National Institute of Advanced Industrial Science and Technology
AIST

EU SCIENCE COUNSELORS' MEETING
DR. LORENZ GRANRATH, 17.07.2020

AIRC

Industry 4.0 to Society 5.0: Research on Cyber Physical Systems at AI Research Center of AIST

Content

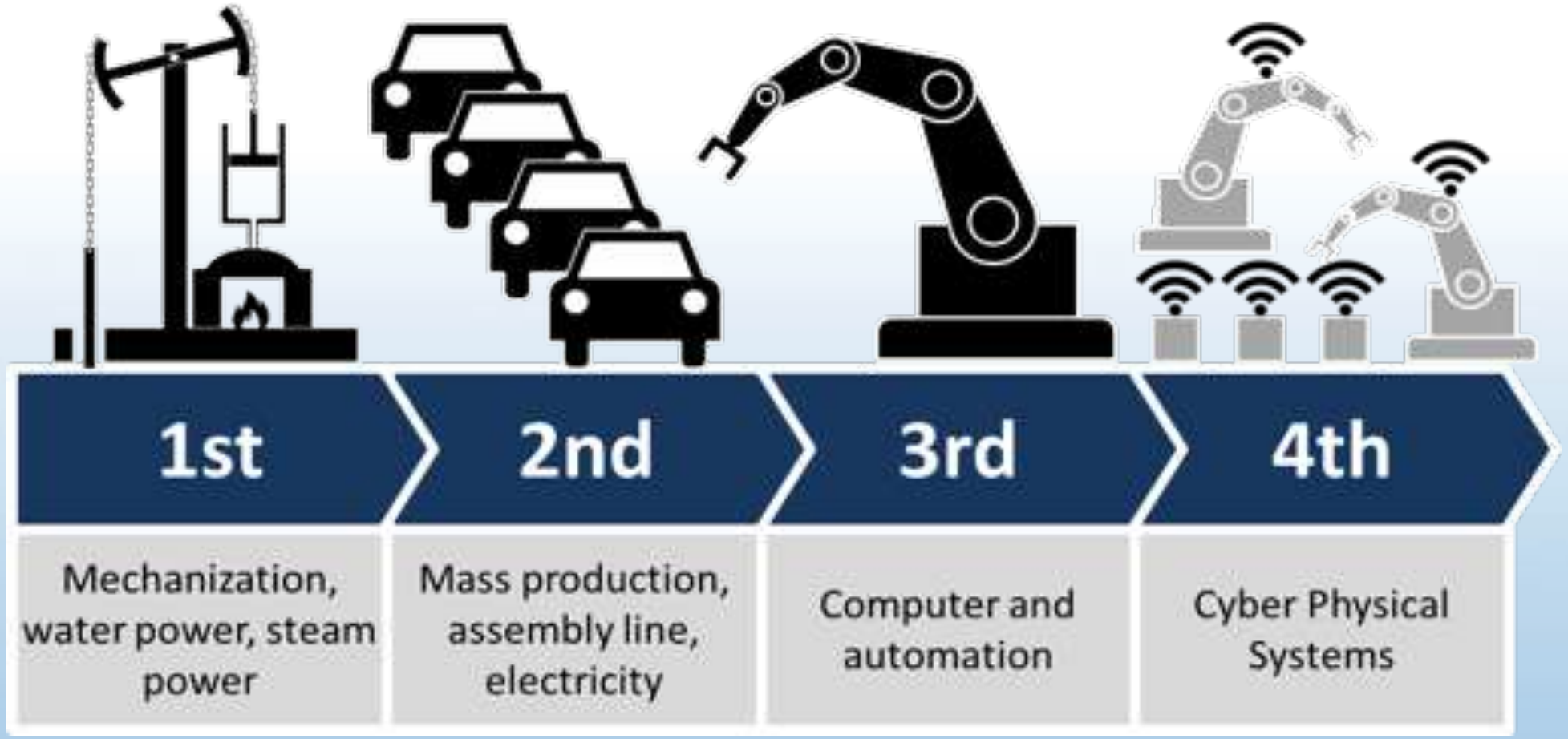
- Industry 4.0 to Society 5.0
- AIST Research in AI and CPS
- Discussion

National Institute of Advanced Industrial Science and Technology
AIST

Industrial Revolutions - Industry 4.0

AIRC

Part of German High-Tech Strategy, introduced at Hannover Messe 2011



Source: Prof. Christian ROSER, KIT

National Institute of Advanced Industrial Science and Technology
AIST

Cyber Physical System CPS

AIRC

Cyber Factory

Physical Factory

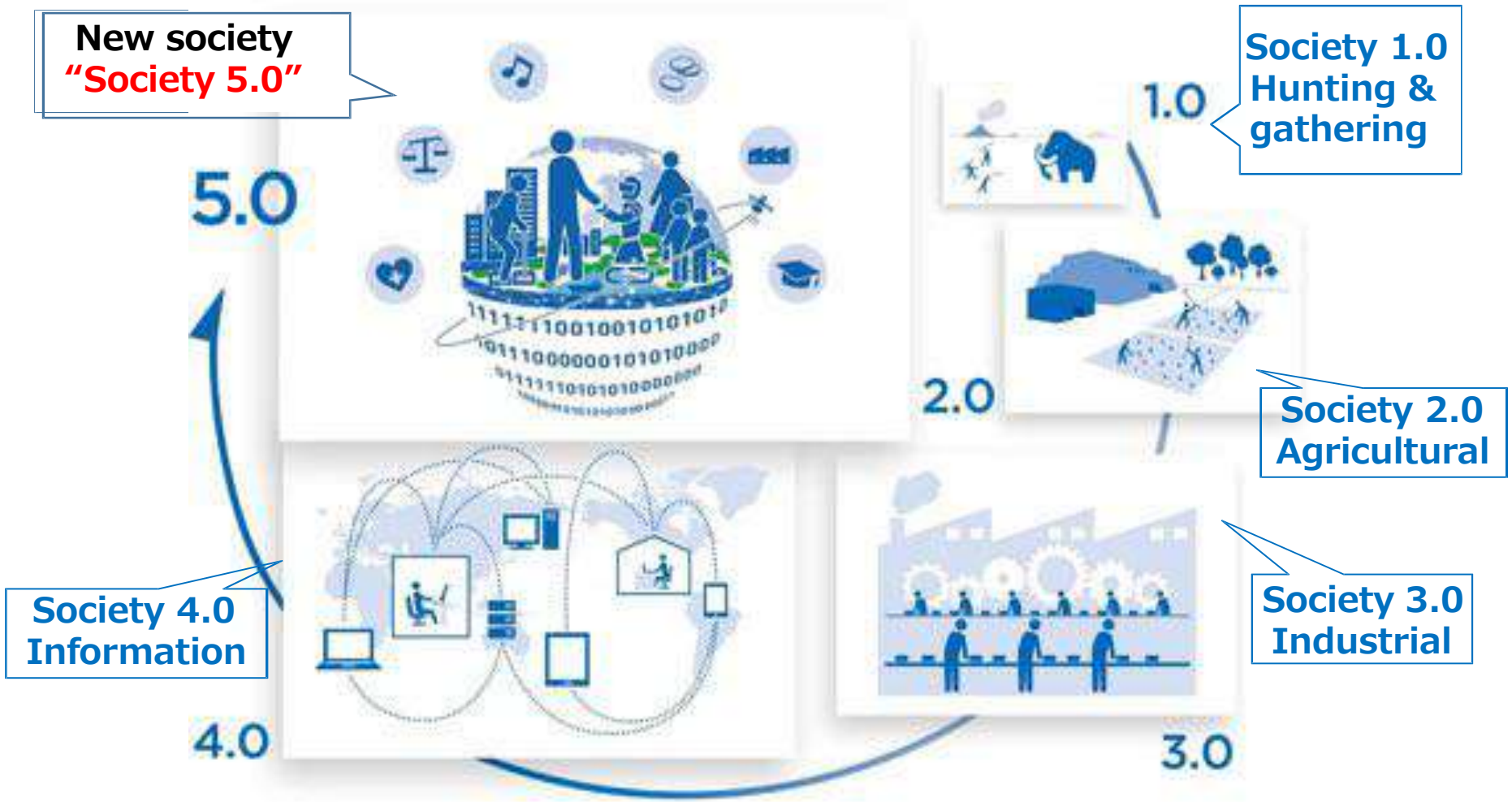
Digital Twin

Suppliers

Products

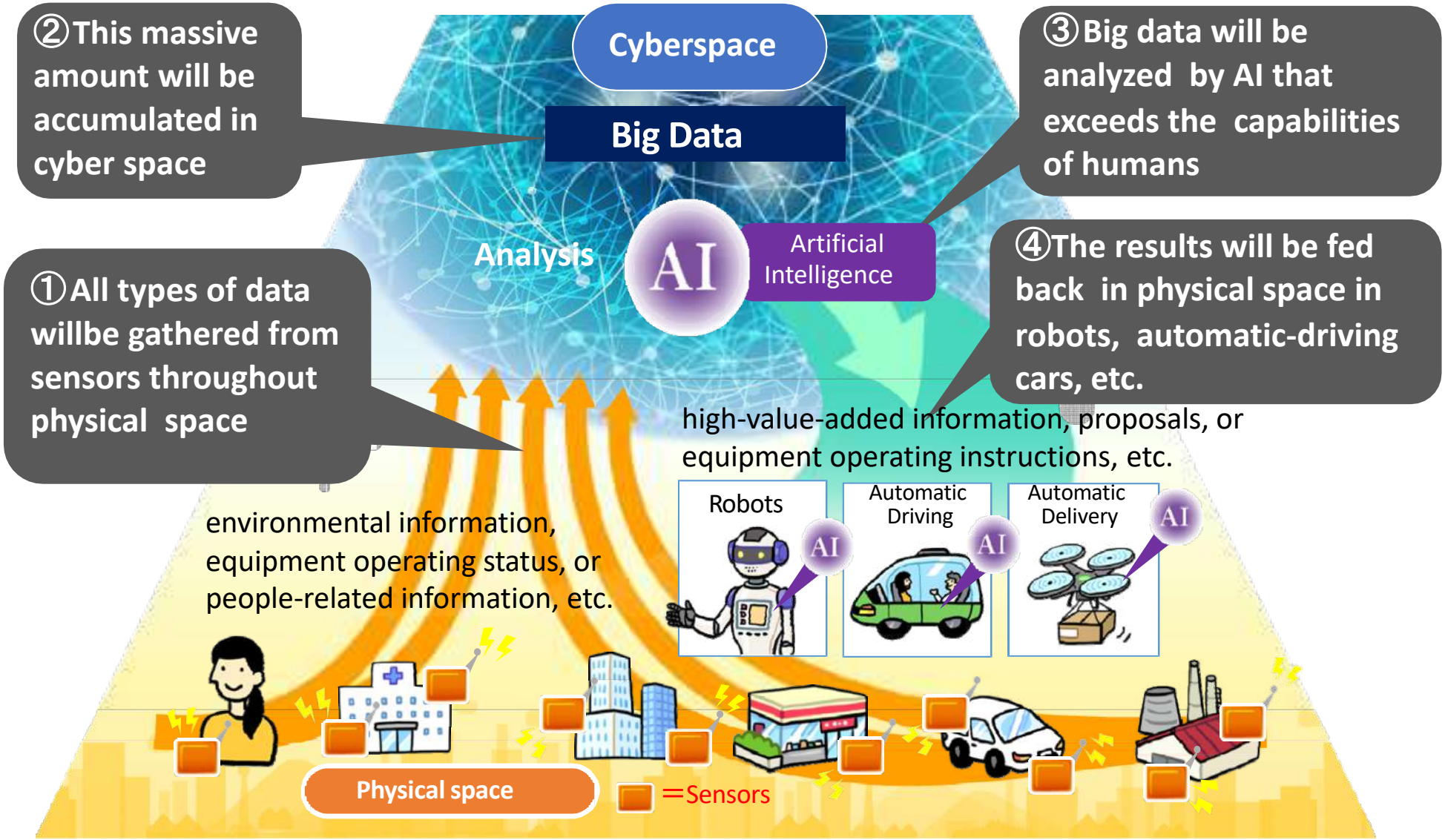
What is Society 5.0?

With ***the integration of cyberspace and physical space***, realize **the solution of social problems and economic growth** and create a **human-centered society**



Courtesy of CAO Cabinet Office

Advanced Fusion of CPS (Cyber and Physical Space)



Courtesy of CAO Cabinet Office

Solution of Social Problems and Economic Growth

Current society

Knowledge and information are not shared and cross-sector value is difficult to create.

IoT will connect all people and things, all sorts of knowledge and information will be shared, and totally new value will be born.

Current society

A variety of constraints exists with respect to social problems such as the aging society and regional depopulation making a sufficient response difficult.

Social issues will be overcome and humans will be liberated from various types of constraints.

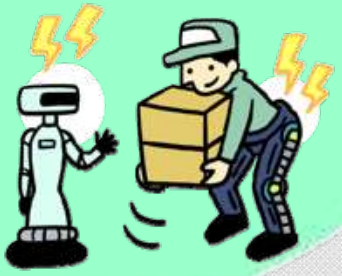
Society 5.0

Current society

Damage Information cannot be enough gathered and evacuation/rescue are delayed.

Deliver supplies to evacuation centers with drone or automatic delivery car.

The possibilities open to humans will expand through the use of robots, automatic-driving cars, etc.



Current society

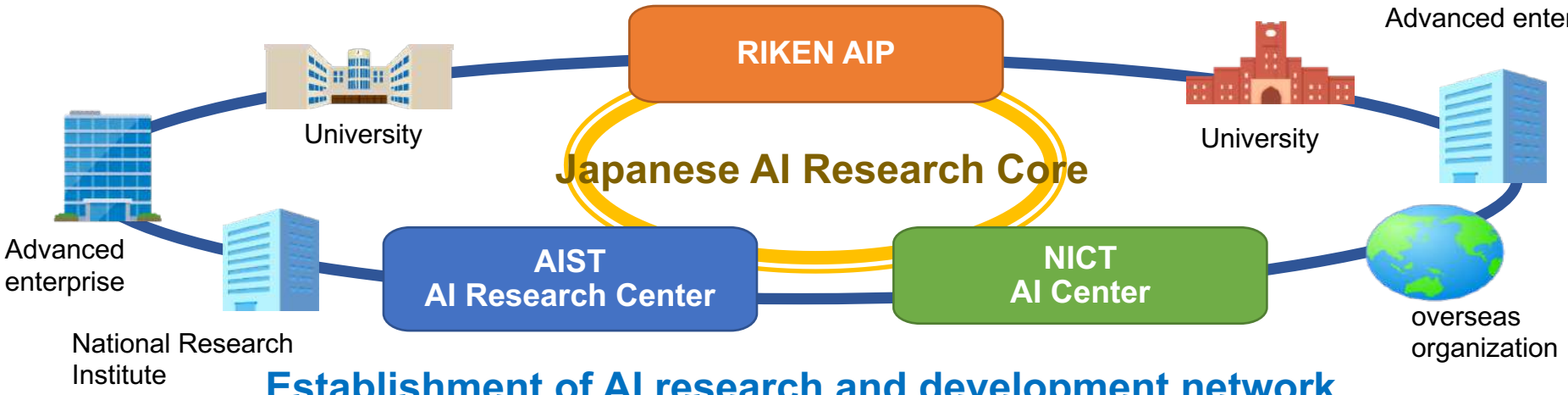
People do a large amount of work, their abilities had limitations, and the behavior of the physically challenged is constrained.

Courtesy of CAO Cabinet Office

Japan's AI Strategy Towards Society 5.0: R&D

- Making Japan an attractive base for researchers from around the world.
- Strategic promotion of next-generation AI technologies and enabling environment for innovative emerging research.

Research environment



Establishment of AI research and development network

Launch of core R&D

Next-generation AI technologies	➢ Middle range：AI to collaborate with people, Trusted AI, etc ➢ Long range：Co-Evolution of AI to understand context and meaning and to enhance people's abilities beyond current AI technologies.
Innovative Hardware for AI	➢ Ultra-low-power IoT chips ➢ innovative AI chip ➢ Ultra-large storage and memory ➢ Brain information based computing
AI for Real-World Industries	➢ AI x Robotics Technologies ➢ AI x Agricultural Technologies ➢ AI x Medical Technologies
AI for Inclusion Technologies	➢ Complement and extend human capabilities, support the disabled, the elderly and non-native Japanese speakers (Multilingual processing, etc.)

Courtesy of CAO Cabinet Office

Content

- Industry 4.0 to Society 5.0
- AIST Research in AI and CPS
- Discussion

National Institute of Advanced Industrial Science and Technology
AIST

Fraunhofer – R&D for Industry

AIRC

- Founded 1949
- 70 Institutes
- > 25.000 staff
- Budget: 1/3 Basic /Public/Industry

(Japan Representative 2001-13)

AIST @ Fh-IPA 9/2018

National Institute of Advanced Industrial Science and Technology
AIST

AIST National Institute for Advanced Industrial Science and Technology

AIRC

(Supervisory Innovation Coordinator since 2014)

Staff: 10.000 (incl. 5.000 visiting researchers)
Founded 1948
Budget: METI/
Public/Industry

AIST Tsukuba

AIST Hokkaido

AIST Tohoku

Fukushima FREA

AIST Kashiwa

AIST Kyushu

AIST Shikoku

AIST Kansai

AIST Chubu

AIST Tokyo Waterfront

AIST Chugoku

National Institute of Advanced Industrial Science and Technology
AIST

Artificial Intelligence Research Center

AIRC

AIST
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Energy and Environment | Life Science and Biotechnology | Information Technology and Human Factors | Materials and Chemistry | Electronics and Manufacturing | Geological Survey of Japan | National Metrology Institute of Japan

CPS Research Center

ABCI

National Institute of Advanced Industrial Science and Technology
AIST

AIRC Organisation & 13 Teams

AIRC

Department of Information Technology and Human Factors(Director-General: Satoshi Sekiguchi)

Artificial Intelligence Research Center (AIRC) Director: Jun-ichi Tsujii

NEC-AIST AI Cooperative Research Laboratory
Leader: Takashi Washio

Knowledge and Information Research Team
Team leader: Hiroya Takamura

Probabilistic Modeling Research Team
Team leader: Yoichi Motomura

Data Platform Research Team
Team leader: Kyoungsook Kim

Artificial Intelligence Applications Research Team
Team leader: Hidenori Sakanashi

Artificial Intelligence Cloud Research Team
Team leader: Hirotaka Ogawa

Machine Learning Research Team
Team leader: Jun Sese

Intelligent Media Processing Research Team
Team leader: Jun Ogata

Service Intelligence Research Team
Team leader: Takuichi Nishimura

Social Intelligence Research Team
Team leader: Masaki Onishi

Living Intelligence Research Team
Team leader: Yoshifumi Nishida

Geoinformation Science Team
Team leader: Ryosuke Nakamura

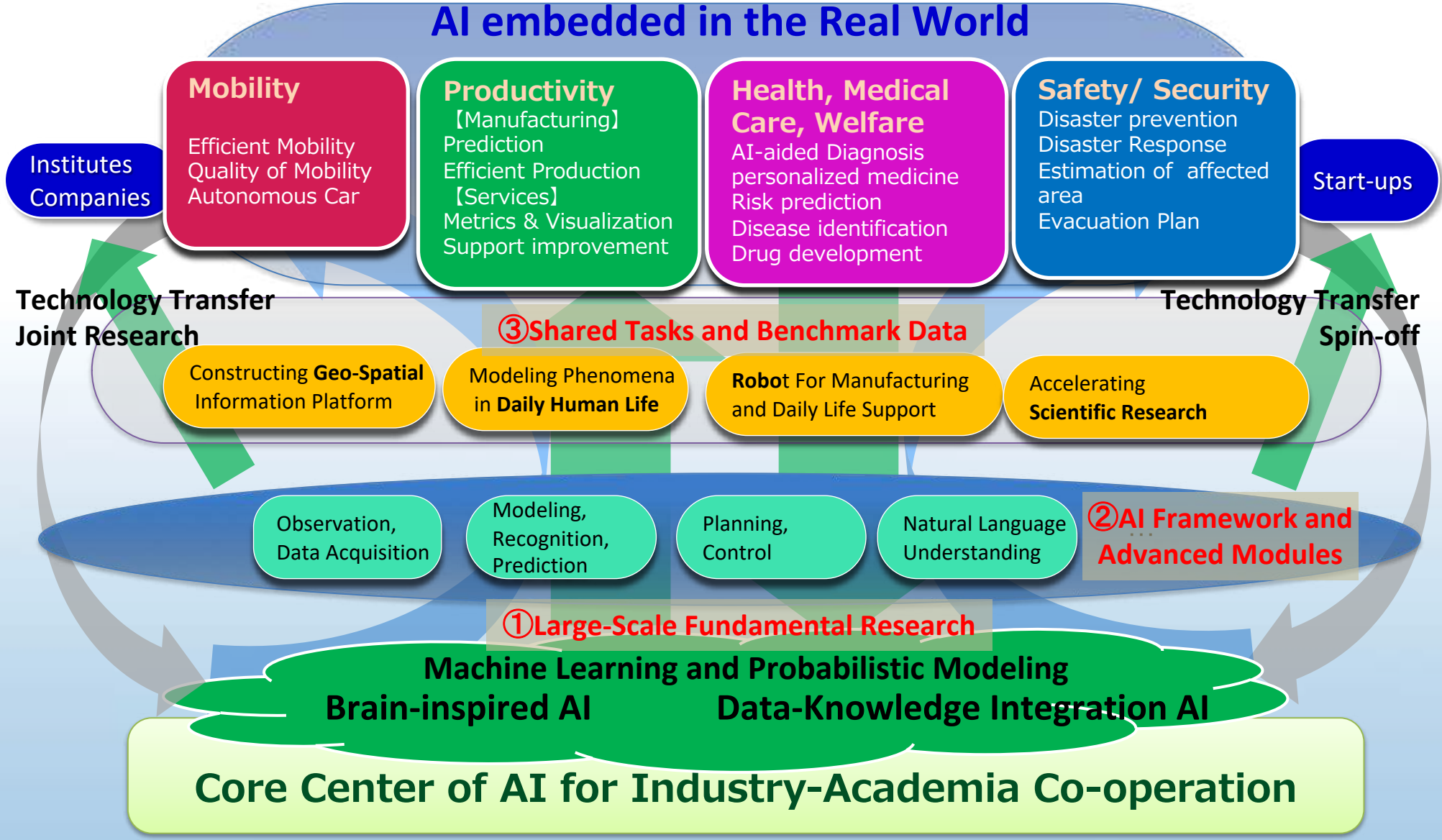
Computational Omics Research Team
Team leader: Totai Mitsuyama

Intelligent Bioinformatics Research Team
Team leader: Kentaro Tomii

National Institute of Advanced Industrial Science and Technology
AIST

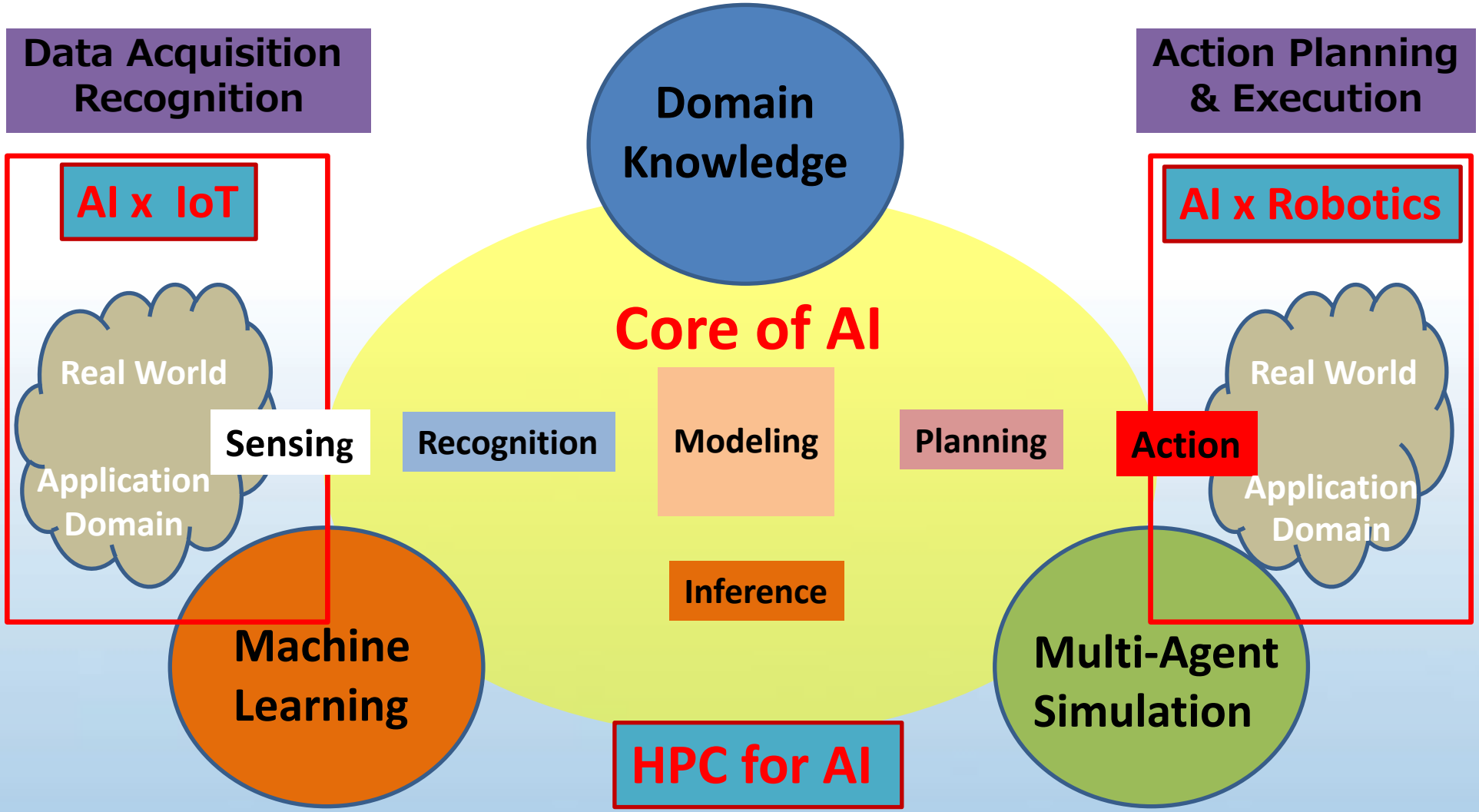
Strategy for AI Research

AIRC



National Institute of Advanced Industrial Science and Technology
AIST

AI Embedded in the Real World



Productivity

National Institute of Advanced Industrial Science and Technology
AIST

AI Technology for a physical service by robots, etc.

AIRC

- AI technology has been used mainly for information services.
- In the future, it is necessary to develop AI technology for physical service using a robot as an edge device.
- For physical service via a robot, AI learning according to the physicality of the robot is necessary.
- From the sensing information based on the robot's physicality, AI should learn for that robot.
- Furthermore, AI should learn from actual data of the environment in which the robot is servicing.
- We build three packages.
  1. a physical robot platform
  2. a physical test environment
  3. its virtual environment (Cyber Physical System: CPS) for AI learning acceleration simulation on the AI cloud.

National Institute of Advanced Industrial Science and Technology
AIST

Construction of CPS for physical service of AI

AIRC

High-performance cloud computer for AI learning

AI Bridging Cloud Infrastructure

AI for legged robot

AI for industrial robots

AI for wheel type robot

Environmental learning data

Knowledge data

Sensor data

task

Sensor data

task

Robot platforms

Legged robot

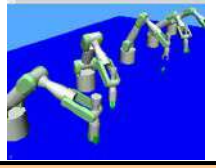
Industrial robots

wheel type robot

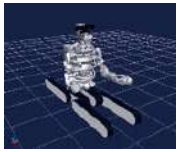
Simulation platform

Legged robot

Industrial robots



wheel type robot



Sensor

actuator

Environment data

Physical service task

Model generation,
Model accuracy check

Testing environments

Logistics service environment Convenience stores etc.

Manufacturing factory environment

Bio experimental environment

Efficient learning by parallel learning using multiple robot and simulator

National Institute of Advanced Industrial Science and Technology
AIST

ICPS Industrial Cyber Physical System Research Center

AIRC

National Institute of Advanced Industrial Science and Technology
AIST

AI x Robotics

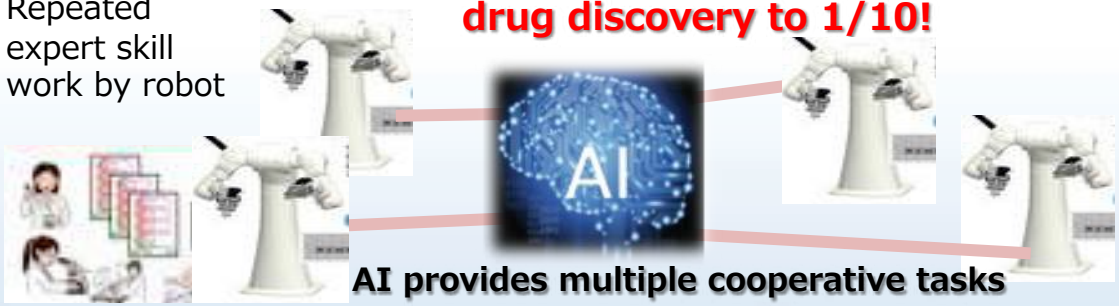
AIRC

- **Formalization study of craftsmanship**
- **Cooperating Autonomous Working Robot**
- **Intelligence and robots for human cooperative work**

Bio research robotics

Demonstrated improvement of drug discovery productivity through AI robot bio-scientist development
Goal: R & D expenses such as drug discovery to 1/10!

Repeated expert skill work by robot



AI provides multiple cooperative tasks

Retail store mock environment

Material handling: AI x robot
Target: Labor saving of store management

Factory Robotics

Demonstrate advanced model of distribution of products and information by linking various processing machines and robots and optimizing them by AI technology.

Processing (Bending, cutting etc.)

+

Manipulation (Assembly, picking, transport.)

×

optimizing by AI

→ **"Shared testing factory" that enables verification of "connecting factory"**

National Institute of Advanced Industrial Science and Technology
AIST

CPS Test Beds

AIRC

National Institute of Advanced Industrial Science and Technology
AIST

AI for Human-Machine Cooperation Utilizing Cyber Physical System

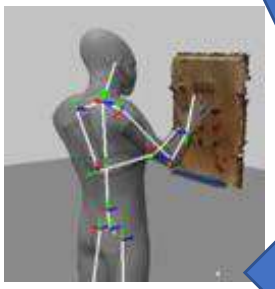
AIRC

Cyber world (AI)

- Understanding of human intention
- Knowledge structuring

Operation information from the machine

Selection of machine support method



Improving learning efficiency using simulation technology

Cyber world (CPS)

Simulation of work support

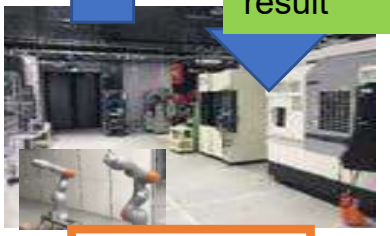
Data acquisition from the real world, visualization of data on CPS

Data acquisition from the real world, visualization of data on CPS

Control command based on simulation result

Physical world

Machine operation



Work support from machine

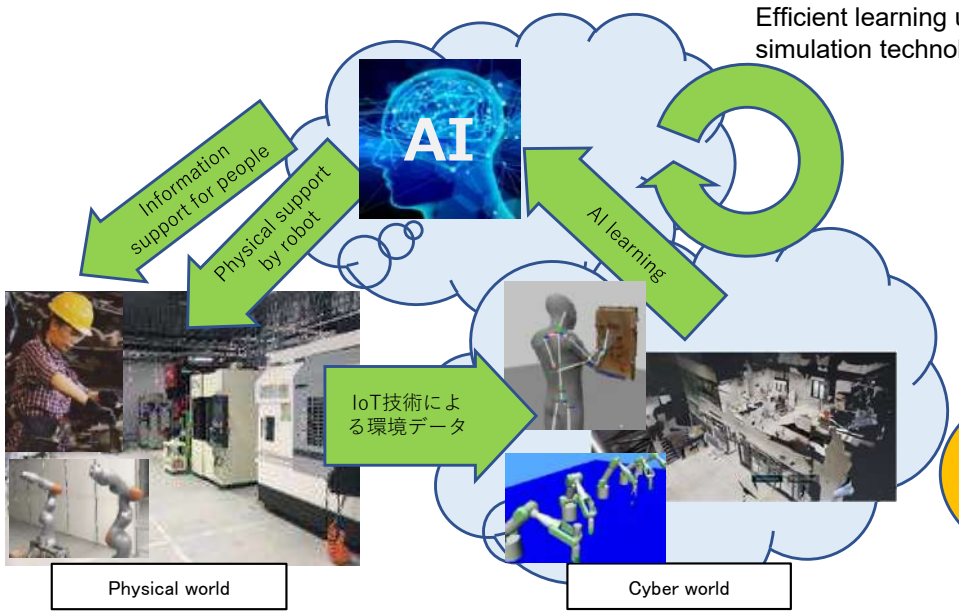
Human

Machine

National Institute of Advanced Industrial Science and Technology
AIST

Research Contents in Testbed Factory – Factory CPS and AI applied target

AIRC



Factory process optimization

Processing machine

Robot

Skilled knowledge structuring

・AI application to human / machine cooperative work
・ Teaching less by imitating human work

Worker

National Institute of Advanced Industrial Science and Technology
AIST

Learning from demonstration

AIRC

National Institute of Advanced Industrial Science and Technology
AIST

Research Contents in Testbed Store

AIRC

Utilization in other fields
logistics
Caregiver
home

Cyber world of testbed store

実験データ

Object database

Material Handling Skill Database

Physical world of testbed store

- Product database construction
- Advanced material handling technology

Goods

Robot

- Supply and demand matching
- Customer analysis

- Safe autonomous mobile technology

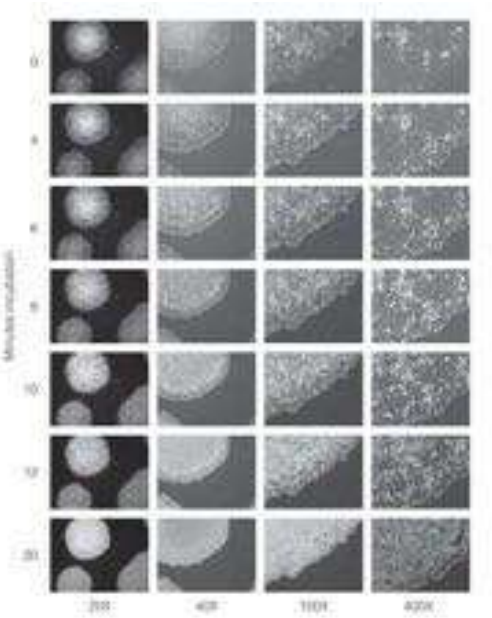
Customer

National Institute of Advanced Industrial Science and Technology
AIST

Research Contents Biolab Environment

AIRC

AI utilization for cell culture recognition and culture automation in drug discovery



・ Process automation with robots and AI

Cells

Robot

・ Culture state recognition technology using AI

・ Teaching less by imitating human work

Worker

National Institute of Advanced Industrial Science and Technology
AIST

Society 5.0 created by Cyber Physical System

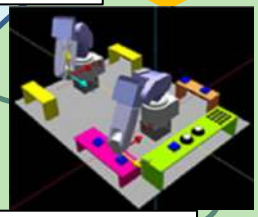
AIRC

Various industries are connected, and the whole social system is optimized. (Society 5.0)

Building distributed production system by linking each factory on Cyber Physical System

Matching supply and demand

Cyber environment

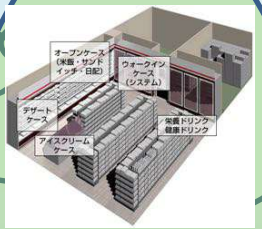


Cyber Physical System in the factory A

Physical environment

Cyber Physical System in the factory B

Cyber Physical System in the factory C



Cyber Physical System in a store

Cyber Physical System in a farm

Content

- Industry 4.0 to Society 5.0
- AIST Research in AI and CPS
- Discussion