

Telexistence avatar robot TELESAR VI and its application to telemedicine



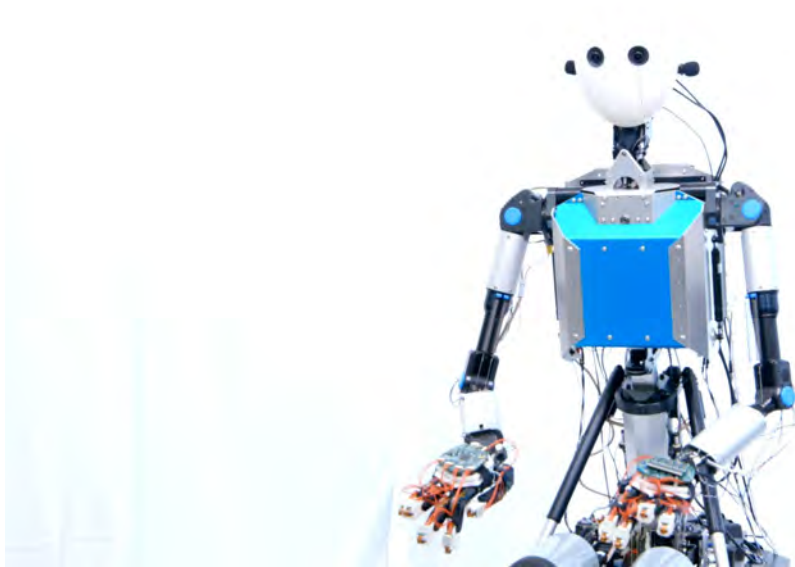
Fumihiro Kato, Ph.D.

Assistant professor, Waseda University, Japan

Invited Talk
IEEE ICRA2023
2nd Workshop on Toward Robot Avatars
2023.6.2 (Fri.) 9:10

Telexistence : Concept and Definition

- telexistence = tel +existence
- tele- or tel- = Distance; distant
- existence = The fact or state of existing; being
- Telexistence = Virtual existence in a remote place



Telexistence is an extended concept of Presence and Existence

Real World



He perform like he is!
=> Sense of Existence

Sense of Presence

Virtual World

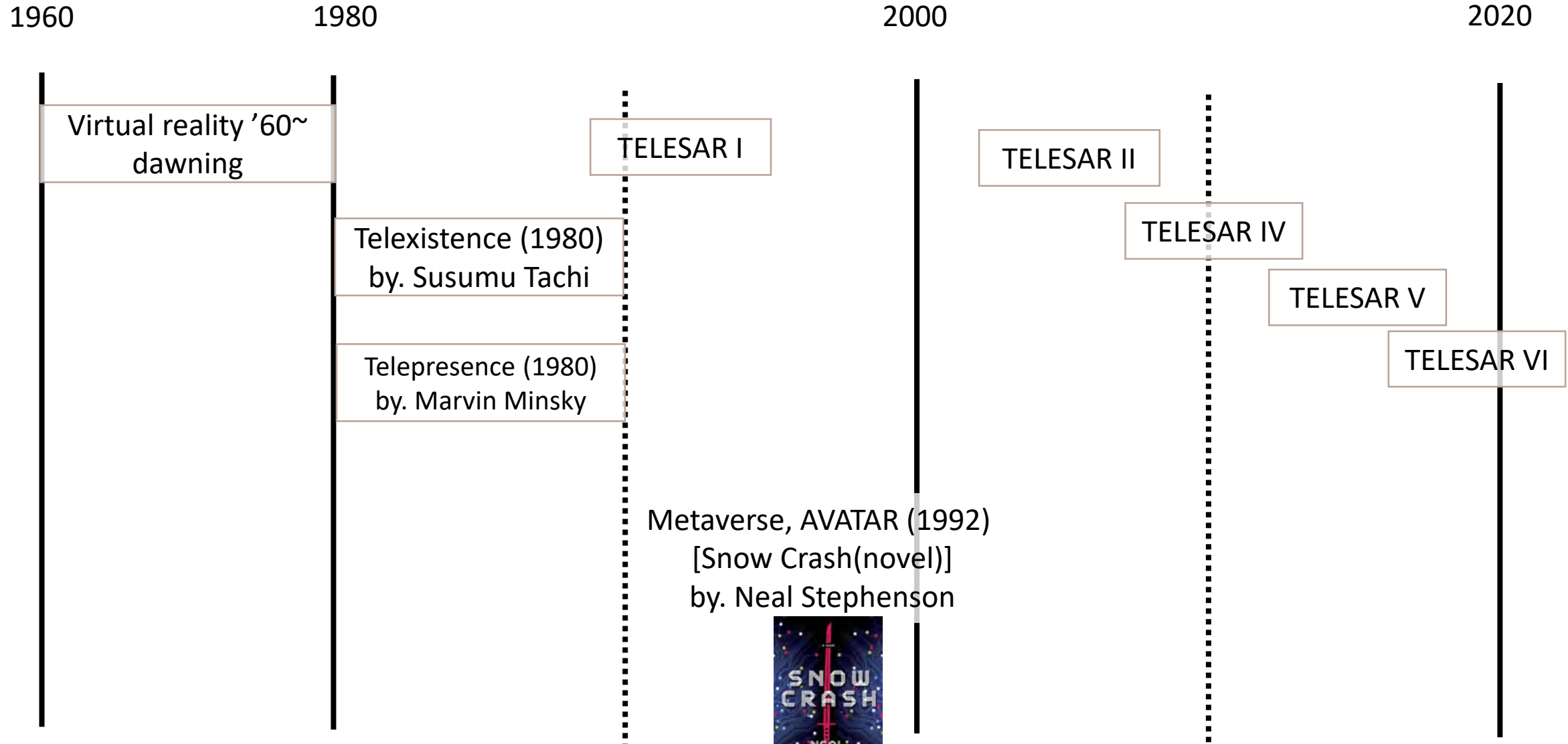


Remote collaborator



Operator

Telexistence was proposed by Professor Susumu Tachi in 1980

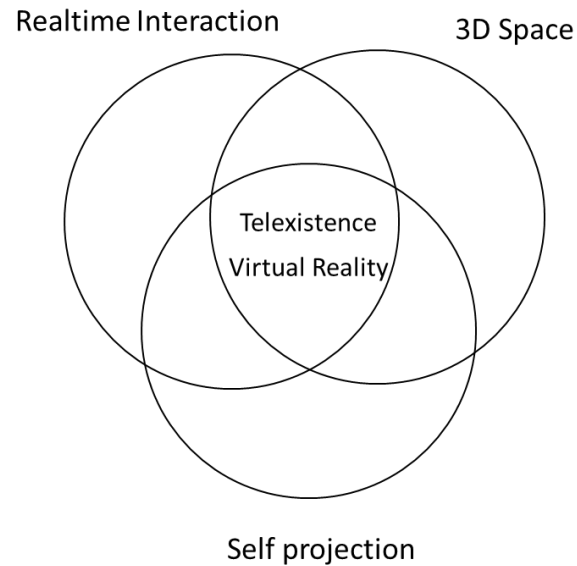


Telexistence, Telepresence, Metaverse, VR have much in common

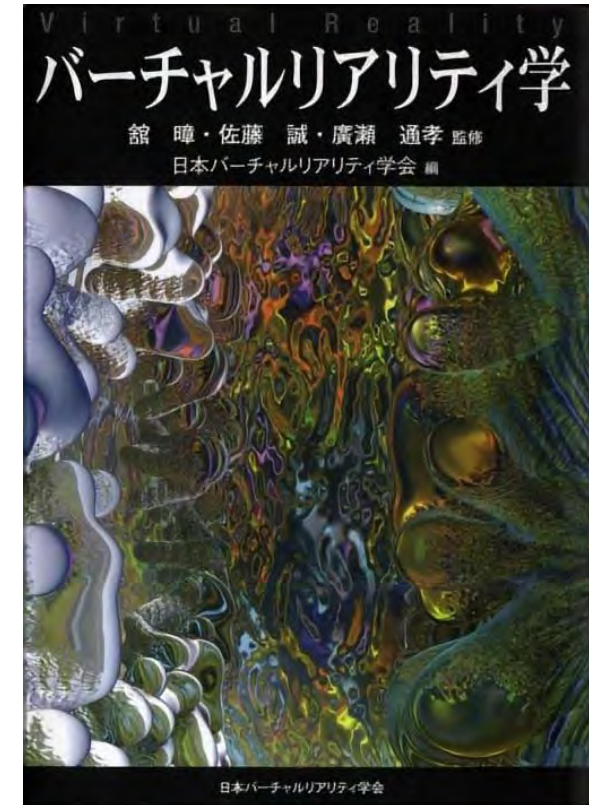
- *3D spatiality, real-time interactivity, self-projection*

Variations on the 3D spatiality;

Telexistence	:	real and simulated environments
Telepresence	:	real environments
Virtual reality	:	simulated
Metaverse	:	simulated



Three elements of telexistence and VR

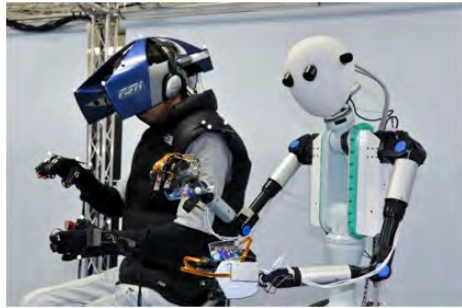


Susumu Tachi et. al.
Virtual Reality
VR Society JAPAN & CORONA PUBLISHING
CO.,LTD.
ISBN-978-490-4490-05-1

From TELESAR V to TELESAR VI



Development of TELESAR series somatic telexistence platforms

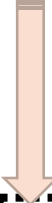


TELESAR V (53-DOF)



The flagship Surrogate AVATAR Robot for Telexistence.

The benefits of simplification ease prototyping for telexistence.

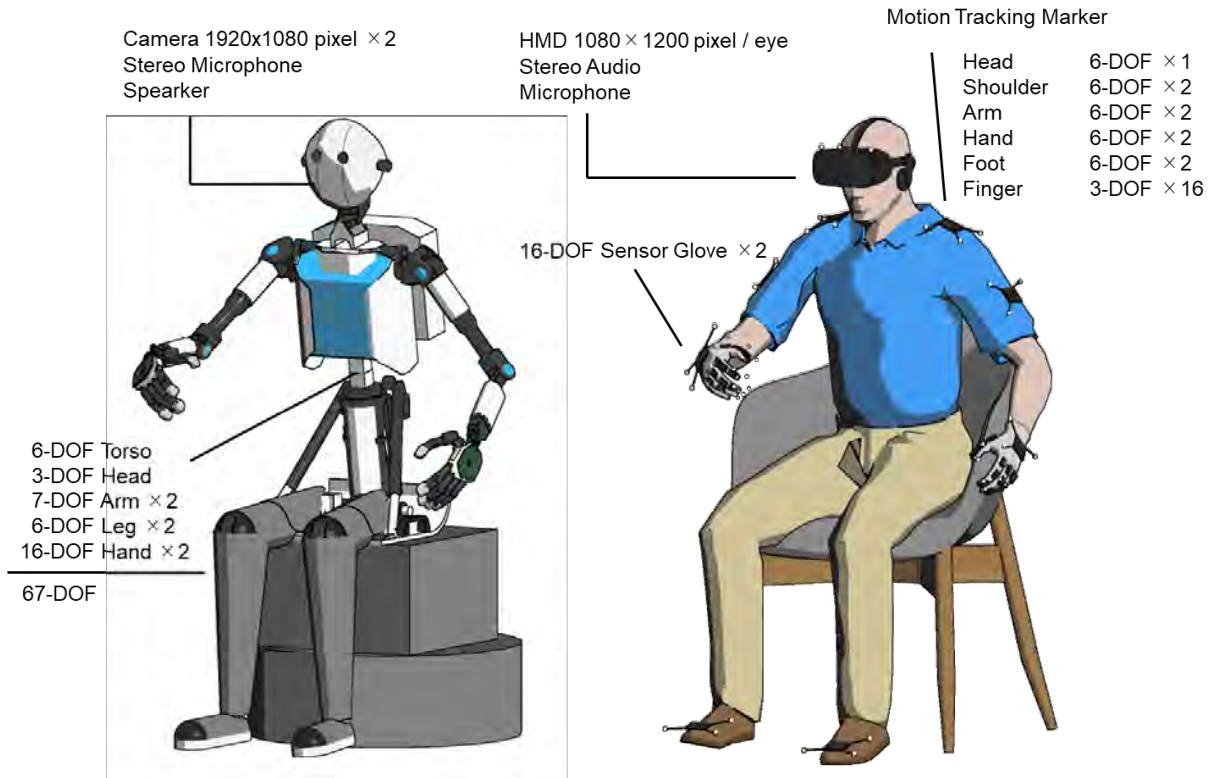


Simplified Robot Tx-kit (3DoF / 6DOF)

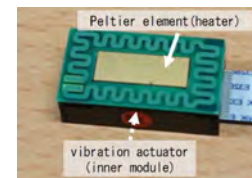


JST ACCEL
EMBODIED
MEDIA
PROJECT

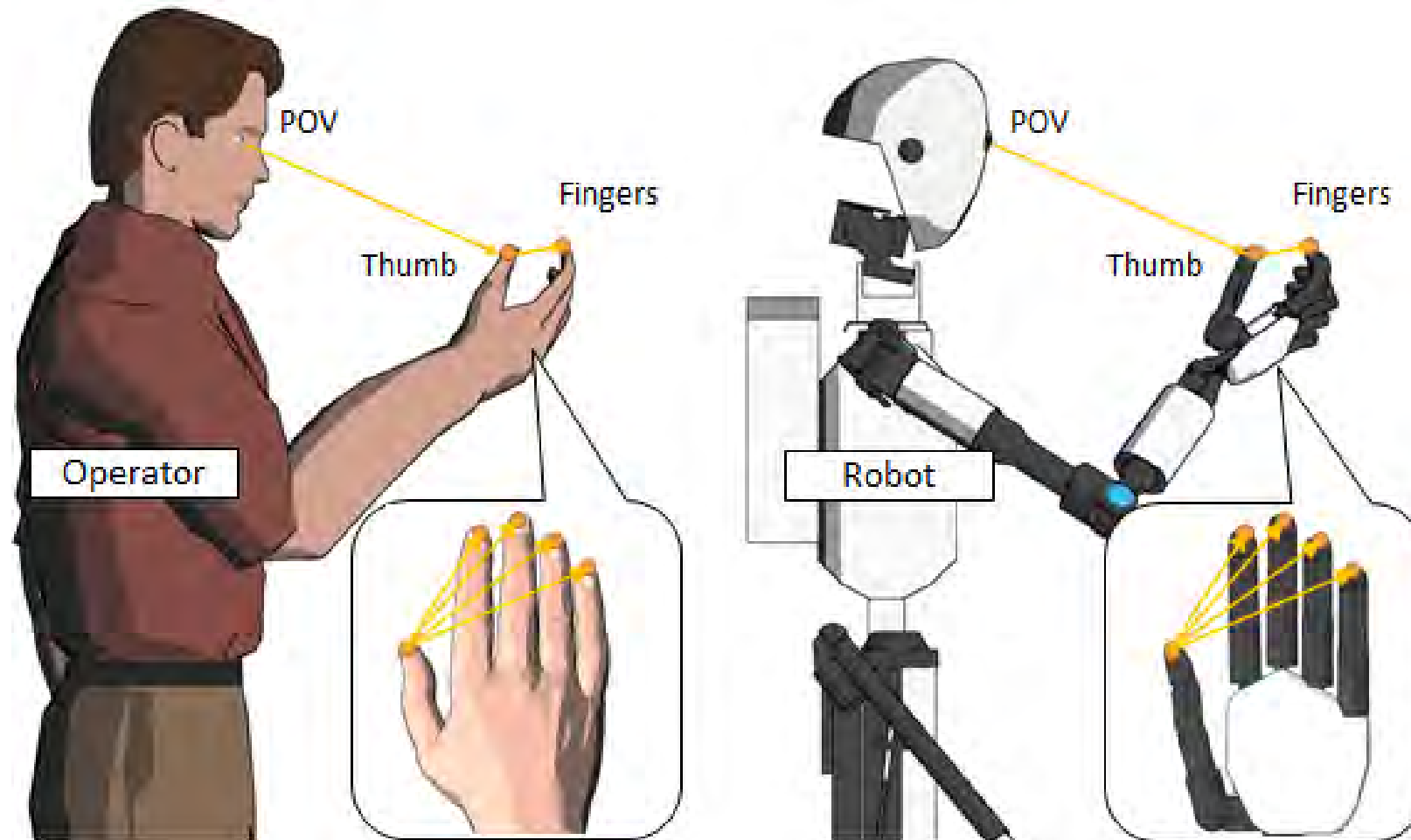
Next generation telexistence TELESAR VI



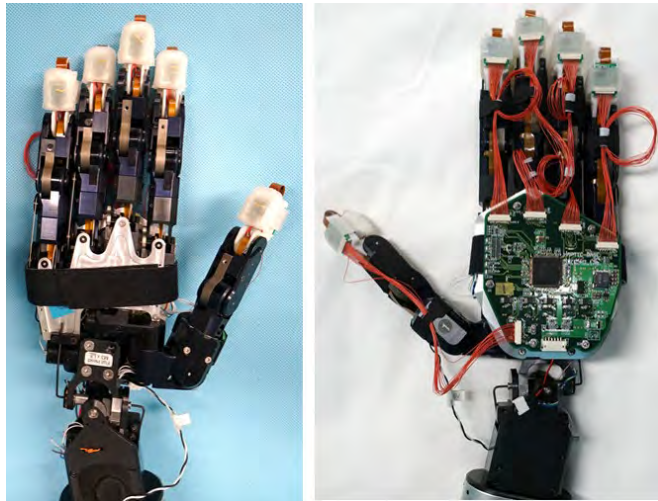
Vibro-thermal display



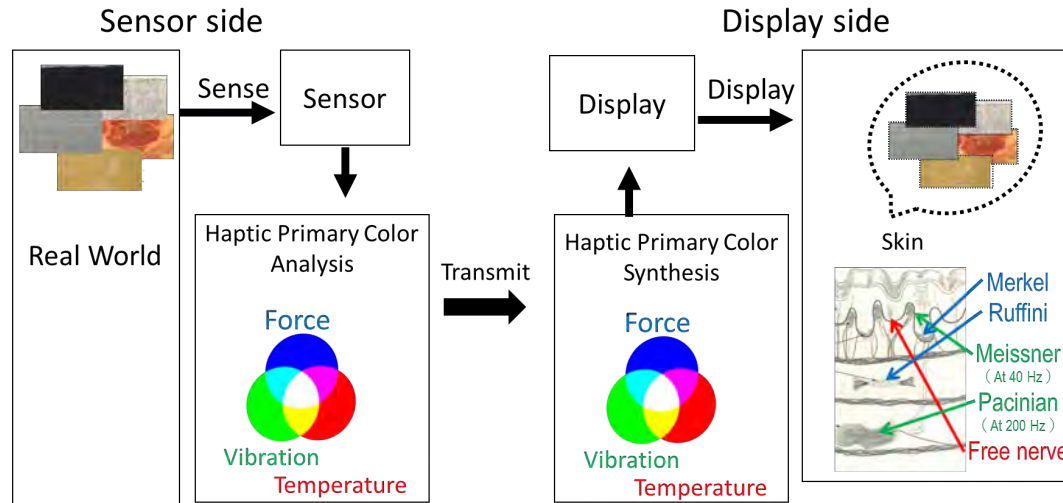
Control Method of TELESAR VI



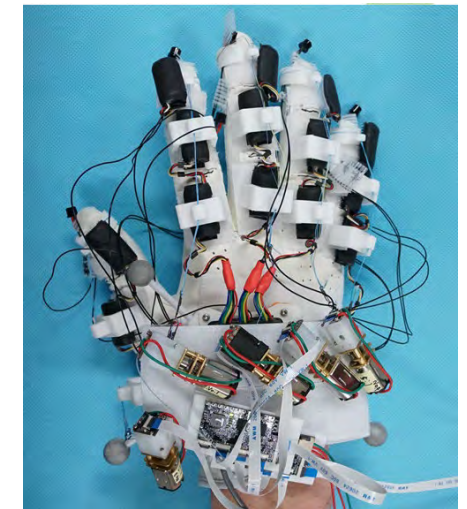
Haptic sensing and Display to the Leader side



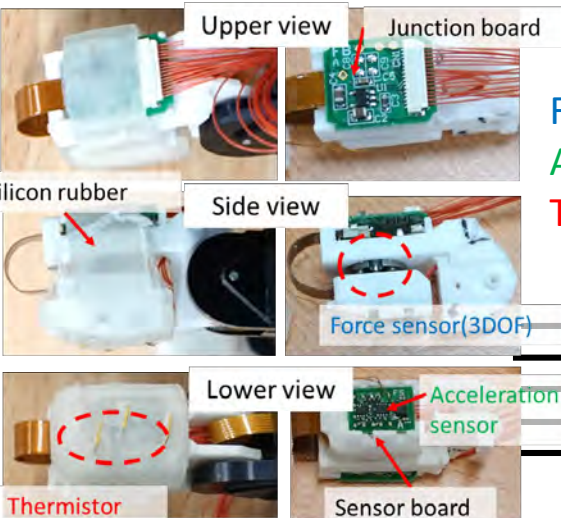
Follower side



Haptic Primary Color Theory

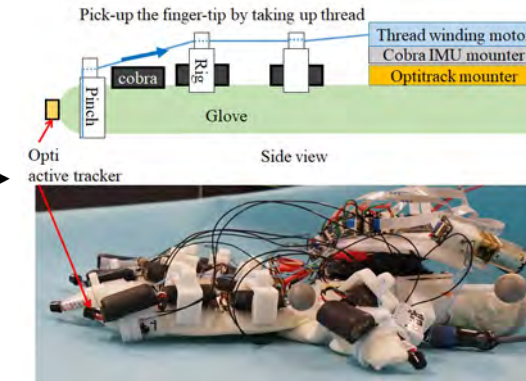
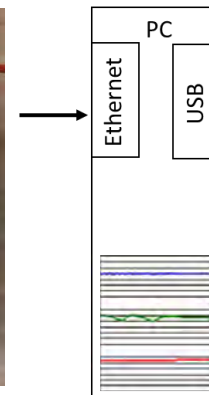


Leader side

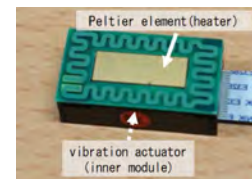


Force (3DoF, 1kHz)
 Acceleration (3DoF, 1.6kHz)
 Temperature (6ch, 100Hz)

5 fingers



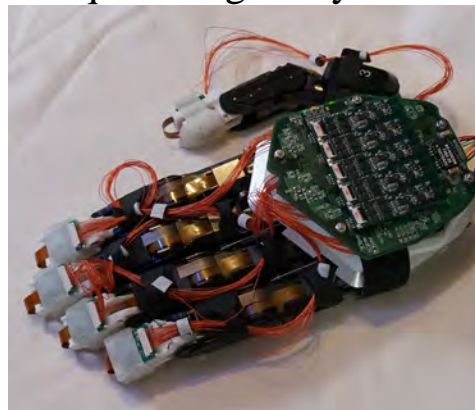
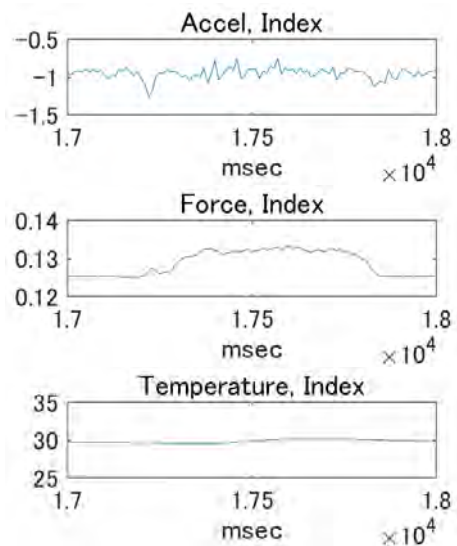
Posture sensing and Force presenting glove



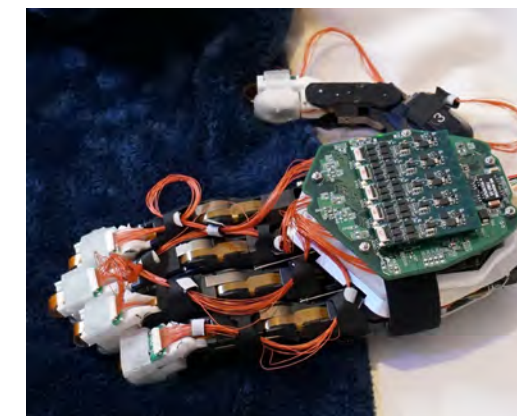
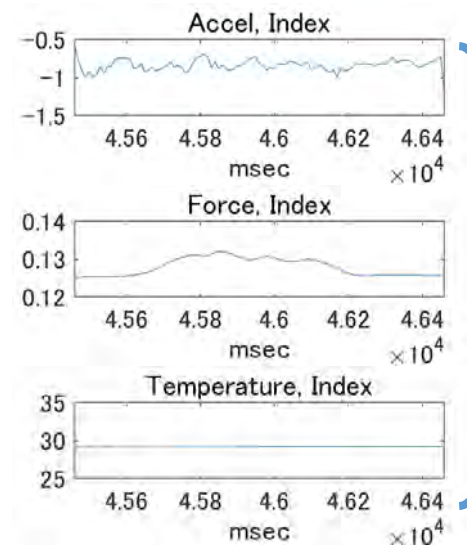
Vibro-thermal display

Difference in the feel of the cloth

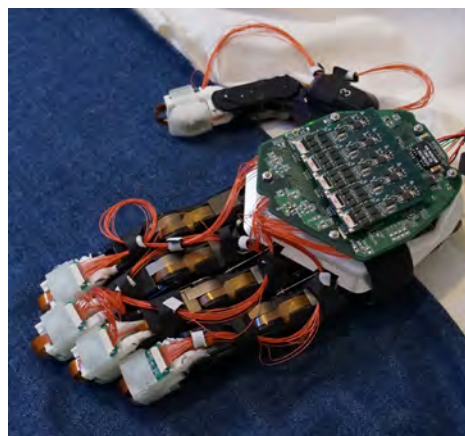
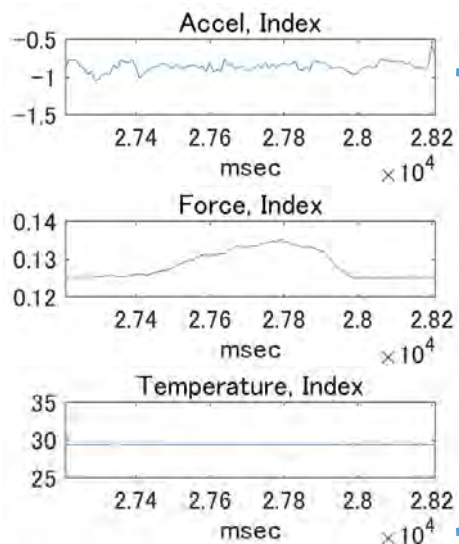
Acquired signal by index finger



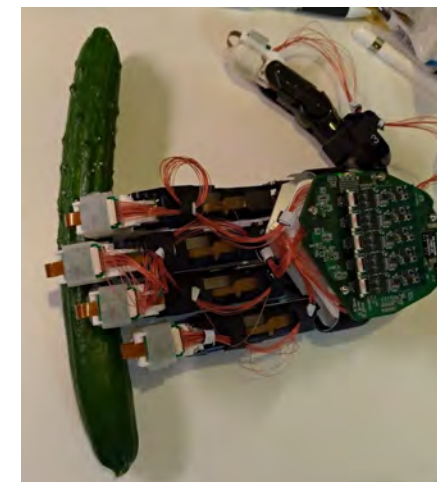
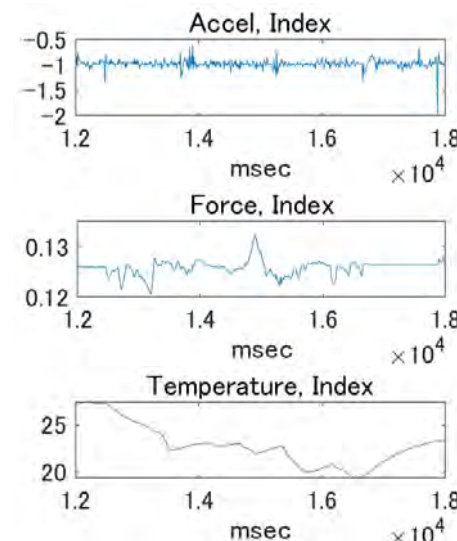
Plain weave



Acrylic fur

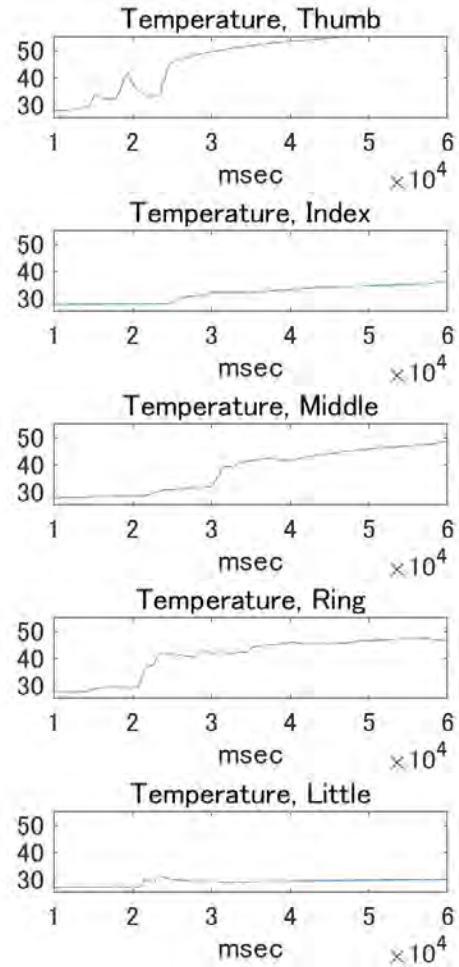


Denim

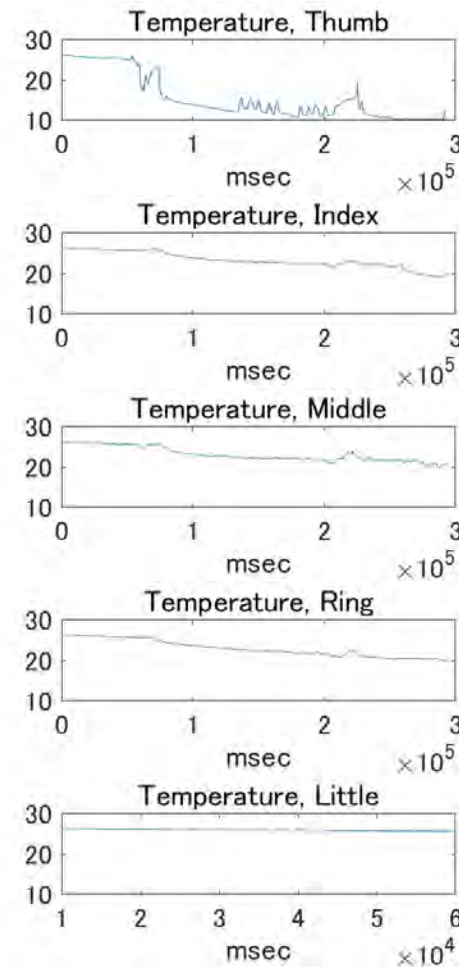


Cucumber

Is that tea hot? Is it cold?

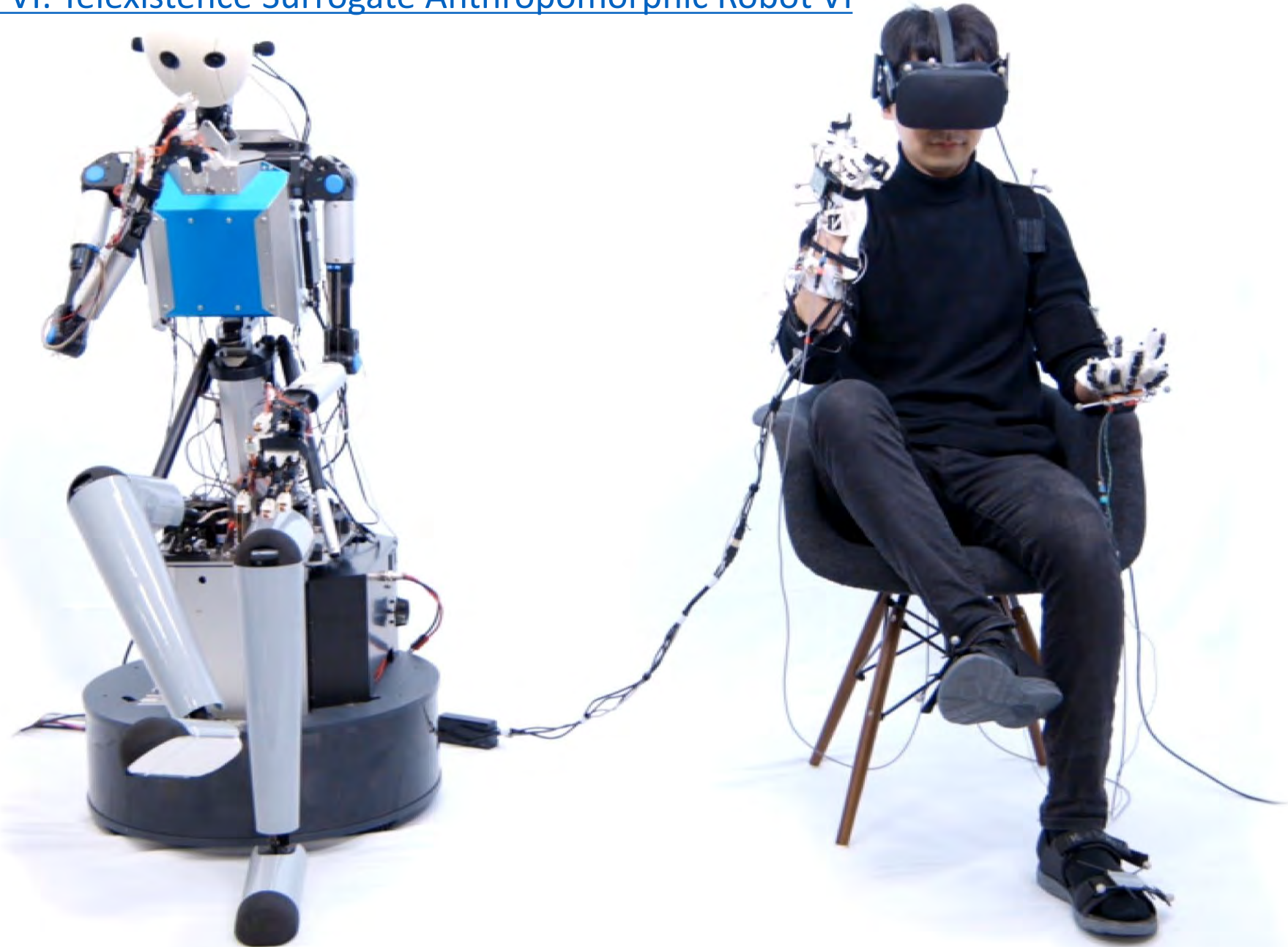


Hot black tea



Cold black tea

TELESAR VI : TELESAR VI: Telexistence Surrogate Anthropomorphic Robot VI

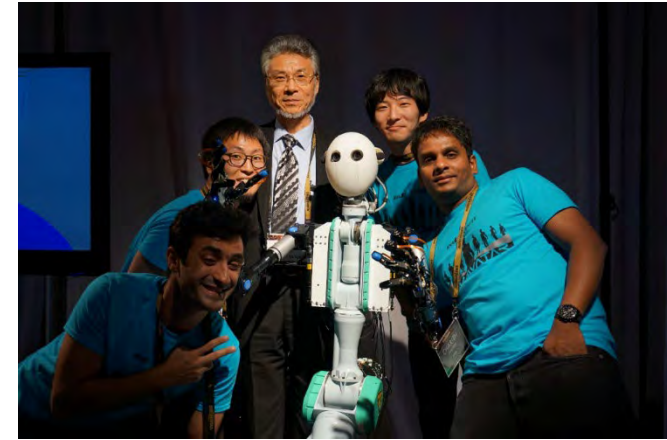


AVATAR XPRIZE was selected as next Challenge.



In October 2016, the XPRIZE Foundation held its annual Visioneers Summit. The foundation held it to choose the next XPRIZE theme from among nine candidates. Over a two-day period, nine teams presented their theme proposals, and their proposals were screened by a panel of around 300 mentors, who included academics, CEOs, and venture capitalists.

Team Avatar, one of the XPRIZE teams, asked Prof. Tachi to come to the 2016 summit to demonstrate his TELESAR V, which they recognized to be the world's most advanced robot avatar. Tachi agreed and presented the technology over the two days with members of Tachi Lab. The panel was impressed with the demonstration, and they picked Team Avatar's as the proposal for the next XPRIZE theme. The ANA Avatar XPRIZE was then launched in March 2018, with the finals scheduled for 2022. Incidentally, the finals were held in November 2022 and won by Team NimbRo from the University of Bonn.

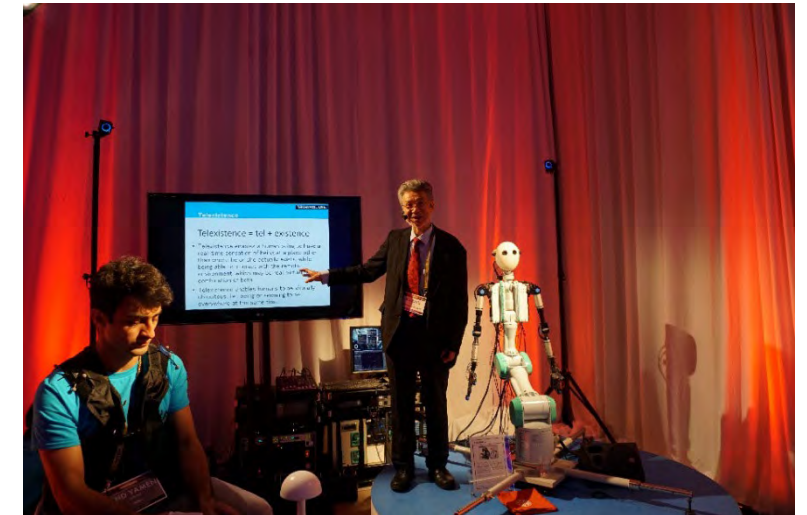


Three Prize Concepts were certified by XPRIZE as 'Ready for Launch':

Avatar XPRIZE
Sponsored by ANA

Conquering Cancer XPRIZE
Sponsored by Deloitte

Cat's Iron Will ALS XPRIZE
Sponsored by Caterpillar



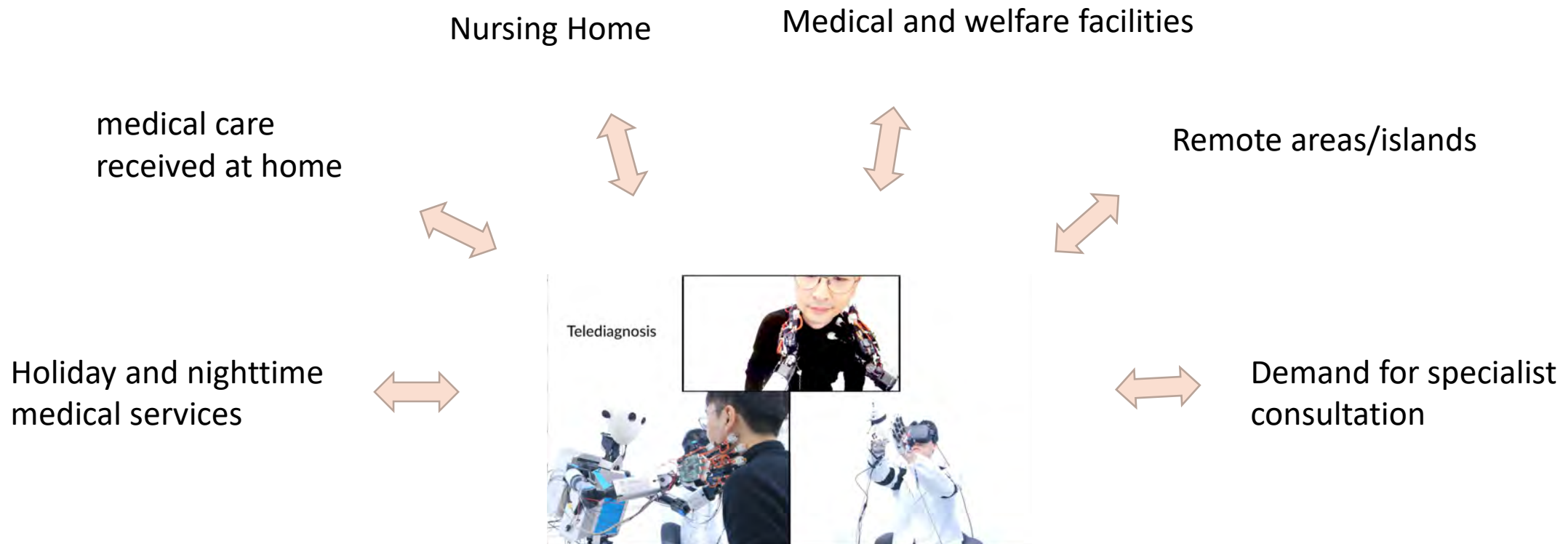
[Tachi 2021] : Telexistence – From Concept to TELESAR VI and Beyond

One application of Telexistence is Telemedicine



Super-aged society and the emergence of COVID19

- Large travel costs for medical visits and consultations (especially for the elderly)
- Promotion of home medical care to reduce insurance burden
- Reduction of risk of morbidity



Interviews with four physicians about medical examination



Basic skills : Visual inspection, percussion, auscultation, and palpation.

Vital sign : Pulse (heart beat), blood pressure, body temperature, sweating, swelling

In a medical examination, physicians perform visual, aural, palpatory, and percussion examinations
As for visual examination, they observe the patient coming into the examination room, during the examination, and until the patient leaves the room.

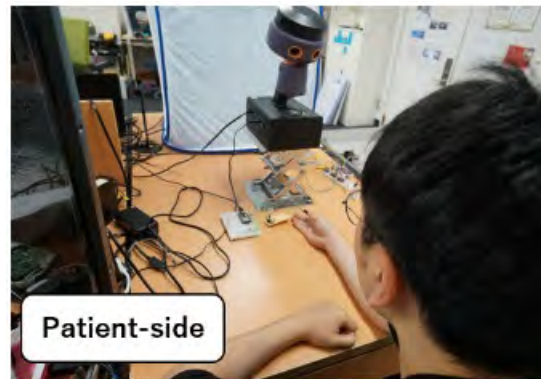
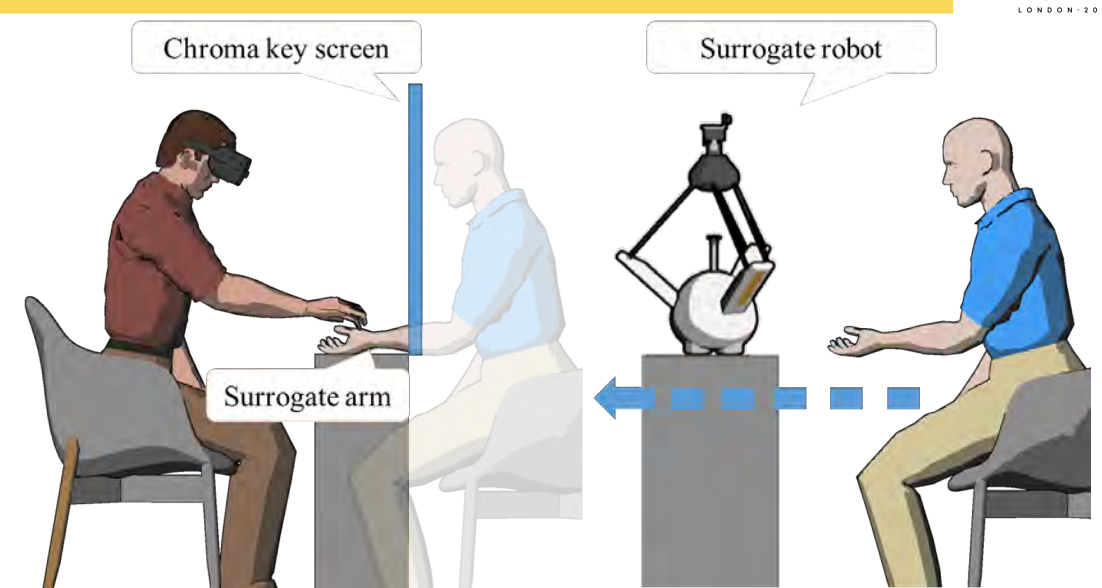
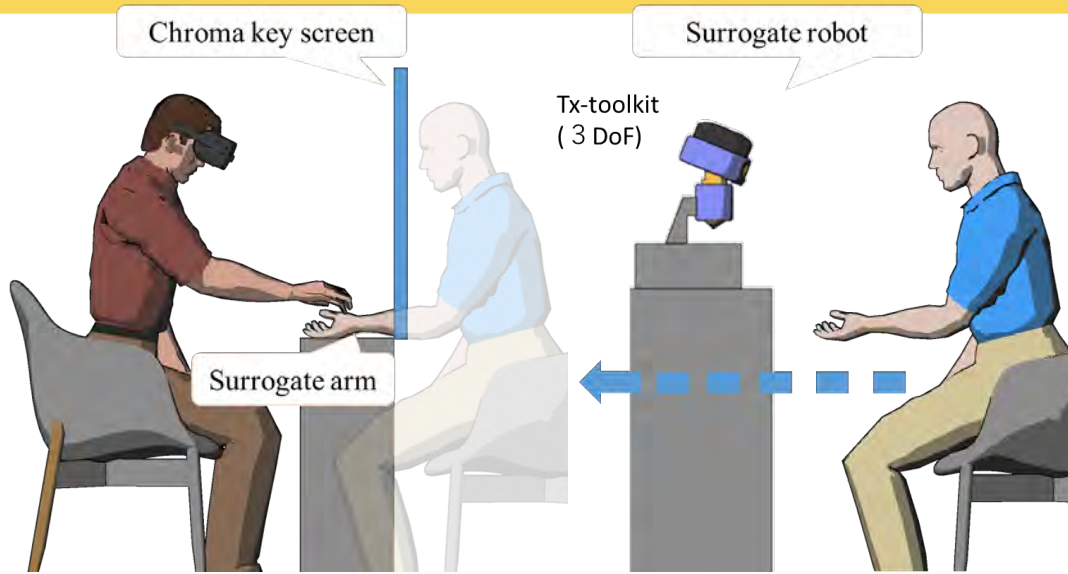
In addition, vital signs are commonly obtained during the examination.

e.g. vital signs : Pulse, blood pressure, body temperature, sweating, swelling

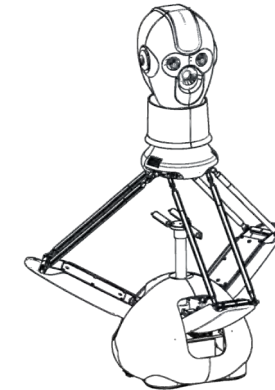
Vital signs are measured with a blood pressure cuff and thermometer, as well as by touching the patient and comparing them with the physician's experience.

We focused on body temperature and heart rate as the minimum necessary.

Head DOF requirement for telemedicine



TX-Toolkit (3 DoF)



Head : 3DoF

Chest : 3DoF

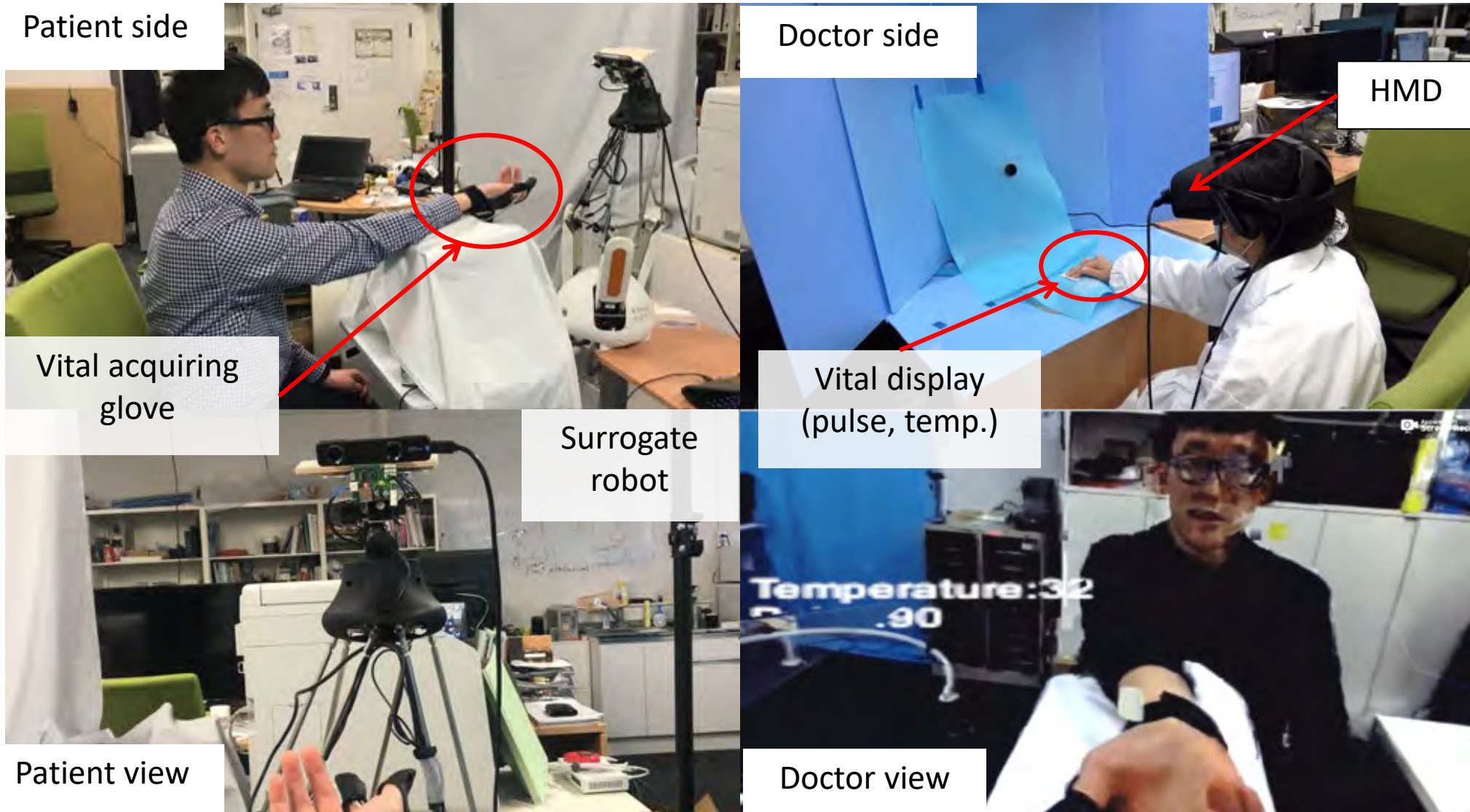
TX-Toolkit (6 DoF)

[2] : Junkai Fu, Fumihiro Kato, Yasuyuki Inoue, Susumu Tachi: Development of a Telediagnosis System using Telexistence Transactions of the Virtual Reality Society of Japan vol.25 No.3 pp.277-283,(2020.10).

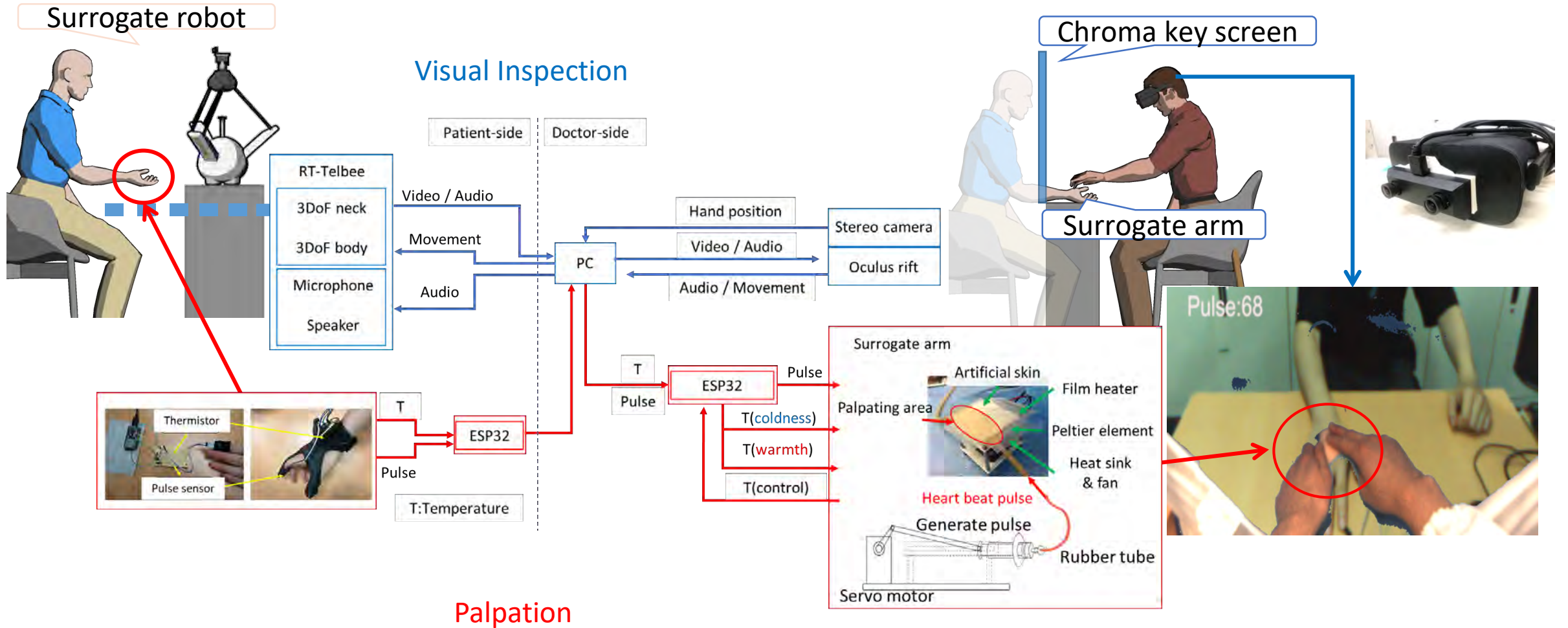
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Fumihiro Kato, ICRA AVATAR Workshop, 2 June, 2023

MR Telediagnosis system overview



Mixed Reality Telediagnosis System Configuration



Telemedicine : comparison between VideoPhone and Telexistence



Medical Interview Scenarios

Patient discusses complaint with physician

Patient wears a vital acquisition glove.

Physician examines while palpating vitals.

SpO_2 (saturation) and blood pressure are asked

Test subjects

11 Physicians and 1 Nurse

Post-experiment evaluation asking physicians about presence

Impressions based on a 7-point Likert scale ranging from -3 (strongly disagree) to +3 (strongly agree).

Self Presence *Q1. I felt as if I was actually in the room with the patient.*

Patient's Presence *Q2. I felt as if the patient was actually in front of me.*

Reality of Examination *Q3. I felt as if the medical examination was actually performed.*

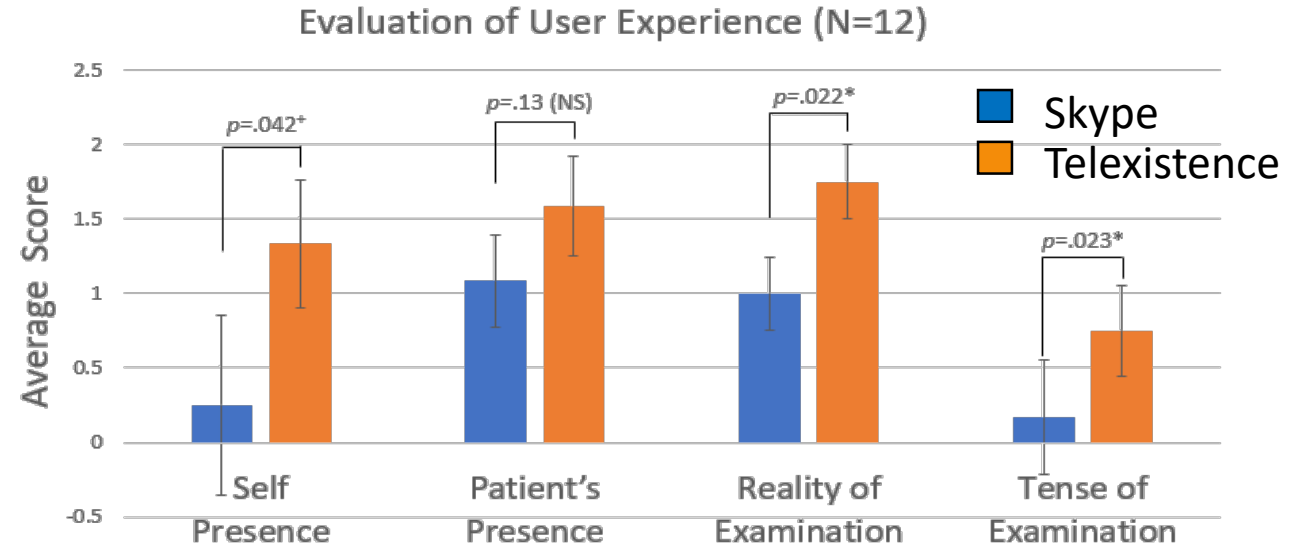
Tense of Examination *Q4. I felt tense while performing the medical examination.*

[2] : Junkai Fu, Fumihiro Kato, Yasuyuki Inoue, Susumu Tachi: Development of a Telediagnosis System using Telexistence Transactions of the Virtual Reality Society of Japan vol.25 No.3 pp.277-283,(2020.10).

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Telemedicine : comparison between VideoPhone and Telexistence



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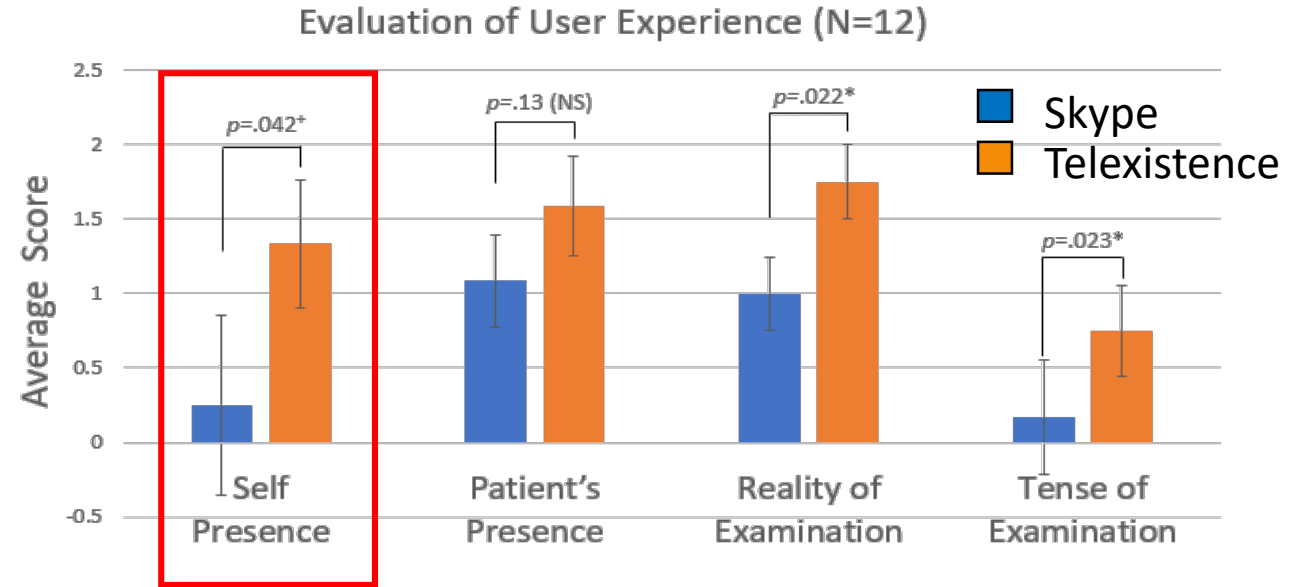
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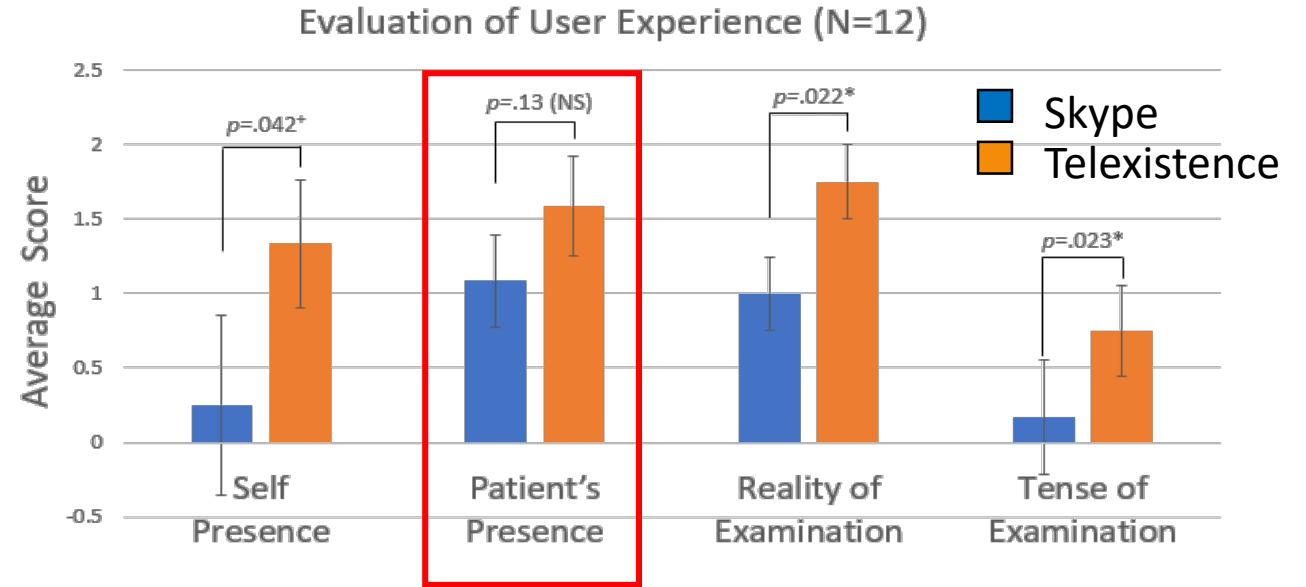
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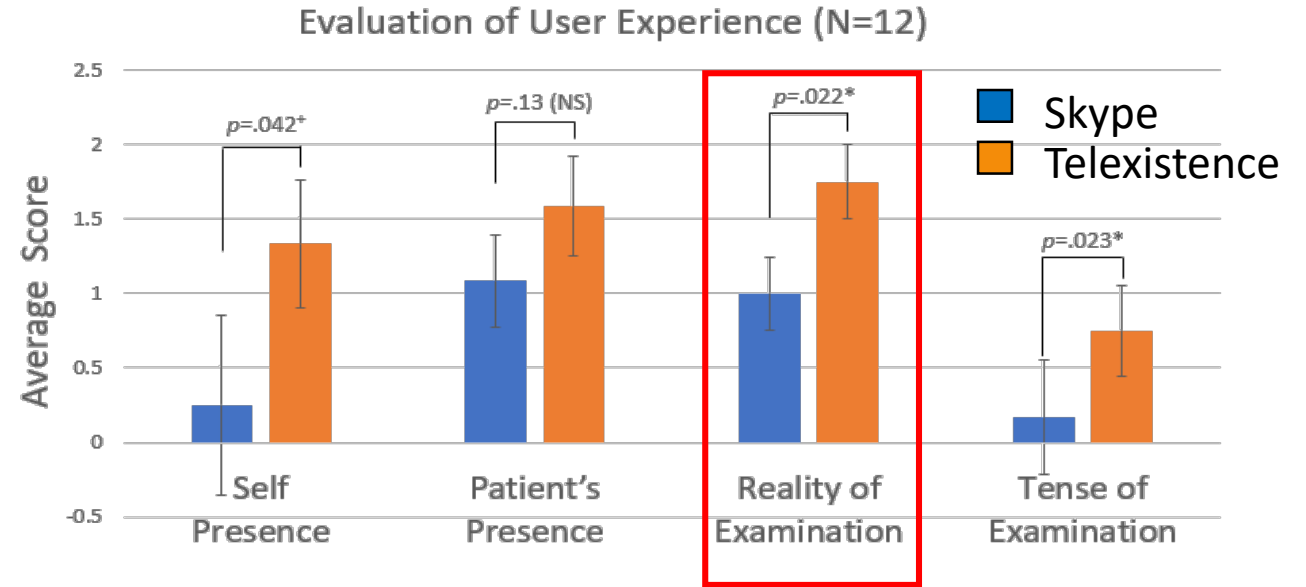
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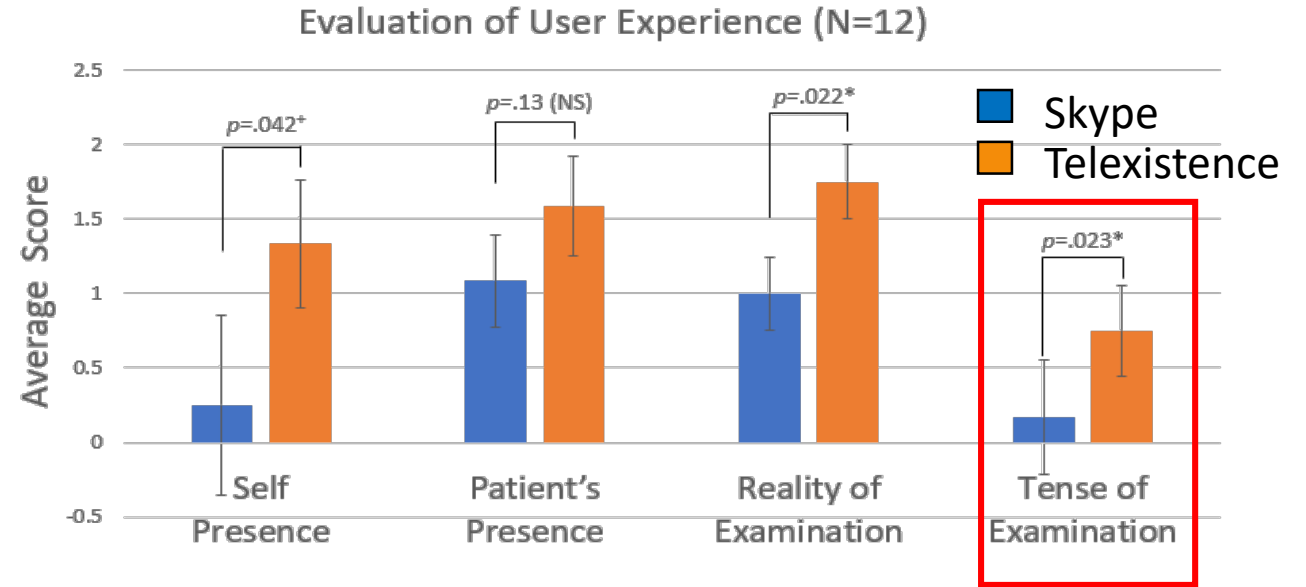
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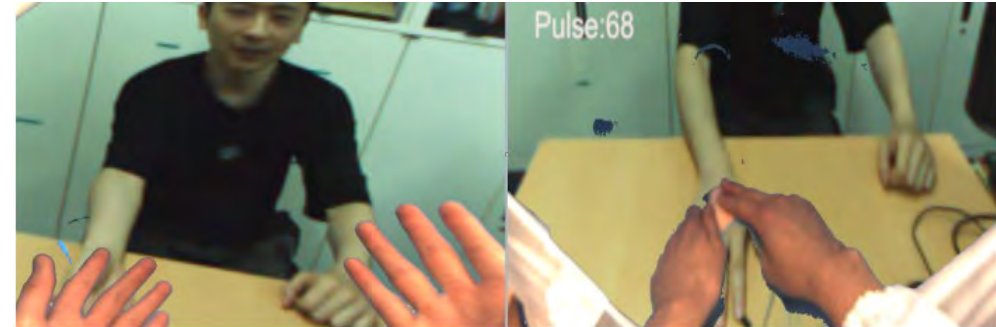
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Conclusion : Feedback from physicians and nurse

According to questionnaire results, experts rated the proposed system higher than traditional systems.

	YES	NO
Q1: Have you ever experienced another telemedicine system?	1	11
Q2.1: If Q1 is "YES," do you think the VR system is more real?	1	0
Q2.2: If Q1 is "NO," do you think the VR system is real?	10	1
Q3: Do you think VR experience is useful for the examination?	12	0
Q4: Do you think the tactile display is useful for the examination?	10	1
Q5: Do you want to use a VR telediagnosis system?	11	1



The Study is just prior to COVID-19) physician wants to touch any part of the body.
In COVID-19, non-contact thermal cameras and thermometers were used in clinical practice.
Palpation is important in some departments and palpation information is still needed.

Remaining Challenges

Palpating is beneficial for both doctor and patient

Doctor : To avoid a risk of missing disease

Patient : feel better ; doctor touching and seriously examine my body condition !

Telexistence + Telepalpating may be the answer to the problems.



Haptic medical value in examinations

general practice, dermatology, gastroenterology, and Chinese medicine

e.g.) dermatology : softness (viscoelastic), surface texture

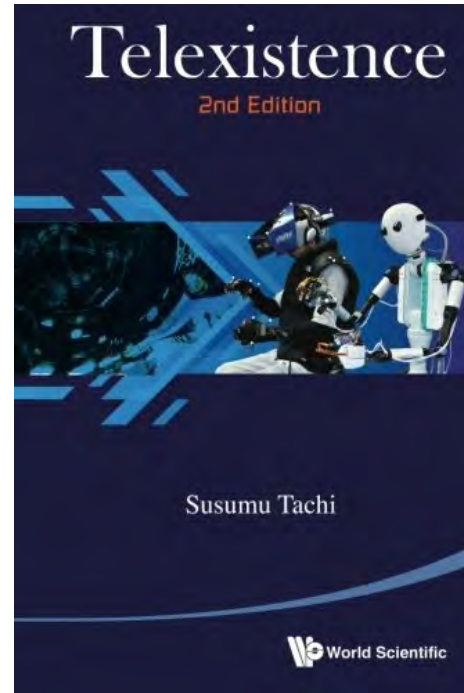
lymph node enlargement : hardness -> not good, softness is better

As a next step, we would like to build a remote palpation system that transmits viscoelasticity and skin temperature, semi-automatically acquires the status of the affected area, and provides easy-to-understand information to physicians.

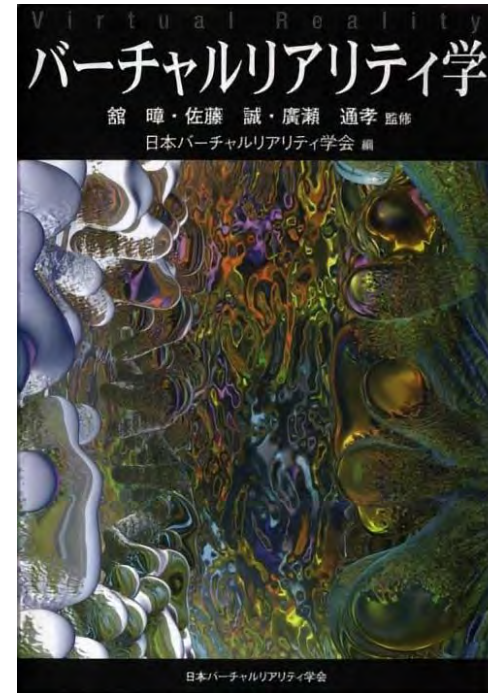
I hope that we can create a society in which patients can be seen by a specialist at any time of the day using telexistence.



Thank you for attention



Susumu Tachi
Telexistence 2nd Edition
World Scientific
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<https://tachilab.org/>



Susumu Tachi et. al.
Virtual Reality
VR Society JAPAN & CORONA
PUBLISHING CO.,LTD.
ISBN-978-490-4490-05-1

Virtual Reality
(New edition)

We are writing a
new book.
It will be published
on 2024.

T.B.D.



References

- [1] : Susumu Tachi, Yasuyuki Inoue and Fumihiro Kato: TELESAR VI: Telexistence Surrogate Anthropomorphic Robot VI, International Journal of Humanoid Robotics, Vol. 17, No. 5, p.2050019(1-33) (2020.10)
 - [2] : Junkai Fu, Fumihiro Kato, Yasuyuki Inoue, Susumu Tachi: Development of a Telediagnosis System using Telexistence Transactions of the Virtual Reality Society of Japan vol.25 No.3 pp.277-283,(2020.10).
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