ScalableBody : A Telepresence Robot Supporting Socially Acceptable Interactions and Human Augmentation through Vertical Actuation

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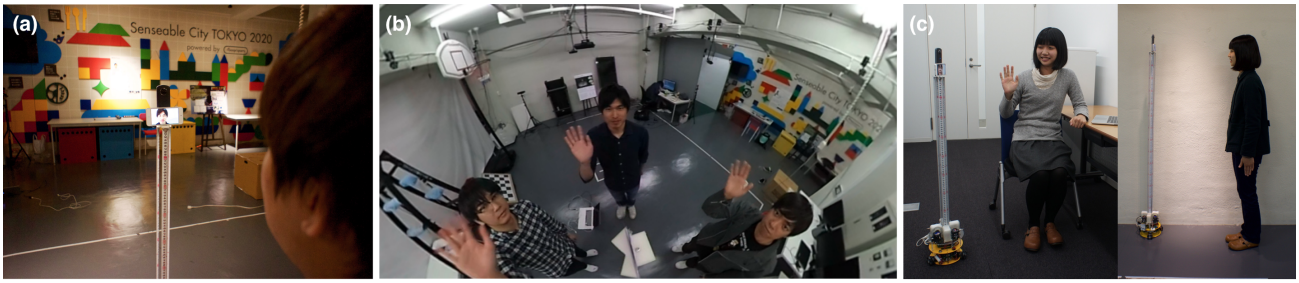

Figure 1. ScalableBody: A Telepresence robot with a vertical actuation mechanism enables to communicate similar to face-to-face communication. (a) The remote user can make eye-contact even though they're using telepresence robot. (b) The remote user can connect the robot to look around the place with 360-degree view. (c) Adjusting its height according to communication contexts.

ABSTRACT

Most telepresence robots have a fixed-size body, and are unable to change the camera or display position. Therefore, although making eye contact is important in human expression, current fixed-size telepresence robots fail to achieve this.

We propose a novel telepresence robot called ScalableBody, which enables users to make eye contact during conversations by changing its height. ScalableBody extends its body to modify the position of its camera or display. This approach provides eye contacts in remote conversations, thus creating almost same situation when the remote and local users make conversation like a real meeting. As for the remote users, this approach also enables them to experience having a conversation from different heights, such as being a giant or a dwarf. This technique extends the possibilities of remote communication by telepresence robots.

Author Keywords

Telepresence robot; surrogate robot; remote communication; eye-contact; human augmentation

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H.5.3. Group and Organization Interfaces: Computer-supported cooperative work; H.4.3. Communication Applications: Computer conferencing, teleconferencing, and video-conferencing

INTRODUCTION

Non-verbal communication is an important component of natural communication. An eye contact is also regarded as an important communication cue that may change impressions during a conversation. These studies [2, 5] suggest the height of a robot is an important social cue for having communication. Thus, it is important to ensure eye contact to enable rich communication.

However, with typical telepresence robots, a remote userâĂŹs expressions are not well conveyed for the following reasons. First, such a robot does not reflect the remote userâĂŹs actual height because a typical telepresence robot cannot change its height. Second, it is also difficult to make eye contact in different conversation contexts. For example, when a person is sitting, it is natural for the other party to also sit down to join a conversation, to enable equal-level eye contact.

To deal with these problems, we designed and implemented a telepresence robot called ScalableBody with the ability to change its height dynamically and produce social equality between remote and local users through eye contact (Figure 1). It is also possible to adjust its height according to communication contexts such as standing or sitting. Furthermore, the robot has a 360-degree camera so the remote user can look around the place easily without any extra mechanism like a

motor actuation. Further still, by augmenting their eye position, the remote user can see the world from a giantâĂŹs or a dwarfâĂŹs point of view.

SCALABLEBODY

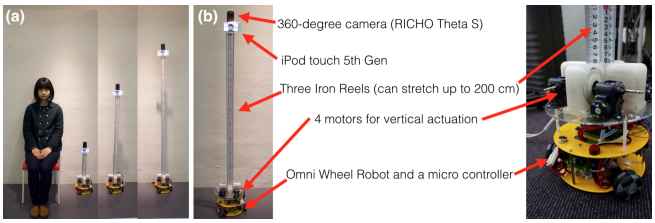

Figure 2. A detail of our telepresence robot, ScalableBody. (a) The vertical actuation allows to change the height dynamically. (b) Changing the height of body, it enables to reflect the same height of remote user.

We use iron reel to implement the vertical actuation mechanism. This is inspired by the dynamic structure of Kinereels, which is developed by Takei et al. [6]. This technique enables high extended ratio with small size and light weight, so it is easy to adopt to robot with limited payload and size. Alternative mechanisms, like leadscrews, a rack-and-pinion and scissor lifts, needs a lot of space. This mechanism enables the robot to change its height within a greater range while keeping a small size, so as to easily move around indoors. Our robot can change height from 65cm to 200cm (Figure 2-a), the range is 135cm, while for a conventional telepresence robot, such as Double [1], the range is just 30cm (120cm to 150cm).

The robot has an iron reel sitting on an omniwheel robot base, a 360-degree camera and a display (Figure 2-b). The camera and display are lifted by the vertical actuation mechanism. To push up or pull down the iron reel, we use four motors and one motor driver. For the base of the robot, we use the omni-wheel robot [1]. The omni-wheel robot and motor driver are operated by Arduino Uno. The robot is controlled wirelessly by a PC on the same network via the UDP protocol. We describe the benefit of the vertical actuation and using a 360-degree camera in the following sections.

Eye-level matching with vertical actuation

With vertical actuation, changing the height provides the following benefits. First, the robot can adapt its height to the context, like standing up or sitting down (Figure 1-c). It can make eye contact and conversation which is similar to face-to-face communication. Second, the user can extend the body in accordance with the users height. This represents the actual height of a remote user. Third, users can have an extraordinary experience (Figure 1-b) such as taking the viewpoint of a giant or a dwarf by stretching the robot to very high or very low height. Namely, the vertical actuation also enables human augmentation.

Free viewpoint through 360-degree camera view

Remote conversation is common in collaboration work, and previous studies [3, 4] shows that 360-camera views are useful to understanding a local environment. So we added the 360-degree camera and its wide omnidirectional view allows the remote user to overlook the local environment easily (Figure 1-b). The camera view is live streamed to the remote user and the user can change the angle at will.

[1] http://www.nexusrobot.com/product.php?id_product=87

DISCUSSION

Changing the height of the robot enables the following applications.

Collaboration work

It helps in collaboration work, such as a factory inspection. A highly located pipe, unreachable for inspection by the local user, could still be inspected by the remote user.

Designing society from another persons view

This system allows the remote user to see the world from different height. A child view, might enable finding dangerous furniture in a house or a bad sight location in a residential areas.

Sport Coaching

The vertical actuation removes a gap of physique in sport coaching. A coach can see the view of a athlete and teach more flexibly in sports that require accurate aiming dependant on body height, like golf, baseball or archery.

CONCLUSION AND FUTURE WORK

In this study, we propose a novel telepresence robot using vertical actuation. It allows for matching the eye-level between remote and local users. We also describe a set of usage scenarios which benefit from vertical actuation.

Our system has the following limitations. First, the display sways when the body is extended since its mounted on the top of the robot. We noticed that the swaying pattern, and natural frequency is different depending on the length. This may cause motion sickness, but some types of image stabilization technologies can resolve this issue. Second, because of weight limitations there is a performance limit of the camera and/or display. When the robot has too large a display or camera, the vertical actuation mechanism breaks when the robot is changing its height or moving. We will overcome these limitations in the next version.

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