AI Mapβ 2.0

Overview figure of issues and technologies for novice AI researchers as well as researchers and practitioners in other fields

AI Map Task force,
the Japanese Society for Artificial Intelligence

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Overview figure of issues and technologies for novice AI researchers as well as researchers and practitioners in other fields

The field of AI research is expanding, and it is becoming increasingly difficult to step back and see the entire field. In addition, AI systems developed from the results of AI research are beginning to be applied in the real world, making it difficult to grasp the relationship between AI systems and AI technology. In response, we created AI Mapβ 2.0 as a guide for novice AI researchers, as well as researchers and practitioners in other fields who aim to utilize AI. AI Mapβ 2.0 is an advanced version of the AI Mapβ published in 2019 and comprises two map: an AI problems map and an AI technology map (Figure 1). An overview is presented below.

【AI problems map】

The AI problems map consists of a set of "problem cards," which feature approaches to problems that AI systems are expected to solve, and a "problems-relation map" showing the relationships among them. Researchers and practitioners in various fields can use the map to help them organize and explore issues from the perspective of AI utilization, while keeping their own issues in mind. We hope that the map will provide novice researchers with an overview of problems/approaches and help them set clear goals. Case studies of AI systems and their industrial applications are already widely available in print and online. This map is not intended to replace them but rather to provide a broader perspective of the issues and the relationships between these issues and AI technology, which may be difficult to obtain at present.

【AI technology map】

The AI technology map is a revised version of the AI Mapβ, published in 2019. With input from the editorial committee of the Japanese Society for Artificial Intelligence (JSAI), we replaced the keywords with those used in technical papers and added some new ones as well. In addition, the standardization of keywords makes it possible to search technical papers published in the future by keyword. We believe the AI technology map will be a useful guidepost for researchers and practitioners in various fields, helping them collect information for research and development activities. We hope that novice researchers will recognize where their own research field fits into the larger puzzle and use it as a guide for their studies.

As shown in Fig. 1, the two maps complement each other and can be used to arrange various combinations of issues and technologies. We hope you will use AI Mapβ 2.0 to find an approach to research and system construction that is suitable for you by moving back and forth between the two maps.

This document also includes an updated map of JSAI special interest groups (SIGs map) and an illustration named "AI Map: From Everyone, for Everyone." The "AI Map: From Everyone, for Everyone" visualizes trends of opinions and perspectives, and hopes and fears on AI-related technologies on the basis of frank voices from Japanese respondents by the National Museum of Emerging Science and Innovation (Miraikan). (https://www.miraikan.jst.go.jp/en/resources/provision/aimap/)

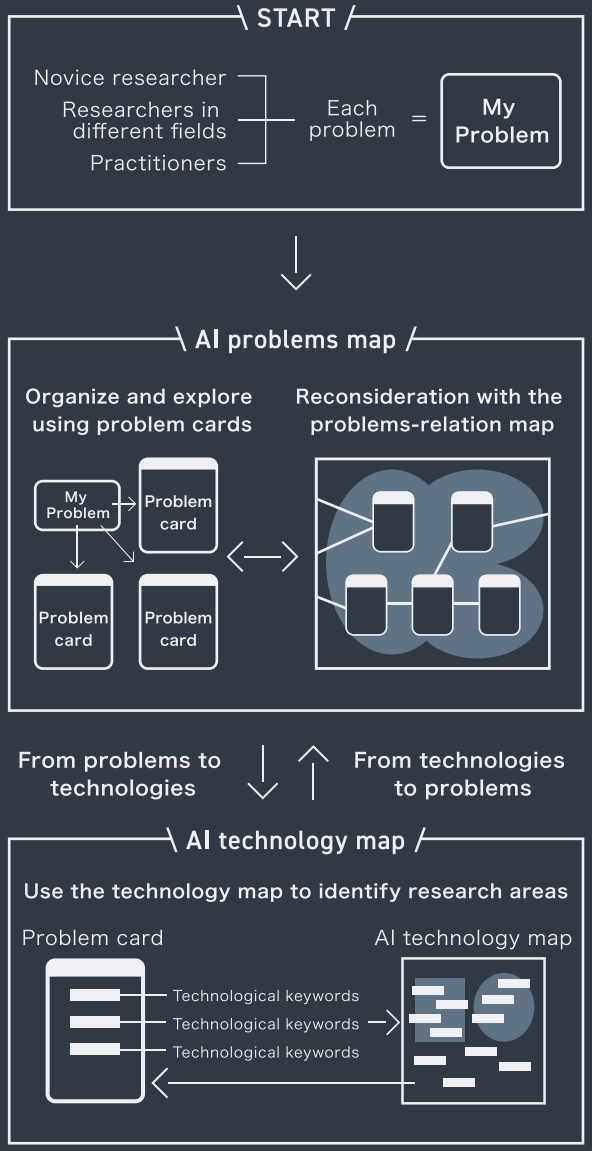


Figure 1 Composition and usage of AI Mapβ 2.0

Target users

Figure 2 shows the target users of AI Mapβ 2.0. The horizontal axis shows the level of understanding regarding AI research and technology. The vertical axis shows the level of understanding of the problem to be solved.

AI Mapβ 2.0 provides assistance in moving from the left side of the figure to the right.

Note that in practice, to deepen one's understanding, it is necessary to read published research papers and surveys, make progress in one's research, study under the supervision of professors, and build experience in performing real-world implementations. For these activities, AI Mapβ 2.0 aims to provide guidance and assistance on approaches or ways to find better solutions or to develop broader range of technologies.

Furthermore, there are times when certain methods will lead to dead ends in research and development. The latest techniques or the most popular methods may not necessarily be the best solutions for your problems.

We hope that AI Mapβ 2.0 will provide hints that lead to a solution or a reexamination of the issue.

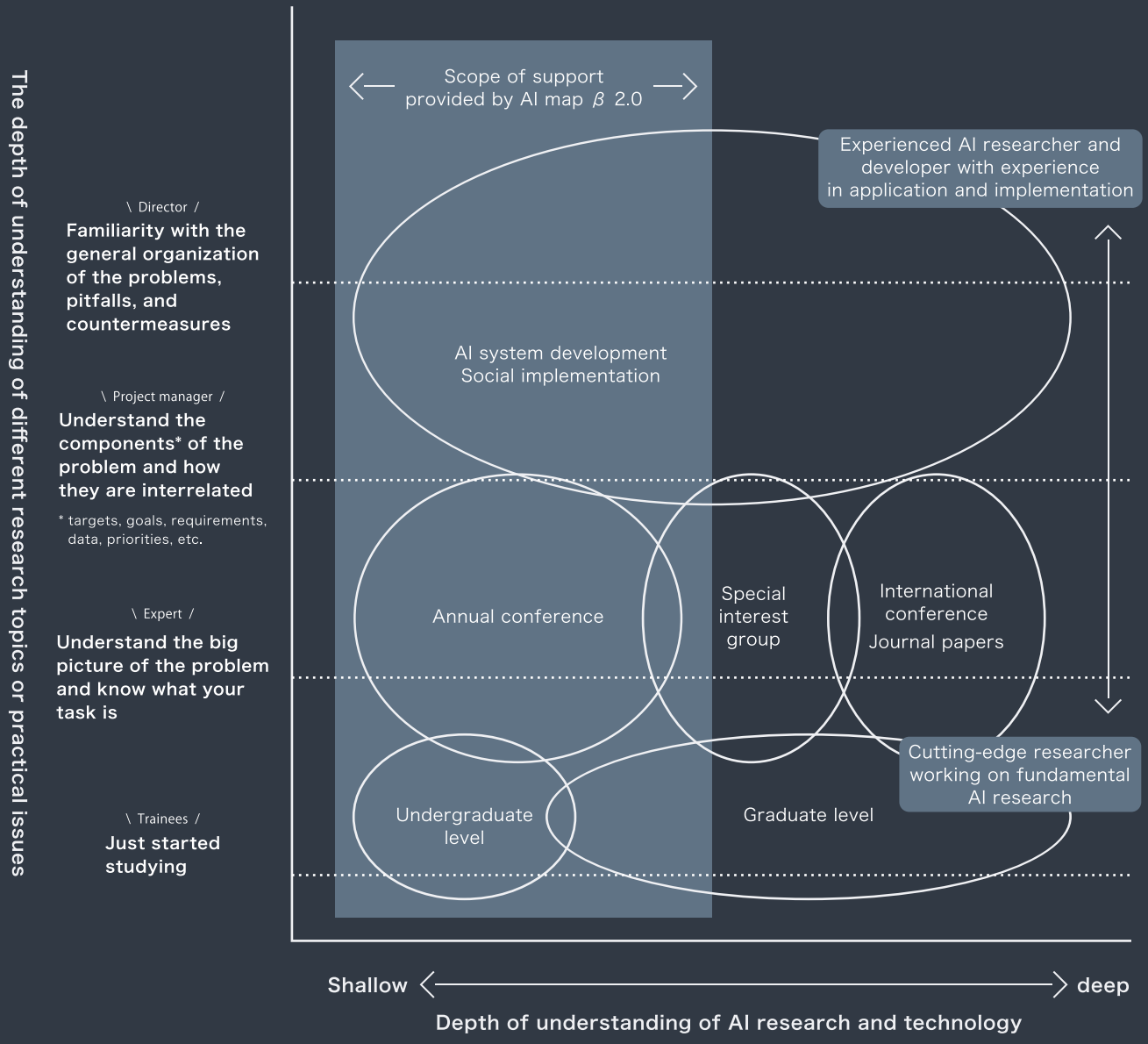


Figure 2 Scope of The beginning stages of study

AI problems map

As a result of progress in AI research, many AI information systems have been implemented in society. In the near future, more and more AI systems will be used to address a wide variety of societal needs. However, the diversification of AI research and its application have made it difficult to understand the relationship between these issues and AI research. Many AI systems consist of multiple modules where various results of AI research and technologies (ex. database or IoT) have been applied.

While the target users of this AI map may be capable of gaining experience and knowledge by working on such AI systems, it's possible that they get bogged down in viewing their problems/approaches within narrow scope and fail to see other possibilities. We consider it important to use this map to provide a broad perspective on groups of problems group as well as multifaceted information on the relationship between each problem and AI technology. In other words, our intention is to provide a simple and highly flexible perspective on problems group.

The members of the AI Map Task force decided to create a map with two layers, one containing problem cards and the other a problems-relation map.

The problem cards employ intermediate expressions for specific problems, and act as a bridge between specific problems and various AI technologies. For example, “scheduling” problem card summarizes specific problems such as deliveries scheduling or meetings scheduling, and shows typical approach to solve the problem; ex. a multi-agent system or a genetic algorithm.

The problems-relation map shows the relationships between the problem cards. For example, “scheduling” belongs mostly to the “design” group and it is clear that it is closely related to the problem cards for “placement/design” and “operation plan.” This page and the next explain how to read the problem cards and problems-relation map.

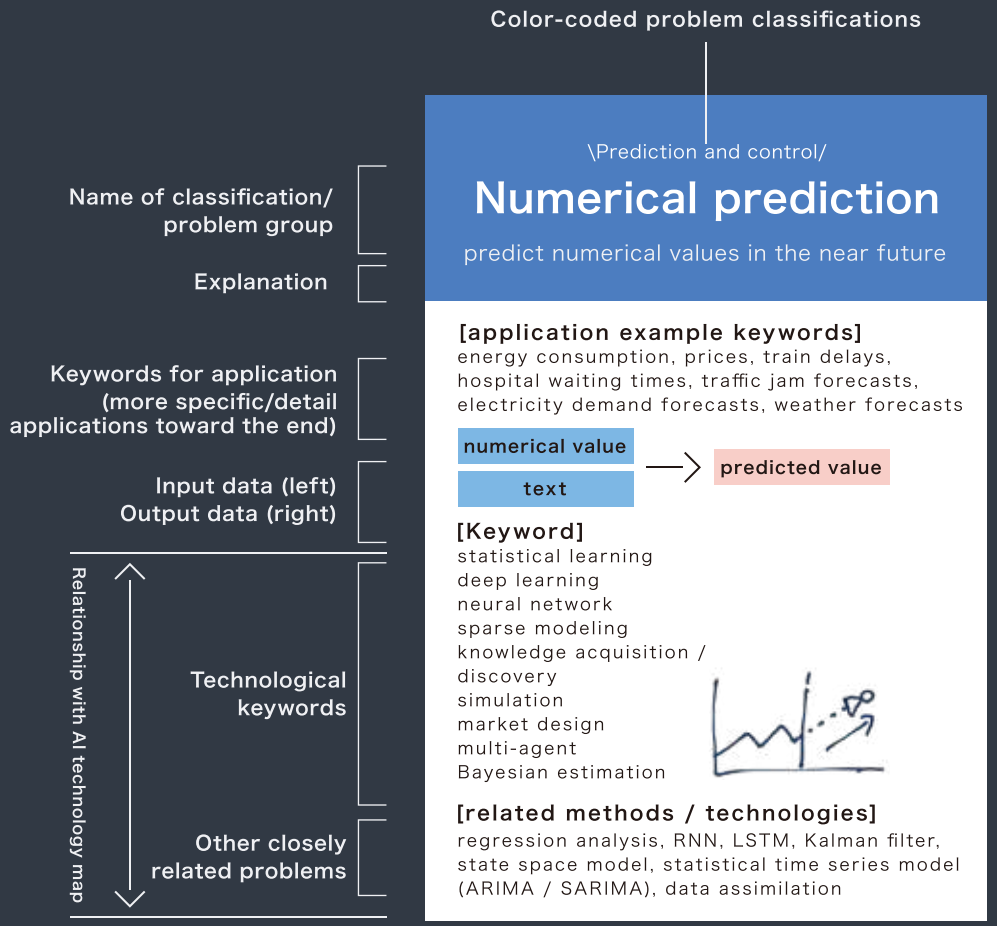


Figure 3 Legend of a problem card

Problem card pp. 7–10

The legend of a problem card is shown in Figure 3. In total, there are 28 cards and each represents a group of specific problems. The cards show the application keywords, data types required for input data, and examples of expected output. Use of technical term is avoided in supplementary explanation. Keywords related to AI research and technology are listed on the bottom of each card. The cards are color-coded according to classification. For example, blue indicates problems in the “prediction and control” classification.

Problems-relation map pp. 11–12

The legend of a problems-relation map is shown in Figure 4. The map shows the classification of each problem card and how the cards relate to each other. Problem cards of the same classification are closely placed. The background colors of problem cards indicate the classifications. It is naturally expected that problems within a classification are strongly related, but there are cases where problems belonging to different classifications are related from application and technological aspects. In such cases, problem cards are connected by lines.

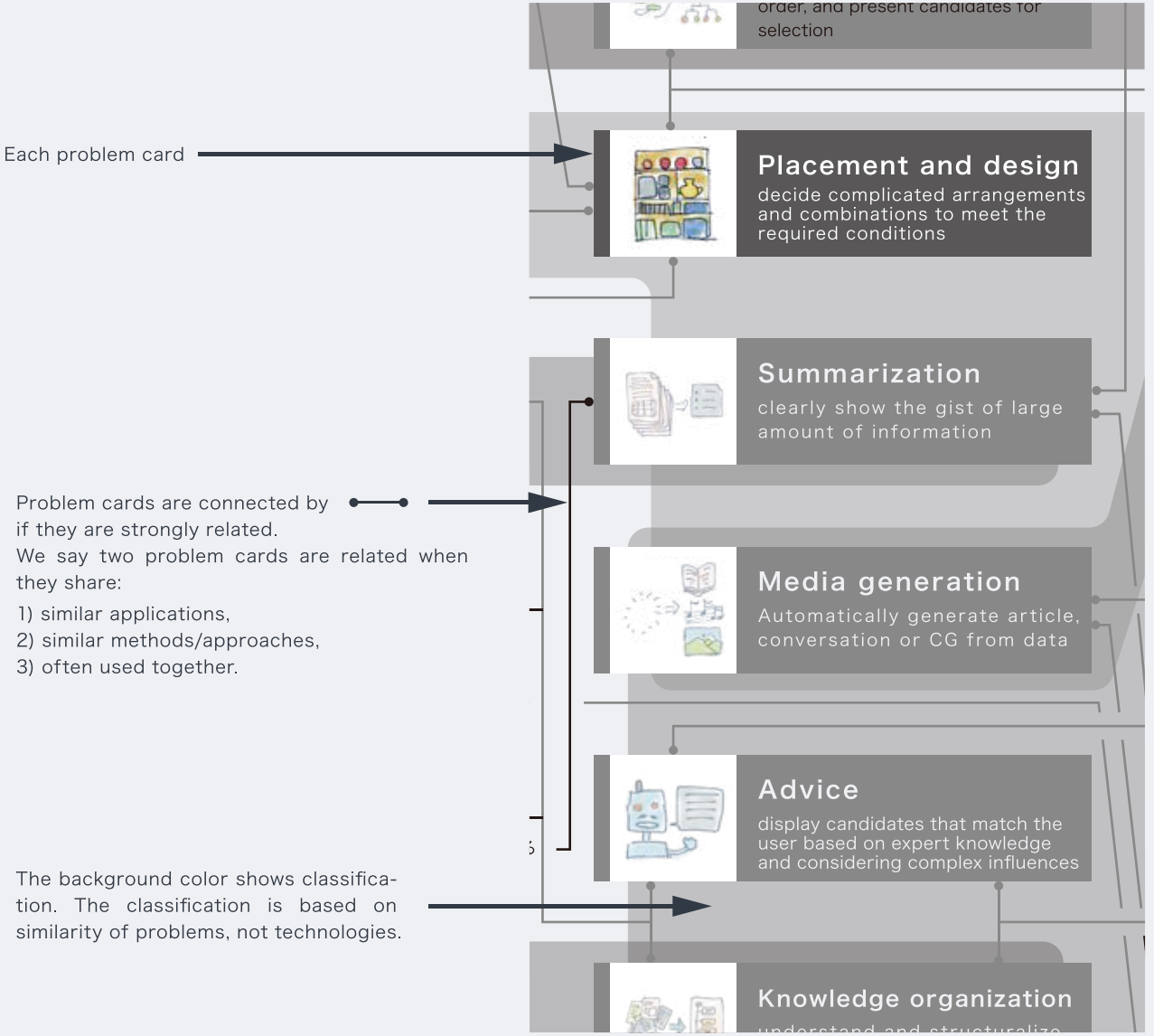


Figure 4 Legend of the problems-relation map.

Tutorial

Example of AI problems map usage

To utilize the results of AI research, it is necessary to consider problems to be solved from the perspective of applying AI technology. However, a wide variety of problems can be understood only by the people involved. Therefore, AI maps may not be able to provide direct support for problem solving.

Considering such aspect, we prepared a template (see right) called “My Problem Sheet” in the AI problems map. Please use this template when tackling your own problems. The completed sheet will be useful for future research and development as well as interviews with experts.

Furthermore, on the next page, steps 1–5 are a tutorial for using the AI problems map. Using the problem card and problems-relation map, you can imagine activities to organize and delve deeper into your problem to a manner that can be applied to AI. The usage of the AI problems map is not limited to this example, but we recommend following this tutorial at first.

First, give your problem a simple name.

Be as specific as possible by describing the current situation, how you want to improve it, and so on.

Describe what you want the solution and the behavior of AI to be, including judgment and prediction results, response text, voice output, and so on.

Describe the type, quantity, diversity, and quality of the AI input data.

Describe the allotted processing time, the minimum accuracy, budget, effort, and so on. Please include expert scarcity, computational resource constraints, communication constraints, and so on.

You can leave this blank at first and add details later by using the AI problems map.

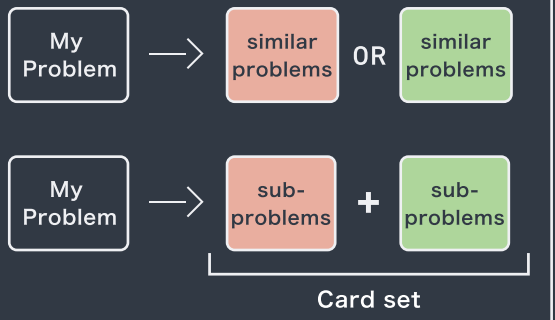
STEP 01

Fill out “My Problem Sheet.”

STEP 02

Select cards.

Collect cards similar to your own problem. Combine multiple cards to compose your problem. (These cards are called a “card set.”)



Revise the “My Problem Sheet” by referring to your card set.

- Revise “My Problem Sheet” if it can't be well organized with your card set, since the problem may not be suitable for AI application.
- Of course the current card set could be insufficient to cover all of the problems. When you encounter such case, please contact the JSAI AI Map Task Force to supplement cards at the next AI map revision.

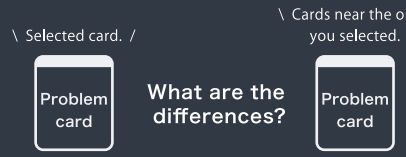
STEP 03

Reconsideration of cards.

In the problems-relation map, consider the following points after checking the cards near the one you selected.

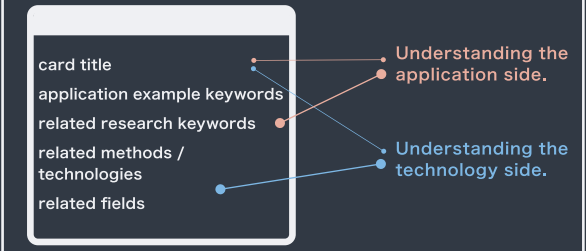
- Is the card you selected the right one?
- Can it be replaced with another card?
- If not, why?
- What are the essential points in “My Problem” ?

Revise “My Problem Sheet” by referring to the newly selected cards.



STEP 04

Select technical or application keywords shown in the card set.



STEP 05-a

Search in AI technology map.

- Find out the position of your problem by searching technical keywords in the AI technology map in the latter part of this pamphlet. (Simple search function of PDF may be useful.)
- Add other keywords or research subjects of your interest to “My Problem Sheet.” (These can be useful when finding information or sessions to attend at the JSAI Annual Conference and JSAI SIG meetings.)

STEP 05-b

Search via search engine.

- Search with [technical keywords] or/and [card title], and understand the technology by reading articles, books, and papers.
  (e.g., stochastic prediction + Bayesian estimation)
- Search with [application example keywords] + [technical keywords], and understand application aspects.
  (e.g., news articles + personalization)
- Search with [technical keywords] or/and [card titles] + (“system” or “service” or “application”), and understand other related applications.

STEP 05-c

Search the contents of the JSAI website

Papers presented at the JSAI Annual Conference are publicly available on J-Stage.
https://www.jstage.jst.go.jp/browse/-char/ja

The JSAI members can download all articles published in JSAI journals on AI Shoko (URL below).
https://jsai.ixsq.nii.ac.jp/ej/

Prediction and control

\Prediction and control/

Numerical prediction

predict numerical values in the near future

[application example keywords]

energy consumption, prices, train delays, hospital waiting times, traffic jam forecasts, electricity demand forecasts, weather forecasts

numerical value
text
→ predicted value

[Keyword]

statistical learning
deep learning
neural network
sparse modeling
knowledge acquisition / discovery
simulation
market design
multi-agent
Bayesian estimation

[related methods / technologies]

regression analysis, RNN, LSTM, Kalman filter, state space model, statistical time series model (ARIMA / SARIMA), data assimilation

\Prediction and control/

Probability prediction

predict the probability of the near future event

[application example keywords]

market size, delivery probability, congestion rate, behavior model, weather forecast

numerical value
text
→ probability

[Keyword]

statistical learning
state space model
graphical model
deep learning
neural network
sparse modeling
knowledge acquisition / discovery
simulation
market design

[related methods / technologies]

Bayesian network, data assimilation

\Prediction and control/

Predicted candidate presentation

present diverse possibilities in the future

[application example keywords]

typhoon outbreak location, new services / markets, regional economy, location of failure

numerical value
text
→ candidates
scenario

[Keyword]

Bayesian estimation
semi-supervised learning
neural network
knowledge acquisition / discovery
auction
market design
Web intelligence
behavior estimation
multi-agent

[related methods / technologies]

simulation, scenario planning

\Prediction and control/

Operation and control

move devices automatically according to the purpose

[application example keywords]

automobile, heavy machinery, airplane, machine tool , agricultural machinery, ship, traffic light, plant, forklift

Image
sensor
manual input
→ control value

[Keyword]

simulation
multi-agent
reinforcement learning
deep learning
semi-supervised learning
neural network
HRI

[related methods / technologies]

cloud robotics, probabilistic robotics

\Prediction and control/

Operation plan

make a operation plan that maximizes the objective under given condition

[application example keywords]

device operation plan, workforce plan, material usage plan, beer factory, personnel shift, delivery plan

past plan
numerical value
relational table
→ schedule
efficiency

[Keyword]

planning
genetic algorithm
evolution calculation
simulation
multi-agent
reinforcement learning
heuristics

[related methods / technologies]

meta-heuristic, search

Recognition and estimation

\Recognition and estimation/

State estimation

estimate invisible internal states such as quality and health

[application example keywords]

machine, patient, food and farm product, operation mode, quality, congestion, infrastructure monitoring

sensor data	numerical value
Image	text

[Keyword]

Bayesian estimation
pattern recognition
deep learning
transfer learning
semi-supervised learning
adversarial learning
neural network
data mining
knowledge acquisition / discovery

[related methods / technologies]

filter bank, blind signal separation, state space model, Kalman filter, hyper spectrum analysis

\Recognition and estimation/

Anomaly detection

find anomalies that exceed normal or acceptable ranges.

[application example keywords]

machine, manufacturing site, historical data, natural phenomena, human body, collective action, transaction data, defective product, incident detection, satellite, power generator vibration, railroad vehicle vibration, falling, sudden illness

sensor	time
Image	location
text	cause

[Keyword]

anomaly detection
data mining
deep learning
representation learning (embedding)
semi-supervised learning
computer vision

[related methods / technologies]

exception detection, anomaly detection, one-class SVM, MT method, kernel density estimation, subspace method, invariant method, auto encoder

\Recognition and estimation/

Sensor data recognition

recognize objects based on sensor data (ex. whether it's a man or an object / whether it's a craw or a crane.)

[application example keywords]

ultrasonic sensor, temperature sensor, vibration sensor, line sensor, distance sensor, LIDAR, gas sensor, electromagnetic radar, biosensor, behavior history

sensors	type
histories	individual identification
time series	number

[Keyword]

pattern recognition
deep learning
Bayesian estimation
representation learning (embedding)
transfer learning
adversarial learning

[related methods / technologies]

SHOT feature descriptor, PPF descriptor, 3D-DNN, Point Net, dead reckoning, DP matching

\Recognition and estimation/

Authentication

identify a person based on biological information or historical data

[application example keywords]

fingerprint authentication,
face authentication, vocal cord authentication,
gait authentication, history authentication

histories	authentication result
Image	
voice	

[Keyword]

pattern recognition
Image recognition
voice recognition
statistical learning
Bayesian estimation

[related methods / technologies]

life science, face authentication, DNA authentication

\Recognition and estimation/

State change detection

estimate state changes in device such as degradation or clogging.

[application example keywords]

noise / sound, image, plant, wear,
cutting machine, valve, motor, gear, roller, filter

sensor data	amount of damage
Image	location
	distribution

[Keyword]

Bayesian estimation
semi-supervised learning
representation learning (embedding)
transfer learning
adversarial learning
deep learning
clustering

[related methods / technologies]

hidden Markov model, state space model, density ratio estimation

\Recognition and estimation/

Indicator creation

give an index to the nature of an object under complex and ambiguous criteria

[application example keywords]

negotiation skill, design, health, development capability, movement capability, resume, economic indicators, sports

text	evaluation results
Web	
Image	

[Keyword]

deep learning
representation learning (embedding)
clustering
knowledgebase
knowledge acquisition / discovery
knowledge sharing / management
auction

[related methods / technologies]

regression analysis, PCA (principal component analysis), A/B test, hierarchical clustering

\Recognition and estimation/

Media change detection

recognize objects or what's heard from image, video, or sound information

[application example keywords]

speech recognition, Image recognition,
visual inspection, waste, products, people,
trees, automobiles, animals, heavy machinery

Image・video	type
2D・3D	individual identification
sound	number

[Keyword]

computer vision
image recognition
speech recognition
generic object recognition
pattern recognition
representation learning (embedding)
semi-supervised learning
transfer learning

[related methods / technologies]

phonetics, acoustic scene analysis, pre-learning

\Analysis and summarization/

Numerical analysis

clearly show analysis results by inspecting big and various numeric data

[application example keywords]

statistical data, operation data, management data, stocks, financial report, sales amount, shipping record, output, amount of power generation, numerical inspection record, number of users

numerical value
attribute
→ trends / group / relation / topics

[Keyword]

data mining
data science
clustering
semi-supervised learning
information visualization
representation learning (enbedding)
sparse modeling

[related methods / technologies]

privacy preserving data mining, secure computing, Bayesian networks

\Analysis and summarization/

Language data analysis

clearly show analysis results by inspecting big and various text data

[application example keywords]

Web data, SNS, e-mail, questionnaire, speech transcription data, call center, news article, dictionary, popular words, Q&A data, new market analysis, news topic extraction

text
Web
knowledge graph
→ topics / relevance / trends

[Keyword]

text mining
web mining
data mining
Web intelligence
computational social sciences
knowledge graph
social media

[related methods / technologies]

pre-training, statistical analysis of text, corpus, privacy preserving data mining, secure computing, word2vec

\Analysis and summarization/

Summarization

clearly show the gist of large amount of information

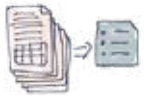
[application example keywords]

text, numerical data, video, web data, report, academic material, SNS, news article and video, Q&A summary, questionnaire result, document, article

text
media
numerical date
→ summarized sentence / map / diagram / album

[Keyword]

summarization
text mining
reinforcement learning
Web intelligence
segmentation



[related methods / technologies]

extractive summarization, abstract summarization, lead method, GAN, pointer networks, pre-training, LexRank

\Design/

Scheduling

determine what to be done in what order

[application example keywords]

advertisement, meeting, delivery, personnel shift

condition
numerical value
objective index
category
→ schedule

[Keyword]

scheduling
planning
genetic algorithms
multi-agent
constraints satisfaction problem / satisfiability testing (CSP/SAT)
reinforcement learning
heuristics
simulation
distributed cooperation
evolutionary computation

\Analysis and summarization/

Causal inference

find causal relationship based on data; predict what changes what

[application example keywords]

epidemiology, economics, chemistry, sleep disorders, sales changes, root cause of failure estimation

numerical value
text
→ causal relation

[Keyword]

AI understandability
semantics
search/logic / inference algorithm
clustering
knowledge graph

[related methods / technologies]

statistical causal analysis, structural equation modeling, causal graph, independent component analysis, LiNGAM

\Analysis and summarization/

Media data analysis

clearly show analysis results by inspecting big and various image / video data

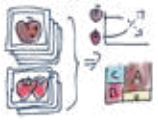
[application example keywords]

image, sound, vibration, surveillance image, fixed-point camera, microscope image, manufacturing line image, sports image

Image
video
sound
→ trends / trouble / anomaly / group

[Keyword]

computer vision
image recognition
generic object recognition
data mining
data science
information visualization
representation learning (embedding)



[related methods / technologies]

privacy preserving data mining, secure computing

\Design/

Placement and design

decide complicated arrangements and combinations to meet the required conditions

[application example keywords]

production planning, procurement planning, personnel shift, investment planning, layout planning, layout optimization, shelving allocation

condition
numerical value
category
objective index
→ combination example / design plan / layout plan

[Keyword]

planning
constraints satisfaction problem / satisfiability testing (CSP/SAT)
genetic algorithm
simulation
evolutionary computation
graph theory
multi-agent
heuristics
market design

\Design/

Coordination

show proposals from many combinations

[application example keywords]

fashion, travel plans, class attendance plans, food menus

user preference input
data about candidates
→ combination of data that matches user preferences

[Keyword]

information recommendation
genetic algorithm
kansei
onomatopoeia
constraints satisfaction problem / satisfiability testing (CSP/SAT)
evolutionary computation
art / entertainment application
knowledge base
knowledge acquisition / discovery

Collaboration and trust formation

\Collaboration and trust formation/

Ordering and selection

show appropriate selection criteria or order, and present candidates for selection

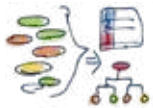
[application example keywords]

screening, tournaments, selection

conditions	order
candidate data	combination

[Keyword]

planning
constraints satisfaction problem / satisfiability testing (CSP/SAT)
genetic algorithms
knowledge sharing / management
knowledge acquisition / discovery
AI fairness
social problem application, market design
multi-agent
decision-making and consensus building
information visualization
swarm intelligence
sparse modeling



\Collaboration and trust formation/

Mediation and planning

support fair consensus building and give advice on ethical issues

[application example keywords]

voting, consensus building, compliance

text	
Web	text
numbers	

[Keyword]

multi-agent
information recommendation
social media
collective intelligence
knowledge sharing / management
Web intelligence
management applications
intelligent UI
text mining
Summarization
ontology
knowledge acquisition / discovery

Generation and dialogue

\Generation and dialogue/

Speech dialogue

respond appropriately by understanding people's intentions based on natural language, intonation, facial expressions, etc. (paralanguage)

[application example keywords]

handling at the counter, call center, web service, elderly people support

speech	speech
text	text
Image	Image

[Keyword]

dialogue processing / dialogue system
speech recognition
speech generation
non-task-oriented dialogue
conversation understanding / discourse understanding / intention understanding
HAI
multimodal interaction

[related methods / technologies]

cognitive science

\Generation and dialogue/

Media transformation

generate target data by transformation or augmentation of input data

[application example keywords]

photo, line art, manga, 3D, speech quality, image compression

text	text
Image	image
sound	sound
time series data	time series data
3D	3D

[Keyword]

image generation
speech generation
adversarial learning
deep learning
pattern recognition
ontology
knowledge graph

[related methods / technologies]

Style Transfer, VGG, GAN, Cycle GAN

Design

\Design/

Personalization

customize the displayed contents to match the users' (hidden) preferences

[application example keywords]

news articles, video distribution, dialogue, services, advertisement distribution

evaluation metrics	
text	example of customization
numerical value	
category	

[Keyword]

information recommendation
dialogue processing / dialogue system
text mining
knowledge acquisition / discovery
kansei
onomatopoeia

[related methods / technologies]

privacy preserving calculation
privacy preserving data mining

\Generation and dialogue/

Knowledge organization

understand and structuralize meaning from documents for extracting relevant knowledge

[application example keywords]

FAQ generation, Web search, risk assessment, investment decision, information retrieval, data sharing, knowledge sharing

document	text

[Keyword]

ontology
summarization
knowledge sharing / management
crowdsourcing
knowledge graph
text mining
web interaction
expert system
onomatopoeia
intelligent UI
knowledge base

[related methods / technologies]

database, knowledge management

\Generation and dialogue/

Advice

display candidates that match the user based on expert knowledge and considering complex influences

[application example keywords]

finance, health care, legal consultation, fitness, daily matters consultation, energy conservation, safe driving

user input	text
	Image

[Keyword]

information recommendation
reinforcement learning
expert system
knowledge base
dialogue processing / dialogue system
knowledge acquisition / discovery
AI ethics
HAI
multimodal interaction

[related methods / technologies]

A/B test

\Generation and dialogue/

Media generation

Automatically generate article, conversation or CG from data

[application example keywords]

news article script, CG of sign language, novel, music

text	text
CG	Image
	CG
	sound

[Keyword]

speech generation
image generation
video processing
conversation understanding / discourse understanding / intention understanding
summarization
knowledge sharing / management
ontology
knowledge graph

[related methods / technologies]

GAN, DeepFake, StyleGAN, speech synthesis, Text to Speech (TTS) , hidden Markov model (HMM), Deep Belief Network, spectral envelope

Prediction and control

Prediction of short-, mid-, and long-term future states
Device control based on predictions

Probability prediction

predict the probability of the near future event

Predicted candidate presentation

present diverse possibilities in the future

Mediation and planning ›

Scheduling ›

Numerical prediction

predict numerical values in the near future

Operation and control

move devices automatically according to the purpose

Operation plan

make a operation plan that maximizes the objective under given condition

Placement and design ›

Recognition and estimation

Image and sound/noise recognition
Estimation of past and present states

Anomaly detection

find anomalies that exceed normal or acceptable ranges.

Numerical analysis ›

Causal inference ›

State estimation

estimate invisible internal states such as quality and health

State change detection

estimate state changes in device such as degradation or clogging.

Indicator creation

give an index to the nature of an object under complex and ambiguous criteria

Sensor data recognition

recognize objects based on sensor data (ex. whether it's a man or an object / whether it's a craw or a crane.)

Media data analysis ›

State change detection

recognize objects or what's heard from image, video, or sound information

Authentication

identify a person based on biological information or historical data

Predicted candidate presentation

Probability prediction
Operation plan

Operation plan

Operation and control

Anomaly detection
Sensor data recognition
State changedetection

Media recognition

Anomaly detection
State change detection

Mediation and planning

support fair consensus building and give advice on ethical issues

Ordering and selection

show appropriate selection criteria or order, and present candidates for selection

Collaboration and trust formation

Generation and adjustment of appropriate selection criteria and order

Scheduling

determine what to be done in what order

Placement and design

decide complicated arrangements and combinations to meet the required conditions

Coordination

show proposals from many combinations

Design

Propose adjusted combinations that conform to the conditions

Numerical analysis

clearly show analysis results by inspecting big and various numeric data

Summarization

clearly show the gist of large amount of information

Personalization

customize the displayed contents to match the users' (hidden) preferences

Media data analysis

clearly show analysis results by inspecting big and various image / video data

Media generation

Automatically generate article, conversation or CG from data

Generation and dialogue

Response upon listening to a human utterance
Generation of new images, data, and sentences

Analysis and summarization

Analyze, summarize, and visualize data

Language data analysis

clearly show analysis results by inspecting big and various numeric data

Advice

display candidates that match the user based on expert knowledge and considering complex influences

Speech dialogue

respond appropriately by understanding people's intentions based on natural language, intonation, facial expressions, etc. (paralanguage)

Causal inference

find causal relationship based on data; predict what changes what

Knowledge organization

understand and structuralize meaning from documents for extracting relevant knowledge

Media transformation

generate target data by transformation or augmentation of input data

Correspondence between the AI problems map and AI technology map

Research subject classification	explanation	application fields	AI technology map			
			MapA	MapC	MapD	MapE
Prediction and control	・Prediction of short-, mid-, and long-term future states ・Device control based on predictions	Utilized mainly in industrial sectors(manufacturing, infrastructure, logistics, energy, and telecommunications), with some application in wholesale and retail as well as event management	Evaluation Objective Operation selection Execution Robots and the real world	Machine learning, Metaheuristics, Agent, Image, Audio, and Media processing, Robotics, Robots and the Real world, Human interface, Environment, Art / Entertainment applications, Logic / Reasoning, AI and Society, Fundamentals and Theory, Medical and Biology, Management, Environment, Industrial application	Learning, Recognition, Prediction, Body, Robots, Motion	Fundamentals and Theory Machine learning Agent Robots and the Real world AI applications
Recognition and estimation	・Image and sound/ noise recognition ・Estimation of past and present states	Utilized in the security, medicine, and industrial sectors	Perception Interpretation Evaluation	Machine learning, Image, Audio, and Media processing, Robotics, Robots and the Real world, Knowledge engineering, Machine learning, Agent, Medical and Biology, Art / Entertainment applications, Education, AI and Society, Environment, Fundamentals and Theory, Industrial application	Learning, Recognition, Prediction, Inference, Knowledge, Language,	Image, Audio, and Media processing Fundamentals and Theory Machine learning AI applications
Generation and dialogue	・Response upon listening to a human utterance ・Generation of new images, data, and sentences	Utilized in the service and media art industries	Human Dialogue Emotion Media	Language media processing, Image, Audio, and Media processing, Knowledge engineering, Use and Sharing of knowledge, Social computing, Web intelligence, Agent, Human interface, Medical and Biology, Art / Entertainment applications, Robotics, Robots and the Real world, Education, Logic / Reasoning, AI and Society, Fundamentals and Theory, Industrial application	Discovery, Search, Creation, Human, Dialogue, Emotion, Evolution, Life, Growth	Human interface Robots and the Real world Image, Audio, and Media processing Language media processing Agent Use and Sharing of knowledge
Analysis and summarization	・Analyze, summarize, and visualize data	Utilized in office work, monitoring, and maintenance services	Interpretation Evaluation	Machine learning, Language media processing, Image, Audio, and Media processing, Web intelligence, Human interface, Agent, Knowledge engineering, Use and Sharing of knowledge, AI and Society, Environment, Medical and Biology, Fundamentals and Theory, Education, Management, Logic / Reasoning, Industrial application	Inference, Knowledge, Language, Learning, Recognition, Prediction	Image, Audio, and Media processing Language media processing Use and Sharing of knowledge Web intelligence
Design	・Propose adjusted combinations that conform to the conditions	Utilized in upstream processes, the service industry, design and manufacturing	Interpretation Evaluation Media	Machine learning, Metaheuristics, Agent, Knowledge engineering, Use and Sharing of knowledge, Logic / Reasoning, Medical and Biology, Management, AI and Society, Fundamentals and Theory, Education, Industrial application	Discovery, Search, Creation, Learning, Recognition, Prediction	Fundamentals and Theory Web intelligence Agent Machine learning
Collaboration and trust formation	・Generation and adjustment of appropriate selection criteria and order.	Utilized in social activities such as screenings, elections, tournaments, candidate selection, and consensus building	AI and Society	Agent, Knowledge engineering, Use and Sharing of knowledge, Social computing, Robots and the Real world, Human interface, Web intelligence, Use and sharing of knowledge, Knowledge engineering, AI and Society, Logic / Reasoning, Fundamentals and Theory, Management, Industrial application	Human, Dialogue, Emotion, AI frontier	AI and Society AI applications Fundamentals and Theory Language media processing Use and Sharing of knowledge

Remarks: Map B is organized in view of handled data and technology development, and hence correspondence with research subject classification is very complicated.

AI technology map

The field of AI research consists of many diverse areas that are intricately linked and rapidly developing, so it is difficult for a single map to encompass the relevance of all research fields without introducing contradictions. Considering this type of situation, five maps have been created that capture AI research from five different perspectives.

These five maps comprise the revised versions of four maps published in 2019 as well as a new map created by the Editorial Committee. We encourage users to propose additional maps. We also hope that experts in specific fields will create partially detailed maps and tutorials and link them to this map, thereby expanding the into multiple layers.

As an introduction, the perspectives of the five maps and their usage are described. Details for reading each map are found in the respective map explanation.

In map A, attention is focused on the processes of intelligence. The concept of intelligence as an input/output process flow is shared by many AI researchers, with constant advancements in component technologies. The map can be used to develop complex processes for advanced component research or to decompose intellectual processes into their individual components. The map also incorporates the viewpoint of individual and group intelligence.

Map B shows the relationship between technologies and application targets. In many AI studies, component technology is developed with a focused aim, and the map indicates representative combinations of technologies and targets. Many successful studies have been conducted by shifting targets, suggesting that the next successful research field might be found among closely related keywords. This map can be used when shifting research targets or considering related technologies for applications.

In map C, attention is focused on the fundamentals and applications that extend from AI research. AI research covers highly academic fields and is rooted in the natural sciences, humanities, and social sciences. This map also shows the application areas that are undergoing rapid development. This map can serve as reference when reconsidering research subjects from a fundamental point of view or when exploring new applications.

Map D showcases various answers by AI researchers to the question, “What is intelligence?” Some answers can be found in rapidly developing technological fields, including “ Learning, Cognition, and Prediction,” “Reasoning, Knowledge, and Language,” and “Discovery, Search, and Creation.” Studies in these fields are investigating various aspects of intelligence and are influencing each other. The map reveals the wide range of AI research and the uncharted territory remaining to be explored.

Map E presents keywords for use in the JSAI research papers that were chosen by the Editorial Committee. Keywords that have attracted attention in recent years are collected here so that they may be used in papers reporting state-of-the-art research results.

【Comments on the collected keywords】

- Each map has keywords representing AI-related research fields.
- The keywords were first selected by the taskforce in consideration of whether the words were representative of the big picture of AI research, and in reference to keywords used in academic journals and research meetings.
- Because of the ever-expanding nature of AI applications, the taskforce selected application keywords that were deemed important at the time of publication. (ex: materials informatics)
- The keywords include terms from broader research fields that encompass AI research. In such cases, the keywords should be interpreted from the point of view of AI research in those fields. (ex: information retrieval)
- The keywords also include term from other research and application fields that are closely related to AI research. (ex: behavioral economics)
- The keywords were selected as journal keywords by the Editorial Committee after careful examination and new keywords were added to the list by the taskforce.
- In principle, the keywords on each map are based on the journal keywords mentioned above. However, each map contains keywords not found among the journal keywords and reflect the perspective taken for that map.
- Some keywords may not be visible on a particular map depending on its viewpoint. Accordingly, groups of keywords within a given map may not be the same as those on other maps.
- It's possible that other important keywords have been overlooked. Therefore, we strongly encourage users to suggest new keywords.

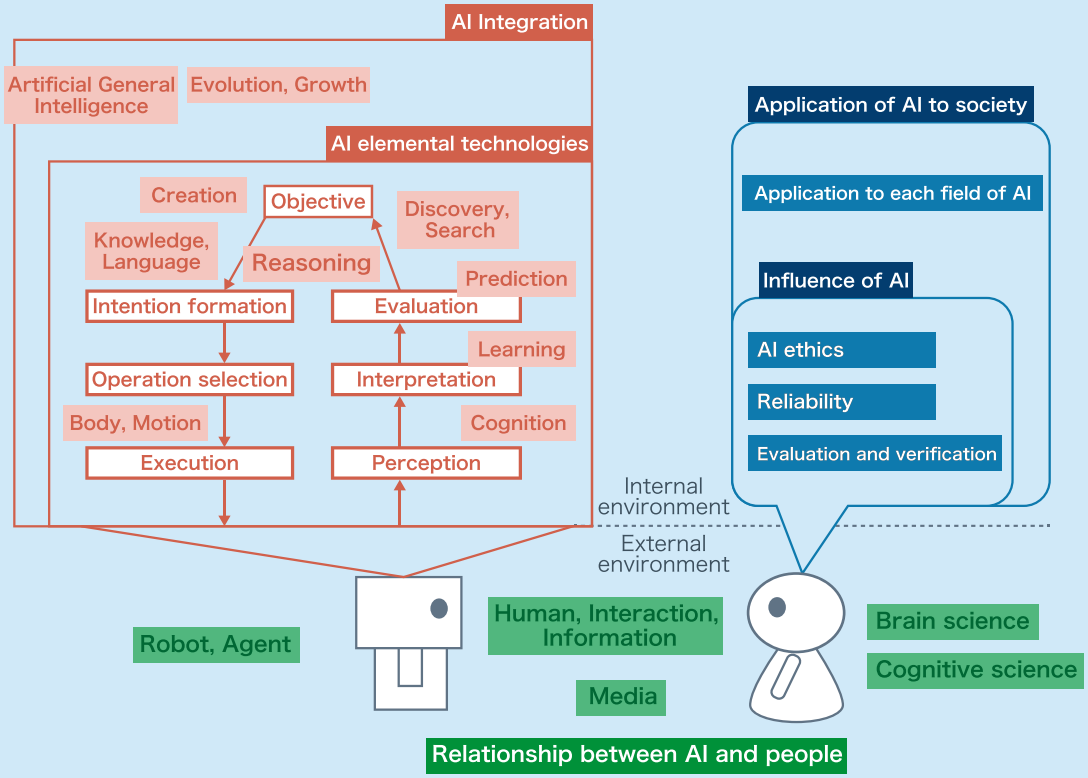
Flow of intelligence activity

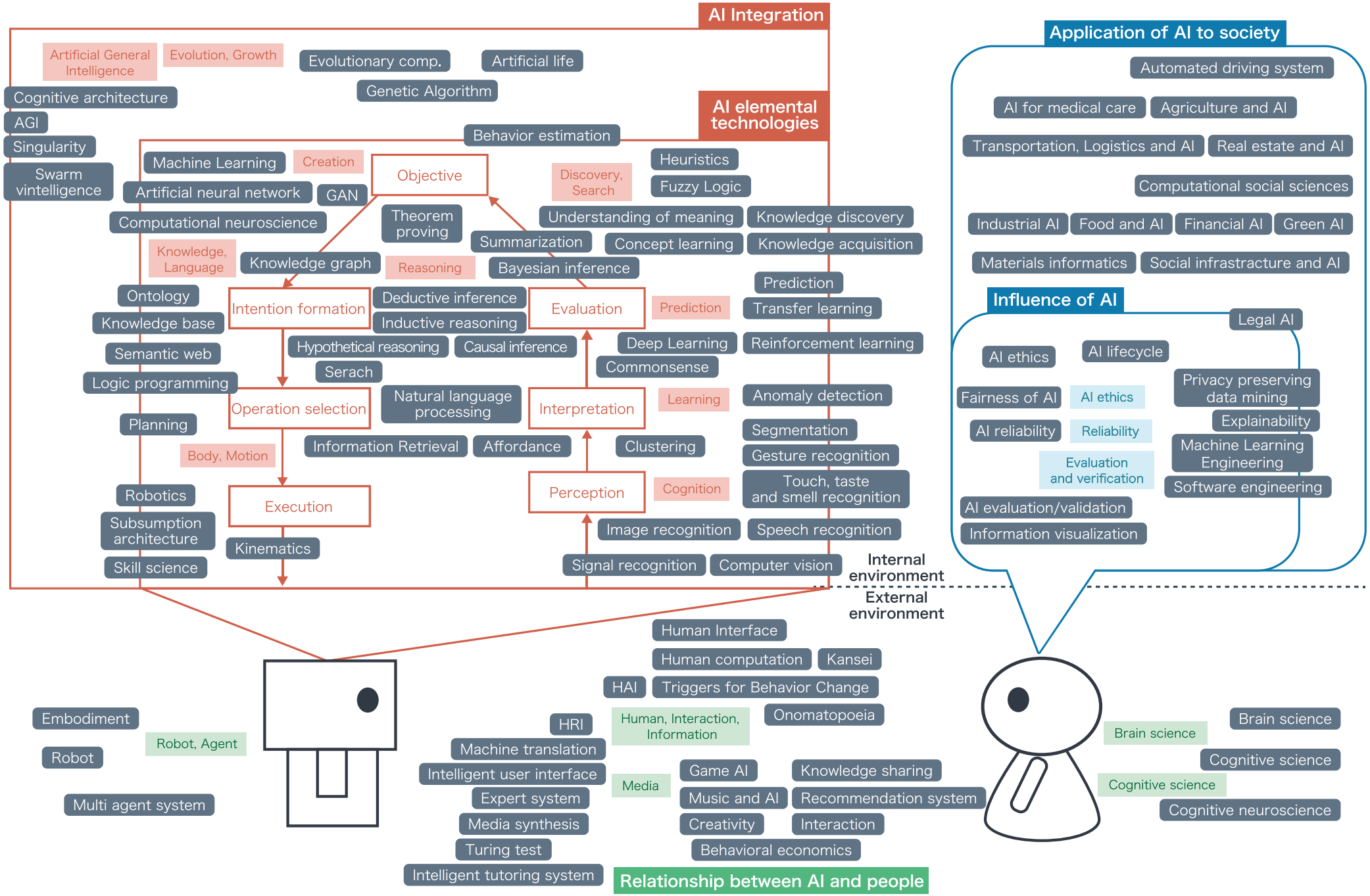
AI research sees human activity as a flow consisting of a combination of many intellectual activities. There are research fields that correspond to each step in this flow. Humans perceive and interpret the visual image, pay attention to the required information, evaluate the information based on the selected information, form an intention, and decide a series of operation sequences. For example, let' s consider a fellow researcher who approaches while holding out his right hand. I recognize the right hand approaching and identify the person as non-Japanese. In addition, his expression is friendly. I remember that there is a custom of shaking hands in foreign countries. I combine the recognition, and construct a series of actions, such as putting out my right hand, smiling while making eye contact, and shaking his hand.

AI also needs to work with humans by communicating with the people around it, and this involves many areas of research. For example, one area of research studies the interaction and dialogue between humans and robots with physical bodies.

In addition, many new research fields are emerging that examine how humans view AI. Research is also required on the appropriate use of AI, and includes evaluating AI' s reliability and operability.

Novices can learn about applications and activities related to their academic fields. For those who are already researching a certain field, the map can show related AI research themes and highlight possible partners for collaboration.





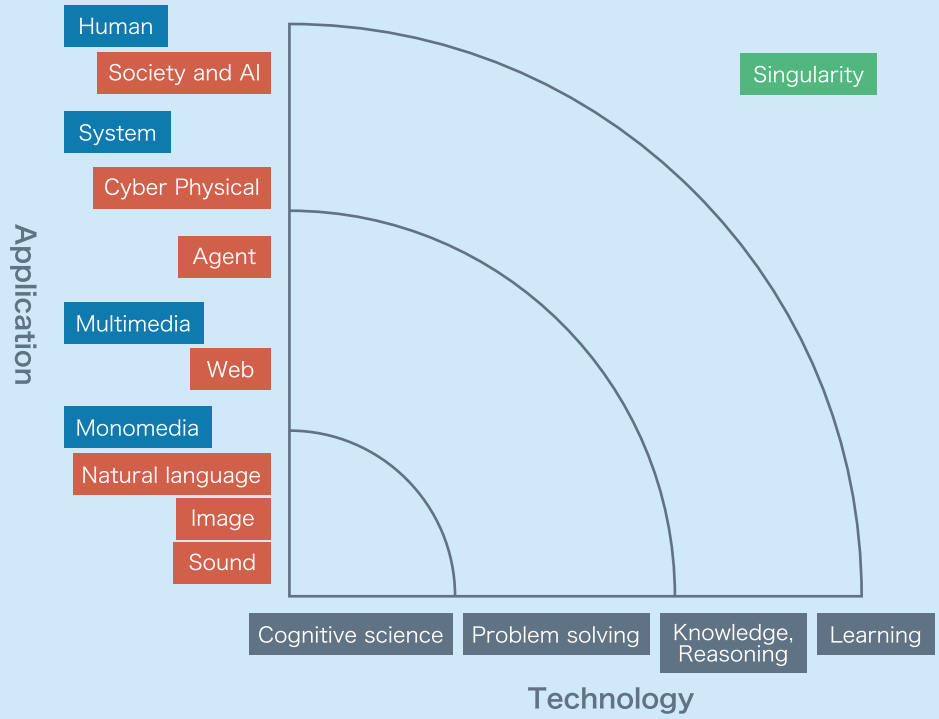
B

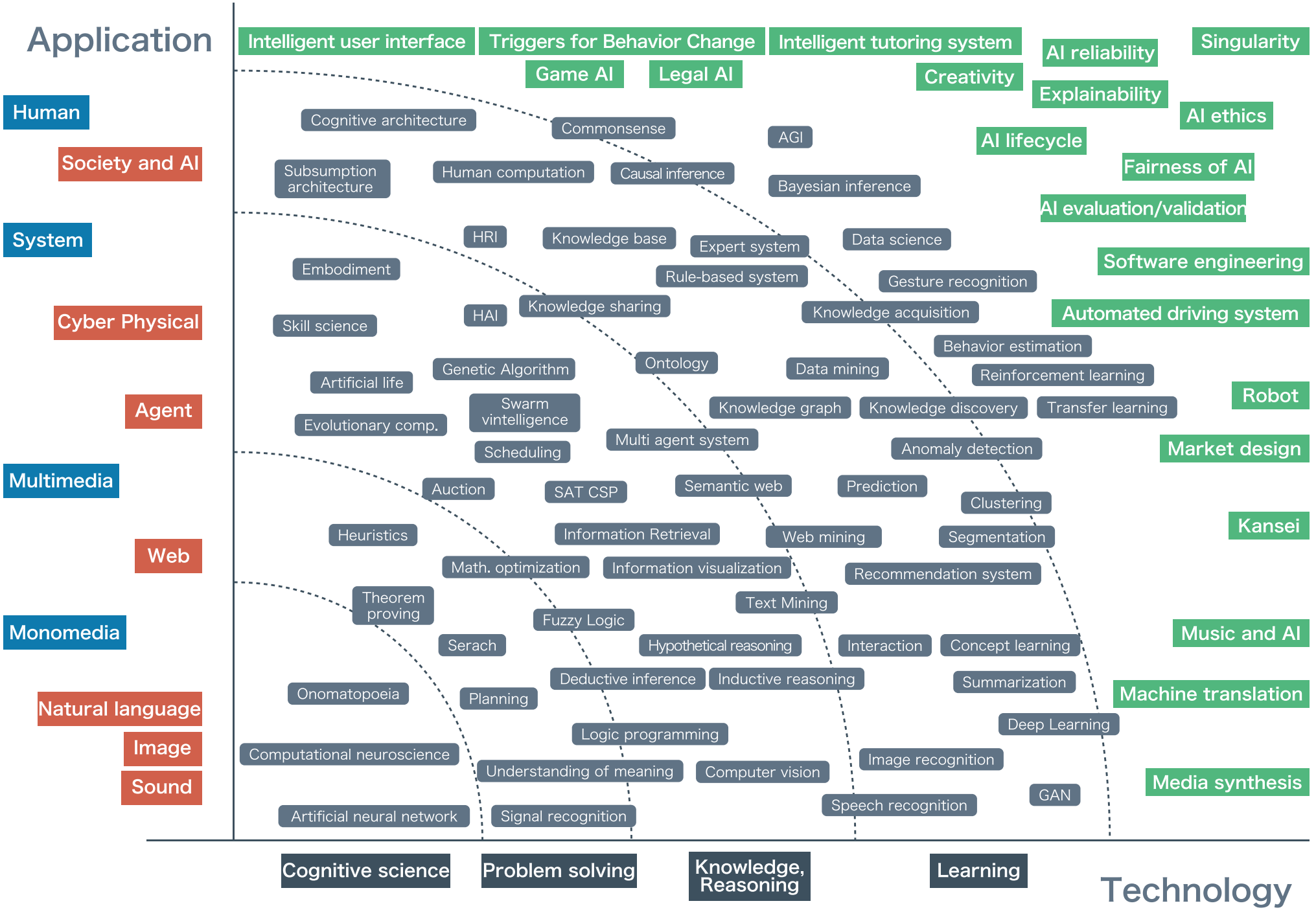
Matching technology and applications with the next target

AI research has produced a large number of technologies that are general-purpose with no specific target. However, during development, targets have been defined within a certain range, and realization methods and fundamental technologies have been developed for them. For example, image targets have evolved from simple signal recognition to complex image recognition, and then to generative adversarial network (GAN).

In addition, technological development in a specific field has stimulated related technical fields, and has created new technology-target pairs. Therefore, the area around coordinates that is currently producing a large number of new technologies could be developed by changing the target or changing the technical goal.

For example, as a hypothesis, in recent years the practicality of multi-agent systems has been rapidly improved by increases in computing power and the preparation of large amounts of data. Looking at surrounding areas on the map, scheduling is likely to be closer to problem solving, and as the target moves closer to knowledge and reasoning, new technological advances may emerge in multi-agent systems (e.g., the Semantic Web).





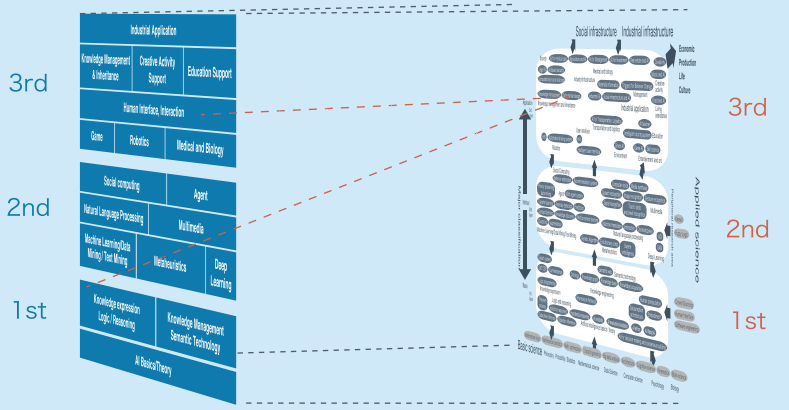
C

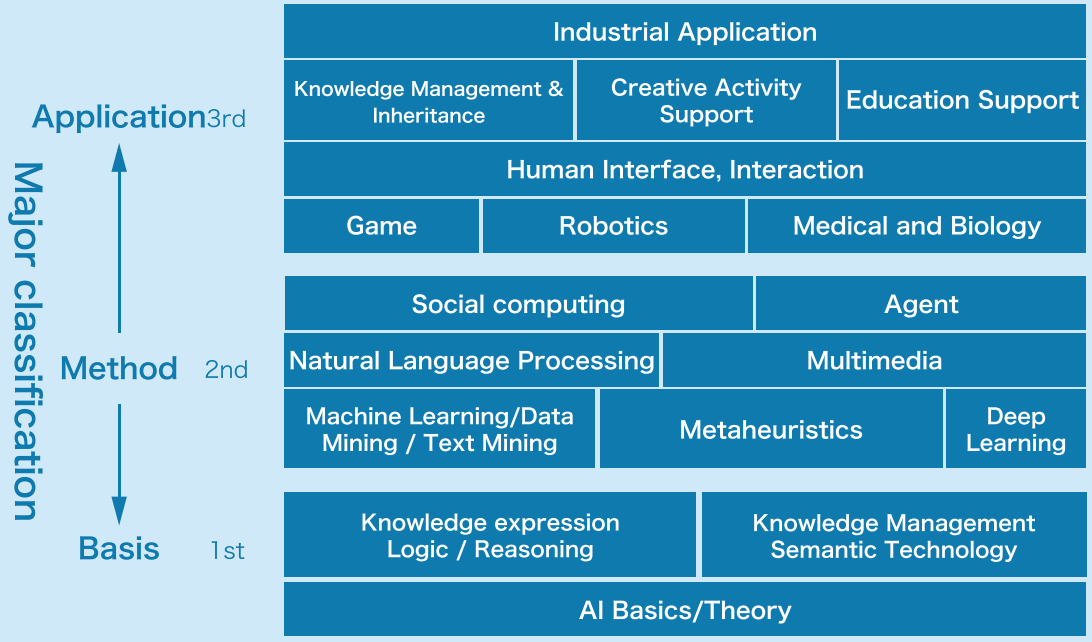
Connectivity of fundamentals with methods and applications

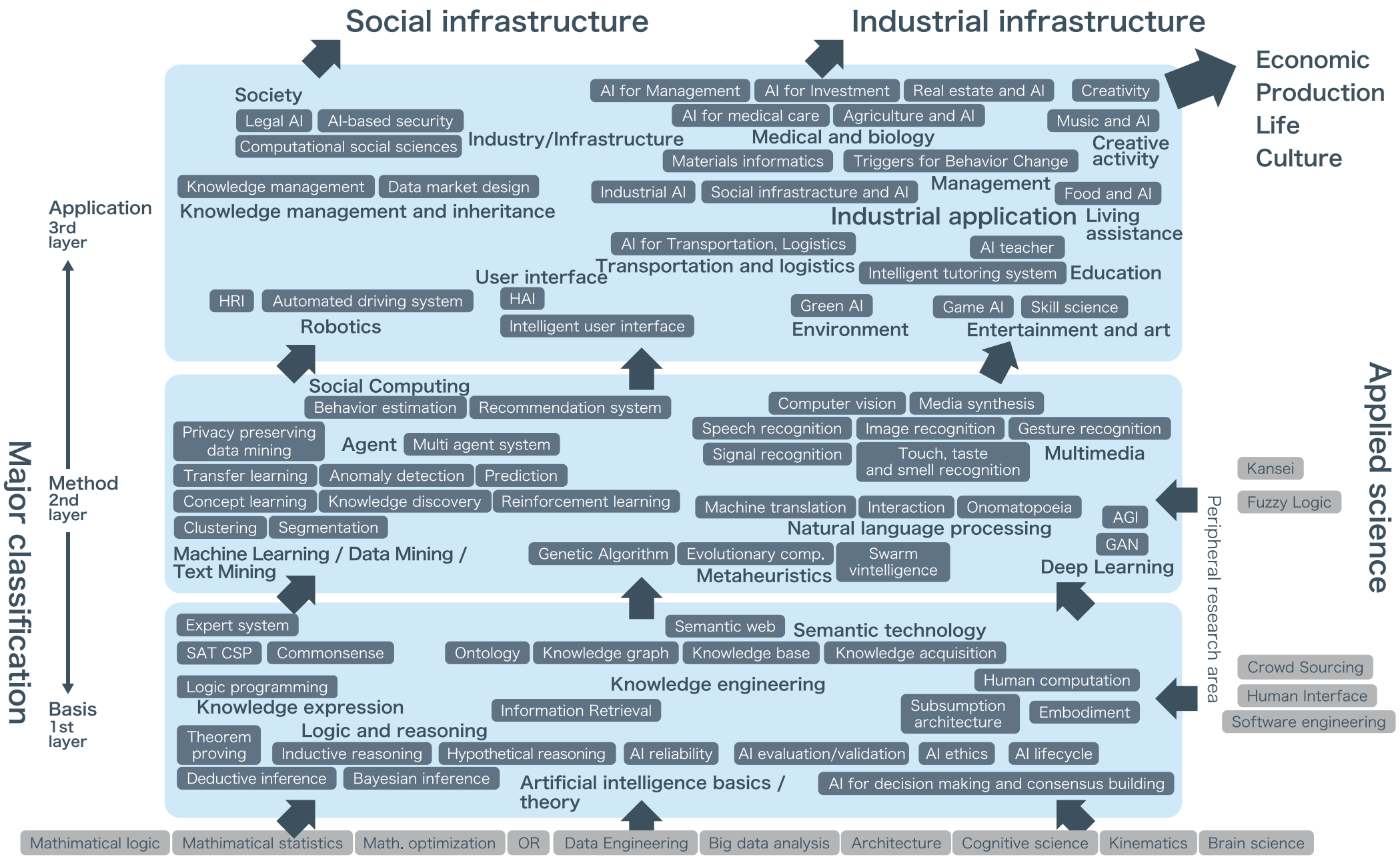
Map C shows how the roots and branches of AI research spread widely.

AI is built on many fundamental disciplines, including mathematics, statistics, logic, cognitive science, and neuroscience. Of course, it is impossible to master all these subjects before you start AI research. However, it may be useful to return to the basics before aiming to go beyond the horizon of current research. Along with reading the latest papers and comparing and evaluating the latest libraries on GitHub, it is also worthwhile spending time studying the fundamentals.

Map C shows the scope of AI applications, which is rapidly expanding. Applications will probably extend to every aspect of human society as practicability improves. As a starting point, the map shows the application areas that are now booming. For example, AI is used in various fields such as financial technology, medicine, real estate, music, and agriculture. In addition, as the applications expand, new technical issues and social issues are emerging, including ethics, credibility, and explainability. These are fed back as learning into the foundations of AI, and the large tree of AI research spreads further.







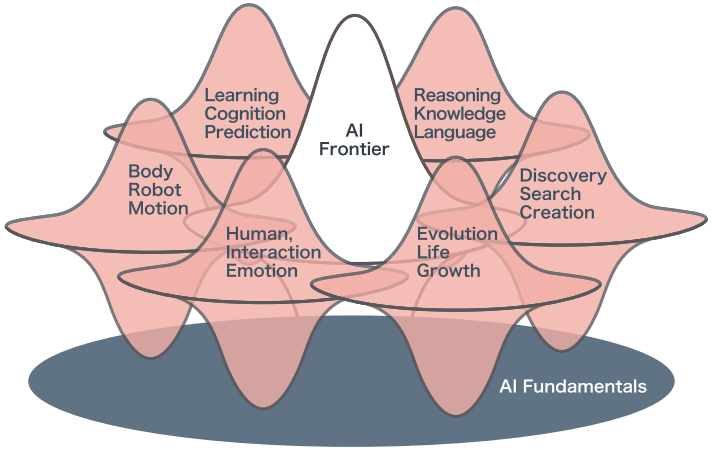
* An example of interpretation : Inductive inference is created based on probability / statistics and mathematical science, machine learning technology develops, prediction technology advances social infrastructure AI, and contributes to infrastructure maintenance, environmental conservation, and economic activity development

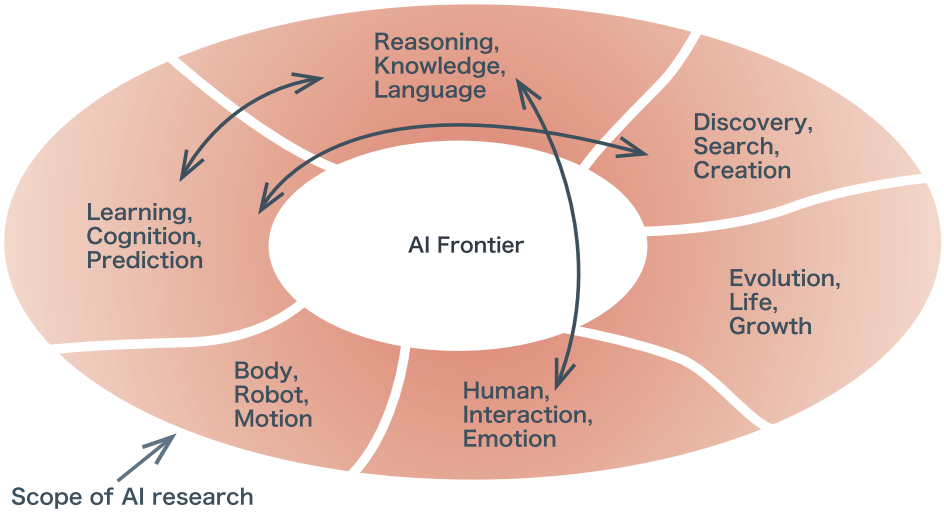
AI research is diverse
The vast frontier of AI

In AI research, there are various approaches for realizing mechanical intelligence. The ultimate goal of the “AI frontier” is the realization of intelligence comparable to or beyond that of humans and other living things, and its integration into society. In the surrounding area of the map, there are multiple viewpoints with different ways of thinking about intelligence that continue to be studied in depth, and each has made steady scientific and technological progress. Furthermore, AI research is related to many other research fields, and through close coordination with these other fields it can split from or fuse with other fields, opening up new horizons.

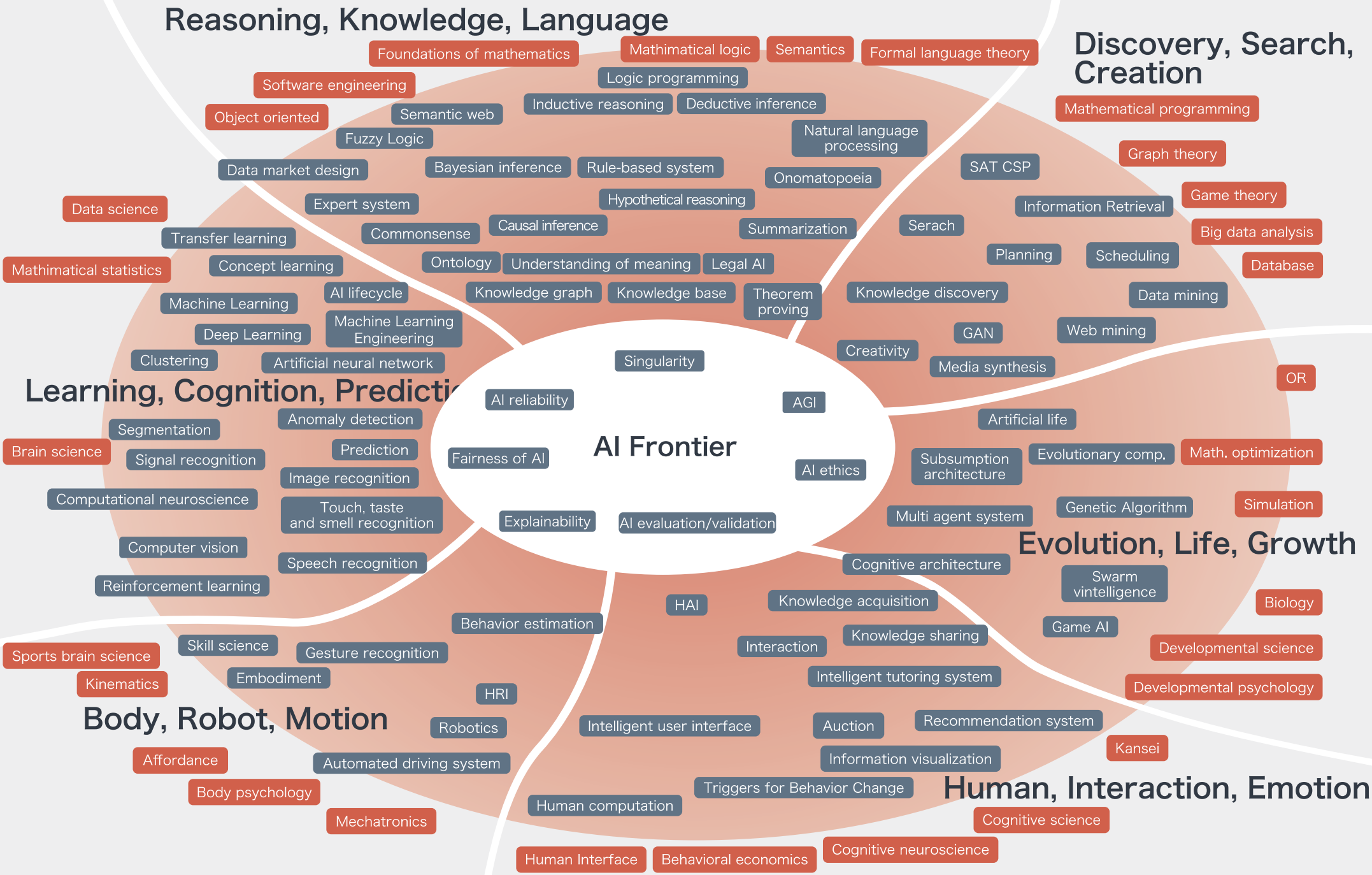
For example, in this map, the area of “reasoning, knowledge, and language” (also called “adult intelligence”) is shown in the upper right of “learning, recognition, and prediction” . Humans can use words, build and share knowledge, and make various inferences. Some of these processes are formalized in AI research and have theoretical explanations and practical applications. In this area, new technologies and research directions are being developed with data-driven approaches. In addition, research is beginning to show that language and reasoning influence recognition itself.

To keep the map in a single plane, two main adjacent areas were used. However, in practice, fusion with the opposite region across the AI frontier is also popular. For example, the relationship between “reasoning, knowledge, and language” and “human, interaction, and emotion” is deep, and “onomatopoeia” is a research field located between these two opposite fields. In addition, image generation using GAN which is an application of deep learning, is a fusion of “learning, recognition, and prediction” and “discovery, search, and creation” . Future AI research may have great potential for merging areas that do not have deep links.





AI research is developing in conjunction with a number of academic disciplines around it. The closer to the center, the more AI-specific or unresolved / undefined problems.



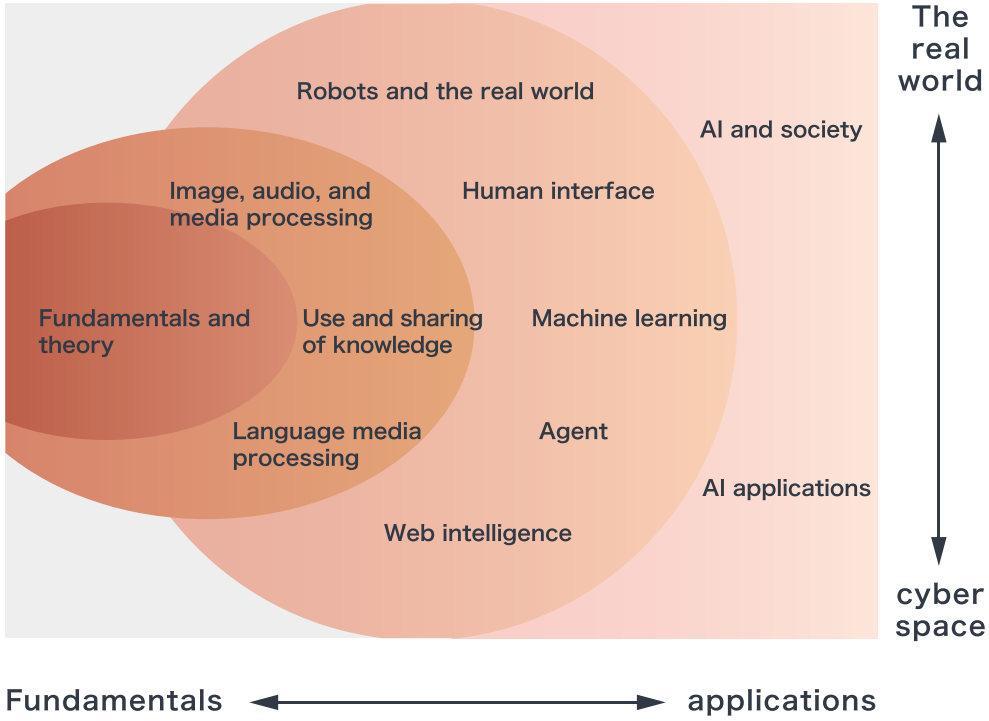
Current state of AI research

Map E was created by the Editorial Committee of the Transactions of the JSAI. The committee revised and added keywords that should be assigned to academic papers by the JSAI, based on keyword groups selected by the AI Map Task Force. The keyword groups are available for download in the “Guide to Writing Manuscripts” document on the JSAI website (URL below).
https://www.ai-gakkai.or.jp/en/published_books/transactions_of_jsai/toukou/

Furthermore, these keywords were divided into several groups and each group was given a classification name. As shown in the figure on the right, these classifications include “Fundamentals and Theory” and “Image, Audio, and Media Processing.” Because academic papers are at the cutting edge of current AI research, we selected keywords that were frequently used in papers published within the last 5 years, and the classification names were based on the current most active research fields.

Next, we placed the keywords according to two axes. The horizontal axis ranges from fundamentals on the left to applications on the right, whereas the vertical axis, ranges from cyberspace research at the bottom to real-world research at the top. Given that research fields do not necessarily define their research targets narrowly, the arrangement may not align with our intentions.

Consequently, this map is a prospective figure that more or less represents the current state of AI research.
In particular, the top and bottom five research fields centered on “Machine Learning” in the third circle from the left are highly active and a large number of papers have been published in these fields. Research on the impact of such research on society is on the right side, and the supporting research fields are on the left side. It is useful to have this type of overview of the current state of AI research.



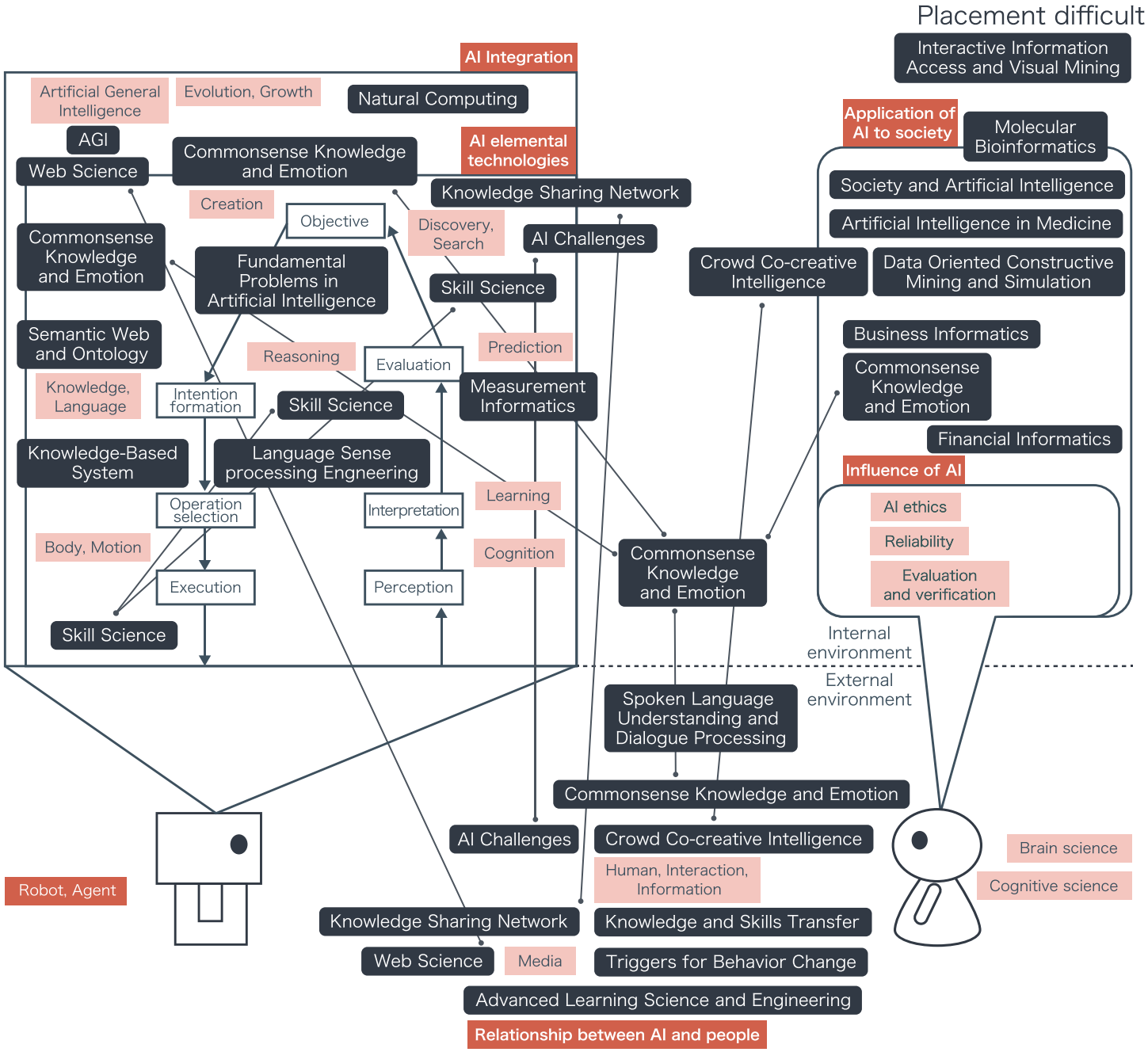

intelligent mechatronics
intelligent robots
human-robot interaction
intelligent robotics
cyber physical systems
embodiment
cognitive robotics
Robots and the real world
symbol emergence in robotics
AI ethics
AI fairness
AI and society
privacy
AI understandability
reliability of AI
Well-being C omputing
image generation
speech synthesis
image recognition
voice recognition
human-agent interaction
multimodal interaction
shikakeology
affordance
Human interface
kansei
human-computer interaction
Image, audio, and media processing
computer vision
acoustic signal processing
video image processing
multimodal processing
language and vision
generative model
VR
skill science
action estimation
Behavior modification
information visualization
intelligent user interface
cognitive science
fuzzy logic
symbol grounding problem
Bayesian estimation
computational neuroscience / brain science
OR
search / logic / inference algorithm
rule-based systems
knowledge sharing / management
knowledge acquisition / discovery
adversarial learning
pattern recognition
transfer learning
semi-supervised learning
AI life-style
behavioral economics
Fundamentals and theory
Use and sharing of knowledge
deep learning
neural network
computational learning theory
data science
cognitive architecture
heuristics
production systems
knowledge representation
sparse modeling
Machine learning
social problem application
constraints satisfaction problem / satisfiability testing (CSP/SAT)
knowledge base
data mining
concept learning
clustering
Web intelligence
subsumption architecture
planning
expert system
knowledge graph
ontology
information-based learning theory
error detection
social infrastructure applications
artificial general intelligence (AGI)
scheduling
representation learning (embedding)
statistical learning
evolution calculation
bioinformatics
machine translation
reinforcement learning
genetic algorithm
dialogue processing / dialogue
AI applications
graph theory
morphological analysis
swarm intelligence
medical / healthcare application
morphological analysis
summarization
non-task oriented dialogue
distributed coordination
multi-agent system
materials informatics
syntax analysis
Language media processing
game theory
Agent
simulation
academic application
educational applications
understanding of meaning (word-sense disambiguation / resolution)
text mining
decision making / consensus
market design
auction
industrial application
conversation / discourse / intention understanding
onomatopoeia
collective intelligence
management applications
semantic Web
cloud sourcing / human computation
art / entertainment applications
Web intelligence
social media
information retrieval
information recommendation
web interaction

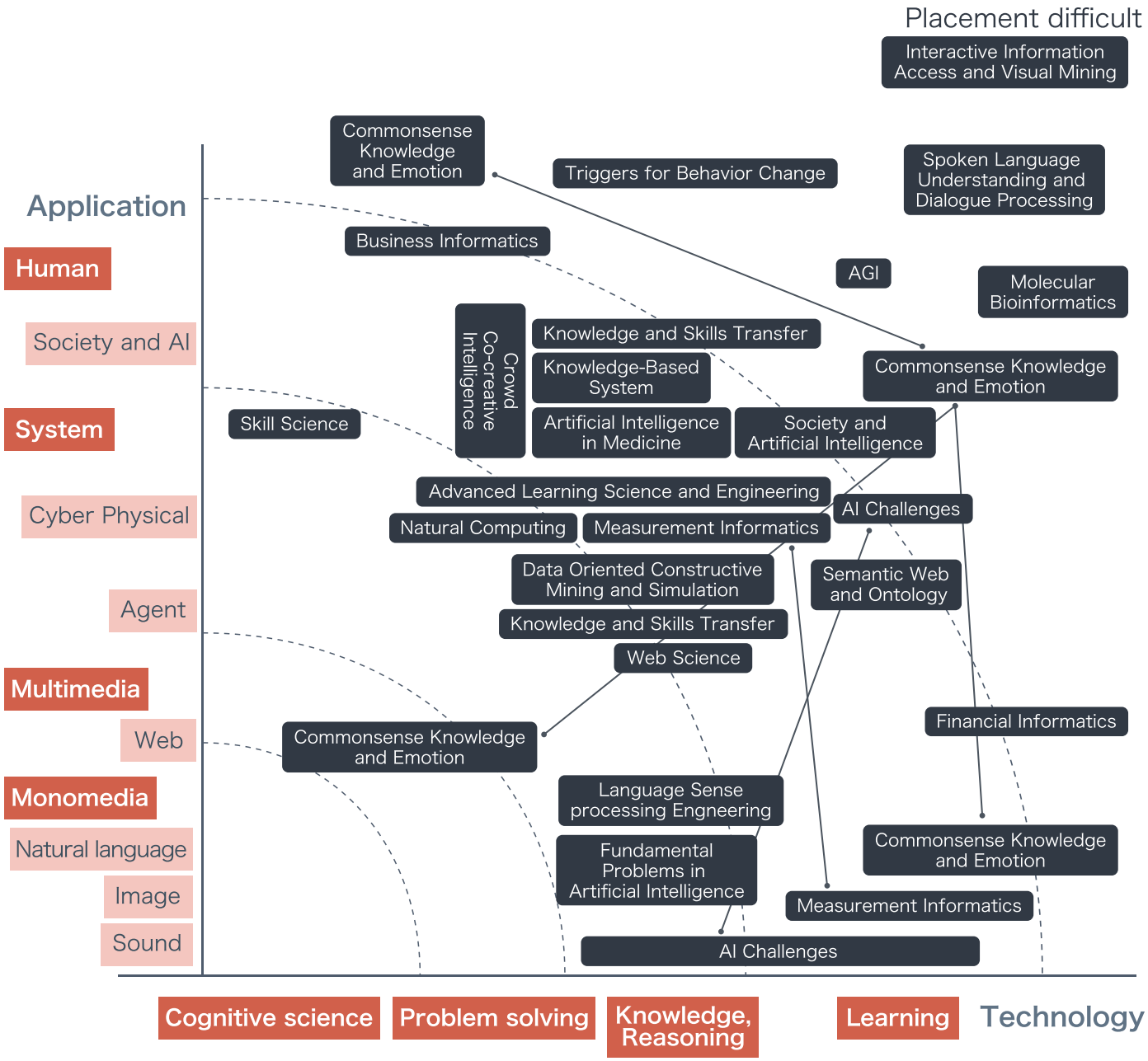
Map of special interest groups

There are 24 special interest groups (SIGs) in the Japanese Society for Artificial Intelligence (JSAI). The following website provides information on SIGs.
https://www.ai-gakkai.or.jp/sig/sig-list/

For beginners and interdisciplinary researchers who are interested in AI research, active participation in SIGs is desirable for obtaining up-to-date research information and making contact with front-line researchers.

However, it is difficult to link the names of groups, titles of papers, and users' interests. Therefore, we have created maps of the groups that overlap with AI Map, beta version to encourage participation.





However, it is difficult to link the names of groups, titles of papers, and users' interests. Therefore, we have created maps of the groups that overlap with AI Map, beta version to encourage participation.

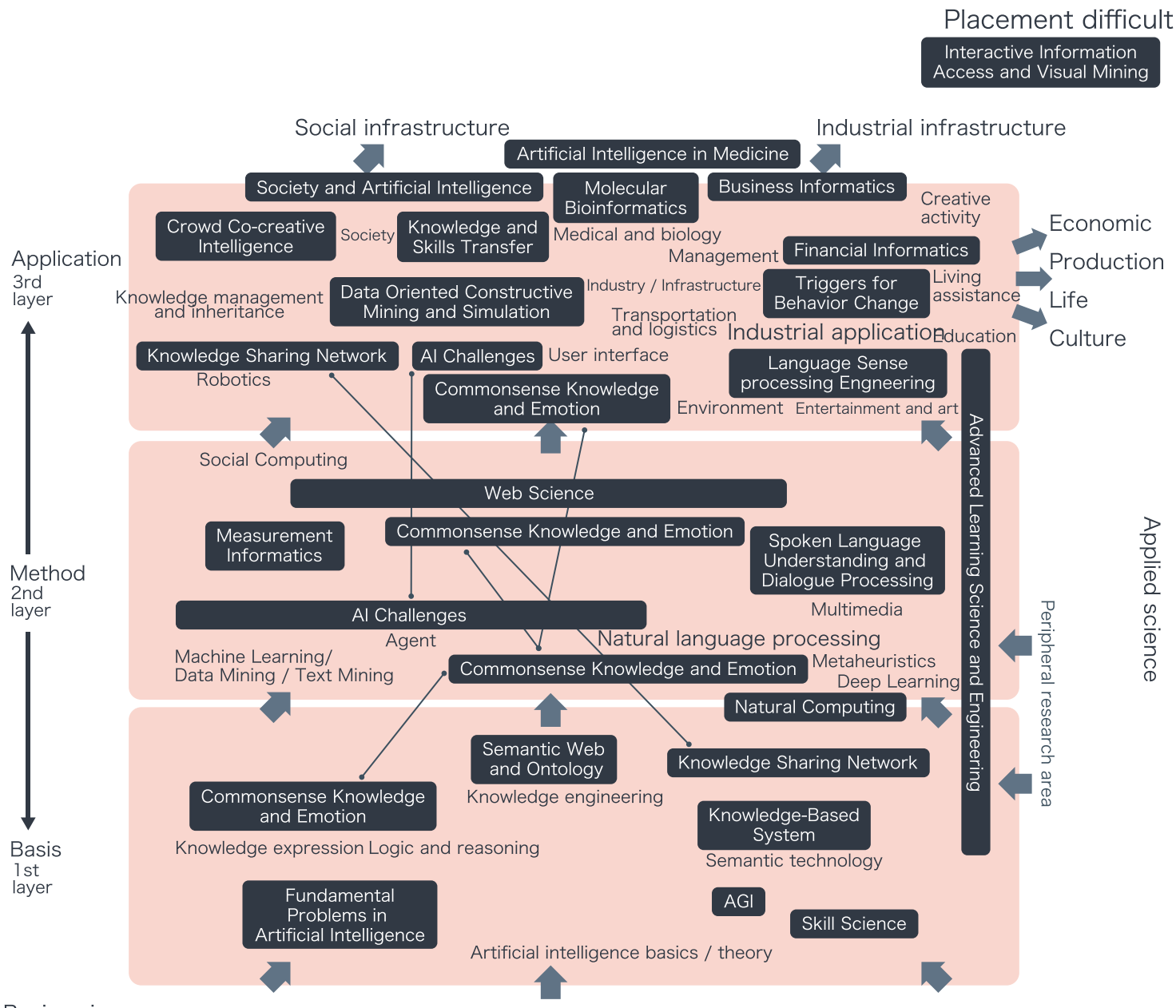
The four SIG maps shown here were created based on the results of a questionnaire answered by the leaders of each group. The maps are arranged to ensure maximum visibility.

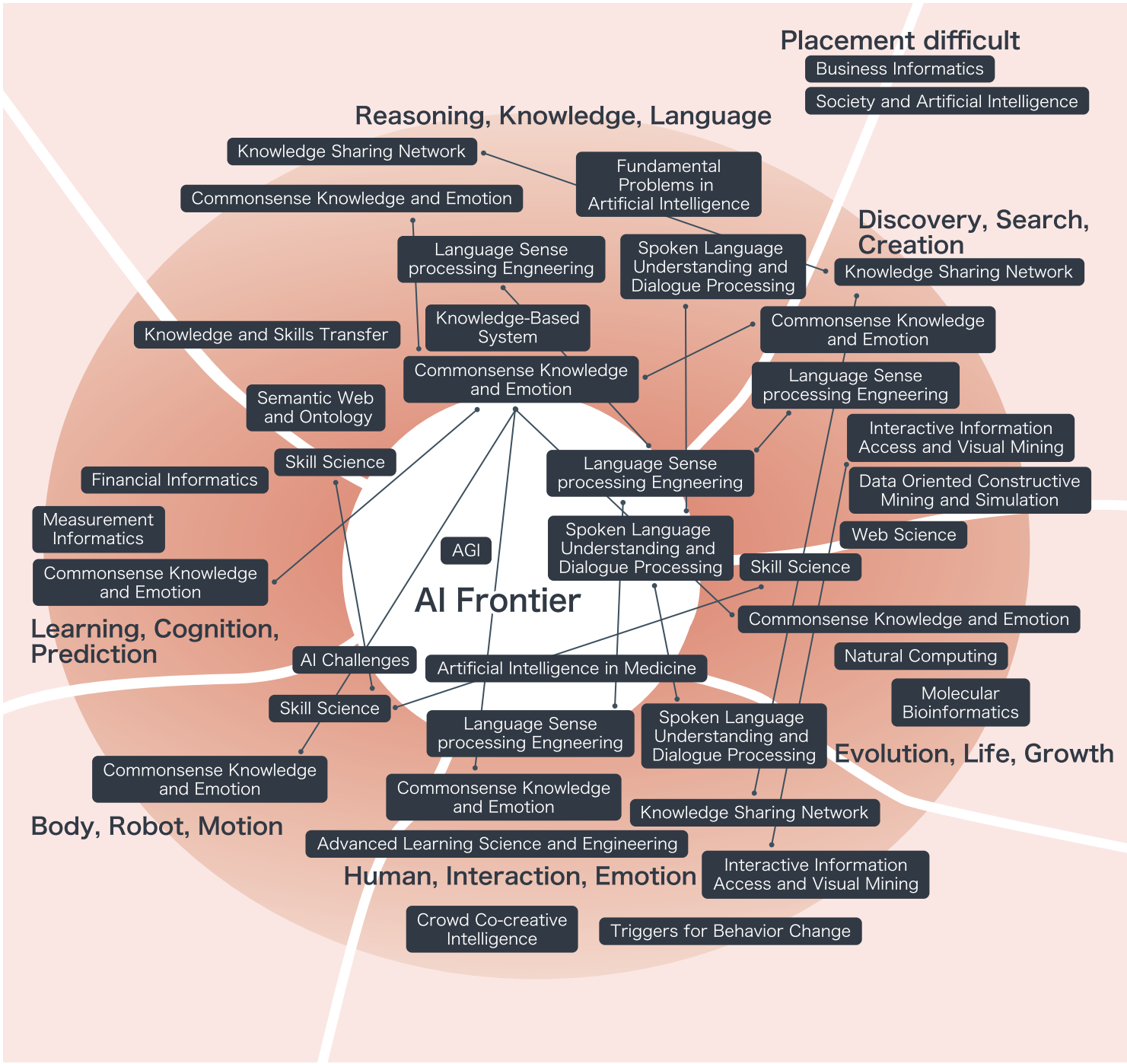
There were several groups that were difficult to place on a specific map because of their diverse scope, so we have placed them outside of the maps. In addition, some groups are combining or simultaneously handling distant areas on the map. We have shown the spread of the target area by connecting areas with a line or vertically and horizontally.

These maps show the areas where research groups are concentrated, and the similarities between groups.

The JSAI holds joint research meetings of the SIGs once a year. Joining neighboring groups on the map will allow researchers to grasp the latest research trends in related areas quickly.

In addition, the areas in which the groups are concentrated on the map are likely to be hot topics in AI research and will highlight current research trends.





List of SIGs

AGI :	Artificial General Intelligence
AIMED :	Artificial Intelligence in Medicine
ALST :	Advanced Learning Science and Engineering
AM :	Interactive Information Access and Visual Mining
BI :	Business Informatics
CCI :	Crowd Co-creative Intelligence
Challenge :	AI Challenges
CKE :	Commonsense Knowledge and Emotion
DOCMAS :	Data Oriented Constructive Mining and Simulation
FIN :	Financial Informatics
FPAI :	Fundamental Problems in Artificial Intelligence
KBS :	Knowledge-Based System
KSN :	Knowledge Sharing Network
KST :	Knowledge and Skills Transfer
LSE :	Language Sense processing Engneering
MBI :	Molecular Bioinformatics
MEI :	Measurement Informatics
NAC :	Natural Computing
SAI :	Society and Artificial Intelligence
SKL :	Skill Science
SLUD :	Spoken Language Understanding and Dialogue Processing
SWO :	Semantic Web and Ontology
TBC :	Triggers for Behavior Change
WebSci :	Web Science

Miraikan -The National Museum of Emerging Science and Innovation

“AI Map : From Everyone, for Everyone”

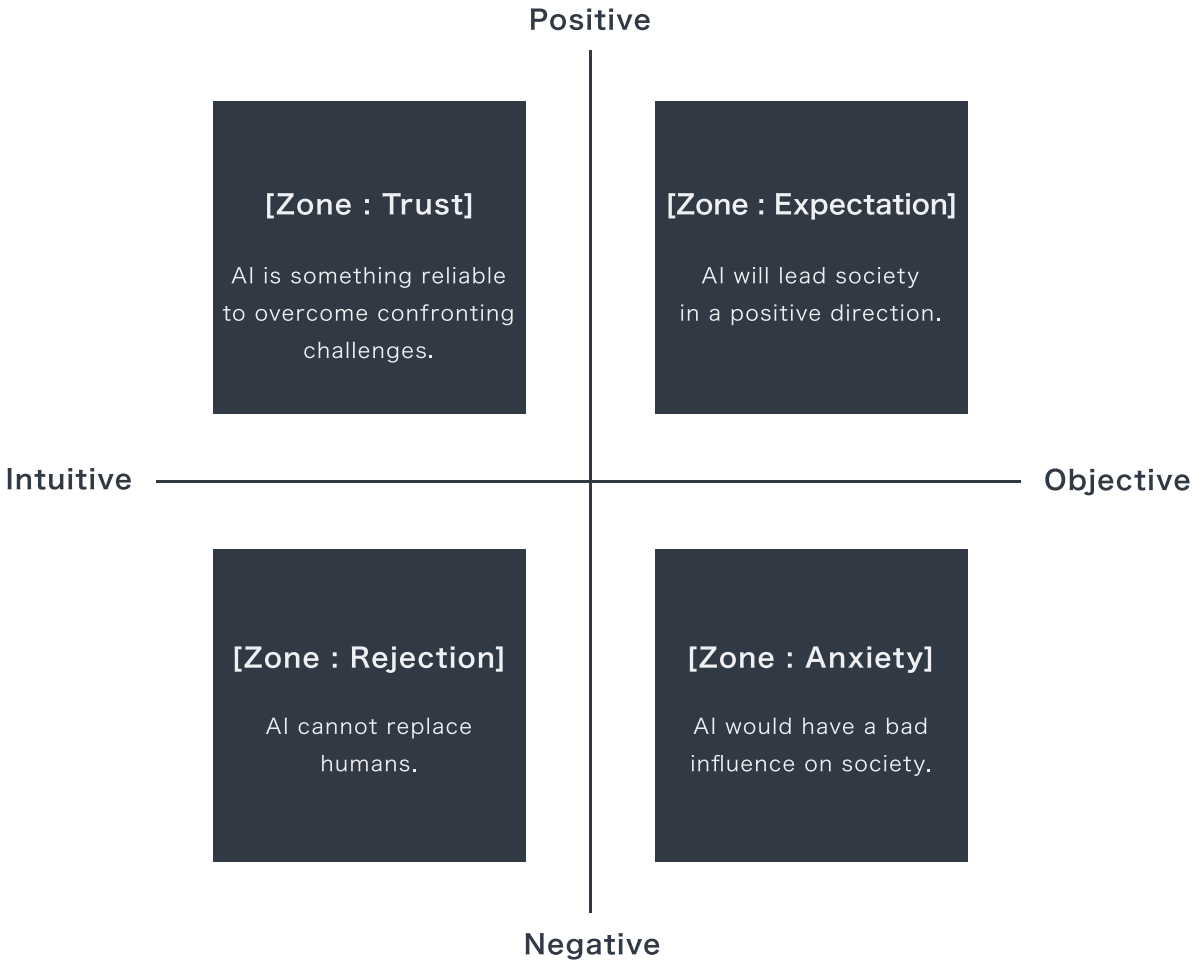
› https://www.miraikan.jst.go.jp/en/resources/provision/aimap/

What Citizens Truly Feel Toward AI

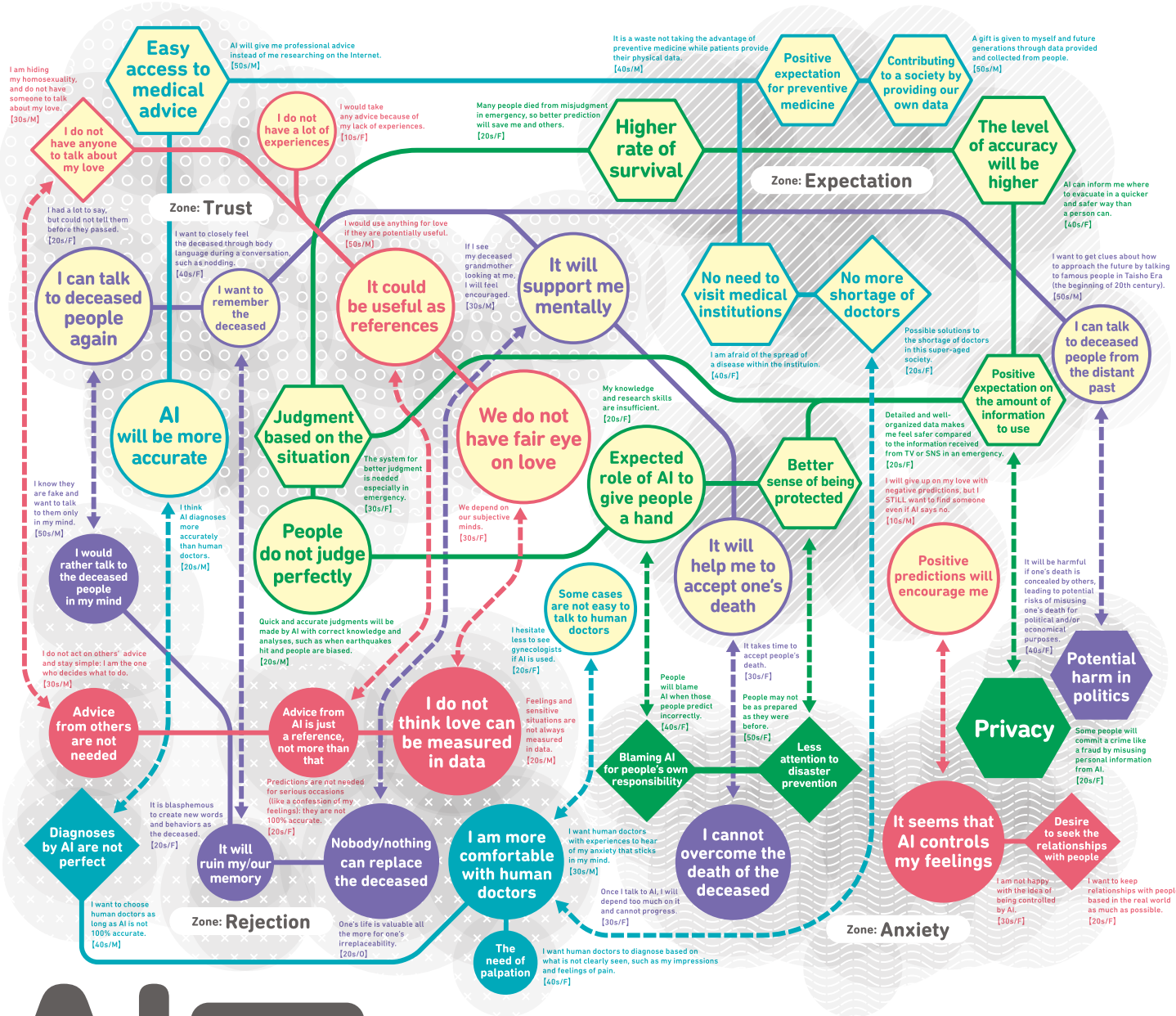
Once AI technology makes serious inroads into society, people are more likely to interact and contact with that technology on daily basis. Therefore, AI development along with acknowledging users’ attitudes and true feelings, will be needed even more seriously. Responding to this growing demand, Miraikan designed a map, “AI Map: From Everyone, for Everyone” based on a survey that was delivered to 900 people. Here, the goal was to present and visualize citizens’ responses toward AI as a society.
The survey showed interesting results, such as the fact that their attitudes can be interpreted in four categories of emotions. In addition, we discovered how diverse and complex citizens felt toward AI.

Through making this AI Map, Miraikan designed survey questions to make citizens imagine possible lifestyle where AI was already a part of their everyday life. We then asked respondents their intentions and reasons for using AI technology at specific scenes, described in the survey. The survey results were visualized as a map shown on the next page. A total of four types of emotions are arranged on the map; on the left, two types of emotions are shown — “Trust” and “Rejection” over resolving the latest social challenges. On the right, other two types are shown— “Expectation” and “Anxiety” over a future society in which AI is familiar to citizens. This method was to illustrate the relationships between the obtained opinions. Here, four scenes in everyday life were selected: “Medical Care” and “Disaster Prevention,” that had a large number of consenting opinions, and “Love” and “Digital Cloning,” which positive and negative opinions were equally seen.

As an overall trend, a large number of citizens were interested in and approved of AI that contributes to resolving social challenges. At the same time, opinions were split toward AI when it closely relates to individuals’ preferences, perceptions and moral values. Pay close attention to adversarial relationships of opinions, represented by the dotted lines. People accept AI, through their reflections on comparisons with one’ s physical abilities and their challenges. This deeply connects to disparities in how people view others, leading conflicts in opinions. In order to foster social implementation of AI technology, and to enhance technological understanding, communication plays an important role to closely reflect on people’ s true feelings.



* The following page shows a scaled-down version of the actual map.
The actual map is 25cm x 35.3cm and is printed on the final page of this pamphlet.



AI Map

From Everyone, for Everyone

Legend

Negative | Positive

Proximity relationship

Adversary relationship

Persuit of one's happiness

Adjustment of individuals and society

Change of social system

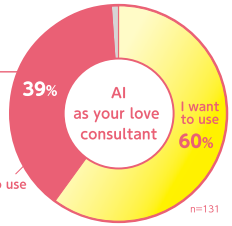
Note: Demographic characteristics of participants are shown as 【age/gender】after their opinions. Gender is shown as M(Male), F(Female) and O(Other).

How to view this map

1. Choose 1 topic from "Love", "Medical care", "Disaster prevention" and "Digital cloning of the deceased".
2. Find a word or phrase that may interest you, based on the colors of four categories.
3. Follow the lines and see other's opinions that may be similar to or different from yours.

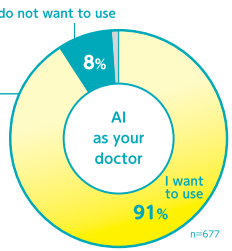
Love

Do you want to use AI that tells you how likely your confession of love will be accepted?



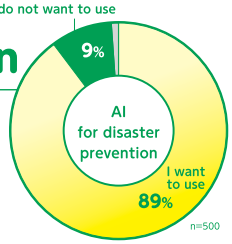
Medical Care

Do you want to use AI that checks your physical condition instead of human doctors?



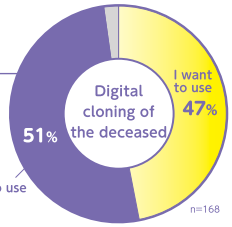
Disaster Prevention

Do you want to use AI that predicts and suggests the most appropriate and safest way to evacuate?



Digital Cloning

Do you want to use AI that faithfully copies the behaviors and words of the deceased?



Project "AI Map: From Everyone, for Everyone"
https://www.miraikan.jst.go.jp/en/resources/provision/aimap/

"AI Map: From Everyone, for Everyone" was created based on the Japanese opinions from online surveys and surveys on the exhibition floor (Valid data: 887) on February 2020 at Miraikan. The above pie charts are pros/cons of AI in four scenes in one's life. The left charts illustrate the reasons.

Miraikan

Production: Miraikan - the National Museum of Emerging Science and Innovation / Miraikan Focus Project Team (Fumiya Urushibata, Yoshiyasu Watanabe, Ryu Miyata, Ayuko Sakurai, Atsushi Ozawa and Mizuki Kawano)
Cooperation: The Japanese Society for Artificial Intelligence
Design: Takashi Tokuma (bowlgraphics Inc.)

We have a favor to ask of you.

To create a more refined map

In the process of creating this AI map, we had to abandon many of the things we wanted to include due to resource limitations.
We also omitted important information on research and application as follows because we prioritized presenting the overall view of these issues. However, all of these fields are hoped for further development in future.
First, in the application of AI technology, it is very important to strike a balance between cost and benefit. For example, even if a highly accurate prediction engine can be created, it cannot be applied if the cost of collecting data, training, and maintenance is too high. Although the balance between cost and benefit is changing, information for determining an appropriate balance would be very valuable.
When we enter the application stage, we may encounter many technical problems such as overfitting, parameter tuning, data cleansing, unstable output, and slow convergence. Well organized information on such issues should prove very useful.
Next, we should point out that the AI problems map itself is incomplete. There is little precedent for mapping out issues in AI research field with various abstract terms. Accordingly, the problem cards have room for improvement in terms of granularity and coverage. In the future, we expect that hackathons will be held in which the AI problems map will be used and that shortcomings and problems will be revealed and addressed, leading to further refinement of the map.
We expect that the AI Mapβ 2.0 will be of great benefit, from AI research to practical application. Accordingly, we hope that it will be used as not only for this pamphlet but also as data for practical solutions. To that end, we have prepared the problem card in tabular format data and AI technology map in CSV data format, and are planning to release them for public use.
We are also considering to continue our activity to realize the interactive map that we proposed in 2019. The map is web content where the user can interactively search for target issues within the map for R&D purposes. We are looking forward to your continued support.

Join JSAI (Japanese society for Artificial Intelligence)

This AI Mapβ 2.0 was created as part of the activities of the JSAI. If you are interested in this map, please consider joining JSAI. Members have access to useful information, including journals featuring articles on the latest AI research and applications. In addition, members can contribute to the Annual Conference, workshops, and the academic journal. Discounts for seminars and other events are also available. The membership application can be found online (URL below).
https://www.ai-gakkai.or.jp/about/membership/

We are recruiting people to make maps.

In addition to the proposed additional maps shown earlier, each AI researcher may have ideas for maps based on his or her own perspective as well as maps related to his or her research field. Also, for each research group, it may be possible to create a map showing the research trends in their respective fields as well as tutorials for novice researchers.

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The members of the Leader, Secretary of JSAI SIGs

Pamphlet production: Apricot Design
https://apricot-design.com/

Contact information on AI Map:
info [at] ai-gakkai.or.jp (Convert [at] to @)

Date of issue: September 1, 2021

AI Map

From Everyone, for Everyone

Zone: Trust

Zone: Expectation

Zone: Rejection

Zone: Anxiety

Easy access to medical advice

AI will give me professional advice instead of me researching on the Internet. 【50s/M】

I am hiding my homosexuality, and do not have someone to talk about my love. 【30s/M】

I do not have anyone to talk about my love

I do not have a lot of experiences

I would take any advice because of my lack of experiences. 【10s/F】

I had a lot to say, but could not tell them before they passed. 【20s/F】

I can talk to deceased people again

I want to closely feel the deceased through body language during a conversation, such as nodding. 【40s/F】

I want to remember the deceased

I would use anything for love if they are potentially useful. 【50s/M】

It could be useful as references

If I see my deceased grandmother looking at me, I will feel encouraged. 【30s/M】

It will support me mentally

Many people died from misjudgment in emergency, so better prediction will save me and others. 【20s/F】

Higher rate of survival

It is a waste not taking the advantage of preventive medicine while patients provide their physical data. 【40s/M】

Positive expectation for preventive medicine

Contributing to a society by providing our own data

A gift is given to myself and future generations through data provided and collected from people. 【50s/M】

The level of accuracy will be higher

AI can inform me where to evacuate in a quicker and safer way than a person can. 【40s/F】

I want to get clues about how to approach the future by talking to famous people in Taisho Era (the beginning of 20th century). 【50s/M】

I can talk to deceased people from the distant past

No need to visit medical institutions

I am afraid of the spread of a disease within the institution. 【40s/F】

No more shortage of doctors

Possible solutions to the shortage of doctors in this super-aged society. 【20s/F】

Positive expectation on the amount of information to use

Detailed and well-organized data makes me feel safer compared to the information received from TV or SNS in an emergency. 【20s/F】

I will give up on my love with negative predictions, but I STILL want to find someone even if AI says no. 【10s/M】

Positive predictions will encourage me

It will be harmful if one's death is concealed by others, leading to potential risks of misusing one's death for political and/or economical purposes. 【40s/F】

Potential harm in politics

Privacy

Some people will commit a crime like a fraud by misusing personal information from AI. 【20s/F】

Desire to seek the relationships with people

I want to keep relationships with people based in the real world as much as possible. 【20s/F】

I am not happy with the idea of being controlled by AI. 【30s/F】

It seems that AI controls my feelings

AI will be more accurate

I know they are fake and want to talk to them only in my mind. 【50s/M】

I would rather talk to the deceased people in my mind

I think AI diagnoses more accurately than human doctors. 【20s/M】

Judgment based on the situation

The system for better judgment is needed especially in emergency. 【30s/F】

People do not judge perfectly

Quick and accurate judgments will be made by AI with correct knowledge and analyses, such as when earthquakes hit and people are biased. 【20s/M】

We do not have fair eye on love

We depend on our subjective minds. 【30s/F】

My knowledge and research skills are insufficient. 【20s/F】

Expected role of AI to give people a hand

Better sense of being protected

It will help me to accept one's death

It takes time to accept people's death. 【30s/F】

People may not be as prepared as they were before. 【50s/F】

Some cases are not easy to talk to human doctors

I hesitate less to see gynecologists if AI is used. 【20s/F】

People will blame AI when those people predict incorrectly. 【40s/F】

Blaming AI for people's own responsibility

Less attention to disaster prevention

I do not think love can be measured in data

Feelings and sensitive situations are not always measured in data. 【20s/M】

Advice from AI is just a reference, not more than that

Predictions are not needed for serious occasions (like a confession of my feelings): they are not 100% accurate. 【20s/F】

Advice from others are not needed

I do not act on others' advice and stay simple: I am the one who decides what to do. 【30s/M】

Diagnoses by AI are not perfect

I want to choose human doctors as long as AI is not 100% accurate. 【40s/M】

It is blasphemous to create new words and behaviors as the deceased. 【20s/F】

It will ruin my/our memory

Nobody/nothing can replace the deceased

One's life is valuable all the more for one's irreplaceability. 【20s/O】

I am more comfortable with human doctors

I want human doctors with experiences to hear of my anxiety that sticks in my mind. 【30s/M】

Once I talk to AI, I will depend too much on it and cannot progress. 【30s/F】

I cannot overcome the death of the deceased

The need of palpation

I want human doctors to diagnose based on what is not clearly seen, such as my impressions and feelings of pain. 【40s/F】

Legend

Negative | Positive

Proximity relationship

Adversary relationship

Persuit of one's happiness

Adjustment of individuals and society

Change of social system

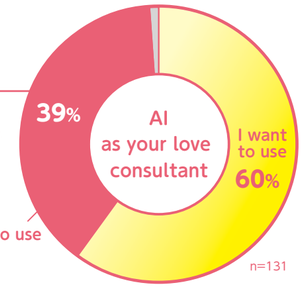
Note: Demographic characteristics of participants are shown as 【age/gender】after their opinions. Gender is shown as M(Male), F(Female) and O(Other).

How to view this map

1. Choose 1 topic from "Love", "Medical care", "Disaster prevention" and "Digital cloning of the deceased".
2. Find a word or phrase that may interest you, based on the colors of four categories.
3. Follow the lines and see other's opinions that may be similar to or different from yours.

Love

Do you want to use AI that tells you how likely your confession of love will be accepted?



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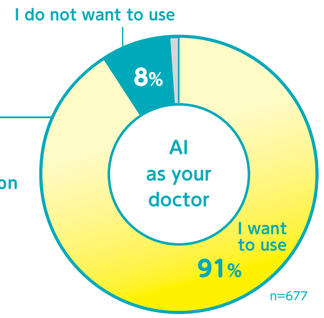

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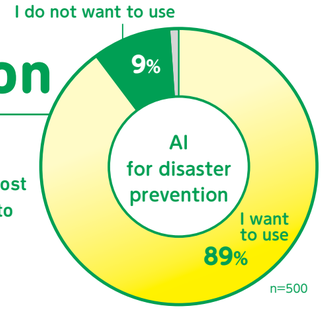

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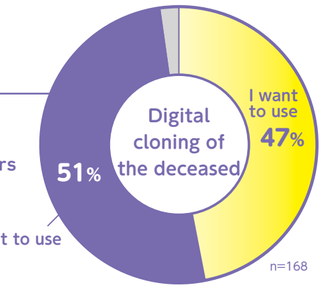

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Cooperation: The Japanese Society for Artificial Intelligence
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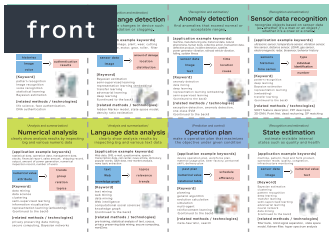
How to make problem cards

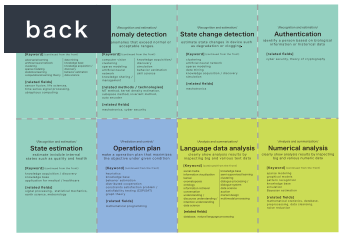
\STEP1/

Make a double-sided print on a A4 sheet in landscape.

front

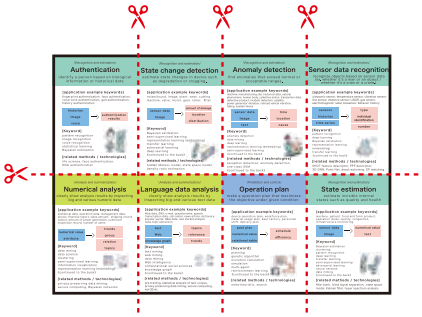


back

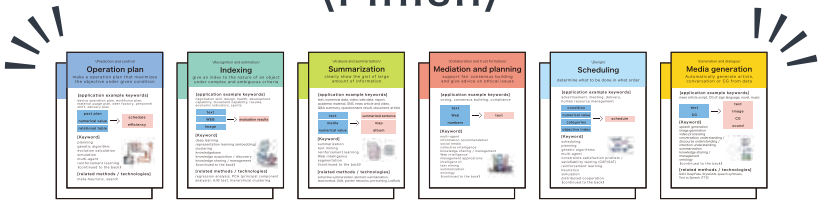


\STEP2/

Cut along dotted lines.



\Finish/



\Prediction and control/

Numerical prediction

predict numerical values in the near future

[application example keywords]

energy consumption, prices, train delays, hospital waiting times, traffic jam forecasts, electricity demand forecasts, weather forecasts

numerical value
text
→ predicted value

[Keyword]

statistical learning
deep learning
neural network
sparse modeling
knowledge acquisition / discovery
simulation
market design
multi-agent
《continued to the back》

[related methods / technologies]

regression analysis, RNN, LSTM, Kalman filter, state space model, statistical time series model (ARIMA / SARIMA), data assimilation

\Prediction and control/

Probability prediction

predict the probability of the near future event

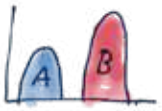
[application example keywords]

market size, delivery probability, congestion rate, behavior model, weather forecast

numerical value
text
→ probability

[Keyword]

statistical learning
state space model
graphical model
deep learning
neural network
sparse modeling
knowledge acquisition / discovery
simulation
《continued to the back》



[related methods / technologies]

Bayesian network, data assimilation

\Prediction and control/

Predicted candidate presentation

present diverse possibilities in the future

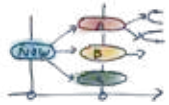
[application example keywords]

typhoon outbreak location,new services / markets, regional economy, location of failure

numerical value
text
→ candidates
scenario

[Keyword]

Bayesian estimation
semi-supervised learning
neural network
knowledge acquisition / discovery
auction
market design
Web intelligence
behavior estimation
《continued to the back》



[related methods / technologies]

simulation, scenario planning

\Prediction and control/

Operation and control

move devices automatically according to the purpose

[application example keywords]

automobile, heavy machinery, airplane, machinetool, agricultural machinery, ship, traffic light, plant, forklift

Image
sensor
manual input
→ control value

[Keyword]

simulation
multi-agent
reinforcement learning
deep learning
semi-supervised learning
neural network
《continued to the back》

[related methods / technologies]

cloud robotics, probabilistic robotics

\Prediction and control/

Probability prediction

predict the probability
of the near future event

[Keyword] (continued from the front)

market design
multi-agent
Bayesian estimation
decision making / consensus building
fuzzy logic

[related fields]

earth science, meteorology,
control engineering

\Prediction and control/

Numerical prediction

predict numerical values
in the near future

[Keyword] (continued from the front)

Bayesian estimation
decision making / consensus building
fuzzy logic

[related fields]

earth science, meteorology,
control engineering

\Prediction and control/

Operation and control

move devices automatically
according to the purpose

[Keyword] (continued from the front)

HRI
behavior estimation
swarm intelligence
distributed coordination
symbol emergence
in robotics
intelligent mechatronics
intelligent robots
intelligent robotics
cognitive robotics
embodiment
subsumption architecture
constraints satisfaction
problem / satisfiability
testing (CSP/SAT)
planning
fuzzy logic
ontology

[related fields]

control engineering robotics

\Prediction and control/

Predicted candidate presentation

present diverse possibilities in the future

[Keyword] (continued from the front)

multi-agent
decision making / consensus building
graphical model

[related fields]

earth science, meteorology

\Recognition and estimation/

Authentication

identify a person based on biological information or historical data

[application example keywords]

fingerprint authentication, face authentication, vocal cord authentication, gait authentication, history authentication

histories, Image, voice → authentication results

[Keyword]

pattern recognition
Image recognition
voice recognition
statistical learning
Bayesian estimation

[related methods / technologies]

life science, face authentication, DNA authentication

\Recognition and estimation/

State change detection

estimate state changes in device such as degradation or clogging.

[application example keywords]

noise/sound, image, plant, wear, cutting machine, valve, motor, gear, roller, filter

sensor data, Image → amount of damage, location, distribution

[Keyword]

Bayesian estimation
semi-supervised learning
representation learning (embedding)
transfer learning
adversarial learning
deep learning
《continued to the back》

[related methods / technologies]

hidden Markov model, state space model, density ratio estimation

\Recognition and estimation/

Anomaly detection

find anomalies that exceed normal or acceptable ranges.

[application example keywords]

machine, manufacturing site, historical data, natural phenomena, human body, collective action, transaction data, defective product, incident detection, satellite, power generator vibration, railroad vehicle vibration, falling, sudden illness

sensor data, Image, text → time, location, cause

[Keyword]

anomaly detection
data mining
deep learning
representation learning (embedding)
semi-supervised learning
《continued to the back》

[related methods / technologies]

exception detection, anomaly detection, one-class SVM
《continued to the back》

\Recognition and estimation/

Sensor data recognition

recognize objects based on sensor data (ex. whether it's a man or an object / whether it's a craw or a crane.)

[application example keywords]

ultrasonic sensor, temperature sensor, vibration sensor, line sensor, distance sensor, LIDAR, gas sensor, electromagnetic radar, biosensor, behavior history

sensors, histories, time series → type, individual identification, number

[Keyword]

pattern recognition
deep learning
Bayesian estimation
representation learning (embedding)
transfer learning
《continued to the back》

[related methods / technologies]

SHOT feature descriptor, PPF descriptor, 3D-DNN, Point Net, dead reckoning, DP matching

\Analysis and summarization/

Numerical analysis

clearly show analysis results by inspecting big and various numeric data

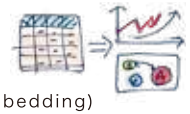
[application example keywords]

statistical data, operation data, management data, stocks, financial report, sales amount, shipping record, output, amount of power generation, numerical inspection record, number of users

numerical value, attribute → trends, group, relation, topics

[Keyword]

data mining
data science
clustering
semi-supervised learning
information visualization
representation learning (enbedding)
《continued to the back》



[related methods / technologies]

privacy preserving data mining, secure computing, Bayesian networks

\Analysis and summarization/

Language data analysis

clearly show analysis results by inspecting big and various text data

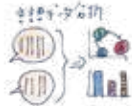
[application example keywords]

Web data, SNS, e-mail, questionnaire, speech transcription data, call center, news article, dictionary, popular words, Q&A data, new market analysis, news topic extraction

text, Web, knowledge graph → topics, relevance, trends

[Keyword]

text mining
web mining
data mining
Web intelligence
computational social sciences
knowledge graph
《continued to the back》



[related methods / technologies]

pre-training, statistical analysis of text, corpus, privacy preserving data mining, secure computing, word2vec

\Prediction and control/

Operation plan

make a operation plan that maximizes the objective under given condition

[application example keywords]

device operation plan, workforce plan, material usage plan, beer factory, personnel shift, delivery plan

past plan, numerical value, relational table → schedule, efficiency

[Keyword]

planning
genetic algorithm
evolution calculation
simulation
multi-agent
reinforcement learning
《continued to the back》

[related methods / technologies]

meta-heuristic, search

\Recognition and estimation/

State estimation

estimate invisible internal states such as quality and health

[application example keywords]

machine, patient, food and farm product, operation mode, quality, congestion, infrastructure monitoring

sensor data, Image → numerical value, text

[Keyword]

Bayesian estimation
clustering
pattern recognition
deep learning
transfer learning
semi-supervised learning
adversarial learning
neural network
data mining
《continued to the back》

[related methods / technologies]

filter bank, blind signal separation, state space model, Kalman filter, hyper spectrum analysis

\Recognition and estimation/

Sensor data recognition

recognize objects based on sensor data (ex. whether it's a man or an object / whether it's a craw or a crane.)

[Keyword] (continued from the front)

adversarial learning
artificial neural network
clustering
sparse modeling
statistical learning
computational learning theory
data mining
knowledge base
knowledge acquisition / discovery
behavior estimation
data science

[related fields]
sensor fusion, life sciences, time series signal processing, ubiquitous computing

\Recognition and estimation/

Anomaly detection

find anomalies that exceed normal or acceptable ranges.

[Keyword] (continued from the front)

computer vision
clustering
sparse modeling
artificial neural network
knowledge sharing / management
knowledge acquisition/ discovery
simulation
behavior estimation
skill science

[related methods / technologies]
MT method, kernel density estimation, subspace method, invariant method, auto encoder

[related fields]
mechatronics, cyber security

\Recognition and estimation/

State change detection

estimate state changes in device such as degradation or clogging.

[Keyword] (continued from the front)

clustering
artificial neural network
sparse modeling
data mining
knowledge acquisition / discovery
simulation

[related fields]
mechatronics

\Recognition and estimation/

Authentication

identify a person based on biological information or historical data

[related fields]
cyber security, theory of cryptography

\Recognition and estimation/

State estimation

estimate invisible internal states such as quality and health

[Keyword] (continued from the front)

knowledge acquisition / discovery
knowledge base
application for medical / healthcare

[related fields]
signal processing, statistical mechanics, earth science, meteorology

\Prediction and control/

Operation plan

make a operation plan that maximizes the objective under given condition

[Keyword] (continued from the front)

heuristics
knowledge base
behavior estimation
distributed cooperation
constraints satisfaction problem / satisfiability testing (CSP/SAT)
graph theory

[related fields]
mathematical programming

\Analysis and summarization/

Language data analysis

clearly show analysis results by inspecting big and various text data

[Keyword] (continued from the front)

social media
information visualization
kansei
onomatopoeia
ontology
information retrieval
conversation
understanding / discourse understanding / intention understanding
data science
knowledge base
semi-supervised learning
clustering
dialogue processing / dialogue system
data science
auction
market design
multimodal processing

[related fields]
database, natural language processing

\Analysis and summarization/

Numerical analysis

clearly show analysis results by inspecting big and various numeric data

[Keyword] (continued from the front)

sparse modeling
graphical models
pattern recognition
knowledge base
simulation
Bayesian estimation

[related fields]
mathematical statistics, database, preprocessing, data cleansing, noise reduction

\Recognition and estimation/

Indicator creation

give an index to the nature of an object under complex and ambiguous criteria

[application example keywords]

negotiation skill, design, health, development capability, movement capability, resume, economic indicators, sports

text
WEB
Image
→ evaluation results

[Keyword]

deep learning
representation learning (embedding)
clustering
knowledgebase
knowledge acquisition / discovery
knowledge sharing / management
《continued to the back》

[related methods / technologies]

regression analysis, PCA (principal component analysis), A/B test, hierarchical clustering

\Recognition and estimation/

State change detection

recognize objects or what's heard from image, video, or sound information

[application example keywords]

speech recognition, Image recognition, visual inspection, waste, products, people, trees, automobiles, animals, heavy machinery

Image・video
sound
2D・3D
→ number
type
individual identification

[Keyword]

computer vision
image recognition
speech recognition
generic object recognition
pattern recognition
representation learning (embedding)
semi-supervised learning
《continued to the back》

[related methods / technologies]

phonetics, acoustic scene analysis, pre-learning

\Design/

Personalization

customize the displayed contents to match the users' (hidden) preferences

[application example keywords]

news articles, video distribution, dialogue, services, advertisement distribution

evaluation metrics
numbers
text
category
→ example of customization

[Keyword]

information recommendation
dialogue processing / dialogue system
text mining
knowledge acquisition / discovery
kansei
《continued to the back》

[related methods / technologies]

privacy preserving calculation,
privacy preserving data mining

\Design/

Scheduling

determine what to be done in what order

[application example keywords]

advertisement, meeting, delivery, personnel shift

condition
numerical value
categories
objective index
→ schedule

[Keyword]

scheduling
planning
genetic algorithms
multi-agent
constraints satisfaction problem / satisfiability testing (CSP/SAT)
reinforcement learning
heuristics
simulation
distributed cooperation
《continued to the back》

\Analysis and summarization/

Summarization

clearly show the gist of large amount of information

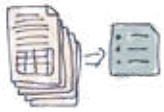
[application example keywords]

text, numerical data, video, web data, report, academic material, SNS, news article and video, Q&A summary, questionnaire result, document, article

text
media
numerical value
→ summarized sentence
map
diagram
album

[Keyword]

summarization
text mining
reinforcement learning
Web intelligence
segmentation
《continued to the back》



[related methods / technologies]

extractive summarization, abstract summarization, lead method, GAN, pointer networks, pre-training, LexRank

\Analysis and summarization/

Causal inference

find causal relationship based on data; predict what changes what

[application example keywords]

epidemiology, economics, chemistry, sleep disorders, sales changes, root cause of failure estimation

numerical value
text
→ causal relation

[Keyword]

AI understandability
semantics
search / logic / inference algorithm
clustering
knowledge graph

[related methods / technologies]

statistical causal analysis, structural equation modeling, causal graph, independent component analysis, LiNGAM

\Analysis and summarization/

Media data analysis

clearly show analysis results by inspecting big and various image / video data

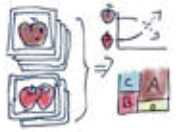
[application example keywords]

image, sound, vibration, surveillance image, fixed-point camera, microscope image, manufacturing line image, sports image

Image
video
sound
→ trends
trouble / anomaly
points of caution
group

[Keyword]

computer vision
image recognition
generic object recognition
data mining
data science
information visualization
《continued to the back》



[related methods / technologies]

privacy preserving data mining, secure computing

\Collaboration and trust formation/

Mediation and planning

support fair consensus building and give advice on ethical issues

[application example keywords]

voting, consensus building, compliance

text
Web
numbers
→ text

[Keyword]

multi-agent
information recommendation
social media
collective intelligence
knowledge sharing / management
Web intelligence
management applications
intelligent UI
text mining
summarization
ontology
《continued to the back》

\Design/

Scheduling

determine what to be done in what order

[Keyword] (continued from the front)

evolutionary computation
swarm Intelligence
behavioral economics
graph theory
knowledge acquisition / discovery

\Design/

Personalization

customize the displayed contents to match the users' (hidden) preferences

[Keyword] (continued from the front)

ontology
knowledge base
knowledge graph
game theory
reinforcement learning
social media
affordance
art / entertainment application
non-task oriented dialogue
information retrieval
semi-supervised learning

\Recognition and estimation/

State change detection

recognize objects or what's heard from image, video, or sound information

[Keyword] (continued from the front)

transfer learning
deep learning
adversarial learning
artificial neural network
gesture recognition
clustering
sparse modeling
knowledgebase
knowledge acquisition / discovery
medical / healthcare application
kansei engineering
action estimation
affordance
cloud sourcing / human computation
video processing

\Recognition and estimation/

Authentication

give an index to the nature of an object under complex and ambiguous criteria

[Keyword] (continued from the front)

auction
kansei engineering
onomatopoeia
knowledge graph
ontology
dialogue processing / dialogue systems
multi-agents
cloud sourcing / human computation

[related fields]
marketing research, management studies, product design, natural language processing

\Collaboration and trust formation/

Mediation and planning

support fair consensus building and give advice on ethical issues

[Keyword] (continued from the front)

knowledge acquisition / discovery,
knowledge graph
AI ethics,
privacy
computational social sciences
behavioral economics
Behavior modification (nudge)
shikakeology
application of social issues
auction
game theory
kansei
decision making and consensus building
swarm intelligence
human-agent interaction
fuzzy logic
constraints satisfaction problem / satisfiability testing (CSP/SAT)

\Analysis and summarization/

Media data analysis

clearly show analysis results by inspecting big and various image / video data

[Keyword] (continued from the front)

representation learning (embedding)
semi-supervised learning
clustering
sparse modeling
multi modal analysis
speech recognition
video image processing
art / entertainment applications
affordance

[related fields]
optics, acoustics,
mechanical vibration engineering,
preprocessing, data cleansing,
noise reduction

\Analysis and summarization/

Causal inference

find causal relationship based on data; predict what changes what

[related fields]
statistical causal analysis, design of experiments
randomized controlled trials, stratified analysis
econometrics

\Analysis and summarization/

Summarization

clearly show the gist of large amount of information

[Keyword] (continued from the front)

information retrieval
deep Learning
sparse modeling
representation learning (embedding)
information visualization
conversation understanding / discourse understanding / intention understanding
pattern recognition
image generation
knowledge sharing / management
ontology
knowledge graph
knowledge base

[related fields]

information retrieval

\Design/

Placement and design

decide complicated arrangements and combinations to meet the required conditions

[application example keywords]

production planning, procurement planning, personnel shift, investment planning, layout planning, layout optimization, shelving allocation

condition	combination example
numerical value	design plan
category	layout plan
objective index	

[Keyword]

planning
constraints satisfaction problem / satisfiability testing (CSP/SAT)
genetic algorithm
simulation
evolutionary computation
graph theory
multi-agent
heuristics
《continued to the back》

\Design/

Coordination

show proposals from many combinations

[application example keywords]

fashion, travel plans, class attendance plans, food menus

user preference input	combination of data that matches user preferences
data about candidates	

[Keyword]

information recommendation
genetic algorithm
kansei
onomatopoeia
constraints satisfaction problem / satisfiability testing (CSP/SAT)
evolutionary computation
art / entertainment application
knowledge base
knowledge acquisition / discovery
《continued to the back》

\Generation and dialogue/

Speech dialogue

respond appropriately by understanding people's intentions based on natural language, intonation, facial expressions, etc. (paralanguage)

[application example keywords]

handling at the counter, call center, web service, elderly people support

speech	speech
text	text
Image	Image

[Keyword]

dialogue processing / dialogue system
speech recognition
speech generation
non-task-oriented dialogue
conversation understanding / discourse understanding / intention understanding
HAI
《continued to the back》

[related methods / technologies]

cognitive science

\Generation and dialogue/

Media transformation

generate target data by transformation or augmentation of input data

[application example keywords]

photo, line art, manga, 3D, speech quality, image compression

text	text
Image	Image
sound	sound
time series data	time series data
3D	3D

[Keyword]

image generation
speech generation
adversarial learning
deep learning
pattern recognition
ontology
《continued to the back》

[related methods / technologies]

Style Transfer, VGG, GAN, Cycle GAN

\Collaboration and trust formation/

Ordering and selection

show appropriate selection criteria or order, and present candidates for selection

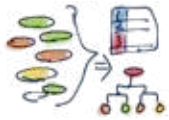
[application example keywords]

screening, tournaments, selection

conditions	order
candidate data	combination

[Keyword]

planning
constraints satisfaction problem / satisfiability testing (CSP/SAT)
genetic algorithms
knowledge sharing / management
knowledge acquisition / discovery
AI fairness
social problem application
market design
multi-agent
decision-making and consensus building
information visualization
swarm intelligence
sparse modeling



\Generation and dialogue/

Knowledge organization

understand and structuralize meaning from documents for extracting relevant knowledge

[application example keywords]

FAQ generation, Web search, risk assessment, investment decision, information retrieval, data sharing, knowledge sharing

document	text

[Keyword]

ontology
summarization
knowledge sharing / management
crowdsourcing
knowledge graph
text mining
web interaction
expert system
onomatopoeia
intelligent UI
《continued to the back》

[related methods / technologies]

database, knowledge management, philosophy

\Generation and dialogue/

Advice

display candidates that match the user based on expert knowledge and considering complex influences

[application example keywords]

finance, health care, legal consultation, fitness, daily matters consultation, energy conservation, safe driving

user input	text
	Image

[Keyword]

information recommendation
reinforcement learning
expert system
knowledge base
dialogue processing / dialogue system
knowledge acquisition / discovery
AI ethics
HAI
《continued to the back》

[related methods / technologies]

A/B test

\Generation and dialogue/

Media generation

Automatically generate article, conversation or CG from data

[application example keywords]

news article script, CG of sign language, novel, music

text	text
CG	Image
	CG
	sound

[Keyword]

speech generation
image generation
video processing
conversation understanding / discourse understanding / intention understanding
summarization
knowledge sharing / management
ontology
《continued to the back》

[related methods / technologies]

GAN, DeepFake, StyleGAN, speech synthesis, Text to Speech (TTS)

\Generation and dialogue/

Media transformation

generate target data by transformation or augmentation of input data

[Keyword] (continued from the front)

knowledge graph
knowledge base
conversation understanding / discourse understanding / intention understanding
information visualization
art / entertainment application
VR

\Generation and dialogue/

Speech dialogue

respond appropriately by understanding people's intentions based on natural language, intonation, facial expressions, etc. (paralanguage)

[Keyword] (continued from the front)

multimodal interaction
kansei
gesture recognition
HRI
symbol emergence in robotics
behavior estimation
shikakeology
business applications
biomedical and health care applications
speech generation

\Design/

Coordination

show proposals from many combinations

[Keyword] (continued from the front)

game theory
distributed collaboration

\Design/

Placement and design

decide complicated arrangements and combinations to meet the required conditions

[Keyword] (continued from the front)

market design
business application
distributed coordination

\Generation and dialogue/

Media generation

Automatically generate article, conversation or CG from data

[Keyword] (continued from the front)

knowledge graph
adversarial learning
deep learning
pattern recognition
HAI
kansei
intelligent UI
bioinformatics
materials informatics
art / entertainment application

[related fields]
hidden Markov model (HMM), Deep Belief Network, spectral envelope

\Generation and dialogue/

Advice

display candidates that match the user based on expert knowledge and considering complex influences

[Keyword] (continued from the front)

multimodal interaction
statistical learning
computational learning theory
kansei
intelligent user interface
conversation understanding / discourse understanding / intention understanding
HRI
Web interaction
behavior modification (Nudge)
onomatopoeia
text mining

ontology
knowledge graph
knowledge sharing / management
fuzzy logic
collective intelligence
well-being computing
educational applications
behavioral economics
information retrieval, auction
decision making / consensus building
skill science
embodiment
speech generation

[related fields]
medical science
economics
Jurisprudence

\Generation and dialogue/

Knowledge organization

understand and structuralize meaning from documents for extracting relevant knowledge

[Keyword] (continued from the front)

knowledge base
knowledge acquisition / discovery
decision making / consensus building
social media
information recommendation

\Collaboration and trust formation/

Ordering and selection

show appropriate selection criteria or order, and present candidates for selection