

Japanese Research Direction for AI and Robotics

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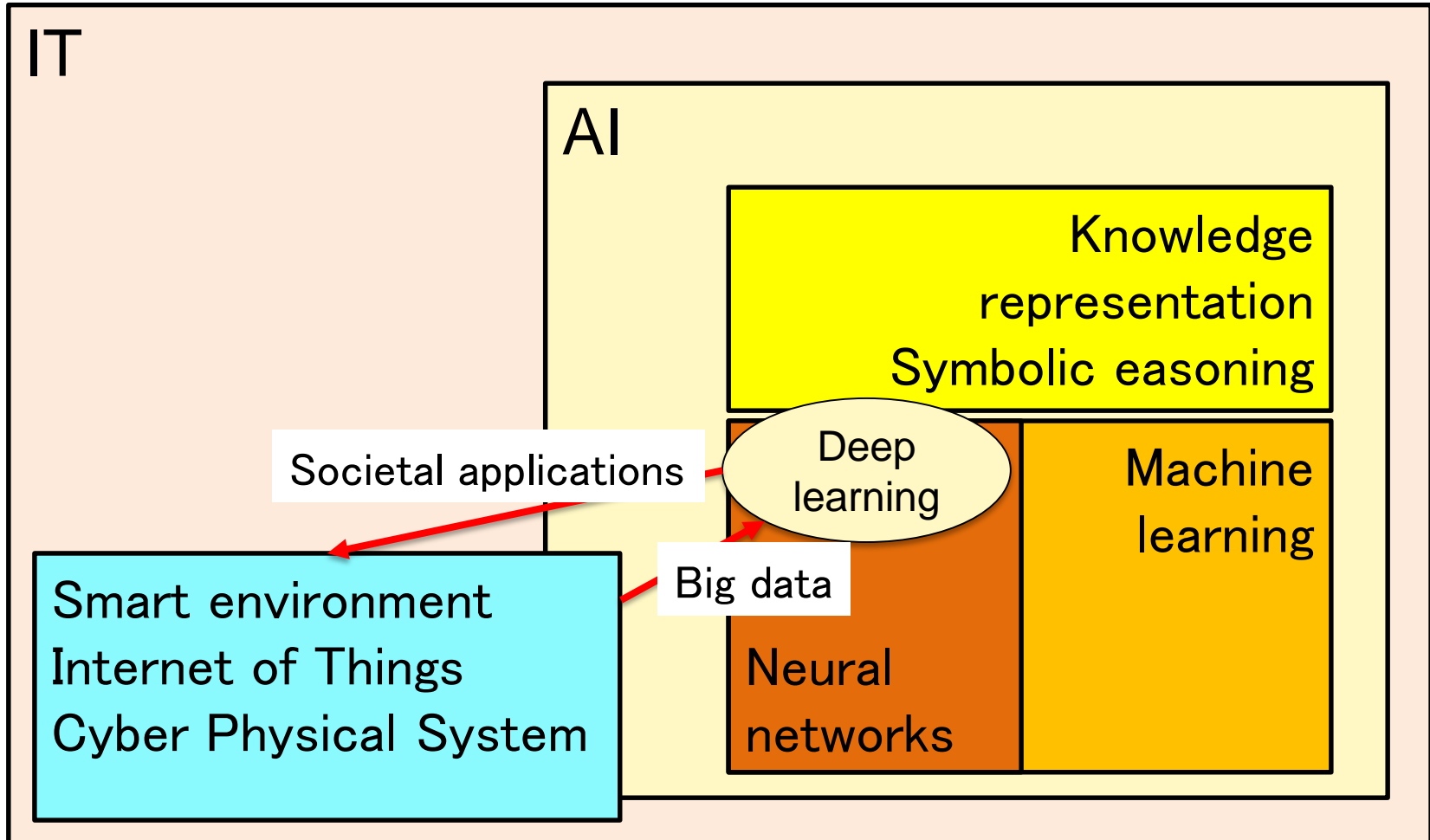
Vio

- 1978-9 MIT AI Lab (exchange student)
- 1983 Ph.D. from the Univ. of Tokyo
- 1983 ElectroTechnical Laboratories (ETL: 電総研)
- 1987-8 Center for the Study of Language and Information, Stanford Univ. (visiting scientist)
- 2001 Cyber Assist Research Center (director), AIST:産総研
- 2004 Future University Hakodate (president)
- 2016 Chair for Frontier AI Education, Univ. of Tokyo
- 2018 Sapporo City University (president)

Artificial Intelligence

- The name of the research area launched at Dartmouth Workshop (1956)
- But recently used as a computer program showing intelligent behaviors as well
 - I will follow this use too

AI is a part of IT



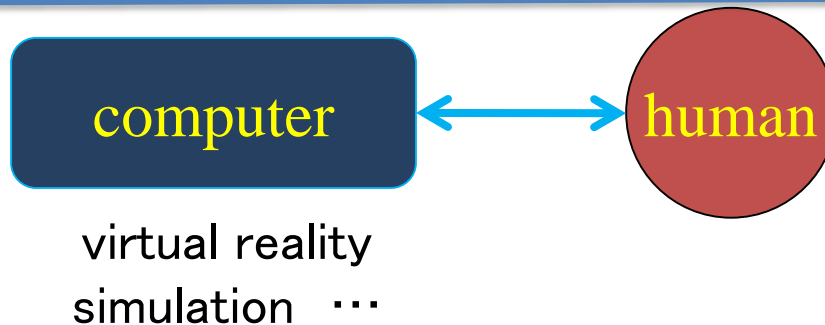
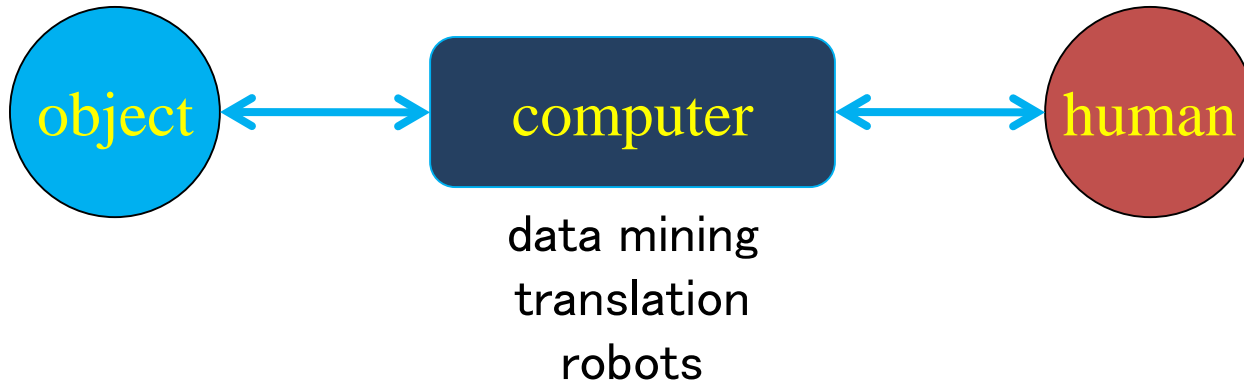
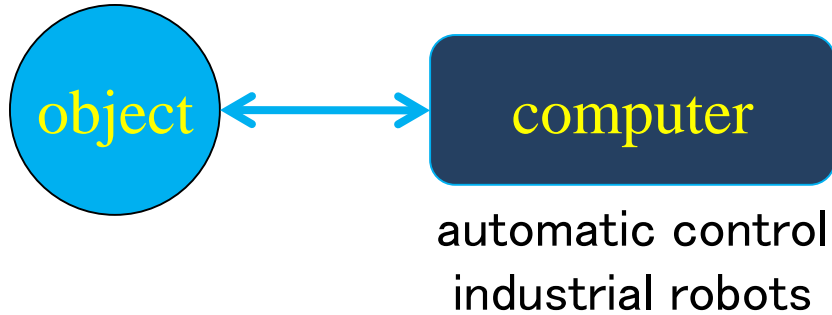
Information Communication

human to human
Computer system does not
change the contents



beacon
telephone
broadcast
Internet
...

Information Processing

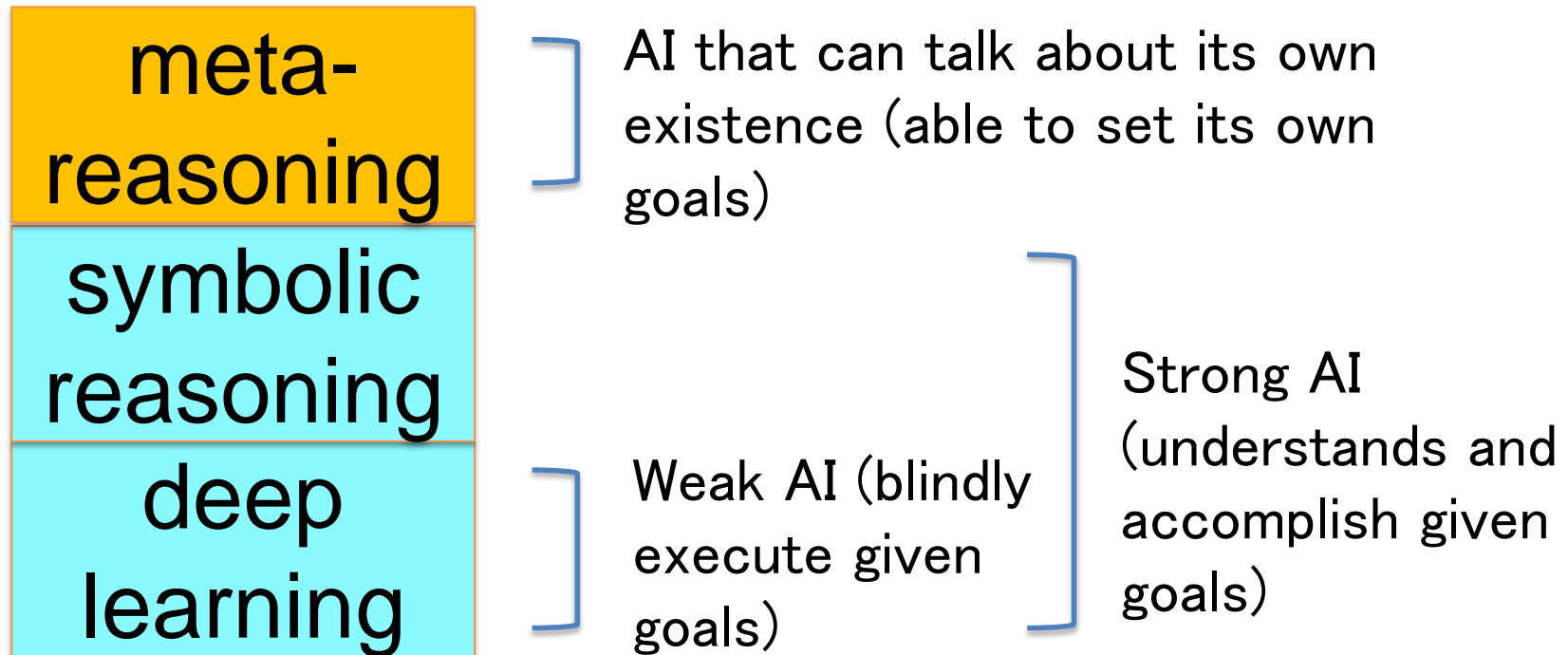


Positions for research of intelligence

1. **Symbol processing** is essential for intelligence
2. **Pattern recognition** (process of symbolization) is essential for intelligence
Including **Deep Learning**
3. Interaction between the agent and the environment is important

My claim: we need all three

Hierarchy of an AI system



Description of *Society 5.0* by Our Government

- New value is defined **by IoT**
- Human is relieved from complicated tasks of information analysis **by AI**
- Problems caused by declining birthrate and aging are solved **by innovation**
- Possibility of human activities are extended **by robots and autonomous driving**

Society 5.1 (by Nakashima)

- We can create a new societal systems by use of IT and AI, which was impossible without them
 - Company organization/ work style
 - Political (national decision making) system
 - Economical system (redistribution of wealth)
 - Education (life long)
 - How to spend our life

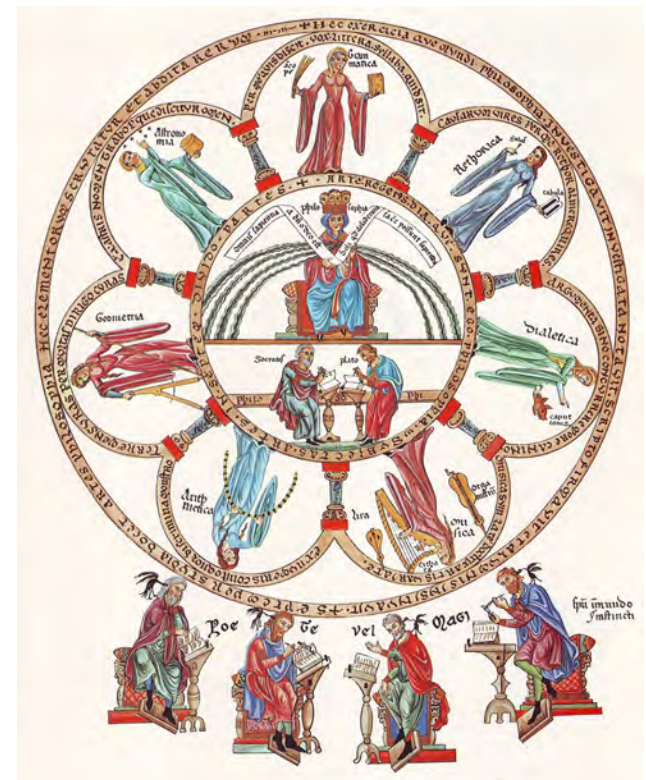
“AI strategy in Japan” by Government (AI戦略会議)

- AI as Liberal Arts
- 250 thousand AI experts / year

- But: Lack of teachers
 - Solution: AI programs as teachers

AI and IT as Liberal Arts

- Original LA
Grammar, logic, rhetoric,
arithmetic, geometry, theory of
music, and astronomy
- New LA of AI era (*my
proposal*)
IT, theory of design, statistics,
rhetoric, philosophy, human
history, art



the seven liberal arts. From the *Hortus deliciarum* of Herrad of Landsberg (12th century)

Human vs. AI & Robots

Human	AI and robots
<i>spending everyday life</i>	<i>fast computing</i>
Nouvelle cuisine	Follow recipe (cooking robots)
Judgment of trials	Document preparation for judgment
Teaching liberal arts	Technical/professional education

Proposal

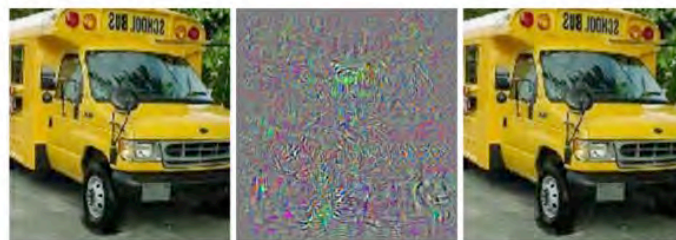
- Application Layer
 - Design and implementation of better societal systems
 - Education {of | by} AI
- Basic Research Layer
 - Solution to the *Frame Problem*
 - To use AI as a talented assistant
 - Fusion of Deep Learning and symbolic reasoning
 - DL can be a black-box (tacit knowledge)

Goal

- Robots that collaborate with human
 - As talented assistants
 - With NL communication

Limitations of Machine Learning

- Over fitting
- Easy to create false positive examples (taking advantage of over generalization)



元画像

右の画像に導入された
ノイズを増幅した画像

深層学習ニューラルネットが、
ダチョウと判定した画像

上列の画像は、Szegedy, et al., "Intriguing properties of neural networks," International Conference on Learning Representation, 2014より



このようなダチョウの画像にも見える
Free Image (<https://pixabay.com/>より)

Limitation of Symbolic Processing

- Frame problem
- Symbol grounding problem

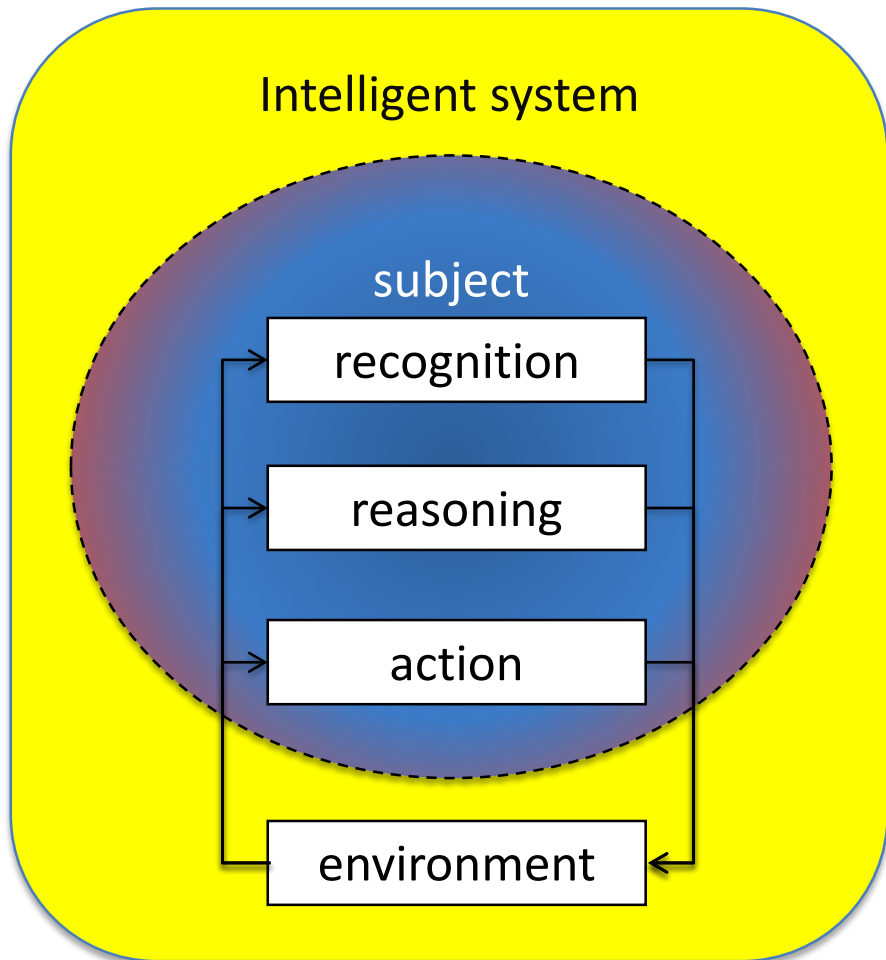
A Solution

- Enhancement of machine learning:
Expectation/anticipation based reasoning and learning
 - Hard to deceive with false-positive examples
- Enhancement of symbolic reasoning:
Top-down reasoning with bottom-up deep leaning
 - Gives symbol grounding, and
 - Solve the frame problem

NEW ARCHITECTURE

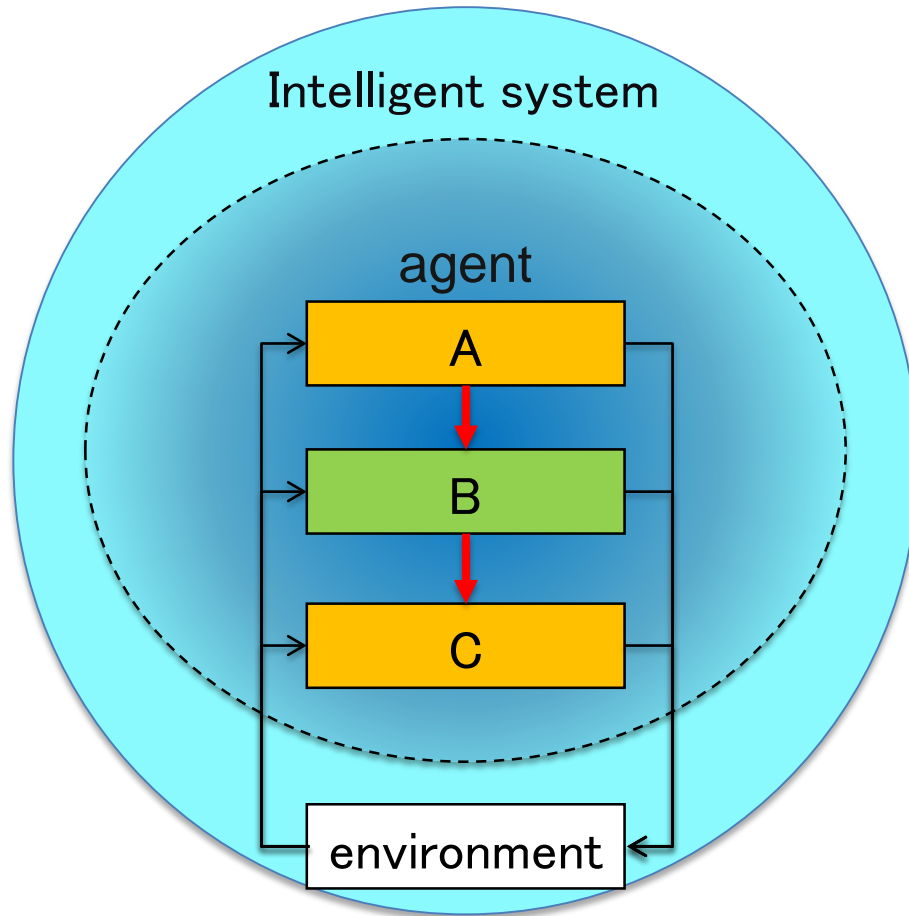
To connect expert systems and DL

Enhancement of the Interaction with the Environment



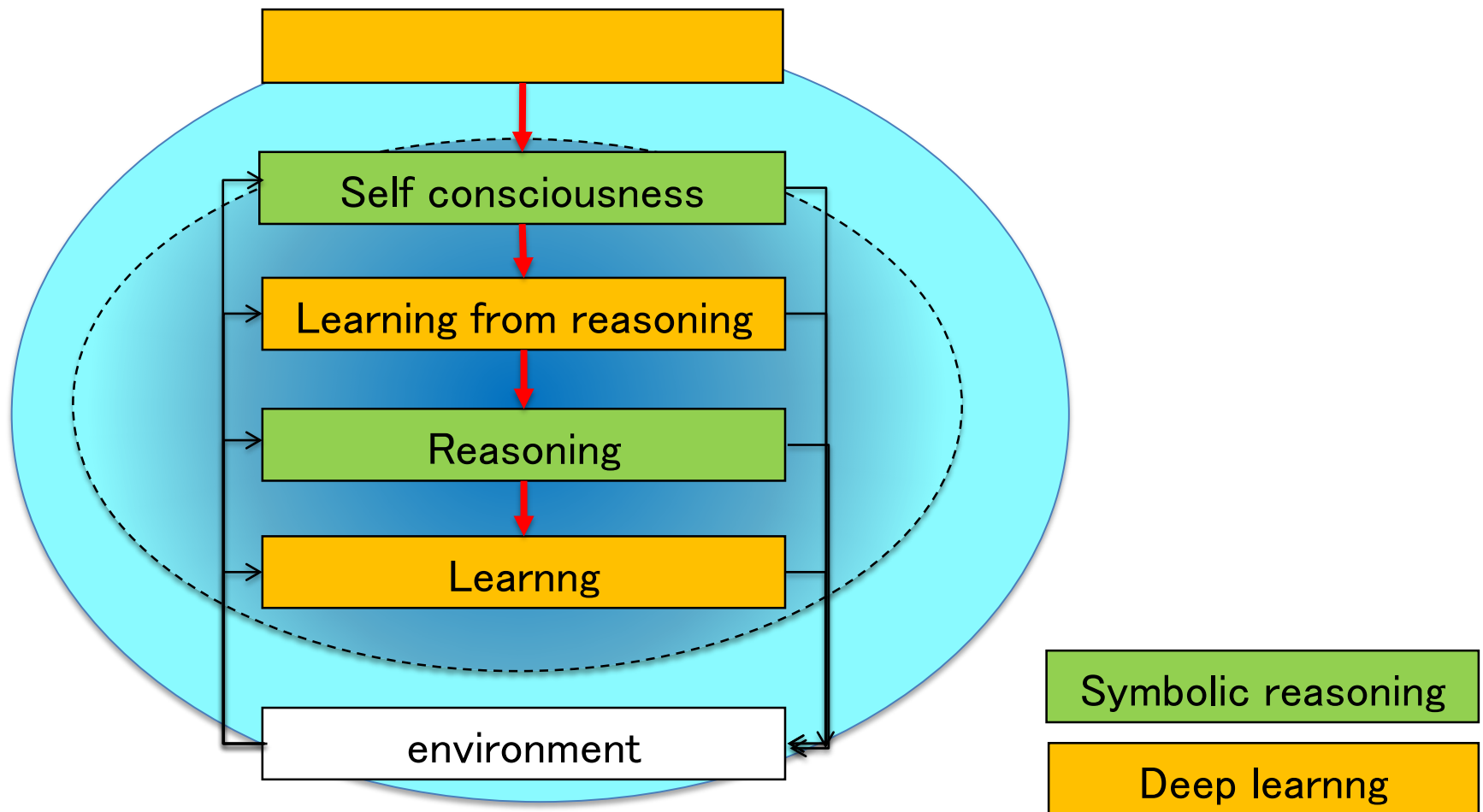
- *Subsumption architecture* (by R. Brooks)
- *Umwelt* (by Uexküll)
- *Autopoiesis* (by Maturana & Varela)
- *Situatedness*

Connecting Symbols and DL



- A: **Deep Learning**
Monitor (consciousness)
 - B: **Symbolic reasoning**
 - C: **Deep Learning**
Acquisition of tacit knowledge
- Independent processes with
 - Inter-process connections (red arrows)

And Further...



Summary

- AI is an intelligent tool
- Value judgement is on human side
- Goal and value must be communicated to AI
 - The frame problem
 - Symbol grounding problem
- Solve the frame problem and symbol grounding problem by a hybrid architecture