AI and the Future of Society
-- from the Perspectives of the AIRC--

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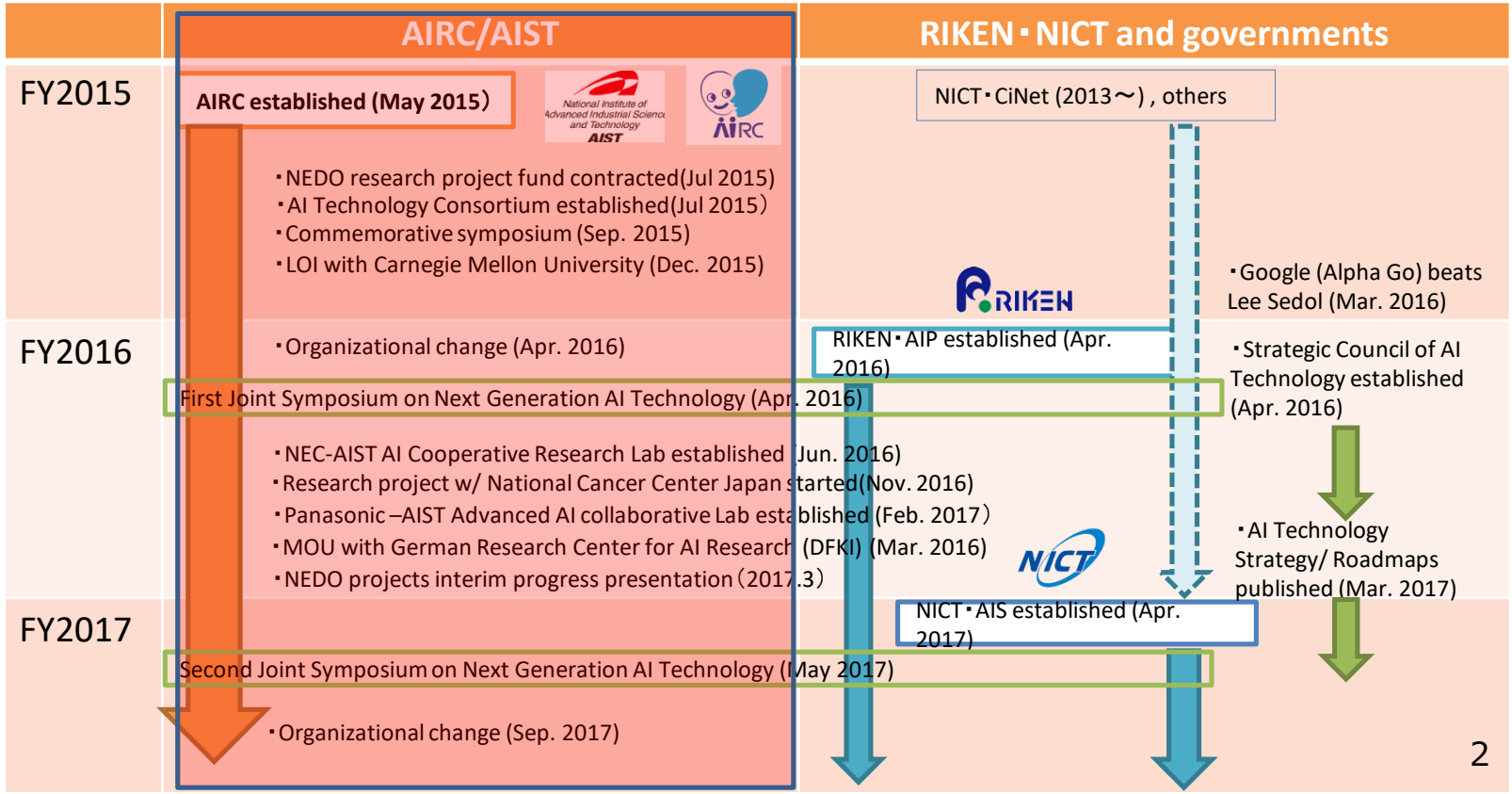
History of AIRC

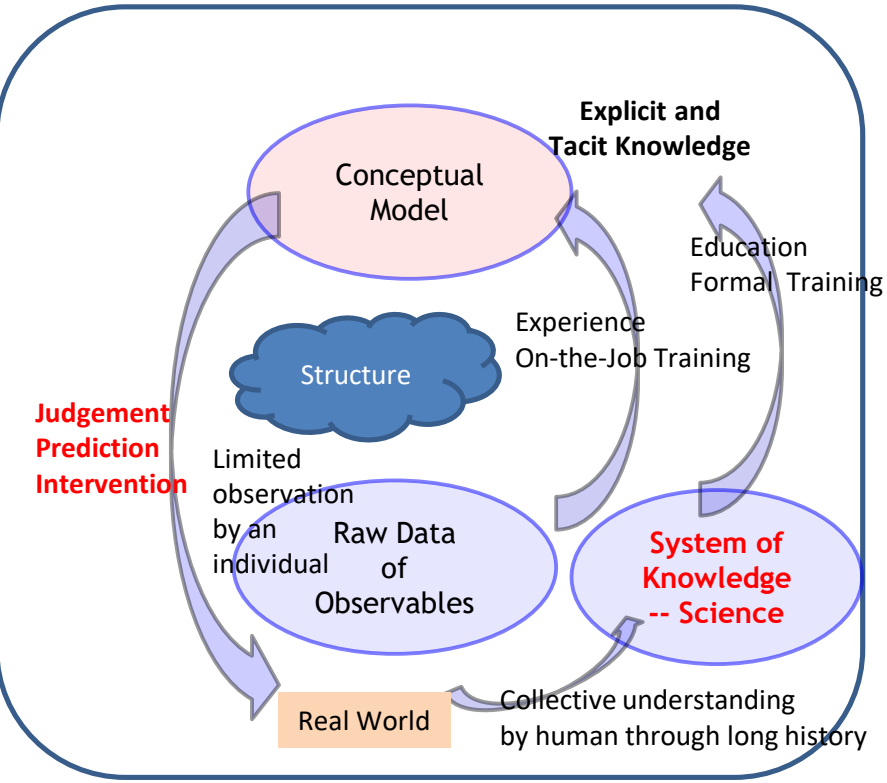
- AIRC/ AIST was established in May 2015 to be the largest AI research center in Japan for promoting large-scale AI research with PPP.
- Cooperating with RIKEN and NICT, AIRC/AIST accelerates AI R&D and deployment with industries and overseas research institutes.



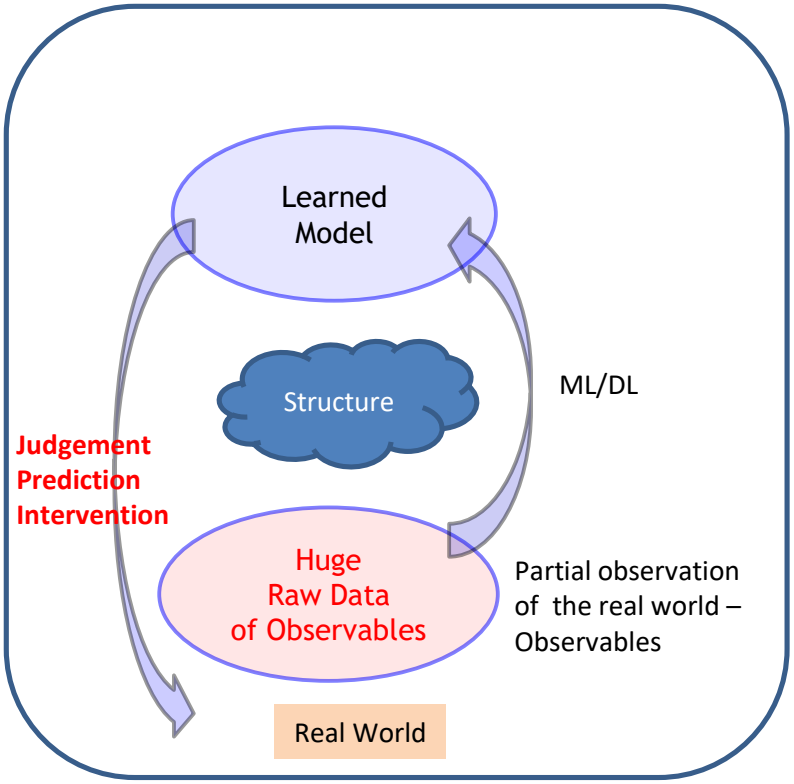
Co-Operation and Co-Evolution of Humans and AIs

- Human Intelligence : Combination of Explicit (Symbolic) and Tacit Knowledge
- AI Intelligence : Modelling based on Big Data, Black Box
- How Tacit Knowledge in Human is represented and interacts with explicit knowledge is not well-understood
- How results of ML and DL contribute to intelligent judgement is not well-understood
- XAI is to make models learned by ML/DL transparent and help Humans relate them with their knowledge

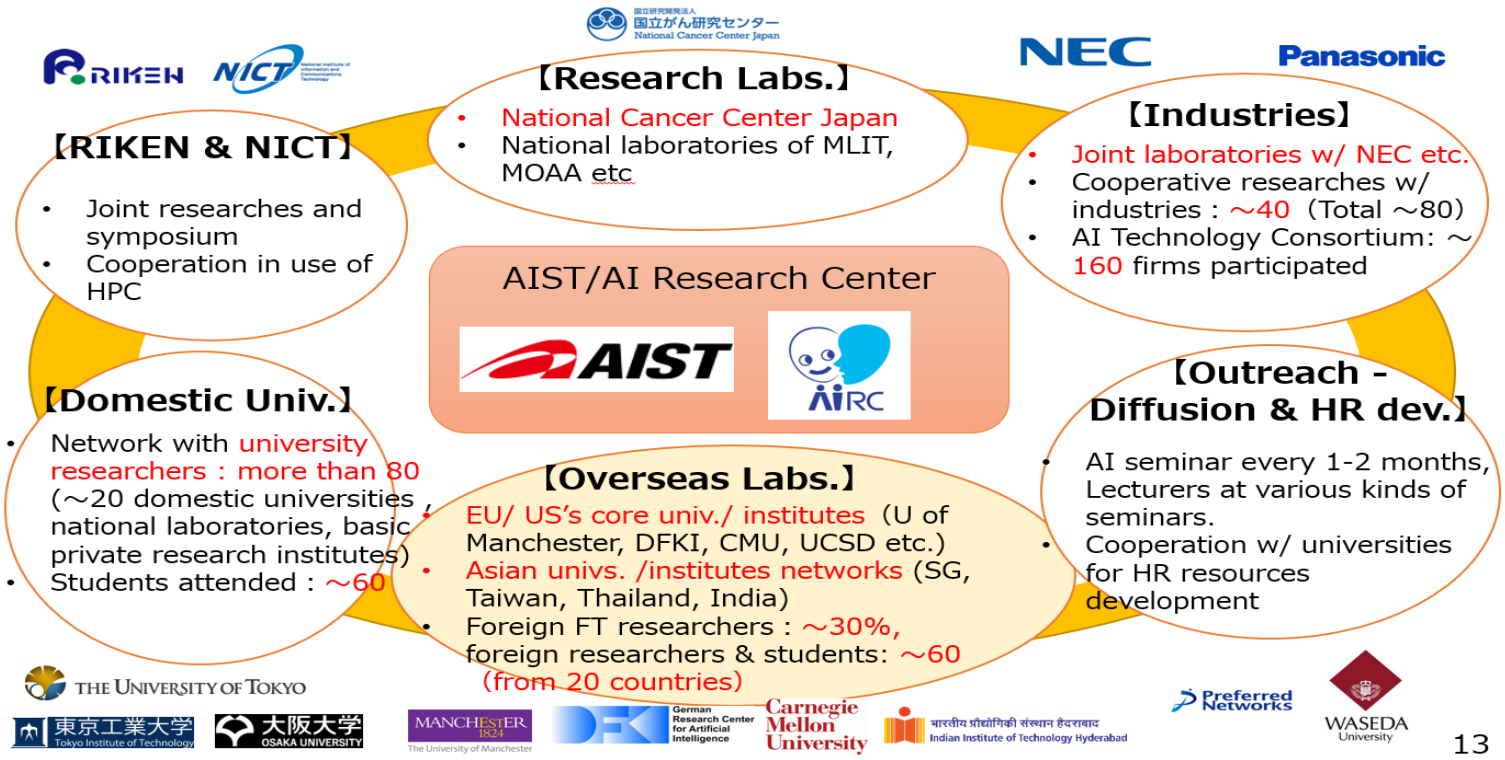
Human



AI based on Big Data and ML/DL



Network of Partners



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MOU with U-Manchester and ATI

Next AI Research Direction

- Current AI development is led by tech giants in US and China, based on Big Data from Internet.
- New AI platform technology is necessary to **utilize AI for real world with human**, including mobility, health and welfare, and industrial productivity.
- Our strategic focus is on **data-knowledge fusion** in industrial and service sectors in which Japan has advantage

<Our research direction of AI development>

	Internet-based AI - US/Chinese tech giants are leading
Data / knowledge	<AI using Big Data> • Learning from Big Data in Internet • Developing correct data by cloud sourcing
Reliability	<Priority in agility> • Releasing β-version and improving
Development process	<Manpower based> • Self-sourced business using huge AI manpower

	AI embedded in real world AI to cooperate with Human - Utilizing data and knowledge in industry
Data / knowledge	**<AI to cooperate with Human>** • Utilizing sound data in industry and service sector (e.g. health data, IoT data in factories) • Utilizing professional knowledge (conversion to AI)
Reliability	**<AI reliable in real world>** • Assessing reliability of AI before introducing into real world
Development process	**<Easily-implementable AI>** • Promoting business development by user-driven AI development

Real World AI

- from the Internet to the Real World -

AI which cooperates with Human

Cooperative Autonomy, Explainable AI

AI in Contexts

[1] AI in Digital Transformation

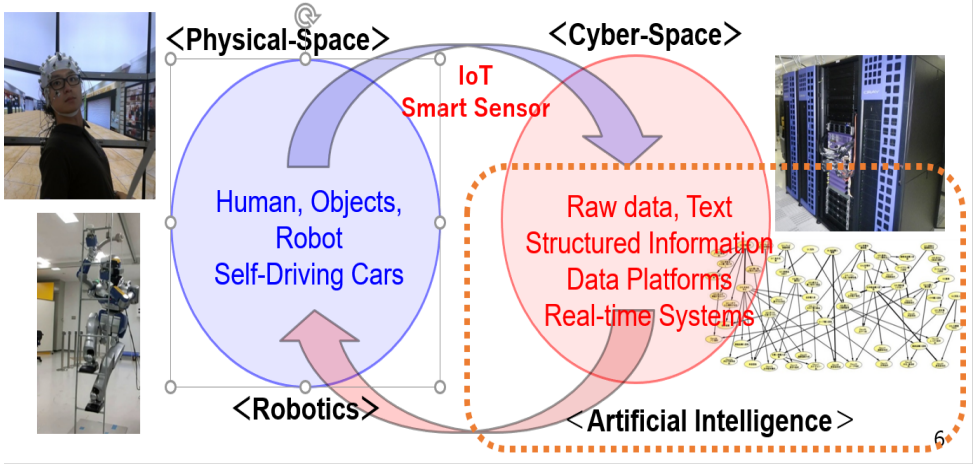
[2] AI for Competition/Cooperation

[3] AI as Existential Threats

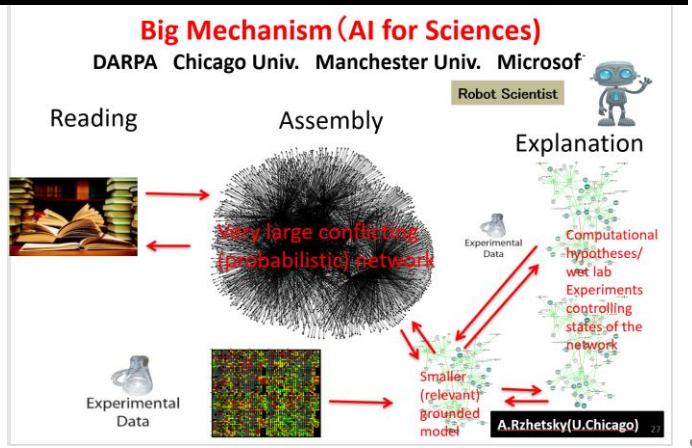
[1] AI in Digital Transformation

- **Society 5.0 : Next Stage of Human Society**
  - Digital Twin, Cyber-Physical System, Industry 4.0, Connected Factory, Connected Health, Precision Medicine, Robot Co-Workers, Connected Logistics, …
- **5th Paradigm in Science/Engineering**
  - Computational Science (Simulation) + 4th Paradigm (Big Data Analytics)
    -> 5th paradigm **(Simulation + ML + Knowledge)**

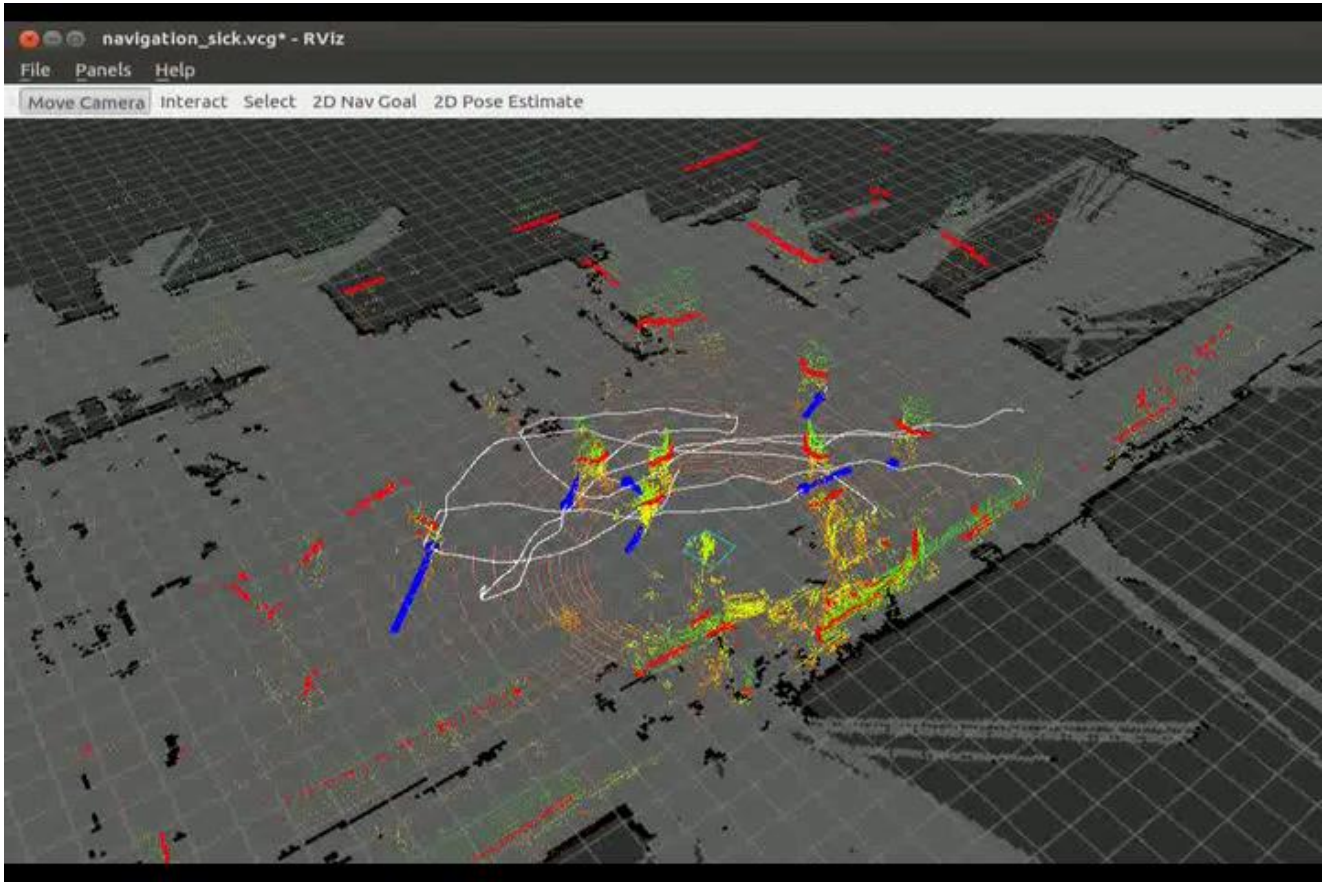
Judgement, Prediction and Intervention based on Models



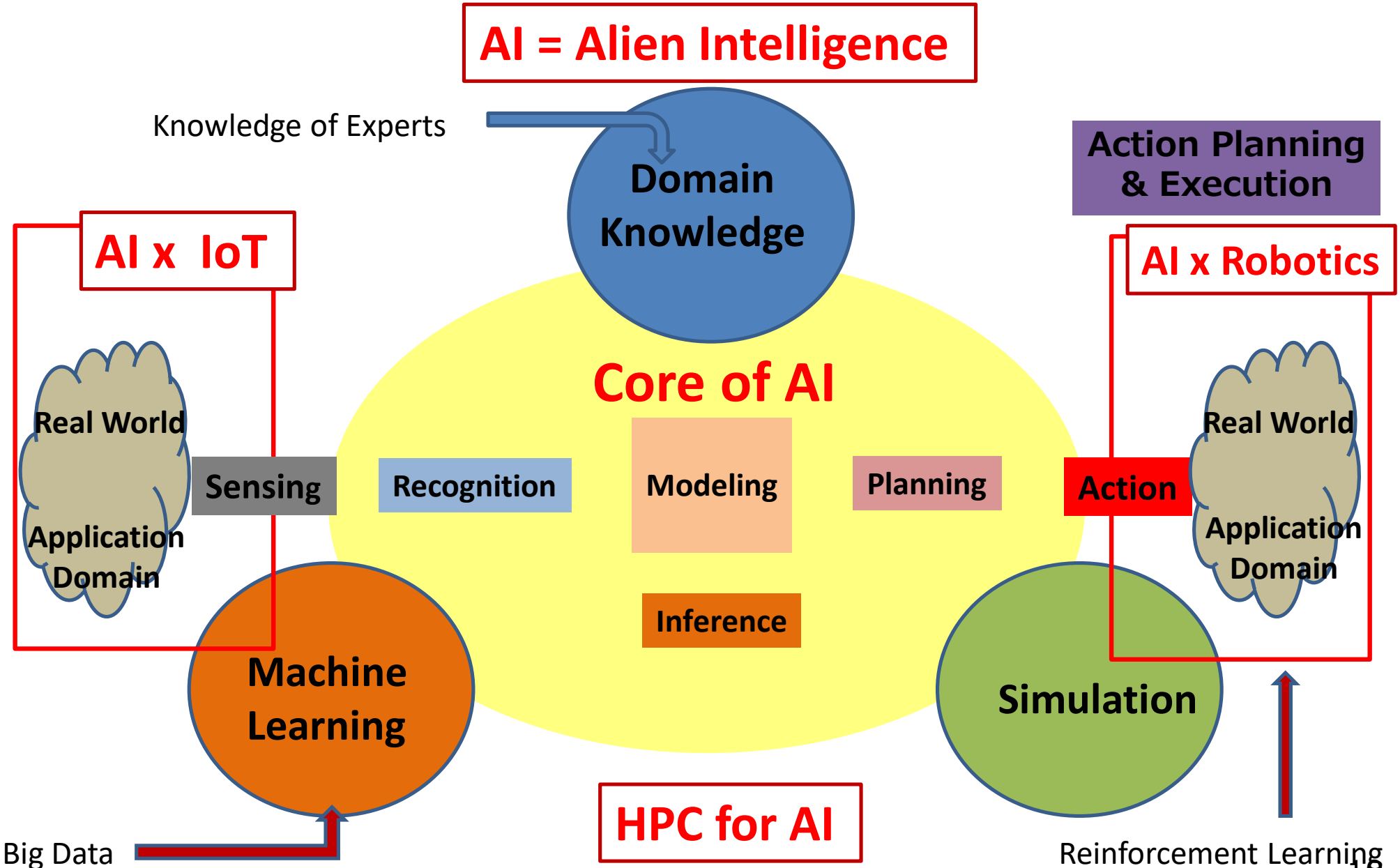
Model Construction for Understanding of Unknowns



Self-Navigating Robot with a model of environment

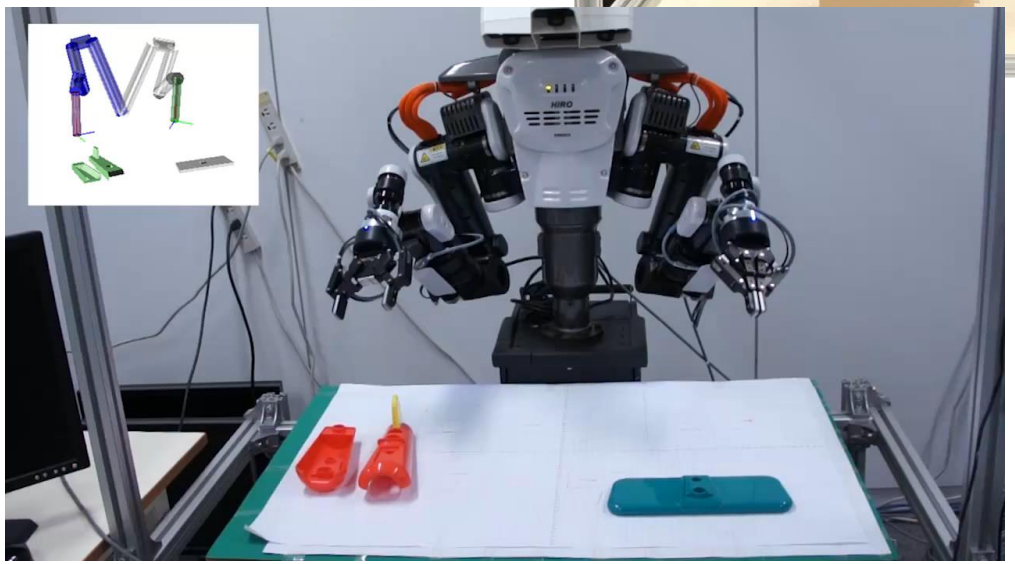


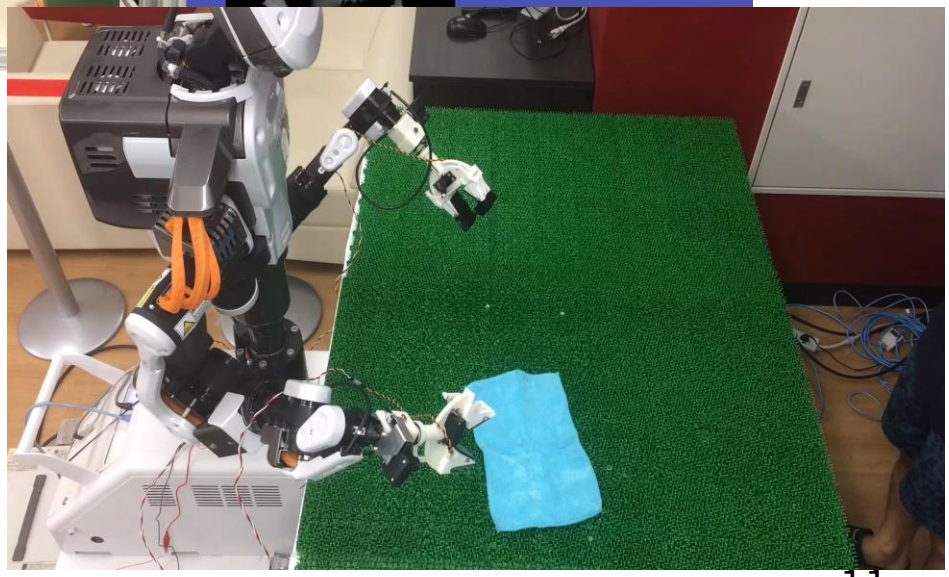
AI Embedded in the Real World



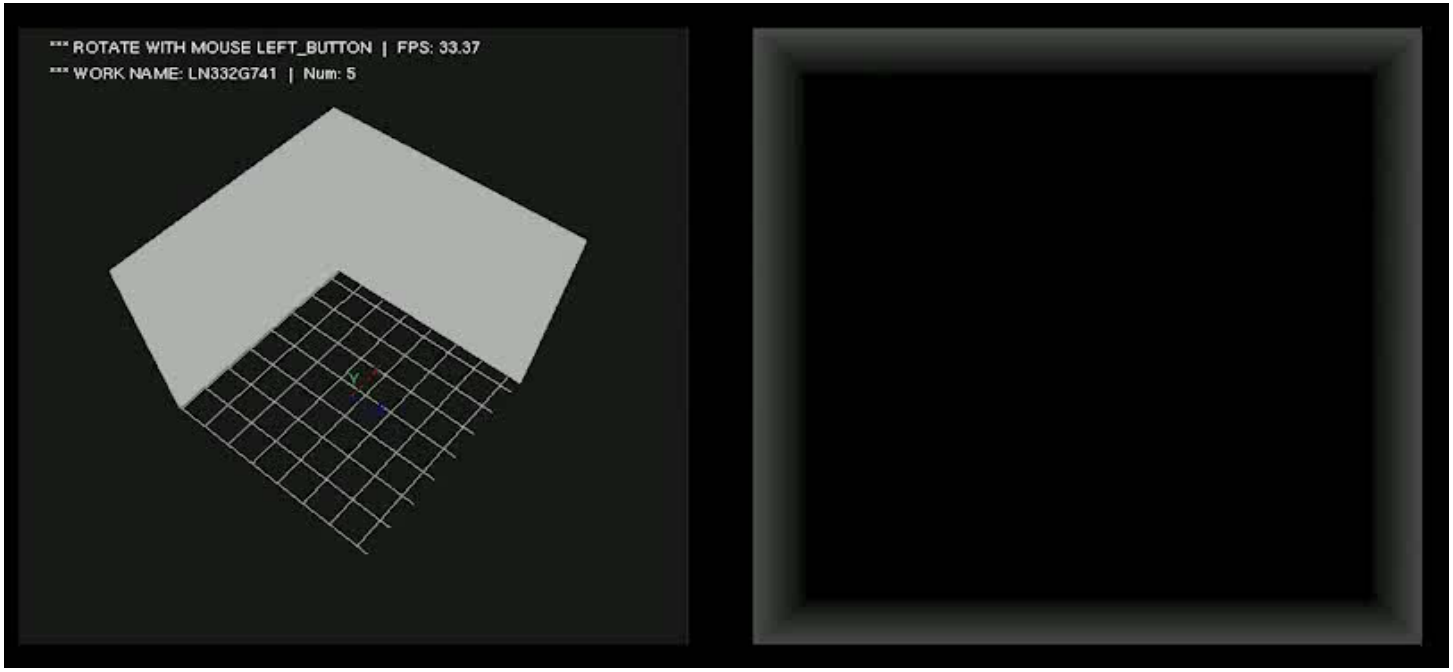
Model-Driven Robotics to Data-Driven Robotics

Data-Driven Robotics



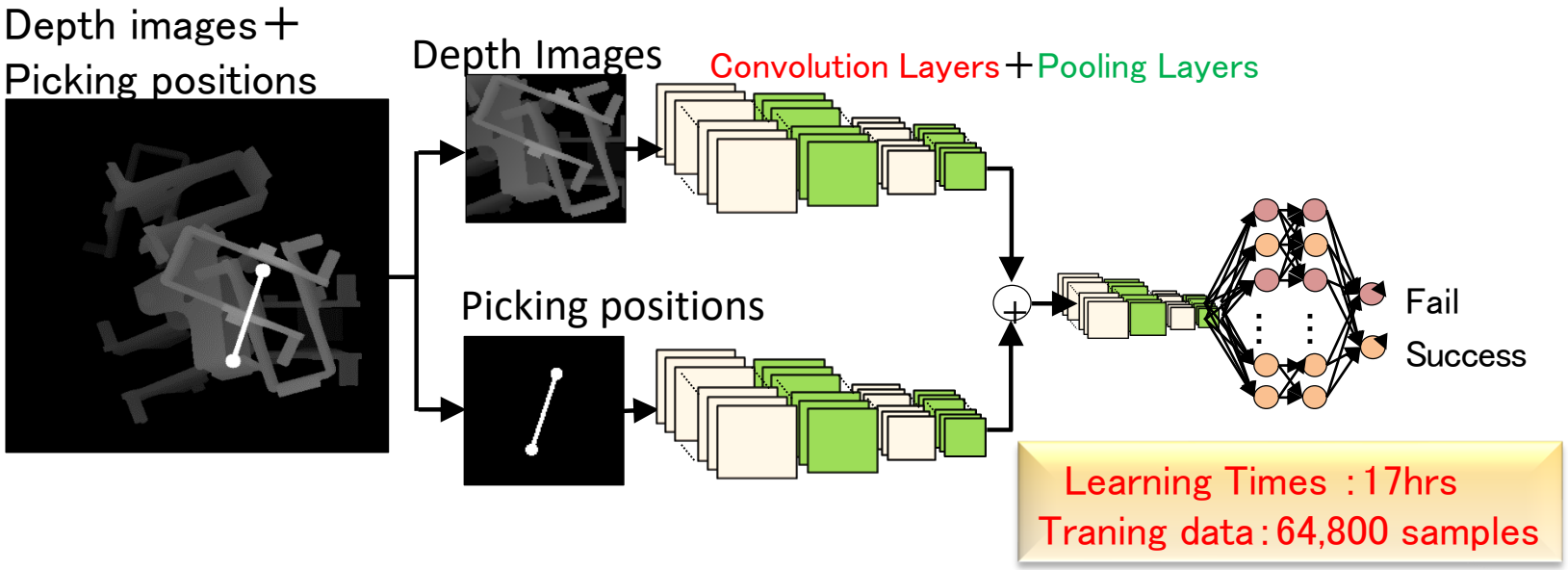


Data Generation by Simulation

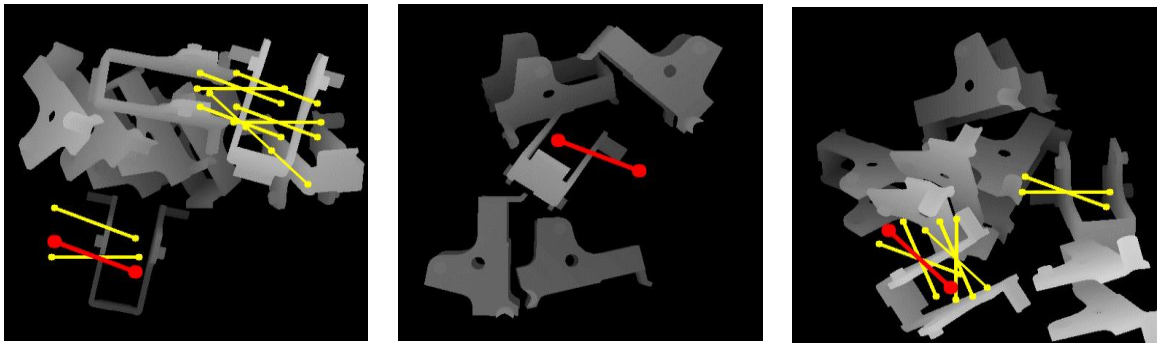


Base Engine for Simulation : PhysX
Recognition of interaction among objects
Real-time Simulation

Learning of the best picking positions



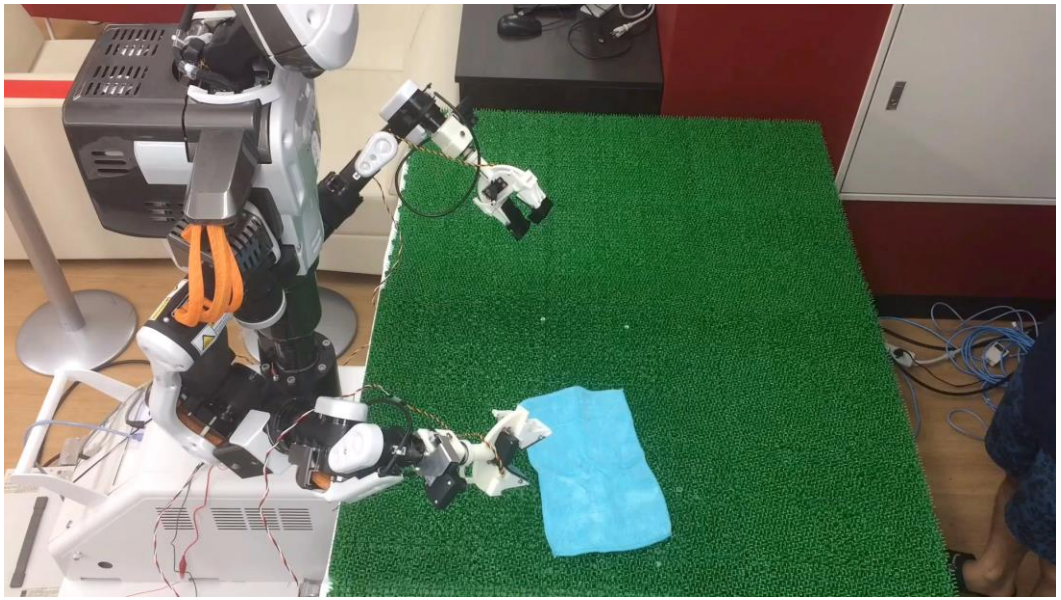
Red：Best
Yellow：90%

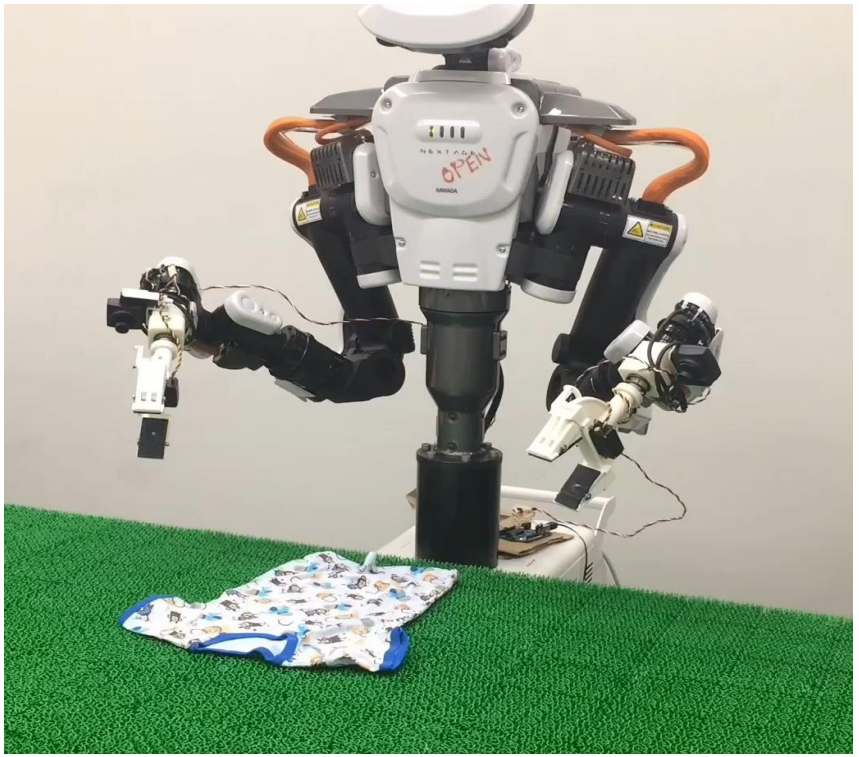


Learning from Demonstration

【Learning from Demonstration with Deep Neural Networks】

- *able to handle flexible objects*
- *learning from small number of demonstrations*

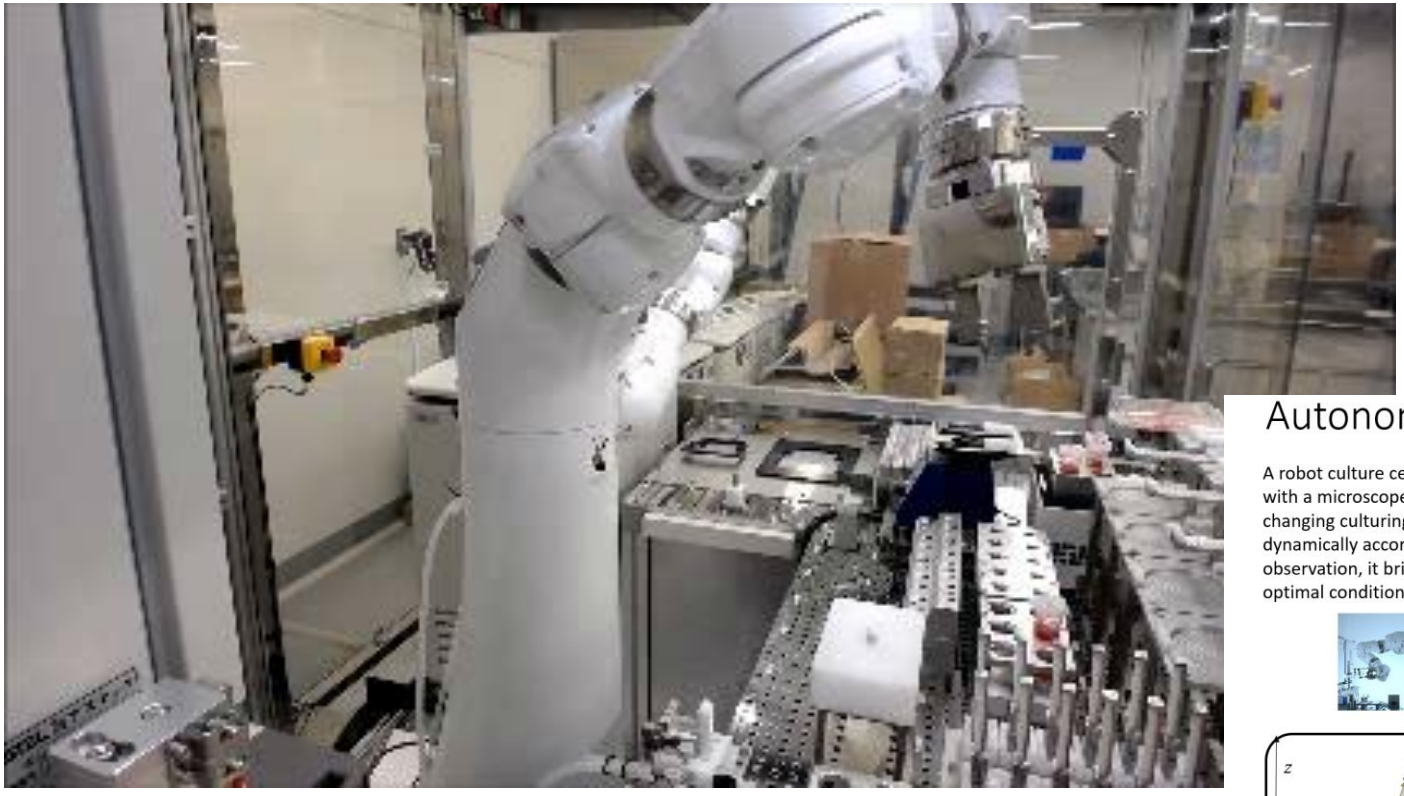


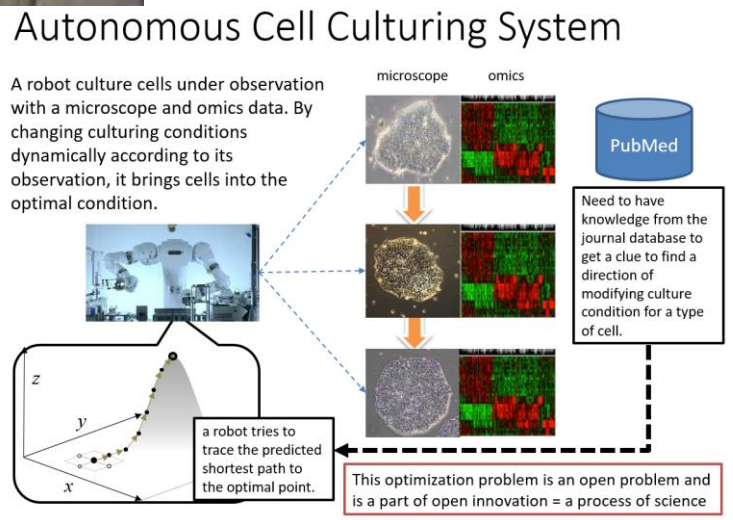


Lab Droid “Mahoro” x AI

【Autonomous Cell Culturing System】

- Combining bio-LabDroid “Mahoro” and computer vision for measuring cell cultivation
- Optimizing the conditions of cell culturing autonomously by Bayesian optimization

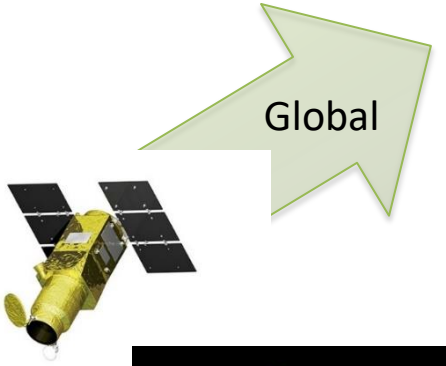


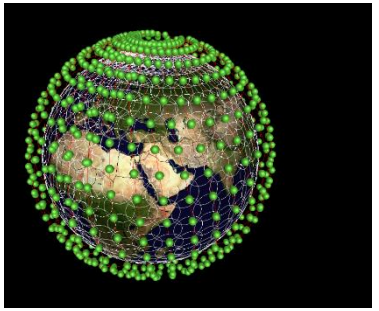


Computational Omics Research Team

Construction of Multiscale Geospatial/Temporal Information Platform

- Maps can be created by various moving bodies other than satellites
- Recording more accurate changes by using multi-scale map





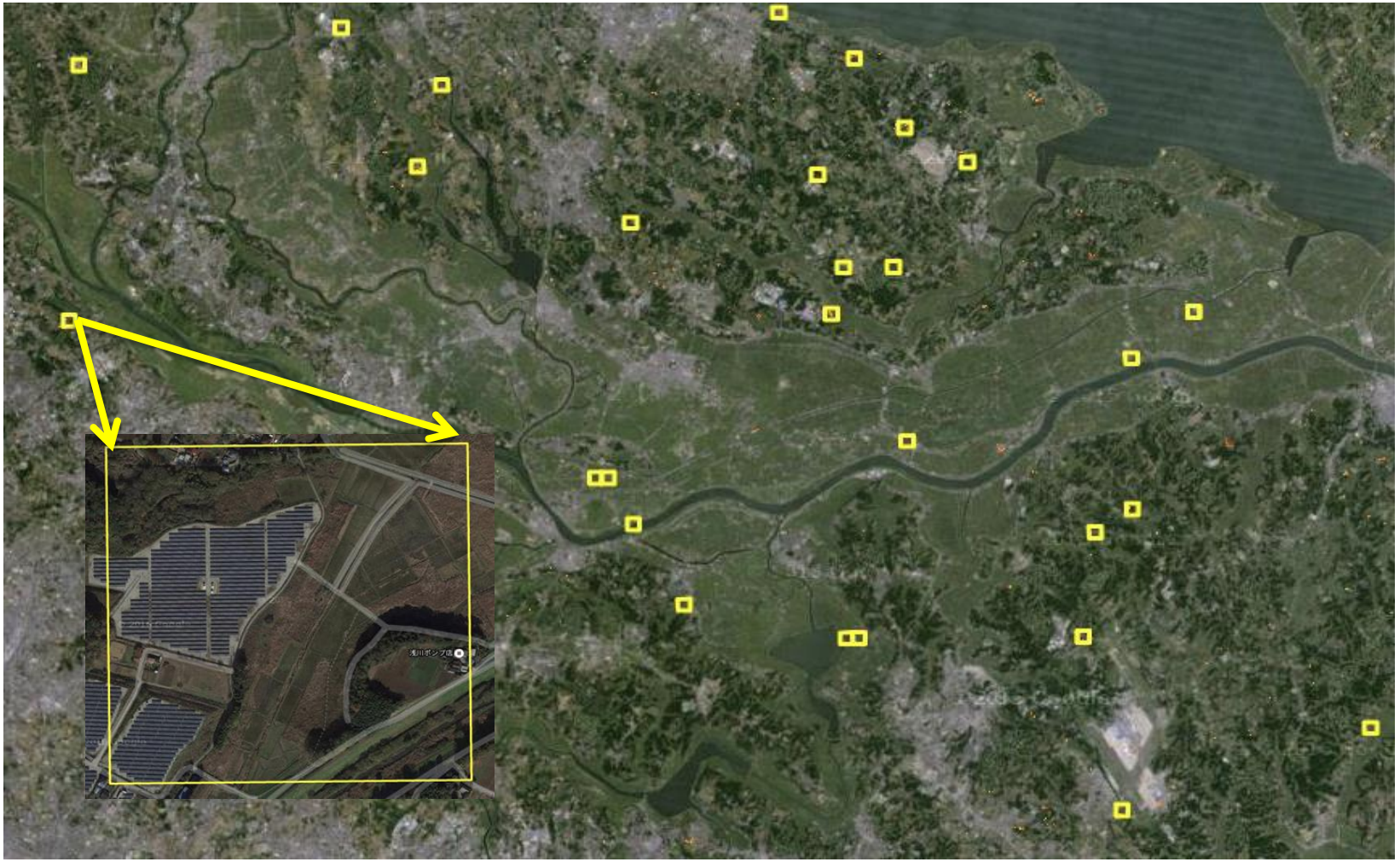
Local

- Real-time copy of real space built on cyber space
- Common functions at all scales: object recognition / change detection and dynamic update

Object Detection from Satellite Images

【Mega-solar detection from satellite images】

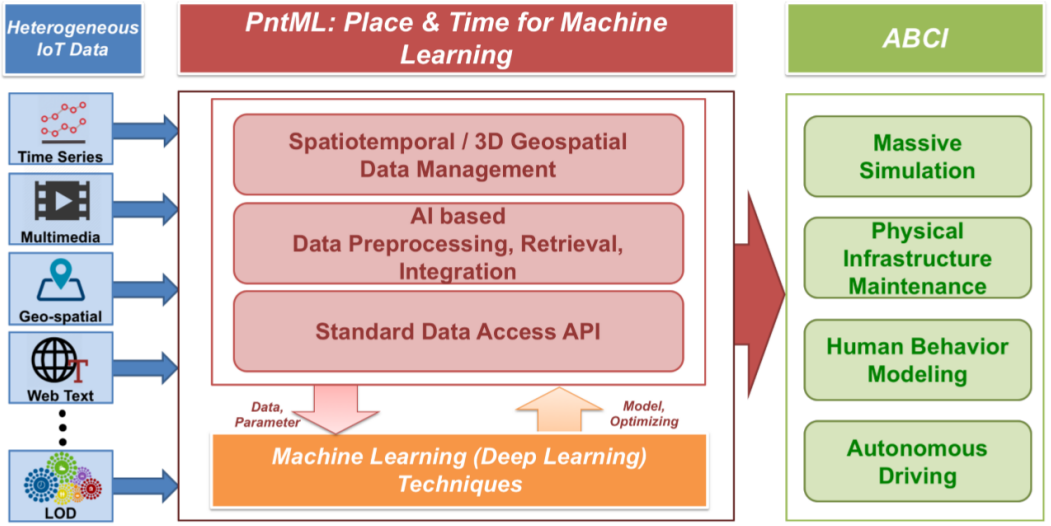
- application of deep learning to very large-scale data



Geoinformation Science Research Team

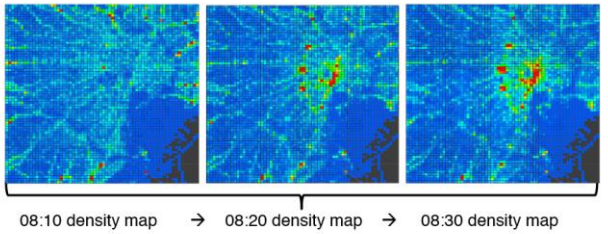
GeoAI platform

GeoAI Data Platform for AI+IoT+Robotics

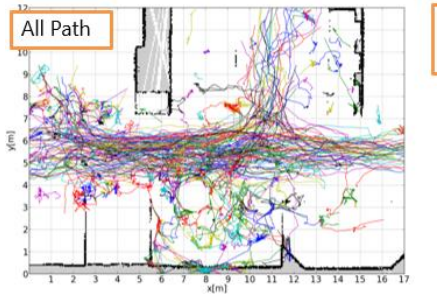


DeepUrbanVideo

Movement prediction for the future (e.g. 2 hours later)



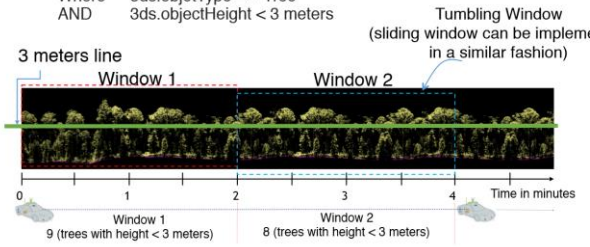
How to predict movement flow for urban computing and simulation based on density observations

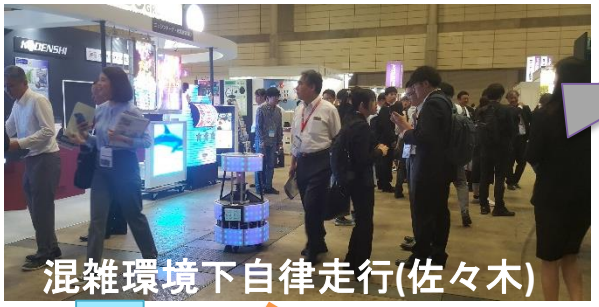


Sample Window-based Continuous Query over 3D Stream

- Count the number of trees with height less than 3 meters for window size of 2 min.

```
Select   COUNT (*)
From     3DStream[2 minutes] as 3ds
Where    3ds.objetType == 'Tree'
AND      3ds.objectHeight < 3 meters
```

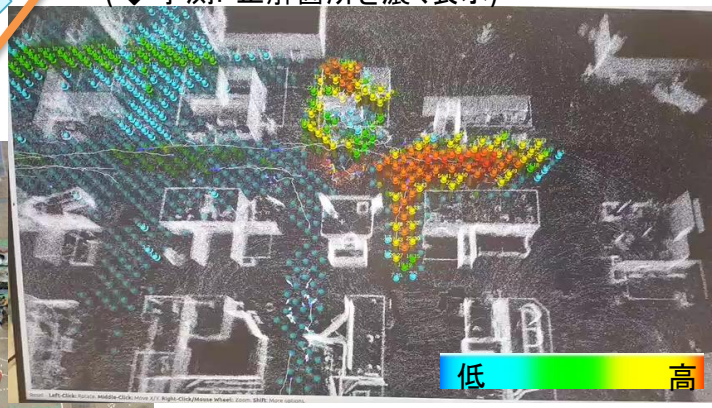




混雑環境下自律走行(佐々木)

動作生成に利用(今後実装予定)

人の滞留解析・予測 on AAIC (金)
(現在の解析結果を棒グラフ表示)
(↓ 予測．正解箇所を濃く表示)



統合歩行者データを
Moving Feature (OGC)変換，
AAICへ送信

歩行者位置
速度ベクトル

観測した歩行者を
リアルタイム統合
(白線は歩行軌跡)

歩行者位置

ロボットの安全走行
シミュレータ (阪野)
(動作生成が人混み未対応のため，
デモはSim内で歩行者を歩かせたのみ)

リアルタイム人流観測(大西)

3D地図作成(中村)
(将来連携予定)

ロボットが観測した
歩行者データ

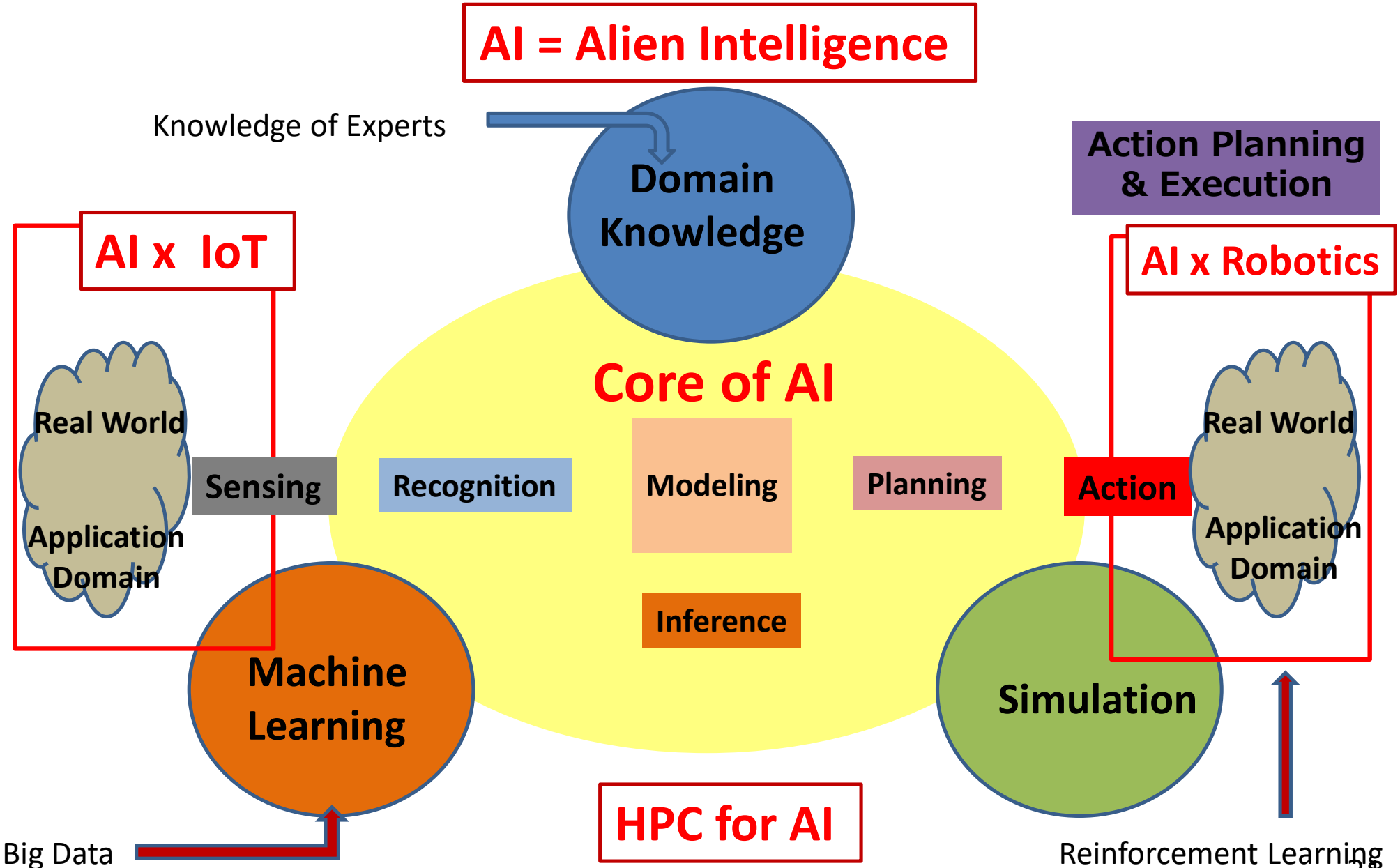
AI Embedded in the Real World

- from the Internet to the Real World -

AI which cooperates with Human

Cooperative Autonomy, Explainable AI

AI Embedded in the Real World



Communication

- **Narrow Channels for communication between AI and HI**

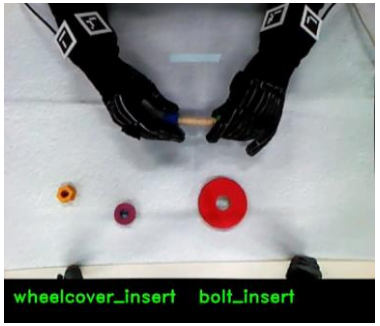
  Transferring knowledge to AI systems by HI
  - Knowledge Acquisition Bottle-Neck (2nd AI boom)
  - Data Annotation Bottle-Neck (3rd AI boom)

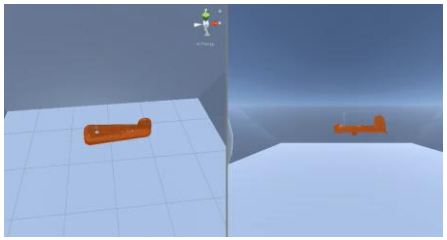
  Explaining the thought processes to HI by AI systems

- Data + Annotation, Teaching by program
  - Language
  - Rules
  - Mathematics
  - Simulation models
  - Teaching by showing
  - Active Learning

- Black box
  - Explainable AI
  - Visualization
  - Simulation

Baseline method: A man is drinking.
Proposed method: A girl is doing makeup.





From Video to textual explanation

Output="A monkey is doing a karate with a man."

Video Captioning

Recognition of sequences of actions with fine-grained object detection
Significant error reduction by sequence recognition

Baseline method : A man is drinking.
Proposed method : A girl is doing makeup.

Baseline Method : A dog is playing with a dog.
Proposed Method : A boy is playing with a dog.

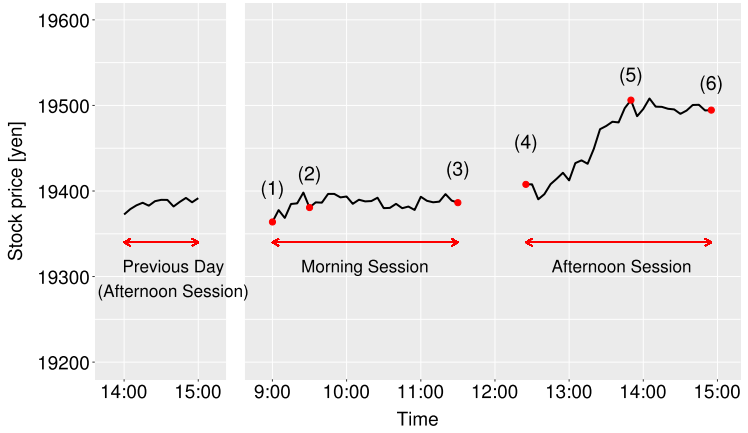
Baseline Method : A man is riding a car.
Proposed Method : A woman is riding a boat.

Baseline Method : A man is riding a bicycle.
Proposed Method : A man is riding a bike.

From Data to Text

Characteristics of the task

Numerical time series data
(Nikkei stock average)



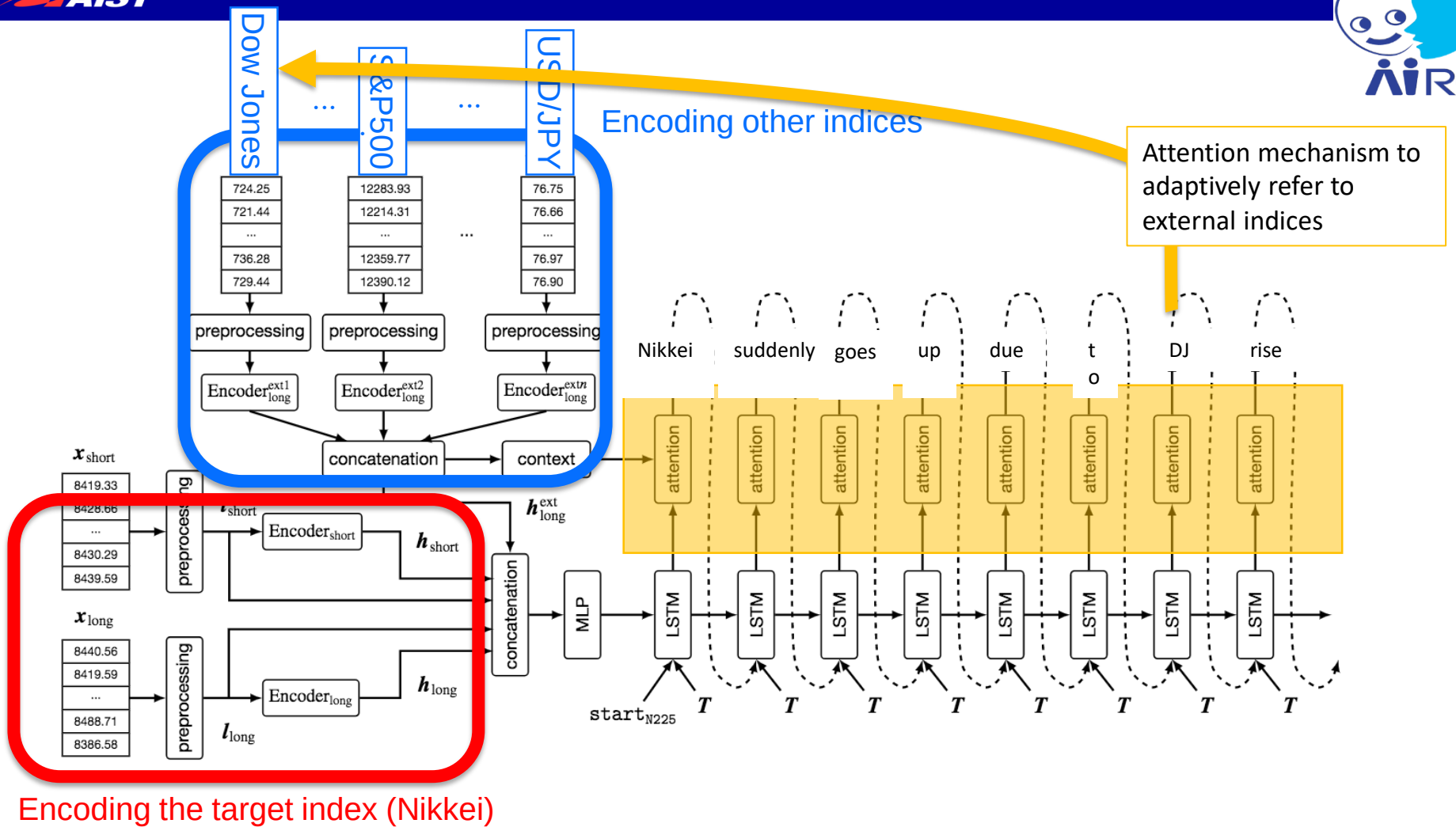
Generate

Market comments

(1)	09:00	Nikkei opens with a continual fall
(2)	09:29	Nikkei turns to rise
(3)	11:30	Nikkei continues to fall. The closing price of the morning session decreases by 5 yen to 19,386 yen
(4)	12:30	Nikkei rises at the beginning of the afternoon session
(5)	13:54	Nikkei gains more than 100 yen.
(6)	15:00	Nikkei rebounds and closes up 102 yen to 19,494 yen

Characteristics of market comments

1. Both short- and long-term changes are described
2. Some expressions depend on their delivery time
3. Numerical values are often mentioned



円高が進んだため、輸出関連株が下落し、日経は反落して始まった。

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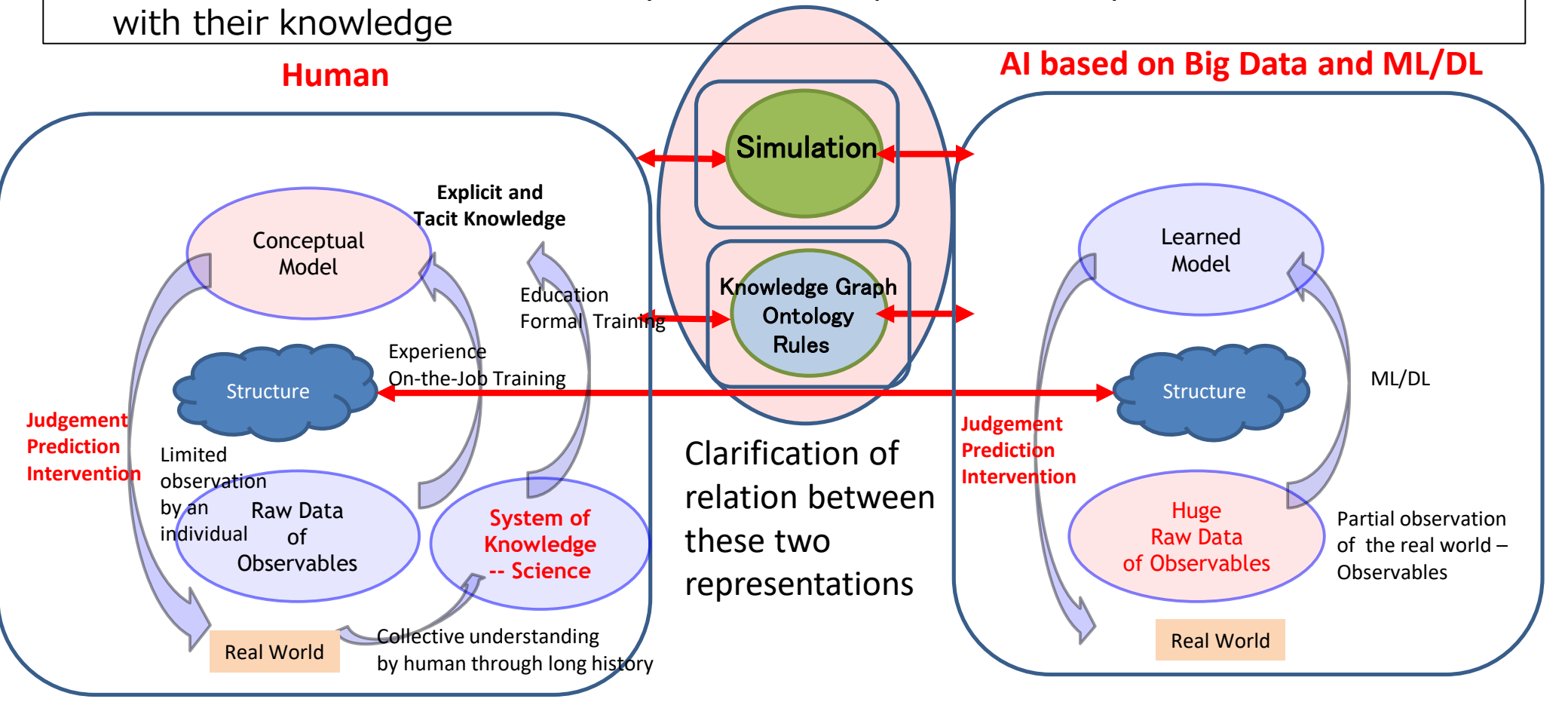


AI in Contexts

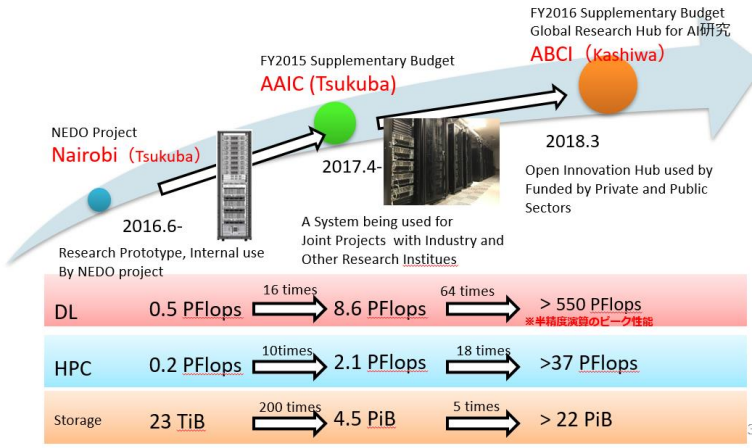
[1] AI in Digital Transformation

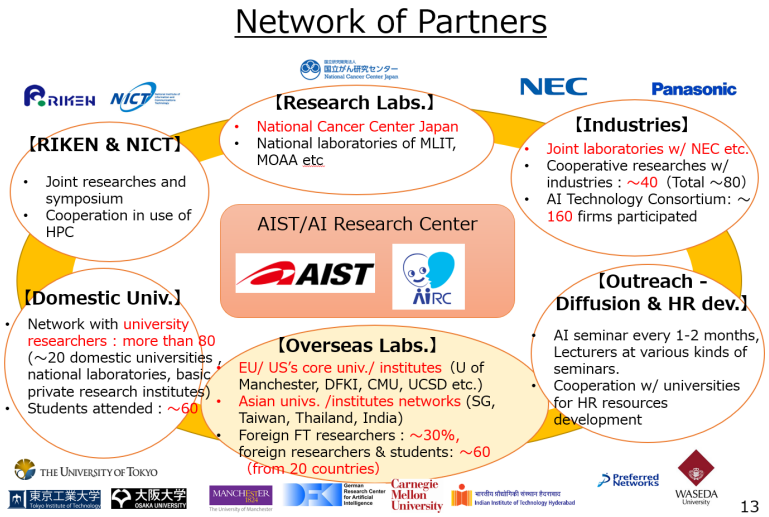
[2] AI for Competition/Cooperation

[3] AI as Existential Threats

[2] AI for Competition/Cooperation

- **Nations/Regions**
  - AI as one of the focal technologies of international competition/Cooperation
    - **Technologies made in X:** USA, China, Europe, Asia ….
- **IT Giants vs. other Industries, Private vs. Public**
  - Manufacturing, Retailing, …., Health care, Transportation(Mobility), ….
- **Competition for Resources**
  - **Human Resources** (AI researchers/engineers), **Computation Resources** (Cloud and HPC), and **Data Resources**
  - **Monopoly of Resources by IT giants**





AI Cloud Computational Infrastructure :ABCI

- **AI research needs a large scale computational infrastructure**. AI Bridging Cloud Infrastructure (ABCI), developed by AIRC/AIST and Tokyo Tech OIL especially for ML/DL, was placed at the 5th of a ranking list in the Top500's high-performance supercomputers (Jun. 2018)
- ABCI started its operation in Aug. 2018. Open data and model will be available with open innovation systems on ABCI.
- A Japanese company attained the world fastest deep learning speeds by using ABCI (Nov. 2018)

November 13, 2018

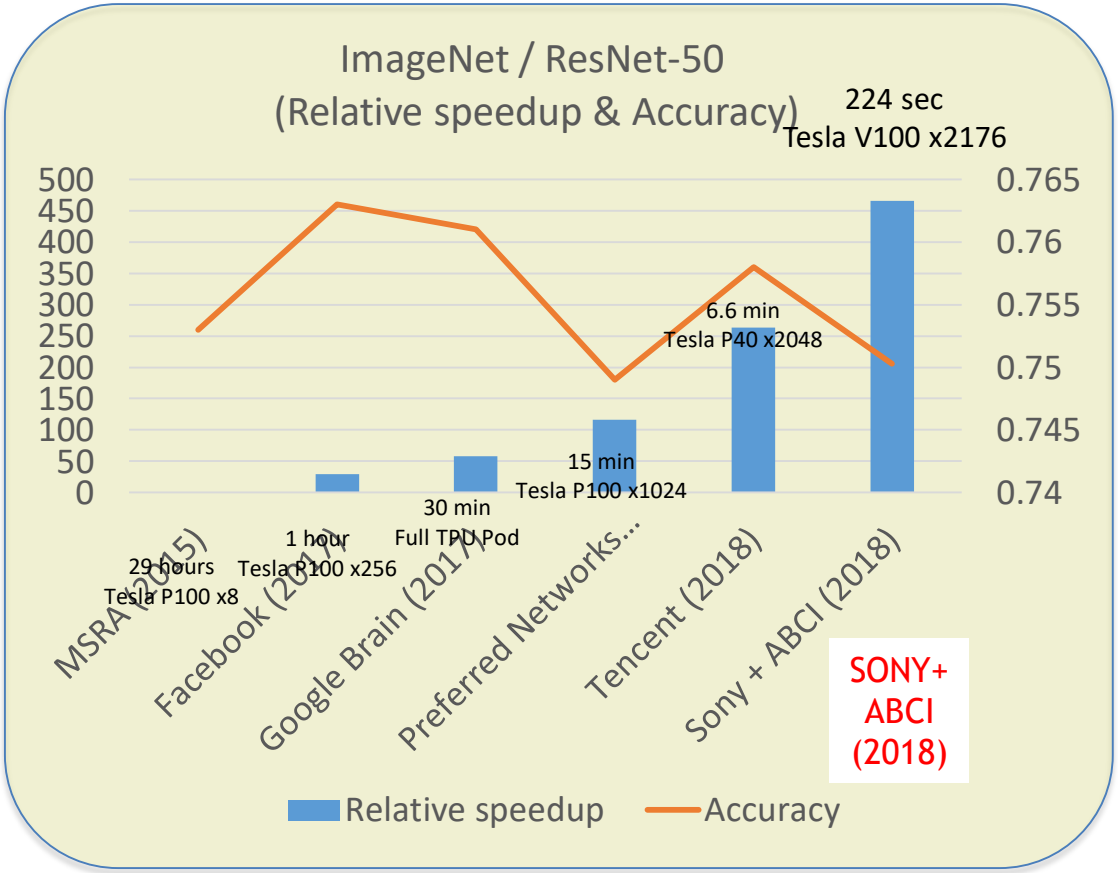
Sony Achieves World's Fastest[*1] Deep Learning Speeds through Distributed Learning

Reaches Efficiency Milestone for AI Development

Top500's high-performance supercomputers (2018/6)

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/SC/Oak Ridge National Laboratory United States	2,282,544	122,300.0	187,659.3	8,806
2	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
3	**Sierra** - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband , IBM DOE/NNSA/LLNL United States	1,572,480	71,610.0	119,193.6	
4	**Tianhe-2A** - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000 , NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.5	100,678.7	18,482
5	**AI Bridging Cloud Infrastructure (ABCI)** - PRIMERGY CX2550 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, Infiniband EDR , Fujitsu National Institute of Advanced Industrial Science and Technology (AIST) Japan	391,680	19,880.0	32,576.6	1,649
6	**Piz Daint** - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100, Cray Inc.	361,760	19,590.0	25,326.3	2,272

Imagenet – Competition of Learning Speed



【プレスリリース2件】

2018年6月26日

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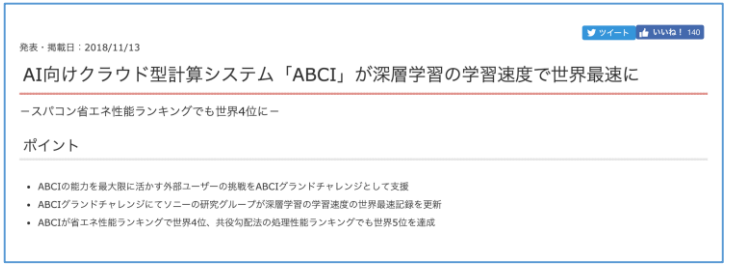
大規模AIクラウド計算システム「ABCI」がスパコン性能ランキング世界5位

－大規模で省電力のクラウド型計算システムで高度な人工知能処理を可能に－

ポイント

- 計算ノードと冷却システムの統合設計により世界トップクラスの性能を実現
- 人工知能（AI）に適した半精度演算の性能が、実運用される計算システムとしては国内最高
- 公開学習済みモデルやオープンデータも提供する大規模高速計算基盤としてAIの実用化を加速

2018年11月13日



発表・掲載日：2018/11/13

AI向けクラウド型計算システム「ABCI」が深層学習の学習速度で世界最速に

－スパコン省エネ性能ランキングでも世界4位に－

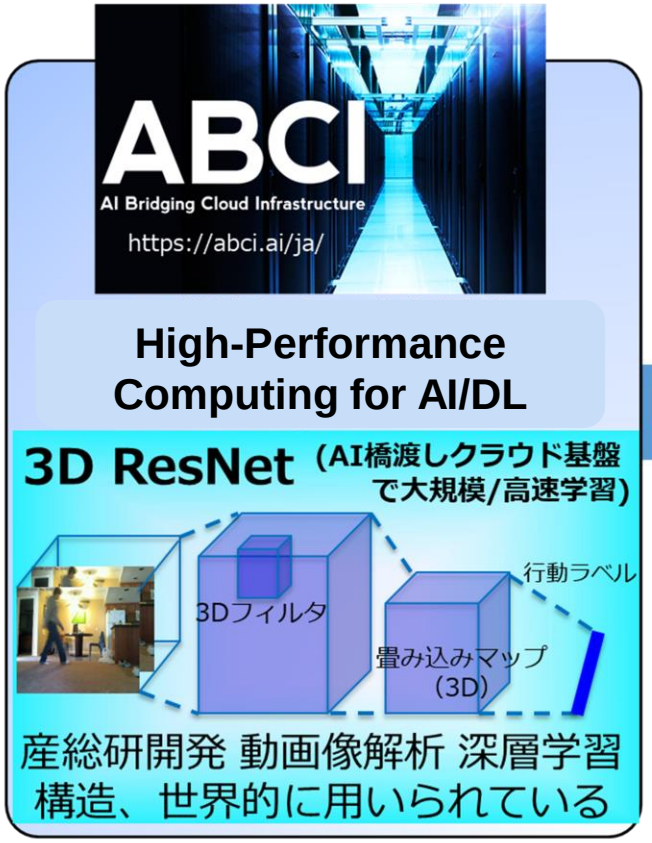
ポイント

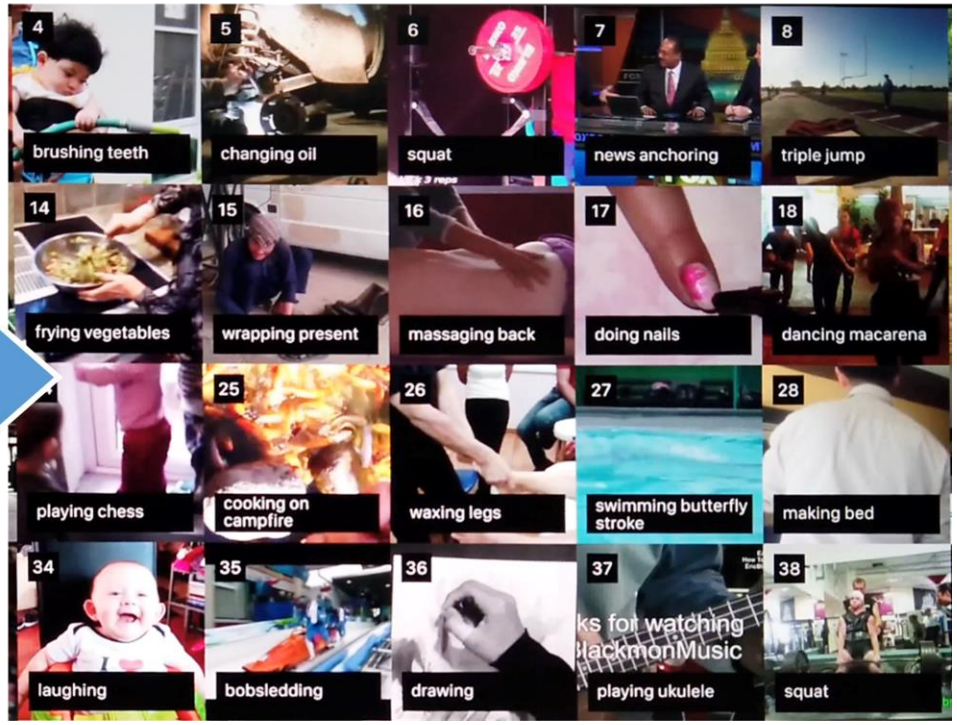
- ABCIの能力を最大限に活かす外部ユーザーの挑戦をABCIグランドチャレンジとして支援
- ABCIグランドチャレンジにてソニーの研究グループが深層学習の学習速度の世界最速記録を更新
- ABCIが省エネ性能ランキングで世界4位、共役勾配法の処理性能ランキングでも世界5位を達成

The team of the AIRC/AIST and Sony is in the top tier.

Action Recognition from Video with 3D ResNet

K. Hara, H. Kataoka, Y. Sato: Can Spatiotemporal 3D CNNs Retrace the History of 2D CNNs and ImageNet?, CVPR 2018



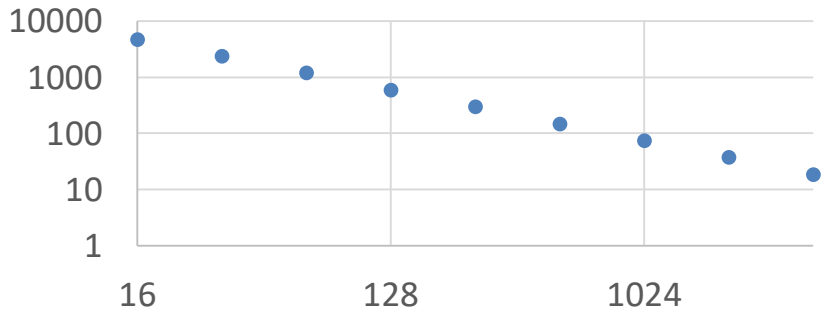


Significant Improvement of Action Recognition

Training time of BERT on ABCI

Implementation	Environment	Training time	Cost ($) (excl. tax)
Tensorflow [1]	16 Cloud TPUs	4 days	8,017
Tensorflow	64 GPUs (ABCI)	4.06 days	4,014
PyTorch (Apex, FP16)	64 GPUs (ABCI)	2.35 days	2,323

- The same training data and epochs as in [1]
  - Time for preprocessing is excluded



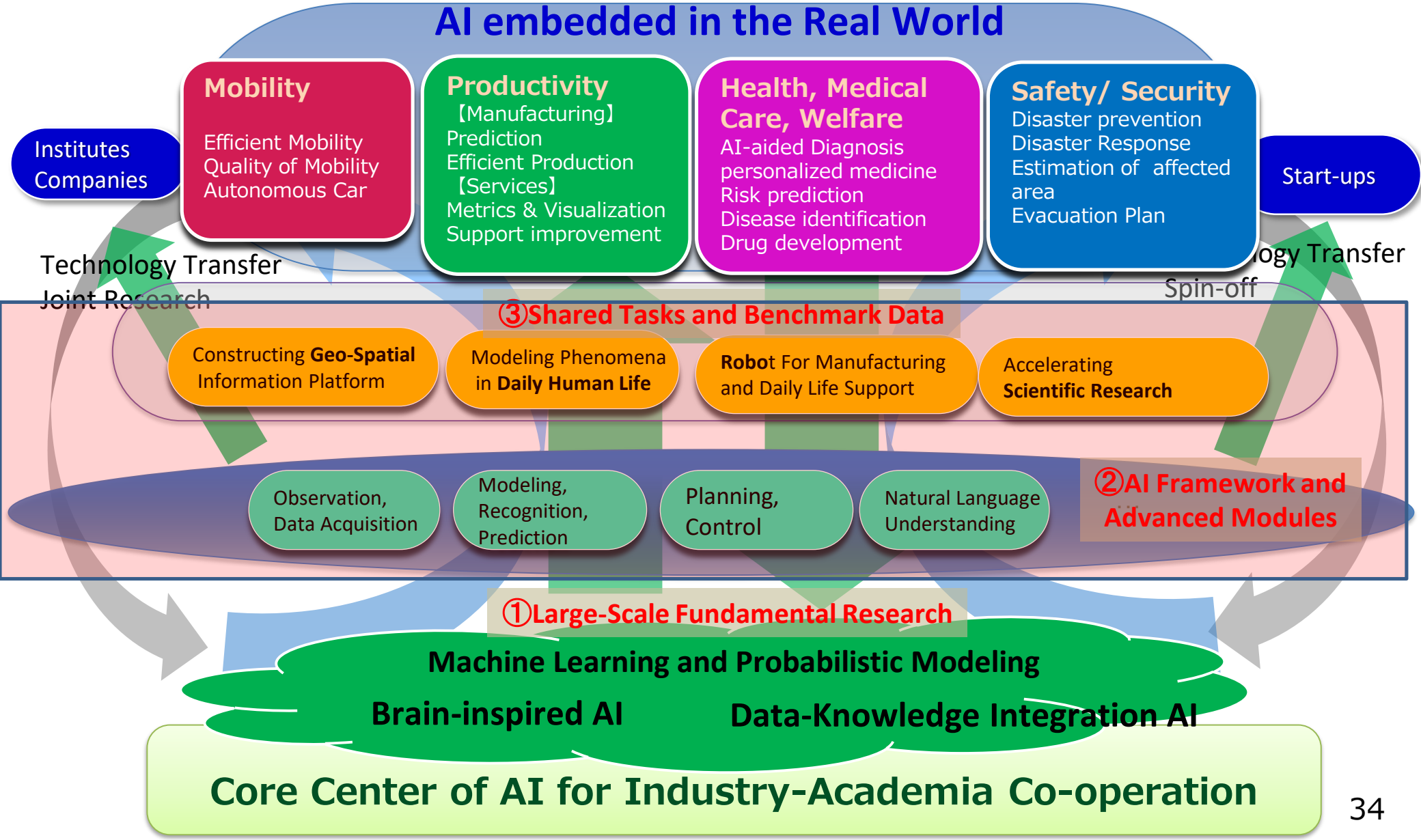
18.4m with 4,096GPUs

※ABCI has 4,352 GPUs.
BERT training works well or even better with a large batch size [2,3]

[1] Jacob Devlin et al., BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding. NAACL-HLT, 2019.
[2] Yang You et al., Large Batch Optimization for Deep Learning: Training BERT in 76 minutes, arxiv, 2019.
[3] Yinhan Liu et al., RoBERTa: A Robustly Optimized BERT Pretraining Approach, arxiv, 2019.

Strategy for AI research

- Creating positive cycle among research and deployment of AI



Main Research Results at AIRC

Observation, Data Acquisition

- Publish Satellite image data (more than 1PB) in international standard format with cutting edge AI functions.
- Autonomous robots which move around and detect / follow other moving objects (human, vehicles). Modeling trajectories and predicting directions.
- Construct "Living Lab", which connect AIST and nursing facilities. Data acquisition for precision care at real living environment.
- Construct a VR-interaction data acquisition system (beta version)

HPC – Large Scale Computing

- AIST AI Cloud (AAIC), a HPC which is focusing on AI/ machine learning, attained No.3 in the world at Green 500 List.
- Contribute to standardization of data access format which facilitates usage of moving features data

Modeling, Recognition, Prediction

- Probabilistic modeling system using Bayesian-net and PLSA. Realize optimization of customers behavior and services (36 licensing contacts during 2015-16)
- Create systems to recognize humans behavioral patterns by using deep learning technology from video of every day life. Will publish training video data (more than 100 thousands) soon (world largest)
- Develop a system for detecting suspected parts of breast cancer from data of ultrasonic diagnosis.
- Develop systems to identify household items/ functions from their 3D data. Win 1st place at an international competition of 3D object retrieval.
- Win 1st place at an international competition of protein structure prediction.
- Develop a method of pedestrian flow measurement and large scale simulation of indoor and outdoor evacuation of people.

Planning, Control

- Develop systems that automatically assemble simple parts by using database of humans behavior. Verified at three kinds of parts assembly.
- Develop systems to learn complex behavior such as folding towels only by teaching several times (using deep learning technology)
- Enable of properly manipulating deformable object such as hanging a shirt to a hanger.

Natural Language Understanding

- Construct and publish elemental function modules of natural language processing.
- Realize clustering and visualization of large scale scientific literature. (world top level)
- Automatically generate captions of short video or time-series data using deep learning technology (world top level)
- Construct an ontology for describing knowledge of elderly care and apply to service improvement.

AI in Contexts

[1] AI in Digital Transformation

[2] AI for Competition/Cooperation

[3] AI as Existential Threats

[3] AI as Existential Threats

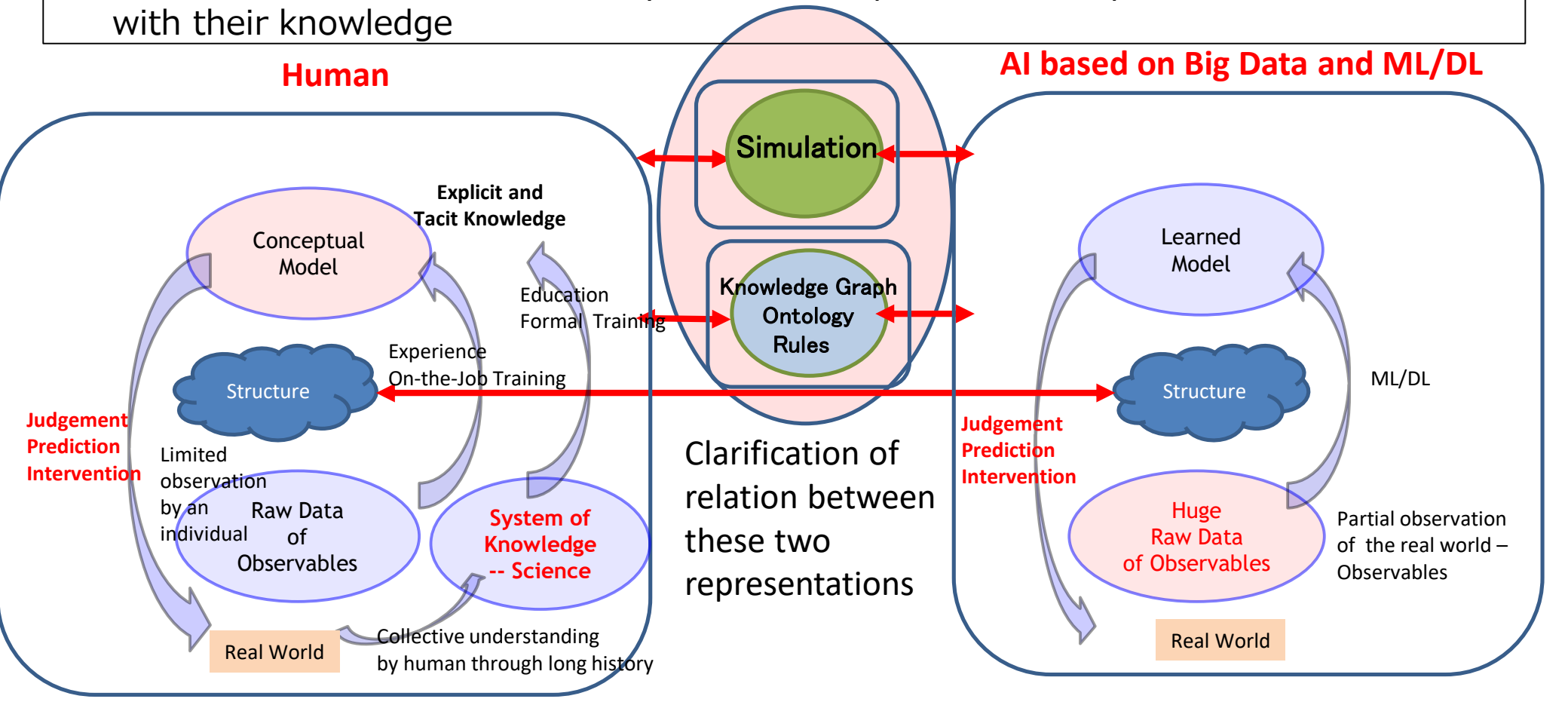
- AI : Alien Intelligence
  - Black box and Autonomous System
  - Superseding human intelligence
- **Human controls tools -> AI controls Human**

AI based on big data by using HPC

AI which supersedes human intelligence

Co-Operation and Co-Evolution of Humans and AIs

- Human Intelligence : Combination of Explicit (Symbolic) and Tacit Knowledge
- AI Intelligence : Modelling based on Big Data, Black Box
- How Tacit Knowledge in Human is represented and interacts with explicit knowledge is not well-understood
- How results of ML and DL contribute to intelligent judgement is not well-understood
- XAI is to make models learned by ML/DL transparent and help Humans relate them with their knowledge



Communication

- **Narrow Channels for communication between AI and HI**

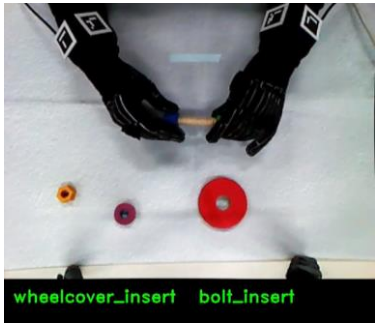
  Transferring knowledge to AI systems by HI
  - Knowledge Acquisition Bottle-Neck (2nd AI boom)
  - Data Annotation Bottle-Neck (3rd AI boom)

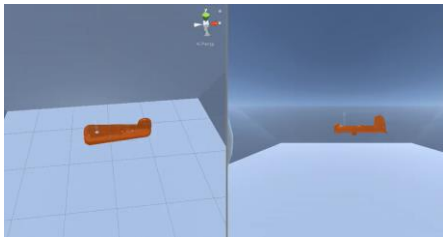
  Explaining the thought processes to HI by AI systems

- Data + Annotation, Teaching by program
  - Language
  - Rules
  - Mathematics
  - Simulation models
  - Teaching by showing
  - Active Learning

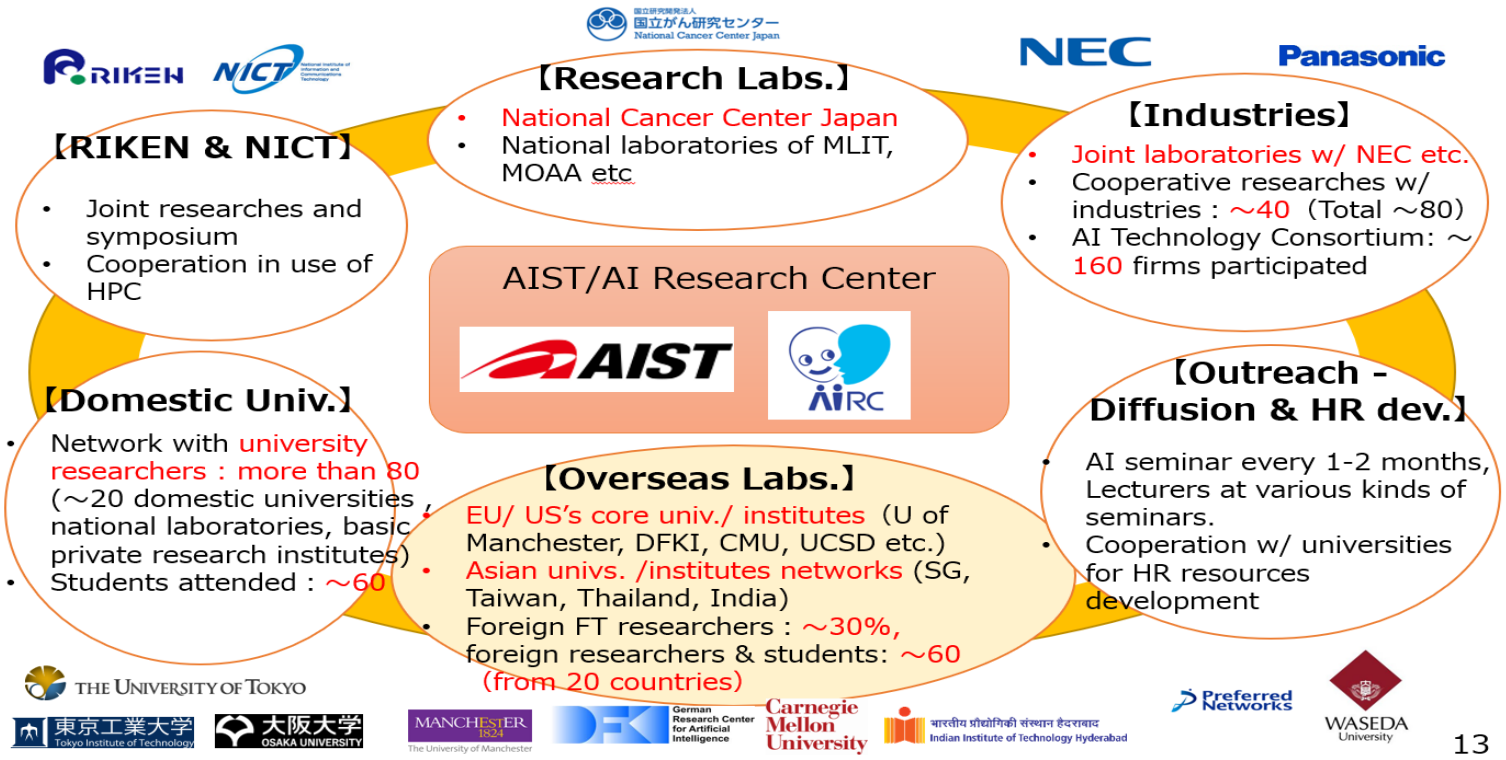
- Black box
  - Explainable AI
  - Visualization
  - Simulation

Baseline method: A man is drinking.
Proposed method: A girl is doing makeup.





Network of Partners



Thank you for your attention