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Development of a telepresence agent

Abstract

The concept of “telepresence” describes the combinations of technologies that send the “presence” of a human operator to a distant place, and provide the operator a feeling of actual presence in the distant place. It is an interesting field that combines virtual reality implementations with human-system interface, communication technologies and robot control systems. This paper describes an on-going project in Yuan Ze University, Department of Mechanical Engineering, for developing a “telepresence agent.” The telepresence agent is accessed and controlled through the Internet, using the user’s own biological signals. It is an extension of the distant user’s own body, which enables the user to deal with simple tasks in daily life at the remote site. Sensory feedbacks such as visual, audio or multi-functional tactile are also provided to create an immersive experience for the user. We also plan to add some human behavioral characteristics into the telepresence agent such as facial expression to increase its “humanity.” The final goal is that the user

and people in a distance place can feel the presence each other through the telepresence agent.

Keywords: telepresence, robot, Internet, virtual reality.

1. Introduction

"Telepresence" is an interesting field that combines virtual reality implementations with human-system interface, communication technologies and robot control systems. Early in 1983, Akin et al. [1983] defined telepresence as, "At the worksite, the manipulators have the dexterity to allow the operator to perform normal human functions. At the control station, the operator receives sufficient quantity and quality of sensor feedback to provide a feeling of actual presence at the worksite." Sheridan's [1986] definition of telepresence is, "Telepresence means visual, kinesthetic, tactile or other sensor feedback from the teleoperator to the human operator that is sufficient and properly displayed such that the human feels that he is present at the remote site, and that the teleoperator is an extension of his own body." Arvin et al. [1998] also defined telepresence as, "Telepresence has the ability to be present in another environment through the use and control of a system composed of local interfaces and remote devices such as vision and robots with mobility capabilities."

In summary, the concept of telepresence describes the combinations of technologies that send the "presence" of a human operator to a distant place, and provide the user a feeling of actual presence in the distant place. Figure 1 diagrams our current model of the telepresence system. The user in the control station obtains a real immersive experience from the worksite when he/she controls the robot system. According to Sheridan's suggestion [1992] that virtual presence is a function of three independent components. The first is the resolution of sensory channels, including visual, audio or tactile. The second component is the user's ability to move the sensor about in space. The third component is the capability to actually modify the relative positions of objects in the environment. All three components will be included in a "telepresence," typically a robot system that mimics human. With a sense of “being there,” the human operator can contact other persons in the remote site, visit anywhere, work, etc., even though he is not real there.

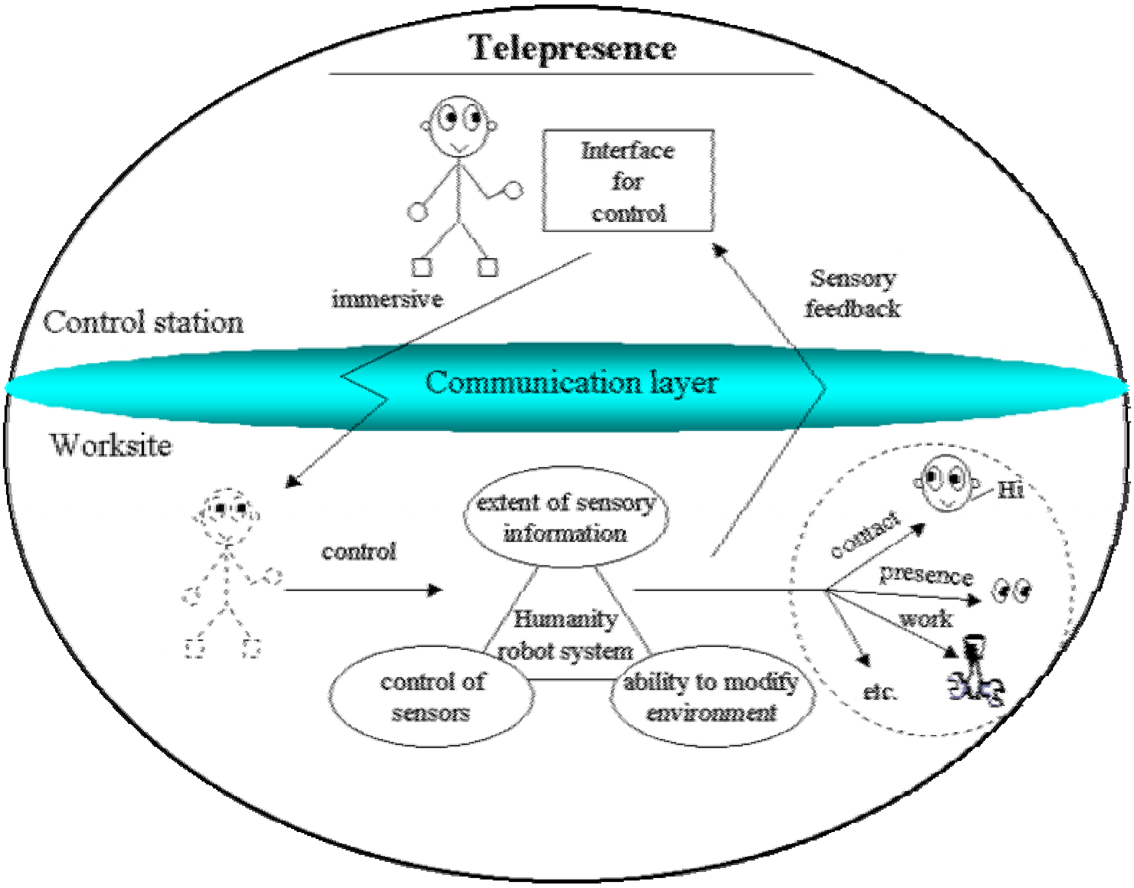

Figure 1. A model of the telepresence system

Methods of controlling the telepresence devices are not new. Radio waves were commonly used in early developments of telepresence devices. As the Internet has become the most important communication tool today, researches combining elements of the Internet and telepresence have attracted many attentions. Goldberg et al. [1994] developed a system in their Mercury Project, which consists of an industrial robot arm fitted with a CCD camera and a pneumatic system. It was the first to allow World Wide Web (WWW) users to manipulate a remote environment. They pointed out that the WWW provides a low-cost and widely available interface that can make teleoperated resources accessible to anyone with a desktop (or laptop) computer and modem.

Paulos et al. [1997] used a blimp as a telepresence device called “tele-embodiment” over a network. They combined the “lighter-than-air technology” for the remote robot with a wide-area network such as the Internet for ubiquitous and inexpensive telepresence. Their goal in this work was to provide a truly immersive experience for users tele-visiting a remote space. They felt that, barring some extremely extenuating circumstances, any system developed today should be accessible to the entire internet community.

Paulos et al. [1998] further presented a project called “PROP (Personal Roving Presence),” whose goal was to enable “personal telepresence.” They were interested in identifying and distilling a small number of human behavioral traits or skills that are inherent to human communication, understanding and interaction. The ultimate goal was to provide a reasonable degree of personal telepresence that allows humans to communicate and interact in a useful manner with remote people and places in ways beyond those available with current systems.

This paper describes an on-going project in Yuan Ze University, Department of Mechanical Engineering, for developing a “telepresence agent.” We consider the telepresence agent a vehicle for the transmission of “presence” between the control site and the remote site. The telepresence agent may have many different forms and applications, but the final goal is still to develop a robot system that mimics human. This robot is accessed and controlled through the Internet, using the user’s own biological signals. It is an extension of the distant user’s own body, which enables the user to deal with simple tasks in daily life at the remote site. Sensory feedbacks such as visual, audio or multi-functional tactile are provided to create an immersive experience for the user. We also plan to add some human behavioral characteristics into the robot such as facial expression to increase its “humanity.”

2. Critical technologies

There are three critical technologies that need to be developed in the telepresence agent project: human-system interface, Internet communication, and the robot control system.

2.1 Human-system interface

The goal of the human-system interface is to provide an interface to enable the user to send his/her presence to a remote site, and to receive enough sensory feedback from the remote site so that the user obtains an immersive feeling of being there. Specifically, the user should be able to send commands to and receive sensory feedback from the telepresence agent at the remote site through this interface.

As shown in Figure 2, there are two ways to send commands:

(1) Indirect control

By “indirect control” we mean that the user controls the telepresence agent through an extra controllable interface. Mouse, keyboard, and joystick are convenient tools for users to operate the telepresence agent using a common computer. Programming languages like JAVA, Visual C++, or Visual Basic to design software to provide different command options according to the telepresence agent’s abilities and functions.

(2) Direct control

“Direct control” means that the telepresence agent follows the user’s motions directly, so that the robot at the remote site synchronously mimics the user’s motion. To achieve this, we use the user’s biological signals to control the telepresence agent. Biological signals that are currently used in this project are head rotations, hand motions, steps of the legs, and the user’s voice. Sensors are used to detect the biological signals, and these signals are then converted into commands and sent to the telepresence agent.

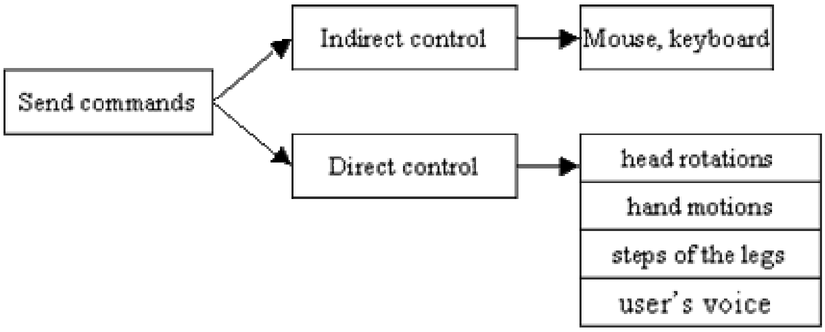

Figure 2. Two ways to send commands

Technically, we use a two-axis tilt sensor to detect the rotation of the user's head. This magnetic sensor has heading, roll, and pitch data. The roll and pitch data is converted into commands to control the rotational degrees of freedom of the CCD camera set upon the telepresence agent to synchronize with the motion of the user's head. This way the user can rotate his/her head to get what he/she wants to see at the remote site via the Internet. Data gloves are generally used to detect the degrees of freedom of fingers in Virtual Reality researches. We design a sample robot hand with three talons, which is controlled using the data gloves via the Internet. Our telepresence agent has a wireless controlled motor system, which expands its range of activity. A stepping machine with optics sensors is used to measure motions of the user's legs to synchronously control telepresence agent's mobility. We also plan to use the user's voice to control the facial expression of the telepresence agent to increase its humanity. The facial expression will be made of simple mechanisms or LEDs.

Sensory feedbacks are provided to give the user a sense of actual presence in the remote environment. As shown in Figure 3, visual and audio feedbacks are supported in our telepresence agent, while environmental data at the remote site like temperature, humidity, wind velocity, etc., are also displayed to the user.

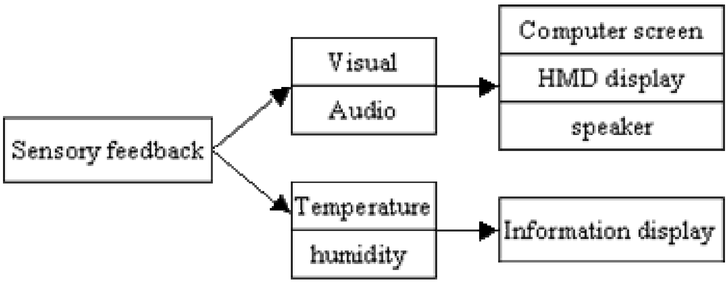

Figure 3. Sensory feedback provided in our telepresence agent

Visual and audio feedbacks are important and necessary. As mentioned earlier, the user can see through CCD that set upon the robot at the remote site. The field of view is controlled by the rotation of the user's head. A CCD camera with USB interface, which can play on computer directly like webcam, is used. As shown in Figure 4, an electrical wireless device is used to bridge the USB CCD camera and computer. We also plan to use a periscopic CCD camera to provide a wide-angle view similar to that of human eyes. In the mean time, a two-way stereo system can help the user to engage in remote conversations. Head mounted display (HMD) devices commonly used in virtual reality applications can give more reality to the user than receiving the visual feed back from a computer screen. HMD and the head rotation sensor can be integrated into one device.

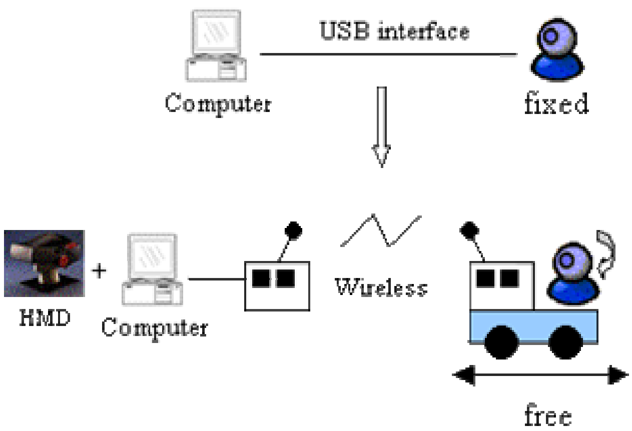

Figure 4. The wireless CCD camera

2.2 Internet communication

The Internet has become the most important communication tool today. Our telepresence agent also uses the Internet to send commands to and receive sensory feedbacks from the remote site, as shown in Figure 5. There is an IP and a server connected with each telepresence agent. A web page that integrates controlling programs is set up on the server. This web page can be one way or two ways. The user can log in this web page merely to receive visual and audio feedbacks embedded in the web page. In order to control telepresence agent at the remote site via Internet, CGI (Common Gateway Interface) programs are developed to complete the two-way bridge between client and server.

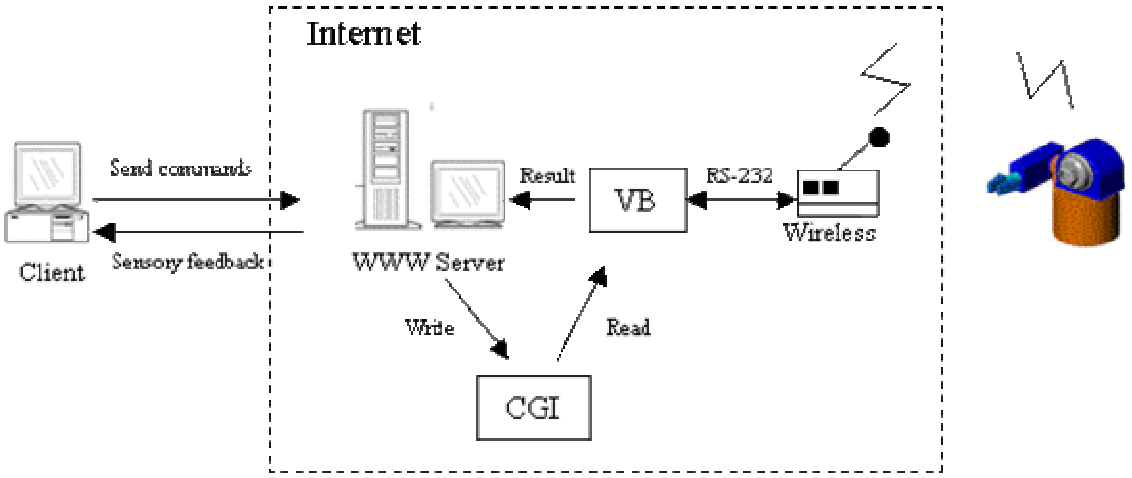

Figure 5. Internet communication service

The user can log in the web pages to visit his favorite true distant place through the telepresence agent, and sensory feedbacks are also sent back to the user via the Internet. The user operates the telepresence agent according to the visual feedback sent back from the remote site. Therefore Internet bandwidth is a deciding factor for the quality and speed of the visual feedback. How to integrate the telepresence agent with broadband technologies is an important issue.

2.3 Robot control system

Figure 6 diagrams the conception of the robot. A CCD camera is set upon a two-axis mechanism. Its motion is controlled be rotation of the head of the user. A robot hand with three talons is controlled by the motion of the hand of the user. A wireless controlled motor system gives the robot mobility so that it can move around to interact with people. The 8051 chips are used as the heart of the robot control system.

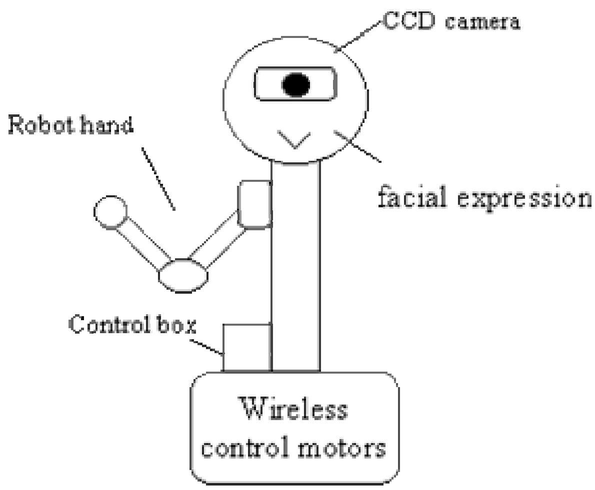

Figure 6. Conception of the robot

We plan to add human facial expression into the telepresence agent to transmit a richer representation of the remote user. We can use voice-controlled virtual electrical LED screen to display the user's facial expressions or we can simply set a LCD screen to display the user's real face.

3. Application examples

Figure 7 summarizes the technologies discussed in the previous section. The blocks at the outer circle represent the technology modules required in this project. Actually a selected combination of the technology modules can produce a unique telepresence application. Three application examples are described below:

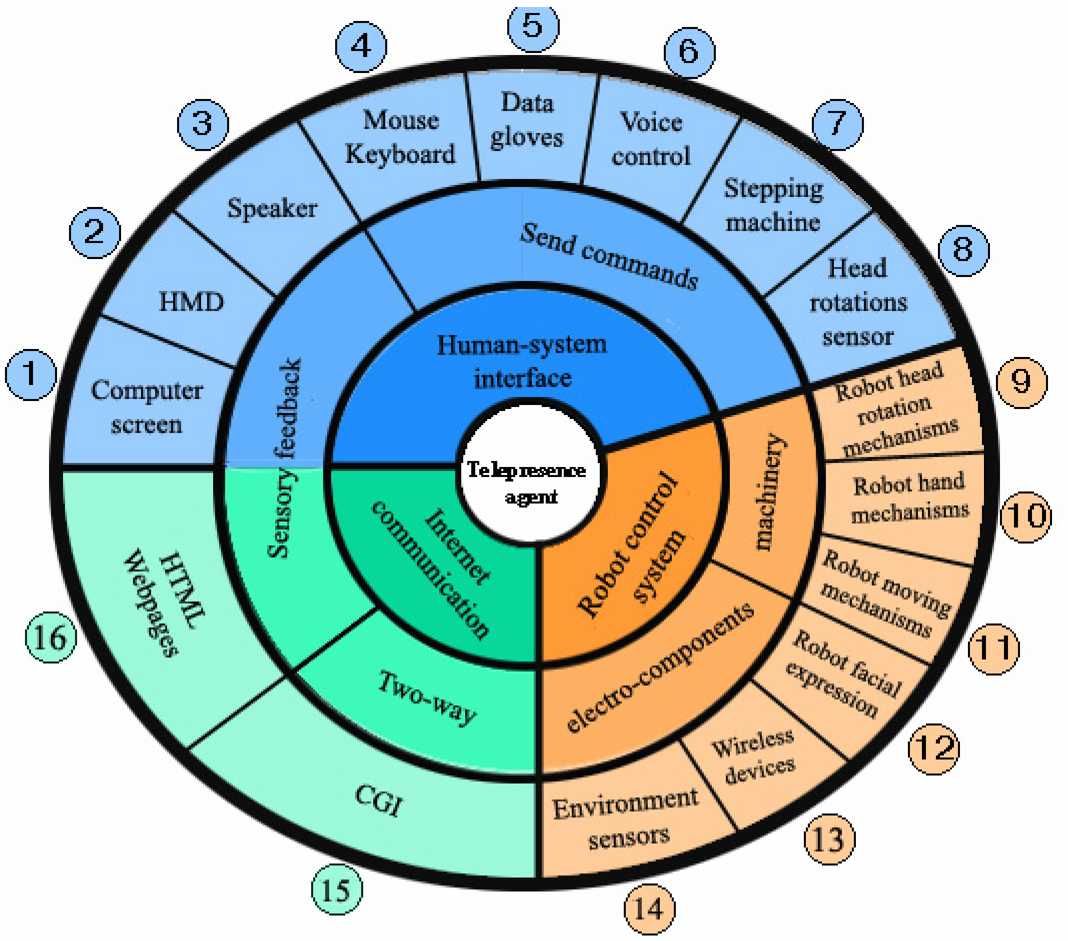

Figure 7. Technology modules required in the telepresence agent

An Internet remote monitoring system

As shown in Figure 8, technology modules 1, 4, and 15 can be combined to produce an Internet monitoring system, which is a very common telepresence application. A CCD camera is set up in the site to be monitored. Users can log in the web page and technology module 16 provides direct visual feedback.

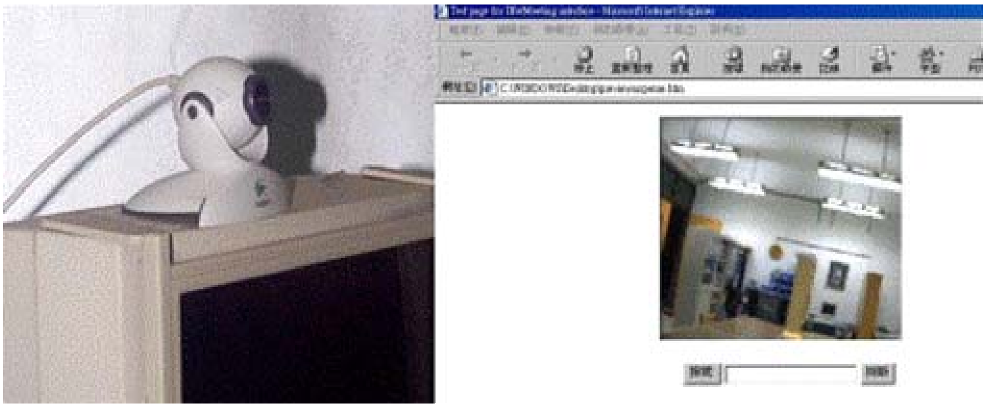

Figure 8. An Internet remote monitoring system

<u>A telepresence agent with no mobility</u>

Figure 9 shows a telepresence agent with no mobility, which includes technology modules 2, 3, 4, 5, 8, 9, 10, 15 and 16. This telepresence agent only has a two-axis CCD camera (module 9) and a hand with three talons (module 10). After login in the server connected with the telepresence agent, the user can use mouse and keyboard to control the CCD camera and the robot hand (module 4, 15), and receive visual feedback from the computer screen (module 1, 16). Or the user can wear an HMD with the rotations detector to synchronically control the CCD camera (module 8, 9, 15) to obtain views he/she is interested in the HMD (module 2, 16). The user can also wear the data glove to synchronically control the hand with three talons (module 5, 10, 15).

Figure 9. A telepresence agent with no mobility

<u>An Internet racing-car game</u>

Figure 10 shows another application, an Internet racing-car game, which combines technology modules 1, 3, 4, 11, 13, 15 and 16. In this application, we add mobility to our telepresence agent, the racing car in this case. We design a racing car with a wireless controlled motor system (module 11, 13) and a wireless CCD camera (module 9, 13). We also build an exciting racing place as the remote site our telepresence agent is visiting. After login in the server connected with the telepresence agent, the user can use mouse and keyboard to control the telepresence agent, the racing car to move around in the remote site (module 15), and receive visual feedback from the computer screen (module 16).

Figure 10. An Internet racing-car game

A first generation telepresence agent

Figure 11 shows our recent achievement, the first generation telepresence agent, which includes technology modules 1, 3, 4, 9, 11, 12, 13 and 16. It has a two-axis CCD camera (module 9) and free mobility (module 11 and module 13), both are controlled by a joystick through Internet (module 4). With this agent, the user can move freely in the remote site to observe whatever he/she is interested in, in a position and angle he/she prefers. More importantly, this agent also incorporate two-direction Audio and Video communication (module 3 and module 12), so it has become an internet communication tool which enables people in the remote site to better feel the user's “presence”.

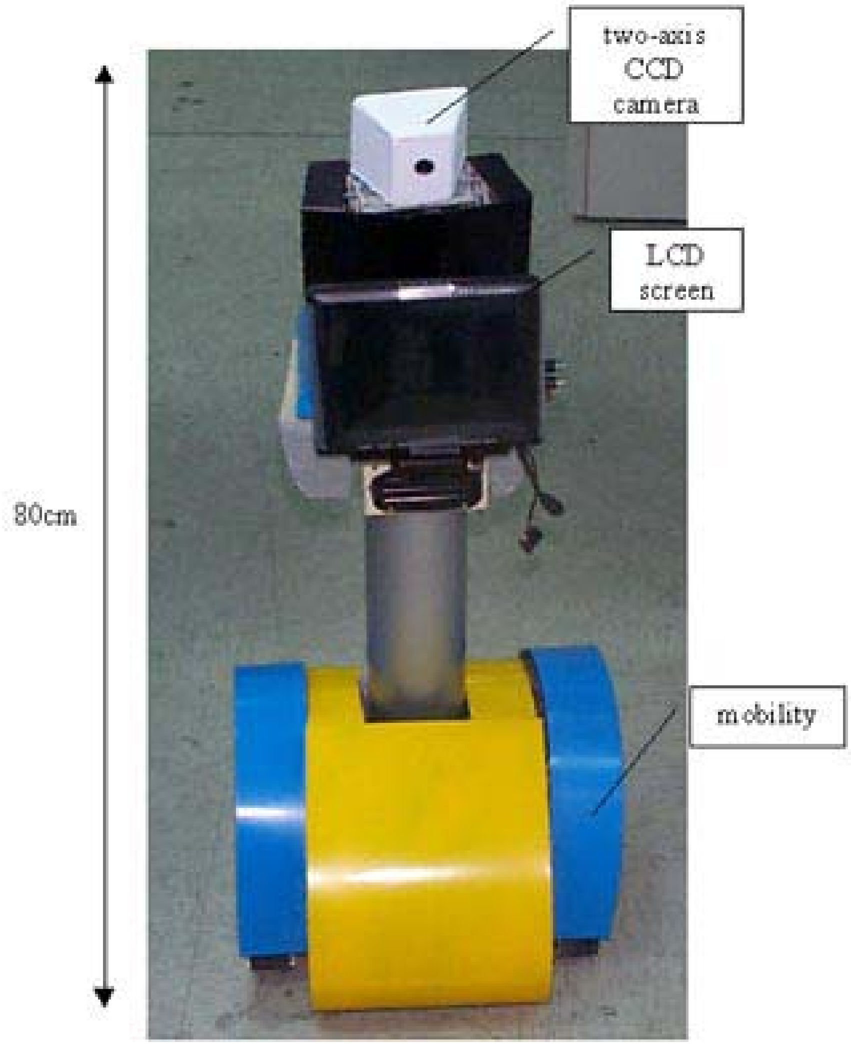

Figure 11. A first generation Telepresence agent

4. Conclusions and future work

Our claim is that telepresence agent is a useful, functional assistant for supporting human presence and interaction at a distance. It finds applications in security monitoring, health care, elderly care, and even entertainments. Now we have presented a first generation telepresence agent. In the future, we will be developing all the technology modules and construct the "full-function" telepresence agent. In the mean time, we will try to find combinations of technology modules that might produce useful telepresence applications.

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