

*Developing a telepresence robot for
interpersonal communication
with the elderly
in a home environment*

Ph.D. thesis oral examination

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Research issues

- ① *Design of Telepresence robot*
- ① *Interpersonal communication*
- ① *Interaction with elderly*
- ① *Suitable at home*

The earliest research in telepresence in the 1960'

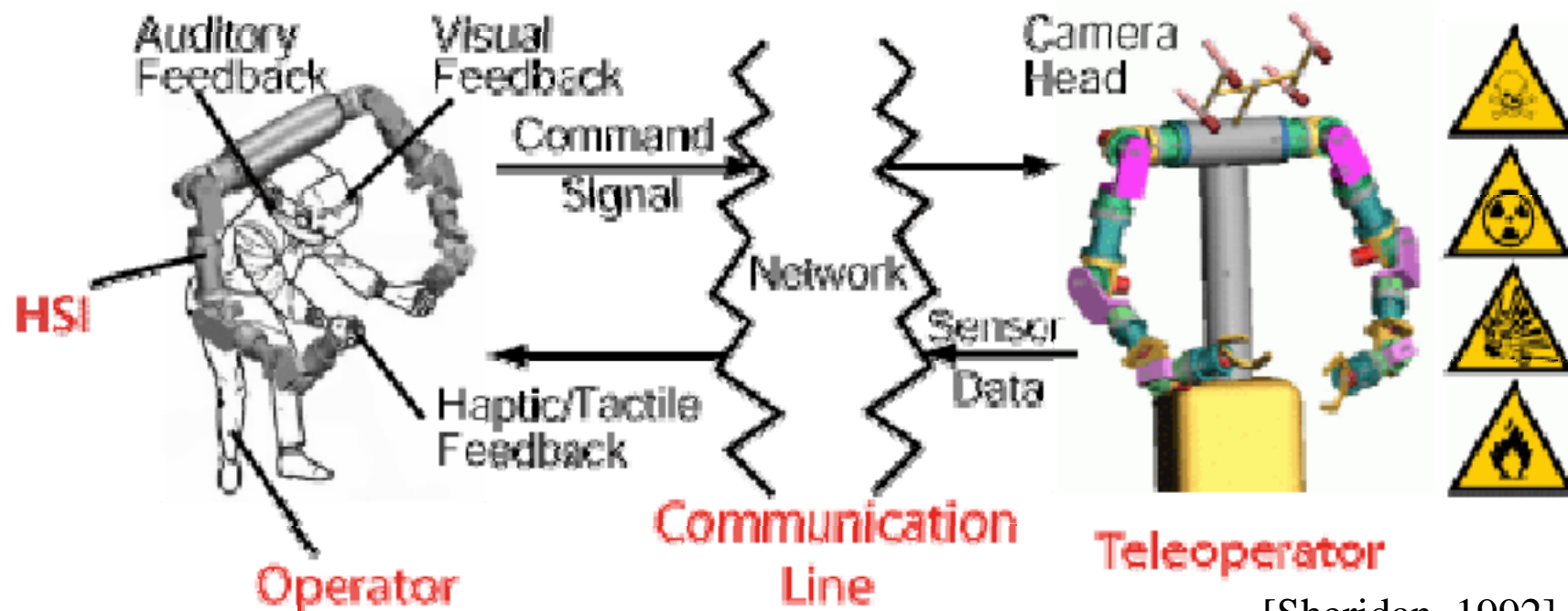
- ✓ A video display is fixed relative to the operator's head.
- ✓ The head's own pan-and tilt drives the camera pan-and tilt.
- ✓ The operator feels as if she were physically present at the location of the camera, however remote it is.



[Goertz, 1965]

Definition of Telepresence

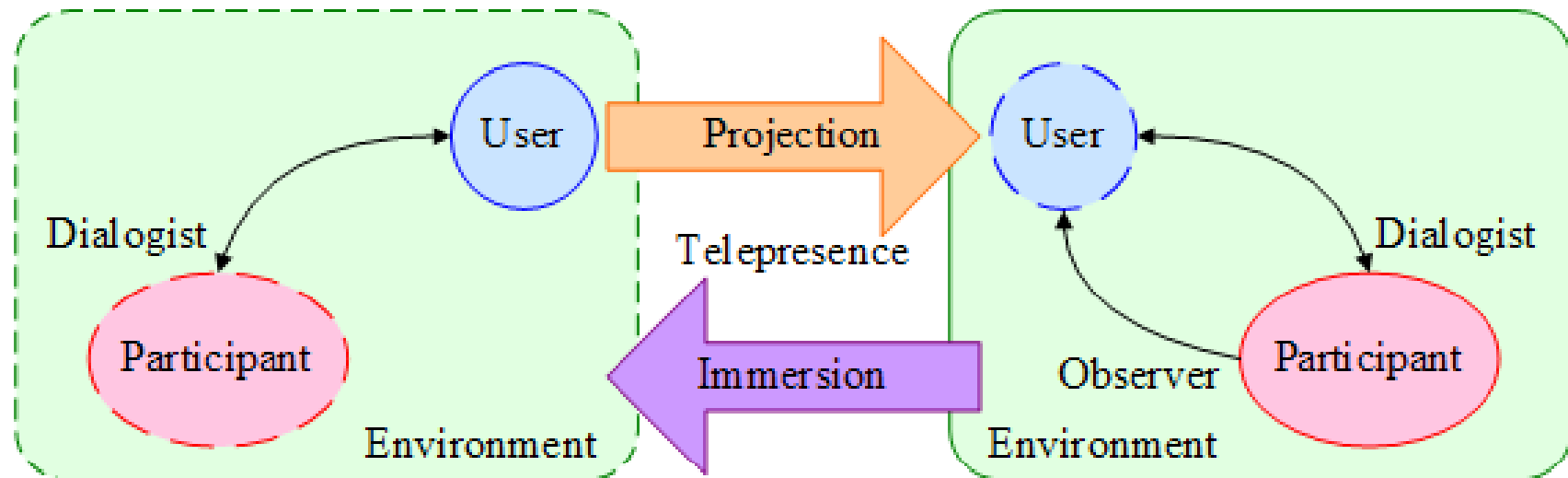
- ✓ MIT, *Sheridan* defines telepresence as: “...visual, kinesthetic, tactile or other sensory feedback from the teleoperator to the human operator that is sufficient and properly displayed such that the human feels that he is present at the remote site, and that the teleoperator is an extension of his own body.”



[Sheridan, 1992]

Telepresence in interpersonal communication

- ✓ The user's view: projection - immersion
- ✓ The participant's view: observer - dialogist
- ✓ Establish a true sense of shared space among geographically remote persons.



Service robots for supporting psychological consolations

- ✓ Service robots have much more interaction with human beings than industrial robots.



MAid [2004]

(Mobility Aid for **Elderly** and Disabled People)



Interactive autonomous robot, *Paro* [2004]

- ✓ Physiological assistance and psychological consolations
- ✓ Improve Activities of Daily Living (ADL) and Quality Of Life (QOL)

Telepresence robot applications in medical care



Re-engineering the patient care process

Patients can now return home sooner

InTouch Health
Increased throughput



Dr. Robot [2005]

- ✓ 160cm
- ✓ 100kg
- ✓ \$150,000
- ✓ 120 Dr. Robots used in some hospitals.



Dr. Robot in Show-Chwan Memorial Hospital [2006]

Telepresence robot applications in medical care

- ✓ Providing Education by Bringing Learning Environments to students
(PEBBLE) [2004]



PEBBLES helps student attend class



Student's face displayed on the PEBBLE screen as she participates in class

Purposes of this research

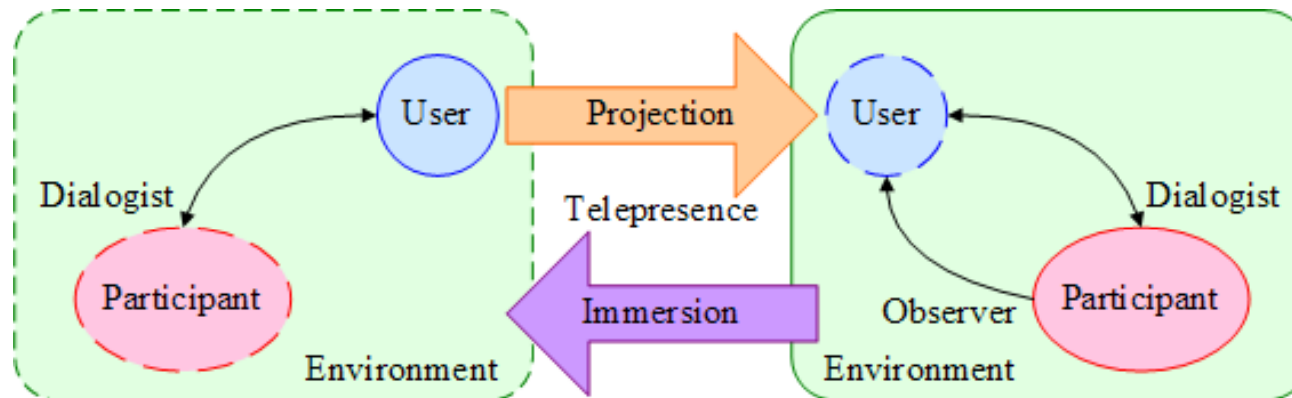
- (1) To create a physical telepresence robot for engaging user and participant in natural social communication scenarios.
- (2) To study how users' verbal and nonverbal communication elements can be expressed through *TRIC*.
- (3) To investigate how *TRIC* can interact with remote participants effectively.

TRIC, Telepresence Robot for Interpersonal Communication

- ⊙ Design of telepresence robot
- ⊙ Interaction with elderly
- ⊙ Interpersonal communication
- ⊙ Suitable at home

Design elements for telepresence literatures

- ✓ Telepresence in interpersonal communication.



Design elements	
Data transmission	Teleoperation
Supersensory	Anthropomorphic elements
Stereoscopic elements	Stereophonic elements
Eye contact	Autonomous behaviors

Reference: 200 articles

Design elements - Data transmission

- ✓ Basic design element
- ✓ Transmission of control commands and sensory feedback
- ✓ Connection between the users and a remote telepresence robot or system

Design elements	Related technology details
Data transmission	RF and Internet transmission, time-delay improved algorithm

[Tzafestas & Prokopiou, 1997; Daniel & McAree, 1998]

Design elements - Teleoperation

- ✓ Enable the user to modify the remote environment.
- ✓ A teleoperator extends the user's sensing and/or manipulating capability to a location remote from that user.



(FITT)

Robonaut [Rehnmark et al., 2005]

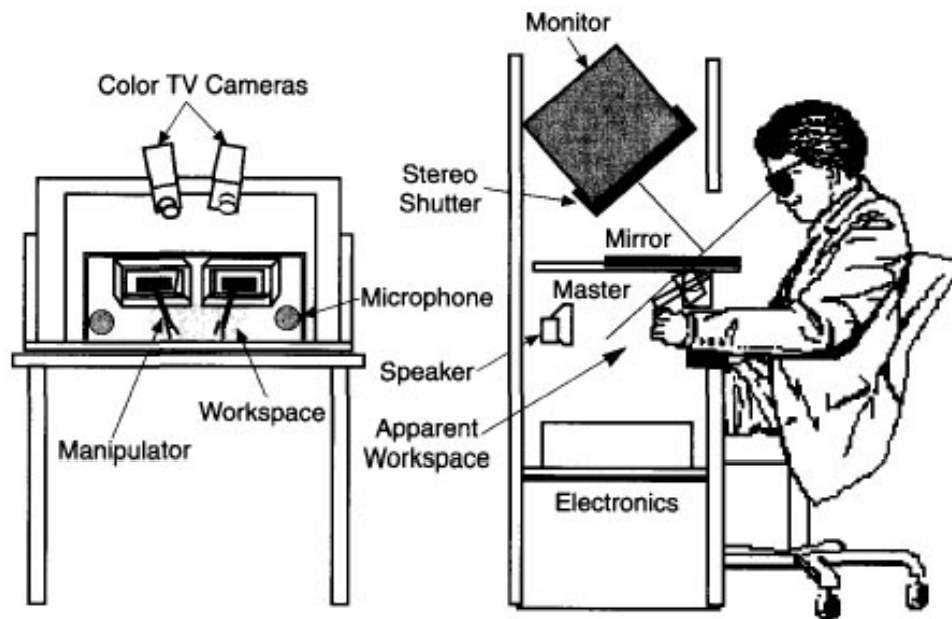
Full-Immersion Telepresence Testbed

Design elements	Related technology details
Teleoperation	simultaneous operation, robotic design

[Stoker et al., 1995; Engelberger, 2001; Spudis, 2001]¹²

Design elements - Supersensory

- ✓ Advanced capability to modify the remote environment.
- ✓ Scaled motion, force reflection and friction minimized.



Remote surgical unit and surgeon's console [Green, 1995]



da Vinci® Surgical System [2005]

Design elements	Related technology details
Supersensory	dexterous mechanism

Design elements - Stereoscopic and stereophonic elements

- ✓ User can identify the distance by binocular vision.
- ✓ Enable user to identify the location and direction of a sound.



Visual communication and telepresence. Rhee et al. [2007]

Design elements	Related technology details
Stereoscopic elements	binocular and panoramic vision, image processing
Stereophonic elements	head-related transfer function, stereo audio

[Brooker et al., 1999; Hawksford, 2002; Izquierdo, 1997; Ohm et al., 1998; Xu et al., 1999]⁴

Design elements - Anthropomorphic elements

- ✓ To improve the interaction between robots and participants.
- ✓ It is arguable whether the LCD display is an anthropomorphic element.



Dr. Robot (2005)



PEBBLE (2004)



Kismet (2006)

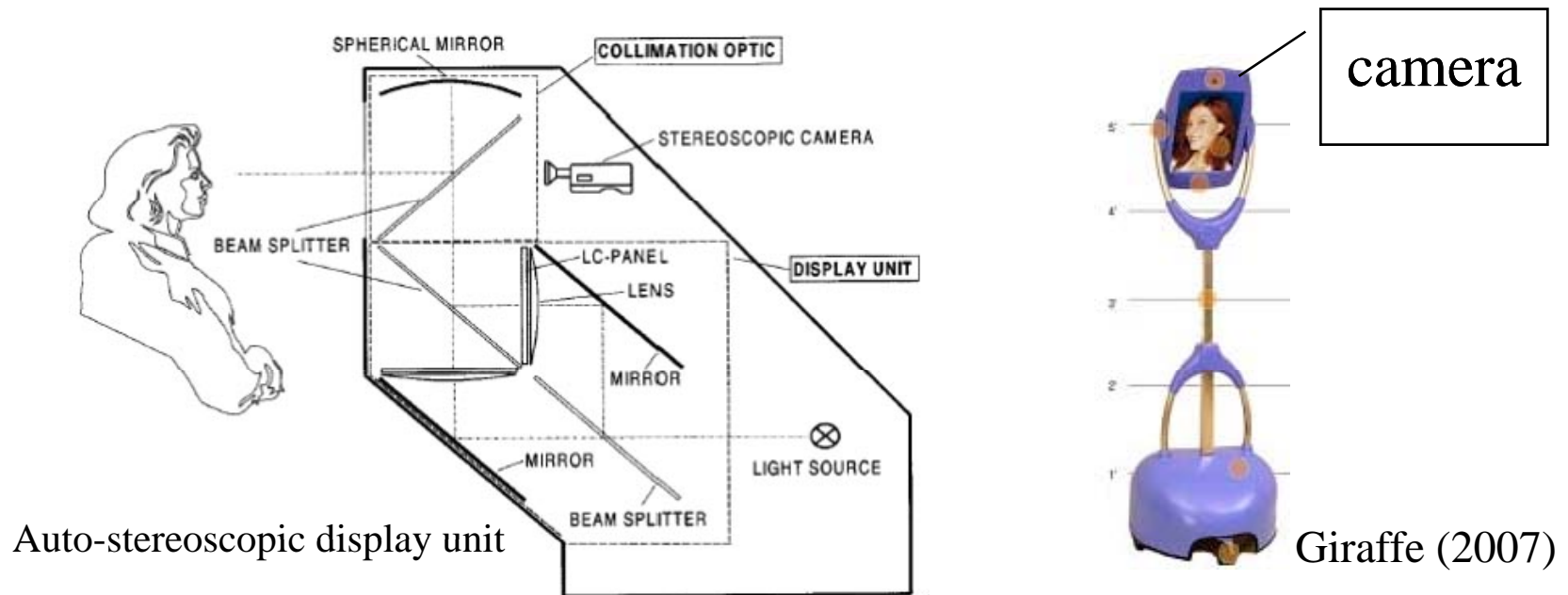
- ✓ Mechanical facial expressions can be used to increase the humanoid characteristics of robot [Fong et al., 2003]

Design elements	Related technology details
Anthropomorphic elements	humanoid mechanism and expression

[Burgard et al., 1999; Schulz et al., 2000; Tachi et al., 2003; Trahanias et al., 2005]15

Design elements - Eye contact

- ✓ The placement of the camera on a telepresence robot is usually on top of the LCD screen, which hinders direct eye contact.

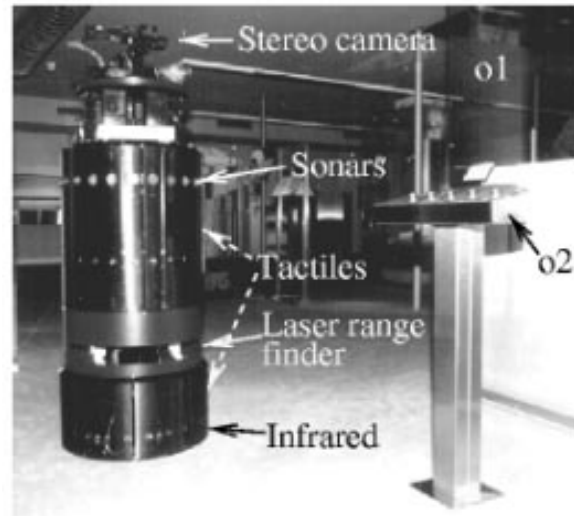


- ✓ Eye contact is an important element for face-to-face communication.

Design elements	Related technology details
Eye contact	camera and screen with specific placement

Design elements - Autonomous behaviors

- ✓ Telepresence robot should be able to deal with possible hazardous situations autonomously.
- ✓ Software architecture which integrates localization, mapping, collision avoidance, planning and etc.



An interactive museum tour-guide robot, pleasing the crowd

Design elements	Related technology details
Autonomous behaviors	Environmental map establishment, self-maintenance capability

[Burgard et al., 1999; Schulz et al., 2000; Trahanias et al., 2005]¹⁷

Design elements included in TRIC

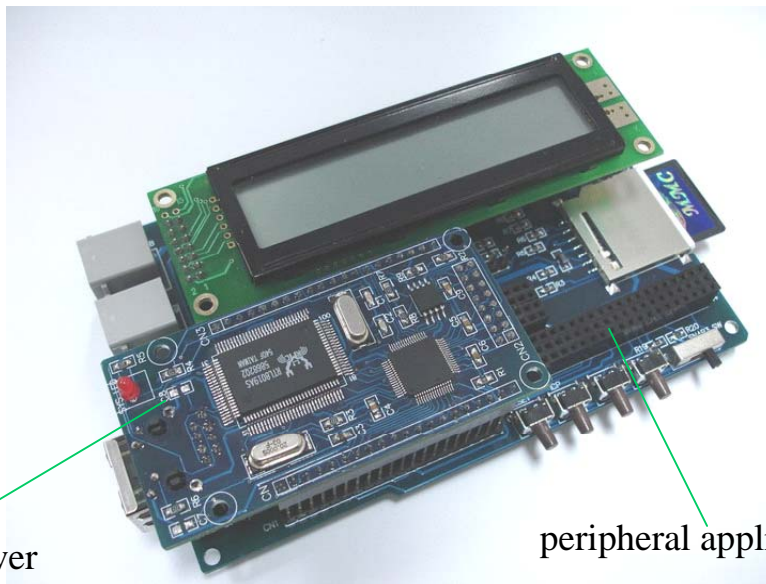
- ⊙ Design of telepresence robot
- ⊙ Interaction with elderly
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- ⊙ Suitable at home

Design elements	Corresponding Technological Strategies
Data transmission	use MDS for the core of system
Teleoperation	design of mobility platform
Supersensory	provide zoom of IP cam, implement various sensors for environment detection
Anthropomorphic elements	design of humanoid appearance and interactive behaviors
Stereoscopic elements	Not included
Stereophonic elements	Not included
Eye contact	control <i>TRIC</i> to gaze at participant
Autonomous behaviors	share control authority to participant and environment

Design elements for TRIC – Data transmission

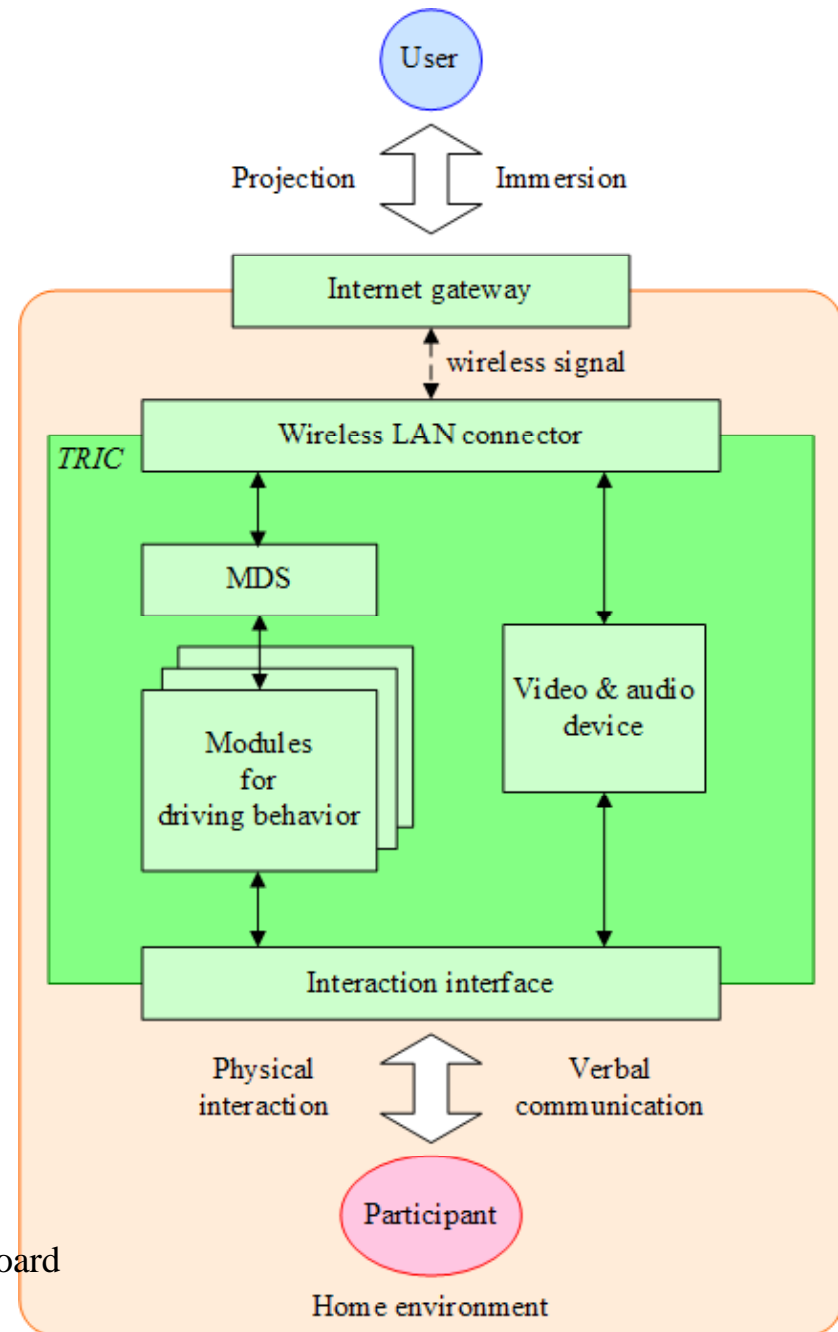
Mobile Data Server (MDS)

- ✓ Core of *TRIC*
- ✓ PIC based
- ✓ Networking capability
- ✓ Web server for multi users to log in
- ✓ Low-cost, reliable in home environment



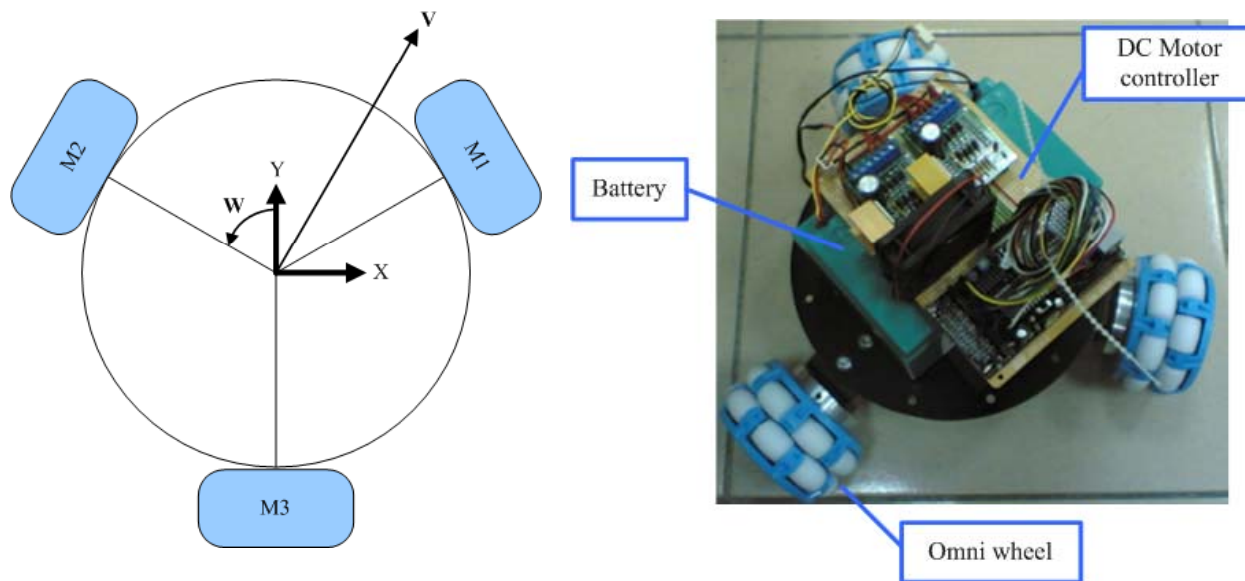
PIC Server

peripheral application board



Design elements for TRIC – Teleoperation

- ✓ **Teleoperation** allows the user to move *TRIC* through the environment while controlling the pan and tilt of the IP camera from a remote client PC.



Omni-directional wheeled platform

- ◎ **Design of telepresence robot**
- ◎ **Interaction with elderly**
- ◎ **Interpersonal communication**
- ◎ **Suitable at home**

Design elements for TRIC – Eye contact, Anthropomorphic elements, Autonomous behavior

- ✓ The camera on *TRIC* is packaged into a “head” with humanoid expression, which also facilitate the design of “**eye contact**” because the camera is indeed the “eye” of *TRIC*. User controls *TRIC* to gaze at participant.
- ✓ **Anthropomorphic elements** enhance the impression of *TRIC* as a true representation of the remote user.
- ✓ **Autonomous behavior** increases the user’s operating capability and reduce the user’s workload during operation.

- ⊙ Design of telepresence robot
- ⊙ Interaction with elderly
- ⊙ **Interpersonal communication**
- ⊙ Suitable at home

Design elements for TRIC – Supersensory, Stereoscopic, Stereophonic

- ✓ **Supersensory** ability is reflected in the zooming capability of the IP cam. Sensing capability of the various sensors installed for environment detection.
- ✓ **Stereoscopic** and **stereophonic** elements have been omitted to keep *TRIC* a low-cost, affordable homecare robot.

⊙ Design of telepresence robot

⊙ Interaction with elderly

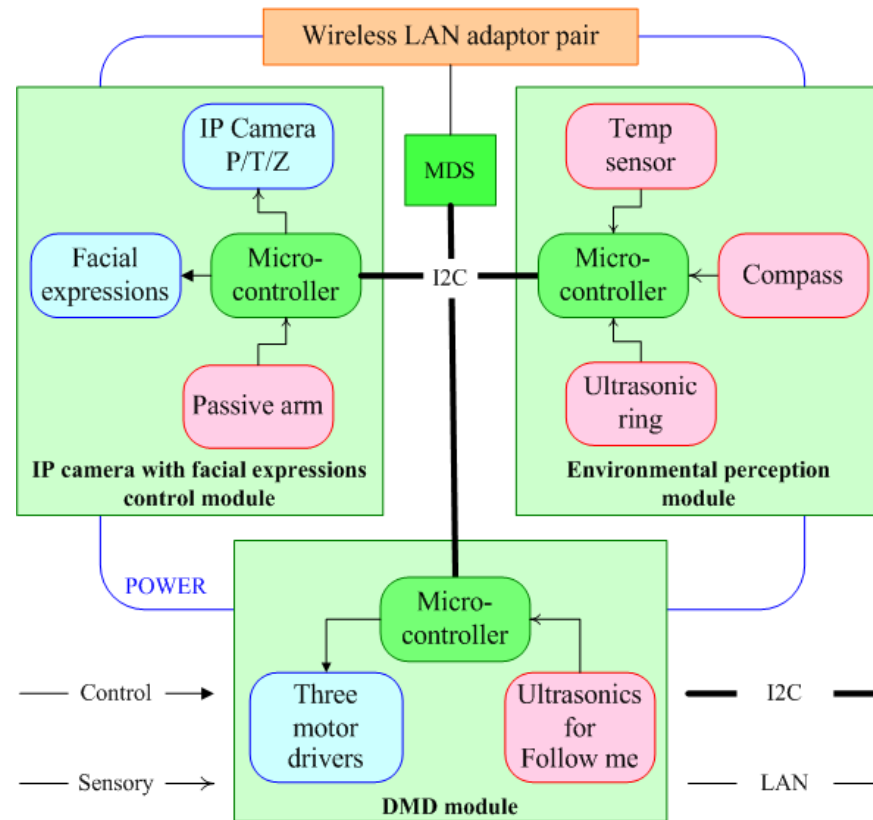
⊙ Interpersonal communication

⊙ **Suitable at home**

Design of TRIC



Prototype of *TRIC*



Hardware architecture of control system

L×W×H	380×380×700mm	Varied speed	10~25cm/sec
Weight	6.5kg	Turning radius	0 cm

Design of TRIC



Anthropomorphic design of *TRIC*



Control interface design of *TRIC*

- ✓ ADSL and Wireless Local Area Network (WLAN).
- ✓ A physical IP address.
- ✓ Control interface for connecting *TRIC*.

Purposes of this research

(1) To create a physical telepresence robot for engaging user and participant in natural social communication scenarios.

→ Telepresence in interpersonal communication.

→ Design elements for telepresence literatures.

→ Design elements included in *TRIC*.

→ Design of *TRIC*.

Purposes of this research

(2) To study how users' verbal and nonverbal communication elements can be expressed through *TRIC*.

(3) To investigate how *TRIC* can interact with remote participants effectively.

→ Evaluation for usability of *TRIC* for the remote user.

→ Evaluation of subjective impression of *TRIC* from participants.

⊙ Design of telepresence robot

⊙ Interaction with elderly

⊙ Interpersonal communication

⊙ Suitable at home

Evaluation for usability of TRIC for the remote user

- ✓ An objective evaluation for assessing **usability** and **functionality** of *TRIC*.

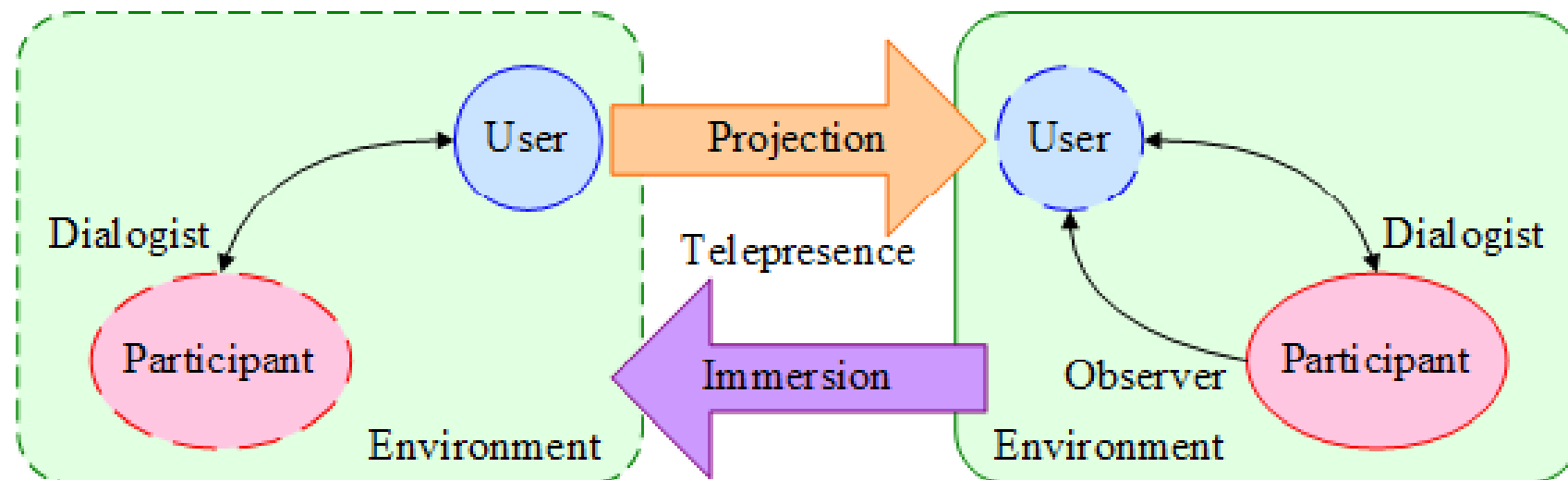
10 subjects

Task A	Trial 1	Trial 2	Trial 3
Average time (sec)	47	34	31
Efficiency	61.7%	85.3%	93.5%
Task B			
Average time (sec)	154	121	113
Efficiency	61.0%	77.7%	83.2%
Task C			
Average time (sec)	92	68	69
Efficiency	70.7%	95.6%	94.2%

“optimal time” achieved by a skilled user

- ✓ It can be assumed that **new users** are able to effectively achieve three tasks using *TRIC*, while improving with as little as 3 attempts.

The user controls *TRIC* to interact with the participant



Evaluation of subjective impression of TRIC from participants

- ✓ Subjects (observers) were asked to **observe** the interaction between the participants (dialogists) and *TRIC*.

A-1. Do you like the appearance of <i>TRIC</i> ? No ___ ___ ___ ___ ___ Yes (1-5 scale).
A-2. How do you feel about <i>TRIC</i> 's height? Short ___ ___ ___ ___ ___ Tall (1-5 scale).
A-3. How do you feel about <i>TRIC</i> 's figure? Fat ___ ___ ___ ___ ___ Thin (1-5 scale).
A-4. Do you like the way <i>TRIC</i> moves? No ___ ___ ___ ___ ___ Yes (1-5 scale).
A-5. Do you think <i>TRIC</i> is suitable in your home? No ___ ___ ___ ___ ___ Yes (1-5 scale).

- ✓ 81% (up to 3) of subjects like the appearance of *TRIC*.
- ✓ 84% (up to 3) of subjects like the way *TRIC* moves.
- ✓ 85% (up to 3) of subjects (observers) felt that *TRIC* is suitable in their **home** environment.

Evaluation of subjective impression of TRIC from participants

- ✓ The operator controlled *TRIC* to **communicate with** subjects (dialogists) for opinions on their final exam.

Experience of interacting with the remote operator through <i>TRIC</i>	
B-1. Was the conversation behavior clear and understandable? (Yes/No)	Yes: 100%
Experience of using instant messenger to interact with another person	
C-1. Was the conversation behavior clear and understandable? (Yes/No)	Yes: 93%

- ✓ 100% subjects (dialogists) agreed that the conversation with *TRIC* was clear and understandable.
- ✓ *TRIC* is effective as a **verbal** communication tool.

Evaluation of subjective impression of TRIC from participants

- ✓ Users' **nonverbal** communication elements were expressed through *TRIC*.

Experience of interacting with the remote operator through <i>TRIC</i>	
B-2. Did you notice the facial expression of <i>TRIC</i> during conversation?	Yes: 89%
B-3. Did you notice the body movement of <i>TRIC</i> during conversation?	Yes: 81%
B-4. Did <i>TRIC</i> look at you when you speak (eye contact)?	Yes: 86%
Experience of using instant messenger to interact with another person	
C-2. Did you notice the facial expression of the other person during conversation?	Yes: 93%
C-3. Did you notice the body movement of the other person during conversation?	Yes: 77%
C-4. Did the other person look at you when you speak (eye contact)?	Yes: 58%

✓ During conversation through *TRIC*, most subjects (dialogists) noticed the important communicative cues for **gaining attention** and **attracting interest**.

✓ When using an instant messenger, only 58% of the subject responded that they felt the eye contact.

Evaluation of subjective impression of TRIC from participants

- ✓ Implications of *TRIC*'s physical embodiment.

Experience of interacting with the remote operator through <i>TRIC</i>	
B-5. Do you think you can touch the head and body of <i>TRIC</i> ? (Yes/No)	Yes: 58%
B-6. Do you think <i>TRIC</i> can go around you and see what's in your back? (Yes/No)	Yes: 82%
Experience of using instant messenger to interact with another person	
C-5. Do you think the other person can look at the view outside your window?	Yes: 35%

- ✓ 82% of the subjects (dialogists) felt that *TRIC* shared the same **space** with them.
- ✓ *TRIC*'s physical **embodiment** provided different feeling of existence from using instant messenger.

Evaluation of subjective impression of TRIC from participants

- ✓ To recognize the *TRIC* as a representation of the operator.

Experience of interacting with the remote operator through <i>TRIC</i>	
B-7. Who did you communicate with? (<i>TRIC</i> /operator in remote site)	<i>TRIC</i> : 42%
Experience of using instant messenger to interact with another person	
C-6. Where was the other person? (Your home/A remote place)	Your home: 11%

- ✓ 42% of subjects (dialogists) felt that they were talking to **a person right here**.
- ✓ Only 11% of the subjects reported the same impression when using an instant messenger
- ✓ *TRIC* successfully gave the **user** a **physical representation** for communication and interaction with **participants** (dialogists).

Conclusions

- ✓ This research presents the development of a telepresence robot *TRIC*.
- ✓ There are three roles in telepresence robot for interpersonal communication: user, telepresence and participant.
- ✓ The design elements could be useful in understanding of telepresence.
- ✓ New users were able to effectively navigate *TRIC* and easily locate visual targets.
- ✓ A large percentage of the participants noticed the facial expression, body movement and eye contact from *TRIC*.
- ✓ *TRIC* successfully gave the remote user a physical representation for communication and interaction with the participant.

Future works

- ✓ To investigate the interaction between elderly participants and *TRIC*.
- ✓ To perform further tests in domestic environments for assessing objective functions

◎ Design of telepresence robot

◎ **Interaction with elderly**

◎ Interpersonal communication

◎ **Suitable at home**

Thank you for your attention

