# IFIP Advances in Information and Communication Technology 539

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## IFIP – The International Federation for Information Processing

IFIP was founded in 1960 under the auspices of UNESCO, following the first World Computer Congress held in Paris the previous year. A federation for societies working in information processing, IFIP's aim is two-fold: to support information processing in the countries of its members and to encourage technology transfer to developing nations. As its mission statement clearly states:

> *IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.*

IFIP is a non-profit-making organization, run almost solely by 2500 volunteers. It operates through a number of technical committees and working groups, which organize events and publications. IFIP's events range from large international open conferences to working conferences and local seminars.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

IFIP distinguishes three types of institutional membership: Country Representative Members, Members at Large, and Associate Members. The type of organization that can apply for membership is a wide variety and includes national or international societies of individual computer scientists/ICT professionals, associations or federations of such societies, government institutions/government related organizations, national or international research institutes or consortia, universities, academies of sciences, companies, national or international associations or federations of companies.

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Zhongzhi Shi · Cyriel Pennartz
Tiejun Huang (Eds.)

# Intelligence Science II

Third IFIP TC 12 International Conference, ICIS 2018
Beijing, China, November 2–5, 2018
Proceedings

Springer

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# Preface

This volume comprises the proceedings of the Third International Conference on Intelligence Science (ICIS). Artificial intelligence research has made substantial progress in certain areas to date. However, the deeper understanding of the essence of intelligence is far from sufficient and, therefore, many state-of-the-art intelligent systems are still not able to compete with human intelligence. To advance the research in artificial intelligence, it is necessary to investigate intelligence, both artificial and natural, in an interdisciplinary context. The objective of this conference is to bring together researchers from brain science, cognitive science, and artificial intelligence to explore the essence of intelligence and the related technologies. The conference provides a platform for discussing some of the key issues that are related to intelligence science.

For ICIS 2018, we received more than 85 papers, of which 44 papers were included in this program as regular papers and four as short papers. We are grateful for the dedicated work of both the authors and the referees, and we hope these proceedings will continue to bear fruit over the years to come. All papers submitted were reviewed by three referees.

A conference such as this cannot succeed without help from many individuals who contributed their valuable time and expertise. We want to express our sincere gratitude to the Program Committee members and referees, who invested many hours for reviews and deliberations. They provided detailed and constructive review reports that significantly improved the papers included in the program.

We are very grateful for the sponsorship of the following organizations: Chinese Association for Artificial Intelligence (CAAI), IFIP TC12, China Chapter of International Society for Information Studies, Peking University, and supported by Beijing Association for Science and Technology (BAST), Shanghai Association for Science and Technology (SAST), Beijing Association for Artificial Intelligence (BAAI), CIE Signal Processing Society and Institute of Computing Technology, Chinese Academy of Sciences. Thanks to Professor Jinwen Ma, who served as chair of the Organizing Committee, and Dingsheng Luo as secretary general.

Finally, we hope you find this volume inspiring and informative.

August 2018

Zhongzhi Shi
Cyriel Pennartz
Tiejun Huang

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# Abstracts of Keynote and Invited Talks

# Progress Toward a High-Performance Brain Interface

Andrew Schwartz

Department of Neurobiology,
University of Pittsburgh

**Abstract.** A better understanding of neural population function would be an important advance in systems neuroscience. The change in emphasis from the single neuron to the neural ensemble has made it possible to extract high-fidelity information about movements that will occur in the near future. Information processing in the brain is distributed and each neuron encodes many parameters simultaneously. Although the fidelity of information represented by individual neurons is weak, because encoding is redundant and consistent across the population, extraction methods based on multiple neurons are capable of generating a faithful representation of intended movement. A new generation of investigation is based on population-based analyses, focusing on operational characteristics of the motor system. The realization that useful information is embedded in the population has spawned the current success of brain-controlled interfaces. This basic research has allowed to us to extract detailed control information from populations of neural activity in a way that this can be used to restore natural arm and hand movement to those who are paralyzed. We began by showing how monkeys in our laboratory could use this interface to control a very realistic, prosthetic arm with a wrist and hand to grasp objects in different locations and orientations. This technology was then extended to a paralyzed patient who cannot move any part of her body below her neck. Based on our laboratory work and using a high-performance "modular prosthetic limb," she was able to control 10 degrees-of-freedom simultaneously. The control of this artificial limb was intuitive and the movements were coordinated and graceful, closely resembling natural arm and hand movement. This subject was able to perform tasks of daily living– reaching to, grasping and manipulating objects, as well as performing spontaneous acts such as self-feeding. Current work with a second subject is progressing toward making this technology more robust and extending the control with tactile feedback to sensory cortex. New research is aimed at understanding the neural signaling taking place as the hand interacts with objects and together, this research is a promising pathway toward movement restoration for those who are paralyzed.

# Predicting the Present: Experiments and Computational Models of Perception and Internally Generated Representations

Cyriel M. A. Pennartz

Cognitive and Systems Neuroscience Group,
University of Amsterdam

**Abstract.** The last three decades have witnessed several ideas and theories on brain-consciousness relationships, but it is still poorly understood how brain systems may fulfill the requirements and characteristics we associate with conscious experience. This lecture will first pay attention to the basic requirements for generating experiences set in different modalities, such as vision and audition, given the rather uniform nature of signal transmission from periphery to brain. We will next examine a few experimental approaches relevant for understanding basic processes underlying consciousness, such as changes in population behavior during sensory detection as studied with multi-area ensemble recordings. For visual detection, the primary sensory cortices have been a long-standing object of study, but it is unknown how neuronal populations in this area process detected and undetected stimuli differently. We investigated whether visual detection correlates more strongly with the overall response strength of a population, or with heterogeneity within the population. Zooming out from visual cortex to larger neural systems, we asked how "visual" the visual cortex actually is by studying auditory influences on this system and considering interactions between visual and auditory systems. Finally, we will consider the topic of perception in the context of predictive coding. Predictive coding models aim to mimic inference processes underlying perception in the sense that they can learn to represent the hidden causes of the inputs our sensory organs receive. They are not only about "predicting-in-time" but also about predicting what is currently going on in the world around us – "predicting the present". I will present novel work on predictive coding in deep neural networks, and link the inferential and generative properties of these networks to conscious representations. I will argue that a productive way forward in research on consciousness and perception comes from thinking about world representations as set across different levels of computation and complexity, ranging from cells to ensembles and yet larger representational aggregates.

# Brain Science and Artificial Intelligence

Xu Zhang

Institute of Brain-Intelligence Science and Technology,
Zhangjiang Laboratory, Institute of Neuroscience,
Chinese Academy of Sciences,
Shanghai Branch of Chinese Academy of Sciences, China

**Abstract.** Cognition is the mental action or process of acquiring knowledge and understanding through thought, experience and the senses. The processes can be analyzed from different perspectives within different contexts, notably in the fields of linguistics, anesthesia, neuroscience, psychiatry, psychology, education, philosophy, anthropology, biology, systemic, logic and computer science. So far, we still do not know how many neuron types, neural circuits and networks in our brain. It is important to construct the basis for deciphering brain and developing brain-inspired artificial intelligence (AI). In 2012, Chinese Academy of Sciences started the Strategic Priority Research Program, mapping brain functional connections. This research program tried to set up new research teams for interpreting and modeling the brain function-specific neural connectivity and network. In 2014, we started the Shanghai Brain-Intelligence Project, for translational research and R&D. We tried to map the somatosensory neuron types and their connectivity with single-cell Tech and the trans-synaptic tracers. We were also interested to link Neuroscience and AI development. Our team has produced the deep-learning, neural network processors, and achieved the applications of AI Tech, such as the speech recognition and translation technology, and the bionics of eyes and control system through the physiological, mathematical, physical and circuit models.

# Intelligence Science Will Lead the Development of New Generation of Artificial Intelligence

Zhongzhi Shi

Institute of Computing Technology,
Chinese Academy of Sciences

**Abstract.** The State Council of China issued the notice of the new generation AI development plan in last year. The notice points out that AI has become a new focus of international competition and a new engine of economic development. We must firmly grasp the great historical opportunity of the development of artificial intelligence, play the leading role of intelligence science and drive the national competitiveness to jump and leap forward. Intelligence Science is the contemporary forefront interdisciplinary subject which dedicates to joint research on basic theory and technology of intelligence by brain science, cognitive science, artificial intelligence and others. The presentation will outline the framework of intelligence science and introduce the cognitive model of brain machine integration, containing environment awareness, motivation driven automated reasoning and collaborative decision making. Finally, explore the principle of cognitive machine learning in terms of mind model CAM.

# Scientific Paradigm Shift for Intelligence Science Research

Yixin Zhong

Beijing University of Posts and Telecommunications

**Abstract.** Intelligence science is a newly inceptive and highly complex scientific field, which is the most height of information science while is rather different from the classical physic science. However, the research of intelligence science carried on so far has been basically following the scientific paradigm suitable for classical physic science. The incompatibility between the properties of intelligence science and the scientific paradigm suitable for classical physic science has caused many problems. For overcoming these problems and making good progress in intelligence science, the shift of the scientific paradigm from the one suitable for classical physic science to the one suitable for intelligence science is demanded. What is the concept of scientific paradigm then? What is the scientific paradigm suitable for intelligence science research? What kinds of progresses can be, or have been, achieved in intelligence science research through the scientific paradigm shift? These are the topics in the paper.

# Visual Information Processing – From Video to Retina

Tiejun Huang

Department of Computer Science, School of EE & CS,
Peking University, China

**Abstract.** Visual perception is a corner stone for human and machine. However, the conventional frame by frame video employed in computer vision system is totally different with the spike train on the visual fibers from the biological retina to the brain. This talk will give a background on the challenges for the visual big data processing nowadays, then introduce our works on mapping and simulation of the neural circuits in the primate retina, and a new sensor chip based on the spiking representation, to be potentiality used for machine vision including autonomous driving, robot perception etc.

# The Human Brainnetome Atlas and Its Applications in Neuroscience and Brain Diseases

Tianzi Jiang

Institute of Automation of the Chinese Academy of Sciences

**Abstract.** Brainnetome atlas is constructed with brain connectivity profiles obtained using multimodal magnetic resonance imaging. It is in vivo, with finer-grained brain subregions, and with anatomical and functional connection profiles. In this lecture, we will summarize the advance of the human brainnetome atlas and its applications. We first give a brief introduction on the history of the brain atlas development. Then we present the basic ideas of the human brainnetome atlas and the procedure to construct this atlas. After that, some parcellation results of representative brain areas will be presented. We also give a brief presentation on how to use the human brainnetome atlas to address issues in neuroscience and clinical research. Finally, we will give a brief perspective on monkey brainnetome atlas and the related neurotechniqes.

# A Brief Overview of Practical Optimization Algorithms in the Context of Relaxation

Zhouchen Lin

Fellow of IEEE, Peking University

**Abstract.** Optimization is an indispensable part of machine learning. There have been various optimization algorithms, typically introduced independently in textbooks and scatter across vast materials, making the beginners hard to have a global picture. In this talk, by explaining how to relax some aspects of optimization procedures I will briefly introduce some practical optimization algorithms in a systematic way.

# Clifford Geometric Algebra

Jiali Feng

Information Engineering College,
Shanghai Maritime University, Shanghai

**Abstract.** Turing question: "Can Machine think?" involves the basic contradiction in philosophy: "Could the material be able to have spiritual?" By it a secondary contradiction chain, that from the general matter to the life, to the advanced intelligence, can be induced. The law of unity of opposites of contradiction and the law of dialectical transformation have become the core issues that must be studied in Natural Sciences, Social Sciences, Noetic Sciences and Intelligence Sciences. The space-time position is the basic attribute of when and where things are represented. If take "two different things must not be in the same position at the same time" as the "simultaneous heterotopy" principle or basic assumption, and the exclusiveness between different objects based on "simultaneous heterotopic" can be equivalented the "overtness" of object, then whether a non-zero distance between two different objects is existing? or not, would not only is a criterion for the existence of differences between them, but also can be seen as a source of contradictions between the two. Since the range of displacement of one object, which such that the non-zero-distance between both contradictions could be maintained, can be considered as "the qualitative criterion" for its quality can be maintained, therefore, the law that "the quality of object can be remained, when the range of quantitative change does not exceed, can be expressed as a qualitative mapping from quantities to quality. The (non-essential) differences in the nature of object caused by different distances between two contradictions, can be expressed by the function of degree of conversion from quantity to quality. The movements, changes, developments of contradictory between both objects, and one changes to its opposites and so on, are regulated by the non-zero distance changes that accompany displacement varies with time, as well as changes of qualitative criterion. In mathematics, distance is defined as "the square root of the inner product of two vectors (positive definite)". The inner product is defined, in physics, as the work done by a force vector (or force function) on an object along with the direction of motion. The inner product is an invariant under the coordinate displacement translation and rotation, by which a polarization circle can be induced. When an object moves with a velocity under the action of a force, since distance is defined as the integral of velocity over time, but the integral of force and the inner product of the velocity is an outer product at the polarization vector. Using an application example, the analyzes about the mutual entanglement relation among the three definitions of distance, inner product and work function, and by it the Geometry Product = Inner product + Outer product (Clifford geometric algebra) structure are induced are presented in this paper, and the corresponding

attribute coordinate for representation of it is given too. In addition, combining with pattern classification and identification, the relationship and the differences between the theories and methods in this paper and the (Clifford and Capsule) Artificial Neural Network are discussed. It improves a referenceable way for the creation of Noetic Science, Intelligent Science, and Synthesis Wisdom.

# Urban Computing: Building Intelligent Cities Using Big Data and AI

Yu Zheng

Urban Computing Lab at JD Group

**Abstract.** Urban computing is a process of acquisition, integration, and analysis of big and heterogeneous data in cities to tackle urban challenges, e.g. air pollution, energy consumption and traffic congestion. Urban computing connects sensing technologies, data management and AI models, as well as visualization methods, to create win-win-win solutions that improve urban environment, human life quality and city operation systems. This talk presents the vision of urban computing in JD group, introducing the urban big data platform and a general design for intelligent cities. A series of deployed applications, such as big data and AI-driven location selection for business, AI-based operation optimization for power plants, and urban credit systems are also presented in this talk.

# New Approaches to Natural Language Understanding

Xiaohui Zou

Sino-American Searle Research Center

**Abstract.** This talk aims to disclose the know-how of launching a new generation of excellent courses and to develop the learning environment in which human-computer collaboration can optimize the expert knowledge acquisition. The method is to form a teaching environment that can be integrated online and offline with some technical platform of cloud classrooms, cloud offices and cloud conference rooms. Taking Chinese, English, classical and summary abstracts as examples, human-computer coordination mechanism, to do the appropriate new generation of quality courses. Its characteristics are: teachers and students can use the text analyzed method to do the fine processing of the same knowledge module, and only in Chinese or English, through the selection of keywords and terminology and knowledge modules, you can use the menu to select as the way to achieve knowledge. The module's precision machining can adopt the big production method that combines on the line first, complete coverage and accurate grasp each language point and knowledge point and original point even their respective combination. This method can finish fine processing instantly for any text segment. The result is the learning environment that enables human-computer collaboration to optimize the expert knowledge acquisition. Natural language understanding is only a research field that has great significance to human beings. Digital Chinese character chess, using numbers and Chinese characters as twin chess pieces, with their meaningful combination as a language point and knowledge point, the purpose is to find the original chess soul namely original point. Assume that every sentence, every paragraph, every article has at least one original point. Whether reading comprehension, writing expression, or even automatic recognition, it is intended to clearly highlight the original points, of course, also to list language points and knowledge points. These jobs were originally mainly experts' expertise, now and in the near future, computers will also be able to handle them automatically. Its significance is that this project of this learning environment software based on the National Excellent Courses is already owned by Peking University and that is constructed by using the numbers-words chessboard with the feature of the introduction on the knowledge big production mode for the textual knowledge module finishing. The new approaches obtains a breakthrough from three types of information processing, namely: phenomenon of object, intention, text and its implication on the nature of mechanism, principle, law, and even chaos or Tao, all can be paraphrased in sequence and positioning logic on essential information, linkage function on formal information and generalized translation on content information, under the guidance of language, knowledge, software three kinds of GPS, such as GLPS and GKPS and GSPS.

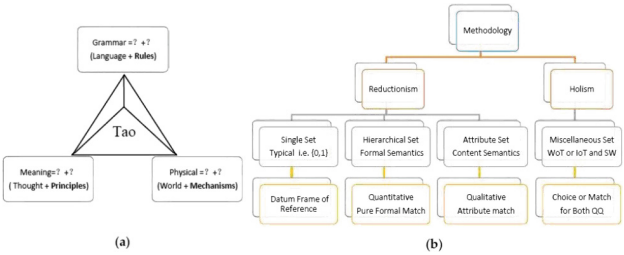


Fig. 1. Model a shows the biggest ontology; Model b shows how formal techniques of set systems link philosophical methodology and scientific methods system.


Fig. 2. Highlight bilingual pairs of Chinese and English arranged separately

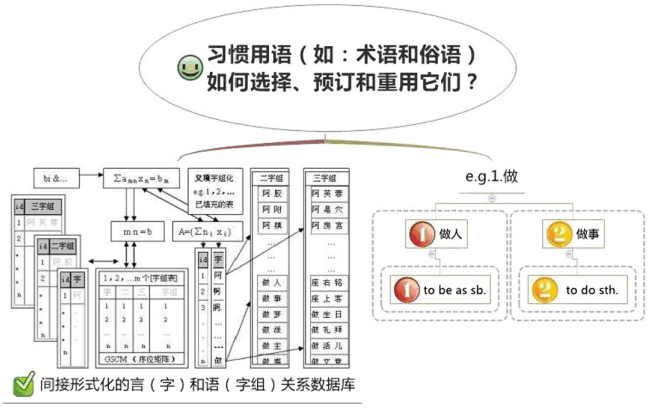


Fig. 3. Three types of bilingual systems as the GLPS and GKPS and GSPS

# Neuromorphic Computing: A Learning and Memory Centered Approach

Huajin Tang

Neuromorphic Computing Research Center,
Sichuan University, China

**Abstract.** Neuromorphic cognitive computing is a new theme of computing technology that aims for brain-like computing efficiency and intelligence. Neuromorphic computational models use neural spikes to represent the outputs of sensors and for communication between computing blocks, and using spike timing based learning algorithms. This talk will introduce the major concepts and developments in this interdisciplinary area from the learning and memory centered perspective, and discuss the major challenges and problems facing this field.

# Theory of Cognitive Relativity

Yujian Li

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Beijing University of Technology
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**Abstract.** The rise of deep learning has brought artificial intelligence (AI) to the forefront. The ultimate goal of AI is to realize a machine with human mind and consciousness, but existing achievements mainly simulate intelligent behavior on computer platforms. These achievements all belong to weak AI rather than strong AI. How to achieve strong AI is not known yet in the field of intelligence science. Currently, this field is calling for a new paradigm, especially Theory of Cognitive Relativity. The starting point of the theory is to summarize first principles about the nature of intelligence from the systematic point of view, at least including the Principle of World's Relativity and the Principle of Symbol's Relativity. The Principle of World's Relativity states that the subjective world an intelligent agent can observe is strongly constrained by the way it perceives the objective world. The Principle of Symbol's Relativity states that an intelligent agent can use any physical symbol system to describe what it observes in its subjective world. The two principles are derived from scientific facts and life experience. Thought experiments show that they are of great significance to understand high-level intelligence and necessary to establish a scientific theory of mind and consciousness. Other than brain-like intelligence, they indeed advocate a promising change in direction to realize different kinds of strong AI from human and animals. A revolution of intelligence lies ahead.

**Keywords:** The principle of world's relativity · The principle of symbol's relativity · First principles · Thought experiments · Artificial intelligence

# Two-layer Mixture of Gaussian Processes for Curve Clustering and Prediction

Jinwen Ma

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**Abstract.** The mixture of Gaussian processes is capable of learning any general stochastic process for a given set of (sample) curves for regression and prediction. However, it is ineffective for curve clustering analysis and prediction when the sample curves come from different stochastic processes as independent sources linearly mixed together. In fact, curve clustering analysis becomes very important in the modern big data era, but it is a very challenging problem. Recently, we have established a two-layer mixture model of Gaussian processes to describe such a mixture of general stochastic processes or independent sources, especially effective for curve clustering analysis and prediction. This talk describes the learning paradigm of this new two-layer mixture of Gaussian processes, introduces its MCMC EM algorithm and presents some effective practical applications on curve clustering analysis and prediction.

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