Smart Robot that is Close to One Person for a Lifetime

AIREC

(AI-driven Robot for Embrace and Care)

Project Manager (PM)
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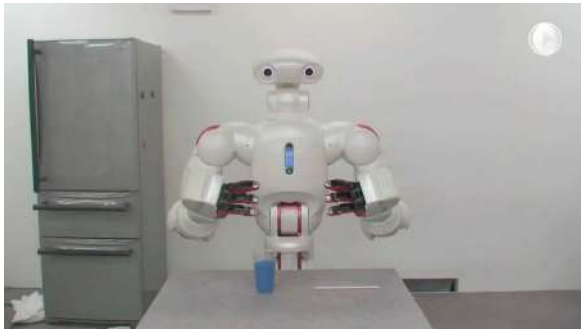
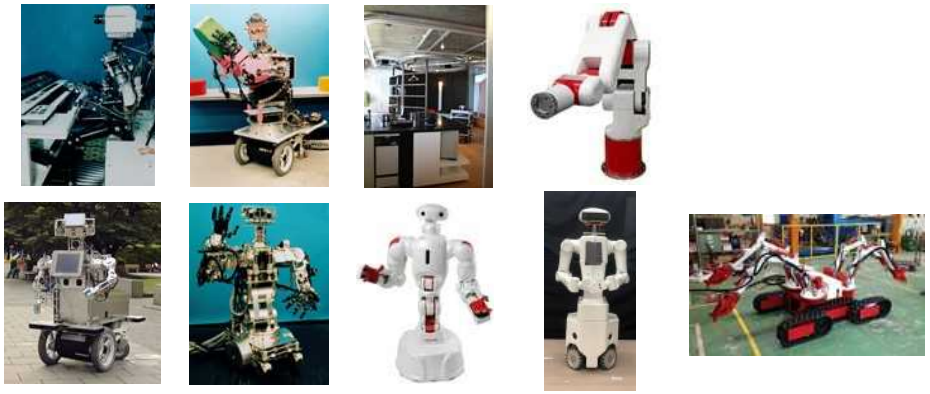
Professor, Waseda University

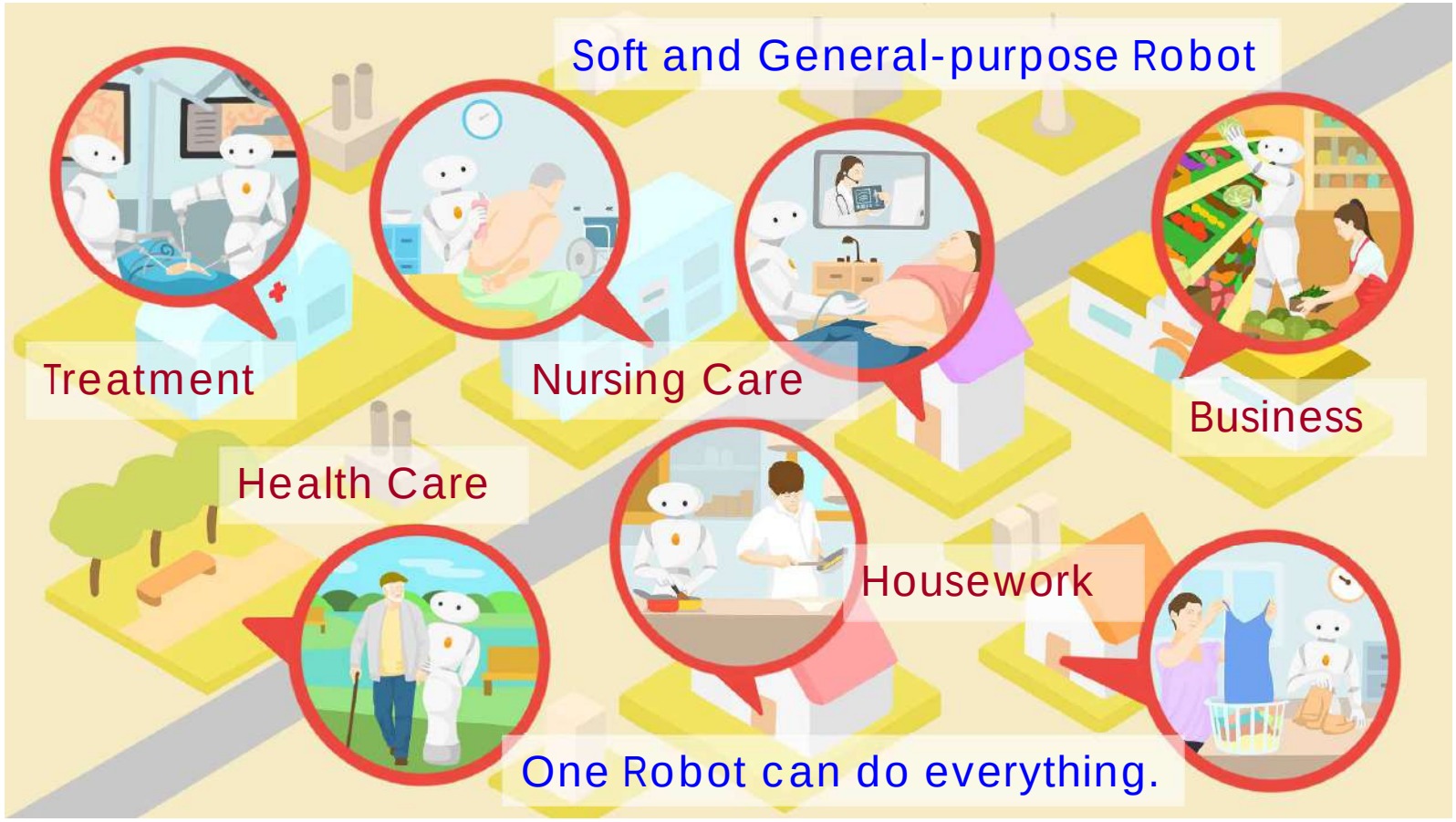
Prof. Shigeki SUGANO

- 1984 WABOT-2 Piano Playing Robot
- 1992- WAMOEBA Emotional Communication
- 1999 Wendy Human Symbiotic Robot
- 2001-2010 WABOT-HOUSE Intelligent House
- 2007- TWENDY-ONE Human Symbiotic Robot
- 2015- Octopus Disaster Prevention Robot





Our Vision of Future Society



General Purpose Robots
- Smart Robots -

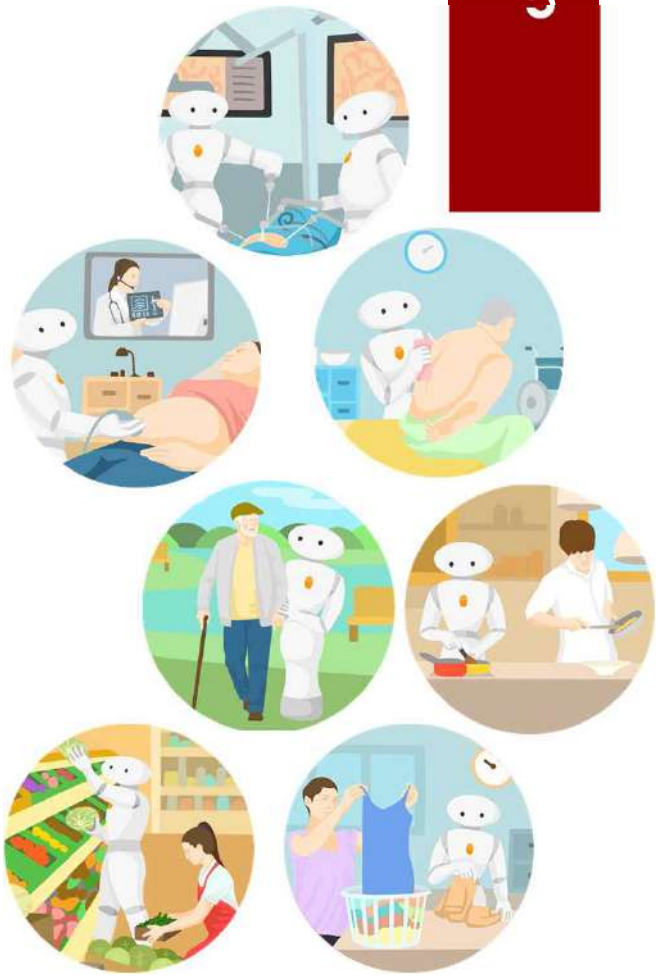
?

- Ex: Housework (cooking, cleaning, etc. in the same way as humans do) is a super-hard task in robotics
- Dedicated machines can do, but it is a different problem setting. (Smartphone)

AI robots that do not need to set up the environments and can perform multiple tasks

Autonomous Level for Smart Robot

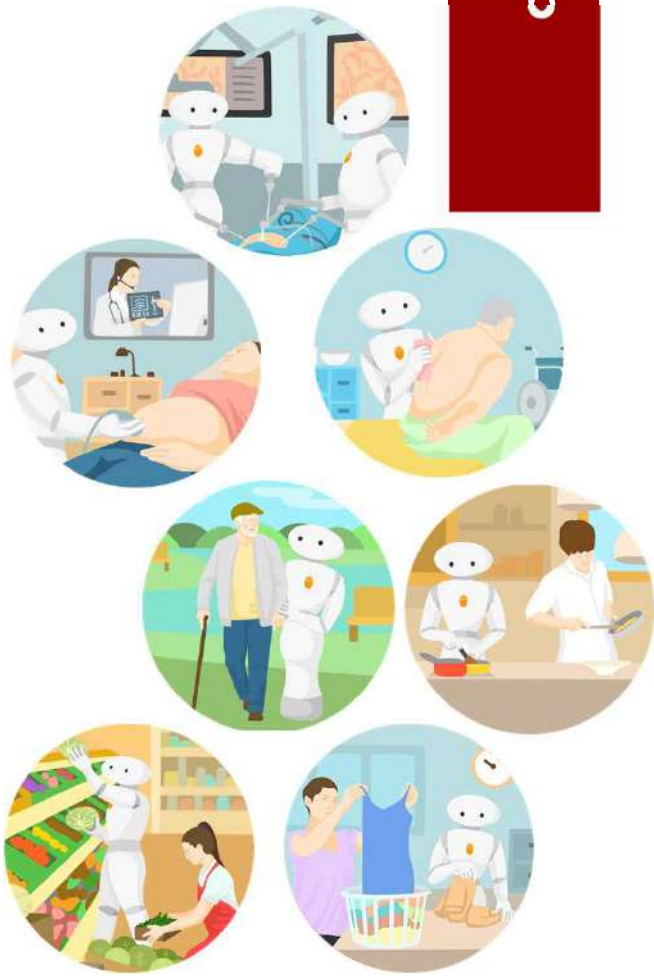
- Level 5 (Target: After 2050) : Fully Autonomous
  - ✓ A single robot can perform multiple tasks with human contact in a fully autonomous manner. Tasks include invasive medical procedures.
- Level 4 (Target: 2040) : Semi-Autonomous
  - ✓ A single robot can perform multi-tasks with human contact in a semi-autonomous manner while emotionally interacting with humans. The tasks include minimally invasive nursing care and treatment.
- Level 3 (Target: 2030) : Cooperative Autonomous
  - ✓ A single robot can perform simple household tasks, nursing care, and medical treatment with human contact semi-autonomously and in cooperation with humans. The robot is capable of expressing emotions.
- Level 2 (Target: 2025) : Routine Autonomous
  - ✓ A single robot can perform several kinds of housework and medical work with a routine interaction with humans.
- Level 1 (current) : Solo Autonomous
  - ✓ An individual robot can perform a specific task.



Milestones
in the Realization of Smart Robots

2030

- We will develop a smart robot (level 3) with emotional interaction capabilities that can perform customer service, household tasks such as cooking and wiping, nursing care such as walking assistance and bed bath, and some medical tasks such as nursing and ultrasonography. The robot will be tested and operated in public facilities, homes, nursing homes, and medical facilities.
- Smart robots (level 3) will enable people to receive assistance, including welfare and medical care.



AIREC's Top Challenges

AI and robots co-evolve based on various social needs

Robotics Innovation

Develop Dry-Wet robots with flexible bodies for physical interaction that realize intelligent behaviors.

AI Innovation

Maximize the capabilities of soft robots through human skill transfer (imitation) by "predictive learning".

OS: ROS50

Understanding Social Needs

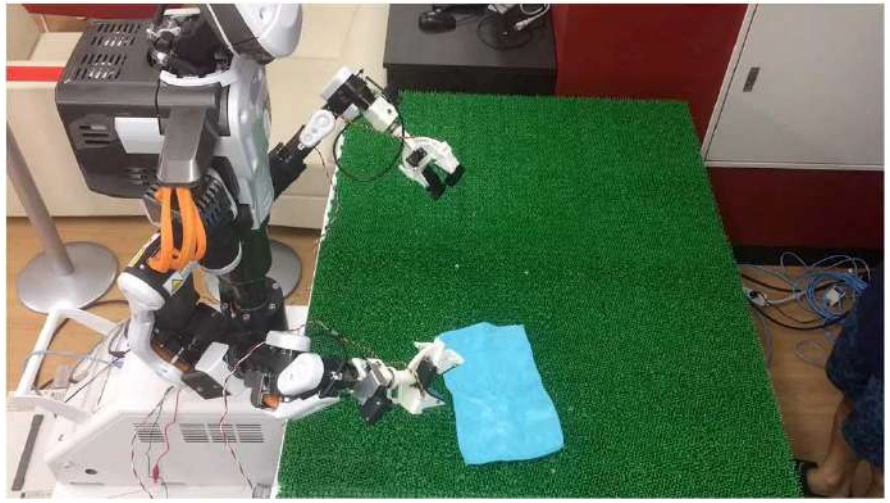
Selecting necessary and appropriate functions through research on the social needs of the AI generation (GEN Z)

AIREC's top challenges: Transform AI from "software" to "software + hardware"

"Embodied Intelligence"

Embodied Intelligence

- Compliant Soft Hardware
  - ✓ Dry-Wet Hybrid Mechanism
  - ✓ Elastomer and Fluid Materials
  - ✓ Self-Preservation Biological System
  - ✓ Self-Recover System
- Deep Predictive Learning
  - ✓ Real time Prediction and Control of Sensory-Motor Value
  - ✓ Transfer Human Skills to Robot (Imitation)
  - ✓ Acquisition of the Subjective World Model
  - ✓ Embodied Emotional Reaction



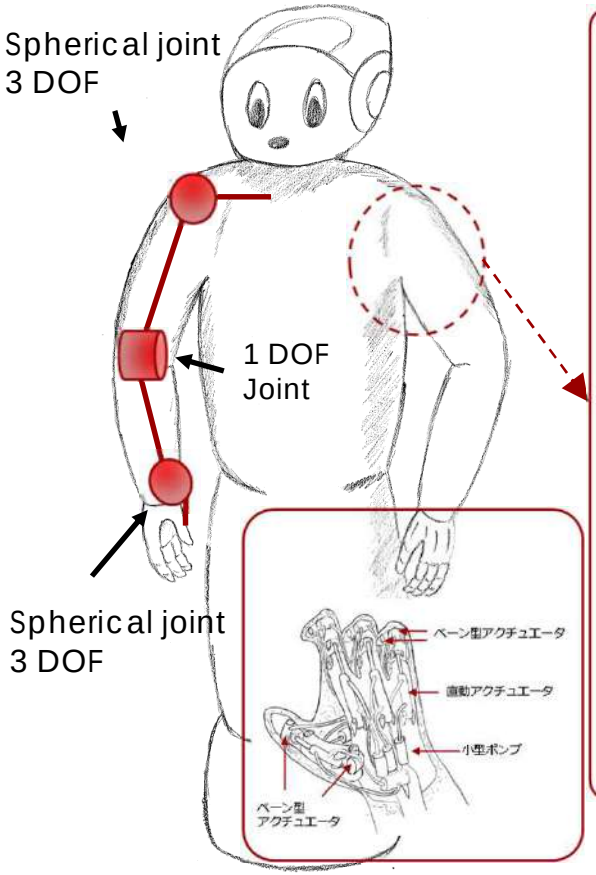
An Example of Embodied Intelligence

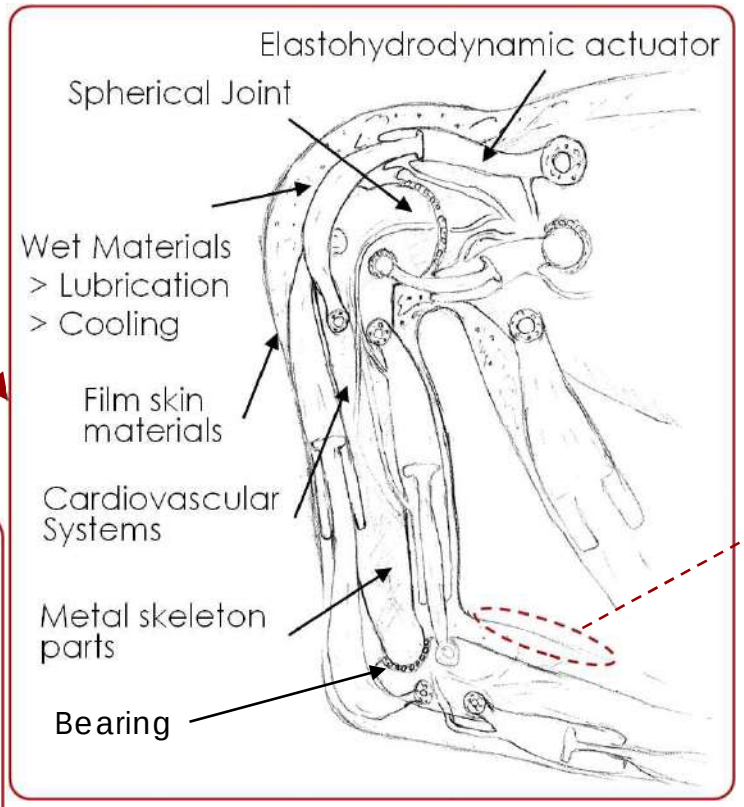
> Folding motion (Soft joint in the wrist)

> Less than a hundred trials with the limited object variations

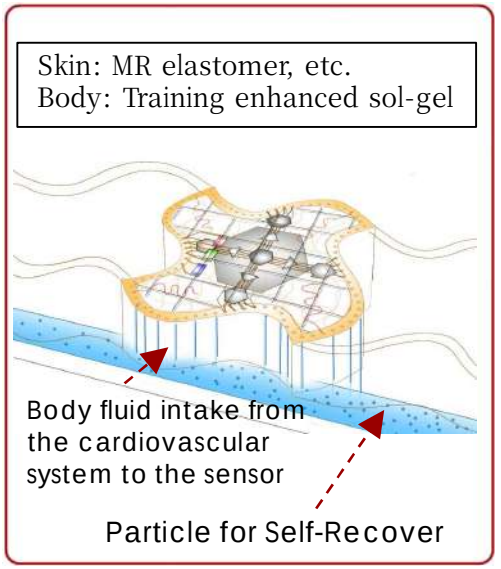
Cebit 2017, CEATEC2017, iRex2017
IEEE RA Letters, 2016., ICRA2017 etc.

Hardware innovation for the year 2050





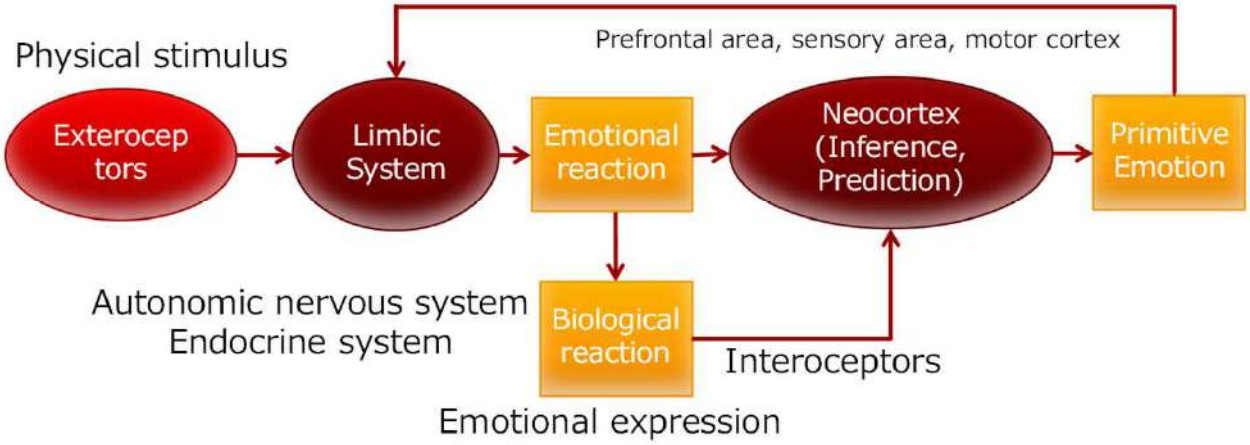
Dry-Wet Robot Mechanism

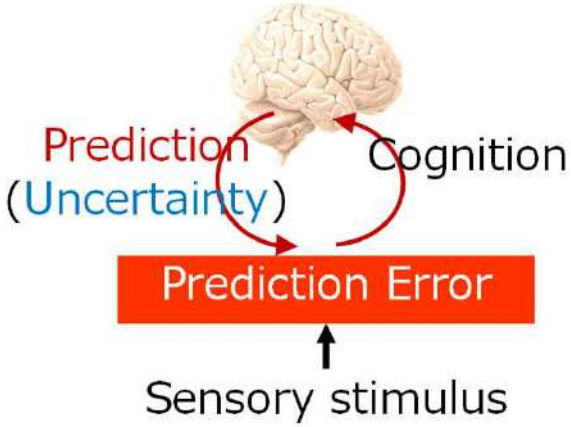


Skin

Modeling of Primitive Emotions

- The limbic system generates the reaction of biological organs (homeostasis) and body changes (emotional reactions) for environmental adaptation. The neocortex recognizes the reactions to create primitive emotions.
- James –Lange theory





Technologies for Welfare and Medical Care with Smart Robots

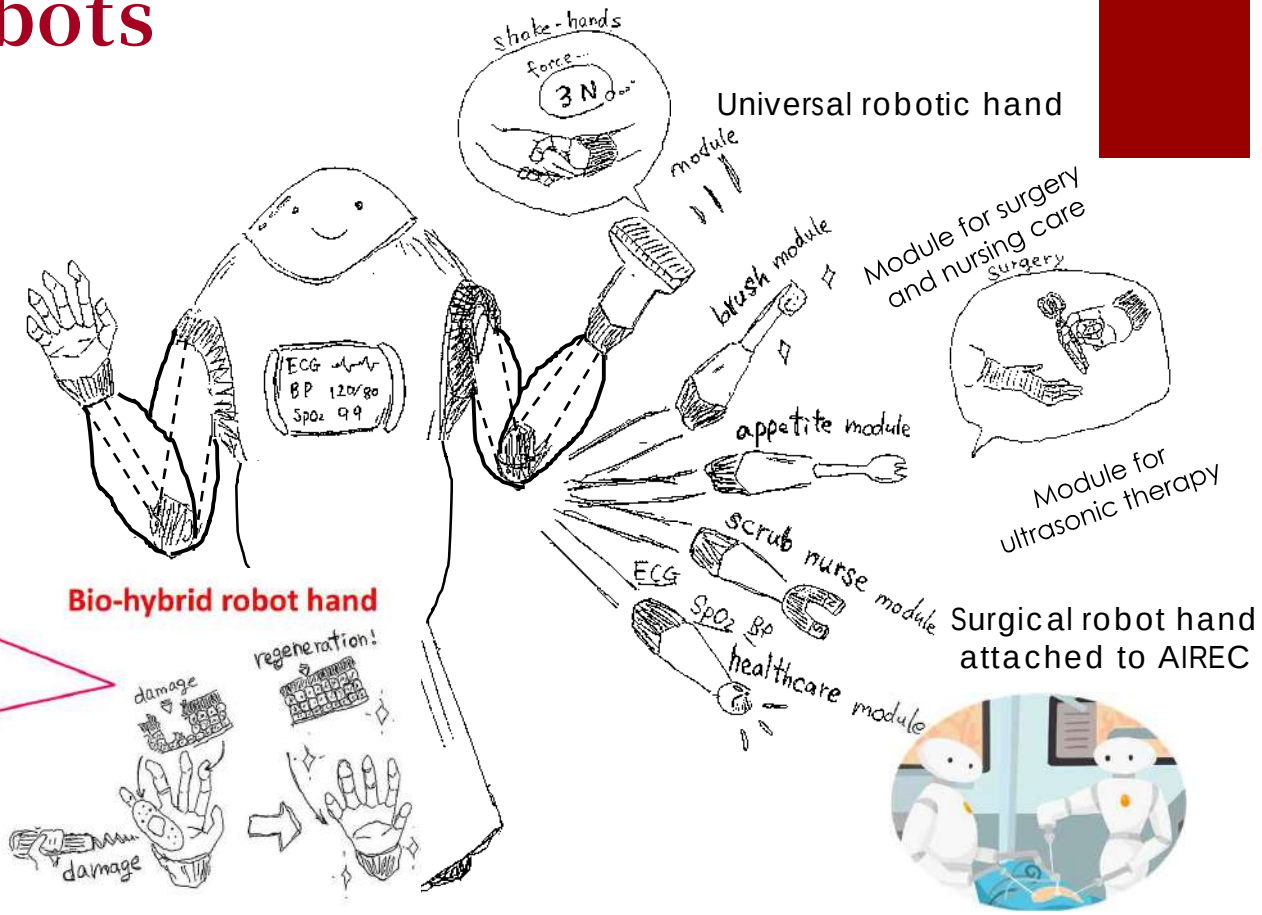
- Care, Nursing Care, and Medical Care in 2050
  - ✓ Transfer Support
  - ✓ Bathing Support
  - ✓ Meal Assistance
  - ✓ Diagnostic Test
  - ✓ Injection
  - ✓ Surgery




- R&D Subjects
  - ✓ Hardware and Control: Adaptive dexterous manipulator and control system according to patients' status with highly invasive interaction.
  - ✓ Standardization: Design of data structure of biological information to be introduced into AIREC
  - ✓ Risk Management: Update the risk management system based on the assessment results


Technologies for Welfare and Medical Care with Smart Robots

For low risk tasks：
Development of adaptor unit to attach the universal robot hand to AIREC
For high risk task：Specially designed robot hand for AIREC



Evaluation of social needs and acceptability

- Status quo:
  - ☹ Specific robots, field experiments in specific regions only
  - ☹ Discussions on international standards are rare

- 2023: Understand needs for standard design
  - Quantitative survey (Europe, US, and Asia, 8 countries)
    - ✓ Comparison survey from 10,000 young people (Generation Z)
- 2025: Evaluation of robot prototypes → Feedback on design
  - International Symposium on ELSI
    - ✓ Potential participants: Harvard (Law), Cambridge (Philosophy and Ethics)
- 2030：Establish a path for social implementation including international cultural differences
  - Qualitative survey: Engagement between people and robots
- 2030-: Literacy education for the general public

Dr. Shibata and Prof. Takahashi
Paro Fieldwork（2018）

Prof. Yoshua Bengio and Prof. Takahashi (2019)

AIREC Project Organization





Application

R&D Goal 2
AI systems for smart robots

R&D Goal 1
Body and control system for smart robots

R&D Goal 3
Technologies for welfare and medical care with smart robots

R&D Issues
- Flexible interaction with dynamic environment by smart robots
- Evaluation standards for demonstration of smart robots
- Mathematical approach to intelligent smart robots

R&D Issues
- Soft robot hardware that can physically support humans with contact
- Robot middleware (OS) for smart robots

R&D Issues
- Practical application of robots that can be introduced into welfare and medical sites
- Quality assurance and international standardization of welfare and medical robot design
- Risk management of welfare and medical robot design

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AI Innovation	Robot Innovation	Social Needs Analysis	Social implementation
- Imitation learning of high-difficulty tasks. - Understanding AI - Emotional communication	- Dry-wet hybrid hardware - Soft body structure - Hydraulic actuator	International comparison of social acceptability of AI and robots	Support and automation of - customer service, cooking, laundry, etc. - welfare and medical care

Technology Selection

R&D Goal 4
Practical measures for smart robots

Feedback

Technological collaboration

AIST

Alan Turing Institute

R&D Issue
International evaluation of the needs and social acceptability of smart robots from the viewpoint of ELSI

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Waseda University

Social research collaboration

Harvard University

University of Cambridge




AIREC URL

https://www.waseda.jp/airec/en/toppage_en/

R&D Plan to 2050