMD and watches video from a Pan/Tilt/Zoom camera mounted on the outdoor user's chest. Thus, the indoor user can look around by simply turning his/her head to the left or right. The orientation of the outdoor user's face is also displayed on the HMD screen to indicate where he/she is looking. In the preliminary test, both users experienced the Out Together Feeling to some extent.

Categories and Subject Descriptors

H.1.2 **[User/Machine Systems]**: Human factors.
I.2.9 **[Robotics]**: Commercial robots and applications.
I.3.6 **[Methodology and Techniques]**: Interaction techniques.

Keywords

Tele-presence, Communication Support, Wearable Mobile and Human Robot Interaction

1. INTRODUCTION

In our research, the "Out Together Feeling" refers to a sensation shared by two people at different locations that they are outside together. Our ultimate goal is to make full use of remote video communication technology to realize the Out Together Feeling. As a step toward this goal, we have designed and implemented a basic system of communication between an indoor user and an outdoor user. In our system, an immersive display such as an HMD enables an indoor user to share a remote environment with an outdoor user wearing a special device that includes a pan/tilt camera for transferring a video stream to the indoor user.

By using this basic system, (1) the indoor user can freely peruse the surroundings of the outdoor user, and (2) each user can know the direction of the other user's gaze. In addition, to realize the Out Together Feeling, it is important that they can also focus together on the same point at the same time. We refer to this coordinated ability to focus on the same object as "joint attention". Joint attention is necessary when users want to chat naturally in a coexistent type of video communication.

In this paper, we first define the Out Together Feeling in greater detail. We explain our basic video communication system and the interface design for realizing "joint attention" in Sections 3 and 4. Implementation of the system is described in Section 5. We present the results of a preliminary evaluation of our system in Section 6, and discuss related work in Section 7. Conclusions are stated in Section 8.

2. THE OUT TOGETHER FEELING

The Out Together Feeling is a sensation shared by two people at different locations that they are going on an outing together. It is a kind of tele-presence technology for use in outdoor environments. Although both users may be going out, in this research, we assume that one user is going out and the other stays inside. Although a number of aspects are necessary to realize the Out Together Feeling, we first define three basic elements, which are necessary for users to be aware of, and to understand the actions of the other:

The indoor user must be able to freely and naturally peruse the surroundings of the outdoor user. When a videophone is used, the shooting direction is controlled exclusively by the outdoor user. If the indoor user can control the camera, he/she can easily look around and locate interesting things to see.

Each user must be able to perceive where the other user is looking, even without conversation. The focus of a user shows his/her interest, and provides a good topic of conversation between users.

We have designed and implemented a basic system called WithYou. It provides the above functions, so that joint attention can easily be achieved in a remote video communication.

3. SYSTEM OVERVIEW

The WithYou system was developed as a step toward realizing the Out Together Feeling. The system is designed for two users; one user (the outdoor user) goes out and the other (the indoor user) stays inside (Figure 1). The outdoor user is defined as the person who actually goes outside and is moving about. The indoor user is defined as the person who uses the system to get the Out Together Feeling, and only goes out virtually.

A wearable device, equipped with a pan-tilt camera and various sensors, is mounted on the outdoor utser's shoulders (Figure 2, left). Live images and action information from the outdoor user are sent to the indoor user. The indoor user remains in the experimental room, uses an HMD as an immersive space, and shares the outdoor user's environment via the immersive space.

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Figure 1. The indoor user and the outdoor user

3.1 Unrestricted view for the indoor user

The pan-tilt camera is mounted on the wearable device at the outdoor user's chest. The direction of the camera is linked with the direction of the indoor user's head. For example, when the indoor user turns his/her head 30 degrees to the right, the camera also rotates 30 degrees to the right. Thus the perspective of the indoor user changes naturally according to the orientation of his/her head (Figure 2).

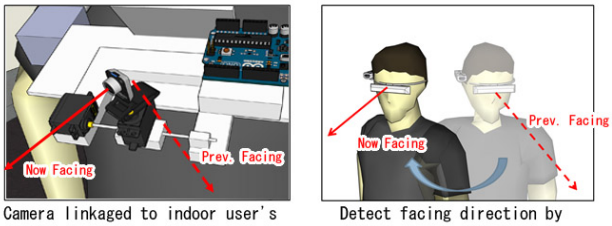

Figure 2. Camera rotation

3.2 Sharing the focus

Sharing the focus means that each user knows where the other is looking. Figure 3 shows a scene in which one user is looking at a doorplate, and the other user has noticed that he/she is looking at the doorplate. WithYou has a function that sends focus information from one user to the other.

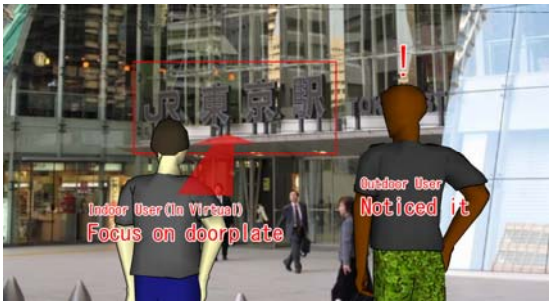

Figure 3. Sharing the focus

3.2.1 Indoor user to outdoor user

Since the pan-tilt camera is mounted on the outdoor user's chest, he/she can know which way the indoor user is facing by observing the direction of the camera.

3.2.2 Outdoor user to indoor user

A gyro sensor is used to measure the horizontal movement of the outdoor user. Measured data (such as turning speed, direction and cross degrees) are displayed on the indoor user's GUI.

However, since the outdoor user may suddenly turn his/her head, it is difficult for the indoor user to infer the outdoor user's focus solely from the current direction. To solve this problem, the system also displays a "rotation icon". If the outdoor user rotates his/her head more than 30 degrees/second, the action is identified as a rotation, and the rotation icon is displayed. The rotation icon is a right/left arrow. If the rotation angle is greater than 135 degrees, the action is identified as a turnaround, and the corresponding icon is displayed.

4. JOINT ATTENTION

Using the basic system functions, it is possible to freely peruse the surroundings and know where a partner is looking. However, these functions are not sufficient to enable the users to focus on the same object together (i.e., joint attention). It is still difficult to communicate the focus (i.e., where the partner really wants to look). In order to achieve joint attention, we designed an interface to notify users of the focus status and its interaction method.

4.1 Focus status and notification of joint attention

We assume a user is in "focusing" mode if his/her focus remains static for more than three seconds. When a user is in focusing mode, the system sends a notification to the other user. This provides a hint of a partner's actions, and may become a topic of conversation.

When one user is in focusing mode, and the other user changes his/her focus accordingly, the system recognizes the situation as joint attention, and sends a notification to both users. Thus, the users are made aware that they are looking in the same direction, and can discuss the matter.

4.2 Forcing joint attention by locking the rotation of the camera

When the indoor user presses the "Camera Linkage" button, the direction of the camera temporarily follows the outdoor user's perspective, and the zooming level is set to the default value (100%), to compel both users to focus together in the same direction. In this instance, the outdoor user controls the indoor user's view, and the "Free View" function of the indoor user is restricted. The system sends the "outdoor user's view" message to both users.

5. IMPLEMENTATION

5.1 Wearable device for the outdoor user

A wearable device is mounted on the outdoor user's shoulders. It consists of gyro sensors, a digital compass, a pan-tilt camera, a mono LCD display, a hand control device, and a mobile computer. The direction in which the outdoor user is facing (body and head) can be measured using geomagnetism sensors. An LCD display shows the outdoor user the system status and the direction in which the indoor user is facing.

To achieve better rotational speed and range, we use a pair of high-speed servomotors to provide two-axis rotation of the USB camera (Logicool C910) mounted on the unit. An embedded computer board (Arduino-mega) is used to control the motors.

The pan-tilt camera can rotate 180 degrees about the pan axis and 130 degrees about the tilt axis. In addition, a digital-zoom function is built into the camera, and the indoor user can zoom in/out on remote images via a hand controller.

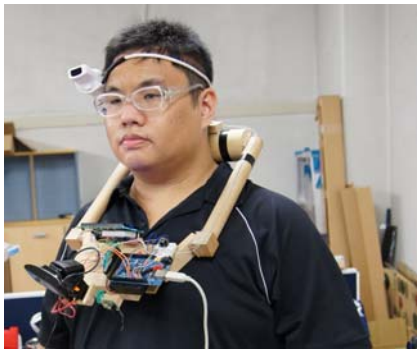

Figure 4. The outdoor user device

5.2 The indoor user's system

The indoor user wears an HMD and a number of sensors. A digital compass is mounted on the indoor user's head to detect the direction in which he/she is facing and synchronize the rotation of the remote camera (Figure 2).

The indoor user views the remote camera images with an HMD. A GUI is overlaid on the camera image to provide information from the outdoor user's sensors.

6. EXPERIMENT

6.1 Purpose of the experiment

To determine the effectiveness of focus interaction in our system, we performed an evaluation experiment to verify the following items:

1. Do users feel as if they are outside with the remote partner?
2. Can users handle the focus direction of the remote partner?
3. Is it useful to have the camera linkage interaction for joint attention?

6.2 Experimental method

Five pairs participated in the experiment. The outdoor user was in the experimental room (A), and the indoor user was in the corridor (B) outside the experimental room.

6.2.1 Setup of the experimental environment

For the outdoor user's experimental environment, we prepared posters and solid objects (quadrangular pyramids) and placed them in the experimental room (Figure 5, left). A large alphabetical character was printed in the middle of each poster to simplify its detection with the camera. Underneath the large alphabetical character, a small four-digit number was also printed on the poster. Each pyramid had a large alphabetical character printed on its front face, and pyramids of different colors were used.

Altogether, ten posters were prepared and pasted along the walls of the experimental room. Eight pyramids were prepared and arranged in an arc-shaped pattern on a large table.

The indoor user wore the HMD while sitting in a chair with a controller in his hand (Figure 5, right).

6.2.2 Experimental conditions

The experiments were conducted in pairs. First, participants practiced using the system for about 10 minutes. The indoor user tried to identify a target (from the posters and pyramids) via the remote camera. The users took turns with the same content. Afterwards, they were asked to fill out a questionnaire.

During the experiments, participants were allowed to interact by voice communication. However, it was forbidden to directly discuss the characters printed on the posters and pyramids.

6.3 Experimental patterns

Task A:

The purpose of this task was to verify that our system can be used for identifying targets. First, 10 posters (A to J) were placed along the walls of the experimental room. We revealed the target character to the indoor user, but not to the outdoor user. The indoor user then employed the system to peruse the surroundings and find the target poster. If the indoor user identified the target poster, he/she asked the outdoor user to write down the four-digit number underneath the large alphabetic character printed on the poster.

Task B:

The indoor user focused on a colored pyramid placed on a desk (Figure 5). The outdoor user was then asked to use the "joint attention" function to focus on the same object. When the outdoor user identified the target, he wrote down the character printed on the front of pyramid.

Task C:

The inverse of task B. The outdoor user focused on the specified pyramid first. The indoor user then used the "joint attention" function to focus on the same object. When the indoor user identified the target pyramid, he wrote down the character printed on the front of the pyramid.

Task D:

Same as Task C, but the automatic camera linkage function was turned on.

Figure 5. Experimental environment for Tasks B,C and D

6.4 Experiment Result

Table 1 and Table 2 are the result of the experiment.

Table 1. The result of experiment

Experiment Content	success rate	Average Time
Task A	100%	2min
Task B	100%	< 1min
Task C	100%	< 1min
Task D	100%	< 1min

Table 2. Questionnaire results

Question	The indoor user	Outside Mover
Did you have a sense of doing something together with remote partners?	3.8	2.8
Did you look around the surroundings feely?	3.6	N/A
Can you handle the facing direction of remote partners?	3.6	3.0
Did you feel video pitching or rolling (unstable camera) ?	2.2	N/A
Do you think "Joint attention" was useful and improved activities together with remote partners?	4.0	2.2
In task C and D, which one was easier to use (no interference) for you?	D=2 C=3	D=3 C=0 Equal=2
Do you think body communication improves the feeling of activities together with remote partners?	3.25	N/A

(point from 1 to 5, 5 means strong agree and 1 means strong disagree)

6.4.1 Realization of the "Out Together Feeling"

Indoor user responses to the question "Can you handle the facing direction of remote partners?" averaged 3.6 points, while outdoor user responses averaged 3.0 points (out of 5 points). However, indoor user responses to the question "Did you have a sense of doing something together with remote partners?" averaged 3.8 points, whereas outdoor user responses averaged 2.8 points. Average indoor user scores were higher for both questions. One possible reason for this is that the indoor users received more information from the HMD than the outdoor users. In the future, we will try to enhance this feeling for the outdoor users.

6.4.2 Evaluation of the "joint attention" function

Based on the results of the questionnaire, indoor users rated the "joint attention" function highly (an average of 4 points out of 5). We received positive comments from examinees, such as "it is convenient to use for seeing what the partner sees". However, in contrast to the indoor users, outdoor users gave this function a low rating (an average of 2.8 points). We received comments such as "difficult to understand the notification of joint attention" and "difficult to hold on focus status with partner".

7. RELATED WORK

Shared-View by Ōta et al. (Ōta, 2000) is a method of directing cardiopulmonary resuscitation by remote environment operation. The system users are the operator and the director. The operator wears an HMD and camera on his head, and follows the instructions of the director. The director guides the emergency resuscitation via pointing screen and voice instruction, and sees a CRT image of what the operator sees at the remote location.

GestureMan by Kuzuoka et al. (Kuzuoka, 2004) employs a robot to create a remote working direction system. The director's head movements cause the robot's head to rotate, and three cameras are mounted on the robot's head to transmit real-time side images to the director. GestureMan also provides a pointing function, using a controllable arm with a laser pointer. The director uses a joystick to control the robot's arm and provide remote instruction. Moreover, the laser pointer can be pointed at a precise position by touching the screen on the director side.

8. CONCLUSION AND FUTURE WORK

As a step toward realizing the Out Together Feeling, we implemented four methods: "Free Views" for the indoor user, "Share for Line of Sight", "Support for Joint Attention" and "Body Communication". Also, the experimental results provided positive feedback for our research.

In this research, we defined the Out Together Feeling, and proposed and implemented four methods to enhance this feeling. The indoor user can feel a sense of presence by looking at the remote environment. Also, the indoor and outdoor users can share their line of sight and get the Out Together Feeling. Moreover, in the successful activation of the "Support for Joint Attention", the indoor and outdoor users can strongly feel each other's presence.

In future work, we will make it possible for the outdoor user to experience the Out Together Feeling at the same level currently enjoyed by the indoor user. We will develop new methods to provide line of sight (the direction in which the indoor user is facing) and joint attention information to the outdoor user.

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