SCHOOL OF INFORMATION SCIENCE 2014

JAIST
JAPAN ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY
1990

National University Corporation
Japan Advanced Institute of Science and Technology

School of Information Science: General Statements

The following summarizes the uniqueness of the school.

Having only graduate courses allows us to offer advanced research opportunities

JAIST was established in 1990 as an independent national graduate university. It has no undergraduate programs or departments. The unique feature of our school is to allow faculty members and students to work together on advanced research around the clock.

The largest education and research institute on information science in Japan

The school that is including the Research Center for Advanced Computing Infrastructure is the largest education and research institute on information science in Japan. Taking full advantage of a newborn university and keeping ourselves apart from the conservative and bureaucracy, we have succeeded in gathering researchers who were active in the information science field from both universities and industries. Since 1990, our activities in education and research have been highly recognized by every layer of society.

Well-organized courses and highly sophisticated program

The school provides the courses that are well-organized and the program that is highly sophisticated. The curriculum is designed to so that students can acquire basic-to expert knowledge towards the world-class researchers and engineers. Because our facilities are supported by the effective and efficient backbone system, lecture materials and videoed lectures are distributed via the Internet and the coursework can be reported via the electronic communication. This flexible and efficient lecture system enables students to access without the constraints of time and place.

Contents

Research facilities and environments are supported by the state-of-the-art technologies

Our backbone system including the high speed networks, computer facilities, massively parallel systems, and software environments, which are regularly maintained by the Research Center for Advanced Computing Infrastructure. These state-of-the-art technologies have been ranked at the top level of among the universities and research institutes.

The best education and research environment

Every student is allocated to a laboratory. Students are given spacious and comfortable working space as their own "office". Besides that, they are given various computers that are accessible directly from their office via the high-speed network to concentrate their research work. The JAIST dormitory that can accommodate all the students has a room that is equipped with the network facility. Couple and family rooms are also available. Furthermore, a free shuttle bus service is available as commuter transportation between JAIST and the nearest train station, Tsurugi Station, which makes the access to the Kanazawa city easy and convenient. Also a free charter bus is available to the gate of the Hokuriku area, Komatsu Airport, which has a frequent flight to/from the major cities in Japan.

Joint research and collaboration with private sectors

The Center for Investigation of Advanced Science and Technology at JAIST, founded in 1993, monitors the trends and tendencies in science and technology, both domestic and international, and provides guideline and information of research directions to the researchers at JAIST. The center also promotes research partnerships with the private sectors and other parties so that the outcomes of research work conducted by JAIST can be transferred to and used by the private sectors.

Substantial support and assistance from the foundation

The foundation for JAIST that is the largest in its kind in Japan, sponsors education and research programs, international exchange, symposia and conferences, as well as partnerships with industry, government, and academia.

Staff and Laboratories

Theoretical Information Science Group

Professor	Hajime Ishihara	Mathematical Logic, Constructive Mathematics, and Theory of Computation	P 4
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Associate Professor	Kazumasa Omote	Network Security and Applied Cryptography	P 9
Research Professor	Yoh Somemura	Fostering ICT Global Leader / Green ICT toward low-carbon society	P 10
Research Associate Professor	Yuichi Futa	Construction of information security system	P 11
Assistant Professor Youta Ohtachi / Assistant Professor Koichi Kobayashi / Assistant Professor Jiageng Chen Assistant Professor Takako Nemoto / Assistant Professor Chunhua Su / Research Assistant Professor Satoru Tanaka			

Computer Systems and Networks Group

Professor	Yasushi Inoguchi	Massively Parallel Systems	P 12
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Professor	Tadashi Matsumoto	New Paradigm of Wireless Communications in Ubiquitous Environments	P 16
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Research Professor	Junichi Shimada	ICT Policy, Network Architecture	
Research Associate Professor	Takashi Okada	Solving social problems using simulation and data analysis	P 20
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Assistant Professor Khoirul Anwar / Assistant Professor Tomoaki Ukezono / Assistant Professor Renyuan Zhang Assistant Professor Satoshi Uda / Assistant Professor Yukinori Sato			

Software Science Group

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Research Professor	Koichiro Ochimizu	Software Engineering	P 29
Research Professor	Kokichi Futatsugi	Language Design, Formal Methods, CafeOBJ: toward next generation modeling languages	P 30
Assistant Professor Yuki Chiba / Assistant Professor Francois Pierre Andre Bonnet / Assistant Professor Kenrou Yatake Assistant Professor Keita Yokoyama / Assistant Professor Daniel Mircea Gaina			

Human Information Processing Group

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Professor	Nak-Young Chong	Realizing Intelligent Robots within Informatically Structured Environment	P 33
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Associate Professor	Masashi Unoki	Auditory-motivated sound signal processing	P 35
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Assistant Professor Shinichi Kawamoto / Assistant Professor Atsuo Suemitsu / Assistant Professor Fan Chen / Assistant Professor Sungmoon Jeong
Assistant Professor Kenta Hongou / Assistant Professor Ryota Miyauchi / Assistant Professor Daisuke Morikawa

Artificial Intelligence Group

Professor	Hiroyuki Iida	Entertainment, Intelligence and Game Information Dynamics	P 40
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Assistant Professor Katsuhiko Sano / Assistant Professor Alessandro Cincotti
Assistant Professor Simon Robert Michel Viennot

Visiting Chairs

Visiting Professor : Hu Zhenjiang (Linguistic science)
Visiting Professor : Osamu watanabe (Linguistic science)
Visiting Professor : Kazutoshi Wakabayashi (Cognitive Science)
Visiting Professor : Kenjiro Cho (Parallel and Distributed Systems)
Visiting Professor : Tomoji Kishi (Software Engineering)
Visiting Professor : Masayuki Nakamura (Green ICT)
Visiting Professor : Yasuyuki Sugiyama (Green ICT)

Laboratories Operated Jointly with Other Institutions

Visiting Professor : Takahide Matsutsuka (Integrated Processing of Information and Knowledge)
Visiting Associate Professor : Nobuhiro Yugami (Integrated Processing of Information and Knowledge)
Visiting Professor : Makoto Imase (Ultra high-speed communication network architecture)
Visiting Associate Professor : Hiroaki Harai (Ultra high-speed communication network architecture)
Visiting Associate Professor : Masaki Onishi (Distributed information processing)
Visiting Associate Professor : Tomohisa Yamashita (Distributed information processing)
Visiting Associate Professor : Yoshinao Isobe (Distributed information processing)
Visiting Professor : Shin-ichi Honiden (Advanced Software Engineering)
Visiting Associate Professor : Nobukazu Yoshioka (Advanced Software Engineering)
Visiting Associate Professor : Bac Hoai Le (Vietnam Information Science)
Visiting Associate Professor : Viet-Ha Nguyen (Vietnam Information Science)
Visiting Professor : Theeramunkong, Thanaruk (Thai Information Science)
Visiting Associate Professor : Wutiwiwatchai, Chai (Thai Information Science)
Visiting Associate Professor : Suntisrivaraporn, Boontawee (Thai Information Science)
Visiting Professor : Zhang,Jiawan (Tianjin Information Science)
Visiting Professor : Li, Xiaohong (Tianjin Information Science)
Visiting Professor : Liu, Baolin (Tianjin Information Science)

Ishihara Laboratory

Professor : Hajime Ishihara

Mathematical Logic, Constructive Mathematics, and Theory of Computation

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Research Overview

We are studying on mathematical logic, and on reconstruction of mathematics from the viewpoint of computability and complexity using techniques of mathematical logic. To promote the research, we are also studying constructive mathematics which is based on a weaker logic, called intuitionistic logic, than ordinal (classical) logic.

Between Mathematics and Information Science

Our research area is an interdisciplinary area between mathematics and information science. It is classified into mathematical logic or foundations of mathematics, as mathematics, and into theoretical computer science, as information science. We have been especially focusing on constructive mathematics, mathematical logic, and theory of computation.

Constructive mathematics

We have been exploring constructive mathematics as mathematics with intuitionistic logic which originated in Brouwer's intuitionistic mathematics and formalized by Heyting and Kolmogorov. We have been dealing with constructive functional analysis such as theory of Hilbert and Banach spaces and theory of distributions, and with constructive topological spaces such as neighbourhood spaces, formal topology, and basic pair. As a foundation of constructive mathematics, we have also been studying constructive set theory (CZF) which is a predicative system and has a quite natural interpretation in Martin-Löf type theory. Furthermore, we have been advocating, and leading a research on, constructive reverse mathematics which aims at classifying, arranging and systematizing mathematical theorems, in classical mathematics, Brouwer's intuitionistic mathematics and constructive recursive mathematics developed under different philosophies of mathematics, by logical principles and/or function existence axioms from a uniform point of view.

Mathematical logic

We have been studying proof theory and semantics of intuitionisitc logic. Since there is a natural correspondence, called the Curry-Howard correspondence, between proofs in intuitionistic logic and programs (terms of lambda-calculus), we are able to extract programs from proofs in intuitionistic logic, and program extraction systems, based on this fact, such as the Minlog system at University of Munich, has been developed. We have been dealing with relationship between classical logic and intuitionistic logic, and doing a research on extracting programs from constructive contents of classical proofs. Also we have been studying proof theory and semantics of substructural logics such as linear logic.

Theory of computation

We have been studying computability theory and computational complexity theory, and relationship between them and constructive mathematics. We have been characterizing classes of computable functions, such as the class of polynomial time computable functions, as function algebras, and trying to explore relationship between computational complexity and degrees of unsolvability, and logical principles and function existence axioms in constructive reverse mathematics. Furthermore, we have been dealing with lambda-calculus and type theory such as simple types, intersection types and union types.

International Research Cooperation

We have been participating in the International Research Staff Exchange Scheme (IRSES) projects (CONSTRUMATH and COMPUTAL) of the EU 7th Framework Programme (FP7) 'People' (Marie Curie Actions). Marie Curie's IRSES helps research orgatisation to set up or strengthen long-term cooperation through a coordinated exchange programme for their staff. We, together with LMU Munich, Uppsala University, University of Padua and University of Canterbury, had participated in the CONSTRUMATH project, and, together with 11 organisations and 2 associate orgatisations including University of Siegen, University of Cambridge, Technical University of Darmstadt, University of Ljubljana and Swansea University, have been participating in the COMPUTAL project.

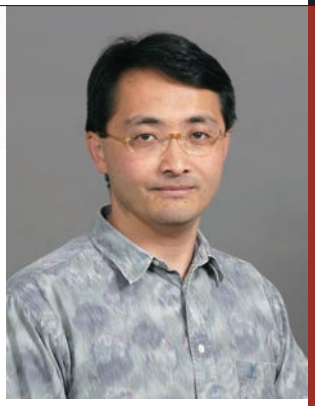
Publications

- H. Ishihara, Relating Bishop's function spaces to neighbourhood spaces, Ann. Pure Appl. Logic 164 (2013), 482-490.
- H. Ishihara, Some conservative extension results on classical and intuitionistic sequent calculi, In: U. Berger, H. Diener, P. Schuster and M. Seisenberger eds., Logic, Construction, Computation, Ontos Verlag, Frankfurt, 2012, 289-304.
- H. Ishihara, The uniform boundedness theorem and a boundedness principle, Ann. Pure Appl. Logic 163 (2012), 1057-1061.
- J. Berger, H. Ishihara, E. Palmgren and P. Schuster, A predicative completion of a uniform space, Ann. Pure Appl. Logic 163 (2012), 975-980.
- H. Ishihara and P. Schuster, On the contrapositive of countable choice, Arch. Math. Logic 50 (2011), 137-143.

Uehara Laboratory

Professor : Ryuhei Uehara

Efficient Algorithms for Intractable Problems



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Research Overview

We sometimes meet some problems which are theoretically intractable. However, what if we need to solve them? We tackle such intractable problems, and give some "reasonable" solutions in practice.

And more...

Many problems can be represented by "vertices" and "edges," which are called "graph structure." We deal with the problems on the abstract models. In other words, we investigate theoretical and fundamental area. We consider the following three approaches are "reasonable:"

1. Conditional inputs

Depending on problems, inputs may be restricted. For example, if you use map data, they can be drawn on a plane, and taking a side trip never give a shortcut. For such a restricted input data, using results from graph theory, we may be able to solve intractable problem within practical cost.

2. Approximation algorithms

It may be sufficient to provide an approximate value in practical. For example, which do you like better; exact solution obtained in one month, or an approximation solution within 110% of optimal obtained in 10 minutes? Sometimes we can obtain approximate solution with approximation ratio in practical time. Especially, it is interesting that we can guarantee the approximation ratio even if we cannot compute the exact solution.

3. Randomization

A randomized algorithm uses random numbers, or it tosses a coin. For example, counting the maximum number of consecutive heads in x coin tosses makes "log x" with high probability, which can be a computation of the function log!! Some computations can be done very efficiently and/or smartly if you can use randomization.

We can achieve better performance by combining these three approaches, which are not independent.

Applications

We deal with
−giant networks like WWW
−graph with attributes like net of Origami
−computational complexity of games and puzzles
as application of graph algorithms.

We have to develop simple data structures and algorithms to deal with very large scale network. Since some social networks have special properties, it is also important to investigate reasonable models of them, give mathematical analysis to the models, and develop efficient algorithms based on the analysis. On the other hand, to deal with some material like Origami, we have to take care of phisical properties like distance and ordering of faces. We cannot avoid such troubles to solve practical problems.

Activities and contributions

Mainly, we attend/present at some international conferences about graph algorithms. Uehara is a member of ACM, IEEE, EATCS, and IEICE.

Publications

- E. Demaine, M. Demaine, N. Harvey, R. Uehara, T. Uno, and Y. Uno: UNO is hard, even for a single player, Theoretical Computer Science, vol.521, pp.51-61, 2014.
- Y. Okamoto, T. Uno, and R. Uehara: Counting the Number of Independent Sets in Chordal Graphs, Journal of Discrete Algorithms, 6(2), pp.229-242, 2008.
- Brandstädt, F.F. Dragan, H.-O. Le, V. B. Le, and R. Uehara: Tree Spanners for Bipartite Graphs and Probe Interval Graphs, Algorithmica, 47 (1), pp.27-51, 2007.
- R. Uehara, S. Toda, and T. Nagoya: Graph Isomorphism Completeness for Chordal Bipartite Graphs and Strongly Chordal Graphs, Discrete Applied Mathematics, 145(3), pp.479-482, 2005.
- P. Zhang, H. Sheng, and R. Uehara: A Double Classification Tree Search Algorithm for Index SNP Selection, BMC Bioinformatics, 5:89, 2004.

Hiraishi Laboratory

Professor : Kunihiko Hiraishi

Formal Modeling of Systems: Theory and Applications

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Research Overview

In our laboratory, we study how to build formal models, i.e. mathematically and computationally tractable models, for complex objects in the real world. In particular, we focus on discrete-state systems and hybrid systems, where discrete-state systems are dynamical systems that can be represented by state transition diagrams, and hybrid systems are dynamical systems that exhibit both continuous and discrete dynamics. Moreover, we apply developed theory and methods to various kinds of targets in information systems, service systems, control systems, and systems biology.

Aim of Formal Modeling Approach

1. High Reliability

We can verify whether designed systems run correctly or not before actual operations. Moreover, if a system is proved to be incorrect, then we can know in which part of the system errors exist. Unlike simulation and test, possible behavior of systems can be comprehensively checked.

2. High Performance

We can optimize systems by assigning appropriate values for system parameters. Moreover, we can qualitatively evaluate performance of systems for given probabilistic inputs.

3. Design Automation

We can automatically synthesize systems that fulfill given specifications. Moreover, if some specification is proved to be infeasible, then feasible alternatives for the specification are presented.

4. System Identification

We can build dynamical mathematical models from observed data.

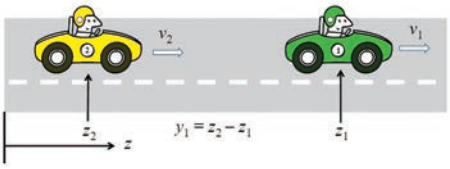
Related Areas

Researches in this laboratory are related to various research areas including theoretical computer science, software science, logics, systems science, control engineering, artificial intelligence, operations research, decision support systems, service science etc.

From Recent Results

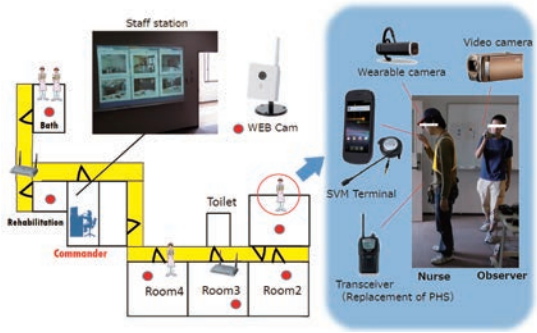
1. Application of Formal Verification Technology to System Control

By combining formal verification technology with existing control theory, it is possible to compute control inputs that achieve satisfaction of logical constraints together with optimization of a given objective function. For example, the figure below depicts the situation in which two cars are running on a road. Given some logical constraint such as "the two cars should come close to less than 0.5m at least every 3s", the objective is to compute control inputs that minimize energy consumption and also achieve the logical constraint. This problem is solvable by combination of discrete abstraction technique based on bisimulation and model predictive control scheme.



2. Modeling Humaavior in Service Fields

Our laboratory participates in a R&D project that aims to improve working environment in hospitals/nursing homes by using special IT devices called "Voice Tweet Device". In the project, we try to build behavior models for human activities based on collected location data from the devices. Using the behavior models, we evaluate differences on the behavior between working staffs, and also detect suspicious activities that should be checked later. To verify the effectiveness of the devices, we also perform experiments on virtual fields, experiment spaces designed for reproducing typical situations in the real field. (URL: http://www.jaist.ac.jp/ks/mot/JSTservice/)



Publications

- S. Kikuchi, S. Tsuchiya, K. Hiraishi: Synthesis of Configuration Change Procedure Using Model Finder, IEICE Transactions on Information and Systems, Vol.E96-D, No.8, pp.1696-1706 (2013)
- K. Kobayashi and K. Hiraishi: Computational Techniques for Model Predictive Control of Large-Scale Systems with Continuous-Valued and Discrete-Valued Inputs, Journal of Applied Mathematics, Vol. 2013, Article ID 615060, 9 pages (2013)
- K, Hiraishi, M. Yoshimoto, K, Kobayashi: Diagnosis of Stochastic Discrete Event Systems Based on N-gram Models with Wildcard Characters, IFIP/IEEE DANMS2013, pp.1383-1388 (2013/05/31, Ghent, Belgium)

Miyaji Laboratory

Professor : Atsuko Miyaji

Information Security: From advanced research to application

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Our research interest is a field of information security, which is covered from theory to application.

Summary of our research field

Information security

In proportion as the information infrastructures be prepared theses days, multifarious systems are becoming to be realized. Information security technology has become to play an important role as a key technology in order for such systems to be established firmly and soundly. Accordingly, we have been working on an information security technology. Specifically, we focus on the cryptography, network or software security including computer viruses, electronic commerce, and criterion of security evaluation. Our results cover from theoretical to practical results such as solutions for efficient implementation.

Information security

In order to use technologies on the information security in a real world, international standardizations is indispensable. Conversely, we may find a new theoretical interest during the procedure of international standardizations or international standardizations themselves. We have been paying attention to the recent tendency of international standardization and setting some research themes according as standardizations.

Policy of our lab

Security Specialist

Our goal, at the time of graduation, is to be skilled enough to play an active part as a security specialist in the world by developing as well as socializing skill. For that purpose, students are to seek problems to be solved and propose a solution to the problem. Discussion lasts intensively in our lab. We also attach great importance to implement a system, in that we believe that a well-balanced skill comes from both a full knowledge of theory and the experiences of implementation. Therefore, the whole staff strives as one and gives full support to students.

Good facilities and environment for research activity

We are generous in preparing facilities in order to maintain a research environment in ideal condition. To say nothing of computer environment and other equipments, we also take into account of surroundings, where members do not suffer from stress.

We are quite positive to participate in international conferences to publish our results. Giving a presentation at international conferences would be a precious experience for students to undergo, and we believe that it could help bring a great deal of confidence and pride throughout a rest of one's life. Making an international relationship may also be a great asset for a student.

Cooperation with Industry

The aim of the study on Information Security is a fruition of the digitized society system (e.g., electronic cash, electronic election) and addition of a new value (e.g. low cost, various functions), which are not achieved in existing systems. Therefore, our research themes and results have a lot with the Industry. We hold our own research area by proposing a new technology to the Industry and upgrading an existing system to meet a modern society.

Publications

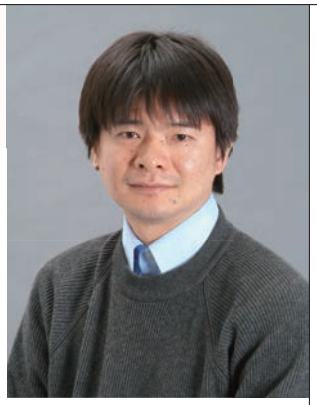
Total: 46 Journal papers, 84 International Conference papers (Refereed), 56 Lecture・Invited Talks, 183 Domestic Reports
Newspapers/Magazines: Total:8
"Newsweek Japan" (2005/10, Vol.26), "Bunshun Business" (2006/4, Vol.5),The Hokkoku Shimbun '05/10/25, The Yomiuri Shimbun '04/1/19, '02/6/11, The Asahi Shimbun '98/6/5, Nikkei '98/4/1, The Nikkan Kogyo Shimbun '96/8/15
2013
3 Journal papers, 3 International Conference papers (Refereed), 4 Lecture・Invited Talks, 5 Domestic Reports
2012
2 Journal papers, 6 International Conference papers (Refereed), 3 Lecture・Invited Talks, 5 Domestic Reports, 2 Awards
2011
6 Journal papers, 15 International Conference papers (Refereed), 3 Lecture・Invited Talks, 6 Domestic Reports, 1 Book, 1 Award
2010
4 Journal papers, 15 International Conference papers (Refereed), 2 Lecture・Invited Talks, 19 Domestic Reports, 3 Awards
2009
2 Journal papers, 5 International Conference papers (Refereed), 1 Lecture・Invited Talks, 14 Domestic Reports, 1 Award
2008
2 Journal papers, 6 International Conference papers (Refereed), 5 Lecture・Invited Talks, 9 Domestic Reports, 2 Awards
2007
3 Journal papers, 2 International Conference papers (Refereed), 7 Lecture・Invited Talks, 12 Domestic Reports, 4 Awards
2006
3 Journal papers, 1 International Conference papers (Refereed), 5 Lecture・Invited Talks, 11 Domestic Reports, 2 Awards
2005
3 Journal papers, 3 International Conference papers (Refereed), 4 Lecture・Invited Talks, 10 Domestic Reports, 1 Patent, 1 Award
Before 2004
・UCD Visiting researcher (2002-2003)
18 Journals papers, 28 International Conference papers (Refereed), 22 Lectures・Invited Talks, 93 Domestic Reports, 7 Awards

Publications

・"Novel Strategies for Searching RC4 Key Collisions", Computers & Mathematics with Applications, Vol. 66, Elsevier, 1-10.
・"Self-healing Schemes Suitable for Various WSNs", The 6th International Conference on Internet and Distributed Computing Systems, Vol. 8223, Springer-Verlag, 92-105.
・"How to Enhance the Security on the Least Significant Bit", The 11th International Conference on Cryptology and Network Security,vol.7712, Springer-Verlag, 263-279.
・"Scalar Multiplication on Weierstrass Elliptic Curves from Co-Z Arithmetic", Journal of Cryptographic Engineering. vol.1, Springer-Verlag, 161-176.
・International Conferences(Co-PC chairs):CANS2009('09/12,Kanazawa, 111 participants), Pairing2010('10/12,Yamanaka, 100 participants)
・Domestic Symposium(General chair): SCIS2012('12/1, Kanazawa, 642 participants)
・A.Miyaji: "Cryptography in algebraic aspects" (Nippon Hyoron Sha), 2012; A. Miyaji, H. Kikuchi (ed/authors): "Information Security", Ohmsha, 2003;
・ISO/IEC/SC27/WG2, A project editor, Science Council of Japan, member
・The IPSJ Sakai Special Researcher Award('02), The Standardization Contribution Award('03), Editorial Committee of Engineering Sciences Society: Certificate of Appreciation('07), The Director-General of Industrial Science and Technology Policy and Environment Bureau Award('07), IPSJ/ITSCJ Project Editor Award('07,'08,'09,'10,'12), DoCoMo Mobile Science Awards('08), ADMA 2010 Best Journal Award('10), Air Self Defense Force: Certificate of Appreciation('10), Engineering Sciences Society: Contribution Award('12)

Ogata Laboratory

Associate Professor : Kazuhiro Ogata



Systems Verification on Safety and Security: Aiming at developing safe and secure systems

URL http://www.jaist.ac.jp/~ogata E-mail ogata@jaist.ac.jp

Safe and Secure Life

No doubt almost all people would like to live safely and securely. The present society has been highly computerized. The tendency would be growing in the future. Therefore, it is necessary to make computerized systems such as electronic commerce (ecommerce) systems safe and secure so as to obtain safe and secure life.

Formal verification

Formal verification is a technique that can partly help ones develop safe and secure computerized systems (which is abbreviated systems later). It can be used to check if systems satisfy desired properties in a systematic way. For example, it is possible to check if an e-commerce system satisfies the property that whenever goods reach a buyer, the price has been charged to the buyer's credit card.

Observational Transition Systems

In order to check if systems satisfy properties with systems verification, it is necessary to make abstract models of systems. We use observational transition systems (OTSs) as abstract models of systems. OTSs have been developed in collaboration with Futatsugi Laboratory in JAIST. OTSs describe systems by paying attention to changes of observable values related to the systems with the execution of the systems.

Tools Used

Tool support is inevitable so as to check if systems satisfy desired properties with formal verification. Tools used are mainly CafeOBJ and Maude.

CafeOBJ is a formal specification language and processor, mainly developed at Futatsugi Laboratory in JAIST. OTSs are written in CafeOBJ in terms of equations such as A = B. As A = C can be deduced from A = B and B = C, CafeOBJ makes it possible to prove that OTSs satisfy properties by means of rewriting, which is an implementation of equational reasoning. That is to say, CafeOBJ can be used as an interactive theorem prover.

Maude is another formal specification languge and processor, mainly developed at SRI International and University of Illinois at Urbana-Champaign. It is a sibling language of CafeOBJ. It is equipped with model checking facilities. Thus, Maude can be used to quickly find counterexamples showing that OTSs do not satisfy properties. It makes it possible to use inductive data types in state machines such as OTSs to be model checked. This is one of the most noticeable characteristics of Maude. This characteristic implies that the entire state spaces of state machines to be model checked do not have to be bounded.

Research Themes

The laboratory studies formal verification on OTSs with CafeOBJ and Maude.

Formal verification techniques: Studies on how to model a variety of systems as OTSs and how to verify that such systems satisfy a variety of properties.

Integration of formal verification techniques: Studies on effective use of formal verification techniques such as interactive theorem proving and model checking.

Design and implementation of tools: Design and implementation of tools that facilitate formal verification on OTSs with CafeOBJ and Maude.

Case studies: Application of such formal verification techniques and tools to actual systems such as e-commerce systems.

Publications

- Kazuhiro Ogata and Kokichi Futatsugi : Equational Approach to Formal Analysis of TLS, 25th Int'l Conf. on Distributed Comp. Sys., IEEE, pp.795-804, 2005
- Kazuhiro Ogata and Kokichi Futatsugi : Formal Analysis of the iKP Electronic Payment Protocols, 1st Int'l Sympo. on Softw. Sec., LNCS 2609, Springer, pp.441-460, 2003
- Kazuhiro Ogata and Kokichi Futatsugi : Proof Scores in the OTS/CafeOBJ Method, 6th IFIP WG6.1 Int'l Conf. on Formal Methods for Open Object-Based Distributed Sys., LNCS 2884, Springer, pp.170-184, 2003

Omote Laboratory

Associate Professor : Kazumasa Omote

Network Security and Applied Cryptography

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Research Overview

In modern society, the essential part of social life, such as politics, economy, judicature, administration, government and education, is being computerized on a network system. On the other hand, the increase in a cyber-attack is reported in recent years. Because of this situation, the technical field which supports the safety and security of these network systems is information security. Information security is integrated science based on mathematical science (e.g., number theory, mathematical analysis, probability theory, statistics theory, and computational complexity theory) and is said to be the field that mathematical principle is effectively applied to practical technology. The business community and public institution put importance on an information-security-technology person. Also, information security is becoming indispensable technology in various fields of information science.

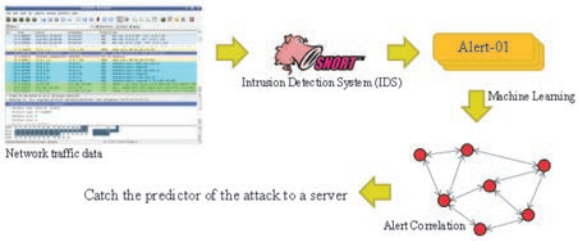
Our laboratory studies information security. We are especially interested in network security and applied cryptography based on probability / statistics theory and cryptographic theory. Above all, we recently focus on countermeasures against illegal access based on machine learning and security of sensor network / cloud based on cryptographic theory.

Security sustainment and recovery of the whole system

Various terminals (e.g., cellular phone and car) are connected with each other in the network. On the other hand, there are many threats (e.g., virus, illegal access, eavesdropping, and falsification) in a network system. It is thus important to aim at improvement in security of each terminal itself. However, security countermeasures may be insufficient because of practical use or cost benefit. Therefore, the mechanism through which damage is not allowed to expand and the mechanism to recover the damaged terminal are very important even if a terminal suffers damage.

Countermeasure against illegal access

It is said that the present cyber-attack can be known from the knowledge and experience about the attack which took place in the past. This means that a certain useful information about the attack of the future is contained in the past attack data. In our laboratory, we measure this information using probability / statistics theory, and research the technology of preventing expansion of attack damage. For example, we research about prediction of malware intrusion using alerts of the botnet on an intrusion detection system (IDS).



Research on malware intrusion prediction

Security of wireless sensor networks

Wireless sensor networks are a network system consisting of some sensors with sensing functions and a communication function. There are many advantage cases where deployment of wired network and dedicated power-supply cable is unnecessary. For such cases, an ad-hoc network can be constituted, but a sensor has restricted resources (low CPU, small memory, battery-operated and non-tamper resistant). It is therefore important to construct an efficient algorithm whose security can recover the whole system, even if a secret key is revealed from a terminal. In our laboratory, we are conducting the design and simulation experiment of such secure algorithm, in which each sensor updates a key with time, under the premise that the secret key in a sensor may be stolen.

Publications

- Yusuke Sakai, Keita Emura, Goichiro Hanaoka, Yutaka Kawai, and Kazumasa Omote, "Methods for Restricting Message Space in Public-Key Encryption", IEICE Transactions 96-A(6), 1156-1168, Jun. 2013.
- Atsuko Miyaji and Kazumasa Omote, "Self-healing Schemes Suitable for Various WSNs", The 6th International Conference on Internet and Distributed Computing Systems (IDCS 2013), Lecture Notes in Computer Science, vol.8223, Springer-Verlag, 92-105, Oct. 2013.
- Atsuko Miyaji and Kazumasa Omote, "How to Build Random Key Pre-distribution Schemes with Self-Healing for Multiphase WSNs", The 27th IEEE International Conference on Advanced Information Networking and Applications (AINA 2013), IEEE, 205-212, Mar. 2013.
- Tran Thao Phuong, Kazumasa Omote, Nguyen Gia Luyen, and Nguyen Dinh Thuc, "Improvement of multi-user searchable encrypted data scheme", The 7th International Conference for Internet Technology and Secured Transactions (ICITST 2012), IEEE, 396-401, Dec. 2012.

Somemura Laboratory Research Professor : Yoh Somemura

Fostering ICT Global Leader / Green ICT toward low-carbon society

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Mission

Fostering ICT Global Leader Course

This course aims to foster the leader who can play an active part in international society. The goal of this course is to establish the graduate education which brings up advanced people who can play an active part in an ICT field, in addition to advanced technical knowledge and capability, the degree program which makes a broad view, special application capability, communications skills, internationalism, etc. The purpose is to foster the ICT Global Leader, which raises the talented people who can assert a standard of Japan and play an important role in technical committees, such as ISO, IEC, and ITU, for the international standardization of an ICT field.

Research Overview

Green ICT toward low-carbon society

Climate change is a concern for all of humanity and requires efforts on the part of all sectors of society, including the ICT sector. ICTs spread rapidly and the environmental impact increases. Therefore, energy saving of the ICTs (e.g. telecommunication systems and data centers) is indispensable.

On the other hand, ICT services (e.g. E-commerce, video conferencing, BEMS, HEMS, smart grid) are expected to reduce overall CO_2 emissions by boosting the efficiency of production processes, reducing demand for transportation and delivery, and reducing the need for production of physical media.

Methodology for environmental impact reduction effects by using ICTs

The ITU-T is aiming at the international standardization of the method of calculating environmental impact regarding ICTs. In order to reduce CO_2 emissions in the future, it is essential to evolve our lifestyles through the comprehensive utilization of ICT. To estimate the effectiveness of these behaviors, the indirect CO_2 reduction effect by using ICT will have to be made visible. That requires a common methodology for evaluating the effects of CO_2 emissions reduction on a global basis. To develop recommendations on the methodology is required as quickly as possible.

Methodology for Biodiversity

In order that human beings may realize sustainable development over the future, a company is obligated to tackle global environmental protection. Corporate activity has a close relation to biodiversity. Each company needs to grasp a sphere of activity and its influence, and is expected to promote preservation activities continuously. However, although the promotion requires a quantitative target and a management tool, since the quantitative evaluation method has not yet established, to develop the general-purpose evaluation method for corporate activity is required.

Environmental / CSR Accounting

In order to promote environmental or CSR activity efficiently, a company achieving the social responsibility about environment or CSR, practical use of environmental or CSR accounting is important. This is an important quantitative tool as business modality which coordinates environment, CSR, and an economic activity. However, since the companies which are using this tool effectively are rare, the practical use method is required.

Publications

- Y. Somemura: Standardization Activities on ICTs and Climate Change in ITU-T, NTT Technical Review, Vol. 7, No.9, 2009.
- K. Okazaki, T. Miyazaki, J. Nishikido, Y. Somemura, Y. Sugiyama and Y. Tanaka: NTT Group Energy Efficiency Guidelines Initiative and Promotion of Green R&D, NTT Technical Review, Vol. 9, No.2, 2011.
- T. Hayashi, T. Origuchi, Y. Somemura and Y. Sugiyama: Quantifying Environmental Load Reduction Effect of Utilizing ICT, NTT Technical Review, Vol. 9, No.2, 2011.

Futa Laboratory

Research Associate Professor : Yuichi Futa

Construction of information security system

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Research Overview

Nowadays, we are immersed in information communication technologies, such as Internet services (E-mail, Web service), electronic money, online banking, broadcasting, etc. At the same time, such situations are risky due to the attacks on the information systems, e.g. illegal data acquisition. In a real life, much damage is brought by cyber-attack, leakage of personal information and illegal money transfer. The damage caused by malicious attack is escalating in every level of our society and bringing severe leakage of important information and financial loss. It is becoming critical issue, e.g. life-threatening problem, in recent years. The information security is one of the most emergent problems which require to be solved.

Our laboratory studies information security and practical information security systems. Especially, we focus on security technologies for cloud computing systems and provable security. We also develop necessary algorithms for implementing security technologies.

Construction of information security system

On various systems such as network services and control systems of automobiles, there are threats of leakage and abuse of data, and damage caused by them may occur. The countermeasures to such threats are necessary. How to execute such countermeasures and how to prove their security are important for information security of systems.

Public-key infrastructure for cloud computing systems

Cloud computing involves many servers collecting and managing data for various organizations. Each organization cannot trust other organizations entirely in the real world, so it is necessary that the system ensure their own security (data protection, etc.).

Our laboratory focuses on the research of distributed public-key infrastructure which can issue certificates to authenticate organizations in the case that each organization is reluctant to share its secret information.

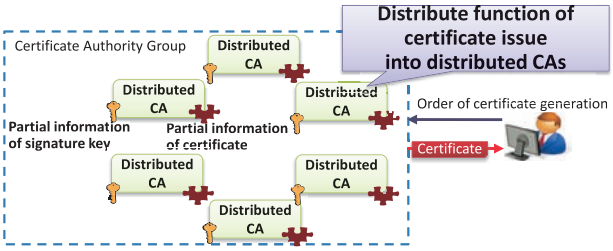

Image of distributed public-key infrastructure

Formal verification of security proofs for cryptographic schemes

Security proofs for cryptographic schemes and protocols guarantee all the attacks on a targeted cryptosystem are harder than some difficult mathematical problems. They are necessary for information security system. Mistakes of the security proof have occurred because cryptographic schemes are becoming more and more complicated. For this reason, security proving by hand has certain limitations. A verification of security proofs by computer (formal verification) to prevent such mistakes is an attractive research area.

Our laboratory studies construction of definitions and theorems to perform security proofs, and generation of security proofs.

Publications

- Hiroyuki Okazaki, Yuichi Futa, Yasunari Shidama, "Formal definition of probability on finite and discrete sample space for proving security of cryptographic systems using Mizar", Artificial Intelligence Research, 2(4), pp. 37-48, 2013.
- Yuichi Futa, Hiroyuki Okazaki and Yasunari Shidama, "Formalization of Definitions and Theorems Related to an Elliptic Curve over a Finite Prime Field by Using Mizar", Journal of Automated Reasoning, Vol. 50, Issue 2, Springer, pp.161-172, 2013.
- Shingo Hasegawa, Shuji Isobe, Masahiro Mambo, Hiroki Shizuya, Yuichi Futa and Motoji Ohmori, "A countermeasure for protecting NTRUSign against the transcript attack", Interdisciplinary Information Sciences, vol. 13, no. 2, pp.181-188, 2007.
- Yuichi Futa and Motoji Ohmori, "Efficient Scalar Multiplication on Montgomery-Form Elliptic Curves", IEICE TRANSACTIONS on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E87-A, No. 8, pp.2126-2136, 2004.

Inoguchi Laboratory

Professor : Yasushi Inoguchi

Massively Parallel Systems

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Research Overview

Our research interest is mainly massively parallel systems. Researches of massively parallel systems have many processing levels; configuration of parallel arithmetic units in a VLSI chip, massively parallel systems that consist of a large number of microprocessors, PC-cluster that combines many Linux-PCs with high speed networks, and widely distributed systems such as GRID. We are developing methods and technologies for massively parallel systems. Followings are major research topics.

Ultra fine grained parallel processing by hard ware programming

Hardware circuit in a VLSI executes their function in parallel essentially, because each sub-circuit works independently. Thus, operator level fine grained parallel processing will be achieved if a software algorithm is implemented on a FPGA which can be reconfigured its circuit dynamically. However, most of C-level design tools aim not to design parallel circuit but to support codesign of hardware and software, thus they can not synthesize parallelized circuits automatically. This research proposes a preprocessor which analyzes parallelism of given C program and insert parallel directives to help C-level design tool to synthesize parallelized circuit.

High-speed detection system of Audio-fingerprint with hardware

Recently, many digitalized music and movies are widely exchanged through the Internet. Digital fingerprinting, which is a compact expression of characteristics of music, is proposed to distinct each digital content. It gives us almost same fingerprint if two music source are same, even if quality of the digital samplings is different. However, detection speed of fingerprint by software is much slower than the Internet speed. In this research, we propose hardware implementation of finger- print detection circuit on a FPGA. The detection speed is over ten times faster than software detection due to the parallel implementation of detection circuit.

Interconnection networks for Massively Parallel Computer

Multiprocessor systems consisting of millions of processing elements have been expected to solve advanced scientific and engineering problems in the next decade. Since the interconnection network is one of the critical components of multiprocessor systems, they are required network feature such as smaller diameter, easy VLSI implementation, fault-tolerant schemes, and good expandability. We are studying hierarchical interconnection network named as Shifted Recursive Torus (SRT) for scientific computing, and discuss network performance, routing algorithms, and fault-tolerant schemes.

Publications

- T.Yiyu, Y.Inoguchi, Y.Sato, M.Otani, Y.Iwaya, H.Matsuoka and T.Tsuchiya, "A Hardware-Oriented Finite-Difference Time-Domain Algorithm for Sound Field Rendering", Japanese Journal of Applied Physics, Vol. 52, No. 07HC03, 6 pages, Jul., 2013
- M.M. Hafizur Rahman, M.Fukushi and Y.Inoguchi, "Reconfiguration and Yield of a Hierarchical Torus Network", IETE Technical Review, Vol. 30, No. 2, pp.120-128, Feb., 2013
- T.V.T. Duy, Y.Sato and Y.Inoguchi, "A Prediction-Based Green Scheduler for Datacenters in Clouds", IEICE Transactions on Information and Systems, Vol. E94-D, No. 9, pp.1731-1741, Sep., 2011
- Y. Inoguchi, T. Yiyu, Y. Sato, M. Otani, Y. Iwaya, H. Matsuoka and T. Tsuchiya, "DHM and FDTD based hardware sound field simulation acceleration", Proceedings of 14th International Conference on Digital Audio Effects DAFx-11, pp.69-72, Paris, Sep. 20, 2011
- T. Yiyu, Y. Inoguchi, E. Sugawara, M. Otani, Y. Iwaya, Y. Sato, H. Matsuoka and T. Tsuchiya, "A real-time sound field renderer based on digital Huygens' model", Journal of Sound and Vibration, Vol. 330, No. 17, pp.4302-4312, Aug., 2011

Kaneko Laboratory

Professor : Mineo Kaneko

LSI Systems Supporting Sound, Comfortable and Secure E-Society

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Research Overview

Large Scale Integrated circuit (LSI) is a crucial and vital device/organ in various electronic, information, communication, control systems, and achieves various numerical computations, signal and information processings, data storage, etc. Rectangles and lines with tens nanometer width are inscribed on a square silicon chip to form hundreds million transistors and wires connecting between them, which is the current LSI! How to design such LSIs? How to optimize circuits and layout for such LSIs? What can we do with hundreds million transistors? How to make use of hundreds million transistors for humankind and sound, comfortable, secure E-Society? These are our research themes and challenges.

Circuit theory and CAD for LSIs

LSI design is to find one or some configurations which satisfy specifications in the functional behavior. Various kinds of performances associated with each configuration, such as area, speed, power and testability, are necessary also to be optimized. Among various hierarchical design levels, high-level and physical (layout)-level syntheses are current major interests. 3D syntheses (concurrent synthesis of data-path and its floorplan) one for wire-delay aware ASIC designs and the other for reconfigurable LSIs, control skew aware high-level synthesis, data-path design for robustness against delay variations are current major challenges targeting LSIs in the tens-nanometer technology and later. Design methodologies, design algorithms, and test methods for asynchronous systems are also our major concerns.

Combinatorics, Graph theory & Optimization

Most of the LSI design problems are reduced to combinatorial optimizations. Combinatorics and graph theory are also used to design algorithms and to analyze characteristics of LSIs. Optimization algorithms, graph theory and system theory are included in our research interests.

Fault Tolerant Computing and LSI Systems

Fault tolerance and dependability are important and indispensable functions for LSI systems. Multiple modular redundancy in mixed spatial-temporal space, algorithm based fault tolerance, reconfiguration for fault tolerance and unified theory of these techniques are studied. We are also interested in High-level synthesis for application specified fault tolerant LSI systems and related design theory and algorithms.

Other Topics

LSI processing & LSI algorithms

The evolution in LSI technology allows various complicated and computation-intensive signal processing/multi-media algorithms to be implemented on VLSI chip. We are trying to find solutions via approaches of the algorithm-software-hardware codesign. Modularity and regularity analysis of numerical computation algorithms, algorithm transformation, algorithm optimization and interaction between algorithm transformation and software-hardware co-design are the central interests of ours.

Analog & Mixed Analog Integrated systems

Analog blocks are important parts in system LSIs and embedded LSIs. Simulations and parameter optimization of analog circuits are involved with numerical nonlinear optimizations, while the topology synthesis with the mixture of combinatorial optimizations and numerical nonlinear optimizations. Qualitative reasoning and AI approaches to topology synthesis are also interesting topics.

Publications

- Keisuke Inoue, Mineo Kaneko, Tsuyoshi Iwagaki, "Backward-Data-Direction Clocking and Relevant Optimal Register Assignment in Datapath Synthesis" , IEICE Trans. Fundamentals, Vol. E94-A, No. 4, pp.1067-1081 April 2011.
- Takayuki Obata, Mineo Kaneko, "Simultaneous Optimization of Skew and Control Step Assignment in RT-Datapath Synthesis", IEICE Trans. Fundamentals, vol. E91-A, No. 12, pp.3585-3595 December 2008.
- Koji Ohashi, Mineo Kaneko, "Statistical Analysis Driven Synthesis of Application Specific Asynchronous Systems", IEICE Trans. Fundamentals, Vol.E90-A, No.3, pp.659-669 March 2007.

Shikida Laboratory

Professor : Mikifumi Shikida

Large-scale Network Services and Groupware

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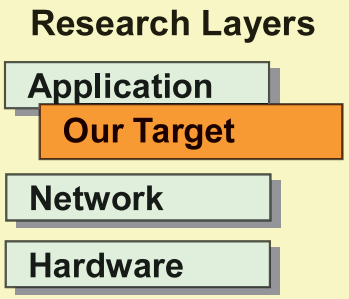
Research Overview

In our laboratory, research aim is to be able to integrate next generation network services, and software architecture of the services. Especially, we focus on large-scale network services and groupware. In these years, scale of computer systems has been getting huge day by day. The methodology of managing large-scale servers is key factor. We investigate application systems using large-scale servers and mobile equipments.

Key Target: Network Services

In business and private life, we often use mobile phones, PDAs and other digital equipments. Moreover, ubiquitous computing environment will be familiar in near future. However, there are not so much studies about network services for integrating these digital equipments seamlessly using some functions of protecting user's privacy. It is an important new research field. Then, we study the next generation network services.



Management of Reliable Large-scale Servers

Reliability is an essential factor for running large-scale systems. To design reliable large-scale servers, we focus on the efficient methods of configuration management, fault control and performance analysis.

Mobile Groupware and Awareness

Digital and mobile equipments using wireless network and sensors such as RFID and GPS have been in general. However, we have another subject when we use these equipments. It is about controlling and protecting user's privacy.

Awareness is one of key factors for using groupware. Awareness is the ability to notice other's context. We apply to protecting privacy. To provide seamless communication environment with privacy, we design new framework based on awareness to integrate many kinds of context information.

Groupware for Cooperative work

To support communications and cooperative works in office, we study workflow system and information sharing system on large-scale systems.

Future

We already have large-scale servers and high speed networks. Controlling software is most important issue in order to activatethem for our society in near future.

Publications

- M. Shikida: A Method of Event Notice Based on Dependencies among Components of Large-scale Servers, Journal of IPSJ, Vol.49, No.3, 2008.
- M. Shikida and H. Goto: Management of Server Log Information Based on Dependencies among Components of Large-scale Servers, Journal of IPSJ, Vol.49, No.3, 2008.
- M. Shikida and K. Onishi: A Method to Provide Context Awareness Using Multiple Resources, Journal of IPSJ, Vol.46, No.1, 2005.
- Mikifumi Shikida, Chie Kadowaki: Effective Organizational Memory Sharing by a Process-linking Approach, Proc. of Int'l Conf. on Information and Knowledge sharing, 2002.

Tan Laboratory

Professor : Yasuo Tan

Network systems for our daily lives

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Other Researches

Personal computers and broadband Internet connections to home are now popular in general consumer market. But most of these digital products are derived from the technologies for business market rather than designed for home-use. This situation causes that next generation household equipments may be hard to use for majority of consumers because of its evolution to support networking and intelligent services.

We are promoting our research work mainly on home networking systems respecting the following points: utilization of legacy or existing equipments and facilities in a home, respect for concepts that users have for household equipments in their minds, development of interconnecting technologies for various kinds of networking and controlling systems.

Projects

JAIST Video LAN

Motivation:
AV equipments are rapidly going to be digital and most of them have digital interfaces. Why don't we use these interfaces as networking interfaces?
Solution:
Bridging system between IEEE1394 digital interface and ATM network interface, and related protocols.
Accomplishments:
Joint research with a company yields commercial products using this technology. This device became popular as a terminal device for Japan Gigabit Network (JGN) and received a prize for its contribution to the industry.

IEEE1394-ATM bridge SONY SEU-TL100

Video Networking Interconnection Architecture

Motivation:
There are several visual communication systems derived from different background technologies: Video conferencing systems based on telephone technology, video on demand systems based on computer technology, networked AV devices based on consumer electronics technology, etc. Why don't we utilize the mixture of these different kinds of devices for just sending a video with audio?
Solution:
Interconnecting system and its architecture based on a simple video communication model.
Accomplishments:
A system that support the playback of VOD contents on a digital VCR with its editing command, and interconnection with IP based and ATM based video transmission systems.

Projects

JAIST Video LAN

We are a member of many standardization bodies in the field of home networking technologies, which include ITU-T, TTC, ECHONET, and Telecommunications Council of Ministry of Internal Affairs and Communications of Japan.

We are also contributing the activity of industrial forum as well as the academic societies as a promoting member or a board member. I am a chairman of Residential ICT SWG of New Generation Network Promotion Forum (NWGN Forum) in Japan, and also a leader of Green Grid Platform at Home Alliance, and a project leader of National Institute of Information and Communications Technology.

Publications

- "Scaling up IEEE1394 DV network to an enterprise LAN with ATM technology", Proc. ICCE98
- " Plug and play campus digital video network with IEEE1394 and ATM", Proc. ICCC99
  (These paper presents the core technology of JAIST Video LAN)
- "Ubicomp Technology Series - Home-networks and networked household equipments", Ohm-sha, 2004 (In Japanese)
  (This book describes the outline of hone networking technologies and equipments)

Matsumoto Laboratory

IEEE Fellow, Finland Distinguished Professor
Professor : Tadashi Matsumoto

New Paradigm of Wireless Communications in Ubiquitous Environments

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Research Overview

A major mission of our laboratory in JAIST is to reformulate the technological bases of wireless communications, and reconstruct them in a scientific way; obviously, wireless communication techniques/technologies are built on the basis of Information Theory, and therefore our research direction is to include as much the new results and findings in Information Theory in to wireless communications research as possible. In fact, a lot of progress has been made recently in Information Theory, such as the discovery of capacity-achieving codes, including Turbo and LPPC codes as well as new findings in network information theory. A major goal of the research work conducted by my research group in Europe has been to apply the new results in Information Theory to wireless communications research; my group has made a lot of accomplishments with this goal definition. A research target of our group in JAIST shall be to further extend what our group in Europe has done in the last 5 years, and also to apply the results to a variety of applications. I would like to lead our research group in JAIST so that we can create new wireless communication system concepts which are independent of technological inheritance from, but significantly outperform conventional systems in terms of efficiency and flexibility.

Cross Layer Optimization in Wireless Communications Networks towards Autonomous Resource Allocation

This research category includes a lot of issues, all related cross layer optimization, such as optimal resource allocation, adaptive coding and modulation, and scheduling.

Joint Decoding of Source and Channel Codes using Message Passing Techniques

Joint decoding of source and channel codes using the Turbo principle is sought for. Convergence property analysis using extrinsic information transfer (EXIT) chart provides us with the information about the matching optimality of the codes, and hence the EXIT curve matching techniques will be used as a tool for the optimization.

Optimal Activation Control of Multiple Turbo Loops:

To detect signals via detector-decoder chains having multiple Turbo loops, the optimal path in the extrinsic information transfer plain has to be found to minimize the decoding/detection complexity. The primary goal of this research is to develop algorithms that can achieve the optimality in activation control of the multiple Turbo loops to minimize the decoding/detection complexity.

Unified Approach to the MAC and Slepian-Wolf Regions and its Applications:

The primary goal of this research is to establish methodologies allowing us to calculate the multiple access (MAC) and Slepian Wolf regions for correlated sources. Major applications of the outcomes of this research include joint optimization of cooperative source and channel coding in sensor and/or relaying networks.

Compression Techniques for Sensor Networks:

The purpose of this research work is to fulfill the battery longevity requirement in sensor network by significantly reducing the information bit rate of the signal transmitted from sensors. To achieve this goal, Turbo decoding techniques will be used, where the correlation among the multiple sources is modeled by hidden Markov chain, and message passing takes place over the trellis diagrams representing the source correlation.

Cooperative Coding for Multi-Hop Networks:

In wireless multi-hop networks, cooperative coding techniques allow us to achieve diversity and coding gains, while also improving the throughput efficiency. This research work aims to develop signal relaying algorithms where account is taken of the fact that the signals received from the primary sender's and relayed terminals are correlated; The correlation is first estimated by the receiver, and then decoding of the codes used for relaying is performed using Turbo techniques.

Publications

- "An Analytical Method for MMSE MIMO Turbo Equalizer EXIT Chart Computation", K. Kansanen and T. Matsumoto , IEEE Trans. Wireless Communications , vol. 6, No.1, pp.59-63, Jan. , 2007,
- "Turbo Equalization; Fundamentals and Information Theoretic Consideration", T. Matsumoto and S. Ibi, IEICE-B (Invited Paper), Vol. J90-B, No. 1, pp. 1-16, 2007 (In Japanese)
- There are many other publications. Please see: http://www.jaist.ac.jp/is/labs/matsumoto-lab/en/publications/index.html
  https://dspace.jaist.ac.jp/dspace/items-by-authorext?query=id%3D185

Tanaka Laboratory

Associate Professor : Kiyofumi Tanaka

Real-time Embedded Systems

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Research Overview

In our life environment, computers are embedded everywhere, for example, in cell phones, in home electric appliances, in network equipments, and in automobiles, which often require realtime property. In our laboratory, we research how to achieve efficient real-time processing, in terms of both hardware and software. In addition, we actually design and implement systems, which helps empirical studies.

Real-Time Embedded RISC Core

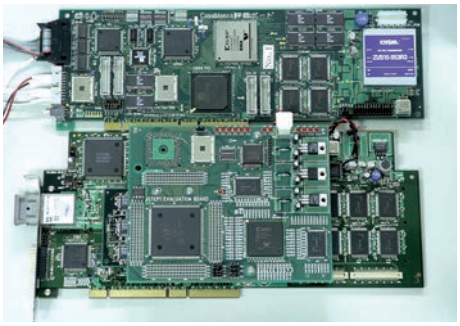
In embedded systems, low-price and low-power controllers/processors are desirable. In addition, fast response is often required especially for embedded control/communication application. We extended an existing RISC processor architecture and developed a real-time embedded RISC core, Casablanca, which is a multi-context processor based on task priorities and provides fast interrupt response mechanisms by low-cost and high-efficient cache memory control.

Real-time Operating Systems

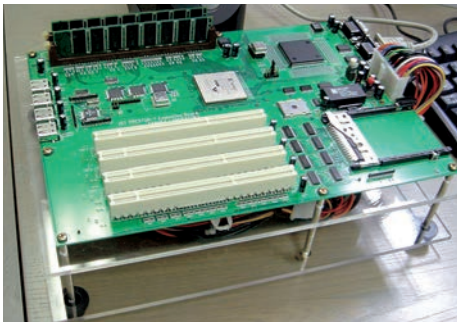
Task scheduling is one of most important mechanisms of realtime operating systems, which impacts response time in realtime processing. In this research, we proposed an adaptive and dynamic scheduling that introduces dynamic time property of task execution and enhances real-time processing. In addition, we develop a real-time embedded operating system that adopts this scheduling. The OS follows ITRON specification, and therefore provides convenient programmability for software development. This OS is implemented on Casablanca and ARM processors

Other Researches

We research other topics; energy-efficient architecture, highly functional memory architecture for data-hungry applications such as multimedia and database, lightweight JAVA execution environment, real-time multithreaded processor architecture, distributed shared memory, parallel computer architecture, etc.



Casablanca in Gigabit communication card.



Real-Time system with PRESTOR-1.

Publications

- Kiyofumi Tanaka, "Adaptive Real-Time Scheduling for Soft Tasks with Varying Execution Times, " Journal of Information Processing, Vol.22, No.2, online (2014).
- Fengxiang Xie, Kiyofumi Tanaka, "JAIST23-Pro : Design of Multicore Processor for FPGA", IPSJ SIG Technical Report, ARC, Vol.2014-ARC-208, No.7, IPSJ Digital Library, 2014. (In Japanese)
- Kiyofumi Tanaka, "Adaptive EDF: Using Predictive Execution Time," ACM SIGBED Review, Vol.10, No.4, pp.41-44, 2013.
- Kiyofumi Tanaka, "A Method of Shortening Average Reponse Times by Adaptive Scheduling -Effects of Estimating Execution Times-", Proc. of IPSJ Embedded Systems Symposium, pp.87-94, 2013. (In Japanese)
- Kiyofumi Tanaka, "Adaptive Total Bandwidth Server: Using Predictive Execution Time," Proc. of IFIP International Embedded Systems Symposium, Springer, pp.250-261, 2013.
- Hitoki Itoh, Kiyofumi Tanaka, "A Hardware/Software Co-Design Method for Java Virtual Machine Oriented to High-Level Synthesis," Proc. of International Conference on Embedded Systems and Applications, pp.131-135, 2012.

Kurkoski Laboratory

Associate Professor : Kurkoski, Brian Michael

BITS: Bits of Information, Transmitted and Stored

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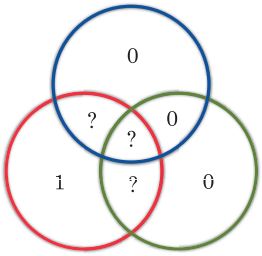
Information Theory and Coding Theory

Information theory deals with the fundamental limits of information transmission and compression. Remarkably, information can be transmitted reliably over a communications channel, even if the channel is unreliable. Claude Shannon showed that the information rate R of transmission can be no bigger than the channel capacity:

$$R < \log (1 + SNR)$$

for a channel with signal-to-noise ratio SNR.

An error-correcting code is a concrete way to correct some errors, and even achieve the channel capacity. One such code can be represented by three circles, as shown in the figure.



A Hamming code can correct 3 erasures.

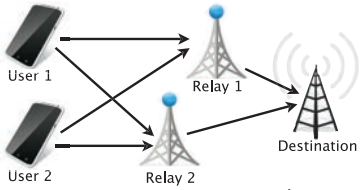
The number of 1's inside each circle must be even. The code consists of seven bits, each either a 0 or a 1. But some bits have been erased to an unknown "?". Can you recover the original bits?

Codes for Data Storage

Data storage is at the core of the information technology revolution, from the smartphones in our hands to data centers in the cloud. Flash memory, hard disk drives and distributed storage networks combine to provide ubiquitous access to data. But these exciting new systems pose curious new problems of storage density, reliability and efficiency. Coding theory can provide an answer.

Cooperative Wireless Communications

With the arrival of the smartphone, the demand for wireless network communications has exploded. But new electromagnetic spectrum is scarce. To increase future data rates, cooperative wireless communications is the new way forward. In cooperative wireless communications, users, relays and base stations work together to increase data rates through bandwidth efficiency, as shown in the figure.



Cooperative communications can increase data rates

Lattices are codes which use the same real-number algebra for both the code and the channel, where electromagnetic signals are superimposed. Lattice codes correct errors introduced by channel noise, satisfy transmission power constraints while simultaneously possessing group theoretic properties needed for network coding. We are developing lattice code theory to enable next-generation cooperative wireless communications.

Efficient Decoding Algorithms

The decoding algorithms for error-correcting codes are fairly complicated. Your smartphone, internet connection and solid-state drive all perform decoding. The design of decoder circuits is generally separated by a wall: LSI engineers design circuits and coding theorists design codes.

What is the most efficient circuit that can be designed? Recently, we have made a remarkable discovery: the design of efficient decoders should be motivated by information theory, breaking down the wall between theory and practice. Using tools from machine learning and information theory, in one case, the best-known decoders can be designed.

Publications

- Brian M. Kurkoski and Hideki Yagi, "Quantization of Binary-Input Discrete Memoryless Channels," to appear in IEEE Transactions on Information Theory, 2014.
- Brian M. Kurkoski, "Coded Modulation Using Lattices and Reed-Solomon Codes, with Applications to Flash Memories," IEEE Journal on Selected Areas in Communications, May 2014.
- L. Xiang, B. M. Kurkoski, and E. Yaakobi, "WOM codes reduce write amplification in NAND flash memory," IEEE Globecom, pp. 3249-3254, December 2012.
- H. Uchikawa, B. M. Kurkoski, K. Kasai, and K. Sakaniwa, "Iterative encoding with Gauss-Seidel method for spatially-coupled low-density lattice codes," in Proceedings of IEEE International Symposium on Information Theory, pp. 1747-1751, July 2012.
- B. M. Kurkoski, P. H. Siegel, and J. K. Wolf, "Joint message-passing decoding of LDPC codes and partial-response channels (invited paper)," IEEE Transactions on Information Theory, vol. 48, pp. 1410-1422, June 2002.

Lim Laboratory

Associate Professor : LIM AZMAN OSMAN

For Future Sensors and Wireless Communications

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Research Overview

The wireless world never stops growing. This results many people are connected wirelessly with mobile devices that allows them to keep up with the up-to-date information. The next largest breakthrough will be the sensory swarm, which enables more pervasive wireless networking and the vast deployment of sensors and actuators. The sensory swarm gives rise to the emergence of cyber-physical systems concept, which comprises the information-gathering network that would feed the massive information technology core with mountains of raw data to be processed and spun back out to us on our portable computing devices and laptops in a timely manner. These wirelessly sensors and actuators will be quite complex, requiring self-contained radio frequency, digital circuitry, clocks, and processing engines. Thus, it inspires architectures that will afford an order-of-magnitude improvement in efficiency and resource management. Our disciplinary research focuses on cyber-physical systems, sensor network system and wireless communications.

Cyber-physical Systems (CPS)

CPS contributes to safety, efficiency, comfort and human health, and help solving key challenges of our society, such as the ageing population, limited resources, mobility, or the shift towards renewable energies. One example of CPS applications is a smart home automation for comfort control. In smart homes, appliances, devices, sensors, and actuators are expected to assist people live on their own comfortable, relax, restful, and pleasant

Wireless Network Coding (WNC)

WNC refers to a technique where a wireless device is allowed to generate output data by mixing its received data. The unique characteristics of wireless medium renders WNC particularly advantageous, e.g., this technique can be used to achieve the minimum energy-per-bit for multicasting in a multihop wireless networks. In recent, this technique has been developed into a data link layer. The WNC engine in the data link layer can opportunistically mix the outgoing packets to reduce the transmissions in the air.

Figure 1: CPS integrates cyber world and real world.

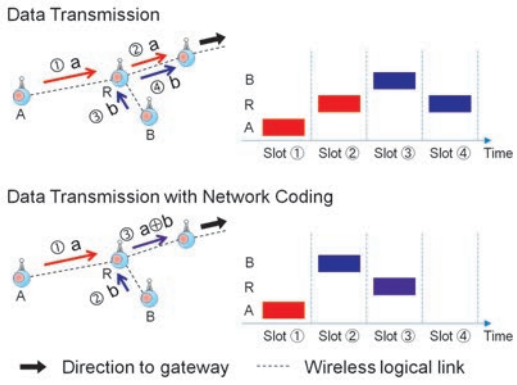

Figure 2: Data transmission using WNC technique.

Publications

- S. Umer, M. Kaneko, Y. Tan, and A.O. Lim, "System design and analysis for maximum consuming power control in smart house," J. of Autom. and Control Eng. (JOACE), vol.2, no.1, pp.43–48, March 2014.
- A.O. Lim, Z. Chen, and Y. Tan, "Optimal latency balancing algorithm for multiple portal in wireless mesh networks," Proc. of IEEE/CIC Int. Conf. on Commun. in China (ICCC), Xi' an, China, 12–14 August 2013, pp.252–258.
- Z. Cheng, W.W. Shein, Y. Tan, and A.O. Lim, "Energy efficient thermal comfort control for cyber-physical home system," Proc. of IEEE Int. Conf. on Smart Grid Commun. (SmartGridComm), Vancouver, Canada, 21–24 October 2013, pp.797–802.

Okada Laboratory

Research Associate Professor : Takashi Okada

Solving social problems using simulation and data analysis

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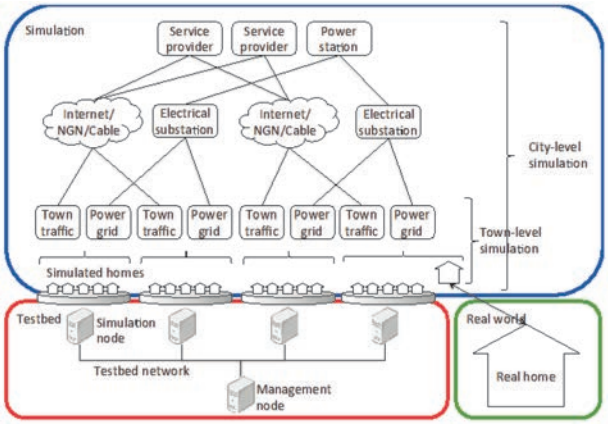
Research Overview

Our laboratory focuses on the construction of intelligent social infrastructure systems and the interaction of human with such systems.

Smart system

Recently, with the rise in popularity of ubiquitous computing, intelligent social infrastructure has become widespread.

We research integration technologies of such intelligent systems with embedded systems, networks, cloud and bigdata analysis.



City Simulation of houses, power grid and networks

Multi-Agent Simulation

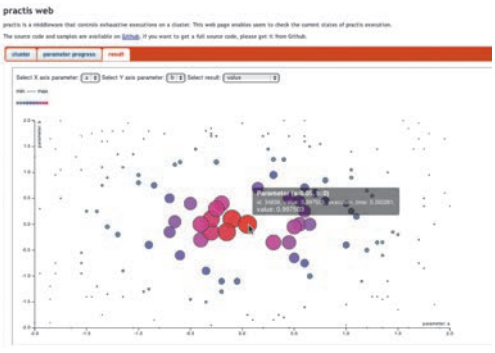
Simulation is used as the main tool to verify the security and safety of such intelligent applications and systems, as well as their effects on society.

Education of Highly-Dependable Smart Embedded Systems Engineer

We promote an educational project that aims to foster students able to design and develop intelligent social infrastructure and applications.

Please check the web page of "Highly-Dependable Smart Embedded Systems Course" for details.

40,000 Pedestrians Simulation



Exhaustive Analysis

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- Implementation of Simulation Environment for Exhaustive Analysis of Huge-scale Pedestrian Flow, T. Yamashita, T. Okada, I. Noda, SICE Journal of Control, Measurement, and System Integration, Vol.6, No.2, pp. 137-146, 2013.03.
- Emulation framework for the design and development of active RFID tag systems, R. Beuran, J. Nakata, T. Okada, T. Kawakami, K. Chinen, Y. Tan, Y. Shinoda Journal of Ambient Intelligence and Smart Environments (JAISE), IOS Press, Vol.2, No.2, pp. 155-177, 2010.04.

Chinen Laboratory

Research Associate Professor : Ken-ichi Chinen

Network Services and Network Experiments

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Network Services

We are living networked society. Most activity of network is using of service. For example, people will access the server of airline company to reserve flight ticket. He/she should use cellular phones and/or Internet to do this access. In mail order, she/he will access the server for the service to order goods. So, "Service" is at the center in the networked society.

We focus us to network services. By consideration of service models, design and implementation of server programs, and building and operation of server computers, we are addressing the improvement of quality and performance in network services.

We build and operated large WWW server sites that handles 100 millions and over accesses per day. Traditional technologies are not enough to manage such scale server. We introduced and developed advanced technologies like load balancing, content synchronization and others.

Network Experiments

Various technologies for network and server have made the society rich. To maintain and improve richness society should keep verifying the ability and safety of technologies. Many verifying approaches (theoretical analysis, logical simulation and others) exist. We verify these technologies using actual equipments (computers and switches) practically. This approach have an advantage of obtaining real or near-real result than other approaches because we can use real programs used in the society. However, this approach needs large human resource and time. To operation and maintenance the facility that have a lot of equipments requires that.

We developed programs and protocols to reduce the resource and time. Network experiment description language to drive the experiment automatically and a switch management program for multi-vendor switch complex are included in our products.

We carried the experiment for WWW server and clients using 300 and more computers. We realized the experiment about the communication of million entities also. Moreover, we received consultation from various companies and research organizations for network experiment. By the consulting, we got a lot of knowledge for network experiments.

A part of experiment facility (a computer rack)

Publications

- 1. Ken-ichi Chinen and Suguru Yamaguchi: *An Interactive Prefetching Proxy Server for Improvements of WWW Latency*, INET'97, Kuala Lumpur, 1997
- Ken-ichi Chinen , Toshiyuki Miyachi and Yoichi Shinoda: *A Rendezvous in Network Experiment — Case Study of Kuroyuri,* Tridentcom2006, Barcelona, 2006.
- Thilme Baduge, Lim Boon Ping, Kunio Akashi, Jason Soong, Ken-ichi Chinen , Ettikan K.K and Eiichi Muramoto: *Functional and Performance Verification of Overlay Multicast Applications - A Product Level Approach*, CCNC 2010, Las Vegas, 2010.

Ogawa Laboratory

Professor : Mizuhito Ogawa

Automated deduction for program analysis and verification

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Introduction

Recent progress in computer science and hardware enlarge possibility of automatic computer support to develop dependable systems. For instance, recent CPU design needs deduction tools, such as satisfiability checkers, model checkers, and theorem provers. We pursue from theoretical foundation (e.g., formal modeling and algorithms), their implementations, and applications to practical software. Background theory contains combinatorics (e.g., graphs, order structures), rewriting, formal languages, mathematical logic, and formal proofs of mathematical theorems; we are interested in implementating/applying deduction tools for complext software, by combining irrelevant/forgotten theoretical results, extensive use of existing tools, and communication with different research areas including industry.

Research topics

1. Term rewriting systems

Although rewriting is simple, it formalizes transition relation and dependency nicely. Typical target properties are termination and confluence. If termination is assumed, confluence is easily decided. If not, there are only several criteria are known mainly for left-linear systems. Our interest on theory includes consistency/confluence of non-linear term rewriting systems (TRS). Those that on applications include complete axiomatization of graphs with bounded tree width, and algebraic specification of formal semantics of programming languages.

2. Formal proof of combinatorical theorems

Our target is formal proof of Kruskal-type theorems on theorem prover, Isabelle/HOL. We first try on the simplest statement, Higman lemma, based on open/update induction, which will be a good example of extraction of computational content from classical proofs.

3. Infinite state model checking

Finite model checking becomes popular in industry, e.g., Spin. When a model contains realtime, context-sensitive, or arithmetic features, a model becomes infinite, resulting undecidability in general. However, we found that if there is a certain ordering structure, decidability is recoverd, and such examples include extensions of Petrinet with a stack, binary operations, and 0-test.

We also show decidability of a pushdown model with timed automata as stack alphabet, which models a scheduler with presence of recursive preemption.

4. Binary program analysis

Malware often circulates only with binary code. Advanced techniques, e.g., polymorphic virus, further apply obfuscation techniques, including self modification and self decryption, which make understanding control structure very difficult. For binary program analysis, we first need to generate precise a control flow graph (CFG). We investigate and develop a tool BE-PUM (Binary Emulation for PUshdown Model generation), which mutually applies static analysis and dynamic emulation (both symbolic and concrete execution).

5. Non-linear constraints solving on reals

Automated roundoff error detection, control parameter design, and testdata generation are often reduced to constraint solving on reals. Recently, SMT (SAT modulo theory) development becomes hot and a competition like SMTcomp is organized every year. They often cover linear constraints (Presburger arithmetic), and nonlinear constraints becomes evolving. We propose a refinement of approximations based on interval arithmetic, and develop an SMT raSAT (refinement of approximations for SAT). (www.jaist.ac.jp/~mizuhito/tools/rasat.html)

Publications

- Xiaojuan Cai, Mizuhito Ogawa. Well-Structured Pushdown Systems, 24th International Conference on Concurrency Theory, CONCUR 2013, Springer LNCS 8052, pp.121-136, 2013.
- To Van Khanh, and Mizuhito Ogawa, SMT for Polynomial Constraints on Real Numbers, Tools for Automatic Program Analysis TAPAS 2012, Elsevier ENTCS vol.289, pp.27-40.
- Masahiko Sakai, Mizuhito Ogawa, Weakly-non-overlapping non-collapsing shallow term rewriting systems are confluent. Information Processing Letters, 110, pp.810-814, 2010.
- Do Thi Bich Ngoc, Mizuhito Ogawa, Checking Roundoff Errors using Counterexample-Guided Narrowing, 25th IEEE/ACM International Conference on Automated Software Engineering ASE 2010, pp.301-304, 2010.

(Please refer to the URL mentioned above for the recent information)

Terauchi Laboratory

Professor : Tachio Terauchi

Program Analysis and Program Verification

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Research Overview

We study program analysis and program verification, with applications to the development of correct software. Our research spans theory and practice, and we design new algorithms and theoretical frameworks as well as tools that work on real-world programs.

Research Background

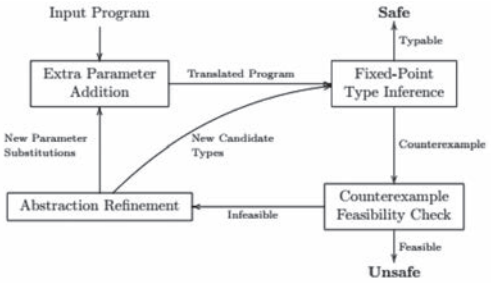
Software correctness is one of the most pressing issues in the modern information age where computer software pervades almost every aspect of life, from aviation control to bank transactions. Program analysis and verification are techniques for correct software development that can detect possible bugs in a program or formally prove that a program correctly implements a specification. The research in program analysis and verification spans a wide range of research areas, including mathematical logic, programming languages, and automated deduction.

Recent Research Topics

Verification of High-Level Programs

Recently, "software model checking" has emerged as a promising approach to the verification of software programs, and has enjoyed some successful adoption in industry as exemplified by Microsoft SLAM model checker. However, the current software model checkers are designed for verifying low-level programs such as C programs, and not very effective at verifying high-level programs that liberally use high-level programming language features such as higher-order functions and objects.

In our research lab, we are developing software model checking techniques that are effective for verifying high-level programs. For instance, we have proposed the first counterexample-guided abstraction refinement technique for higher-order programs, a key component in software model checking, and have also proposed a relatively complete verification framework for such a class of programs. Our recent work also includes the verification of temporal logic properties of high-level programs.

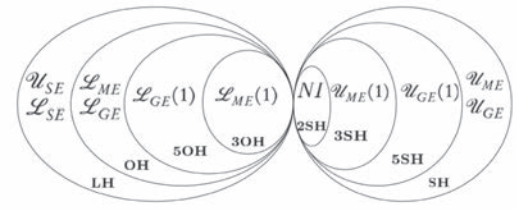


Overview of Higher-Order Program Verification via Counterexample-Guided Abstraction Refinement

Applications to Computer Security

Consider programs handling confidential data (e.g., a user's bank card number). We study program analysis and verification techniques for ensuring that such programs do not leak the secret information to public observers, or measuring the maximum possible leak from potential attacks.

For instance, we have developed a technique which detects possible information leaks by reducing the problem to software model checking via program transformation. We are also studying applications to side channel attack resilience.



Classification of Information Flow Analysis Problems

Publications

- E. Koskinen and T. Terauchi, "Local Temporal Reasoning," In Proceedings of the Joint Meeting of the 23rd EACSL Annual Conference on Computer Science Logic and the 29th Annual ACM/IEEE Symposium on Logic in Computer Science (CSL-LICS 2014), to appear.
- T. Kuwahara, T. Terauchi, H Unno, and N. Kobayashi, "Automatic Termination Verification for Higher-Order Functional Programs," In Proceedings of the 23rd European Symposium on Programming (ESOP 2014), Lecture Notes in Computer Science 8410, Springer, 2014, pp. 392-411.
- H Unno, T. Terauchi, and N. Kobayashi, "Automating Relatively Complete Verification of Higher-Order Functional Programs," In Proceedings of the 40th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2013), ACM SIGPLAN Notices 48 (1), 2013. pp. 75-86.
- H. Yasuoka and T. Terauchi, "On Bounding Problems of Quantitative Information Flow," Journal of Computer Security 19.6 (2011): 1029-1082.
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- T. Terauchi, "Dependent Types from Counterexamples," In Proceedings of the 37th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2010), ACM SIGPLAN Notices 45 (1), 2010.

Aoki Laboratory

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Developing Correct Software

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Correct Software

Today, software plays an important role in our society. It is used not only for personal computers but also airplanes, cars, stock markets, and our personal appliances such as mobile phones and video recorders. Software is becoming more familiar to our daily life. Imagine that such software is incorrect. That might cause the chaos of our daily life and economic activities, the huge loss of money and time, and, in the worst case, loss of life. In fact, such accidents have been reported. To ensure that our society gets a great future and our peaceful life, we have to study how we can develop correct software. One of the ways to realize such software is that we adopt formal methods in software developments.

Formal Methods

Formal methods represent a development style of software based on mathematics. We describe its specification and design in not natural language but languages based on mathematical theories such as sets and functions. That not only makes the specification and design rigorous but also allows us to precisely analyze them, prove their correctness and automatically generate source codes. On the other hand, it is also important to study software itself. Software is not studied for long time compared with the other natural science fields. If it is continuing to play an important role for our future, we have to establish the science of software by revealing its essentials and principles.

Verification of Software

One way to provide correctness with software is that we describe it rigorously, then we prove its correctness. That is called 'formal verification' of software. To realize such verification, we focus on two techniques, model checking and theorem proving. Although those techniques are relatively practical in formal methods, there are gaps between them and practical software developments. Those techniques are still too theoretical. Therefore, we are researching how we bridge such gaps. We mainly focus on object-oriented analysis and design, and embedded software developments. We are also developing computer environments to support them.

Principle of Software

Fundamental theories for software are studying for a long time. Some of them are getting matured such as program semantics and process algebra. To promise bright future of software, it is important to find the principles of software based on those theories. Unfortunately, today's software is developed without such principles. We should change this style of software developments into more scientific ones which are integrated on the mathematics. Thus, we are challenging to establish such fundamental principles of software.

Publications

- Kenro Yatake and Toshiaki Aoki: Automatic Generation of Model Checking Scripts based on Environment Modeling, The 17th International SPIN Workshop on Model Checking of Software (SPIN 2010), pp.58-75, 2010.
- Chaiwat Sathawornwichit, Toshiaki Aoki and Takuya Katayama: Modeling of Real-Time System Designs for Parametric Analysis, the 16th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications(RTCSA 2010), pp.81- 91, 2010.
- Toshiaki Aoki and Takuya Katayama: Statechart-based Verification of Object-Oriented Design Models, 14th Asia-Pacific Software Engineering Conference, p.278-285, 2007.
- Toshiaki Aoki: Model Checking Multi-task Software on Real-time Operating Systems, International Symposium on Object-Oriented Real-Time Distributed Computing 2008, p.551-555, 2008.

Suzuki Laboratory

Associate Professor : Masato Suzuki

Software Development and Comprehension
—An Architecture and Component-based Approach—

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Overviews

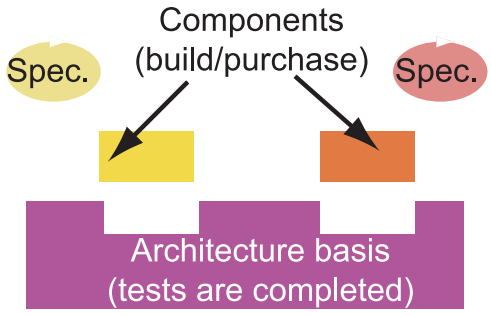
The environment for software depelopment has been changing drastically by high demands of requirements such as increase of variation, shortage of time-to-market, and integration of heterogeneous applications through WEB technologies.

We need a brand new methodology to support development and maintainance of these kind of software.

What is software architecture?

The term 'architecture' is originally used as the meaning of generic structures of constructed objects (houses, bridges etc). In the field of software development, it means a structure of some parts (called components) and a basis which connects the components implementing each functions. Ideally, architcture helps us to build an application automatically by connecting components to the holes of the architecture like a toy blocks.

Architectures are designed reusable, so we can spend all of our efforts to build reliable and efficient components. It is expected to improve the performance and reliability of applications with small costs.



Research interests

We are engaging on architecture and component-based software
engineering. Our goals are as follows:

Supports for development

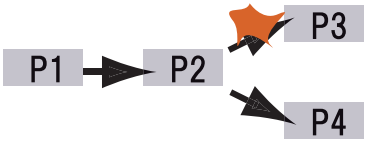
- spec./verification of connectors
- semi-automatic modification of components from their histories

Supports for complehension

- visualization of components

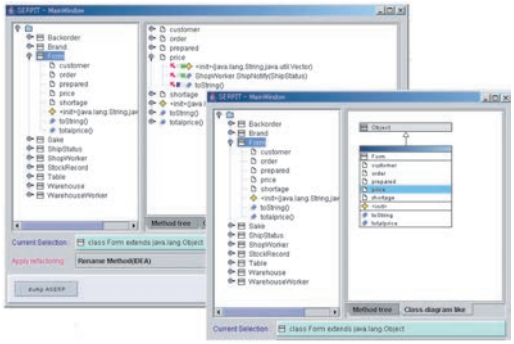
Rebuilding legacy software using components Supporting changes by the history:

We can change P2 to P3 and P4. Though P3 fails further change, it is impossible to detect now.



We can detect whether changes P2→P3 contradicts changes P1→P2 from the history.

An output of visualization tool:



Publications

- Hieu Vo and Masato Suzuki: "An Approach for Specifying Role-Based Access Control in EJB Applications," Proceedings of the 2nd International Conference on Advances in Information Technology (IAIT2007), 2007
- Hieu Vo and Masato Suzuki: "An Approach for Specifying Access Control Policy in J2EE Applications," Proceedings of 14th Asia- Pacific Software Engineering Conference, (APSE2007) pp422-429, 2007
- M. Suzuki : Architecture and Component based Approaches for Dependable Distributed Information Systems, World MultiConference on Systems, Cybernetics and Informatics 2000, Volume 3, pp.656-661, 2000

Hirokawa Laboratory

Associate Professor : Nao Hirokawa

Theory of Computing: Term Rewriting and Automatic Verification

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Research Overview

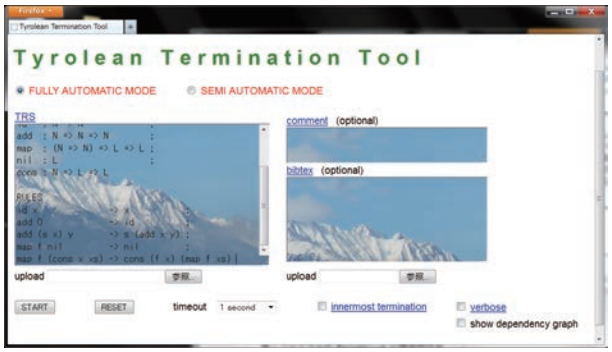
We are concerned with the science of computation. Term rewriting is a simple but powerful computational model, which underlies declarative programming languages (e.g. ML, CafeOBJ), theorem proving, and computer algebra systems (e.g. Mathematica). Our research aim is to establish techniques for analyzing computational properties like termination and confluence. In particular we are aiming at developing automatable methods, which enable us to apply powerful rewriting theory to applications in verification.

Research Topics

Termination Analysis

From time to time we witness that programs freeze. If you have an experience with programming, you must have suffered from such a non-termination bug. It is well-known that the termination problem is undecidable in general, however, there have been enormous researches on termination analysis. In 2004 the annual termination competition started. Our termination tool TTT took second place in 2004 and 2005.

Our current emphasis is to develop a light-weight method for termination analysis so that we can embed termination analyzers in applications like compilers.



Complexity Analysis

Getting one step further, we are tackling to (runtime) complexity analysis too. Once termination is shown, certainly one wants to know how quickly the program terminates. Our immediate goal is to develop an automatic complexity analyzer so as to deduce $O(n^2)$ for the quicksort algorithm automatically.

Confluence Analysis and Theorem Proving

Confluence is a property to ensure uniqueness of computational results. Unlike termination, the research of automatic confluence analysis has just started. Confluence is tightly connected to reduction strategies for lazy evaluation and concurrent programming as well as theorem proving, so we are expecting that this area will get more attentions in the coming years.

Approaches and Policy

Although the theme is theoretical study, our research revolves around programming. For this purpose we make use of functional programming languages and SMT solvers (constraint solvers), both of which are our target applications at the same time.

Publications

- Nao Hirokawa and Aart Middeldorp: Decreasing Diagrams and Relative Termination. Journal of Automated Reasoning 47(4), pp. 481-501, 2011
- Nao Hirokawa and Georg Moser: Automated Complexity Analysis Based on the Dependency Pair Method. Proceedings of the 4th International Joint Conference on Automated Reasoning, Lecture Notes in Artificial Intelligence 5195, pp. 364-379, 2008.
- Nao Hirokawa and Aart Middeldorp: Tyrolean Termination Tool: Techniques and Features. Information and Computation 205(4), pp. 474-511, 2007.
- Nao Hirokawa and Aart Middeldorp: Automating the Dependency Pair Method. Information and Computation 199(1,2), pp. 172-199, 2005.

Défago Laboratory

Associate Professor : Défago, Xavier

Fault-Tolerance and Group Communication

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Research Overview

A distributed system consists of a collection of programs running on different processors (called processes), a communication medium, and, most importantly, protocols to ensure agreement, synchronization and cooperation among the processes. The goal is to make the whole system appear as a single coherent system.

From real-time embedded systems to enterprise information systems, and from power grid control to the Internet, most systems in our current society are distributed. For this reason, distributed systems must be able to survive even if some of the components are faulty.

Our research focuses on two goals: making processes work together, and helping the system survive even if some processors or processes fail. Mainly, we focus on applying the approach to robot systems.

Main Research Projects

Robot networks

We aim at building a multi-robot system based on formally proven algorithms. To do so, we are working on wireless ad hoc network protocols aimed specifically at robot systems. While many ad hoc protocols consider mobility as an input parameter, robot systems must often consider mobility as the main output parameter to control. Low-energy network protocols designed for sensor networks, such as Xbee/Zigbee, can be optimized based on information provided for instance by a motion planning component. At the same time, motion planning can calculate routes such that the system is less likely to face partitions. Or, when partition do occur, a better estimation about their duration can be used to improve the efficiency of disruption-tolerant network protocols.

Robot cooperation algorithms

The problem of cooperative autonomous mobile systems (e.g., Internet-enabled robots) is to control a group of mobile entities in such a way that they cooperate to perform some collaborative actions. This general problem is subject to very active research but, so far, most research in this field have taken an ad-hoc or bottom-up approach; by studying how some complex global behavior can emerge from the interaction of many entities with just a very simple local behavior. In contrast, we try to follow a different (complementary) approach with a top-down perspective. The idea is to consider practical tasks involving large groups of autonomous mobile systems, and extract abstract problems common to many tasks. After formally specifying those problems and developing an adequate computational model, the goal is to find the minimal conditions under which some particular tasks can be achieved.

Performance and scalability of distributed algorithms

The performance and the scalability of distributed algorithms and protocols are often not evaluated as thoroughly as they should be. One important aspect of our research is concerned with improving this situation through the development of adequate tools. These tools include a set of performance metrics for distributed algorithms, a prototyping environment, as well as running adequate network experiments. This research activity has led us to develop the Neko framework, as well as a novel approach to network failure detectors, called accrual failure detectors. One of our proposed instance of such failure detectors are being used in the Cassandra project.

Middleware and protocol composition

We are studying middleware architecture and flexible protocol composition as part of our efforts to devise a fault-tolerant multi-robot middleware framework. Our efforts are based on the Neko protocol framework that was designed to support the prototyping and the evaluation of distributed protocols. The specific interaction models of robotic software components (sensor/actuators, filters, real-time constraints, etc.) are interesting challenges that make it difficult to consider protocols as black boxes.

Publications

- T. Izumi, S. Souissi, Y. Katayama, N. Inuzuka, X. Défago, K. Wada, M. Yamashita. The Gathering Problem for Two Oblivious Robots with Unreliable Compasses. SIAM J. Comput. 41(1): 26-46 (2012)
- J. Clément, X. Défago, M. Gradinariu Potop-Butucaru, T. Izumi, S. Messika. The cost of probabilistic agreement in oblivious robot networks. Inf. Process. Lett. 110(11): 431-438 (2010)
- S. Souissi, X. Défago, M. Yamashita. Using eventually consistent compasses to gather memory-less mobile robots with limited visibility. ACM Trans. on Autonom. and Adapt. Syst., 4(1)9:1-27 (2009)
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- R. Yared, X. Défago, J. Iguchi-Cartigny, M. Wiesmann. Collision prevention platform for a dynamic group of asynchronous mobile robots. J. Networks, 2(4):28-39 (2007)
- X. Défago, P. Urbán, N. Hayashibara, T. Katayama. Definition and specification of accrual failure detectors. In Proc. IEEE/IFIP DSN '05, pp.206-215 (2005)
- X. Défago, A. Schiper, P. Urbán. Total order broadcast and multicast algorithms. ACM Comput. Surv., 36(4):372-421 (2004)
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Preining Laboratory

Associate Professor : Preining Norbert

Logic and Computation
Bridging the gaps between Theory and Praxis

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Research Overview

Our research is devided into two groups: Logic foundations for Intermediate and Fuzzy Logics, in particular Gödel Logics, and Formal Methods, in particular Software Specification and Verification.

Research in the former is mainly on the foundational side, while the one in software specification involves language extensions, actual programming, and development of new tools.

Logic Foundations

Intermediate Logics

In a world that is not binary and decisions have to be taken gradually, engineers modeling systems are often faced with the need for a more expressive logic. Intermediate logics are extensions of classical logic containing more than two truth values (true and false). They find applications in medical expert systems, database theory, and engineering.

We are providing the logic foundation for these many-valued logics, or fuzzy logics, discussing questions like axiomatizability, validity, satisfiability, decidability. Some of the more widely known logics in this area are Intuitionistic logic, Łukasiewicz logics, and Gödel logics.

First-order Gödel Logics

We are primarily targeting first-order Gödel logics, out of two reasons: Remaining at the propositional level restricts expressibility, and serious modeling of complex systems will need first-order (that is quantified) logic. Secondly, Gödel logics behave nicely not only on the propositional level, but also on the first-order, in contrast to most other intermediate logics.

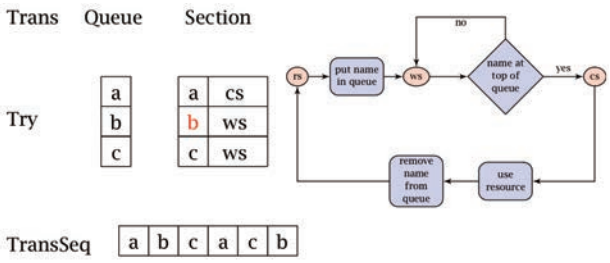
Formal Methods

Software Verification

In a society where computerization permeates every aspect of our life, trust and certification of software is becoming of continuously increasing importance. Software systems that control vital parts of our society need to provide evidence of correctness. We are using formal methods, in particular algebraic specification and verification to model complex systems, describe their properties, and verify their behavior.

Algebraic Specification Languages

The tool of choice for our research on software verification is the algebraic specification language CafeOBJ with its core development center at the JAIST. Providing the engineer with a rich set of language elements, this language is an excellent tool for specification and verification.



Besides carrying out actual specification and implementation, the language design and methodology is within our research area.

Publications

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- Matthias Baaz, Agata Ciabattoni, and Norbert Preining. First-order satisability in Gödel logics: an NP-complete fragment. Theoretical Computer Science, 2011.

Ochimizu Laboratory

Research Professor : Koichiro Ochimizu

Software Engineering

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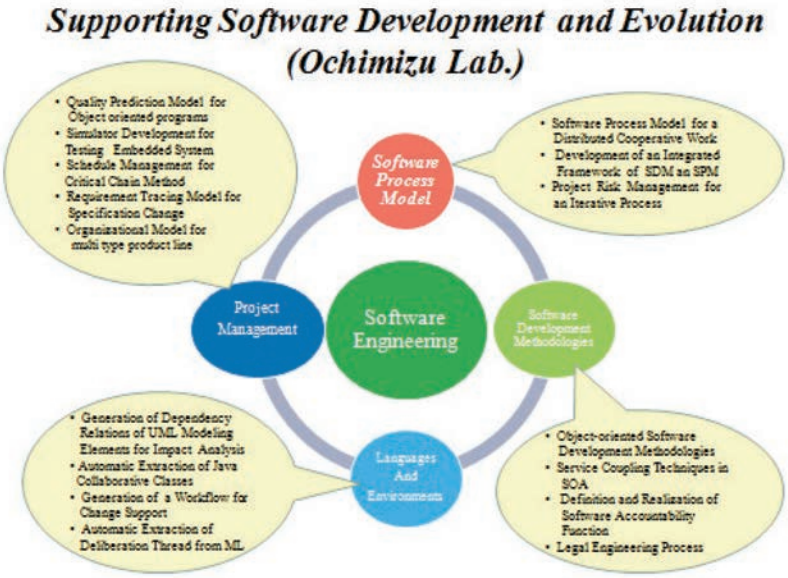
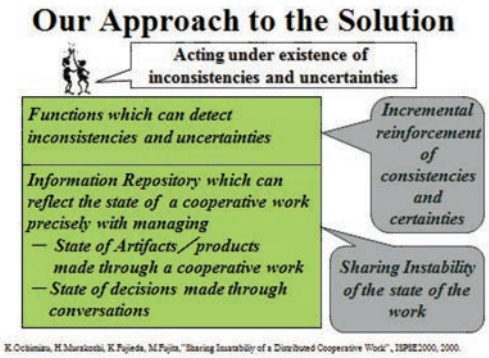
My research interest is in
Software Engineering
especially for:
Software Process Model;
Software Development Methodologies;
Software Development Environments;
and Project Management Technologies.
On-going Topics are: Support Environment for Distributed Cooperative Works;
Simulator Development for Embedded Systems ;
Requirement Tracing Models;
and
Realization of Software Accountability



Software Development Environment for a Distributed Cooperative work

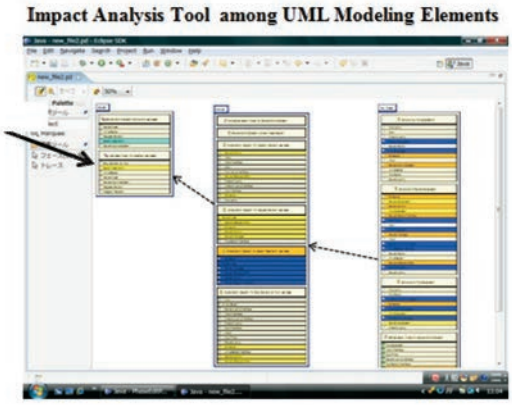
We need another new model to support cooperative works among people who are geographically distributed.

Sharing Instability and Uncertainties



Generation of workflows for supporting multi-threaded interacting changes

We have developed the tool which can generate dependency relationships among UML modeling elements automatically to make change activities safe and efficient.



Publications

- Akinori SAITO, Takumi KUSANAGI, Koichiro Ochimizu, "A Software Project Scheculing Method Based on the Load-Capacity Model" , The IEICE Trans. on Information and Systems, Vol. J95-D, No. 2, pp225-236, 2012
- M. Kotani and K. Ochimizu, "Automatic Generation of Dependency Relationships between UML Elements for change Impact Analysis", Journal of Information Processing Society of Japan, Vol.49 No.7, pp.2265-2291, 2008 (in Japanese)
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- K. Ochimizu, H. Murakoshi, K. Fujieda, M. Fujita, "Sharing Instability of a Distributed Cooperative Work", Proc. of the ISPSE, 2000, IEEE Press, pp.36-45.
- K. Kishida, T. Katayama, M. Matsuo, I. Miyamoto, K. Ochimizu, J. H. Sayler, K.Torii, L. G. Williams, "A Novel Approach to Software Environment Design and Construction", Proc. of the 10th ICSE, pp.69-79, April, 1988

Futatsugi Laboratory

Research Professor : Kokichi Futatsugi

Language Design, Formal Methods, CafeOBJ: toward next generation modeling languages

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Languages

Languages are supposed to bear the kernel of intellectual activities. Needless to mention recent XML or Java language, invention of new languages promote the developments of science and technology for transmission/processing of information/knowledge. Desigh of new languages always inhabits at the kernel of computer/information science and suggests an universal but innovative research approach.

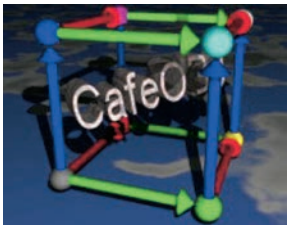
Language Design

Language design plays important roles in many areas. There always is application software which mediates computers/networks and application domains. Word processing software, electric commerce software, and game software are examples of application software. Application software communicates with users by using a language which is specific to the application domain. Designing a language which fits well to the communications about a domain makes it possible to build more reliable and usable application software.

Formal Methods

Solving a problem with computers/networks requires understanding requirements of the problem, making a model, and analyzing the problem with the model. This activity is composed of (1) identifying a vocabulary for the problem, (2) describing a model with the vocabulary, (3) communicating with stakeholders using the model/vocabulary, and (4) refining the model/vocabulary for doing more detailed analysis. Language design is a central activity in these activities, and language design plays an important role in analysis, design, and development of systems. The role of language design is not well perceived in the traditional systems development methodology, but it is a central idea in formal methods (mathematical methods for systems modeling and development).

CafeOBJ



CafeOBJ is a new type of language for describing models and specifications of problems. Ii is not a programming language like C or Java, but an executable language for modeling and analyzing problems at a level more near to human beings. CafeOBJ can also work as a Meta-language for defining a new language for a new problem, and is a language for designing languages. CafeOBJ language system has been designed and developed by an international team of researchers, and FUTATSUGI Lab has played the central role in the design and development for more than ten years.

Research Themes

The following research themes are pursued at FUTATSUGI Lab by using the current CafeOBJ system for exploring next generation modeling languages.

Systems Verification Methodology: Deductive verification method using only reductions which is more easer to use and to understand.

Domain Modeling Methodology: Methodology of domain modeling and description which are formal enough for doing formal reasoning about domains.

Social Systems Modeling: Modeling and Analysis of government systems, business systems, work flows, internal governance systems.

Secure Protocols Modeling: Modeling and analysis of secure protocols like e-commerce protocols.

Systems Biology: Modeling and analysis of biological systems.

Publications

- Fostering Proof Scores in CafeOBJ, Proc. of 12th International Conference on Formal Engineering Methods (ICFEM 2010), LNCS 6447, Springer, pp.1-20, 2010. (invited paper)
- Verifying Design with Proof Scores, 1st VSTTE, LNCS 4171, Springer, pp.277-290, 2008.
- Verifying Specifications with Proof Scores in CafeOBJ, Proc. of ASE2006, pp.3-10, 21st IEEE International Conference on Automated Software Engineering (ASE'06), 2006. (invited paper)
- Logical Foundations of CafeOBJ, Theoretical Computer Science, 285, pp.289-318, 2002.
- Formal Methods in CafeOBJ, Lecture Notes in Computer Science, 2441, pp.1-20, 2002. (invited paper)
- CafeOBJ Report: The Language, Proof Techniques, and Methodologies for Object-Oriented Algebraic Specification, World Scientific, AMAST Series in Computing 6, 1998.

Akagi Laboratory

Professor : Masato Akagi

To make machines' ears and mouth intelligent

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Research Overview

The work of Akagi Lab. is speech signal processing and modeling the speech perception mechanism of humans. Speech is the most natural means of communication between humans. Therefore, it is believed that modeling these compensation mechanisms is able to realize the high-performance speech processing systems.

Research Overview

Fig. 1 shows the principle procedures of speech communication (production and perception). Akagi lab. is mainly focusing on the topics indicated by the red blocks (e.g., speech production, speech communication in real environments, speech perception). In our research, not only engineering (digital signal processing) but also knowledge of physiology and/or psychology is required.

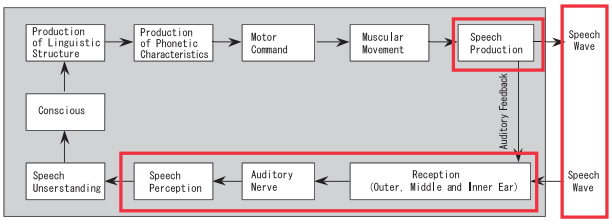

Fig. 1 Principle of speech communication

Research Overview

Production: Through modeling the speech production mechanisms, the research is aimed to synthesize the natural speech. The research includes: to investigate the relationship between speech spectrum and shape of vocal tract, to synthesize natural speech with non-linguistic information (e.g., individuality and emotion), to synthesize singing voice (Fig. 2).

Perception: Through modeling the perception mechanisms of human beings, the research is aimed to recognize speech in realworld conditions. Specifically, the research includes: to realize cock-tail-party effect, to enhance speech (Fig. 3). Moreover, we also study on relations between psychological factors and underlying acoustically physical factors of singing voices and measure brain activities when listening to singing voices, and then synthesize the more natural singing voice.

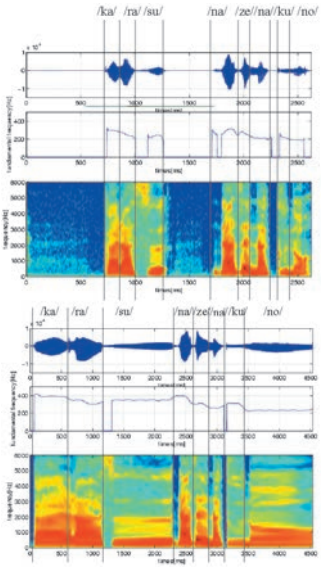

Fig. 2 Speaking voice (a), synthesized singing voice (b).

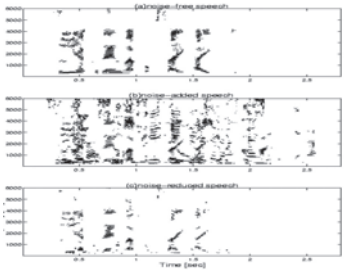

Fig. 3 Enhancement of one person voice from 4-person simultaneous speaking voices.

Publications

- Saitou, T., Unoki, M. and Akagi, M.（2005）. "Development of an F0 control model based on F0 dynamic characteristics for singing-voice synthesis, "Speech Communication 46, 405-417.
- Li, J. and Akagi, M（. 2006）. "A noise reduction system based on hybrid noise estimation technique and post-filtering in arbitrary noise environments," Speech Communication, 48, 111-126.
- Huang, C-F. and Akagi, M（. 2008）. "A three-layered model for expressive speech perception," Speech Communication 50, 810-828.

Dang Laboratory

Professor : Jianwu Dang

Speech Communication: Intention, Articulation, Cognition, and its Applications

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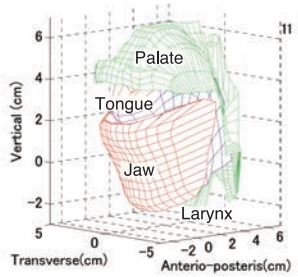
Abstract

Speech communication as well as eating and swallowing are the basic activities concerned with human life, while the tongue is the essential organ playing an important role. In our Lab, we have developed a physiological simulator including the tongue and the other oral-facial organs, and have used it for speech production and inversion. We are also endeavoring to use this approach to clinical application such as glossectomy and swallowing disorder, as well as on speech processing.

Development of the Physiological Simulator

We have constructed a 3D physiological articulatory model based on volumetric MRI and anatomic data (rf. following figure). This model is based on morphologic and physiologic measurements of human speech organs, and is driven by muscle activation patterns. Using this model, we investigate mechanism of normal speech as well as pathologic speech and problems with swallowing.



Speech synthesis with individuals

Individual characteristics of speech sound are dependent on the morphologies and movement of speech organs. We are constructing a physiological based synthesizer by considering the personal morphological and acoustic characteristics.

Interaction between speech production and perception

There is a loop, namely speech chain, in conversation of speakers and listeners and in the human brain.However, it is not clear how the speech production and perception interact each other. There, we treat with this problem from two aspects. ① Estimation of articulation status from speech sound: we investigate "natural" and "unnatural" articulations using the physiological model to minimize the one-to-many problem. ② Interaction between speech production and perception: we use a transformed auditory feedback to investigate the communication process between speech production side and speech perception side.

Speech emotion perception among different cultural backgrounds

In conversation, we can perceive emotion somehow even if we do not understand the language. It suggests that there may exist some common factors beyond the language backgrounds. We are going to discover the common factor from psychological, cognitive and physiological aspects using a space consisting of multiple cultures and emotions.

Visualization of articulation from speech sound

If a person with heavy hearing impairment loses the audio feedback it is difficult to train his/her pronunciation. We are going to find a visual feedback to replace the audio feedback by visualizing teacher's vocal tract (VT) shape and the speaker's VT shape via inverse estimation from speech sound to articulatory status.

Clinical applications of the physiological model

We endeavor to apply the physiological simulator to predict functional damage of the tongue with glossectomy by simulating resection situation of the surgeries, and assist to optimize the plan for the surgery and rehabilitation.

In addition, the physiological simulator is also used to investigate the mechanism of the disorder of swallowing.

Publications

- Songgun Hyon, Jianwu Dang, Hui Feng, Hongchi Wang, Kiyoshi Honda (2014) Detection of speaker individual information using a phoneme effect suppression method, Speech Communication, 57, 87-100.
- Baolin Liu, Yanfei Lin, Xiaorong Fao, Jianwu Dang (2013) Correlation between audio-visual enhancement of speech in different noise environments and SNR: A combined behavioral and electrophysiological study, Neuroscience, 247, 145-151.
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- Xugang Lu, and Jianwu Dang, (2010) "Vowel Production manifold: intrinsic factor analysis of vowel articulation," IEEE Trans. Audio, speech and language processing, Vol. 18, No.5, pp.1053-1062.

Chong Laboratory

Professor : Nak-Young Chong

Realizing Intelligent Robots within Informatically Structured Environment

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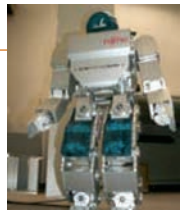
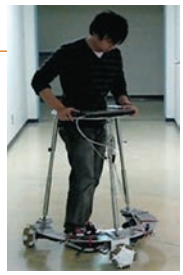
Humanoid Robot



We develop efficient and robust algorithms to the problem of biped humanoid locomotion. By constructing a network of neural oscillators, the locomotion controller will enable the robot to maintain a stable body posture when significant disturbances are applied regardless of how uneven the terrain is.

Human Robot Interaction



Robots are increasingly deployed to serve as assistants to humans. Such robots must coordinate their behaviors with the requirements and expectations of humans. To understand the social and technical issues, welfare/rehabilitation systems are developed.

Enhanced Teleoperation System

To aid the remote operator who lacks the necessary perception, augmented reality systems are developed that overlay virtual objects and information onto the views of the real world. Effective multimodal interfaces are designed.

Networked Robots

Recent advances in sensor and networking technologies provide innovative approaches to facilitating the robot's recognition process by structuring an easy-to-understand environment with networked embedded devices such as wireless sensors and RFID transponders. Our effort is devoted to the development of bearing based ad hoc target acquisition and docking systems using RFID technology for indoor mobile robot applications.developed and tested

RFID antenna and power detector in development

Swarm Robots

Formation generation and navigation controls are developed for a swarm of mobile robots that adapts its geometric shape if the environment changes. Special emphasis is placed on clarifying how group behaviors emerge from inter-robot interactions.

Soft Actuators

A variety of flexible, light weight mobile robot systems are developed using FSB. Of particular interest is energy-efficient acutuators and mechanisms.

External Activities

Editor-in-Chief, International Journal of Advanced Robotic Systems; Editor, IEEE International Conference on Robotics and Automation, IEEE Conference on Automation Science and Engineering Conference Editorial Board; Associate Editor, IEEE Transactions on Robotics,Springer Journal of Intelligent Service Robotics, Springer Journal of Intelligent Service Robotics, International Journal of Assistive Robotics and Systems; IEEE Technical Expert; Co-Chair Emeritus, IEEE Robotics and Automation Society Technical Committee on Networked Robots; Program (Co)-Chair, 2009 JCK Workshop on Robotics, 2010 ICAM, 2011 IEEE Ro-Man, 2012 IEEE CASE, 2013 IEEE Ro-Man, 2013 URAI, 2014 DARS; Director, Korea Robotics Society, JAIST Center for Intelligent Robotics; Marquis Who's Who in Science and Engineering, Who's Who in Asia, Who's Who in the World; Cambridge International Biographical Center.

Publications

- Nak Young Chong and Fulvio Mastrogiovanni (Eds.), Handbook of Research on Ambient Intelligence and Smart Environments: Trends and Perspectives, IGI Global, PA, U.S.A., 2011
- Nak Young Chong (Ed.), Networking Humans, Robots and Environments, Bentham Science Publishers, IL, U.S.A., 2012
- Woosung Yang, Nak Young Chong, and Bum Jae You, Optimizing Neural Oscillators for Rhythmic Movement Control, VDM Publishing House Ltd., Saarbrucken, Germany, 2010
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Asano Laboratory

Associate Professor : Fumihiko Asano

Efficient Motion Control of Robotic Systems Utilizing Physical Principles

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Abstract

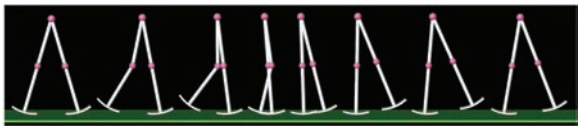
Our laboratory studies robotics and control engineering, especially humanoid robots and their motion control and technologies. We aim to gain a deeper understanding of skillful and adaptive mechanisms of humans and animals through robotics research, and to develop novel machine systems that can achieve more advanced movement than living organisms.

Efficient dynamic bipedal walking

Achieving bipedal locomotion is one of the main subjects in recent robotics research. Our limit cycle approach has potential as a novel locomotion theory, instead of the traditional approach.

Dynamic based control of bipedal walking

Robot control theories developed in the 20th century tend to control or cancel out the robots' own dynamics to achieve the specified desired tasks. Novel approaches that utilize the dynamics of the robot effectively with only small actuation have recently been investigated. Passive dynamic walking (PDW) is a good example in this field and has been actively studied. It is considered as a clue to elucidate natural human walking, as well as robotic legged locomotion. We mathematically investigate PDW mechanisms from the mechanical energy view-point, and apply the results to achieve level dynamic walking and to improve gait efficiency.



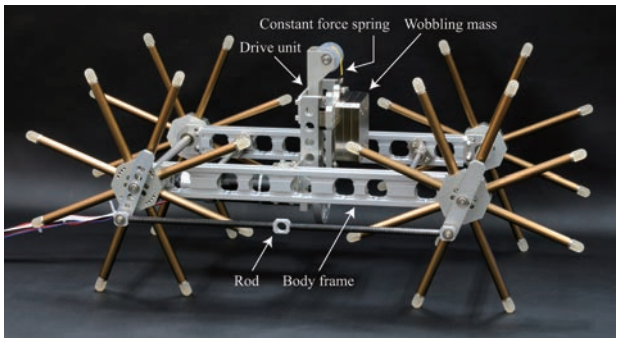
Simulation of efficient level dynamic bipedal walking

Novel control theory for legged robots

In previous control theories of bipedal walking, there has been a tendency to identify the multi-linked bipedal system as a manipulator fixed on the floor based on "zero moment point (ZMP)". However, the limit cycle approach is more effective in achieving high-speed and energy-efficient dynamic walking. By treating dynamic walking as a limit cycle with impacts, and exploiting inherent passivity or instability, we aim to construct more reasonable and convincing theories specialized for legged locomotion.

Physical mechanisms that improves locomotion performance

It is also very important to scheme the robots' physical mechanisms and configuration to improve the locomotion performance. For example, it is known that semicircular feet instead of flat feet dramatically improve walking speed. We aim to mathematically clarify the mechanisms of such elements and their effects on the gait efficiency, and to develop novel mechanisms inspired by the results.



Combined rimless wheel with active wobbling mass that moves up and down in body frame

Publications

- Fumihiko Asano and Masashi Suguro, "Limit cycle walking, running, and skipping of telescopic-legged rimless wheel," Robotica, Vol. 30, Iss. 6, pp. 989-1003, 2012.
- Masataka Ohshima and Fumihiko Asano, "Stability and efficiency of underactuated bipedal walker that generates non-instantaneous double-limb support motion," Proceedings of the 2013 IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 3624-3629, Nov. 2013.
- Fumihiko Asano and Junji Kawamoto, "Modeling and analysis of passive viscoelastic-legged rimless wheel that generates measurable period of double-limb support," Multibody System Dynamics, Vol. 31, Iss. 2, pp. 111-126, 2014.

Unoki Laboratory

Associate Professor : Masashi Unoki

Auditory-motivated sound signal processing

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Research Overview

Humans can easily listen to target sounds that they want to hear in real environments, such as those that are noisy and reverberant one. In addition, hearing abilities can be improved by using attention. However, it is very difficult for machines (i.e., computers) to do the same thing. Implementing auditory signal processing with the same functions as those of human hearing systems onto computers would enable us to accomplish human-like speech signal processing. Such a processing system would be highly suitable for a range of applications, such as speech recognition processing and hearing aids. Achieving this is the ultimate goal of our research team.

Auditory filterbank

The main function of the human auditory system is to decompose sound signals into frequency components (i.e., frequency selectivity), as shown in Fig. 1. It is well known that this frequency selectivity involves nonlinear signal processing. We have been correcting the masking data of various masking situations to find nonlinear frequency selectivity. We have been constructing a nonlinear auditory filterbank whose function is equivalent that of the human hearing system. In addition, we have been investigating active hearing by using attention.

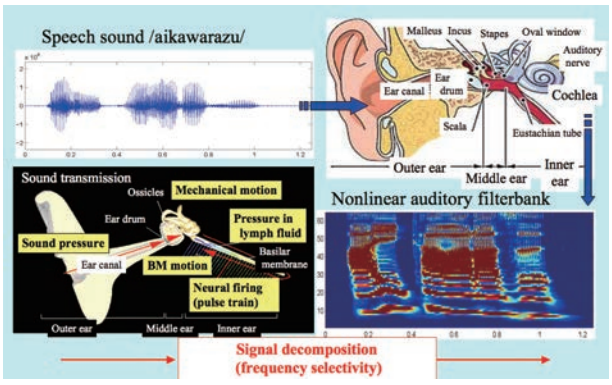

Fig. 1 Signal representation via auditory filterbank

Auditory-motivated speech signal processing

The following research projects have been used in an auditory filterbank to process speech signals: a selective sound segregation model and speech enhancement method based on the concept of the modulation transfer function. Our main purpose was to model the 'cocktail party effect' and to apply this model to solving challenging problems by developing our research projects into a nonlinear auditory filterbank and attain auditory signal processing.

A research project on multimedia information hiding, based on human auditory characteristics, is also currently being carried out for Internet security. There are, for example, digital rights management (DRM) problems with CDs, movies, and Internet speech communications, as shown in Fig. 2. We have been developing a digital audio watermarking technique based on human cochlear delay, which enables us to embed inaudible information into sound and to detect it from this. This technique has three main advantages of inaudibility, robustness against attacks, and confidentiality.

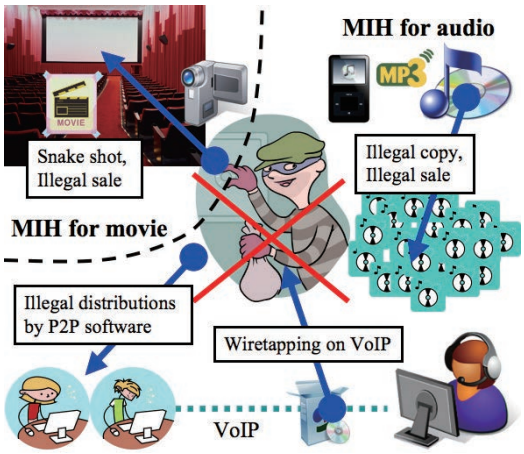

Fig. 2 Multimedia information hiding and its applications

Publications

- Nhut Mihn Ngo, Masashi Unoki, Ryota Miyauchi, Yôichi Suzuki,"Data Hiding Scheme for Amplitude Modulation Radio Broadcasting Systems," Journal of Information Hiding and Multimedia Signal Processing, Vol. 5, No. 3, pp. 307-318, July 2014.
- Masashi Unoki and Ryota Miyauchi, "Method of Digital-Audio Watermarking Based on Cochlear Delay Characteristics," Multimedia Information Hiding Technologies and Methodologies for Controlling Data, Ed. Kazuhiko Kondo, Chapter 2, pp. 42-70, IGI Global, 2012.
- Shunsuke Kidani and Masashi Unoki, "Effect of Presence of Cue Tone on Tuning of Auditory Filter Derived from Simultaneous Masking," Neurophysiological Bases of Auditory Perception, Edited by Enrique Lopez-Poveda, Alan R. Palmer, and Ray Meddis, Chapter 12, pp. 121–130, Springer, New York, 2010.
- Masashi Unoki, Toshio Irino, Brian Glasberg, Brian C. J. Moore, and Roy D. Patterson, "Comparison of the roex and gammachirp filters as representations of the auditory filter", J. Acoust. Soc. Am., vol. 120, no. 3, pp. 1474–1492, 2006.

Kotani Laboratory

Associate Professor : Kazunori Kotani

Computer Vision & Imaging: Image Analysis, understanding and Synthesize

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Research Overview

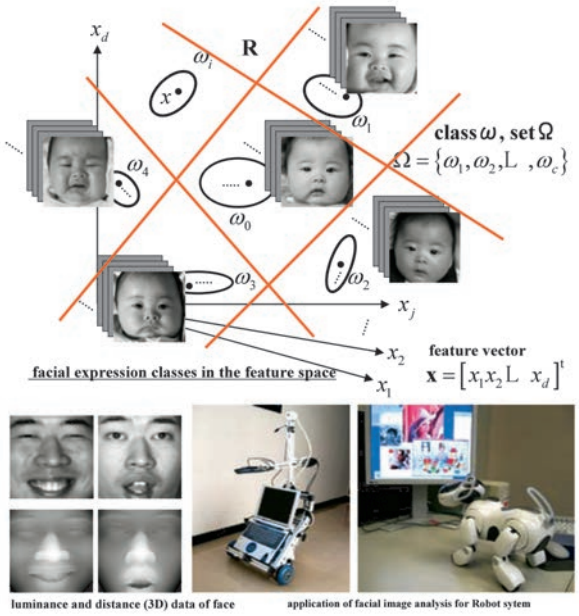
We are researching about an image processing and synthesizing based on image analysis, understanding and description. Our research area is including an image recognition, computer graphics (CG) and computer vision.

Interesting Points of Research for Computer Imaging

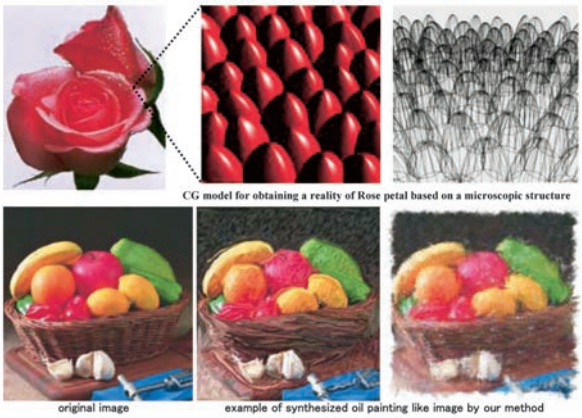
We are getting about 80% of information on around us by human visual system. Human visual system obtains not only shape and color of objects also human emotion and intention. For example, smiling face has some change of facial shape from neutral one, and it gives emotional feeling "happy" or "delightful". Moreover, smiling face gives the same feeling when we are looking the face directly, displayed on a monitor and printed on a paper. That is, visual information can be carrying a human emotion, intention, etc. through a different media. Since the visual information remains in the digital data, a computer will be able to extract image features, recognize image patterns, understand the human emotion and make a processing.

IAM and IAS

We are now studying about computer imaging by the approach of 1) **Image Analysis by Modeling** based on statistical and mathematical modeling and 2) **Image Analysis by Synthesis** based on CG and complex system.
IAM: **y=Tx** This equation shows a transformation from image vector **x** to feature vector **y** by vector **T**. When **T** is given statistically and mathematically principle so that it may be suitable for expressing the feature of image, a feature extracting, processing and recognition can be obtained accurately and efficiently. For example, when an expression class maps a facial image to



IAS: Analysis by synthesis is a suitable method for analyzing a complex system in case of statistical or mathematical modeling are difficult. Vector T is determined by iteration of synthesize and evaluation.



Publications

- "Color Image Engineering", Ohmsha, co-author.
- "Facial expression analysis by Generalized Eigen-space Method based on Class-feature (GEMC)", Journal of Japanese Academy of Facial Studies, Vol.5. No.1, pp.55-66, 2005.9.
- "Estimating Eyeglass less Facial Images using Basis Vectors", Journal of IIEEJ, vol.31 No.3, pp.337-344, 2002.3
- "Facial expression analysis by Kernel Eigenspace Method based on Class features (KEMC) using non-linear basis for separation of expression-classes", Proc. of 2004 IEEE ICIP, TA-p2.7. 2004.9.

Tanaka Laboratory

Associate Professor : Hirokazu Tanaka

Computational Neuroscience: Understanding the Brain through Computational Modeling

URL http://www.jaist.ac.jp/~hirokazu/Site/Welcome.html
https://www.youtube.com/user/ht2022columbia
E-mail hirokazu@jaist.ac.jp

Computational Understanding of Brain

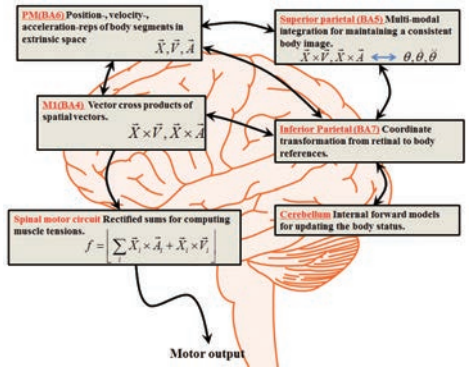
Whereas experimental approaches such as unit recording and functional neuroimaging have so far dominated in neuroscience, computational approaches are indispensable for understanding the representations and algorithms used in the brain. Our mission is to understand the brain through computational models and physiological/neural signal processing.

Computational Motor Control

What brain mechanisms can make possible animals' flexible and adaptive body movements? Our lab tackles this question through computational approaches.

Network of Motor Cortical Areas

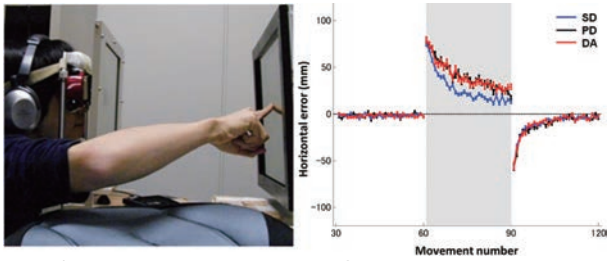
There are several motor-related cortical areas: motor cortex (final cortical output), sensory cortex (somatosensory processing), premotor cortex (sensorimotor integration), and parietal cortex (spatial body schema). Based on the theories of internal models and Bayesian inference, our lab constructs a computational model that explains the whole network of cortical motor areas in a unified way, and provides a framework for understanding the brain' s representations and algorithms in cortical motor control.



Schematics of Cortical Motor-Control Model

Motor Adaptation and Psychophysics

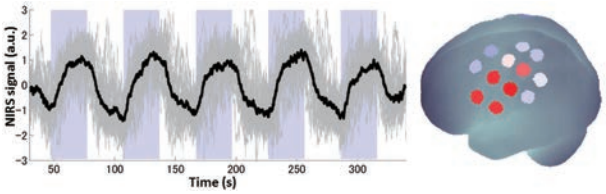
Humans exhibit an extraordinary adaptability to a novel environment such as zero-gravity space. Investigating statistical properties of motor errors during adaptation and generalization to untrained situations reveals adaptive representations and algorithms for motor adaptation. Our lab constructs computational models based on state-space models and statistical inference, and their predictions are tested in human psychophysical experiments.



Motor Adaptation Experiment and Learning Curve

Physiological / Neural Signal Processing

Our lab also studies theories and applications of physiological / neural signal processing. We have recently proposed a method (task-related component analysis, TRCA) that removes task-unrelated artifacts and extracts task-related neural and systemic signals. Detailed analyses of biological signals can provide a window into internal cognitive states that are not visible solely from behavioral observations.



Task-Related Hemodynamics Extracted by TRCA

Publications

- Tanaka H., Katura T. and Sato H. (2014) "Task-Related Oxygenation and Cerebral Blood Volume Changes Estimated from NIRS Signals in Motor and Cognitive Tasks," NeuroImage, to appear.
- Tanaka H. and Sejnoswki T.J. (2013) "Computing Reaching Dynamics in Motor Cortex with Cartesian Spatial Coordinates," Journal of Neurophysiology 109, 1182-1201.
- Tanaka H., Katura T. and Sato H. (2013) "Task-Related Component Analysis for Functional Neuroimaging and Application to Near-Infrared Spectroscopy Data," NeuroImage 64, 308-327.

Maezono Laboratory

Associate Professor : Ryo Maezono

Materials Informatics using High Performance

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Materials Informatics Science

Frontiers of Information Science has enabled the massive data handling with reasonable speed, and has made qualitative changes in materials science recently. The simulation handles vast amount of couplings from at most 100 kinds of realistic atoms on the earth with quantum mechanical calculations to predict materials properties those are useful for our life. Such activities are about to be promoted intensively by several countries as their scientific strategies. The world of quantum mechanics is out of our intuitive expectations and hence the power of computer simulation is essentially in demand.

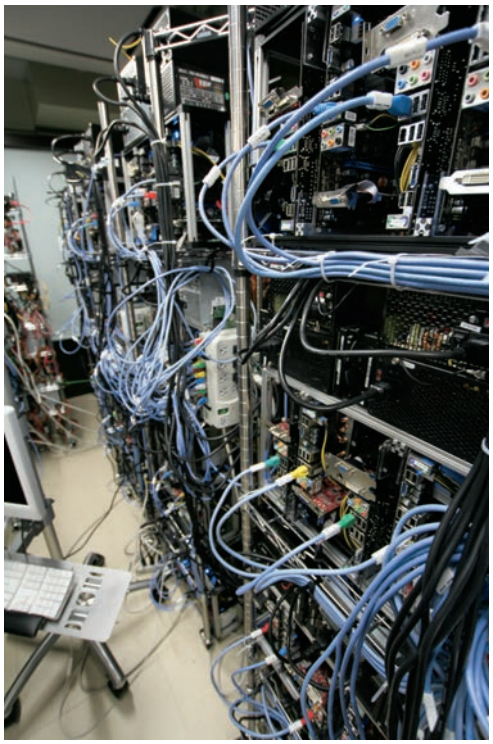
Massive Parallel Simulations

We have worked on the statistical simulations involving random number samplings combined with quantum many-body theory (Diffusion Monte Carlo method). The framework provides the most reliable estimation of electronic properties of materials. Our simulations require massive computational resources, but inherently in harmony with parallel processing. JAIST super computing facilities enable us to carry out such simulations. Recently our group has also accomplished the acceleration using graphic card (GPGPU).

JAIST is a representative center of HPC in Japan, possesing four kinds of super computers.

Interdisciplinary Challenge

There is a huge demand for researchers working on physics, chemistry, and materials science, who are good not only at mathematics but at 'computics' as another tool of analyzing phenomena. It is a great challenge for talented younger students to commit such a novel, exciting interdisciplinary field as a 'Simulation Scientist', experienced by rich computational facilities and fine course work provided by Jaist.



Our group has also worked on hand-made PC clusters so that the group member can learn the details of the parallel clustering construction.

Publications

• Our papers mainly appears in Phys. Rev. B/ Phys. Rev. Lett./ J. Chem. Phys./ J. Comput. Chem.

please visit out web page for more details: http://www.jaist.ac.jp/is/labs/maezono-lab/wiki/linkedPdf/newpub.pdf

Yoshitaka Laboratory

Associate Professor : Atsuo Yoshitaka

Realizing Novel Framework on Video Processing that Fits to Human Ways of Perception

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Overview

A new framework for accessing visual data, that achieves higher affinity to human perception is necessary, since the amount of information we access is increasing year by year. Much of the information that humans perceive is visual; however, current information processing systems do not focus on this factor enough to maximize the efficiency of human-computer interaction. We are studying semantic content detection methods for various kinds of visual information, taking the psychological aspects of human vision into account.

Feature Extraction from Video Data, and Application of These Features

Video data contains various nonverbal information, and primary semantic content that a user wishes to find depends on the situation and circumstances. One effective method of content analysis that fits human perception is to detect the features that relate to emotional information. We focus on the emotional information implied in video data. Once we model the relation between spatiotemporal features that is observable as a result of video processing with features of emotional information, it is possible to access visual data based on emotional features.

Emotional Feature Extraction based on "Film Grammar"

Various editing techniques are applied in producing movies, in order to express emotional information effectively, which is known as "film grammar". This means it is possible to detect emotional information implied in the contents by detecting editorial features related to the film grammar. Based on this idea, we are developing a system that retrieves movie contents based on emotional features, which are parts of the primary features of movies.

Emotional Feature Extraction based on Cinematography

Nonverbal, emotional information is emphasized by cinematography such as panning or zooming in producing movies.

Some emotional features are also extracted by camera work parameter detection, which is based on the emotional model. The emotional model prescribes the correspondence between the emotional parameter and camera work parameter, and brings emotional information into the scope of retrieval.

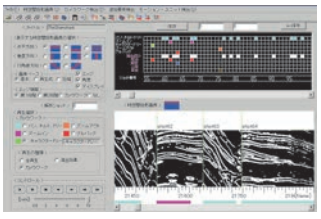
Application for Video Summarization

An application based on the use of film grammar has been developed aimed at improving accessibility of video data by providing end users a video summary containing impressive scenes, where emotional expression is emphasized.

Structuring Real World Information

Taking photographs is very common when a person is archiving visual information in the real world for future reference. However, no context-oriented index is automatically attached to photographs, except time and/or date. This makes it difficult to retrieve specific visual information associated with an event or object in the real world from a large data space.

One of the solutions for resolving this issue is to detect how a user behaves in accessing the visual information for information indexing; we focus on eye movement as a clue. We are developing a system for detecting the characteristics of visual information, as well as the state of concentration of the user on visual information based on eye movement. Visual information from the real world as seen by the user is automatically structured and tagged by our system in order to make information management more convenient.



Evaluating camera work by analysis of video images

Publications

- A. Yoshitaka, S. Chujyou, and H. Kato, "Analysis and Design of Personal Health Record Management System, "Proc. International Conference on Signal-Image Technology & Internet-Based Systems, pp. 800-805, 2013.
- A. Yoshitaka, "Image/Video Indexing, Retrieval, and Summarization based on Eye Movement", Proc. 4th International Conference on Computing & Informatics, pp. 15-21, 2013.
- H. Mitarai and A. Yoshitaka, "Emocap: Video Shooting Support System for Non-Expert Users," International Journal of Multimedia Data Engineering and Management, Vol.3, No. 2, pp. 58-75, 2012.

Iida Laboratory

Professor : Hiroyuki Iida

Entertainment, Intelligence and Game Information Dynamics

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Opponent-model search (Iida et al. 1993)

In game-playing it is often assumed that the opponent has a similar (though opposite) goal and uses a similar strategy. This assumption has led to the development of the famous minimax procedure by John von Neumann in 1928. Shannon proposed in 1950 the framework of game-tree search based on the minimax and Shannon's communication theory (1948).

Since the arrival of modern (fast) computers, a large number of very efficient algorithms have been developed on the basis of this procedure as well as many enhancements (such as Alpha-Beta Search), resulting in computers playing chess or shogi (Iida 2002) at world champion level or even better.

There are, however, situations in which the minimax procedure does not lead to the best possible play because it does not use any knowledge of the actual opponent. The use of opponent models is a practice that even children can master. The game of TicTacToe provides a good illustration. At a certain age, a child learns that the game can best be played using a set of four rules (two knowledge rules and two heuristic ones).

The two knowledge rules are: (1) make three-in-a-row, if you can, and (2) prevent the opponent from making three-in-a-row, if there is such a threat. The heuristic rules are: (3) take the middle square if it is unoccupied, and (4) take a corner square, if it is unoccupied.

This strategy offers the child an advantage over other children who are still unaware of it. However, when time passes, all other children will have learned the strategy and games tend to end in a draw. At a certain point in time, the child will discover that if the opponent uses the strategy of the four rules, it can be exploited. The move sequence in the figure illustrates this clearly.

Cross knows that Circle adheres to the strategy of the four rules.

Game-refinement theory (Iida et al. 2004)

Attractiveness of games can be quantified by a certain measurement. Such a measurement was proposed by H.Iida in 2004 based on the uncertainty of game outcome, and the idea was applied to reasoning the evolutionary changes of game rules in the framework of so-called game-refinement theory. The proposed measurement is derived from the second derivative of a logistic model of information of the game outcome. Attractiveness (excitement in particular) comes from the information acceleration in the sense of dynamics, just like we feel physical excitement by gravity acceleration when playing a roller coaster for example.

Game information dynamics (Iida et al. 2012)

There has been a flurry of activity at Iida Laboratory dedicated to filling in the gaps and further developing the Game information model. Fundamental game patterns, game refinement, certainty of game outcome, a bevy of novel fluid mechanics experiments, and cognitive brain function experimentation are all going along full steam at Iida Lab. The implications of this new model are far reaching with potential influence over the fields of fluid dynamics and information dynamics, and also on AI, cyber security, chaos theory, and of course gaming. The model stands to change the way we understand the nature of information, and the information of Nature.

Publications

- H.Iida et al. (1993). Potential Applications of Opponent-Model Search. Part 1: The Domain of Applicability. ICCA Journal 16(4):201-208
- H.Iida et al. (1994). Potential Applications of Opponent-Model Search. Part 2. Risks and strategies. ICCA Journal 17(1):10-14
- H.Iida et al. (2002). Computer Shogi, Artificial Intelligence 134(1-2):121-144
- H.Iida et al. (2004). An Application of Game-Refinement Theory to Mah Jong. ICEC'2004, LNCS 3166, 333-338
- H.Iida et al. (2012). Game information dynamic models based on fluid mechanics, Entertainment Computing 3(3):89-99

Tojo Laboratory

Professor : Satoshi Tojo

Intelligence as Computation, Language as Logic

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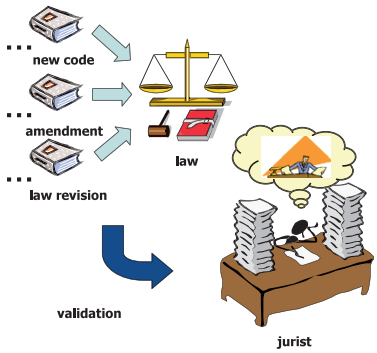
Logic, Language, and Intelligence

We cannot find a substance called intelligence in our brains; as a first step toward AI, we consider human language is the emergence of our intelligence. Is our language is computational? Or, how can logic, as a foundation of computation, approximate our language?

Legal Reasoning

Legal reasoning is a hoard of AI problems, including natural language processing, ontology, non-monotonic reasoning, and so on. We especially pay attention to logical treatment of legal documents, and apply non-classical logics such as paraconsistent logic and relevant logic to them. Also, we consider how we can revise such a large-scale knowledge base as legal code.



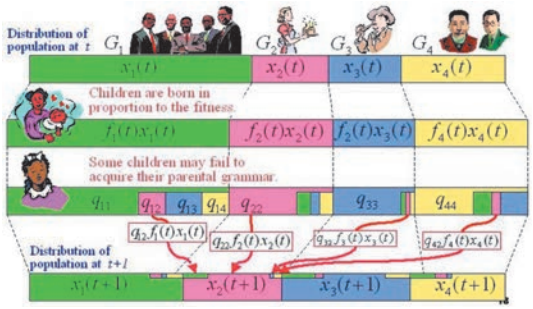
Agent Communication

How can we formalize that an agent can communicate with another agent? For example, the agent should have a communication channel with her partner.

We represent such communicability in terms of BDI/CTL logic, and apply the formalism for various social multi-agent problems.

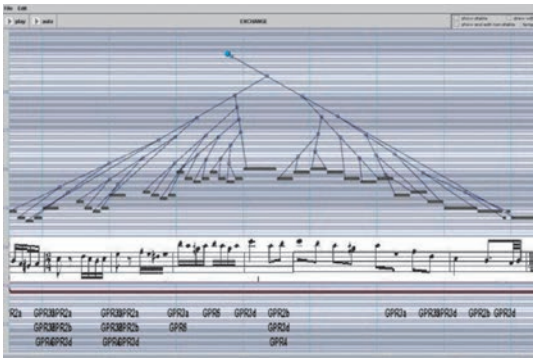
Language Evolution

Languages are destined to evolve, change, and, be mixed up. We show the elasticity of language, simulating generation model on computer where some features of a language may be lost or multiple languages may amalgamate.



Grammar in Music

If we define a language as sequences of symbols generated by a certain grammar, so is music. We are developing a formal analyzer of music score, which produce a parse tree that represents phrasal structure as usual language.



Publications

- Dynamic Epistemic Logic for Channel-based Agent Communication, Fifth Indian Conference on Logic and Its Applications, 2013.
- Structural Similarity Based on Time-span Tree, Computer Music Modeling and Retrieval, 2012
- Computational Reconstruction of Cognitive Music Theory, New Generation Computing, vol.31, Issue 2, 2013.
- Distance and Similarity of Time-span Trees, Journal of Information Processing, vol.20, no.1, 2012.

Ikeda Laboratory

Associate Professor : Kokolo Ikeda

Game and AI, as our rival and teacher

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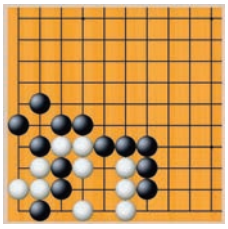
Research Overview

Though computer programs work widely around our life, when we strongly feel the existence of artificial "Intelligence"? It will be when we play a video-game.

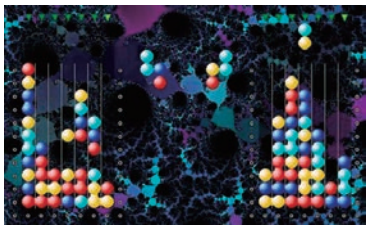
Many researchers have studied AI of game, and the major goal is to make a strong player (agent). However, by the progress of computer technology and research, we can easily make strong AI player, except for go and shogi.

The next goals are, I think, to make "realistic", "enjoyable" and/or "educational" agent. In our lab, many games such as go, scrabble and poje are used for research, and how to make agents as our rival and teacher are studied.

In addition, genetic algorithm, multi- objective optimization and multi-agent simulation are also intensively studied, in order to use them as our weapons.



Go



Poje

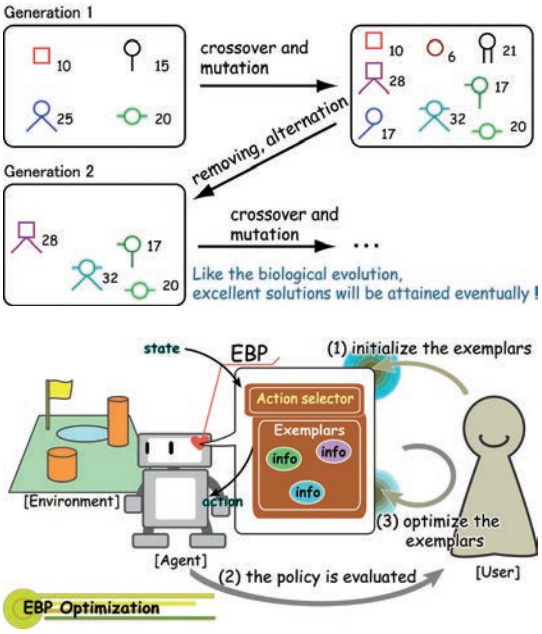
What are required for Game AI?

In these 20 years, computer speed and memory have grown 1,000 or more times. However, game AI has never been 10 times smarter and enjoyable. I think the following points are being required more:

- AI should be strong
- AI's strength should be controllable
- Behavior of an agent should be realistic
- Macro behavior of agents should be realistic
- There should be an agent whose behavior is unimaginable
- AI should be a teacher of human player

Genetic Algorithm

It is well-known that our body and intelligence are the result of evolution. Genetic algorithm (GA) is an effective optimization method inspired by evolution. We use GA for parameter tuning and policy learning of AI.



Overview of GA and learning

Message

Ikeda-lab is new lab born in 2010, and study games with Iidalab. Please visit us if you are interested in go, shogi and any board-games or video-games.

Publications

- Production of Various Strategies and Position Control for Monte-Carlo Go - Entertaining human players, IEEE-CIG, 2013
- Efficiency of Static Knowledge Bias in Monte-Carlo Tree Search, Computers and Games, 2013
- Playing PuyoPuyo: Two Search Algorithms for Constructing Chain and Tactical Heuristics, IEEE-CIG, 2012
- Accelerated UCT and Its Application to Two-Player Games, Advances in Computer Games, LNCS, 2011
- Exemplar-Based Policy with Selectable Strategies and its Optimization Using GA, JSAI, 2010
- Designing Traffic-Sensitive Controllers for Multi-Car Elevators through Evolutionary Multi-Objective Optimization, Evolutionary Multi-objective Optimization, Springer LNCS 4403, pp. 673-686, 2007

Nguyen Laboratory

Associate Professor : Le-Minh Nguyen

Machine Learning and Natural Language Understanding

URL http://www.jaist.ac.jp/~nguyenml E-mail nguyenml@jaist.ac.jp

Research Overview

Structure representations and machine learning models play a key important role for Artificial intelligence (AI). Our research will focus on how tactical structural representation and machine learning are used for formulating problems in AI ranging from text summarization, natural language understanding, legal engineering, and machine reading.

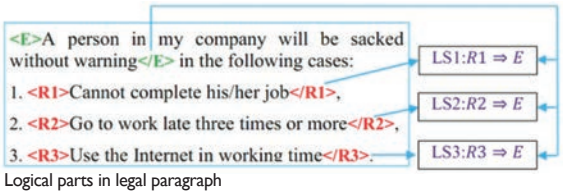
Machine Learning

Fundamental problems in machine learning are focused on our research directions. We particularly study on structured prediction modes, which are used to recognize structure representation such as sequence, tree, and graph. On the other hand, designing feature spaces for machine learning is difficult and requiring much human effort. To deal with this, we are concerned on how feature representation is automatically learnt from data. Regarding to this problem, Deep learning would probably be suitable for our goal. We also study on reinforcement learning which can learn by interacting with environments.

Natural Language Understanding

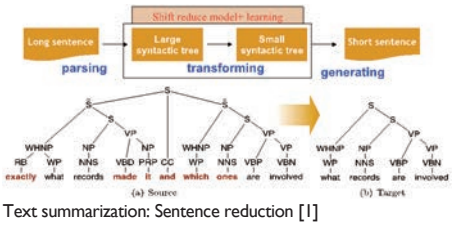
One of the ultimate goals in AI is to enable computers to converse with humans through human languages. To achieve the goal, we especially pay attention on semantic computation. This research is used to support computers to understanding natural language. Our initial work showed how synchronous grammars could be combined with structured learning models to transform a natural language sentence to a logical form representation [2]. On the other hand, we want to investigate how natural language generation (NLG) can help computers for producing a human understandable language sentece from its meaning representation. One research topic we pursue is to know how probabilistic models can be applied for generating natural language sentences from their underlying semantic in the form of typed lambda calculus.

For legal engineering, our mission is to support people for reading legal documents. The first task aims at recognizing logical parts of law sentences in a paragraph, and then grouping related logical parts into some logical structures of formulas, which describe logical relations between logical parts [3].



Logical parts in legal paragraph

Machine Reading: One of the direction in our lab is to study the fundamental problems on how we can extract useful information from texts and how to build knowledge from texts. First, we are interested in text summarization which is used to extract gist information from text documents.



Text summarization: Sentence reduction [1]

We also focus on studying Machine Reading, which automatically extracts knowledge from a large number of documents by reading texts. Communication between human and machine in reading text is also interested in our study. A Question Answering system like IBM-Watson is our expected outcome.

Publications

[1] M.L. Nguyen, M. Fukushi, S. Horiguchi, "A Probabilistic Sentence Reduction Using Maximum Entropy Model" , IEICE Transactions 88-D (2): 278-288 (2005)

[2] M.L. Nguyen, A. Shimazu, X.H. Phan, and T.P. Nguyen "Online Structured Learning for Semantic Parsing with Synchronous and lambda-Synchronous Context Free Grammars" , In Proceedings ICTAI 2008. Vol. 2, pp. 135-142, 2008

[3] B.X. Ngo, M.L. Nguyen, T.T. Oanh, A. Shimazu, "A Two-Phase Framework for Learning Logical Structures of Paragraphs in Legal Articles" , ACM TALIP, Volume 12(1), 2013

[4] M. Pham, M.L. Nguyen, B.X. Ngo, A. Shimazu: A learning-to-rank method for information updating task. Appl. Intell. 37(4): 499-510 (2012)

Shirai Laboratory

Associate Professor : Kiyoaki Shirai

Knowledge Acquisition Assistance based on Natural Language Processing

URL http://www.jaist.ac.jp/nlp/lab/ E-mail kshirai@jaist.ac.jp

Research Overview

We human being newly acquire knowledge by various means in our daily life. For example, we consult a dictionary to know a meaning of a word. Recently, many people have tried to search information using Web search engines. However, our activities to get new knowledge sometimes require much labor. Our laboratory aims at reducing such labor using natural language processing techniques in order to support human knowledge acquisition.

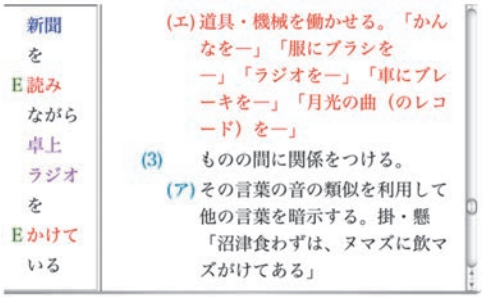
Reading Assistant System for Japanese Learners

What is it?

Japanese learners often look words up in dictionaries when they read Japanese documents. In general, a word has several (sometimes more than 20) meanings. It is rather hard to read definition sentences of all meanings, although a word has only one meaning when it appears in a certain document. Therefore, it is useful to provide a system which can select an appropriate meaning of a word in a text, and show the definition sentence of chosen meaning.

How to choose a correct meaning?

Two knowledge sources are used to select meanings of words. One is a large amount of corpora, from which our system learns typical contexts where a certain meaning of a word often appears. The other is a dictionary itself. For example, dictionaries include example sentences. Correct meaning can be chosen by measuring similarity between example sentences in a dictionary and a sentence in a document.



Snapshot of reading assistant system

Automatic Construction of a Portal Site

When we use web search engines, web pages containing desired information are not always found. Our laboratory aims at developing a system to automatically construct a portal site to support information search on WWW.

What is a portal site?

Portal site is a useful web page to be firstly visited when we search on WWW. For example, a "professional baseball" portal site may contain various inforamtion about baseball, such as a link collection, a glossary of terms about baseball and FAQ about regulation of baseball and so on. Automatic construction of such portal sites for given themes powerfully supports human activities of information search on WWW.

How to construct it?

Our laboratory investigates various techniques to automatically obtain contents of a portal site. For example, to construct a link collection, explanations and impressions of web pages in a link collection are excerpted from WWW. To construct a glossary, definitions of technical terms are automatically extracted from WWW. These can be accomplished by analyzing web page and capturing linguistic features to extract contents of portal sites.

Publications

- Thien Hai Nguyen, Kiyoaki Shirai. Text Classification of Technical Papers Based on Text Segmentation. Natural Language Processing and Information Systems, Lecture Notes in Computer Science, Volume 7934, pp 278-284, 2013.
- Minh Hai Nguyen and Kiyoaki Shirai. Study on Supervised Learning of Vietnamese Word Sense Disambiguation Classifiers. Journal of Natural Language Processing, Vol.19, No.1, pp.25-50, 2012.
- Kiyoaki Shirai and Makoto Nakamura. Clustering and Classification Based Approaches for Japanese WSD. in Proceedings of the 5th International Workshop on Semantic Evaluation, pp.379-382, 2010.

Hasegawa Laboratory

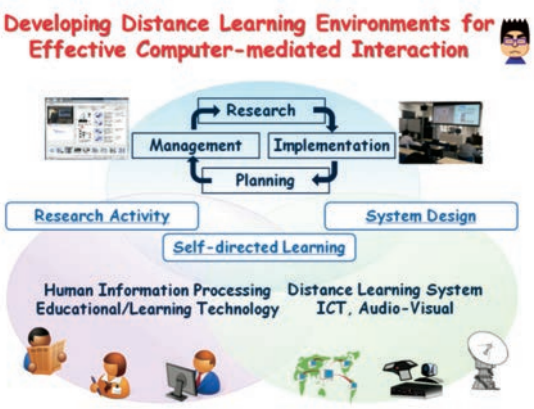
Associate Professor : Shinobu Hasegawa

What is Effective Distance Learning Environment?

URL http://dlc.jaist.ac.jp/hasegawa/ E-mail hasegawa@jaist.ac.jp

Research Interests

The main goal of our research is to facilitate "Human Learning and Computer-mediated Interaction" in distributed environment based on interdisciplinary approach, involving Learning Technology, Educational Technology, Artificial Intelligence, Audio-Visual Processing, and Network Technology. We focus on not only designing and developing advanced distance learning systems but also planning and maintaining practical distance learning programs for JAIST students.



Design Support System for Distance Learning Environment

The main topic addressed in this research is to develop a design support system based on "Design Pattern" methodology in order to implement a distance learning system systematically and sustainably. The design pattern is based on a communication model by integrating educational requirements and system components for actual distance learning programs. This approach makes it possible to aggregate the reusable patterns by integrating practical ideas from the viewpoint of educational technology and hardware/software systems from the viewpoint of ICT.

Portal Site Development for Supporting Research Activities

The main topic addressed in this research is to develop a Web portal site called "rPortal" as workspace and platform for scaffolding of our daily research activities. The key idea of "rPortal" is to integrate diverse web services for supporting each research activity seamlessly by managing vast amounts of contents which are generated, used and published in the related activities. "rPortal" also provides such services that students can easily understand the research activity process itself and manage whole research project.

Self-directed Learning Environment Development on the Web

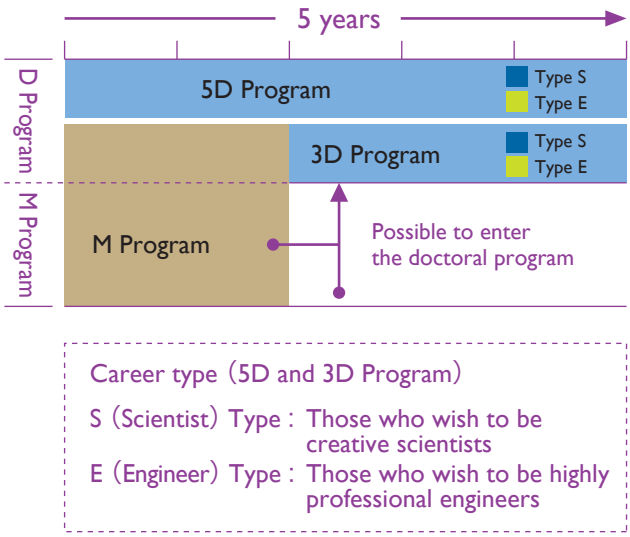
Actual Web-based resources generally provide a learner with a "hyperspace" in which he/she can navigate the Web pages in a constructive and self-directed way. Such learning process often involves meta-cognitive activities which control the page navigation and knowledge construction processes. The main topic addressed in this research is to develop meta-cognitive activity support tools which allow him/her to develop meta-cognitive skill for controlling his/her self-directed learning process.

Publications

- S. Hasegawa and A. Kashihara: A Mining Technique for Extraction of Presentation Schema from Presentation Documents Accumulated in Laboratory, Research and Practice in Technology Enhanced Learning, Vol.8, No.1, pp. 153 - 169, (2013).
- S. Hasegawa and K. Yamane: An Article Revising Support System for Facilitating Research Activities, Proc. of the 19th International Conference on Computers in Education (ICCE2011), pp,247-254, (2011).
- S. Hasegawa, et al.: "A Framework of Design Pattern for Distance Education System", Proc. of The IX World Conference on Computers in Education (WCCE), (2009 in CD-ROM).

Educational System of JAIST

Offering educational Programs that correspond to Career goals



Career type (5D and 3D Program)

S (Scientist) Type : Those who wish to be creative scientists

E (Engineer) Type : Those who wish to be highly professional engineers

5D Program

The 5D (5-year Doctoral) Program is designed for those who have decided to continue their study to the doctoral level at the time of enrollment. It is an integrated education program of master's and doctoral program. Completion of this program requires five years.

3D Program

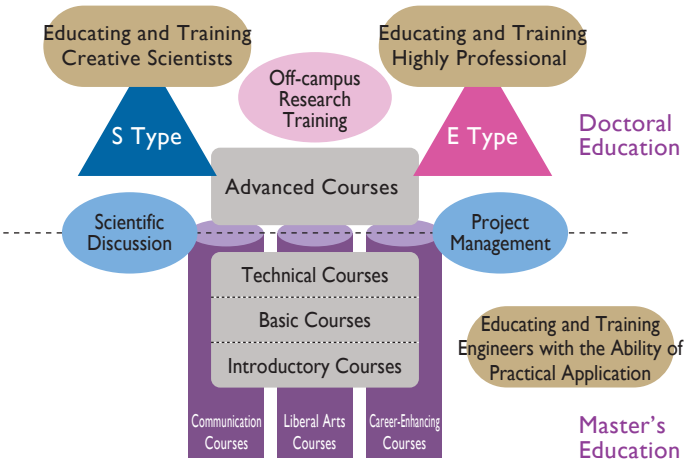
The 3D (3-year Doctoral) Program is a conventional doctoral level education program with a special emphasis on enhancing the ability of practical application. Completion of this program requires three years.

M Program

The M (Master's) Program is a conventional master's level education program with a special emphasis on enhancing the ability of practical application. Completion of this program requires two years.

Practical Education for Career Development

In order to educate and train human resources who can satisfy important social needs, JAIST continuously seeks to enrich practical lectures based on students' diverse career goals. JAIST encourages students to positively participate in off-campus training opportunities including research training within and without Japan and aims to train them as immediate assets of the society. JAIST also provides individual students appropriate guidance and advice regarding their registration problem and career search.



Practical Courses

Master's Program
- ☐Skills of Language and Expression (Presentation Skills, Writing Skills)
- ☐Technical communication

Doctoral Program
- ☐Scientific Discussion
- ☐Project Management

Off-campus Training S Type, E Type
- ☐Research training at research institutes within and without Japan
- ☐Research presentation at international conference overseas
- ☐Internship at companies

Curriculum of School of Information Science

Concept

A goal of School of Information Science is to provide "systematic education". Towards this goal, it has a competitive and comprehensive curriculum. Through solid teaching, flexible scheduling for the milestones, and rigorous and highly concentrated lectures, all taking into account the convenience of the students, the education programs at JAIST have been recognized as being a pilot case with a strong passion to ignite drastic changes in the Japanese education scene, skills and competence of JAIST graduates have been highly recognized around the world. Many of the education programs and systems have made enormous influences to other graduate schools in Japan, in this sense, we are playing the key roles of the path finder in the education scenes in Japan. The following summarizes the uniqueness of JAIST education system:

1. JAIST uses a four-semester system, each spanning two months. In each of the two-month semesters, lectures are provided twice a week, and in addition to the lectures, an exercise session, called office hour, is also provided once a week. This intensive course structure enables the students to acquire deep knowledge in a short period of time.
2. Important subjects are provided twice a year, and one of them is given in English.
3. IS school courses are held in the morning. Their exercise sessions and office hour are in the afternoon. In the office hour, students are able to ask the instructor questions for deeper understanding of the contents. Furthermore, web-based lecture videos are also provided, and the students can review the contents without having to present in the lecture room, which are provided via LAN.
4. It is mandatory for the students of School of Information Science to take credits from different categories; The subjects are classified into five areas, Theoretical Information Science, human information processing, artificial intelligence, computer systems and networks, and software science.
5. Besides the major research theme, a minor research work package is allocated to each student under sub-theme program. Students can broaden their knowledge bases by participating in the sub-theme program.
6. Before starting the major research work, a reasearch proposal, agreed through investigations with the supervisors has to be submitted. Before the submission, the required number of credits and completion of the minor research work need to be fulfilled.
7. Introductory subjects are provided to bridge the gap of the students' skills and a priori knowledge of information science, which are prepared for students from different educational background.
8. Both master and doctoral students who have achieved excellent performance and accomplishments have the option to shorten their study periods. This short-cut option for the early graduation has stimulated many of the enrolled students towards more aggressive research work.

Goals of the master course students of School of Information Science: Expected level of the skills and Competence

Ability of solving problems

Explanation about the latest status of research

Discussion and debate

Skills for fully using computer systems as useful tools

Basic Knowledge in the field of information science

Persuasive explanation about your research

Lectures

1. Lectures are classified into 4 categories, depending on the levels: Introductory, Basic, Technical, and Advanced, which are indicated by 11XX, 12XX, 14XX, and 16XX, respectively. Besides the subject categorization described above, another type of subjects, General Education, such as English, international economics, scientific philosophy, etc. are also provided to further broaden the student's knowledge.
2. Introductory subject are provided primarily to those students who do not have enough a priori knowledge about information science due to different educational backgrounds. Advanced lectures are provided primarily to the doctoral students, however, master students are also eligible to take them.
3. Basic and Technical subjects are further classified into 5 areas Theoretical Information Science, Human Information Processing, Artificial Intelligence, Computer Systems and Networks, and Software Science, indicated by A, B, C, D, and E, respectively. The subjects are organized so that they are complementary to each other; By taking the subjects, students can acquire a broad spectrum of the knowledge bases of information science.
4. Students must take at least 8 subjects, corresponding to 16 credit units, from the 4 course areas out of 5 (A, B, C, D, and E), and in addition to the 16 credit units, 4 more units have to be acquired regardless of the areas, totaling 20 credit units; Thesubject for the additional 4 credit units may be acquired by taking the General Education. In addition to the course work, those students who complete the minor research project can acquire 2 credits, and those who pass the final evaluation of the master's thesis under the main theme can acquire 8 credits, totaling 10 credits acquired from their research work.

List of the Subjects

Introductory Lectures

- I 111 Algorithms and Data Structures
- I 112 Computer Systems
- I 114 Fundamental Mathematics for Information Science
- I 115 Digital Logic and Computer Design
- I 116 Programming Laboratory I
- I 117 Programming Laboratory II
- I 118 Graphs and Automata
- I 119 Statistics in Information Science
- I 120 Fundamentals of Logic and Mathematics

Basic Lectures

- I 211 Mathematical Logic
- I 212 Analysis for Information Science
- I 213 Discrete Signal Processing
- I 214 System Optimization
- I 216 Computational Complexity and Discrete Mathematics
- I 217 Functional Programming
- I 218 Computer Architecture
- I 219 Software Design Methodology
- I 223 Natural Language Processing I
- I 225 Statistical Signal Processing
- I 226 Computer Networks
- I 232 Information Theory
- I 233 Operating Systems
- I 234 Foundation of Software Environment
- I 235 Game Informatics
- I 236 Logical Inference and Knowledge Representation

Intermediate Lectures

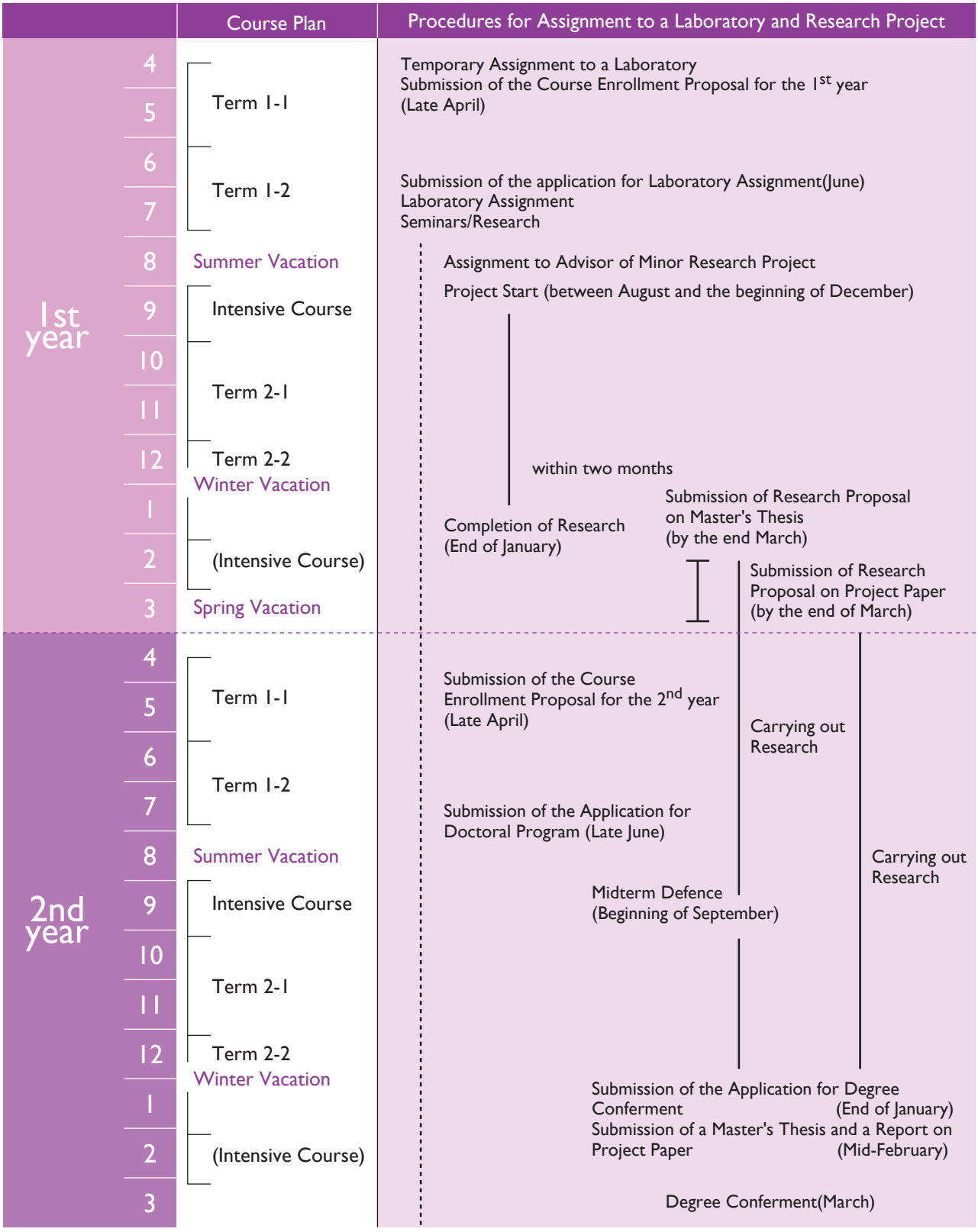
- I 411 Pattern Analysis and Recognition
- I 413 Theoretical Computer Science
- I 414 Natural Language Processing II
- I 416 Parallel Processing
- I 419 Image Information Science
- I 427 System Control Theory
- I 431 Intelligent Agents
- I 432 Theory of Discrete-State Systems
- I 435 Software Architecture
- I 437 Coding Theory
- I 438 Exercises on Graph Theory
- I 439 Speech Signal Processing
- I 440 Enhanced Operating Systems
- I 441 Advanced Computer Networks
- I 442 Advanced System Software Laboratory
- I 443 Foundation of Software Verification
- I 444 Embedded Software Engineering
- I 445 Distributed Systems
- I 446 Computer Systems Performance Analysis
- I 447 Database Systems
- I 448 Distance Learning System
- I 450 Network Design Laboratory
- I 455 Information Security Application
- I 465 Information Security
- I 466 Introduction to International Standardization
- I 467 Processor Design Laboratory
- I 468 Modeling of Dynamics
- I 473 Hardware/Software Codesign
- I 478 IT Project Management
- I 481 Software Development Laboratory for Highly Dependable Embedded Systems
- I 482 Software Process Design for Highly Dependable Embedded Systems
- I 483 Smart Embedded System Development
- I 465S Literacy in Information Security Management
- I 466S Advanced Information Security Theory and Application
- I 469S Law and Management of Information Security
- I 470S Information Security Technology
- I 471S Project-based Learning of Information Security Practice
- I 478S Project-based Learning of Network Security
- I 479S Exercise in Security Project-Based Learning A
- I 480S Exercise in Security Project-Based Learning B
- I 481S Exercise in Security Project-Based Learning C
- I 482S Exercise in Security Project-Based Learning D
- I 483S Exercise in Security Project-Based Learning E
- I 484S Exercise in Security Project-Based Learning F
- I 485S Exercise in Security Project-Based Learning G

Advanced Lectures and Seminars

- I 613 Algebraic Formal Methods
- I 615 Robotics
- I 620 Foundation of VLSI Design
- I 631 Foundation Computational of Geometry
- I 645 Human Perceptual Systems and its Models
- I 649 Wireless Sensor Networks
- I 654 Term Rewriting
- I 655 Modern Quantum and Neural Computation

Master's Program Schedule

The following is the standard schedule for a student entering a master's program in April and completing the program in two years.



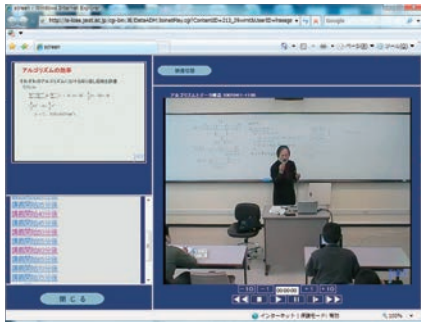
Education and Research Environment

Lecture

Lectures are provided using various multimedia equipment/tools so that course takers can acquire a broad knowledge base covering both bases, and application-oriented and advanced technologies.

Lectures are provided using multimedia equipment/tools

Tokyo Satellite



[Lecture archieve] The lecture archive system is used to review all the lectures given in the School of Information Science at JAIST, and can be accessed on campus at any time.

Facilities

High quality educational and research facilities are available at the School of Information Science to satisfy requirements of research activities.

Pictures of meeting rooms and spacious office where students can concentrate on research work.

Collaboration room 1

Collaboration room 5

Collaboration room 7

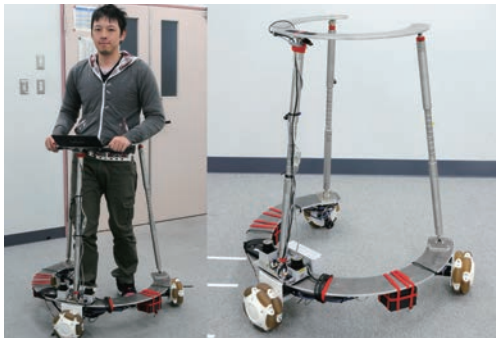
Library

Seminar room

Refresh Corner

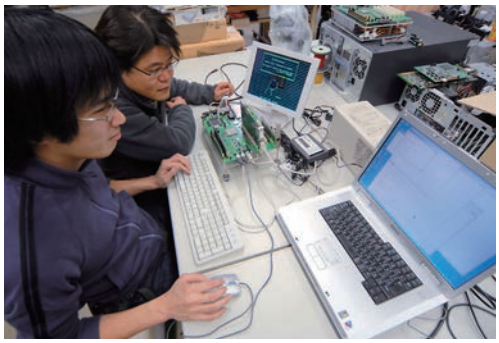
Special Equipment

Pictures exemplifying research environments supporting specified research purposes of each laboratory



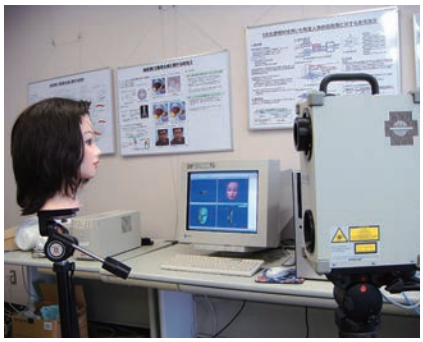
Control of JAIST Omnidirectional Robotic Walker

3D EMA (Electro Magnetic Articulography) AG500



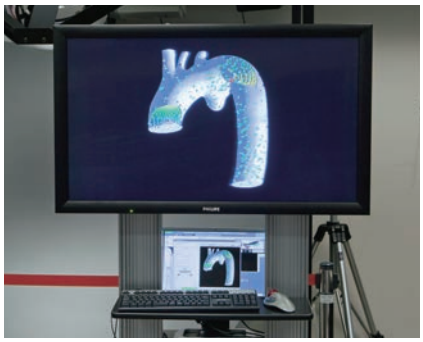
Development and verification environment for real-time systems

CAVE virtual reality system



3D Scanner

Computer Go Program Nomitan



3D Intelligent Display System

Information Environment

☐Campus Network

The campus network in JAIST is built with the high-speed, layer-3 core switches located at the Research Center for Advanced Camputing Infrastructure. As well as the backbone switches, the floor switches which house laboratories are also connected with 10 Gbit Ethernet, which enables the very comfortable network access to any servers, any place in JAIST. Even at Tokyo Campus, an indentical information environment is provided and the users can access to the servers in JAIST over 1Gbit/s network. To the outside of JAIST, through SINET4 and WIDE Project research network, high-speed access to Tokyo and Osaka over 10Gbit/s network bandwidth is available.

Network Core Switches

☐Massively Parallel Processin System

Massive parallel processing (MPP) is a term used in computer architecture to refer to a computer system with many independent arithmetic units or entire microprocessors, that run in parallel. The MPP systems are designed for large scale scientific computing. The Cray XC30 system in JAIST with 360 computing nodes of total 5,760 CPU-core and 22.5TB memory interconnected by "Dragonfly Interconnect Topology". In JAIST, computer systems with various of architectures are available for user’ s computing needs.

Cray XC30

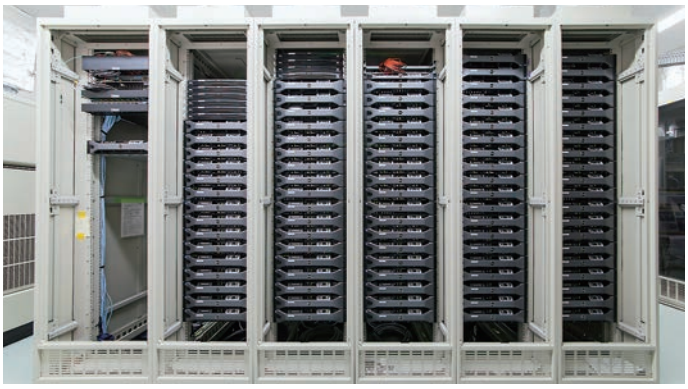
SGI Altix UV1000

FUJITSU CX250

Research Center for Advanced Computing Infrastructure

☐Data Storage Systems

For providing reliable data storage environment, we run some high-speed & large-capacity file server systems in parallel. In combination with high-speed campus network, the users can utilize the information system from any computer in JAIST without changing his computer environment. Since the data backup is provided automatically by the systems, the user can stay focus only on his research or study. The users can select the file servers based on their needs.



File Server Systems

☐Security Systems

Robust fire-wall, virus check and Spam blocking systems are providing secure communication over the campus network. Further, JAIST provides the PKI (Public Key Infrastructure) system service and is used for identification cards , the authentication for internal servers, e-mail services, and incoming access to the campus network such as SSL-VPN.

Fire-wall

PKI System

☐Wireless LAN Over the Campus

In any area at JAIST, the buildings for Information Science, Knowledge Science, Material Science, Administration, library, and even in the kiosk, the high speed wireless LAN service is provided 24 hours. For the dormitories, both wired and wireless LAN services are provided.

Wireless LAN AP

☐Information Terminals

As a tool for research, education and administration work, an information terminal is provided to each researcher, student and administrative staff member. In the campus network, any one can access to his/her information environment, including applications and personal storage area in the file servers from any terminal or workstation. Through this information terminal, Windows and UNIX environment is provided.

Information Terminal

CAMPUS

Access to JAIST

Student Housing

Room

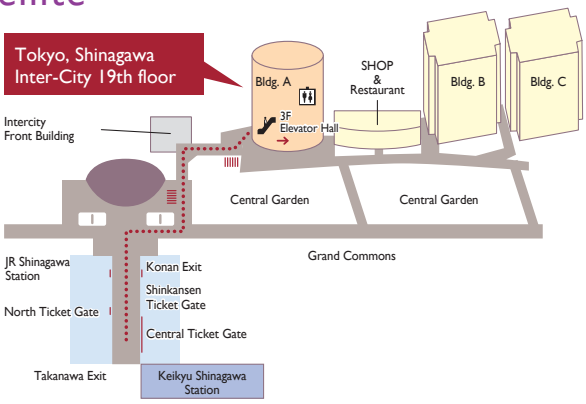
By Airplane

- Tokyo-Komatsu takes 1 hour by plane.
  Komatsu Airport-JAIST takes 40 minutes by the JAIST Courtesy Bus.

By Train

- Tokyo-Kanazawa by Shinkansen and limited express takes 4 hours.
- Osaka-Kanazawa by limited express takes 2 hours 30 minutes.
- Nagoya-Kanazawa by limited express takes 3 hours.
- Kanazawa-JAIST by train and shuttle bus takes 1 hour.

Access to JAIST Tokyo Satellite



From nearest Stations

- Shinagawa Station (JR Line) It takes 3 minutes on foot from Konan Exit.
- Shinagawa Station (Keihin Kyukou Line) It takes 5 minutes on foot from Takanawa Exit.

From airport

- Haneda Airport : by Keihin Kyukou Line Take a Keihin Kyukou train bound for Shinagawa and get off at Shinagawa Station.
- Narita Airport : by Keisei Line or JR Line by Keisei Line Take the Skyliner to Ueno Station and transfer to the JR Yamanote Line bound for Tokyo and get off at Shinagawa Station. by JR Line : Take the Narita Express train to Shinagawa Station.

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