Workshop on Cognitive Neurorobotics
March 5th, 2026, OIST

A Consideration of Robot Foundation Models as Embodied Intelligence

Tetsuya Ogata

- Director, Institute for AI and Robotics, Waseda University, Japan
- Joint-Appointed Fellow, Artificial Intelligence Research Center (AIRC), AIST, Japan
- Visiting Professor, Research and Development Center for Large Language Models, NII, Japan

Waseda University

Reinforcement Learning: Whole Body Control

- Simulation learning is possible
- Inexpensive QDD Motors
- Considerably higher level of perfection

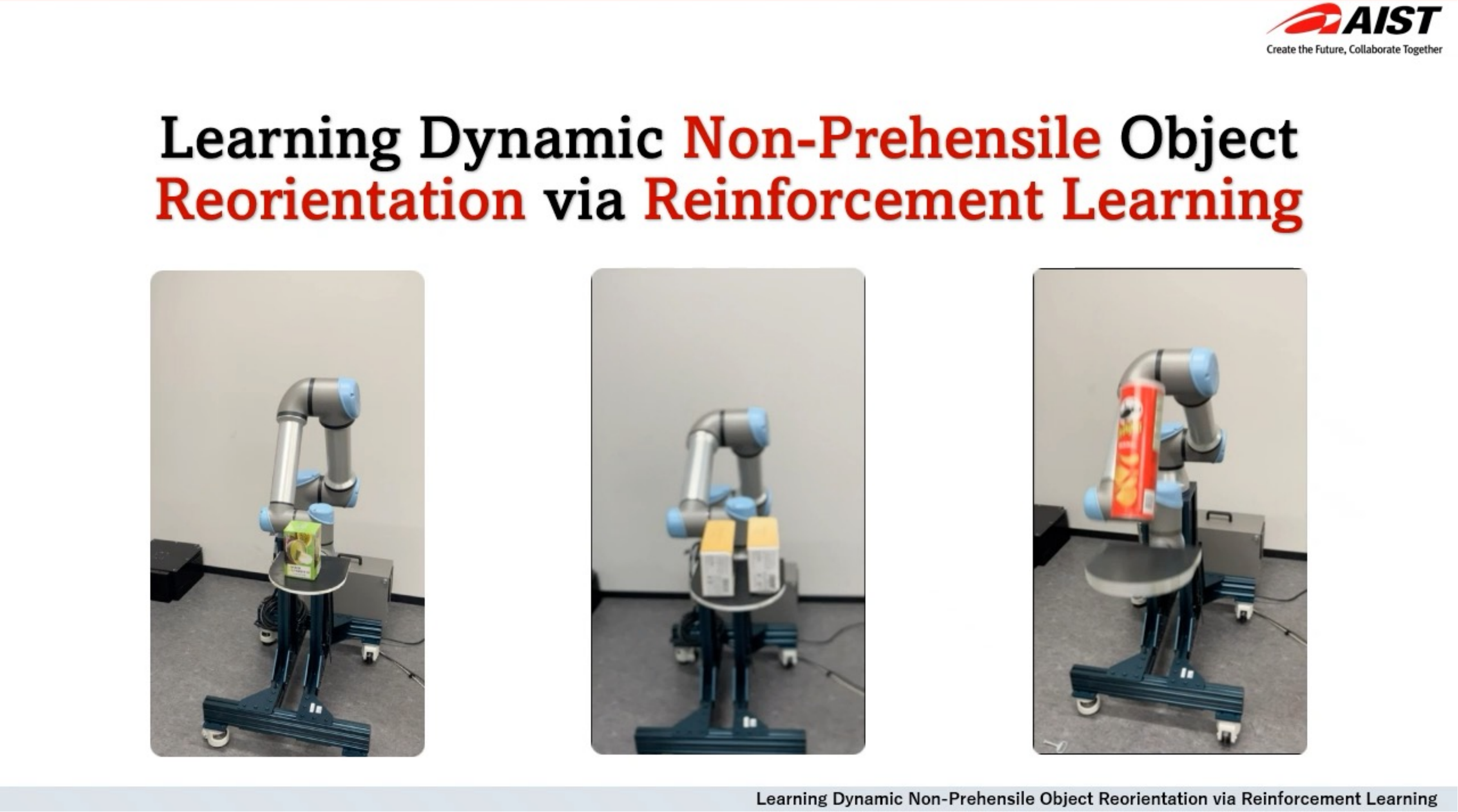
Kungfu Kid
V6.0
Unitree G1

Unitree G1 Kungfu Kid V6.0, 2025年10月13日

Learning Quadrupedal Locomotion over Challenging Terrain

J. LEE et al., Science Robotics, **2021**

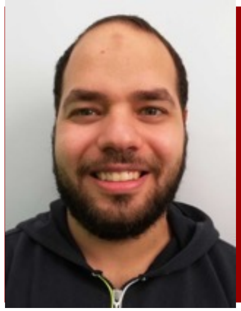
Learning Dynamic Non-Prehensile Object Reorientation



Create the Future, Collaborate Together

Learning Dynamic Non-Prehensile Object Reorientation via Reinforcement Learning

Learning Dynamic Non-Prehensile Object Reorientation via Reinforcement Learning

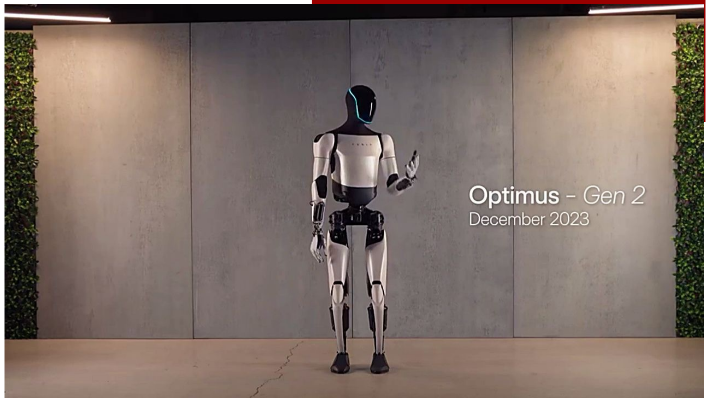


Dr. Abdullah Mustafa

A. Mustafa,
R. Hanai,
I. Ramirez-Alpizar,
F. Erich,
R. Nakajo,
Y. Domae, and
T. Ogata.,
IEEE-SICE SII2026

Imitation Learning: Manipulation

- Rapid progress in 2024
- Requires a large amount of data collection (thousands of times per task)
- Use of the **Fundamental Model**


Optimus - Gen 2
December 2023

Optimus, Tesla, 2023-

Figure, Helix, June 7th, 2025

NEO, 1X, 2025 ($45,000)

VLA (Vision Language Action Model)

- RT-2 (Google)
- Octo (UC Berkeley)
- OpenVLA (Stanford)
- π0, π0.5, π0.6 (Physical Intelligence)
- GR00T n1, n1.5, n1.6 (NVIDIA)
- Gemini Robotics ER 1.5 (Google DeepMind)
- Helix (Figure AI)

etc. etc…

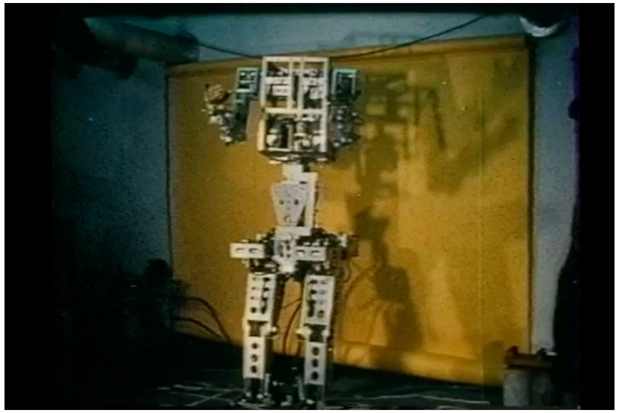
LeRobot

LeRobot Worldwide Hackathon (June 2025, 14-15)
255 teams with 3,000 members from all over the world

Robotics at Waseda University

Prof. Shigeki Sugano

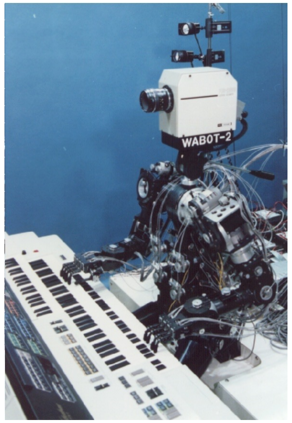
Prof. Ichiro Kato



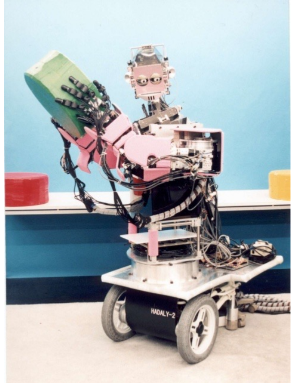
WABOT-1

(1973)

The world‘s first humanoid robot

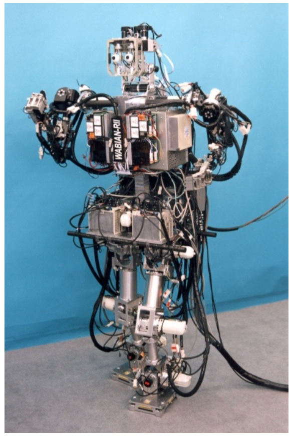


WABOT-2
(1984)



Haday-2
(1997)

TWENDY-ONE
(2007)



WABIAN
(1997)

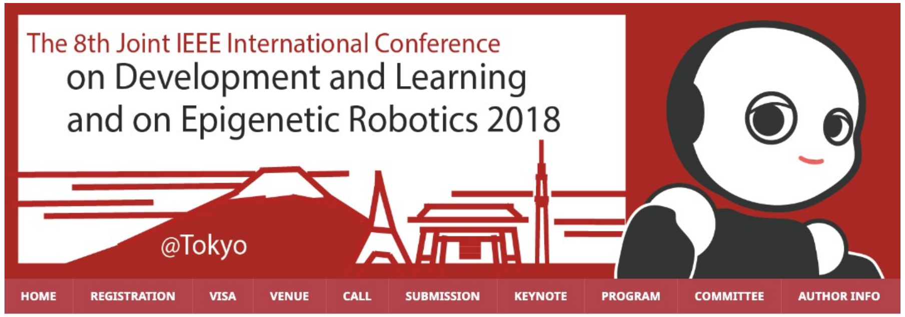
WABIAN-II
(2005)

Dry-AIREC
(2021)

Prof. Atsuo Takanishi

Remained Problems

- Is language the foundation?
  - Integration with real-world experiences (symbol grounding problem)
- Large-scale models + fine-tuning?
  - Necessity of continuous learning (developmental robotics)
- Are large-scale models sufficient for perfection?
  - The need for real-time inference (active inference)



The 8th Joint IEEE International Conference
on Development and Learning
and on Epigenetic Robotics 2018

@Tokyo

HOME
REGISTRATION
VISA
VENUE
CALL
SUBMISSION
KEYNOTE
PROGRAM
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Angelo Cangelosi (University of Manchester, UK)

Program chairs

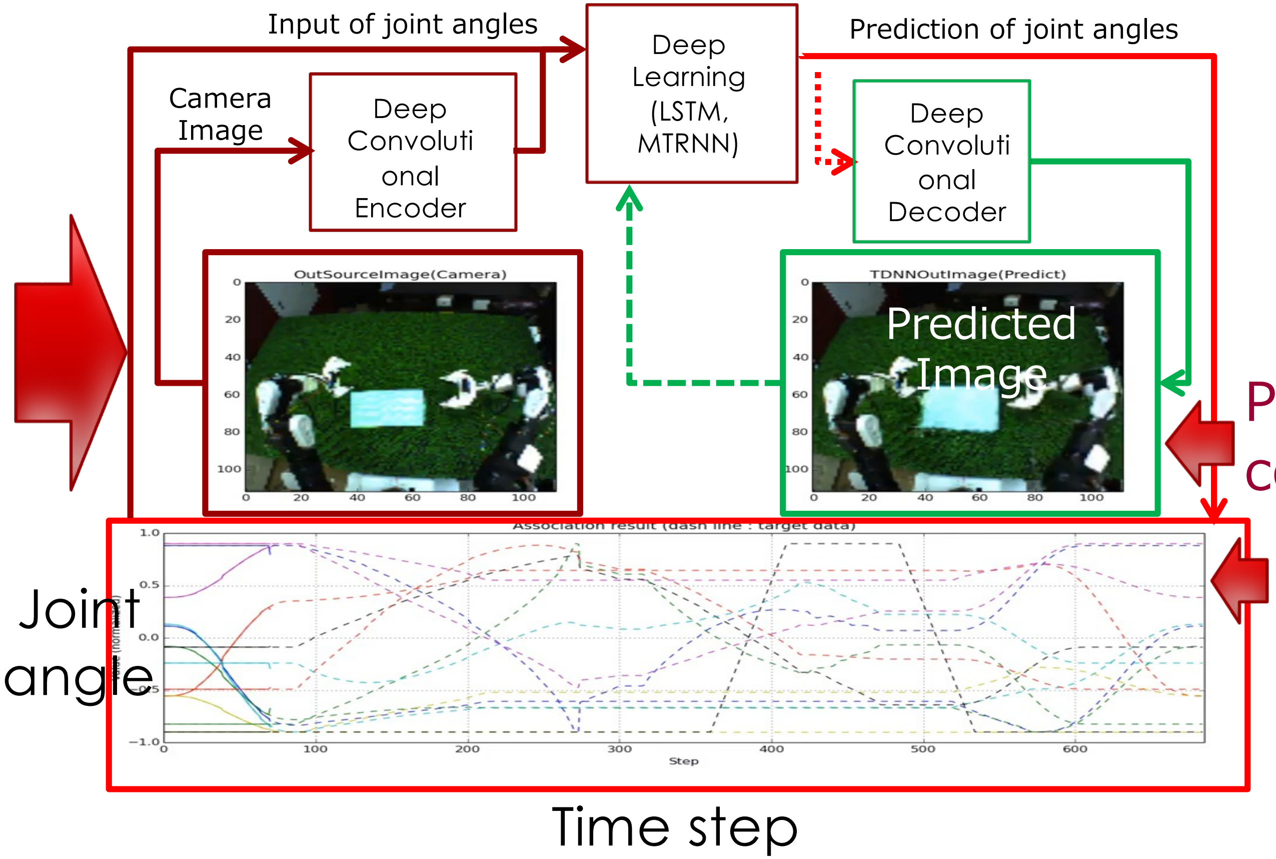
Tadahiro Taniguchi (Ritsumeikan University, Japan)

Deep Predictive Learning (DPL)

[P. Yang+, ICRA2017, RA-L] [K. Suzuki+, RA-L, 2018]

Collecting the data of **"50"** human operations (**skill**)

Subjective world model for **real time** prediction of sensory-motor values



Input of joint angles

Deep Learning (LSTM, MTRNN)

Prediction of joint angles

Camera Image

Deep Convolutional Encoder

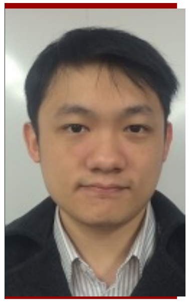
Deep Convolutional Decoder

Predicted Image

Joint angle

Time step

OutSourceImage(Camera)
TDNNOutImage(Predict)
0
20
40
60
80
100
Association result (dash line : target data)
1.0
0.5
0.0
−1.0
0
100
200
300
400
500
600
Step



Dr. P.-C. YANG

Dr. K. Suzuki

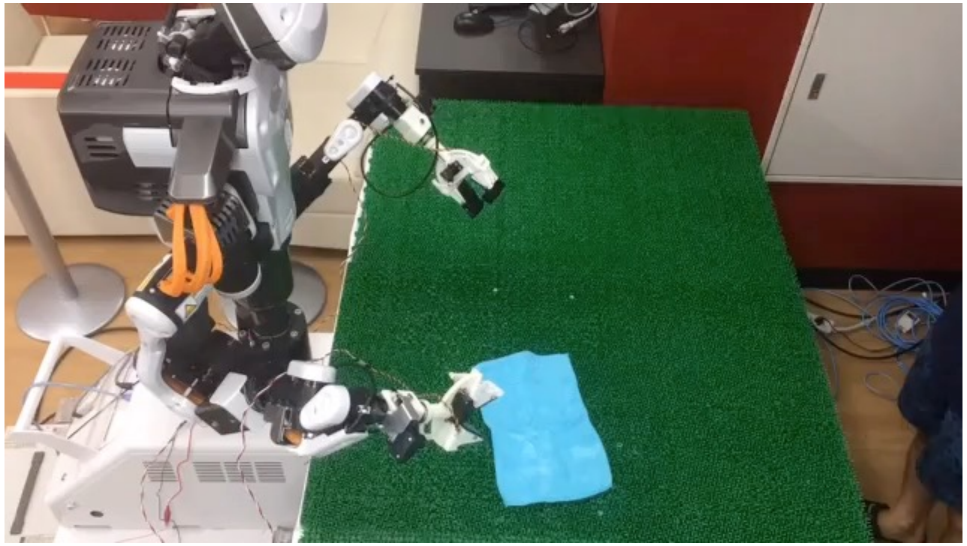
Predictive coding

Active inference

Demonstration of DPL

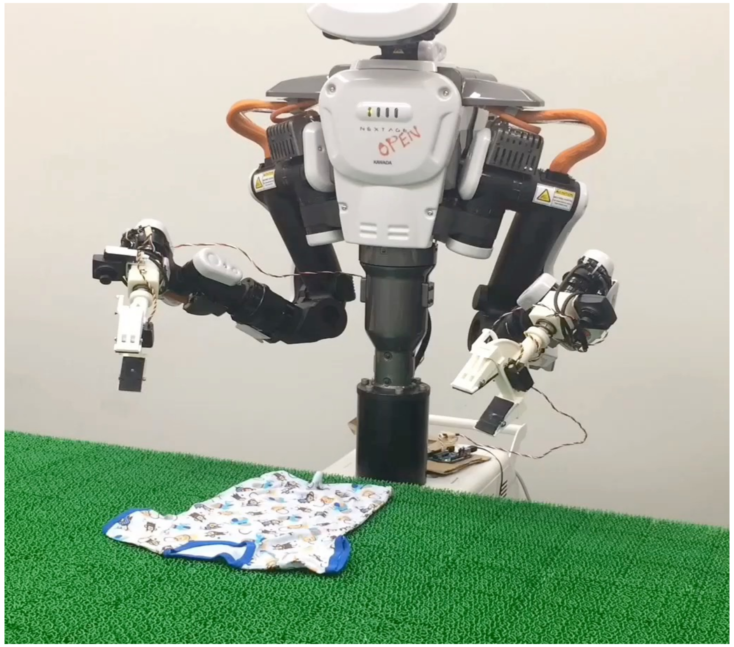
- ☐ E2E motion generation
  IEEE RA-L **2016**, ICRA2017 etc.

- ☐ E2E motion generation
  IEEE RA-L **2018**.



Folding motion with unknown towel and book

Cebit 2017, CEATEC2017, iRex2017



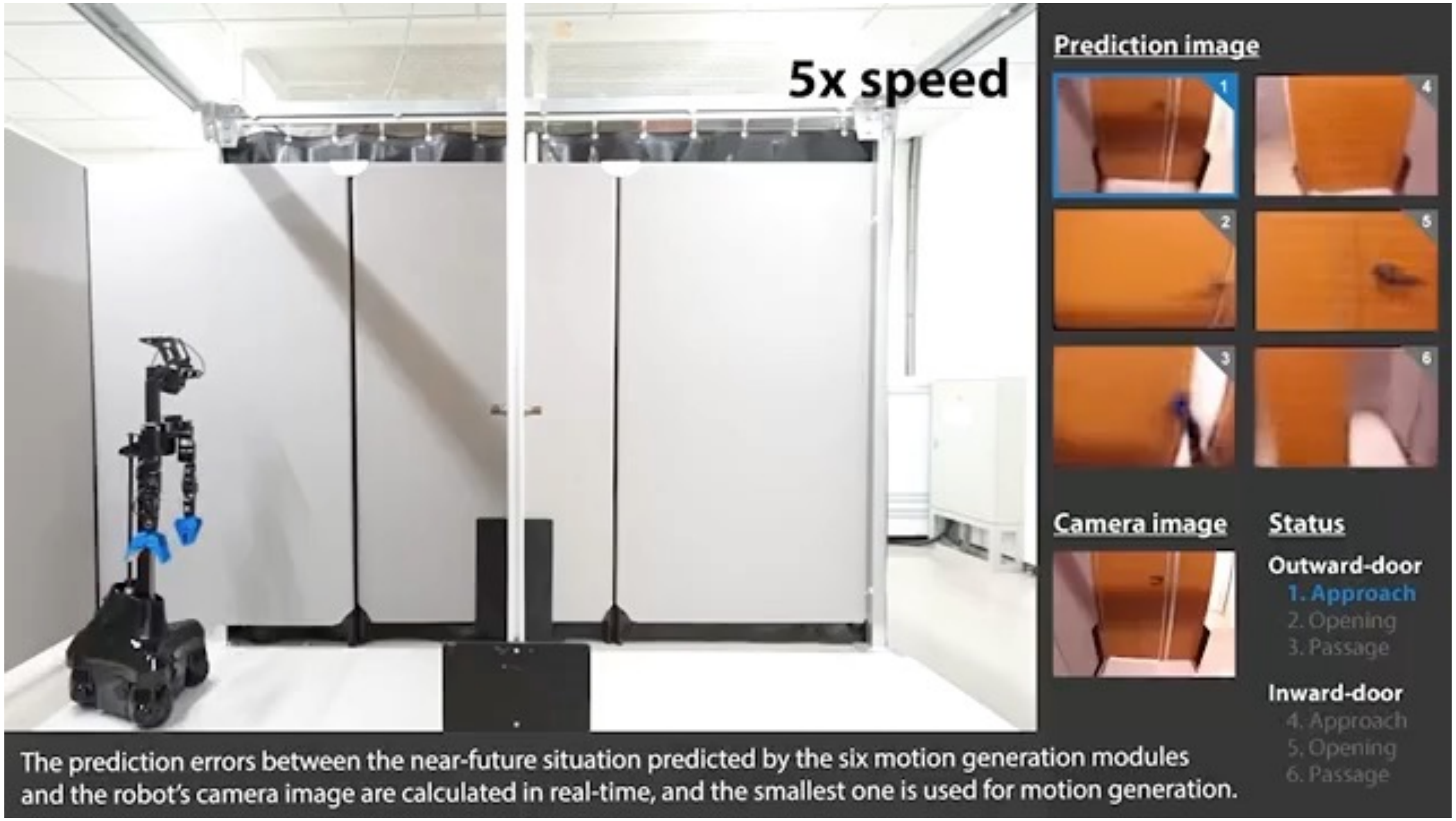
Whole Body Learning

H. Ito, K. Yamamoto, H. Mori, T. Ogata,

Science Robotics(**2021 Impact Factor: 23.748**), Vol. 7, Issue 65, 2022

HITACHI
Inspire the Next

Dr. H. Ito

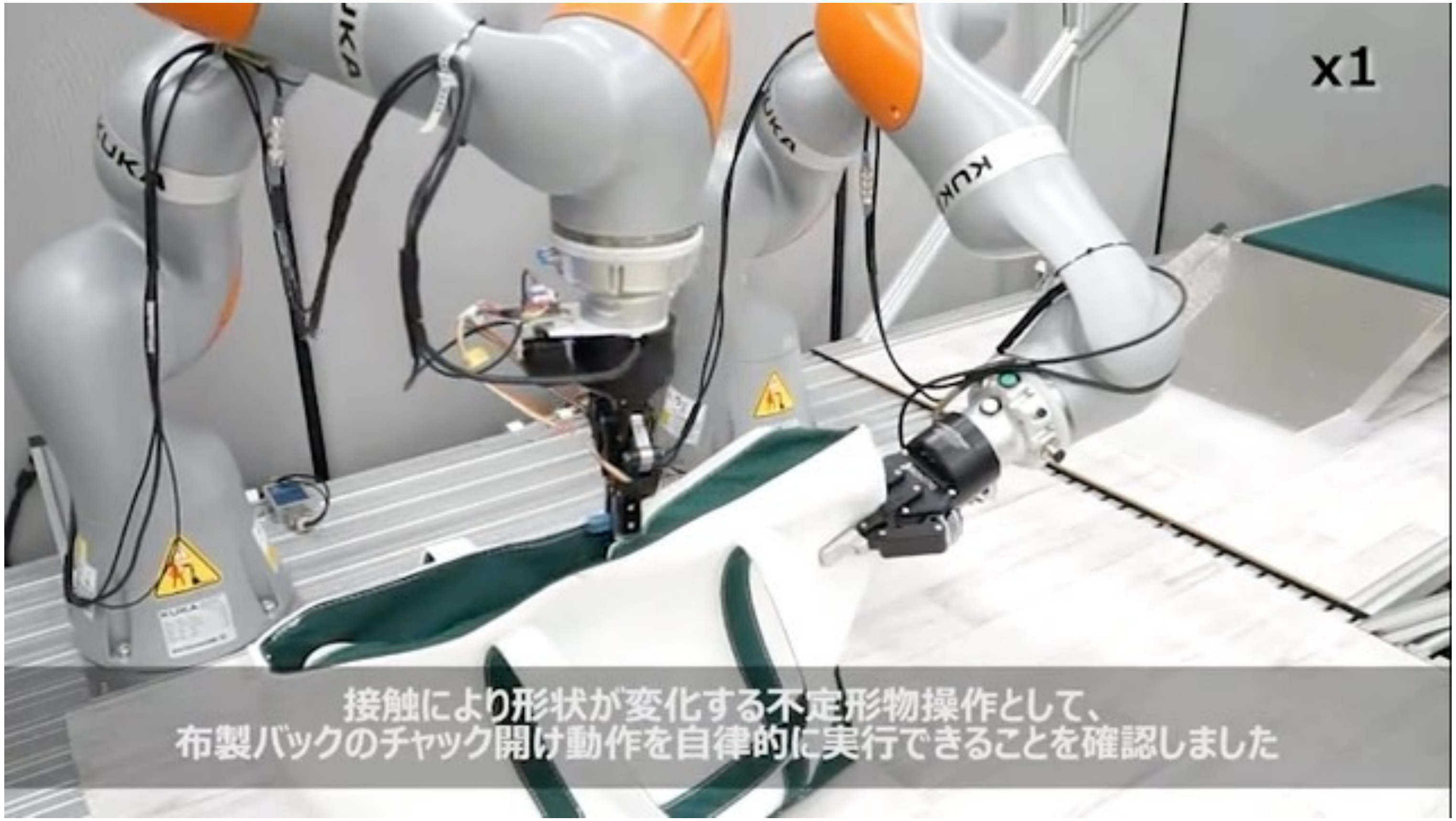

5x speed
Prediction image
1
4
2
5
3
6
Camera image
Status
Outward-door
1. Approach
2. Opening
3. Passage
Inward-door
4. Approach
5. Opening
6. Passage

The prediction errors between the near-future situation predicted by the six motion generation modules and the robot's camera image are calculated in real-time, and the smallest one is used for motion generation.

Science
Robotics
APRIL 2022
AAAS

Flexible object handling by DPL

[H. Ichiwara+, ICRA**2022**] [H. Ito+, ICRA**2022**]



接触により形状が変化する不定形物操作として、
布製バックのチャック開け動作を自律的に実行できることを確認しました

Training with only "**36**" motion data

Mr. H. Ichiwara

HITACHI
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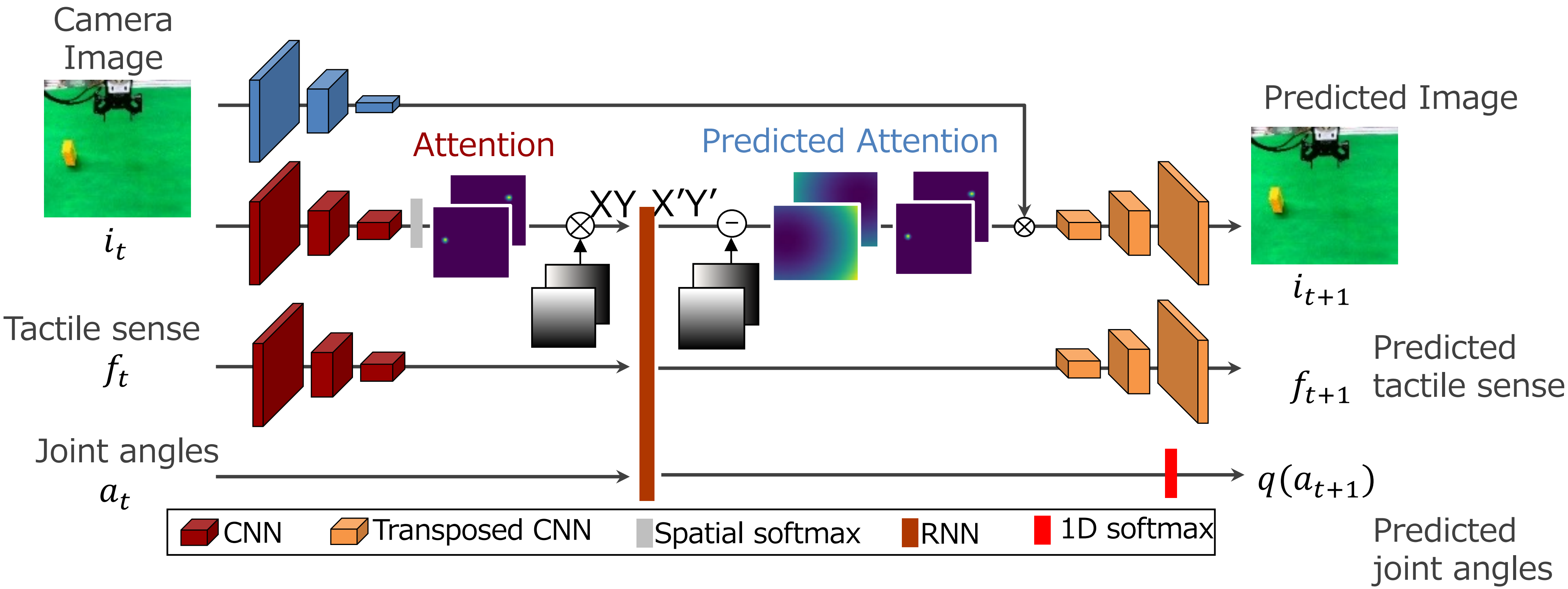
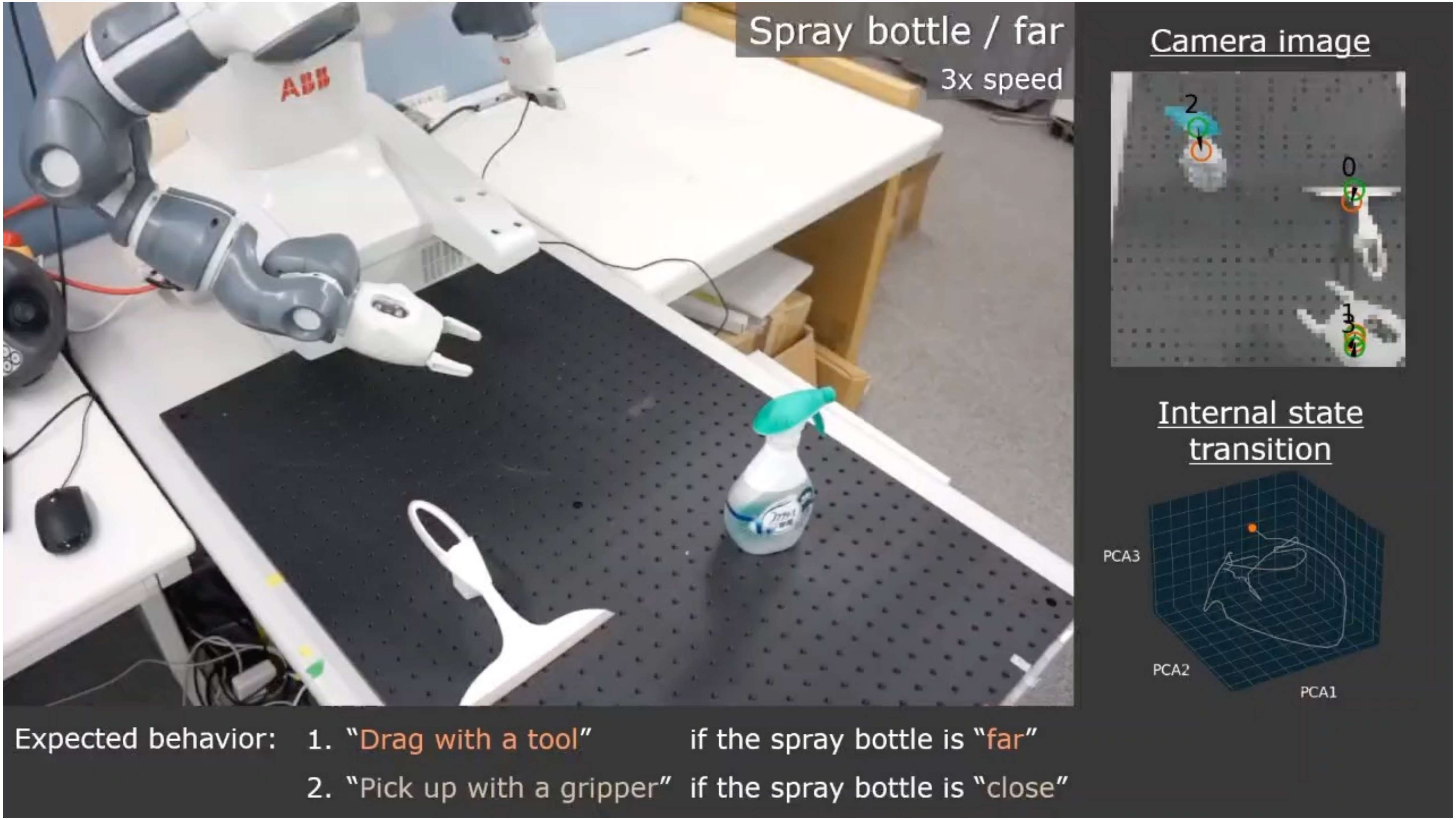
Cloth bag zipper opening by deep predictive learning

HITACHI
Inspire the Next


Camera Image
i_t
Attention
Predicted Attention
XY
X'Y'
Predicted Image
i_{t+1}
Tactile sense
f_t
Predicted tactile sense
f_{t+1}
Joint angles
a_t
$q(a_{t+1})$
Predicted joint angles
CNN
Transposed CNN
Spatial softmax
RNN
1D softmax

Trained with 36 opening motions (10 sec) in different bag conditions



Spray bottle / far

3x speed

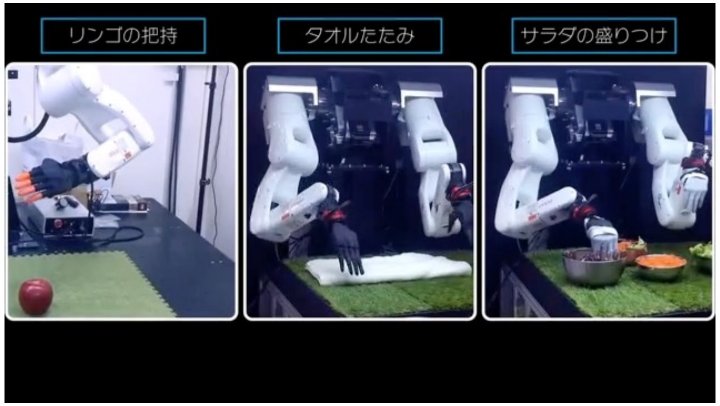
Camera image

Internal state transition

Expected behavior:
1. "Drag with a tool" if the spray bottle is "far"
2. "Pick up with a gripper" if the spray bottle is "close"

ABB
2
0
1
3
PCA3
PCA2
PCA1

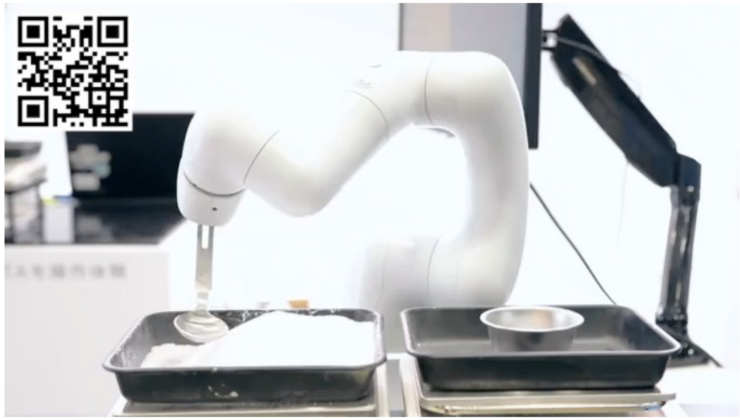
Industrial applications of DPL



ExaWizards BECKHOFF DENSO DENSO WAVE

Multimodal AI robot (2017)

- Towels holding
- Salads serving



ExaWizards DENSO DENSO WAVE

Weighing powders (2018)

AI IMITATION LEARNING
Ai 模倣学習

Harness assembly (2021)

DENSO DENSO WAVE integral

AI IMITATION LEARNING
Ai 模倣学習

Measuring Liquid (2021)

- of different viscosities without prior knowledge

DENSO DENSO WAVE integral

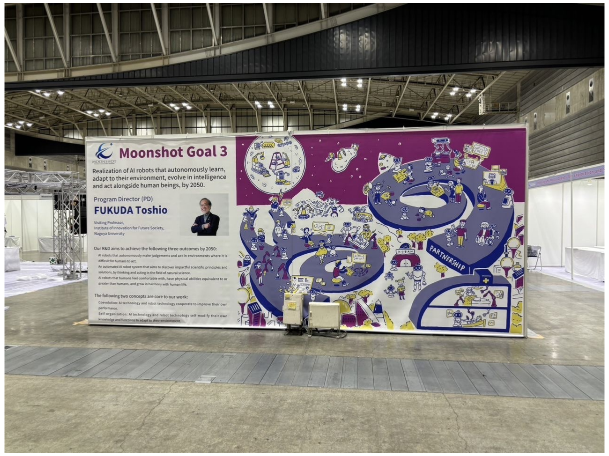
Live demos at ICRA2024

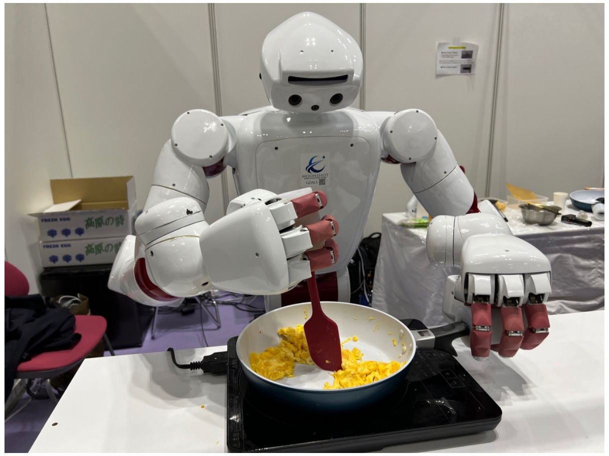
JST

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

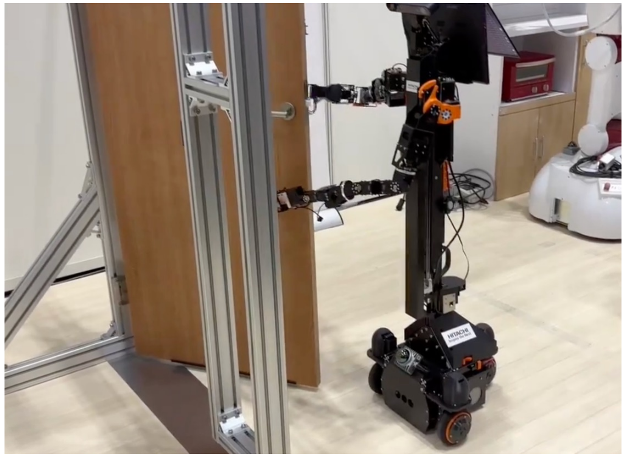
HITACHI
Inspire the Next

TokyoRobotics


Moonshot Goal 3
Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050.
Program Director (PD)
FUKUDA Toshio
PARTNERSHIP



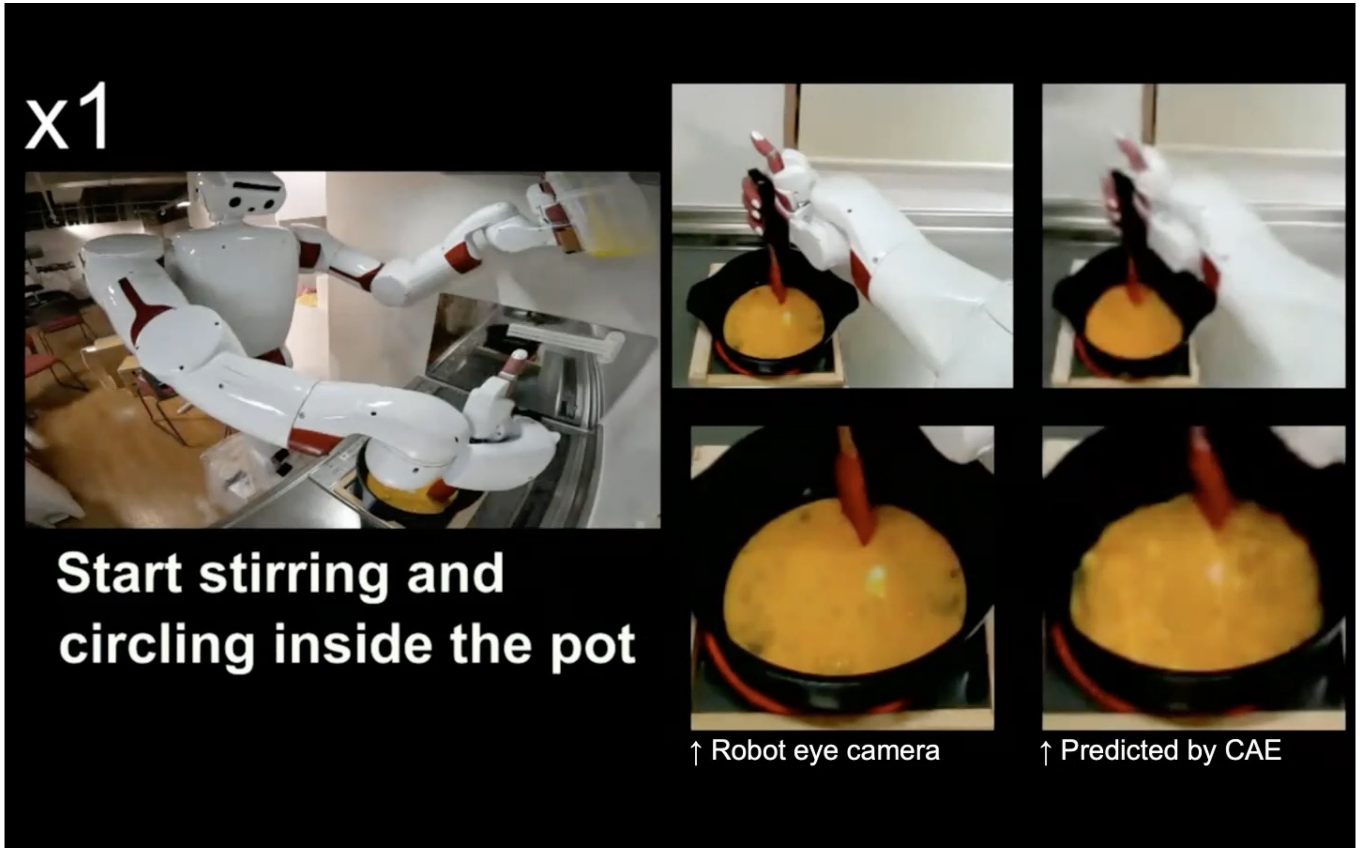
HITACHI
Inspire the Next



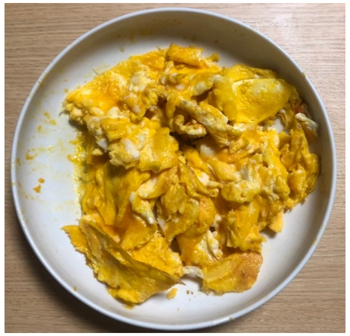
Learning of Cooking with an Attention Mechanism

N. Saito, M. Tatsumi, A. Kubo, K. Suzuki, H. Ito, S. Sugano, and T. Ogata, Humanoids 2025

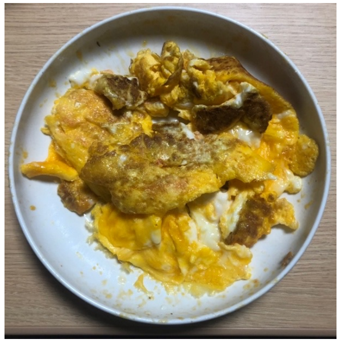
Dr. N. Saito


x1
↑ Robot eye camera
↑ Predicted by CAE

Start stirring and circling inside the pot



Our model



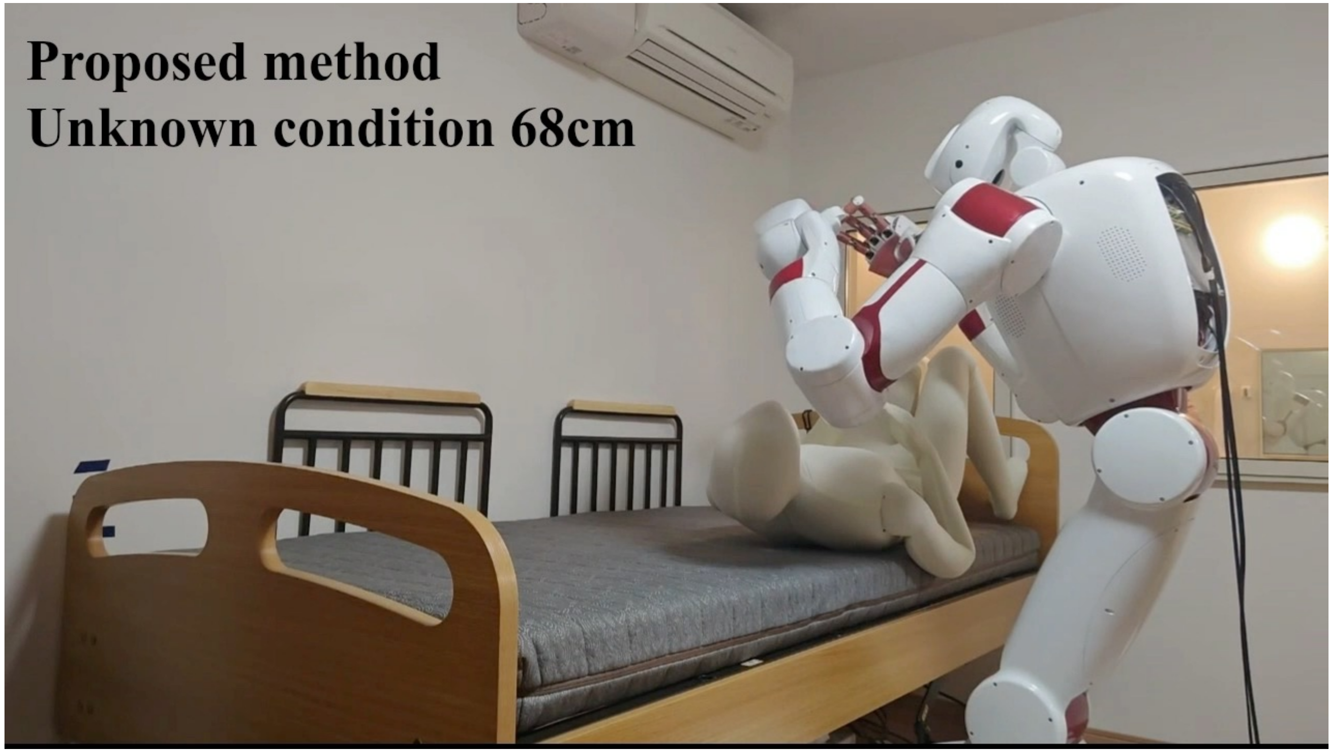
Playback of teacher actions

Trained only “32” cooking motions with different heat levels

Repositioning Assistance by Deep Predictive Learning

T. Miyake, N. Saito, T. Ogata, Y. Wang, and S. Sugano, **IROS2025**

Dr. T. Miyake


Proposed method
Unknown condition 68cm

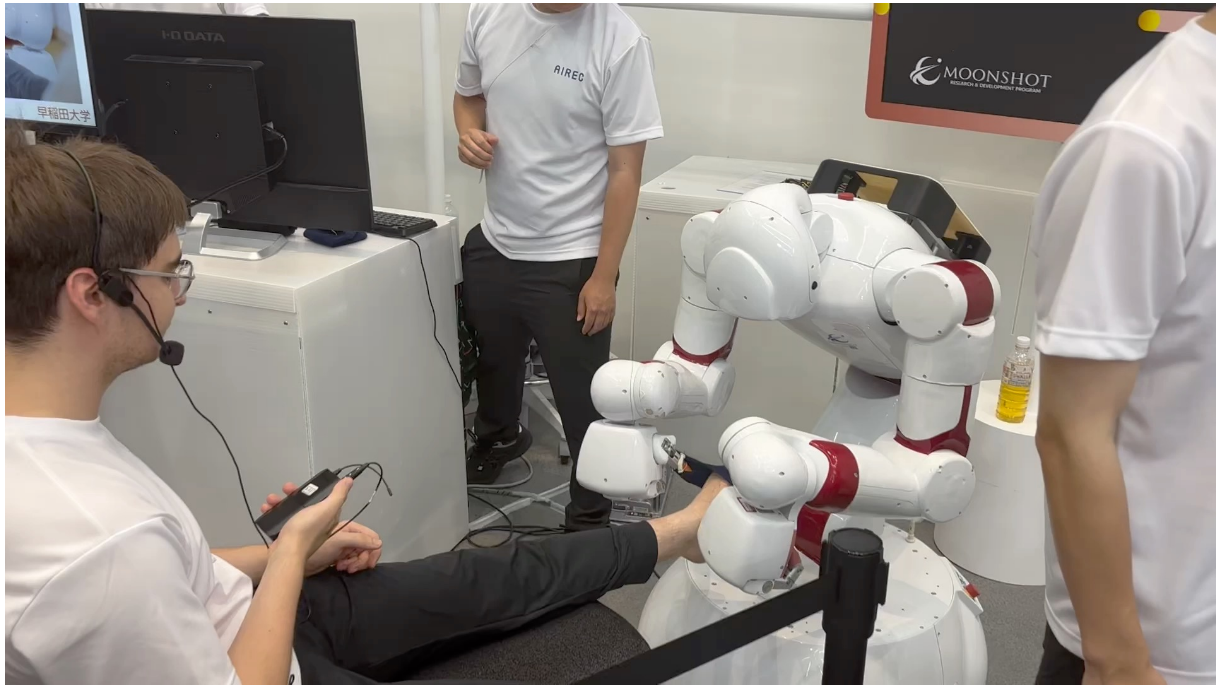
Input image

Predicted image

Human Robot Interaction with End-to-end motion generation

[RA-L accepted, 2026]

- human-robot interaction to support putting on socks.



MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

JAIST
JAPAN
ADVANCED INSTITUTE OF
SCIENCE AND TECHNOLOGY
1990

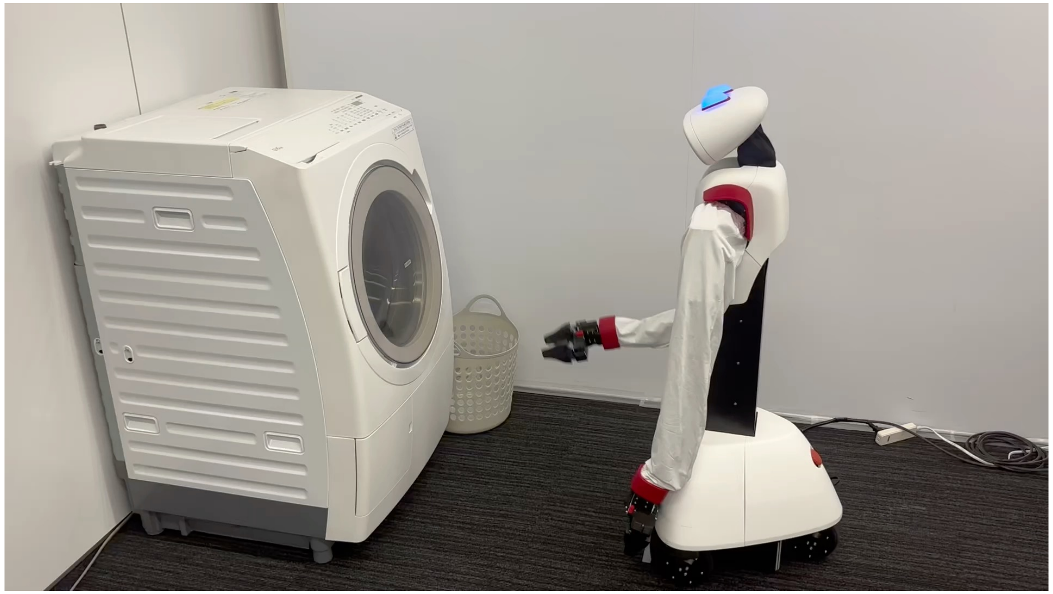
WASEDA
University

OSAKA, KANSAI, JAPAN
EXPO
2025

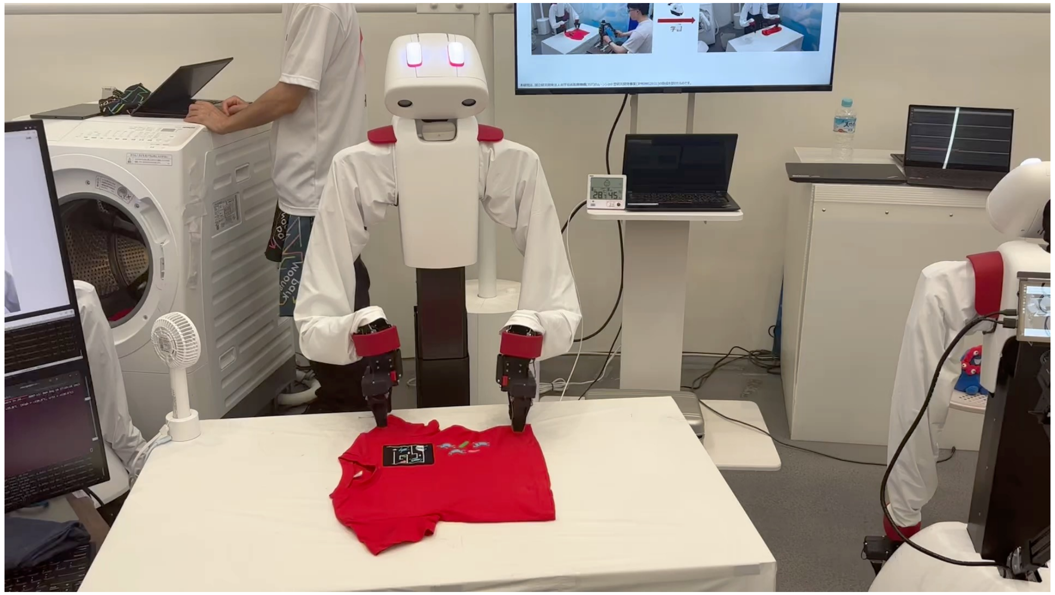
Demonstration in Expo 2025 Osaka, Kansai, Japan (August 6th)

AIREC-Basic

End2End live demonstration



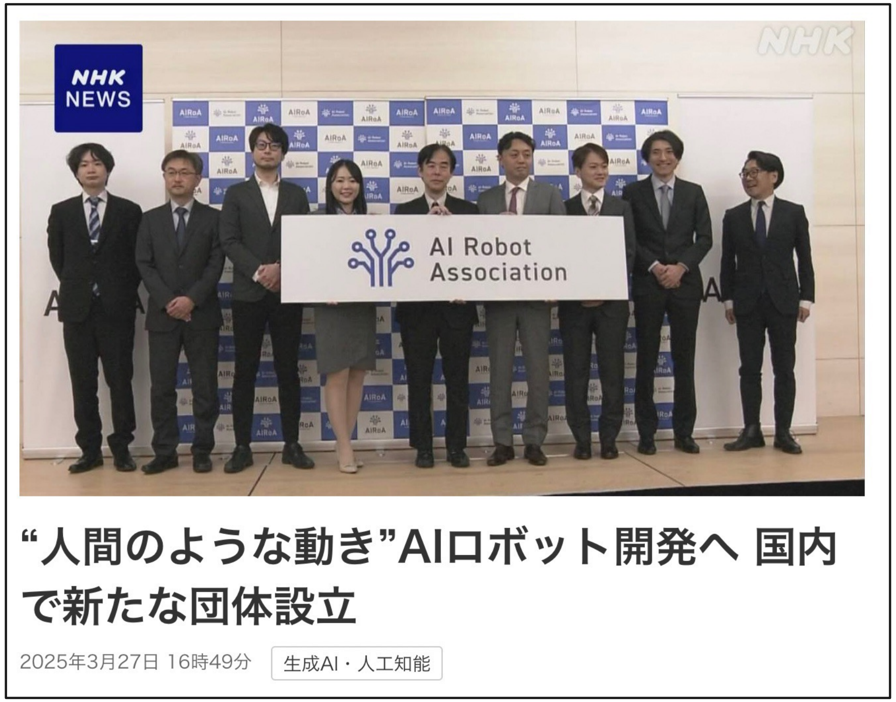
1X (March 7th, 2025@Miraikan, Tokyo)



1X (August, 2025@Kansai EXPO, Osaka)

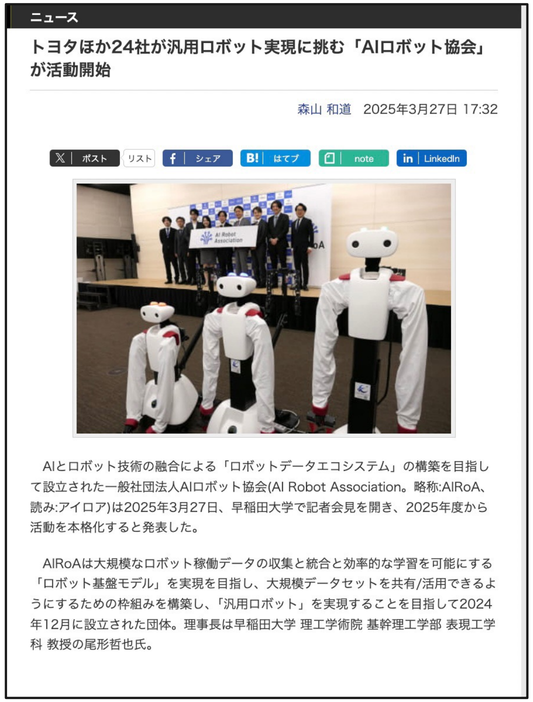
AIRoA (AI Robot Association)

On March 27, 2025, a press conference was held to establish AIRoA.
It has been featured in various media.



“人間のような動き”AIロボット開発へ 国内で新たな団体設立

2025年3月27日 16時49分 生成AI・人工知能

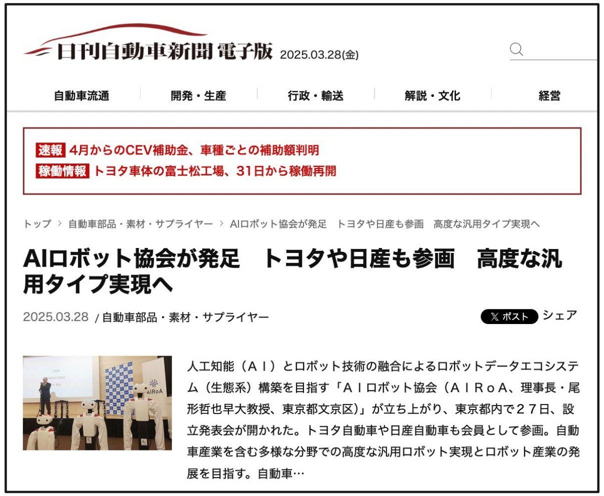


トヨタほか24社が汎用ロボット実現に挑む「AIロボット協会」が活動開始

森山 和道 2025年3月27日 17:32

AIとロボット技術の融合による「ロボットデータエコシステム」の構築を目指して設立された一般社団法人AIロボット協会(AI Robot Association。略称:AIRoA、読み:アイロア)は2025年3月27日、早稲田大学で記者会見を開き、2025年度から活動を本格化すると発表した。

AIRoAは大規模なロボット稼働データの収集と統合と効率的な学習を可能にする「ロボット基盤モデル」を実現を目指し、大規模データセットを共有/活用できるようにするための枠組みを構築し、「汎用ロボット」を実現することを目指して2024年12月に設立された団体。理事長は早稲田大学 理工学術院 基幹理工学部 表現工学科 教授の尾形哲也氏。



2025.03.28(金)

速報 4月からのCEV補助金、車種ごとの補助額判明
稼働情報 トヨタ車体の富士松工場、31日から稼働再開

トップ > 自動車部品・素材・サプライヤー > AIロボット協会が発足 トヨタや日産も参画 高度な汎用タイプ実現へ

AIロボット協会が発足　トヨタや日産も参画　高度な汎用タイプ実現へ

2025.03.28 / 自動車部品・素材・サプライヤー

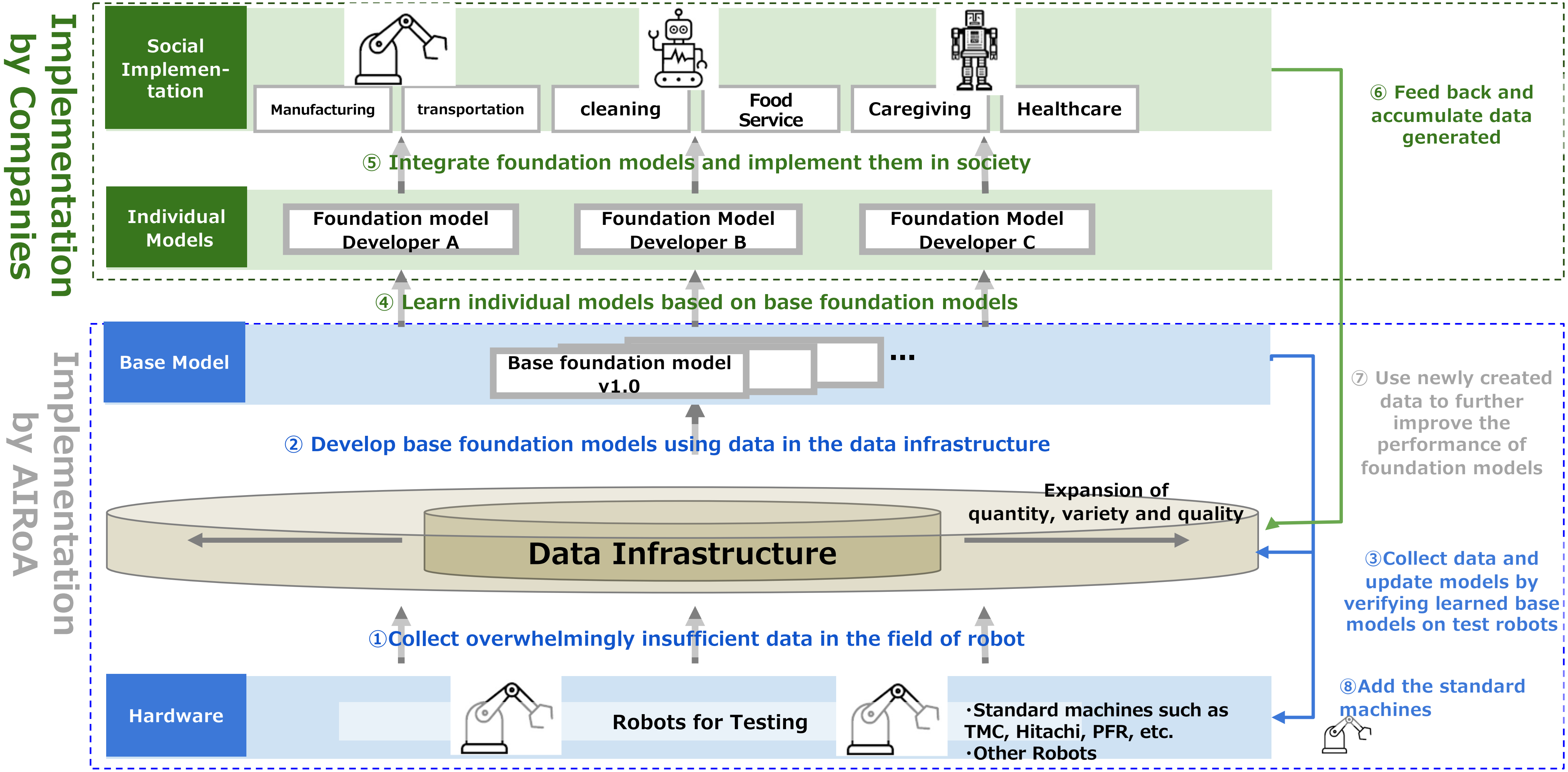
人工知能（ＡＩ）とロボット技術の融合によるロボットデータエコシステム（生態系）構築を目指す「ＡＩロボット協会（ＡＩＲｏＡ、理事長・尾形哲也早大教授、東京都文京区)」が立ち上がり、東京都内で２７日、設立発表会が開かれた。トヨタ自動車や日産自動車も会員として参画。自動車産業を含む多様な分野での高度な汎用ロボット実現とロボット産業の発展を目指す。自動車…

- **参加メディア (一部)**：NHK / テレビ東京 / 読売新聞社 / 朝日新聞社 / 日本経済新聞社 / 日本経済新聞社 /科学新聞社/電波新聞社/日本物流新聞社/日刊建設通信新聞社/日刊自動車新聞社/ライノス・パブリケーションズ/リックテレコム/日本流通産業新聞社/日経BP/アイティメディア株式会社/インプレス

20B JPY (approx. 130M USD) supported by NEDO (METI) in August 2025

Robot PF| Create a Scalable/Data Driven Robot Learning Ecosystem

AIRoA



Implementation by Companies

Social Implemen-tation

Manufacturing

transportation

cleaning

Food Service

Caregiving

Healthcare

⑤ Integrate foundation models and implement them in society

Individual Models

Foundation model Developer A

Foundation Model Developer B

Foundation Model Developer C

⑥ Feed back and accumulate data generated

④ Learn individual models based on base foundation models

Implementation by AIRoA

Base Model

Base foundation model v1.0

…

⑦ Use newly created data to further improve the performance of foundation models

② Develop base foundation models using data in the data infrastructure

Expansion of quantity, variety and quality

Data Infrastructure

③Collect data and update models by verifying learned base models on test robots

①Collect overwhelmingly insufficient data in the field of robot

Hardware

Robots for Testing

- ・Standard machines such as TMC, Hitachi, PFR, etc.
- ・Other Robots

⑧Add the standard machines

Regular, Startup, and Supporting Members (as of Sept. 19, 2025)

Regular Members

ABEJA
GMO
KDDI
SB Intuitions
TELEXISTENCE
SAKURA internet
TOYOTA
松尾研究所 Matsuo Institute, Inc.
MITSUBISHI ELECTRIC
NEC
FUJITSU
NISSAN MOTOR CORPORATION
KAWADA technologies
PKSHA TECHNOLOGY
INNOVATOR TO INNOVATOR HIGHRESO
DENSO Crafting the Core
pwc
HITACHI
EPSON
Qualcomm

Startup Members

Connected Robotics
Jizai
PREFERRED Preferred Robotics
TokyoRobotics
ALGOMATIC
RT CORPORATION
FastLabel
ugo
APTO
KUFUSHA
SINIC X

Supporting Members

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ISUZU ADVANCED ENGINEERING CENTER, LTD

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Matsuo Research Institute Co.

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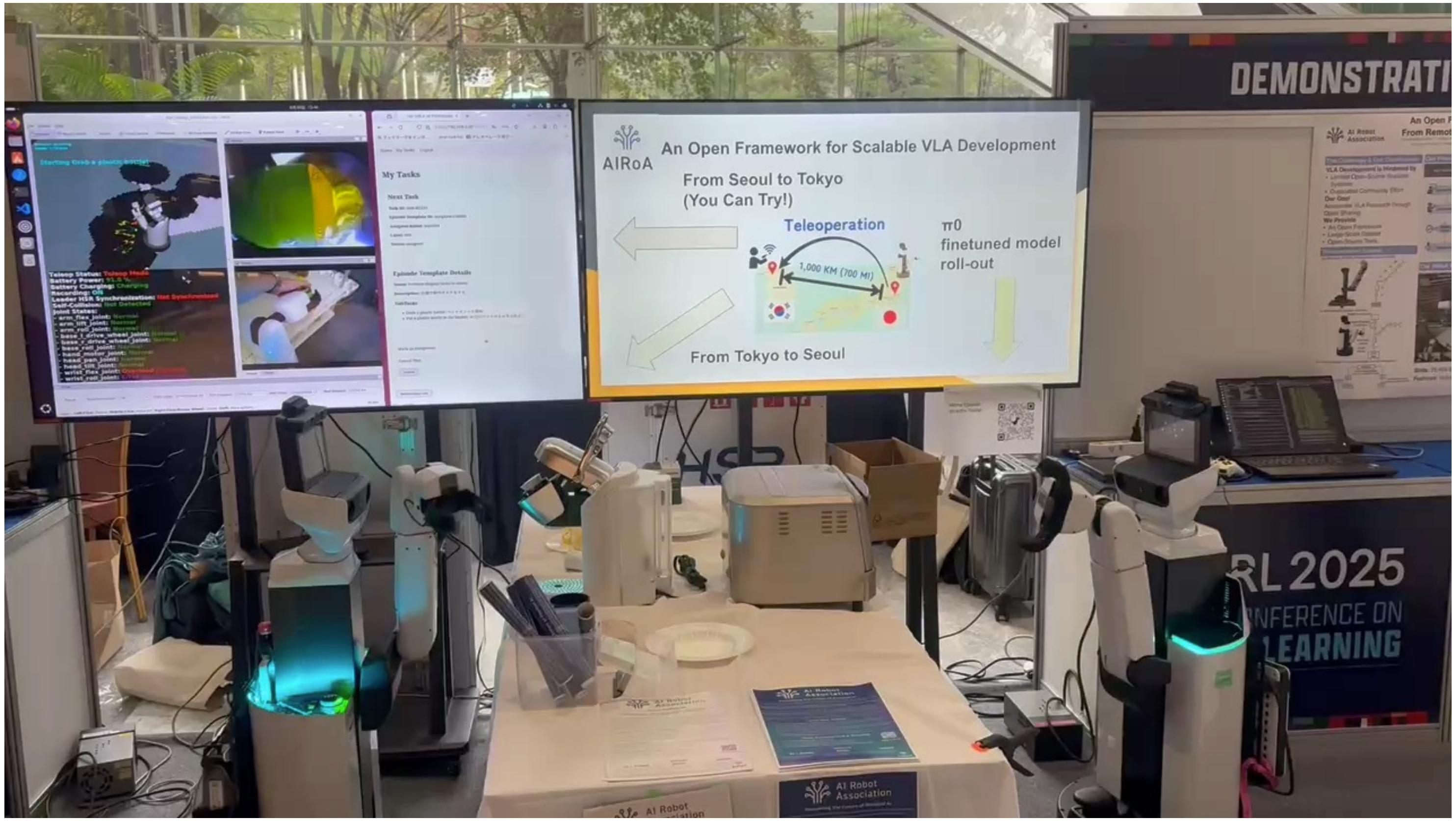
Special Advisor: Teruo Fujii
President of the University of Tokyo

Data Collection Using HSR and Live Demonstration at CoRL2025

AIRoA MoMa Dataset: A Large-Scale Hierarchical Dataset for Mobile Manipulation


AIRoA
An Open Framework for Scalable VLA Development
From Seoul to Tokyo
(You Can Try!)
Teleoperation
π0
finetuned model
roll-out
1,000 KM (700 MI)
From Tokyo to Seoul
DEMONSTRATI
RL 2025
NFERENCE ON
LEARNING
AI Robot Association

Teleoperated from Tokyo

Autonomous (finetuned PI0)

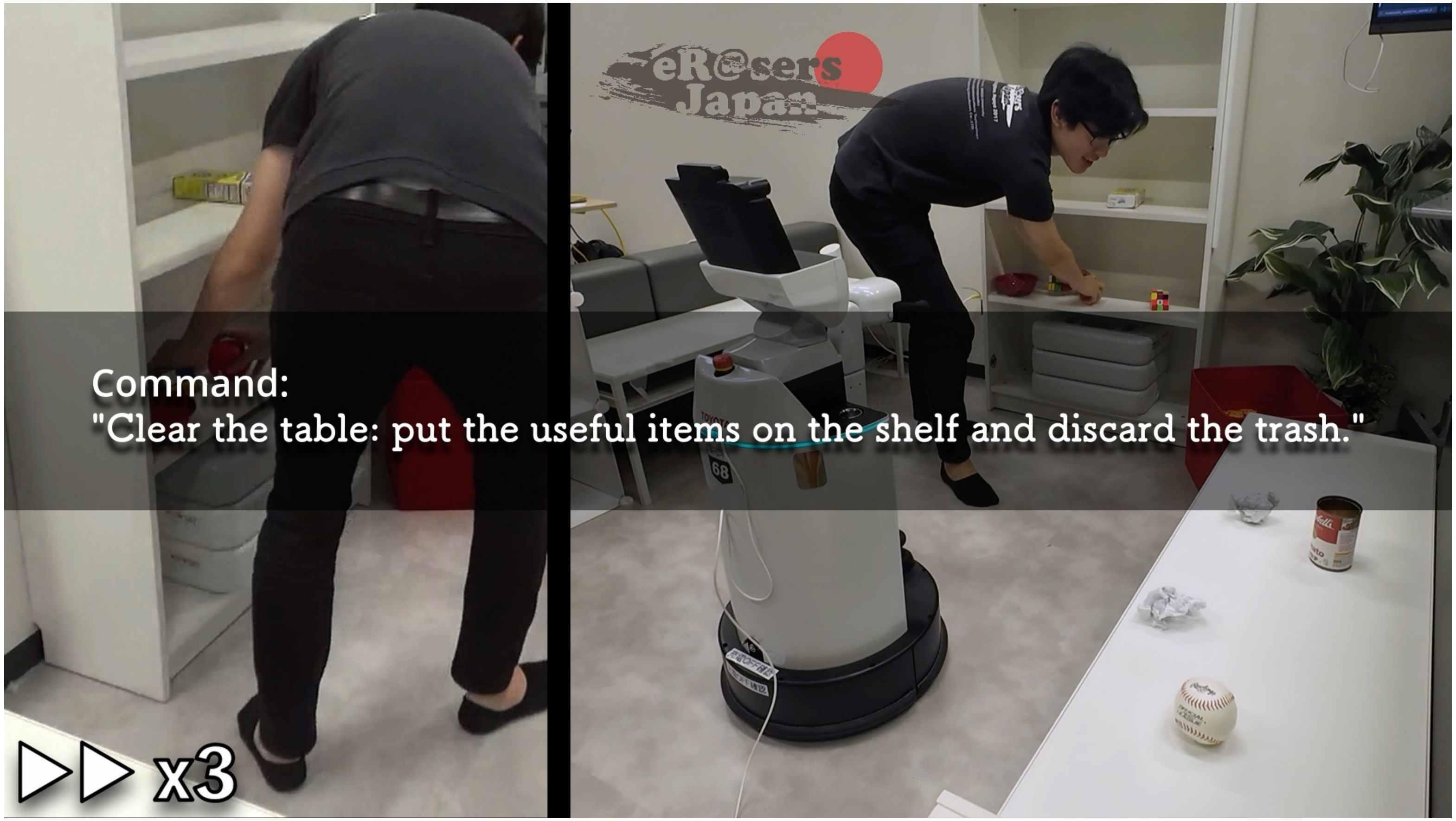
Dr. T. Matsushima
(AIRoA CTO & U of Tokyo)

CoRL
@Seoul
Sept. 30th, 2025

Case study with the platform developed by AIRoA @ Tamagawa Univ.

Partnering with the HSR community to validate pi0 finetuning

Collect three types of data for about 5 hours: pick, place, and the movement that connects them.

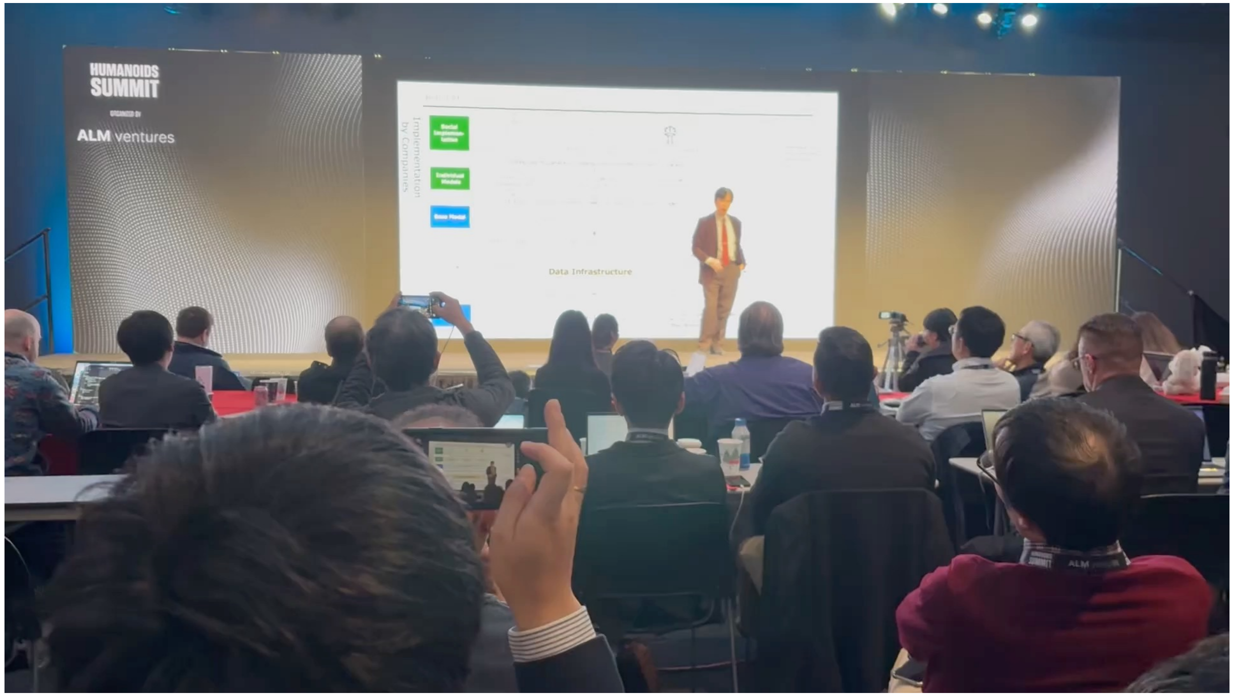

eR@sers Japan
Command:
"Clear the table: put the useful items on the shelf and discard the trash."
▷▷ x3

Prof. T. Inamura

Humanoids Summit in Silicon Balley (2025 Dec.)

Google DeepMind, Disney Research, Boston Dynamics, 1X, etc.

HUMANOIDS SUMMIT
ALM ventures
Humanoids Summits 2025
December 12th, 2025
AI Robot Association
AIRoA Japan:
Building the Foundation for Next-Generation Robotics and AI Technologies in Japan and Beyond
Tetsuya Ogata
Waseda University


HUMANOIDS SUMMIT
ALM ventures
Implementation by Companies
Data Infrastructure

一般社団法人AIロボット協会（AIRoA)、シリコンバレー発・会員主導型ロボティクス団体「Bay Area Robotics Association（BARA)」と国際連携を開始

日本と米国のロボティクスエコシステムを結び、社会実装に向けた協働を推進

Fundamentals and Core Technologies for Embodied AI

[Embodied AI Systems]
Research Supervisor:
Tetsuya Ogata

April 2025

Tetsuya Ogata
Professor, Waseda University

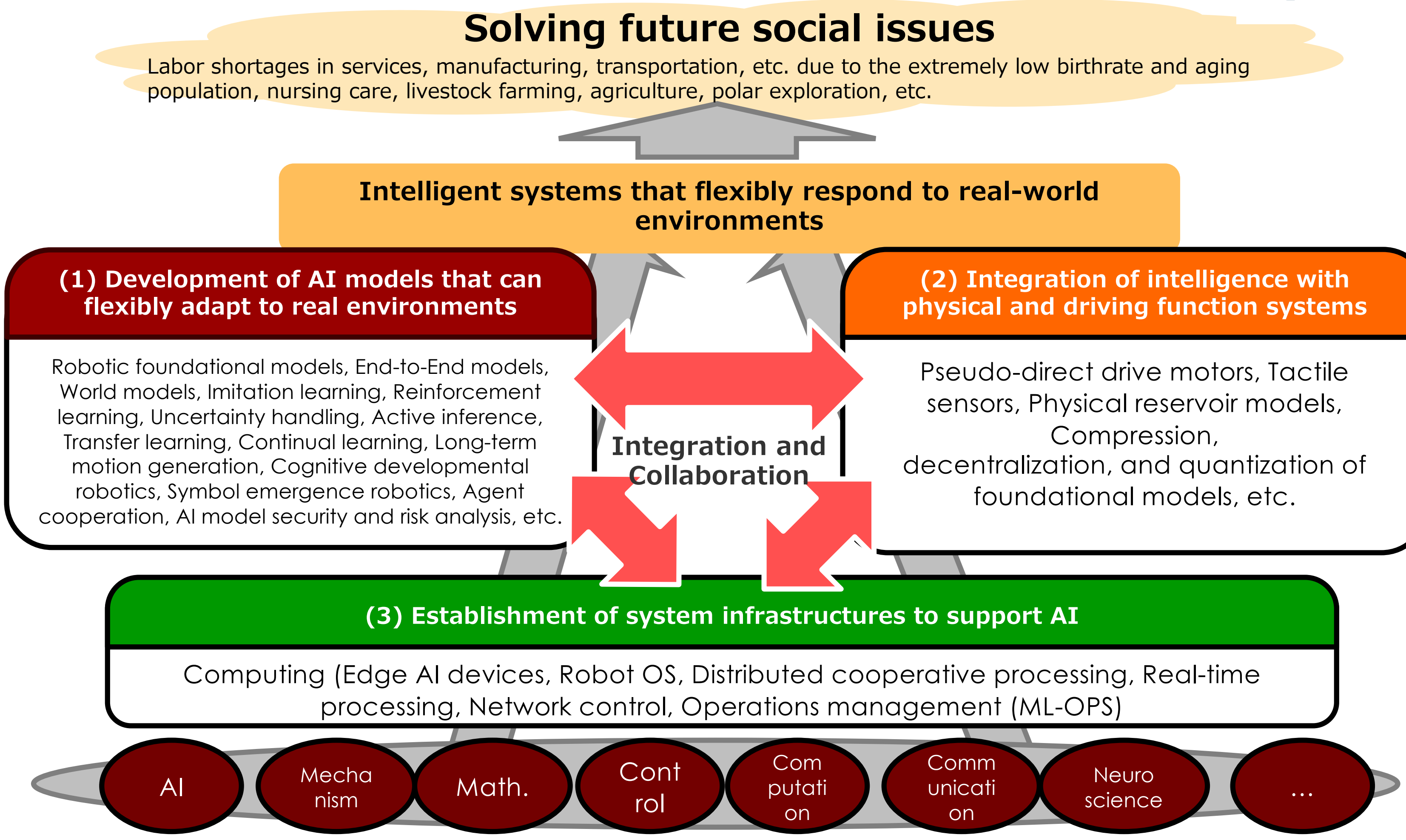
Research Fund and Duration

2025 year proposal

- Research period: 5.5 years (from October 2025 to the end of March 2031)
- A total of approximately 15 proposals will be adopted, including those for 2026 and 2027.
- Budget size of each proposal (upper limit): Total 300M JPY (approx. 2M USD) (excluding indirect expenses)

# The amount of the application may be adjusted by scrutiny, etc.

Ogata CREST (2025-)



Solving future social issues

Labor shortages in services, manufacturing, transportation, etc. due to the extremely low birthrate and aging population, nursing care, livestock farming, agriculture, polar exploration, etc.

Intelligent systems that flexibly respond to real-world environments

(1) Development of AI models that can flexibly adapt to real environments

Robotic foundational models, End-to-End models, World models, Imitation learning, Reinforcement learning, Uncertainty handling, Active inference, Transfer learning, Continual learning, Long-term motion generation, Cognitive developmental robotics, Symbol emergence robotics, Agent cooperation, AI model security and risk analysis, etc.

Integration and Collaboration

(2) Integration of intelligence with physical and driving function systems

Pseudo-direct drive motors, Tactile sensors, Physical reservoir models, Compression, decentralization, and quantization of foundational models, etc.

(3) Establishment of system infrastructures to support AI

Computing (Edge AI devices, Robot OS, Distributed cooperative processing, Real-time processing, Network control, Operations management (ML-OPS)

Integration and collaboration of various fields

Research Area Advisors

- Prof. Koichi Osuka
  - Faculty of Robotics and Design, Osaka Institute of Technology
- Prof. Hiroyuki Okada
  - Information Design, Tokyo Information Design Professional University
- Dr. Chihiro Ono
  - Executive Director, Data Intelligence Division, KDDI Research, Inc.
- Prof. Asako Kanezaki
  - School of Computing, Institute of Science Tokyo
- Prof. Keiji Kimura
  - Faculty of Science and Engineering, Waseda University
- Prof. Hideaki Shimazaki
  - Graduate School of Informatics, Kyoto University
- Prof. Kazuhiro Nakadai
  - Dept. of Systems and Control Engineering, Institute of Science Tokyo
- Prof. Kouta Minamizawa
  - Graduate School of Media Design, Keio University

Ogata CREST Projects (2025)

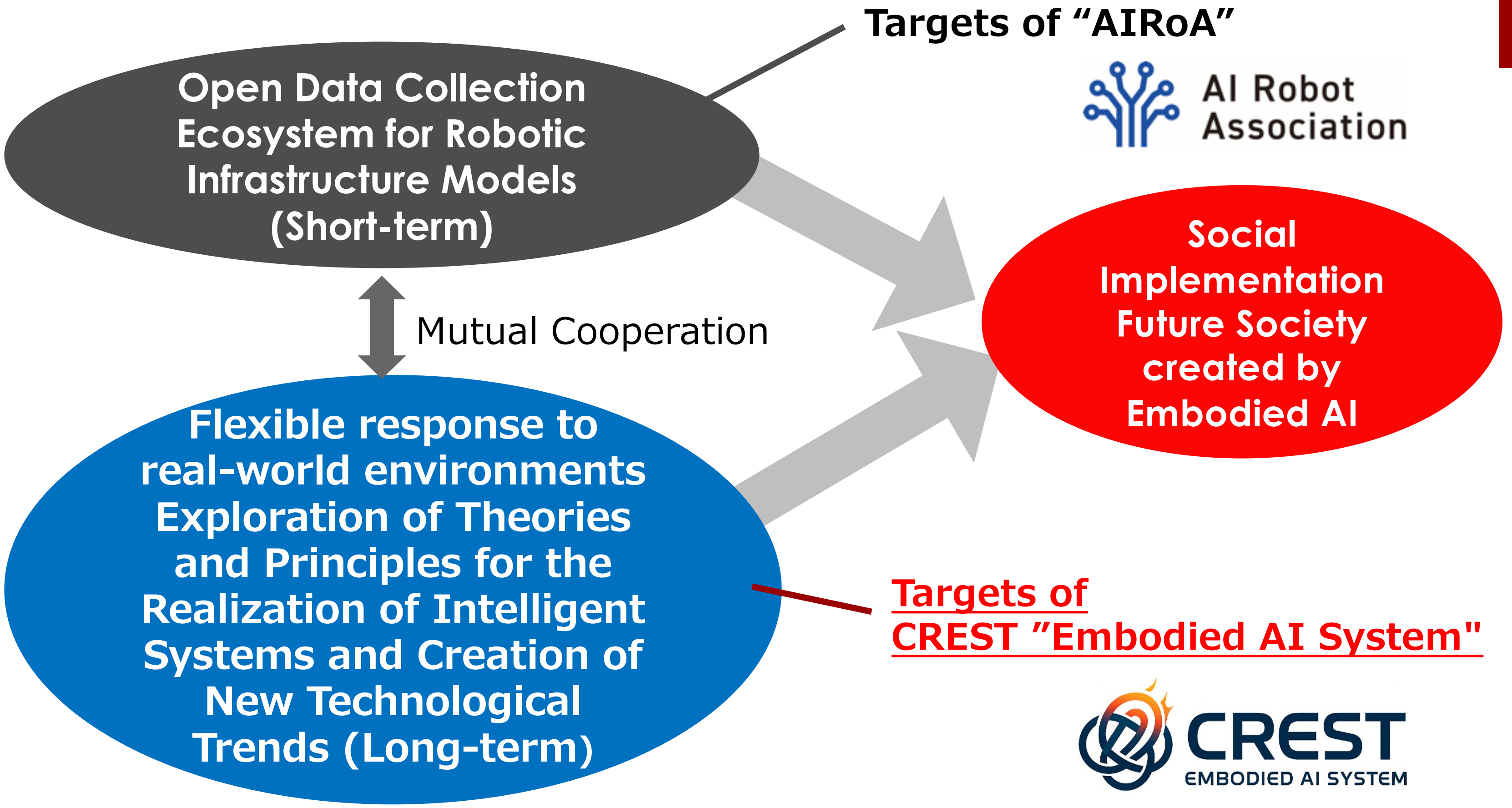
- Prof. Genki Kanda (Science Tokyo)
  - The Living Laboratory: Embodied AI Agents Conduct Life Science Research
- Prof. Yoshihiro Tanaka (Nagoya Institute of Technology)
  - Body Integration Learning Framework for Highly Skilled Robots
- Dr. Yukiyasu Domae (AIST)
  - MORAL: A Body-Thinking Robot Foundation Model
- Prof. Ho Anhvan (JAIST)
  - Cross-X: AI-Driven Tactile/Proximity, Adaptive Components Delivering Physical Intelligence Across Embodiments
- Prof. Ko Hosoda (Kyoto University)
  - Real-world Adaptive Intelligence emerging from Soft Embodiment

CREST
EMBODIED AI SYSTEM

Supported by MEXT, JST

15 proposals X 300M JPY (approx. 2M USD)

Positioning of CREST and AIRoA



Targets of “AIRoA”

AI Robot Association

Open Data Collection Ecosystem for Robotic Infrastructure Models (Short-term)

Mutual Cooperation

Flexible response to real-world environments Exploration of Theories and Principles for the Realization of Intelligent Systems and Creation of New Technological Trends (Long-term)

Social Implementation Future Society created by Embodied AI

Targets of CREST ”Embodied AI System"

CREST EMBODIED AI SYSTEM

Acknowledgements

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

JST

AIRoA

AIRC

Waseda University