

Plate-forme Intelligence Artificielle

PFIA2018

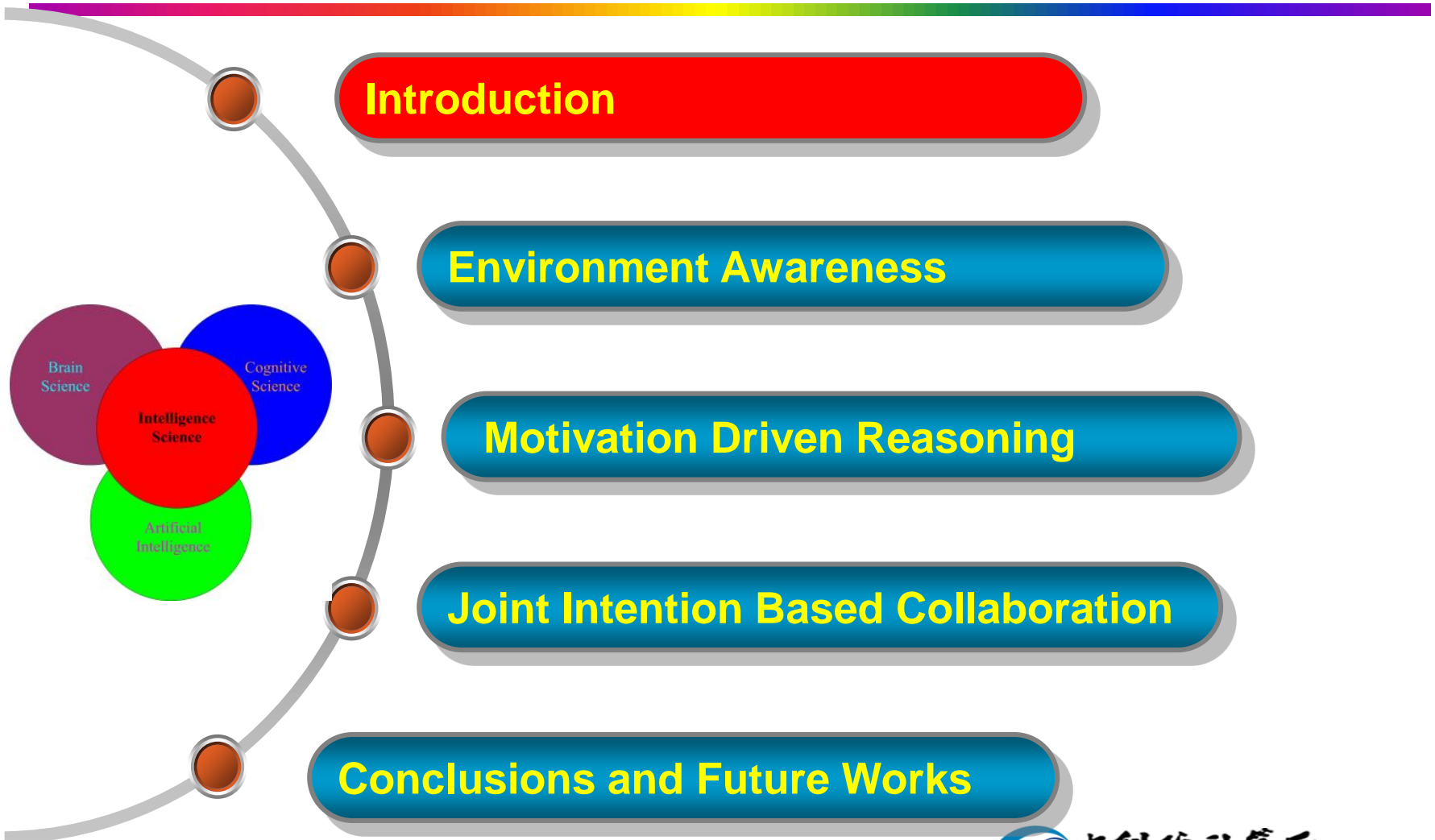
Nancy, France

Brain Machine Integration

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Chinese Academy of Sciences
<http://www.intsci.ac.cn/en/shizz>*

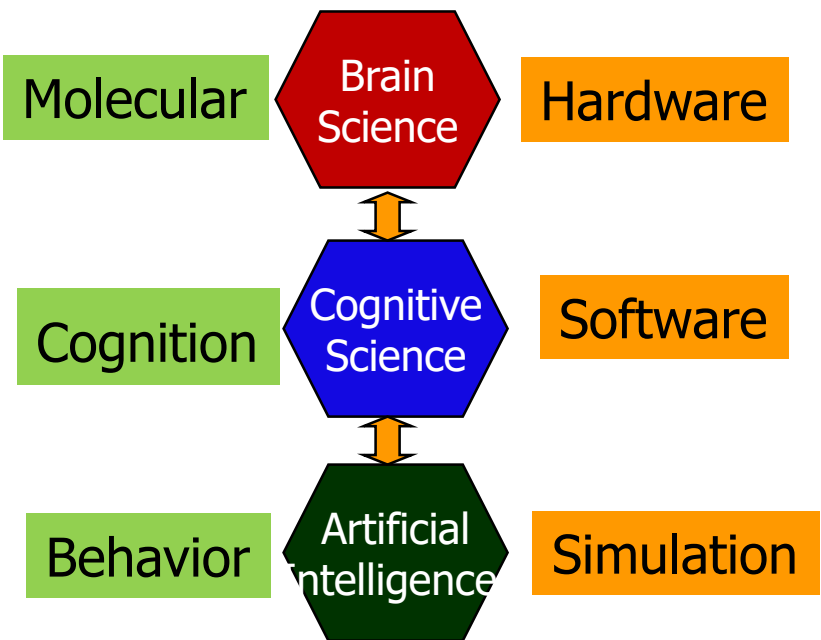
Contents Outline



Intelligence Science

Intelligence science is an interdisciplinary subject on basic theory and technology of intelligence, mainly including brain science, cognitive science, artificial intelligence and others.

- **Brain science** explores the essence of brain, research on the principle and model of natural intelligence in molecular, cell and behavior level.
- **Cognitive science** studies human mental activity, such as perception, learning, memory, thinking, consciousness etc.
- **Artificial intelligence** attempts simulation, extension and expansion of human intelligence using artificial methodology and technology

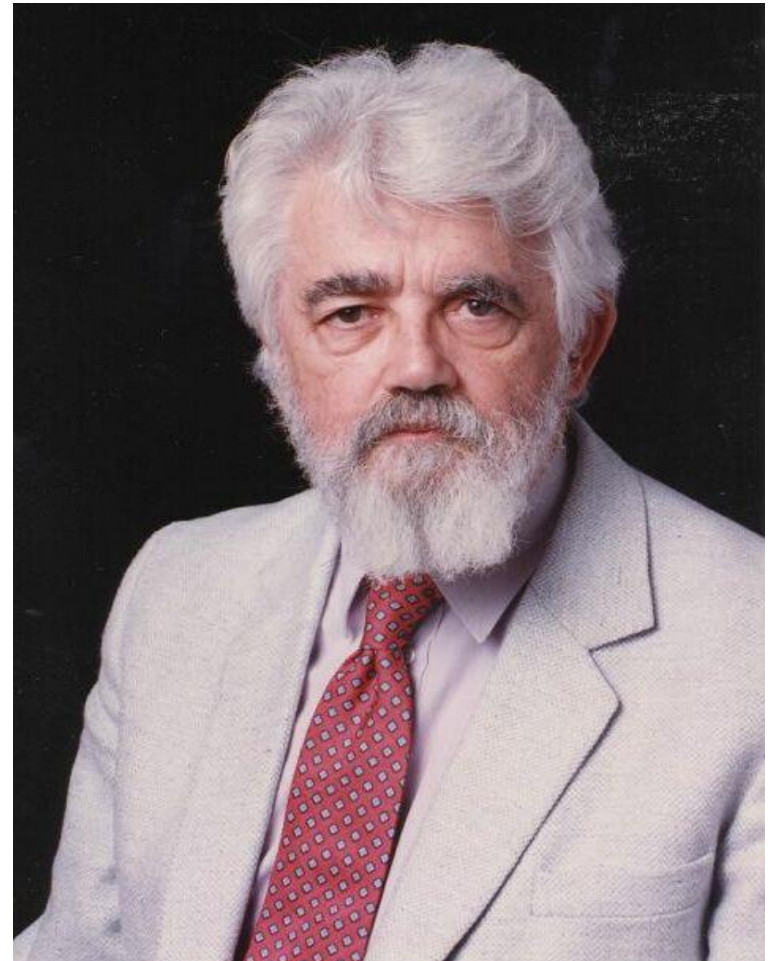


Human-Level AI

The long-term goal of Artificial Intelligence is human-level Artificial Intelligence.

Cite from: John McCarthy. The Future of AI—A Manifesto. AI Magazine Volume 26 Number 4, 2005.

Intelligence Science Is The Road To Human-Level Artificial Intelligence



Big Issues

- **Signaling in the Nervous System**
- **Synaptic Plasticity**
- **Perceptual Representation**
- **Learning Emergence**
- **Coding and Retrieval of Memory**
- **Linguistic Cognition**
- **Formalizing of Commonsense knowledge and Reasoning**
- **Nature of Consciousness**
- **Mind model**
- **Architecture of Brain-like Computer**

Intelligence Science Website

The screenshot shows the Intelligence Science Website in a Windows Internet Explorer browser window. The page layout includes a navigation menu on the left, a main content area, and a 'Latest News' section on the right.

Navigation Menu (Left):

- Intelligence Science Lab
 - Introduction
 - Direction
 - Zhongzhi Shi
 - Qing He
 - Member
 - Contact Us
- IntSci Research
 - Artificial Intelligence
 - Brain Science
 - Cognitive Science
 - Progress
 - Publication
 - Related Links
- Intelligent Systems
 - AGrip
 - SWSBroker
 - KMSphere
 - MAGE
 - MSMiner
 - GHunt
 - IDSS
 - MIRES
 - More Intelligent Tools
- Intelligent Applications
 - Agent Grid Intelligence PlatformAGrip
 - Agent Grid Emergency Interactive System GEIS
 - Intelligent Service MISE
 - Intelligent Platforms
- Links
 - THRR

Main Content Area:

Intelligence Science Website

Intelligence science is an interdisciplinary subject which is jointly studied by brain science, cognitive science, artificial intelligence and others. Intelligence science not only to conduct functional simulation of intelligent behavior, but also should research on the mechanism to explore new theory of intelligence, new technologies. World Scientific publishes book <Intelligence Science> which is Volume 1 of the Series on Intelligence Science. Here is the first chapter Introduction.

Focus Highlight

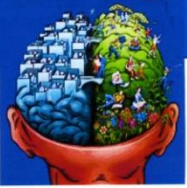
- Chinese Society for Cognitive Science was formally established**
On November 30, 2011 Chinese Society for Cognitive Science (CSCS) Inaugural and First National Representatives conference held at China Science and Technology Hall, Beijing. Academician Chen Lin was elected chairman of the Chinese Society for Cognitive Science..
- Brain-like Intelligent Machines**
Sponsored By Intelligent Science and Technology Online Cooperative Research Centre of Ministry of Education, Zhejiang University hosted the second "Intelligent Science and Technology Conference" on November 29, 2011 held in Hangzhou. Zhongzhi Shi was invited to deliver the report on brain-like intelligent machines .
- The Human Brain Project**
Henry Markram, coming from Brain Mind Institute, EPFL in Switzerland, is going to organize the human brain project for applying Future and Emerging Technologies (FET) Flagship Programme
- John McCarthy**
John McCarthy, a computer science pioneer, father of AI and Lisp, died October 24, 2011 at his home in Stanford, California.
- Cognitive Cycle in Mind Model CAM**

Latest News

- Prof. Xiaowen Xu working at University of Arkansas, USA visited Intelligence Science Lab and discuss the future cooperation.
- On Nov. 14 2011 Prof. Zhongzhi Shi visited Tsinghua University in Hsinchu, Taiwan, and meet Prof. Von-Wun Su.
- Prof. Zhongzhi Shi attended IEEE GrC 2011held in Gaohsung, Taiwan, Nov. 7-10, 2011.
- Prof. Toru Ishida who is working at the Kyoto University visited Prof. Zhongzhi Shi and shared dinner on Oct.24, 2011in Beijing.
- Prof. Pei Wang who is working at Temple University, USA, visited Intelligence Science Lab. on September 24.
- From July 16-20 2011 AGI Series Conference President Ben Goertzel visits Beijing and meet Zhongzhi Shi. They discuss about International Journal of Intelligence Science.
- IJCAI-11held in Barcelona from July 16 -22. Qing He and Xudong Ma attend conference and present paper.
- 22 to 27 January, 2011 Zhongzhi Shi, visited University of Illinois at Chicago and discussed with

Series on Intelligence Science

Connecting Great Minds



Call For Book Proposal on Intelligence Science

Special Advisors
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Shun-ichi Amari (Japan)
Wenjun Wu (China)
Lotfi A. Zadeh (USA)

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Yixin Zhong (China)


Series on Intelligence Science

Aims and Scope
Intelligence science is an interdisciplinary subject dedicated to joint research on the basic theory and technology of intelligence among the fields of brain science, cognitive science, and artificial intelligence. Brain science explores the essence of the brain, and conducts research on principles and models of natural intelligence at the molecular, cellular, and behavioral levels. Cognitive science studies human mental activity, such as perception, learning, memory, thinking, consciousness, etc. In order to implement machine intelligence, artificial intelligence is concerned with the simulation, extension, and expansion of human intelligence using artificial methodologies and technologies. Research scientists from these three disciplines work together to explore new concepts, theories, and methodologies in order to create a successful and brilliant future in the modern 21st century.

Aims of Series on Intelligence Science
The Series on Intelligence Science will reflect the most updated progress and achievements in intelligence science. It provides a platform for scientists to exchange new ideas and share knowledge so as to promote cross-research between brain science, cognitive science, and artificial science.

Areas of particular interest encompass:

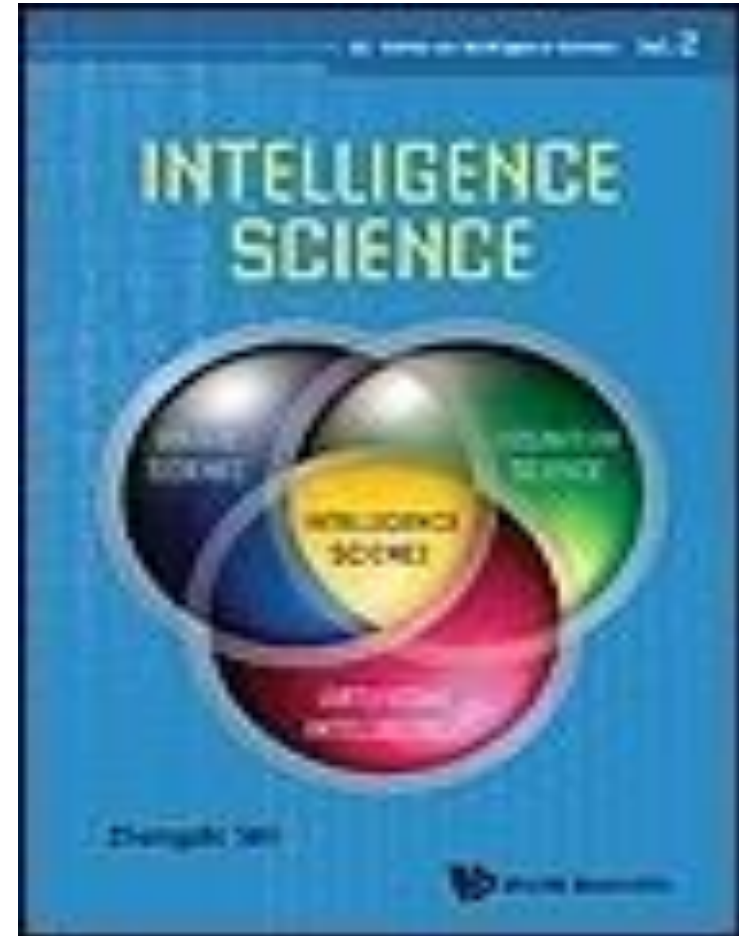
- Cognitive neuroscience
- Perception
- Memory
- Linguistic cognition
- Learning
- Thought
- Emotion
- Nature of consciousness
- Mind modeling
- Intelligent systems



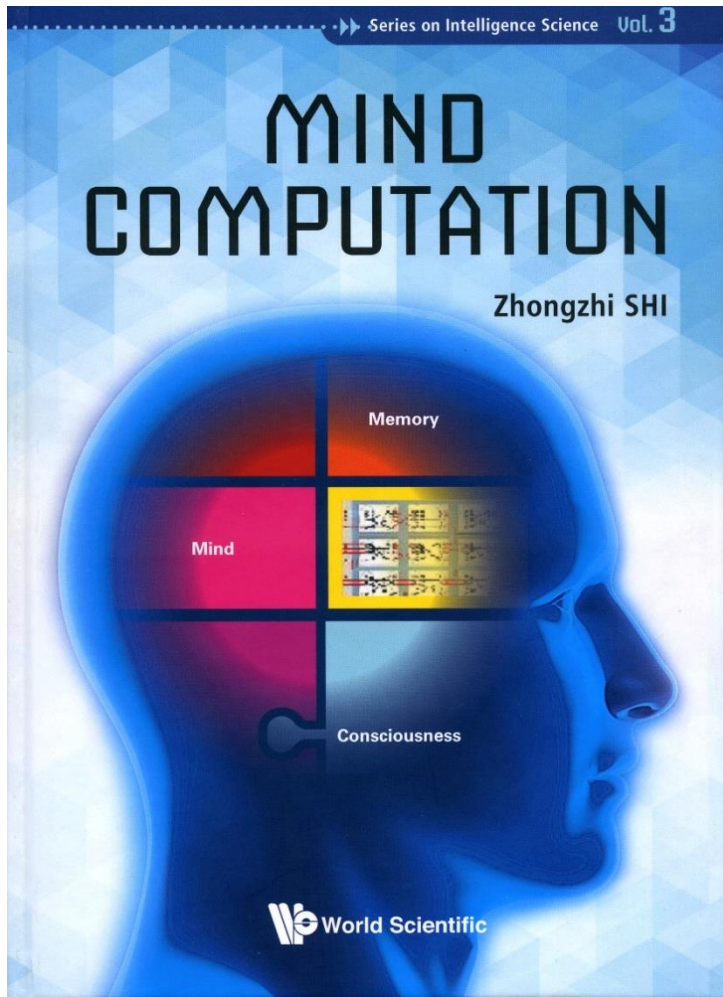
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ICP Imperial College Press
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Preferred Publisher of Leading Thinkers



Mind Computation



1. Introduction
2. Mind Model CAM
3. Memory
4. Consciousness
5. Visual Awareness
6. Motor Control
7. Linguistic Cognition
8. Learning
9. Brain-like Computing

International Conference on Intelligence Science

The First International Conference on Intelligence Science (ICIS2016)

ICIS2016, October 31 - November 1, Cheng Du, China

The basic theory of intelligence science is urgent need to construct. The goals of the conference is to carry out the theory of collective exploration, put up the discipline kernel of intelligence science.



International Conference on Intelligence Science



**The Second
International
Conference on
Intelligence Science**

ICIS2017

**October 25-28, 2017,
Shanghai, China**



**IFIP AICT 510
Zhongzhi Shi
Ben Goertzel
Jiali Feng
(Eds.)**

Intelligence Science I

The 2nd International Conference on Intelligence Science ICIS2017
Shanghai, China, October 25-28, 2017
Proceedings

Springer

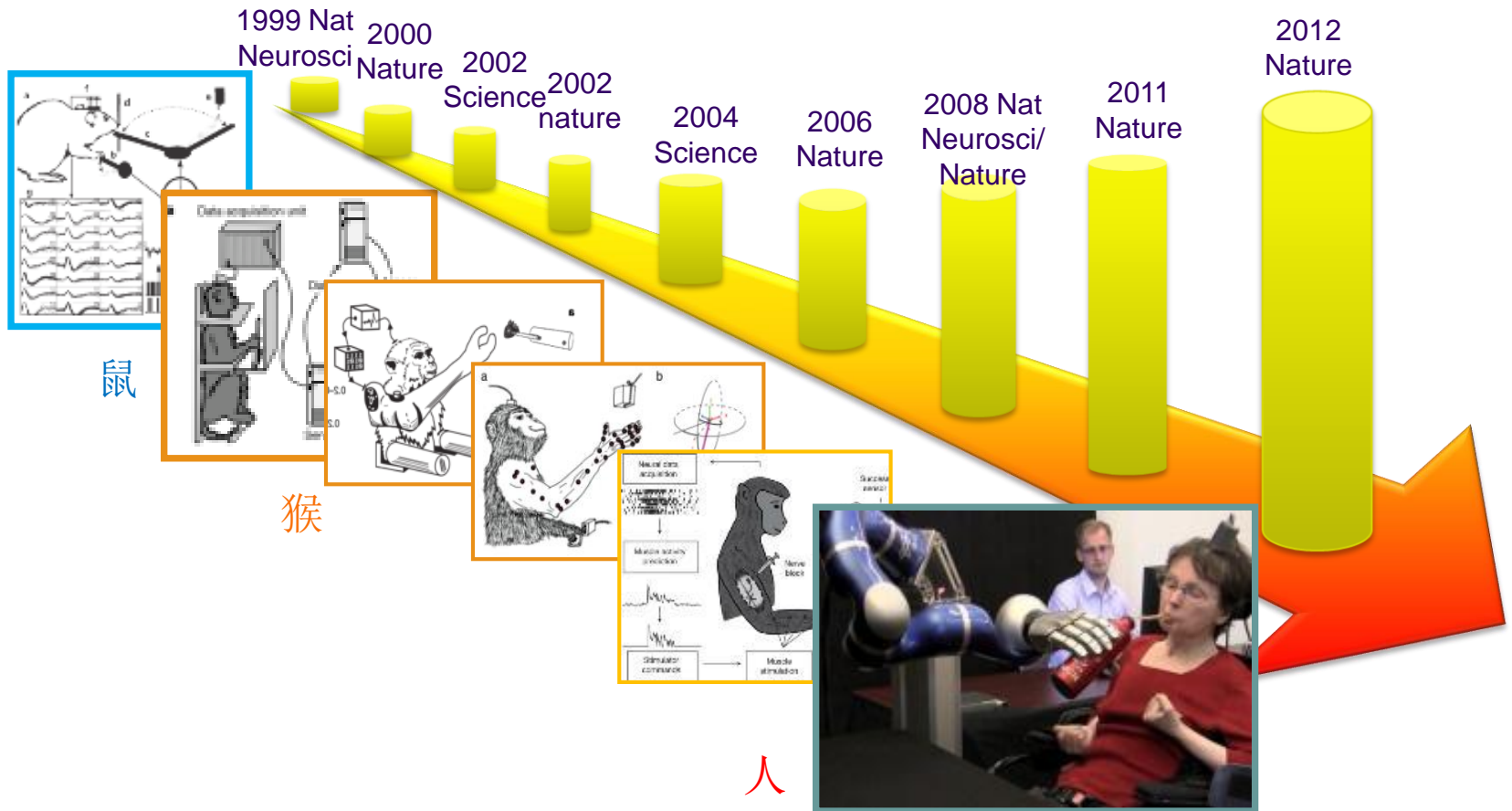
International Conference on Intelligence Science



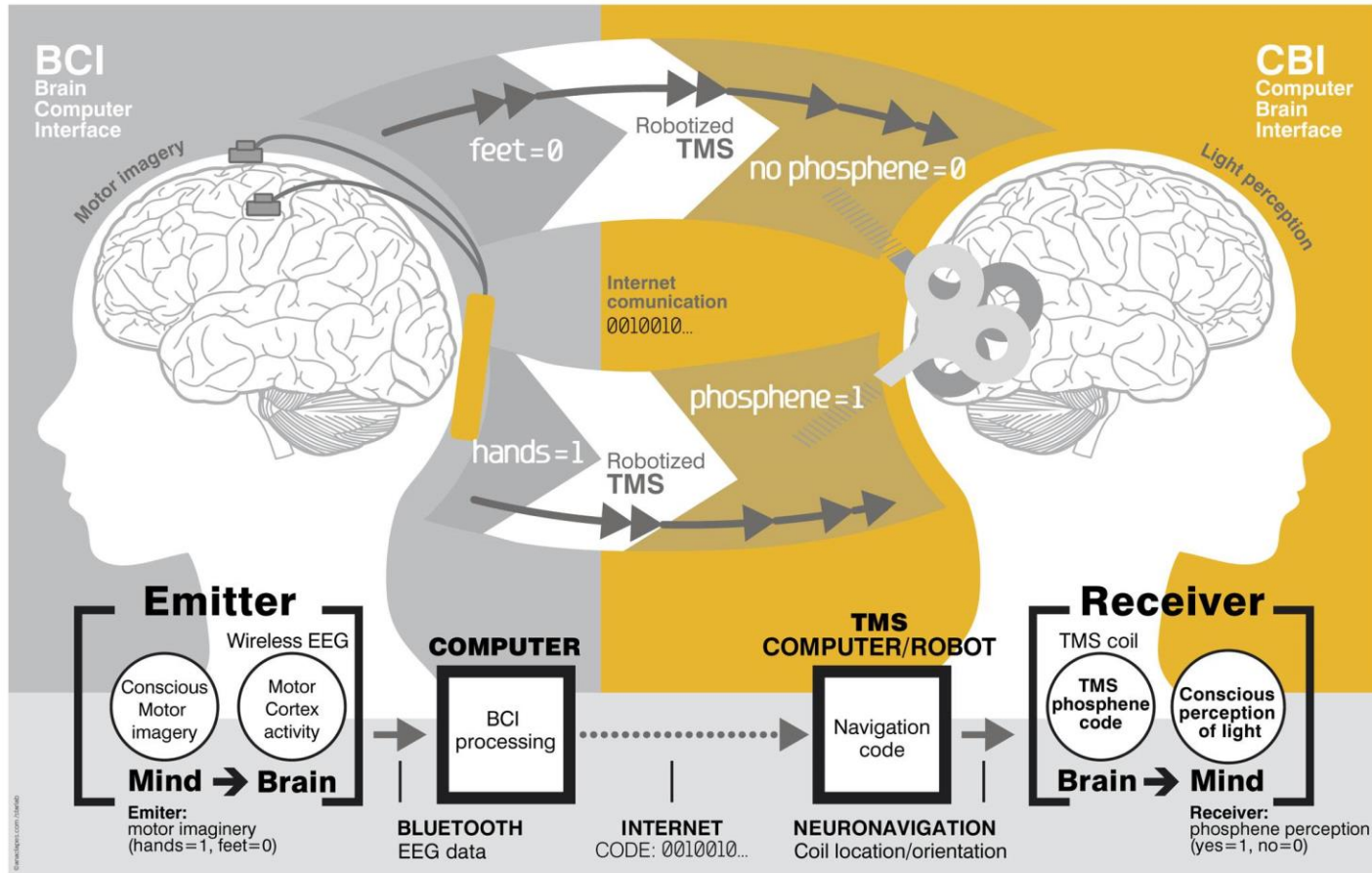
<http://www.intsci.ac.cn/icis2018/>

The Third International Conference on Intelligence Science (ICIS2018) will be held in Beijing, China, on November 2-5, 2018, focusing on Intelligence Science, Information Science. It is sponsored by Chinese Association for Artificial Intelligence (CAAI), China Chapter of International Society for Information Studies; Organizer is Peking University; and Co-supported by Beijing Association for Science and Technology (BAST), Beijing Association for Artificial Intelligence (BAAI).

Brain Machine Interface



Brain Machine Interface



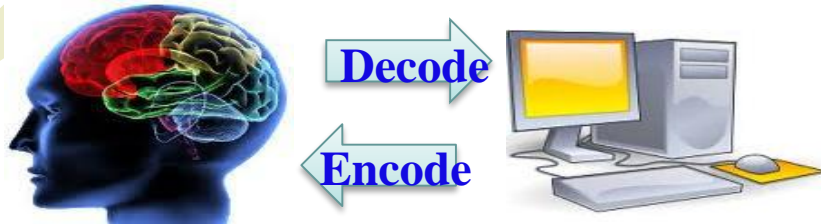
Brain Machine I³



● Integration

● Interaction

● Interface



Musk Neuralink



- On March 28, 2017, SpaceX and Tesla CEO Elon Musk is backing a brain-computer interface venture called Neuralink Corp , a company devoted to developing neural implants. It is a closer merger of biological intelligence and digital intelligence

Brain Implants



- On June 1, 2018, Microsoft CEO Satya Nadella revealed the news at the eighth "Ability" conference in Microsoft, researchers are working on whether brain implants can enhance human intelligence to increase the help of people with disabilities

Chinese 973 Program

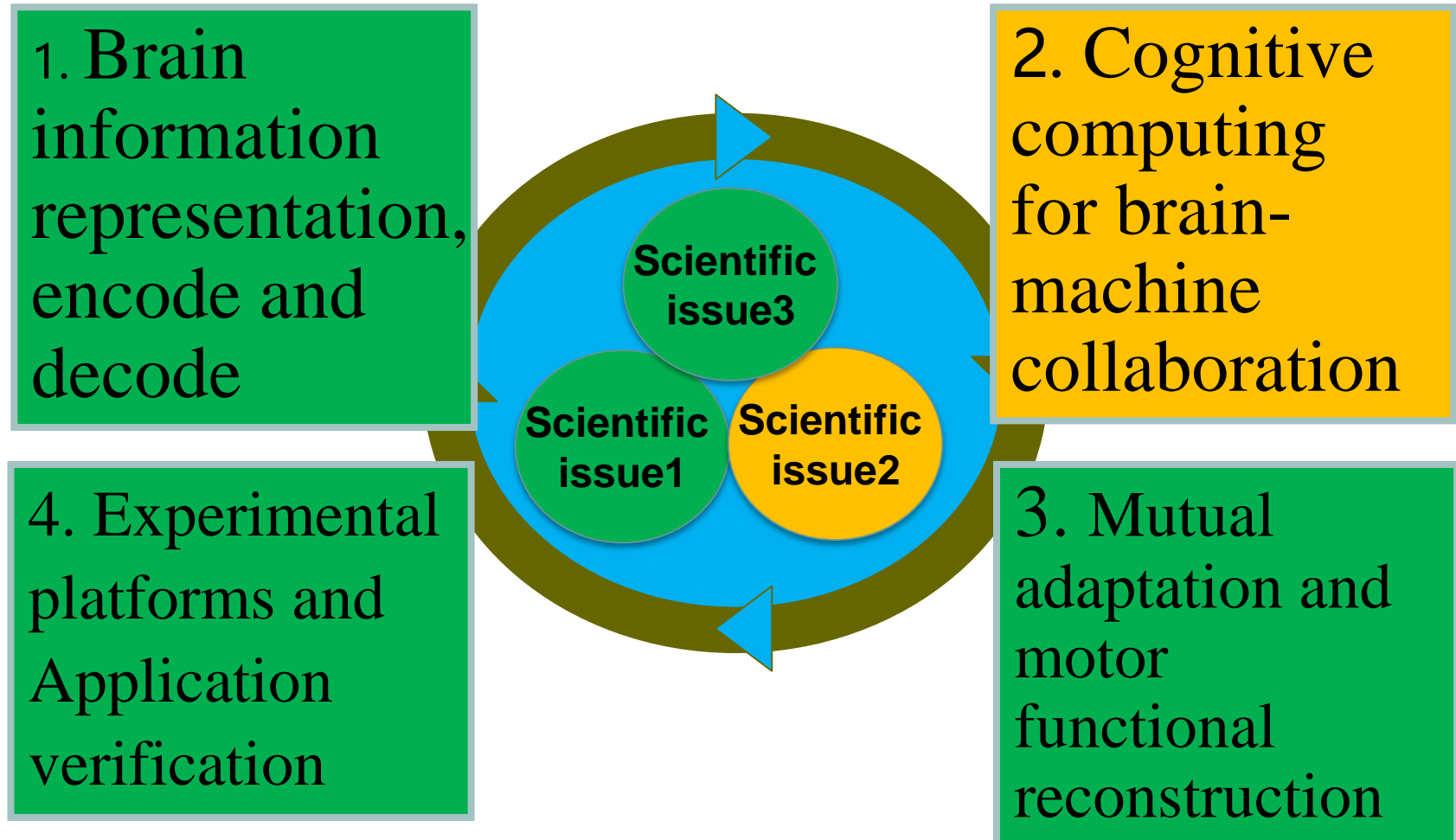
- 973 Program (The National Basic Research Program) is China's on-going national keystone basic research program
- Approved by the Chinese government in June 1997 and is organized and implemented by the Ministry of and is organized and implemented by the Ministry of Science and Technology.
- To meet the nation's major strategic needs.
- To create an excellent scientific research environment and to scale the peak of the world's science

Chinese 973 Program

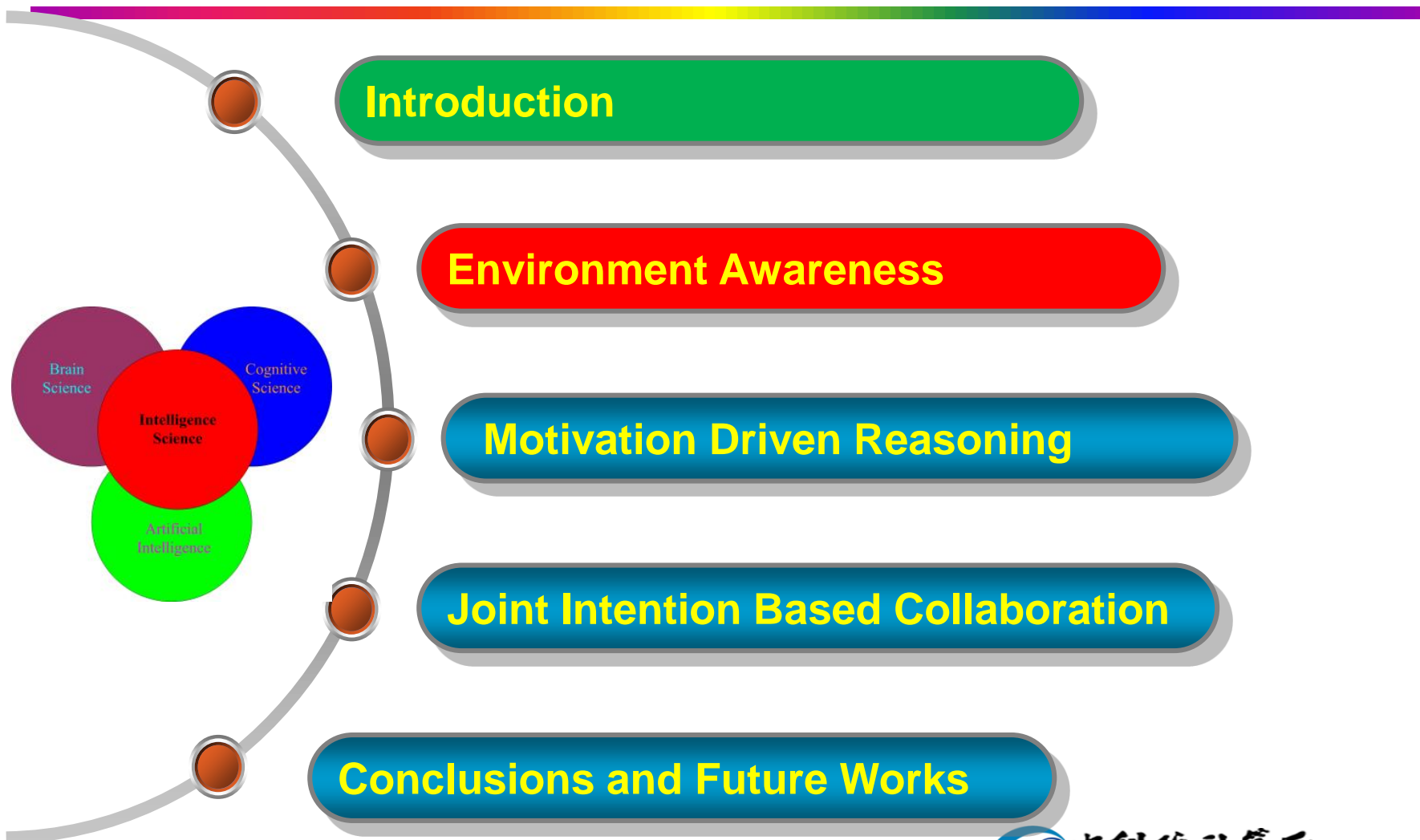
973 Program emphases:

- Agriculture
- Energy
- Information
- Resource and Environment
- Population and Health
- Materials
- Synthesis and Frontier Science

Computing Theory & Method for Perception & Cognition of Brain Machine Integration



Contents Outline



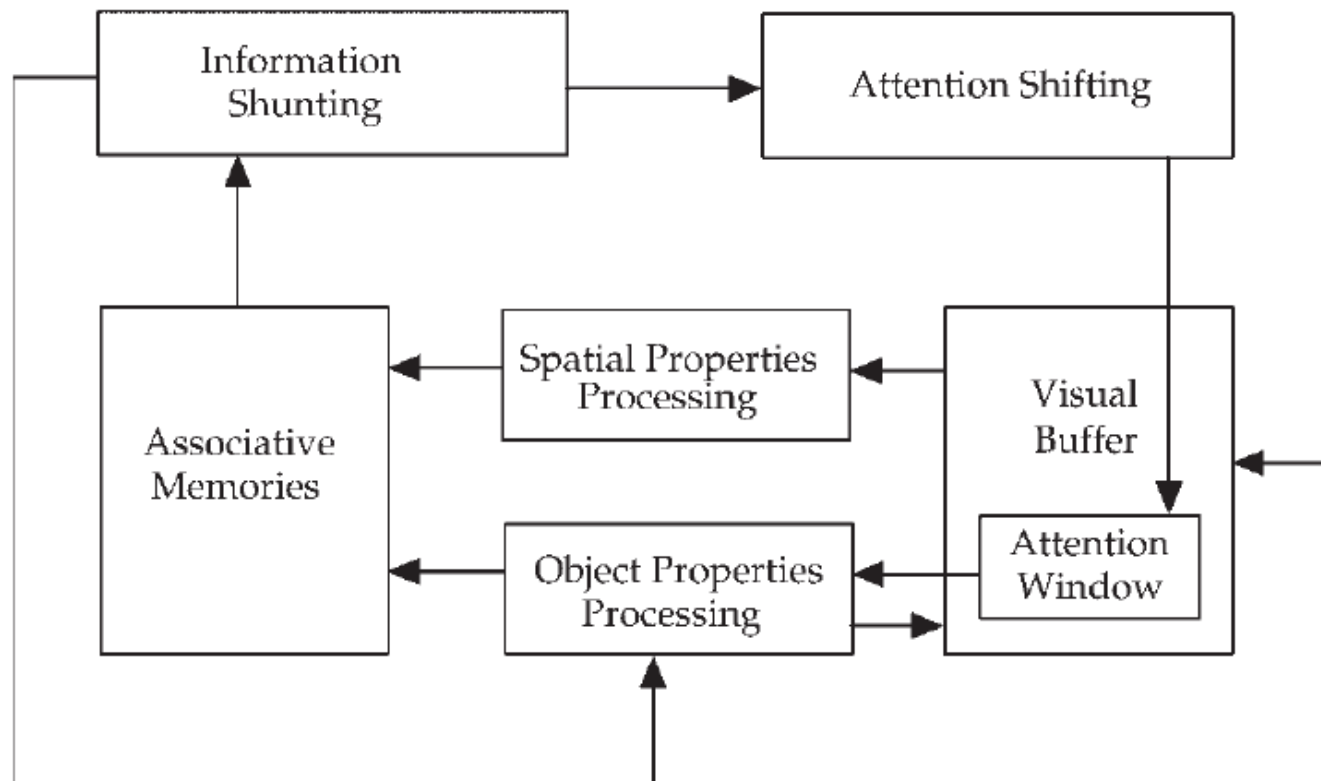
Environment Awareness

Cyborg intelligent systems require bidirectional information perception between rat brain and computer. Awareness is the state or ability to perceive, to feel events, objects or sensory patterns, and cognitive reaction to a condition or event. Awareness has four basic characteristics:

- Awareness is knowledge about the state of a particular environment.
- Environments change over time, so awareness must be kept up to date.
- Agents maintain their awareness by interacting with the environment.
- Awareness establishes usually an event.

Visual Imagery Processing

- Framework



Cite from: S. M. Kosslyn. *MENTAL IMAGES AND THE BRAIN. COGNITIVE NEUROPSYCHOLOGY*, 2005, 22 (3/4), 333–347

Environment Awareness

The brain machine collaborative awareness model is defined as 2-tuples: {Element, Relation}, where **Element of awareness** is described as follows:

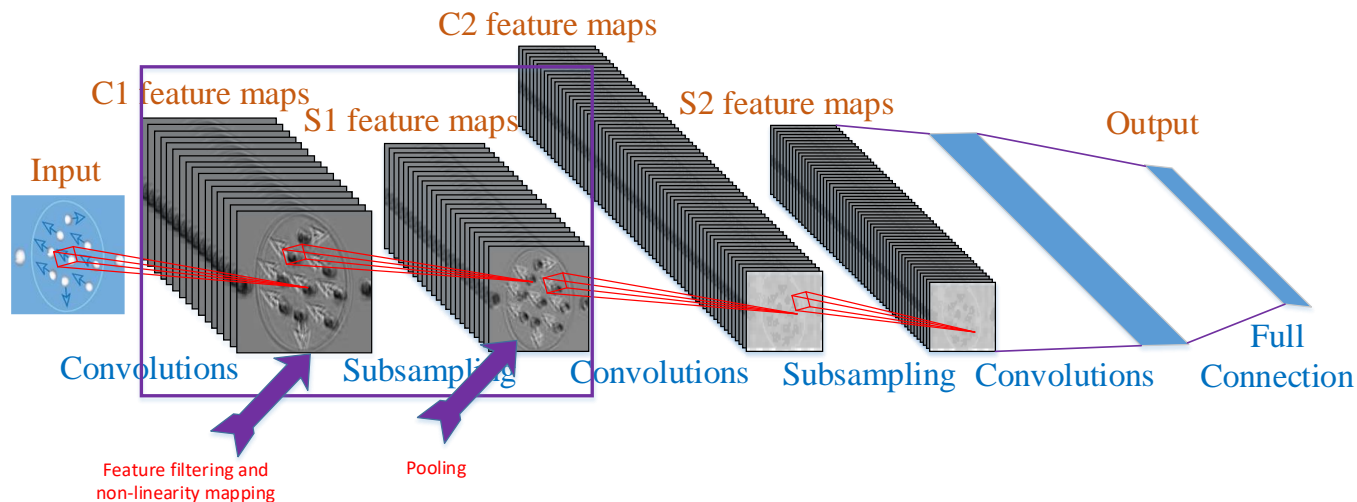
- a) **Who**: describes the existence of agent and identity the role, answer question who is participating?
- b) **What**: shows agent's actions and abilities, answer question what are they doing? And what can they do? Also can show intentions to answer question what are they going to do?
- c) **Where**: indicates the location of agents, answer question where are they?
- d) **When**: shows the time point of agent behavior, answer question when can action execute?

Basic Relationships

- Task relationships define task decomposition and composition relationships. Task involves activities with a clear and unique role attribute
- Role relationships describe the role relationship of agents in the multi-agent activities.
- Operation relationships describe the operation set of agent.
- Activity relationships describe activity of the role at a time.
- Cooperation relationships describe the interactions between agents.

CNN Model

- Convolutional Neural Networks (CNN)
 - Biology visual theory
 - Multi-level hierarchy feature representation



- Weaknesses ☹
 - Weak capability to overcome some noise

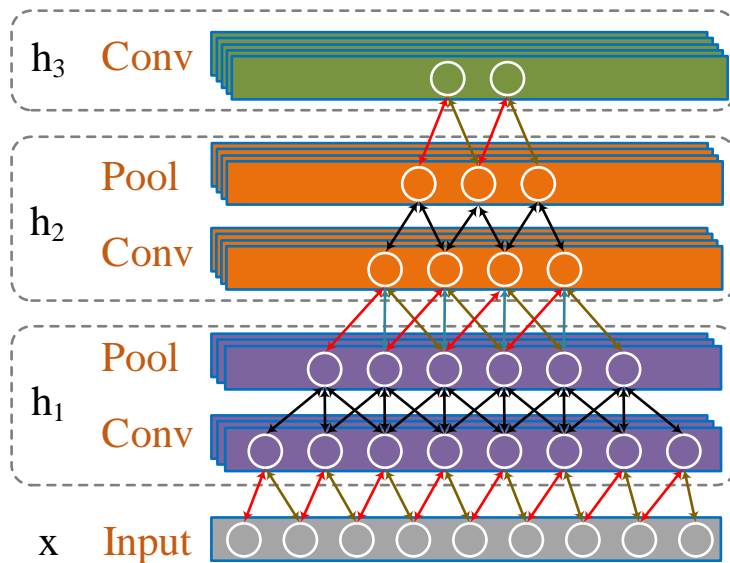
Deep Model B

- Generative Stochastic Networks (GSN)
 - Probability model
 - Without explicitly specifying a probabilistic graphical model
 - Learning deep generative model through back-propagation
 - Stronger capability to overcome noise
- Weaknesses ☹
 - Weak capability to extract the multi-level hierarchies of invariant features

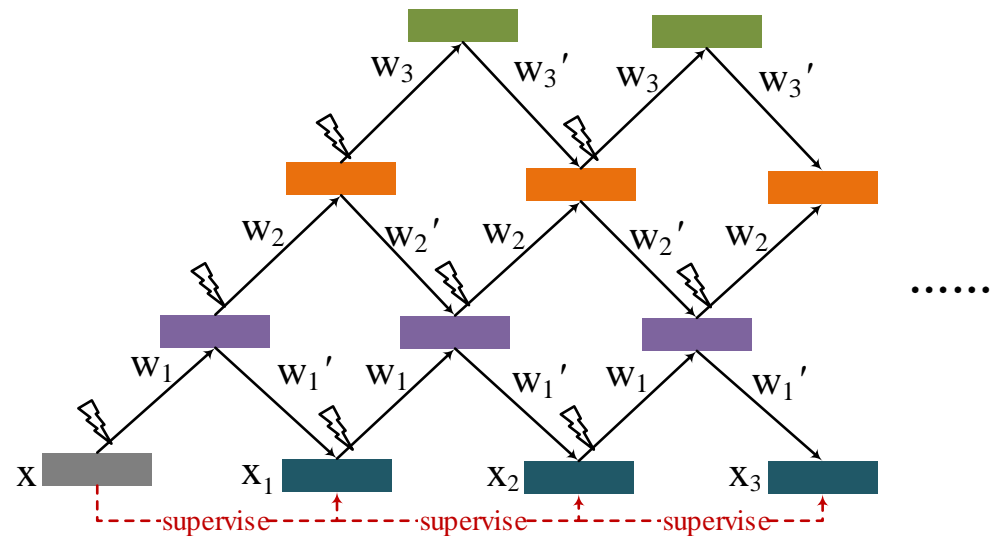
Bengio Y, Éric T, Alain G, et al. Deep Generative Stochastic Networks Trainable by Backprop[J]. Computer Science, 2013, 2:226–234.

CGSM Model

- Convolutional Generative Stochastic Model(CGSM)
 - Multi-level hierarchy feature representation
 - Stronger capability to overcome noise



(a) Framework of CGSM



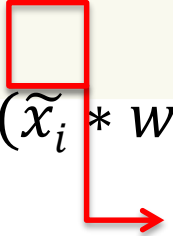
(b) Computational graph of CGSM

CGSM Model

- Convolutional Generative Stochastic Model(CGSM)

Output y_i in convolutional layer for input feature map x_i :

$$y_{i,k} = \sigma(\tilde{x}_i * w_{i,k} + b_{i,k})$$

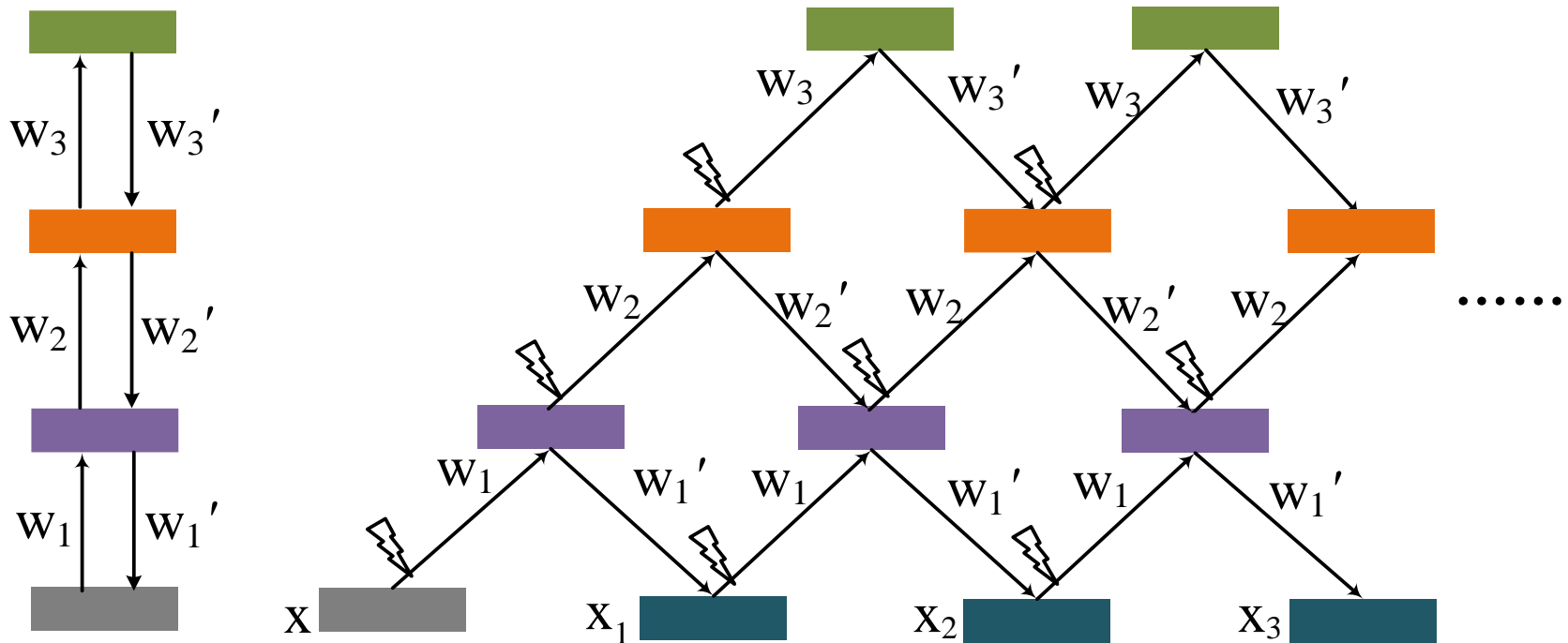
 $C(\tilde{x}_i | x_i)$

Reconstruct output of visible layer:

$$x'_i = \sigma(\sum_k y_{i,k} * w'_{i,k} + b'_{i,k})$$

CGSM Model

- Convolutional Generative Stochastic Model(CGSM)



Roadmap Data

Random Noise

2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 0 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 3 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 0 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3

No Noise

2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
2 0 3 3 0 2 2 0 3 2 3 2 1 2 3 0 3 2 3 2 3 3 1 3 2 2 1 2 2 0 3
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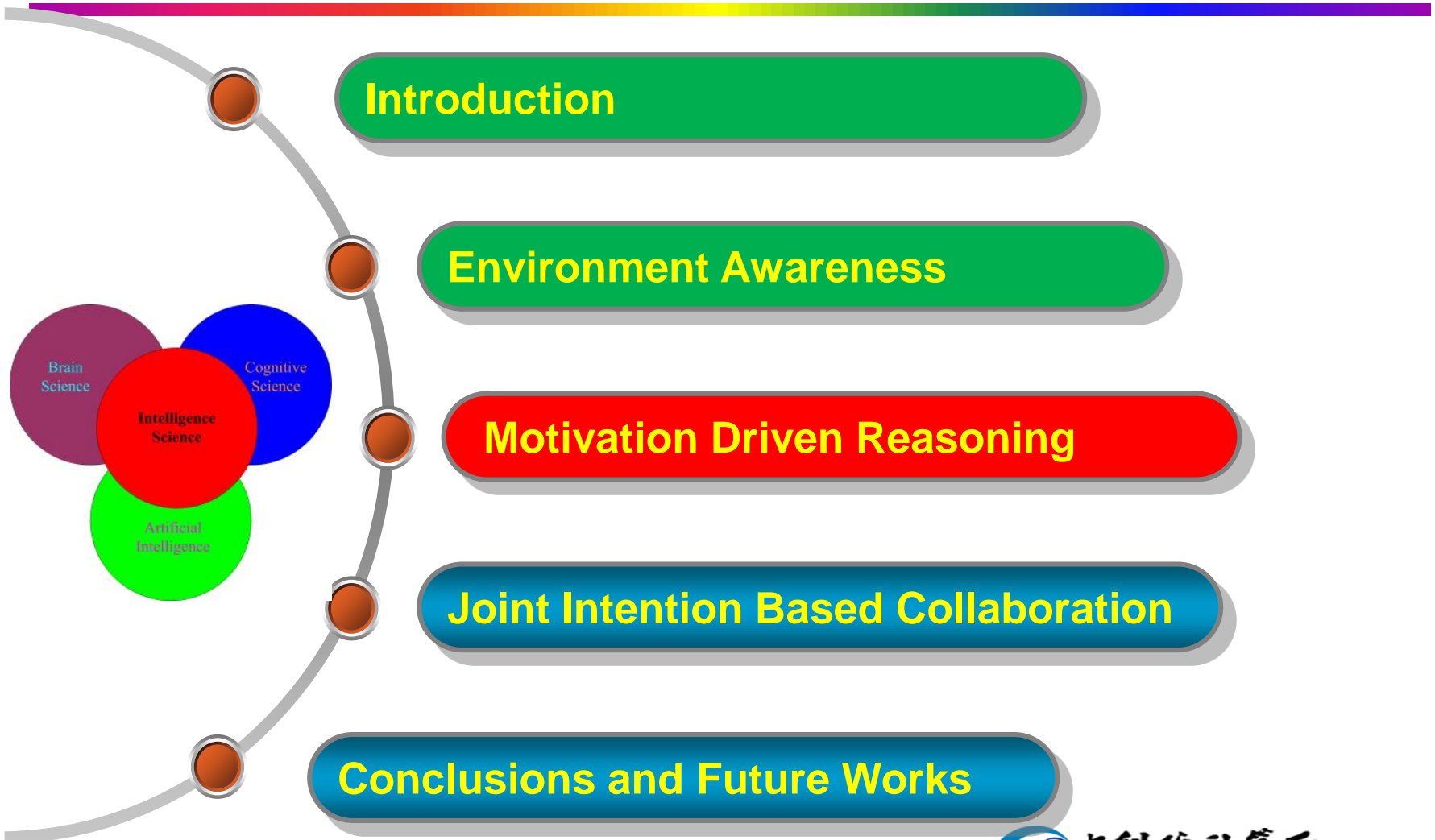
No Noise

Dataset	Awareness Model	Framework	Recognition Rate (%)	
			Single	Sequence
Original Dataset	MLP	Input-H-H-H-Log	98.0272	52.6600
		Linear	97.2817	29.9600
	SVM	Polynomial	89.4154	0.6500
		Radial Basis	98.7250	56.6200
		Sigmoid	98.3401	47.0800
	CNN	Input-C-C-H-Log	99.7231	91.5200
CGSM	Input-C _r -C _r -H-Log	99.8024	93.8652	

With Random Noise

Dataset	Awareness Model	Framework	Recognition Rate (%)	
			Single	Sequence
Noisy Dataset	MLP	Input-H-H-H-Log	96.2637	29.3700
		Linear	96.3154	0.3000
		Polynomial	46.3706	0.0000
	SVM	Radial Basis	97.1561	39.8400
		Sigmoid	96.6435	33.5600
		CNN	Input-C-C-H-Log	99.0306
CGSM	Input-C _r -C _r -H-Log	99.7503	92.2500	

Contents Outline



What is Motivation

Motivation is an internal process that directs and maintains behavior with a certain goal within an individual that account for the direction, level, and persistence of effort.

Direction — an individual's choice when presented with a number of possible alternatives.

Level — the amount of effort a person puts forth.

Persistence — the length of time a person stays with a given action.

Motivation Theories

Behaviorist Theory

- Motivation is the result of responses to reinforcement.

Cognitive Theory

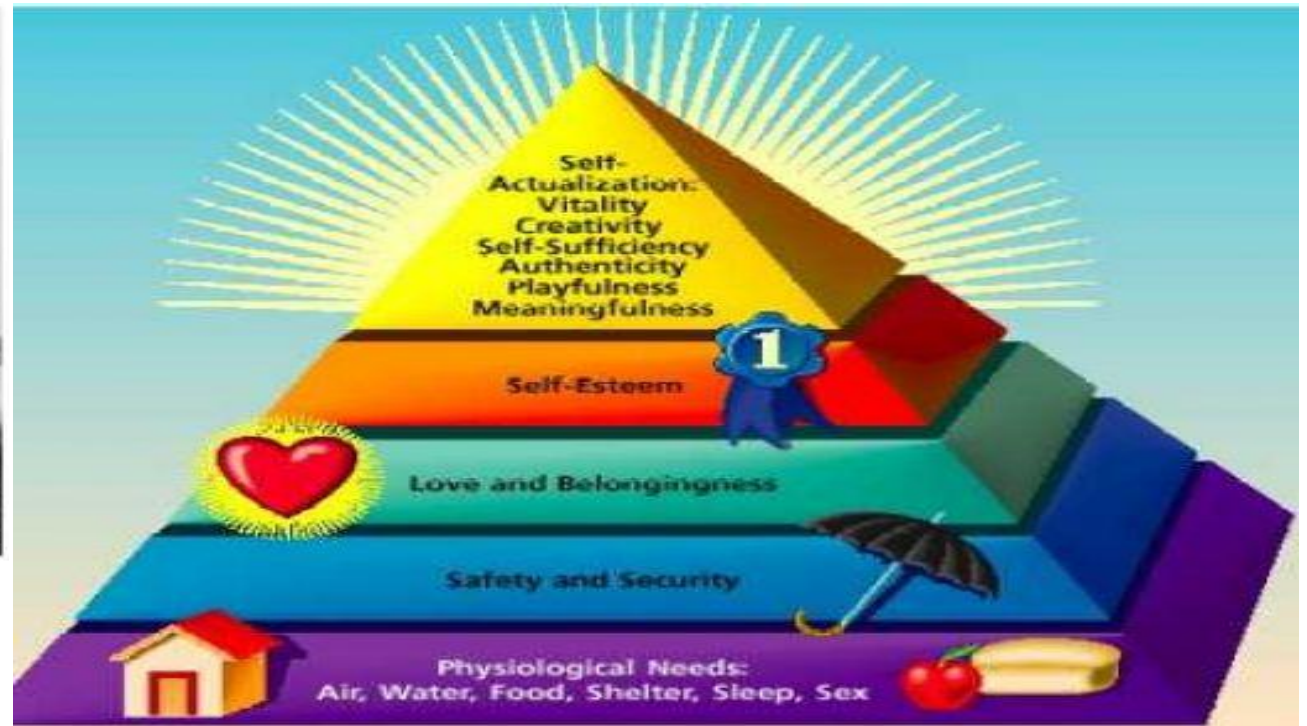
- Motivation results from individuals attempting to maintain order or balance and an understanding of the world.

Humanist Theory

- Motivation results from individuals attempting to fulfill their full potential as human beings.

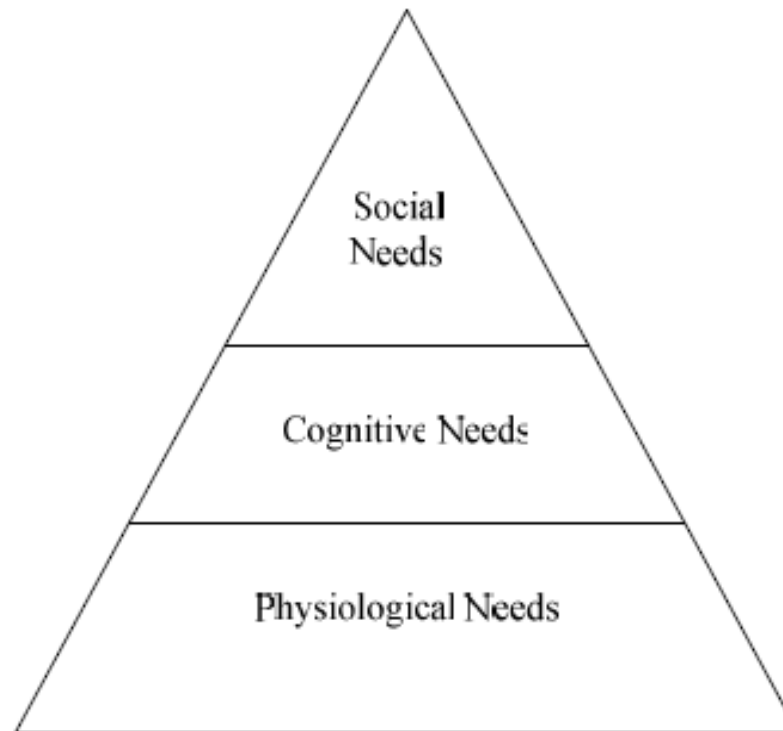
--Wiseman & Hunt, 2001

Need Hierarchy Theory



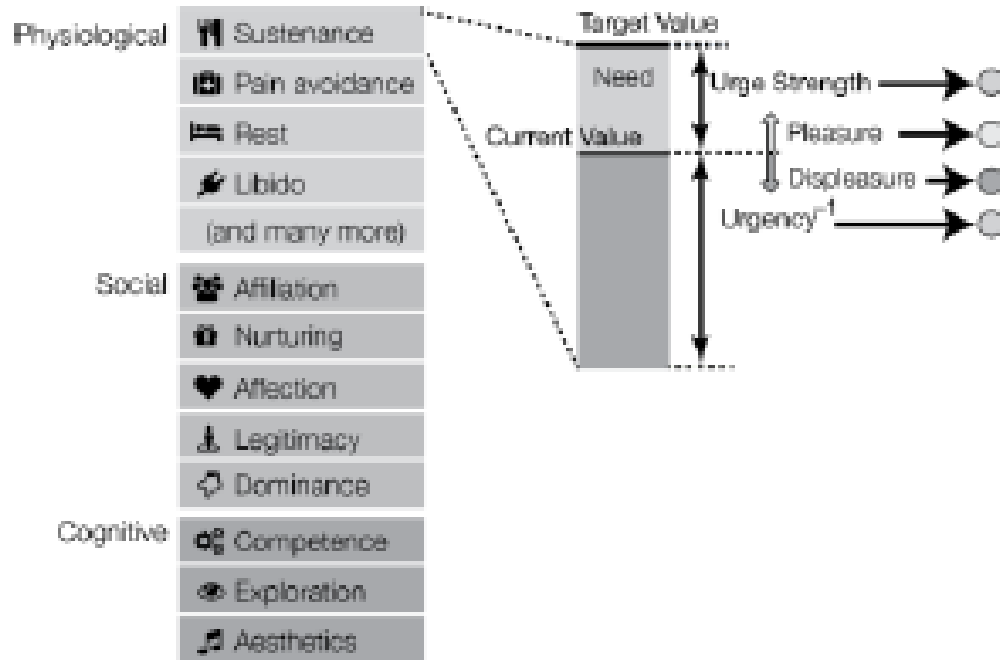
Maslow's-Hierarchy of needs theory is based on the assumption that people are motivated by a series of five universal needs.

Hierarchy of Agent Needs



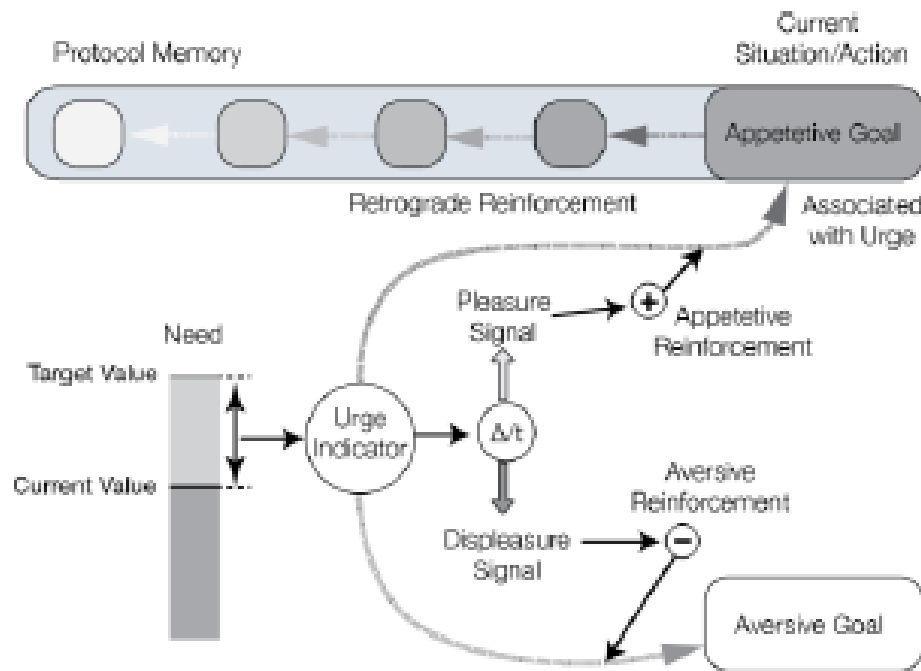
Bach uses Psi theory to define a possible solution for a drive-based, poly-thematic motivational system.

MicroPsi2 Urgency



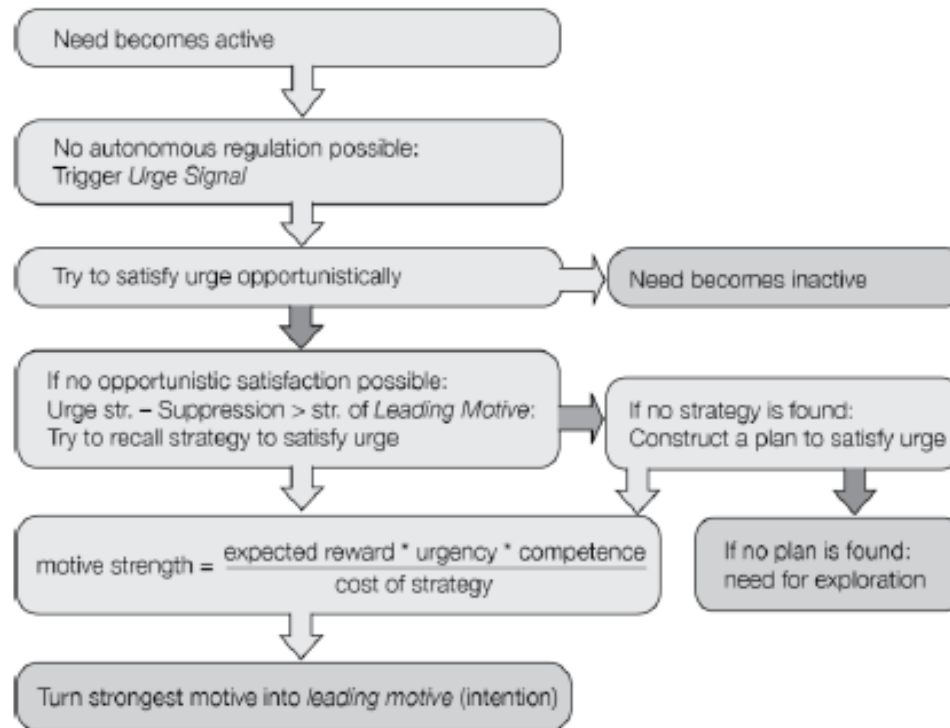
J Bach. Modeling Motivation in MicroPsi 2. AGI-15, Springer International Publishing, 2015 : 3-13

MicroPsi2 Urgency



J Bach. Modeling Motivation in MicroPsi 2. AGI-15, Springer International Publishing, 2015 : 3-13

Urgency-based MicroPsi2 Decision-Making



J Bach. Modeling Motivation in MicroPsi 2. AGI-15, Springer International Publishing, 2015 : 3-13

Motivation Learning in CAM

- 1. Observe $\mathbf{O}_{S(t)}$ from $\mathbf{S}_{(t)}$ using the observation function
- 2. Subtract $\mathbf{S}_{(t)} - \mathbf{S}_{(t')}$ using the difference function
- 3. Compose $\mathbf{E}_{S(t)}$ using the event function
- 4. Look for $\mathbf{N}(t)$ using introspective search
- 5. Repeat (for each $N_i(t) \in \mathbf{N}(t)$)
- 6. Repeat (for each $I_j(t) \in \mathbf{I}(t)$)
- 7. $Attention = \max I_j(t)$
- 8. Create a *Motivation by Attention*.

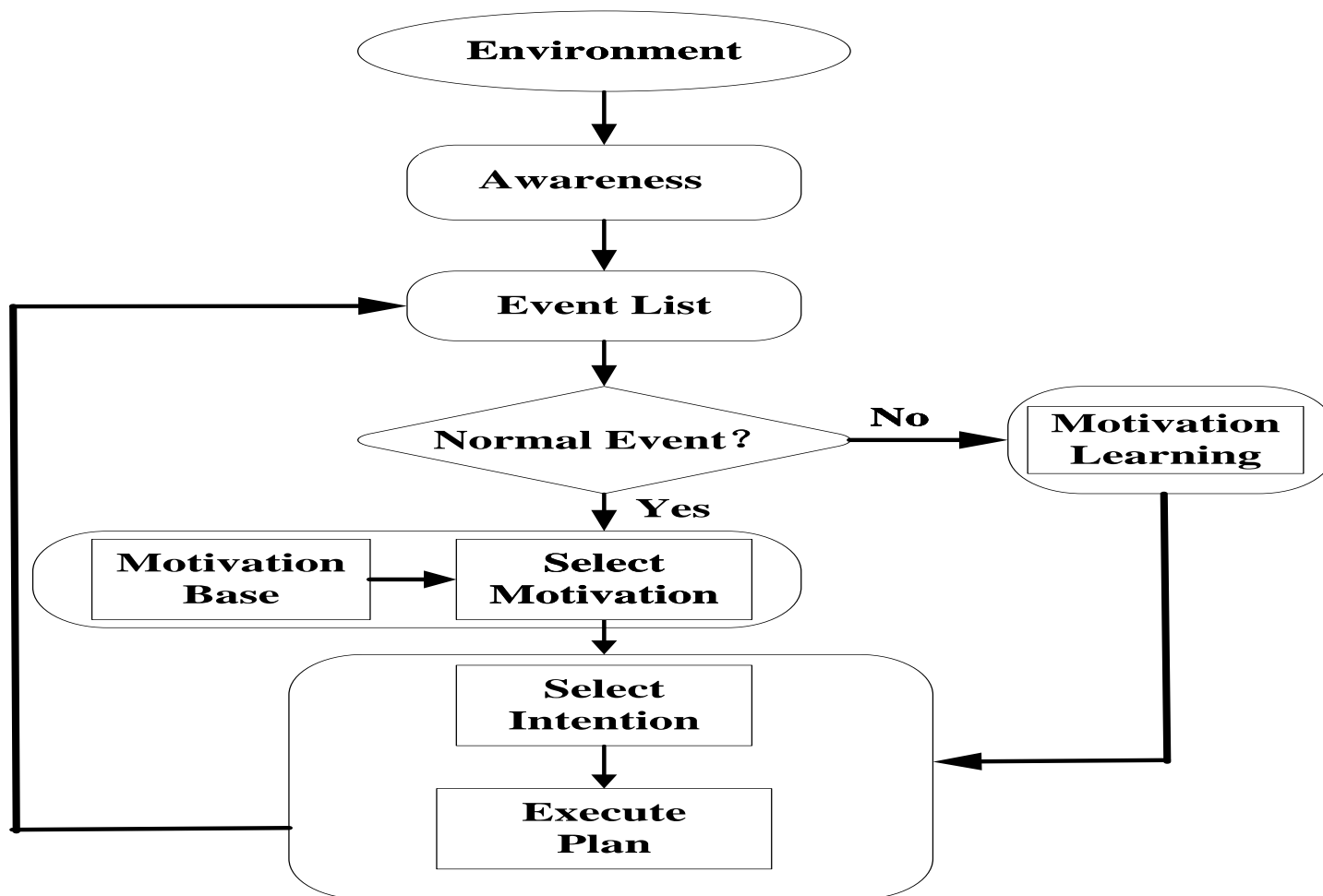
Motivation Rules

- Motivation could be represented as a 3-tuples $\{N, G, I\}$, where N means needs, G is goal, I means the motivation intensity. A motivation is activated by motivational rules which structure has following format:

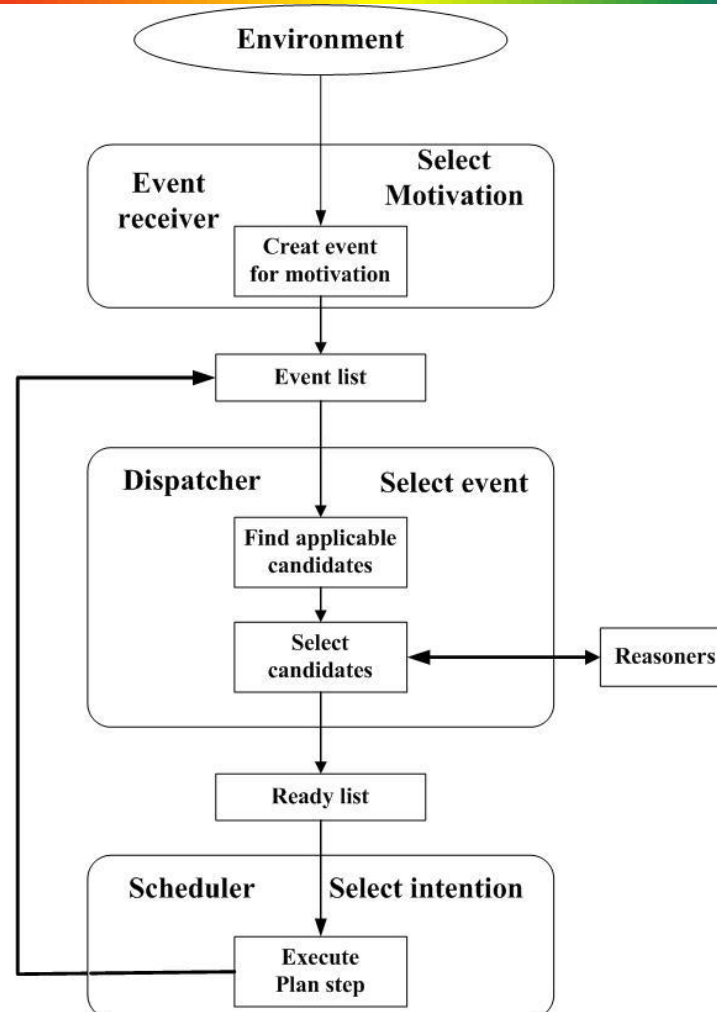
$$R=(P, D, \text{Strength}(P|D))$$

- where, P indicates the conditions of rule activation; D is a set of actions for the motivation; $\text{Strength}(P|D)$ is a value within interval $[0, 1]$.

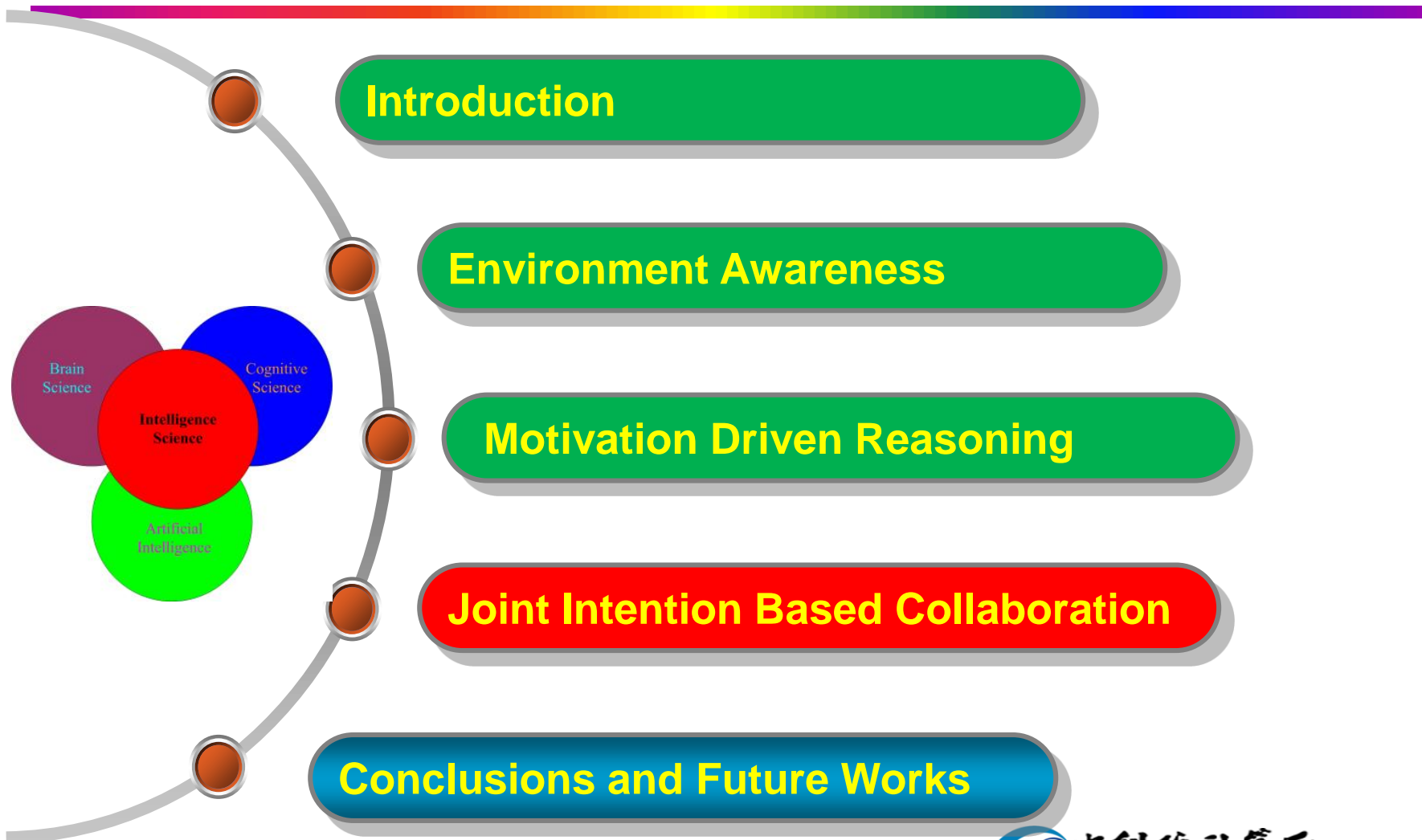
Motivation Module in CAM



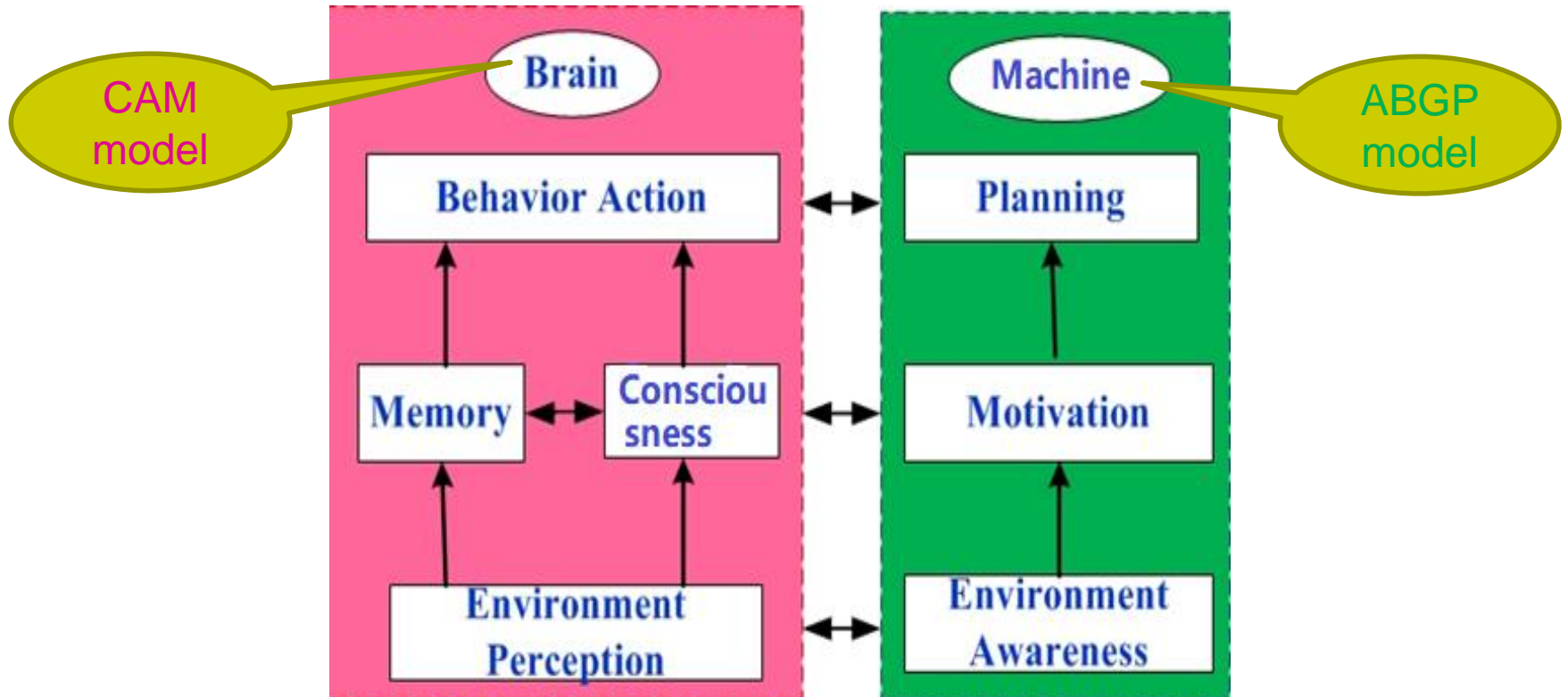
Motivation System in CAM



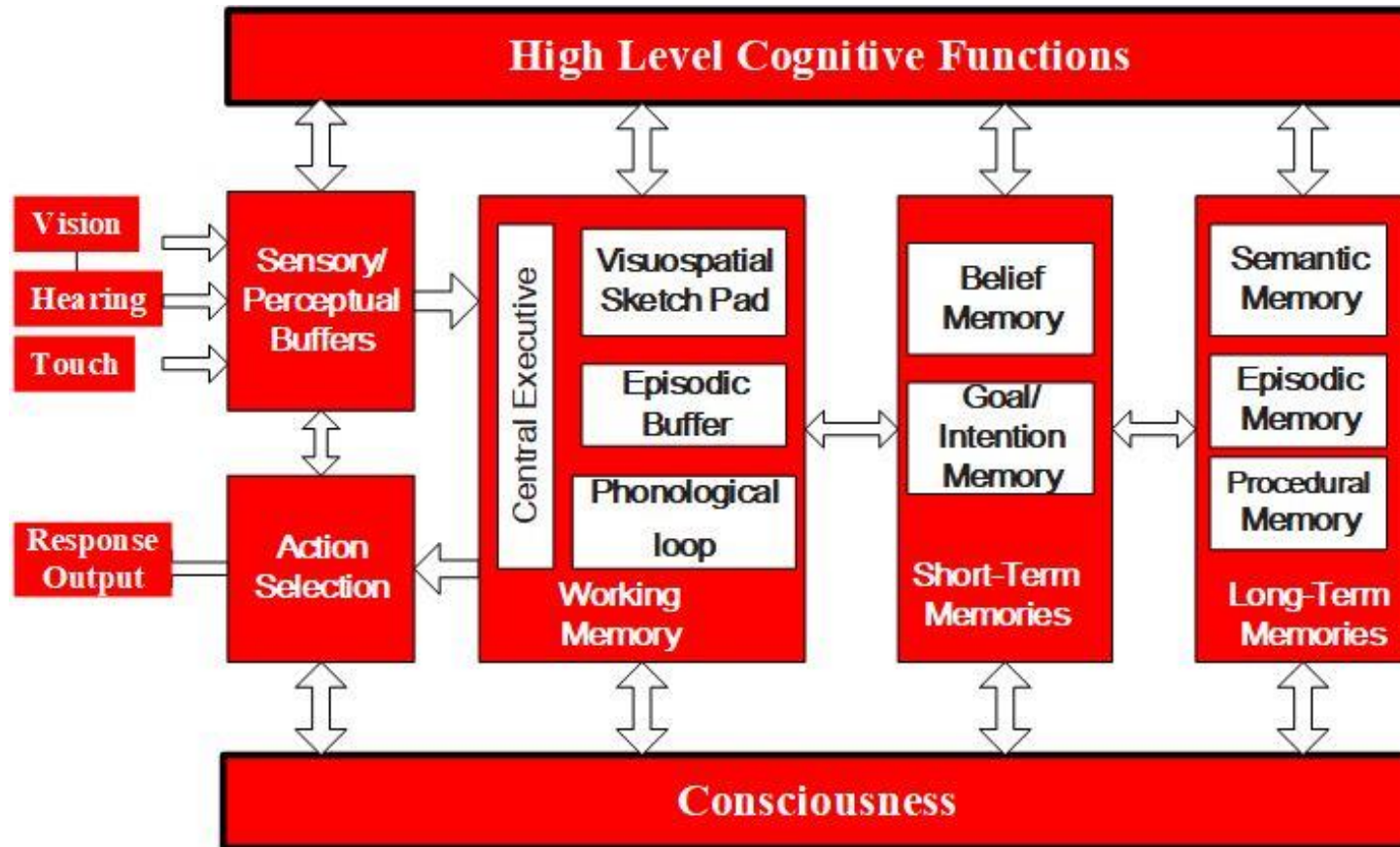
Contents Outline



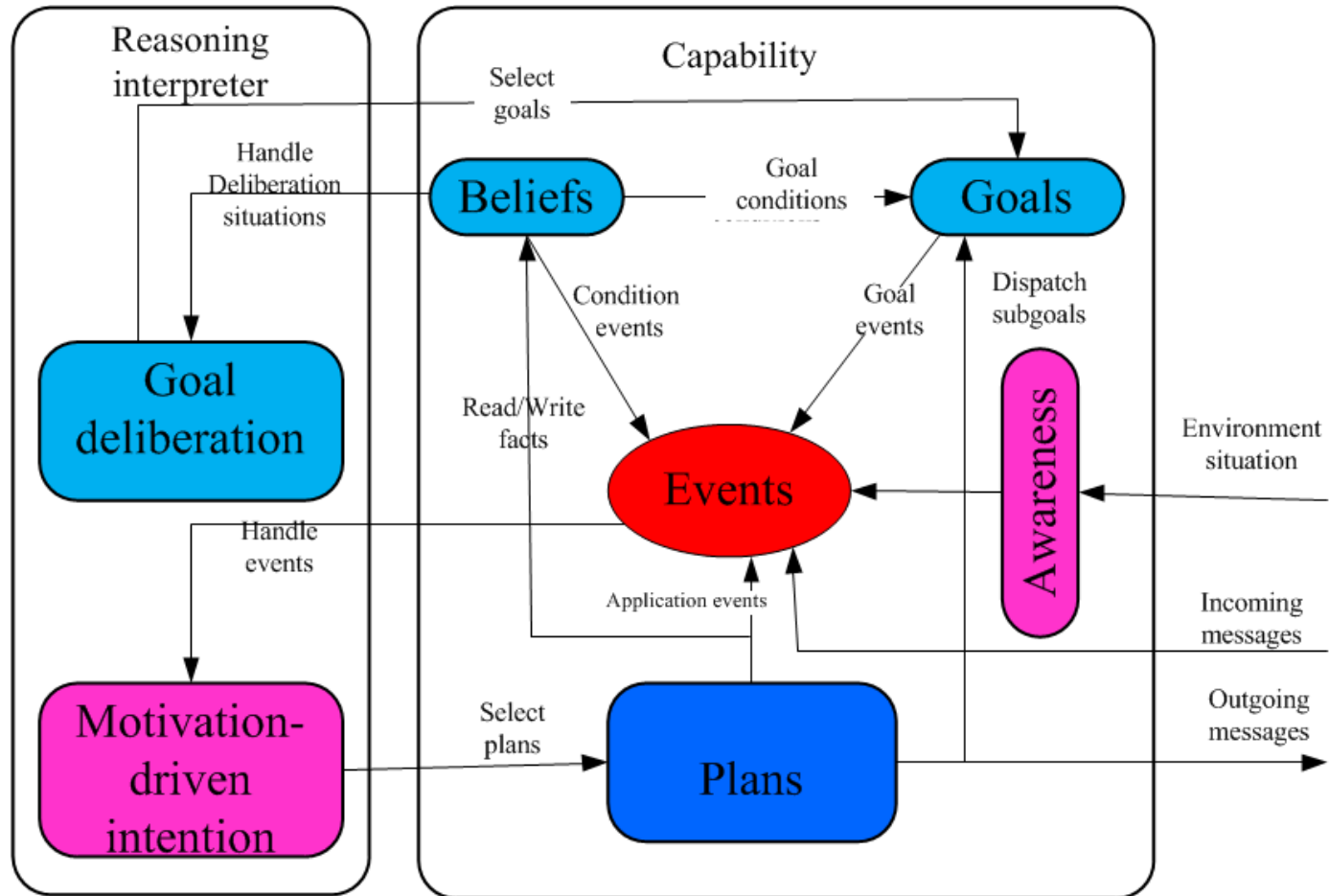
Cognitive Model of Brain Machine Integration



Mind Model CAM



ABGP Model



Joint Intention

- In the joint-intention theory, a team is defined as “a set of agents having a shared objective and a shared mental state.”
- Agent joint intention means an agent wants to achieve a formula, which corresponds to the agent’s goal.
- A joint intention to perform a particular action is a joint commitment to enter a future state wherein the agents mutually believe the collaborative action is imminent just before they perform it

Individual Intentions

- 1984 Bratman, BDI
- 1990 Cohen and Levesque, intention model.
- 1990 Pollack, intention model
- 1988/1989 Werner, intention model,
Social role $R_{rol} = \langle I_{rol}, S_{rol}, V_{rol} \rangle$

Joint Intentions

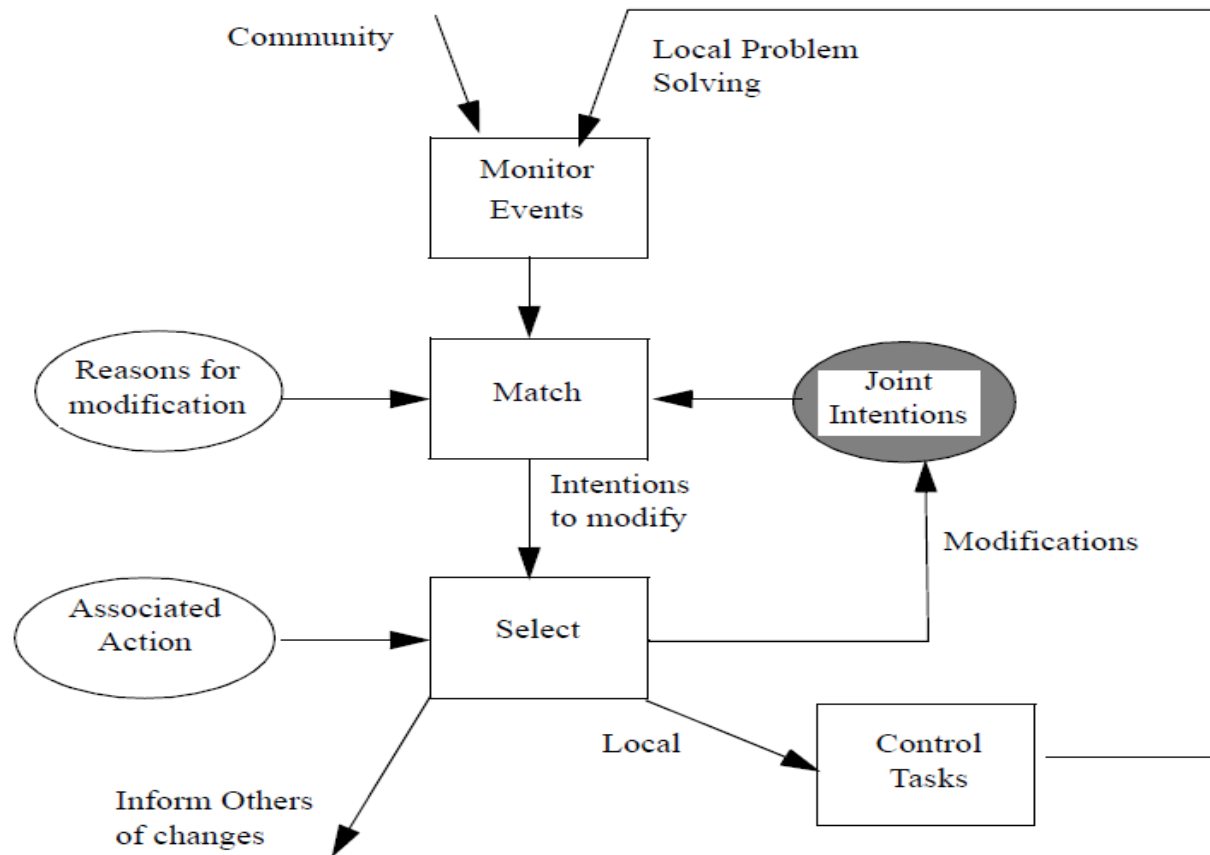
- 1989 Conte, Group Mind
- 1990 Searle, collective intentions
- 1990 Grosz and Sidner, Shared Plan
- 1988 Tuomela and Miller, we-intentions
- 1990 Rao *et al.* *Social Plans*
- 1990 Singh Group Intentions

Joint Intentions

1992 Jennings claimed the need to describe collectives as well as individuals.

- agents must agree on a common goal.
- agents must agree they wish to collaborate to achieve their shared objective.
- agents must agree a common means of reaching their objective.
- action inter-dependencies exist and must be catered for in general terms.

GRATE* : A Cooperation Knowledge Level System

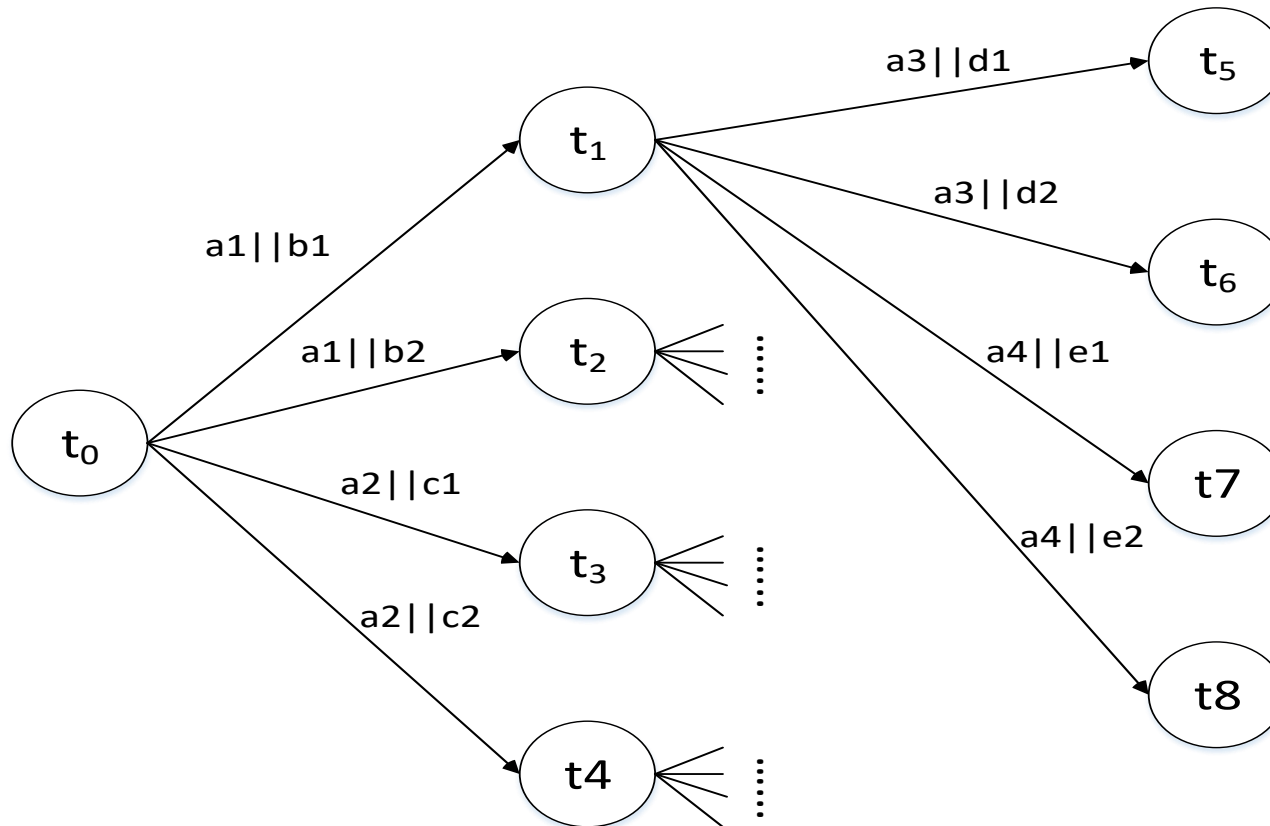


Nicholas Robert Jennings. Joint Intentions as a Model of Multi-Agent Cooperation in Complex Dynamic Environments. University of London, 1992.

2018/7/4

Zhongzhi Shi: Brain Machine Integration

Joint Intention



Description Logic

Description Logic

- Concepts and Role
- Tbox——Assertions
- Abox——Instance
- Reasoning mechanism in terms of Tbox and Abox

Description Logic

TBox(Scheme)

Man = Human \sqcap Male

Happy-father = Human \sqcap \exists Has-child. Female \sqcap ...

Abox(Data)

John: Happy-father

<John, Mary> : Has-child

Reasoning

Interface

Dynamic Description Logic

- **Concept name:** C_1, C_2, \dots ;
- **Role name:** R_1, R_2, \dots ;
- **Individual constant:** a, b, c, \dots ;
- **Individual variable:** x, y, z, \dots ;
- **Concept operation:** $\neg, \sqcap, \sqcup, \exists, \forall$;
- **Axiom operation:** $\neg, \wedge, \rightarrow \forall$;
- **Action:** A_1, A_2, \dots ;
- **Action construction :** ; (composition) , U (alternation), * (repeat), ? (test);
- **Action variable:** α, β, \dots ;
- **Axiom variable:** $\varphi, \psi, \square, \dots$;
- **State variable:** u, v, w, \dots ;

Dynamic Description Logic

Concepts in DDL are defined as the following:

- ***(1) Primitive concept P , top \top and bottom \perp are concepts.***
- ***(2) $\neg C$, $C \sqcap D$, $C \sqcup D$ are concepts.***
- ***(3) $\exists R.C$, $\forall R.C$ are concepts.***

Dynamic Description Logic

An action description is the form of

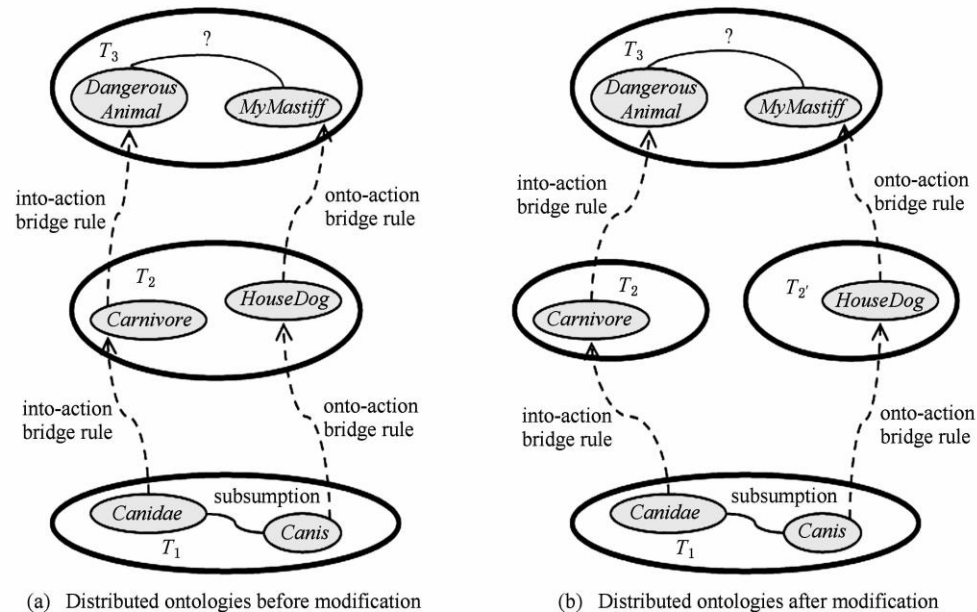
$$A(x_1, \dots, x_n) = (P_A, E_A)$$

where

- (1) A is the action name.*
- (2) x_1, \dots, x_n are individual variables, which denote the objects the action operate on.*
- (3) P_A is the set of preconditions, which must be satisfied before the action is executed.*
- (4) E_A is the set of results, which denote the effects of the action.*

Distributed Dynamic Description Logic

Bridge rules provide an important mechanism describing semantic mapping and propagating knowledge for distributed dynamic description logics(D3L). The current research focuses on the homogeneous bridge rules which only contain atomic element



Xiaofei Zhao, Dongping Tian, Limin Chen, Zhongzhi. Reasoning Theory for D3L with Compositional Bridge Rules. IFIP IIP 2012, 2012, 106-115.

Distributed Dynamic Description Logic

Each BR_{ij} is a collection of bridge rules in direction from T_i to T_j which are of four forms:

$i: C \xrightarrow{\sqsubseteq} j: E$ (into-concept (relation) bridge rule);

$i: C \xrightarrow{\sqsupseteq} j: E$ (onto- concept (relation) bridge rule);

$i: \alpha \xrightarrow{\sqsubseteq} j: \beta$ (into-action bridge rule);

$i: \alpha \xrightarrow{\sqsupseteq} j: \beta$ (onto-action bridge rule).

Xiaofei Zhao, Dongping Tian, Limin Chen, Zhongzhi. Reasoning Theory for D3L with Compositional Bridge Rules. IFIP IIP 2012, 2012, 106-115.

Collaborative Decision Making

Collaborations occur over time as organizations interact formally and informally through repetitive sequences of negotiation, and commitment development and execution. Under the support of the National Program on Key Basic Research Project (973) we focus on Computational Cognitive Models for Brain–Machine Collaborations:

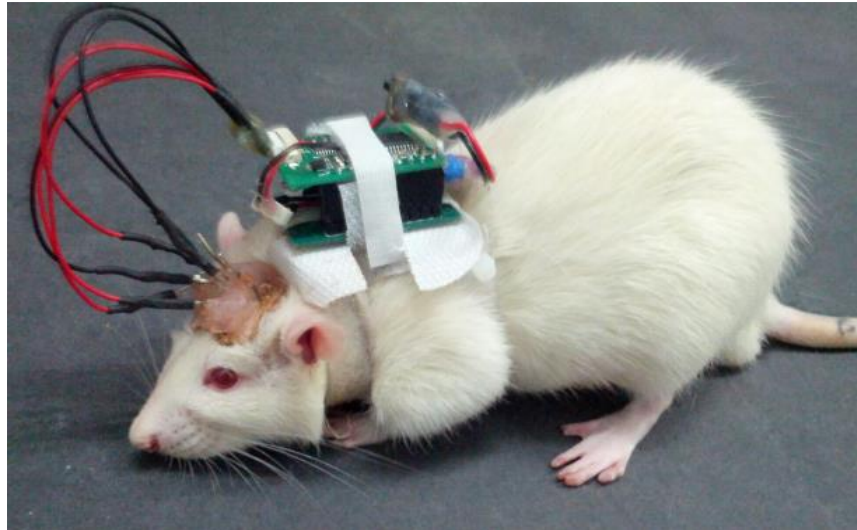
- **Awareness-Based Collaboration**
- **Motivation-Based Collaboration**
- **Joint Intention-Based Collaboration**

*Zhongzhi Shi, Jianhua Zhang, Xi Yang, Gang Ma, Baoyuan Qi, Jinpeng Yue.
Computational Cognitive Models for Brain-Machine Collaborations. IEEE Intelligent Systems 29(6): 24-31 (2014).*

Maze Simulation of Rat Cyborg

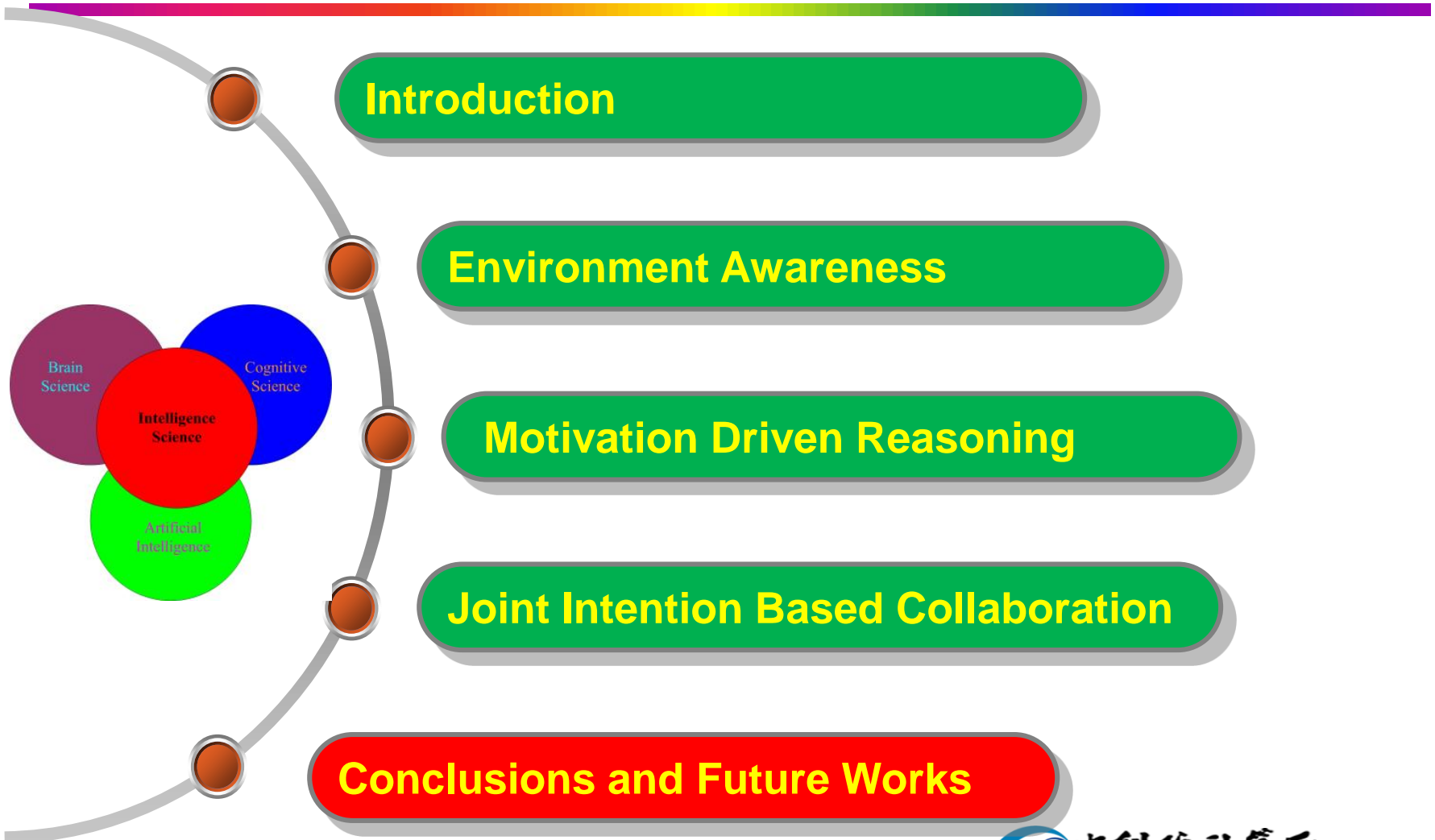


Rat Cyborg



In the automatic navigation of rats, five bipolar stimulating electrodes separately are implanted in medial forebrain bundle (MFB), somatosensory cortices (SI), and periaqueductal gray matter (PAG) of the rat brain. There is also a backpack fixed on the rat to receive the wireless commands.

Contents Outline



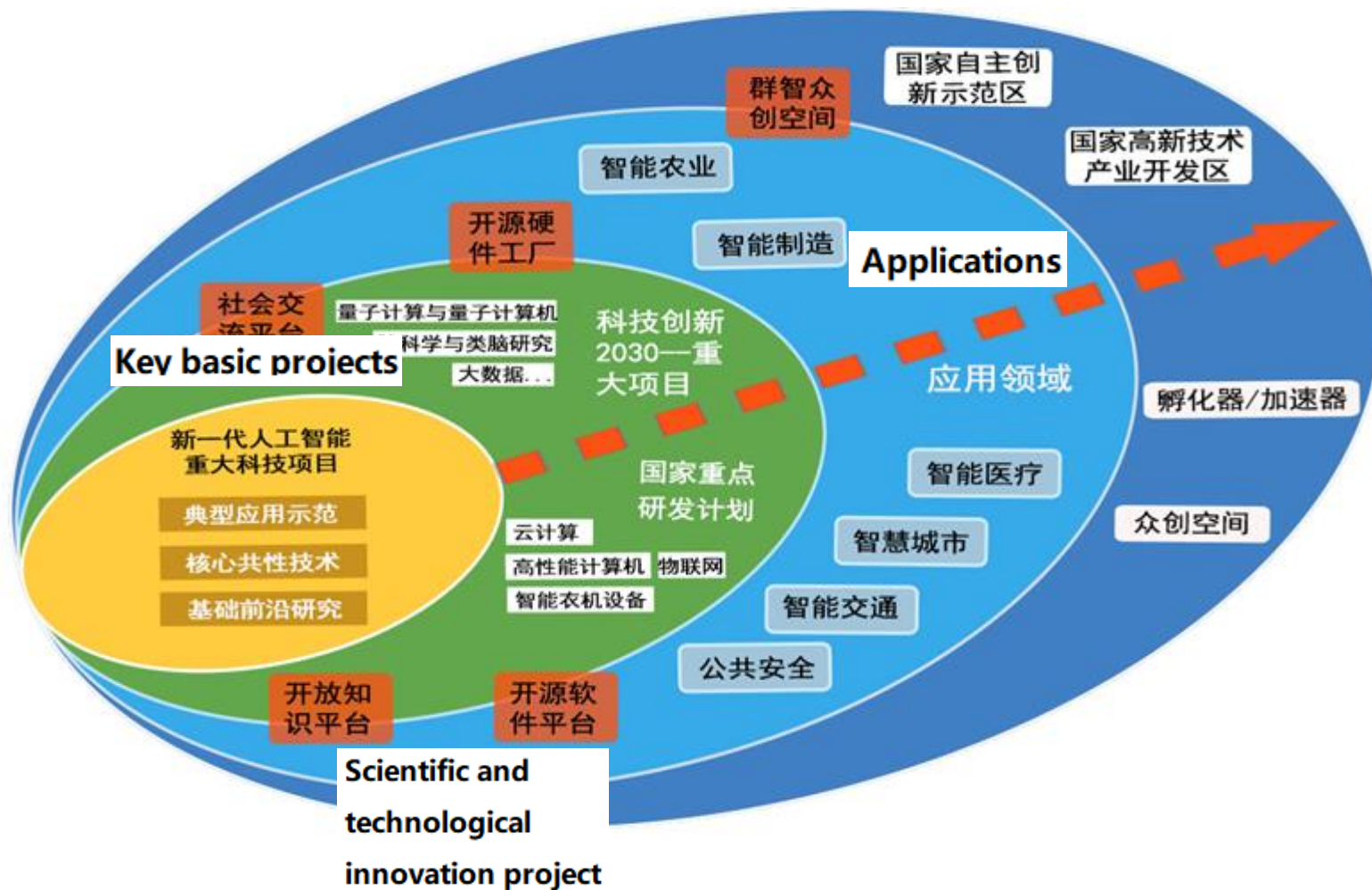
Conclusions

- Intelligence Science is the road to human-level artificial intelligence.
- Develop a cognitive model of brain machine integration
- Environment awareness, motivation and joint intention for collaborative decision-making

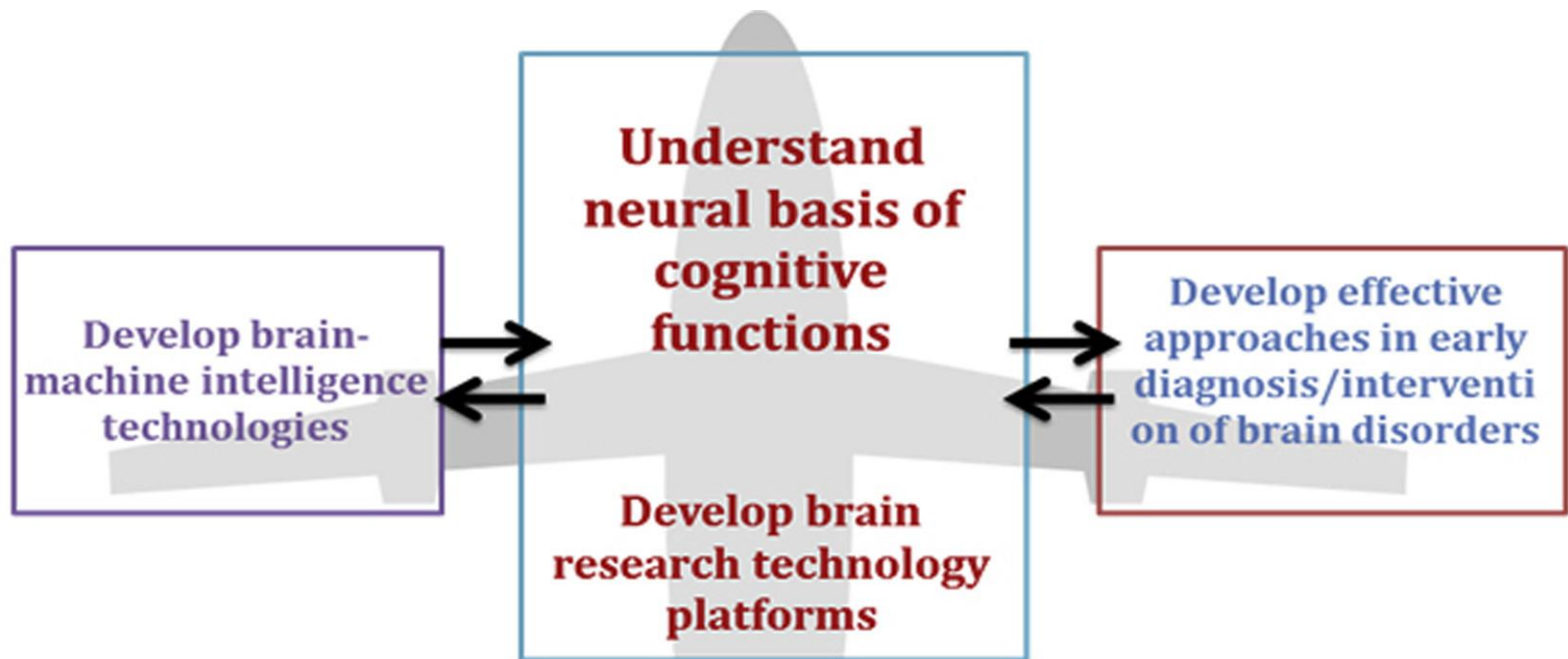
China Intelligentization

- ☛ 20 July 2017, The State Council of China issued The Development Plan of the **New Generation Artificial Intelligence**.
- ☛ The Development Plan of the **Brain Science and Brain-like Intelligence** are under working.

A Sketch Map of the New Generation of AI development planning



Brain Science and Brain Inspired Project

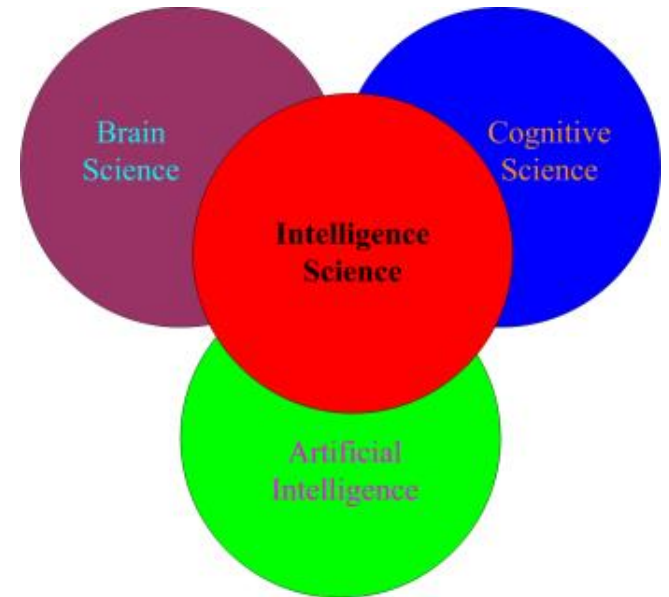


“One body two wings (一体两翼)”

Building the core and developing the applications

Thank You

Question!



Intelligence Science
<http://www.intsci.ac.cn/>