<table>
<thead>
<tr>
<th><strong>Study Area</strong></th>
<th>B. Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>University</strong></td>
<td><strong>Doshisha University</strong> (Private)</td>
</tr>
<tr>
<td><strong>Graduate School</strong></td>
<td>Graduate School of Engineering (Engineering)</td>
</tr>
</tbody>
</table>
| **Field of Study**   | 4. Environmental Engineering  
                          5. Mine Engineering / Geological Engineering / Geographical Information System  
                          6. Computer Science  
                          7. Electrical Power Engineering / Electrical Engineering |
| **Actual Study and Research Field** | See “7. List of faculty members capable of guiding Afghan participants in English”  
                                         (1) information and computer science, (2) electrical and electronic engineering, (3) mechanical engineering, (4) science of environment and mathematical modeling |
| **URL of Graduate School** | http://istc.doshisha.ac.jp/course/index.html |
| **Degrees**          | Master of Science in Engineering |
| **Status**           | Graduate School Student (2years) |
| **Credits and years needed for graduation (In the case of Graduate School Student)** | Master of Science in Engineering / (30) Credit / 2 years |
| **Subjects with English as the language of instruction** | Our International Science and Technology Course (ISTC) all subjects taught in English |
| **Selling Point**    | *Laboratories experimental apparatus has been equipped  
                         *Living facilities has been developed (accommodation only for single person, book store, cafeteria, medical center, sport facilities)  
                         *Professors provide detailed guidance for each students |

## 2. Features of University

Please refer to the following websites:

(1) **History:** [http://www.doshisha.ac.jp/english/information/overview/about.php](http://www.doshisha.ac.jp/english/information/overview/about.php)  

1875 Doshisha Academy is established by Jo Neesima.
1889 ‘The Aim in Establishing Doshisha University’ is published in major newspapers and magazines.
1890 Jo Neesima passes away at the age of 46.
1912 Doshisha University (School of Theology, Faculty of Political Science and Economics
1920 Doshisha University (Faculty of Letters, Faculty of Law, Graduate School and Preparatory School) is approved under the University Ordinance.

1944 Doshisha Engineering College is established.

1948 Universitiy (School of Theology, Faculty of Letters, Faculty of Law, Faculty of Economics) is approved under the New School System Ordinance.

1950 Master’s Programs (Graduate Schools of Theology, Letters, Law, Economics, and Commerce) are established.

1953 Doctoral programs are established.

1955 Master’s program in Engineering is established.

1986 Tanabe Campus, the present Kyotanabe Campus, is opened.

2010 Graduate School of Global Studies is established.

(2) Access:  http://www.doshisha.ac.jp/english/access/
Imadegawa Campus. (Graduate School of Global Studies is in here)
Karasuma Higashi-iru, Imadegawa-dori, Kamigyo-ku, Kyoto
602-8580 Japan
Telephone: +81-75-251-3120
9 minutes from Kyoto Station by subway, one minute on foot from the Imadegawa Station on the subway

Kyotanabe Campus. (Graduate School of Engineering is in here)
1-3 Tatara Miyakodani, Kyotanabe City, 610-0394 Japan
Telephone: +81-774-65-7010
15 minutes on foot from the Kintetsu Kodo Station
8 minutes by bus from the Kintetsu Shintanabe Station
5 minutes by bus from the Kintetsu Miyamaki Station
10 minutes on foot from the JR Doshishamae Station

(3) Education policy: http://www.doshisha.ac.jp/english/information/overview/president.php

Doshisha University has 135 years history and one of the most qualified private universities in Japan. The educational goal of Doshisha University is to foster people as “the nation’s conscience,” and “education of conscience (Ryoshin-kyoiku in Japanese)” has been the major principle of our education. What sets Doshisha, a private university, apart from many other universities in Japan, both private and public, is its strong belief in giving students an education based on conscience. The passion of the founder of Doshisha University, Jo Neesima, for education is encapsulated in the graven words on the memorial monument at the main campus gate, which read, “I earnestly desire that many young people filled with conscience will be raised and sent out by our school.”
Doshisha University has been recently working on active educational reforms to respond to the needs of the time. With an emphasis on medical education, which was the founder’s ardent wish, we opened two new faculties at Kyotanabe Campus in April 2008, the Faculty of Life and Medical Sciences and the Faculty of Health & Sports Science, as well as reorganized the Faculty of Engineering as the Faculty of Science and Engineering. With these reforms, Kyotanabe and Gakkentoshi Campuses have become an educational and research center specializing in such areas including integrated humanities and sciences, life science, information, health science and advanced science, while Imadegawa Campus will focus on its role as an educational and research center for internationalism and liberal arts.

There is no doubt that the mission of the university is transmission of academic knowledge and expertise. In addition to this, fostering humanity and developing personality are also important missions. Doshisha University is determined to continue to work hard at ever-improving its educational and research environments in order to fulfill its responsibilities and missions.

3. Features of Graduate School
Graduate School of Engineering (International Science and Technology Course) (hereinafter ISTC) which provides courses in the field of engineering.

ISTC will provide English courses in (1) information and computer science, (2) electrical and electronic engineering, (3) mechanical engineering (4) science of environment and mathematical modeling.

Afghan participants will also have an opportunity to take basic courses aimed to understand Japan such as Japanese society, administration, and corporate ethics through which they can adapt to Japanese society smoothly. This would help them to concentrate on their study.

4. Features of the Program and Curriculum in each Field of Study
Students have to take total 30 credits in 2 years as follow;

International Science and Technology Course (ISTC)
Students should follow his/her supervisor’s instructions and take courses according to the chart below.

Chart of credits required (minimum) for completion of the M.Sc. Program

<table>
<thead>
<tr>
<th>Elective subjects</th>
<th>A</th>
<th>B (Common General Courses)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I (Subjects of Specialized Fields)</td>
<td>II (Common Core Subjects)</td>
<td></td>
</tr>
<tr>
<td>Experiment I ~ IV</td>
<td>※</td>
<td>8 or more</td>
<td>4 or more (less than 6)</td>
</tr>
<tr>
<td></td>
<td>8 or more (less than 8)</td>
<td>6 or more (less than 8)</td>
<td></td>
</tr>
<tr>
<td>Credits</td>
<td>22 or more</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

※ 1. Earn more than 8 credits from subjects for ISTC of your own course.
   2. Specified ones of A I subjects for ISTC of other than your own course can be counted.

For ISTC subjects of Life and Medical Sciences Course, refer to the syllabus of Life and Medical Sciences Course.
3. Subjects of your own course other than ISTC (i.e. regular course subjects) can be counted.

4. For non ISTC students to take subjects of ISTC, visit office of Faculty of Science and Engineering/Graduate School of Science and Engineering to register. Credits can be counted toward completion of the M.Sc. Program within the limit of 6 credits together with other credits earned by subjects of other than your own course and of MOT course.

Follow the prerequisites and take subjects from your own course other than ISTC.

<table>
<thead>
<tr>
<th>(A I) Subject</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Communications Engineering (E)</td>
<td>2</td>
</tr>
<tr>
<td>Advanced Emergent Systems (E)</td>
<td>2</td>
</tr>
<tr>
<td>Advanced Language Processing (E)</td>
<td>2</td>
</tr>
<tr>
<td>Advanced Embedded Systems (E)</td>
<td>2</td>
</tr>
<tr>
<td>Advanced Nature-Inspired Computing (E)</td>
<td>2</td>
</tr>
<tr>
<td>Advanced Information and Computer Sciences (E)</td>
<td>2</td>
</tr>
<tr>
<td>Internship (E)</td>
<td>2</td>
</tr>
<tr>
<td>Research and Experiments I (E)</td>
<td>2</td>
</tr>
<tr>
<td>Research and Experiments II (E)</td>
<td>2</td>
</tr>
<tr>
<td>Research and Experiments III (E)</td>
<td>2</td>
</tr>
<tr>
<td>Research and Experiments IV (E)</td>
<td>2</td>
</tr>
<tr>
<td>Master's Thesis (E)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A II (Common Core Subjects)</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation Structure (E)</td>
<td>2</td>
</tr>
<tr>
<td>Electric Circuit Theory (E)</td>
<td>2</td>
</tr>
<tr>
<td>Nonlinear Physics (E)</td>
<td>2</td>
</tr>
<tr>
<td>Materials Chemistry (E)</td>
<td>2</td>
</tr>
<tr>
<td>Applied Mathematical Analysis (E)</td>
<td>2</td>
</tr>
<tr>
<td>Biology (E)</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B (Common General Courses)</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethics for Scientists and Engineers (E)</td>
<td>2</td>
</tr>
<tr>
<td>Technology and Business Project Management (E)</td>
<td>2</td>
</tr>
<tr>
<td>Science and Engineering Writing 1 (E)</td>
<td>2</td>
</tr>
<tr>
<td>Science and Engineering Writing 1 (E)</td>
<td>2</td>
</tr>
<tr>
<td>Science and Engineering Writing 2 (E)</td>
<td>1</td>
</tr>
<tr>
<td>Science and Engineering Writing 2 (E)</td>
<td>1</td>
</tr>
</tbody>
</table>
5. Academic Schedule

ACADEMIC CALENDAR  2011-2012

2011 FALL SEMESTER

September
21 (Wed)  Start of Fall Semester
26 (Mon)  Classes begin

December
27 (Tue)  Winter Recess begins

January, 2012
5 (Thu)  Winter Recess ends
6 (Fri )  Classes recommence
26 (Thu)  Classes end
27 (Fri )  Final examinations begin

February
16 (Thu) Final examinations end

March
20 (Tue)-22 (Thu)  Fall Semester Ceremony for Bestowing Degrees
31 (Sat )  End of Fall Semester

6. Facilities

There are following facilities at Doshisha University.

(1) canteens and cafeteria (halal foods are available.)

(2) praying room or space

(3) student houses which the University recommends

(4) library

Doshisha University have two libraries house over 630,000(Imadegawa) and 240,000(Kyotanabe) books. In addition, each department has own research library. Students can access a wide range of electronic resources on the library website, such as the online library catalog, e-journals, e-book, and databases and use them at no charge.

(5) Student Health Centers

Student Health Centers are located on both campuses to help maintain the physical and mental health of the students and to provide them with support.

(6) information environment

Doshisha University maintains about 2,300 high-performance computers for student use in 28 computer
classrooms and 16 open computer labs. In addition, Multimedia Lounges (both campuses) provide content creation tools.

7. List of faculty members (supervisors) capable of guiding Afghan participants in English

Both Graduate Schools must carry out interviews between the candidates and professors through telephone, TV, or the Internet and professors will decide whether he/she can accept the candidates based on the results of interviews as well research plans submitted in advance. Graduate School of Engineering will announce you to your supervisors after it.

(1) information and computer science

Prof. Yoichiro WATANABE, Jun CHENG
Information Theory and its Applications
http://istc.doshisha.ac.jp/course/information/lab_01.html

Research Contents

In communication systems such as broadcasting, satellite communication, and telephone networks, multiple users share a single communication system that is transmitting and receiving each users' information. This kind of communications system is called a multi-user channel. Issues in transmitting information by a multi-user channel are the elimination of interference between users, transmitting information even faster, and measures for the deterioration of sent data caused by noise. In this research laboratory, we are researching methods to transmit information "even faster and more accurately" through these multi-user channels based on the concepts of "information theory," "coding theory," and "communication theory." For the purpose of creating even better communication environments, we are modeling various communication systems and researching the performance, characteristics, coding, and decoding of those models. This research can be applied to multi-user communication systems such as wireless LANs and cellular telephone networks.

Principal research topics include:

<1> Analyzing the information transmission capability of communication channels
<2> Multi-user coding that can be error corrected and its decoding
<3> Adaptive signal processing using array antennas
<4> Code division multiplexing communication (CDMA communication)
<5> MIMO (Multi-Input Multi-Output)
Keywords

- Entropy
- Channel coding
- Multi-user channel
- Channel capacity
- Capacity region
- Error-correcting code
- CDMA
- Spread spectrum
- MIMO
- Array antenna
- Wireless LAN
- Mobile communications

Prof. Shigeo KANEDA, Hirohide HAGA
Information System Laboratory
http://istc.doshisha.ac.jp/course/information/lab02.html

Research Topics

- Sensor information processing
- Information system development methodology
Engineering differs from science in that it cannot be considered separately from society. In this laboratory, we are searching for answers to the question of what is necessary for society, without losing the perspective of "society."

In order to grasp the needs of society, we can't keep ourselves shut away in a university. In this laboratory we are actively collaborating with organizations and groups outside of academia. Specifically, we are cooperating with Kyoto Prefecture (taxes, civil engineering related parties), nursery schools, and preschools. Our aims are to solve real world problems, so we are developing and researching systems to specifically solve those individual issues. Through the creation of useful things at these sites and having our students experience these processes, we hope to cultivate their insight as engineers. However, if we just stopped there, this wouldn't be academic research. We can contribute to the accumulation of academic knowledge by resolving these individual issues, discovering the universality that hides inside them, and formulating this.

We welcome people who are willing to involve themselves in hands-on research, who can proactively challenge the unknown, and who don't fear failure. Universities are not a place to wait for things to be given to you. For example, you can't do anything with a "didn't learn that, don't know, so I won't do it" attitude. Our research is an action that basically keeps opening up paths into unknown areas. Therefore, put in an extreme way, you can say that everything "hasn't been learned yet and is unknown." Therefore, research is fundamentally a progression of failures. However, by the accumulation of learning from individual failures and using that for the next research, you can achieve a single success after 99 failures. Like in our laboratory, for types of research where we go out into the field, if we don't deeply commit to our partner's field, we won't be able to create anything genuinely useful. For example in the realm of taxes, you must commit in the field to a level where you can quickly perform tax work. At the same time, it's also important to not forget your "foundation" as an IT engineer. In other words, you don't just stay cooped up in the IT realm, you go out into the field and run into problems, you generalize and abstract issues from what you find there, and sublimate it up to a methodology in the IT field, and you must keep on maintaining that kind of spirit.

Our major research fields are listed below.

<1> Sensor information processing:

Using videos and various sensors, research on home appliance control technologies, dietary education assistance systems, and technology that aims to establish an analysis methodology for people's movements. For example, we want to develop a system that focuses on people's "chewing" movement to guide young children and the elderly to chew properly, and a system that can analyze the movement of children. A portion of our movement analysis research is being done cooperatively with a university in Finland (University of Oulu).
Information system design/development technology based on PBL (project based learning):

With the cooperation of local government (Kyoto Prefecture) and early childhood education specialists, we are developing a PBL-based information system to "design, develop, and introduce a genuine system that can be used in the real world by students only." In fiscal year 2010, we would like to conduct field research on the prefectural tax system, while deepening our knowledge of object oriented analysis/design, and design the "Super Tax Object."

Software engineering research:

"Testing" problems are very important in current software development. Our research theme for this is the development of testing support tools. There are many kinds of testing research, our current target areas are:

- Quality evaluation of test cases set using mutation analysis (evaluating the worth of a test cases set)
Multi-agent simulation (MAS) research:

In MAS, execution subjects called agents mutually interact, and through the process of changes in their statuses, you can view in what way a macro (artificial society) as the micro (agent) aggregate changes its structure. The analysis of this micro (agent) and macro (artificial society) loop (Micro-Macro Loop) is one of the central issues of MAS. People are normally interested in the effect (emergence) from micro to macro, but in this laboratory we are conversely aware of the problem; "what kind of interactions at the micro level are necessary to make the desired macro phenomena emerge?" For this issue, the major issues are developing and implementing simulation models in the realm of ITS (Intelligent Transportation System) and discovering dominant factors from there.

Multi-agent simulation

**Agent**
- Subject of action
- Possess “rules” and “attributes”

**Field**
- Area of activity
- Contributes an influence on the activity of agents

Keywords
- Ubiquitous
- Sensor
- Data mining
- Software engineering
- Multi-agent
<1> Research on concept base automatic construction/refinement methods
Automatically extract various concepts from electronic dictionaries and web information, construct a concept base of over 200,000 words, and automatically refine it.

<2> Research methods to quantify the degree of association between concepts
From the correlation of meanings of words defined by the concept base, make it possible to quantify the relationship between concepts and associate and recall them.

<3> Methods to implement a common-sense judgment mechanism for time/location
Make natural conversations possible by implementing a common-sense judgment mechanism for seasons, time, and location.

<4> Methods to implement a common-sense judgment mechanism for emotions/senses
Make natural conversations possible by implementing a common-sense judgment mechanism that feels happiness, sadness, or the beauty of sunset.

<5> Research on intelligent conversation mechanism
Make natural conversations with humans, like greetings and small talk, possible while understanding the meaning of speech with intention understanding and common-sense judgment.

<6> Research on document classification/summary
Based on concept processing, compare many documents such as articles, classify them into categories, and create document summaries.

<7> Research on chart meaning comprehension
Make it possible to understand the meaning of information expressed as various types of charts in the same way as humans do.

<8> Research on intelligent search methods; web, etc.
By associations using concept bases and common-sense judgment, make information searches on the web, etc., more intelligent and easy to use.

<9> Research on signboard understanding
Extract, recognize, and understand character information, image information, and map information contained on signboards and understand the meaning of the signboard as a whole.

<10> Research on environment understanding based on maps and images
Understand simple overview maps, recognize and understand roads and buildings from the corresponding image data, and create an actual map.

<11> Research on intelligent robot
Implement intelligent robots that autonomously move, gesture, and change expressions based on spoken conversations with humans.

Errand robot Robovie!

Environment understanding and autonomous movement

Must have the ability to understand its environment and move autonomously

- Recognize objects such as signs, buildings, people
- Recognize the meaning of characters and diagrams in signboards, markers
- Understand guide maps and comprehend routes
- Compare guide maps to the actual environment and move autonomously

Research Contents

Research to make computers intelligent is important for the advancement of information technology in the 21st century. In this research laboratory, our goal is to implement intelligent computers that can appropriately pick up on people’s intentions and to advance research on intelligent mechanisms that are the basis of that goal. To implement intelligent computers, we must develop mechanisms that can make common-sense judgments like humans such as judging amounts (big, small, etc.), time, and locations, and emotional/sensory judgments such as emotions and the five senses; judgments that are logical relationships with language concepts. The association mechanism implemented by measuring the degree of association with the concept base plays a particularly important role. As an application for intelligent computers, an intelligent robot is being developed that can hold spoken conversations with humans, understand its environment from images, and move autonomously.
Intelligent Interface Implementation

Its keywords are:
- Knowledge processing
- Neural network
- Fuzzy
- Genetic algorithm

Logical Construction of Intelligent Interface

Keywords
- Knowledge processing
- Neural network
- Fuzzy
- Genetic algorithm
Research Contents

<1> Speech, Language, Music and Hearing

**Spoken Language Processing:**
Human Interface for a Voice-controlled TV system: Design of Language Model & Word Set
Noise Reduction for Speech Recognition

**Music Information Processing:**
Automatic Scoring of Free Songs
Training Systems for Playing Piano, Guitar and Brass Instrument
Tension Voicing based on Sonority in Music Context

**Auditory Perception and Cognition:**
Basic research in Pitch perception
Cognitive Model of Music Composition

**Signal Processing:**
Estimating Direction of Arrival by a 7-Element Array on 3-D Orthogonal Axes Blind Source Separation by Independent Component Analysis
Neuro-physiological study Using NIRS

<2> Vision

**Natural Patterns:**
Feature Analysis of Natural Patterns
Mechanism of Crypsis in Cryptic Coloration of CuttleFish

**Texture Cognition:**
What dose texture tells us?
Texture Reproduction from the Feature Quantity of Texture
Senso-Emotional Information Processing:
Mathematical Analysis of Texture Features in Paintings
Anisotropic Evaluation of Modern Abstract Paintings

Keywords

- Spoken Language
- Music
- Signal Processing
- Auditory Perception
- Visual Perception
- Auditory Cognition
- Visual Cognition

Prof. Mitsunori MIKI, Masato YOSHIMI
Intelligent System Design Laboratory
http://istc.doshisha.ac.jp/course/information/lab_05.html

Research Contents

Clusters
A PC cluster is a parallel computer connecting multiple commercially available PCs by a network. Compared to supercomputers with the same level of performance, the high cost-effectiveness of PC clusters can be given as its strength. In the Cluster Group, we are constructing PC clusters, evaluating their performance, maintaining and managing them, and developing clustering software. The Cluster Group is a research group pursuing technologies that evolve daily. In the Intelligent System Design Laboratory, we are advancing cluster research by constructing Japan’s largest PC cluster.
Grids

A grid refers to the systems and technologies to unify computational resources, human capital, and other resources that exist distributed in remote locations in order to use them as a single system. Through the development of grid middleware that can integrate multiple computers, applications, and services located distributed on a wide area network, the Grid Group is developing systems that can solve large-scale, complicated optimization problems such as structural optimal design. We are also participating in representative grid test beds such as ApGrid and OBIGrid and by providing large-scale PC clusters, we are contributing to grid research inside Japan and overseas.

Simulated Annealing

Simulated Annealing (SA) is an optimization method that simulates annealing in an attempt to obtain a superior crystal structure by gradually cooling materials melted at high temperatures. In the SA Group, we are improving SA with parallelization/decentralization, other optimization methods, and hybridization with evolutionary computation. SA is also applicable to actual optimization problems represented by LSI wiring design. In the SA Group, we are applying SA to actual optimization problems such as applying SA to the optimum design of Gain Flattening Filters (GFF)*.

* A filter that has a function to smooth out variations in the amplification amount that differs according the light's wavelength
Genetic Algorithms

Genetic algorithms are optimization algorithms that simulate the process of biological evolution. By using the target problem’s candidate solutions to resemble individual organisms and applying operators such as genetic cross over and mutation/natural selection to them, the candidate solution evolves and we can obtain the optimal solution. We are also investigating parallel models for genetic algorithms and conducting broad research on implementing genetic algorithms on PC clusters.

Interactive Genetic Algorithms

In the Interactive Genetic Algorithms Group, we are conducting research using Interactive Genetic Algorithms (IGA), one of the interactive evolutionary computing methods, as a technique for optimization based on human sensibility. We are proposing sign sound generation systems using IGA to create sign sounds used in household appliances and proposing Global Asynchronous Distributed Interactive Genetic Algorithms (GADIGA) as a technique to expand IGA into a massive participation model.
Protein Structure Prediction

The mapping of the human genome, worked on through international cooperation, was completed in April, 2003. Now clarifying the function of proteins is important. The function of a protein is closely connected to its structure and various results are expected such as discovering the formation mechanism of disease that occurs from a protein's mistaken folding (Alzheimer's disease, bovine spongiform encephalopathy) and the development of new drugs with the function of specific proteins. In our research group, we are predicting the structure of proteins with computers using systems that combine a technique called the molecular simulation method and optimization methods.

Multi-objective Genetic Algorithms

Multi-objective optimization problems are problems where the optimal solution is sought from multiple evaluation criteria that have trade-off relationships. In these problems, due to their characteristics, solutions exist as multiple solutions or a set of infinite solutions. In recent years there has been much research on multi-objective Genetic Algorithms (GA) that applies GA to multi-purpose optimization problems. In this group, we are proposing GA to obtain highly accurate solution sets widely distributed in a solution space, and we are conducting research such as the optimization of diesel engine fuel injection scheduling.
Web Communication

Our purpose in the Web Communication Group is to create a system to support the communication of teachers and students in the laboratory to energize research activities. The created system uses blogs and supports creating "connections" between blogs.

Intelligent Lighting Systems

Intelligent lighting systems are systems in which individual lights control the illuminance for respective locations by autonomous learning. Since they have no centralized control mechanism, the system has a high fault tolerance and achieves high reliability in large-scale buildings. The system can automatically judge the effective illumination and supply a suitable illuminance in appropriate locations just by users setting the target illuminance for the illuminance sensors, without requiring the illumination's or illuminance sensor's location information. These next generation illumination systems are attracting attention because they can realize energy savings by avoiding turning on unnecessary lights.
Swarm Intelligence

In recent years swarm intelligence has been gaining attention because although individual intelligences are simple, extremely sophisticated intelligences emerge when these gather and form groups. Swarm intelligence can be viewed in the societies of living organisms. In ants for example, even though individual ants behave simply, as a whole they behave intelligently to efficiently gather food. In our research we are developing algorithms to make this kind of swarm intelligence emerge and applying it to swarm robot behavior learning.

Keywords

- Intelligent systems
- Intelligent home appliances
- Optimization
- Evolutionary computation
Prof. Katsunori SHIMOHARA, Ivan TANEV
Socio-informatics Laboratory
http://istc.doshisha.ac.jp/course/information/lab_06.html

Research Topics

Multi-agent systems:
Aiming to understand the emerging phenomena of organizational, economic, and social population systems

Network dynamics:
Searching for network meaning and function in socio-economic systems

Genetic network simulation (genome informatics):
Opening new regions of bio-information

Software evolution:
Creating intelligent programs using evolution

Driving agents:
For future autonomous vehicles that have used software evolution

Snake robots:
Advanced robots that autonomously evolve behaviors adapted to their environment

Artificial emotions:
Mechanisms to cultivate values and evaluation systems in relationships with others

Information autocatalysis mechanism:
Using narrative techniques as a communication "matrix"

Research Contents
In the Socio-informatics Laboratory, we research the interaction of objects, things, and information. In other words, we research “how we can design relationality” such as those between objects & objects, things & things, information & information, and also objects & things and things & information. The concept of relationality includes both “interactions,” the effect they have on each other, and “linkage” that reach through time and space. We humans exist to seek out relationships with others and find meaning there. Beyond the existence of independent individuals, we can also see ourselves as existences living and being made alive in many kinds of relationship. Relationality includes parts that cannot be seen such as informational/environmental parts, social institutions and economic mechanisms, culture and religion, and values.

Socio-informatics is an academic field that considers perceiving, understanding, and utilizing the interaction of information and the interaction of objects and things conveyed by information as a process that creates, grows, develops, fragments, and destroys relationship networks. For methods to perceive systems as relationships, we can apply the micro level of molecules, genes, and cells all the way up to organizational, economic, and social human population systems. These share mechanisms of superior information processing to collect and edit information, and implement and express certain functions.

For our methodologies, we are using an advance methodology to implement a biological evolution mechanism on the computer and a network science methodology to analyze relationships as a network structure, and through simulations, our goal is to design superior information system mechanisms.
In socio-informatics, from an information viewpoint, we are clarifying the meaning and function of those relationalities and thinking about relationality design for the creation of a social information infrastructure that cultivates trust and makes symbiosis possible.

**Keywords**

- Relationality design
- Relationality-oriented systems design
- Evolutionary multi-agent system
- Genetic programming
- Interaction/linkage/context
- Emergence and evolution
- Genome informatics

Prof. Shigeru KATAGIRI, Miho OHSAKI  
Co-Creation Informatics Laboratory  
[http://istc.doshisha.ac.jp/course/information/lab07.html](http://istc.doshisha.ac.jp/course/information/lab07.html)

**Research Topics**

**<1> Developing remote collaboration support technologies**

- Developing highly realistic sound-field reproduction technologies in multimedia communications
- Developing video echo canceling technologies
- Developing a natural interface with t-Room using body motion
- Developing t-Room’s user interface
- Developing technologies for improving "the feeling of being in the same room" using cross-media information
- Developing technologies for improving "the feeling of being in the same room" by controlling time delay
- Researching evaluation criteria for "the feeling of being in the same room" improvements in t-Room
Knowledge discovery from medical data
(Discovering knowledge useful for medical treatments from data accumulated in hospitals)
- Developing time-series clustering methods
- Developing knowledge discovery assistance systems
- Data modeling by multi-dimensional spectral analysis and using it for knowledge discovery

Researching pattern recognition technologies based on the minimum classification error training method/generalized probabilistic descent method
- Developing an ensemble minimum classification error training method
- Defining geometric margin control in the minimum classification error training method
- Developing “DISCERN,” discriminative training library software for education and research
- Developing feature representation for recognition using genetic algorithms

Research Contents

Research background and goals
We are currently facing many challenges that must be quickly resolved such as environmental problems, the depletion of fossil fuels, and the reduction of industrial might brought about by an aging, low-birthrate society. “Reduce the movement of people and things, and create much value from little energy” – the solution for these challenges can only be highly-efficient value creation using advanced technologies. For us the decisive factor for creating this value is the utilization of computers. We believe that co-creation between computers and we humans will allow humanity to overcome these challenges and is the trump card for creating a truly affluent society.

With these beliefs, in the Co-Creation Informatics Laboratory we are researching remote collaboration support technologies that connect distant people utilizing computers, and researching the technologies to create value from large amounts of complicated data that humans cannot handle by making computers themselves smarter.

Connecting people with the power of computers
With the appearance of the Internet and cellular telephones, telecommunications technologies such as telegraphs and telephones have produced an information society where you can communicate “anytime, everywhere, and with anyone.” Without a doubt, these new communication tools are quite convenient. However, we are stuck with small screens and keyboards, it is by no means easy to fully express our thoughts. Now in the present where the ability of computers and the Internet has improved, we feel we must change the goal of our technology development from the “small, convenient” way that has been pursued up until now to a “large, genuine” way that conveys our entire communication scene.

We in the Co-Creation Informatics Laboratory are doing advanced research of the “Future Telephone t-Room” proposed by NTT Laboratories to bring these ideas to a realization. By controlling multimedia devices like multiple cameras, displays, microphones, and speakers with multiple computers, it connects distant people as if they were right next to each other. However, it’s not good enough to just simply convey video and sound. Current technology has many issues that must be improved such as image/sound reflections (echoes), video blind spots, skewed points of view, unnatural video/sound-field reproduction, and video/sound going out of synchronization. Our current goal is to resolve these issues and work to make t-Room more advanced by utilizing digital signal processing, pattern recognition, and computer communication technologies.

**Mining knowledge with the power of computers**

In recent years, computer calculation and storage performance has been making spectacular progress. If simply repeating the four arithmetic operations, it’s no exaggeration to say that computers have already surpassed humans. Computers’ storage power is the same. The amount of text and video data the computers connected by the Internet is not an amount that can be memorized by a single person. However, we humans have many kinds of high intellectual powers that even powerful computers cannot imitate. One of these intellectual powers is the power to mine for knowledge. This is called the power of data mining or knowledge discovery. To also provide computers with this power to mine, we in the Co-Creation Informatics Laboratory are aiming to establish medical data mining technologies in particular to discover valuable knowledge from the massive and complicated time-sequence data acquired from the medical field, and we are researching and developing those basic technologies. Our approach places an emphasis on a signal processing approach for expressing knowledge with statistical meaning from massive and complicated data.

We are also performing simultaneous modeling of tens of dimensions of time-sequence data that no human could possibly perform to bring to a realization of knowledge mining that fully utilizes the power of computers.

**Making computers smarter**

One more intellectual power that humans can easily perform but computers cannot is pattern recognition. We humans can listen to sounds and understand visual scenes that we see, and we can accurately judge in an instant what is being talked about and what we can see. We can also read text and easily understand its content. However, as an example computers now can search for items to see if they are present such as whether the word “computer” is entered in a database, but they cannot easily judge whether there are
similar items with the searched item, pattern recognition in other words. Please say “good morning” out loud. Everyone says this in a different manner with a different voice. By no means do different people speak with exactly the same voice pattern. Even a single person’s voice will be different each time they say “good morning.” We humans hear this differing pattern as the same words, “good morning,” without any problem. But to make a computer listen like this is not easy at all.

We in the Co-Creation Informatics Laboratory aim to advance these pattern recognition technologies by researching and developing new recognition system design methods with the cutting edge technique called the minimum classification error training method (or the generalized probabilistic descent method) as the foundation. The basic concept is simple. The basis of recognition is in comparisons. The “good morning” pattern the computer is trying to recognize is compared with a number of patterns stored on a computer. If the stored “good morning” pattern is clearly more similar to the “good morning” pattern to be recognized rather than other patterns like “good evening,” there are no problems. The pattern is correctly recognized. However, let’s make the stored “good morning” pattern that of an adult male. And then let’s make the stored pattern for “good evening” a child’s voice. At this time, if the “good morning” to be recognized is a child’s voice, this “good morning” may be judged more similar to the child’s “good evening” rather than the adult’s “good morning.” Depending on whether the computer judges the similarity in voices or words, we can understand that these kinds of variations or errors can occur as a result. In order to prevent these kinds of errors, our technique is to repeat changes in the stored “good morning” and “good evening” patterns to achieve accurate recognition, or learning in other words. We ourselves have been involved in the development of the minimum classification error training method. With this background, we are advancing research to further improve and develop minimum classification error training while competing at an international standard.

Keywords

- Remote Communication and Collaboration
- t-Room
- Multi-media Signal Processing
- Pattern Recognition
- Discriminative Training
- Minimum Classification Error
- Generalized Probabilistic Descent
- Data Mining
- Knowledge Discovery
- Clinical Data
Prof. Masashi OKUBO, Takao TSUCHIYA  
Applied Media Information Laboratory  
http://istc.doshisha.ac.jp/course/information/lab_08.html

Research Topics

<1> Human interface group

- Research on internal motivation by presenting self-behavior
- Research on communication support by presenting many kinds of information
- Research on Kansei shape evaluation
- Research on estimating emotional stress using various sensors

<2> Acoustic group

- Developing elemental technologies for sound field rendering
- Researching high-speed sound field rendering by GPU
- Researching real-time sound field rendering by FPGA (silicon concert hall)
- Research on Lake Biwa’s water temperature monitoring by acoustic tomography
- Research on numerical simulations of thermoacoustic phenomena

Research Contents

1. In the human interface group,

we are researching ways to assist the engagement of people with people, and people with systems. For example, research and development of systems to support communication between people, and research and development of systems that interactively present a person’s movements, exercise, and those results to themselves to encourage self-development based on internal motivation. In addition, in the emotional stress measurement field, which has used contact sensors, we are conducting research on estimating emotional stress using non-contact sensors. We are also researching shape evaluation based on Kansei such as the beauty and complexity of objects in real and virtual spaces.
2. In the acoustic group, we are researching numerical simulation technologies for problems related to general wave phenomena, from sound waves to electromagnetic waves. In particular, by the development of specialized sound field rendering hardware, we are aiming to achieve a "silicon concert hall" to reproduce concert hall sound in real-time.

Keywords

- Human interface
- Communication assistance
- Interaction design
- Virtual reality
- Emotional stress simulation
- Sound field rendering
- Silicon concert hall
- GPU
- FPGA
Research Topics

Digital Home Network

We are constructing a multimedia application platform SONICA (Service Oriented Network Interoperability for Component Adaptation) that implements Plug and Play and streaming data QoS assurance with a XML-based server/client model. To support commands and data usage methods for undefined devices that aren’t registered to the existing system, a network can be simply constructed by exchanging link information using the client/server model, not software module transfers used by UPnP (Universal Plug and Play) and HAVi (Home Audio Video Interoperability).

Grid Computing

In order to efficiently execute genome applications in a grid environment, we are designing middleware to appropriately manage computer and network information and to appropriately allocate and execute processing. Specifically, for InterProScan, HMMer, and other genome applications that analyze protein sequences, we are implementing scheduling and monitoring functions that aim to efficiently execute them in a grid environment. Executing genome applications in parallel with a single computer or uniform computers in a PC cluster is simple. However, for grid environments where computers with many different kinds of performance are connected to a variety of networks, computer and network information must be appropriately managed and processing must be appropriately allocated and executed.

Sensor Network

For multiple moving objects such as automobiles and small aircrafts to work autonomously, distributively, and collaboratively, we are researching and developing protocols related to ad-hoc networks that can be used as sensor networks to exchange information and
control objects in real-time. Ad-hoc network is a technology that does not require an infrastructure such as base stations, and each node has a wireless communications function that autonomously constructs networks. Ad-hoc networks are positioned as a major technology in a ubiquitous network society and applications are expected for sensor information collection, emergency communications during disasters, events such as meetings, and personal services. Specifically in ITS (Intelligent Transport System), in addition to road-to-vehicle communications as a communications technique to supply information to vehicles, in vehicle-to-vehicle communications where communications are conducted directly between vehicles, we are investigating applications such as vehicle congestion warnings and collaborative driving.

Research Contents

Research Background and Goals

Mainframes (large-scale general purpose computers), which first became commercially available in the 1960s, were installed in dedicated computers rooms and multiple people simultaneously used a single computer using telecommunication lines. In the 1970s, computers called minicomputers started to become common, and in the 1980s, in office automation and factory automation, workstations processing graphics and numerical calculations connected by LANs started being used. On the other hand, personal computers appeared from the latter half of the 1970s into the 1980s. From the latter half of the 1980s into the 1990s they could be connected to the Internet, and along with the appearance of the World Wide Web (WWW), personal computers became common
place and widely used in offices, laboratories, and even homes. Along with the miniaturization and declining price of microprocessors, computers have come to be installed in many kinds of embedded devices like home appliances and game consoles, and from cellular telephones to automobiles. In the future as well, we feel computers that individuals can use will only continue to increase. Presently we can consider connecting geographically distributed devices, in offices and homes or moving in trains and automobiles, to the Internet using IPv6. However, by just doing that, even if we can interconnect devices, that doesn't mean they can be used cooperatively taking advantage of each devices' characteristics. In order to implement a true ubiquitous network, these distributed resources must be integrated organically and we must provide an optimal, virtual integrated computing environment for respective users.

**Research Theme Overview**

With the basic concept of "The Network CONNECTS the People," we are aiming to construct an information system that can provide a computing environment usable by anyone, anytime, and anywhere by fusing computers with the network, from personal computers and large-scale computers to embedded systems such as the home appliances and automobiles around us. Concretely, we are conducting research on distributed computing environments to effectively utilize varied ubiquitous computing resources using a grid that virtually implements a high performance computer that links computers around the world.

**Keywords**

- Internet
- Grid computing
- Home network
- Sensor network
- Large-scale distributed processing
- Embedded system
- ITS (Intelligent Transport System)

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**Research Contents**

By making mechatronic systems, such as those represented by robots, more advanced through a fusion of ICT technology and intelligent technologies, we can implement smart mechatronic information systems with a high affinity for people and the environment. This research laboratory is researching the sensing, control, information processing, and the system integration which are the fundamental technologies to construct these kinds of systems. Our current research themes are shown below.

**<1> Vehicle automation**

Autonomous vehicles such as mobile robots and unmanned vehicles have up until now been developed in fields for labor-savings and dangerous work such as factories, ports, construction, agriculture, forestry, and industrial plants. Recently, autonomous vehicles have expanded into fields in close contact with our daily lives such as the Advanced Safety Vehicle in ITS (Intelligent Transportation System), office and home service robots, welfare, and crime prevention/security robots. We can also hope for broad applications in
We are researching the following topics in order to implement intelligent vehicle systems that are safe and easily cooperate with people and the environment.

**Sensing systems:**
Multi-sensor systems to recognize self-location, the situation of surrounding vehicles, and the condition of the environment

**Control systems:**
Autonomous navigation, Multi-robot cooperation, Shared control

**Safety systems:**
Dependable (fault diagnosis/fault-tolerant control) systems that operate safely even when the system fails partially

### Smart interface

To achieve natural communication between humans and machines, it is effective to use the non-verbal communication that plays an important role in human-to-human communication. In view of this point, we are researching the following topics.

**Emotion recognition:**
Emotions and expressions play an important role in human communication. To achieve smooth communication between humans and machines, we are researching emotion estimation from changes that appear on the body surface such as expression, posture, and voice, and emotion estimation from physiological signals such as brain waves and pulse.

**Computer vision-based motion capture:**
Optical and magnetic motion capture is normally used to measure a person's posture and movements, but movement and usage conditions may be limited. For our goal of implementing non-contact, non-wearable motion capture that operates in real-time, we are researching motion capture by image processing.
**Hands-free manipulation:**

For our goal of implementing intelligent systems that operate flexibly by recognizing people’s emotions and intentions, we are researching a hands-free manipulation system that uses information of biosignals and body movements as an interface for information machines.

**Keywords**

- Robotics
- Mechatro-information system
- Vehicle automation
- Sensing
- Non-verbal information processing
- Kansei information processing
- Computer vision
- Soft computing
- Sensor fusion
- Motion control

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**Research Topics**

- Robust speech recognition targeting natural speech
- Constructing a speech dialogue system that considers mental strain
- Developing an optimal speech recognition system for Japanese people’s English speech
- Constructing foreign language learning support systems
- Machine translation by corpora and machine learning
- Communication assistance for visual and other disabilities

**Research Contents**
Research background and goals

The world is globalizing and opportunities to communicate with people speaking different languages are increasing. For computers and robots with a different language recognition mechanism than humans, opportunities are also increasing to give them various instructions by spoken language (voice) and receive information from them.

Spoken language is said to be situation dependent, there are many omitted items easily presumed from the situation where the conversation is taking place, and there is also much ungrammatical speech because of “thinking while speaking, speaking while thinking” speech behavior. What kind of effect do the characteristics of this spoken language have when trying to communicate with foreigners that have differing language media and computers and robots that have differing language recognition mechanisms? Conversely, in what way can we accurately and efficiently establish communication with a subject that differs in these language media and language recognition mechanisms in a spoken language accessible to ourselves?

We are searching for mechanisms to establish such spoken language communication and researching and developing technologies for it. Specifically, we are researching topics such as e-learning to support efficient foreign language learning using information processing technologies, automatic evaluation technologies to accurately measure communication abilities in foreign languages, speech translations systems by computers to assist communication with foreigners via spoken language, and a speech dialogue system that enables computers and robots to understand spoken language and generate speech. For this, we must have spoken language communication science to search for mechanisms to establish spoken language communication along with research and development of speech recognition, speech synthesis, and natural language processing technologies.

Approach and methods to solve these issues

As a technique for natural language processing, a rule-based approach to develop processing rules based on developer’s introspection has been primarily used in the past. A rule-based approach is a valuable knowledge source that concentrates the many years of experience of those developers, but for a large-scale system, maintaining uniformity and maintenance are difficult issues because many developers are involved. With the increases in computer processing ability and corpora (texts with added information such as the part of speech, etc.) useable by computers, a corpus-based approach, an approach to automatically acquire knowledge by machine learning from corpora, is attracting attention. Centered on a corpus-based approach that applies machine learning techniques to foreign language learner’s corpora, speech databases, and parallel translation examples, we are researching and developing e-learning systems and speech dialogue systems with robots.

The corpus-based approach is a powerful approach to natural language processing and spoken language processing, but this does not mean a corpus-based approach is good at everything. How to incorporate the natural knowledge of humans is also an important research theme. We are advancing research on how humans understand spoken language.

Specific research themes
To support the efficient learning of foreign language learners, their abilities must be accurately understood and problems given according to those abilities. For this, methods are required to objectively measure the kinds of abilities below and to measure the difficulty of problems. This research and development requires a large-scale research corpus and development of a speech recognition system. Additionally, in order to extract problems which arise in the actual use, we will develop a system integrating these technologies.

**Speech recognition technology**

- Developing acoustic models and language models suitable to Japanese people’s English speech
- Developing a speech recognition system to recognize Japanese people’s English

**Natural language processing technology**

- Reliability evaluation technology for translations from a large-scale English text corpus
- Corpus-based translation technology such as statistical translation technology
- Developing a robot on the web for collecting a large-scale English text corpus in order to evaluate English text reliability

**Foreign language ability measurement technology**

- Developing Japanese to English translation data and English speech data by people with a variety of English abilities
- Automatic measurement method for English text construction ability (English speech ability) based on the distance, etc., from a reference translation
- In ability measurements, a method to select appropriate problems with different levels of difficulty

**English text difficulty measurement technology**

- Researching a difficulty evaluation scale when translating the given Japanese text into English
- Researching an automated difficulty evaluation scale for Japanese text translated to English

**Speech signal analysis**

- Researching the extraction of useful information from speech, etc., signals using nonlinear analysis method
- Improving signal analysis technology and developing analysis methods
- Discovering random signal generation mechanisms and developing prediction methods

**DIET (Doshisha Interactive English Tutoring) system development**

- Learning support system for English conversations to point out a learner’s problems
- Integrate technologies such as English speech recognition, dialogist ability measurement, translation problem selection, and translation technologies

**Keywords**

- Speech recognition
- Natural language processing
- Nonlinear speech signal processing
- Acquiring foreign language (L2) ability
- Spoken language processing
Research Topics

- Optical neural networks
- Optical chaos
- Fluctuation and noise in semiconductor lasers
- Self-organizing optical networks
- Ultra-high-speed and/or high capacity optical fiber communication
- Advanced optical modulator applications

Research Contents

Our research encompasses areas allied fairly closely with physics and mathematics, such as the foundations of quantum mechanics and nonlinear optics such as solitons. It naturally includes areas deemed cutting-edge in electronics at the moment, such as digital optical communications, optical information processing, development of high-speed optical devices driven by new semiconductor device fabrication technologies like molecular beam epitaxy, and the implementation of optical computing. It includes optical neural networks and chaos theory, and now even bio-electronics is a possibility: research on optical computing and architectures closely resembling the behavior of the human brain. These optoelectronics research areas may form the core of 21st-century scientific technology.

Our laboratory brings research topics to teams, chiefly of graduate students, that pursue long-term research that will serve as a platform for the field of optoelectronics.

Keywords

- Frequency stabilization
- Chaos, Neural networks
- Self-organizing networks
- Ultra-high-speed optical fiber communication
- Radio over fiber
- Advanced optical modulation format
## Research Topics

- Developing computer-aided circuit analysis methods and automated circuit design methods
- Developing wave analysis systems and failure diagnostic methods
- Operation analysis and control methods for power electronic circuits
- Investigating drive methods for rotating electric machines
- Slip control in electric vehicles

## Research Contents

Electric circuits are indispensable to modern life. In the course of ordinary life, however, we do not think much about where electric circuits are in use. Electric circuits are found in all sorts of everyday products, including cars, home appliances, computers and mobile phones, where they perform very important functions. In cars, for example, an amount of injection fuel is determined to run engine efficiently based on information such as the air mass flow and the throttle valve opening. Moreover, head lights, power windows, wipers, air conditioners and so on… which require electric circuits. The hybrid car is a recent development that uses fuel efficiently by combining inverters and motors. The importance of electric circuits is further increasing. At the Laboratory for Electric Circuits and Systems, we are conducting both computer simulations and experimental research that focus on developing operation analysis methods that investigate system behavior, treating the entirety of the electric circuits and their surrounding devices as a system, and control methods to make these systems function as desired. For example, we have following themes.

### 1. Computer-aided circuit analysis and automated circuit design methods

1. **Formulation of a General Circuit Equation**
   A method of formulating a general circuit equation incorporating digital and control elements is under development through the extension of the Modified Nodal Method.

2. **Optimizing Circuit Parameter Design**
   Optimal circuit parameters are computed for a given circuit design by determining the minimum of a selected index function. For this process, efficient computation of parameter sensitivity is under development using the direct method.

3. **Parallel Processing of Circuit Analysis Methods**
   Fast circuit analysis algorithms which are suitable for parallel computing are under development. We are also researching algorithms for parallel processing using two or more computers to speed up analysis of ever more complex circuits.

4. **Automatic circuit design based on Generic Programming**
   PC cluster system has sixteen computers are used to generate active filter circuits. Generic Algorithm (GA) and Genetic Programming (GP) are adopted to design circuits automatically.
Waveform analysis and diagnostic analysis in electric instruments

1. Transfer Function Method for Power Transformer Analysis

The transfer function method, based on convolution and deconvolution operations by FFTs is under development in the application of power transformer and AC motor design and testing.

2. Digital Signal Processing of High-Voltage Measuring Systems

Computer software which provides automatic and objective quantification of lightning impulses is also under development.

Operation analysis and control methods for power electronic circuits

1. Operation Mode Analysis of Power Converters

As converter circuits become more complex (adding clamp circuits, for example), it becomes necessary to use computer-aided numerical methods to analyze their operation modes. We are developing programs that automatically analyze operation modes.

2. Control of Inverters and Converters

Stable and fast converter control methods such as optimal control and sliding-mode control are being developed for efficient power conversion.

Drive methods for rotating electric machines

1. Efficient Drive of AC motor

We research high-efficient drive methods for electric motors and generators. Optimum regenerative torque to convert rotational energy into electrical power is under study when reducing rotation speed.

2. Analysis and Control of Vibration Caused between Motor and Resonant Mechanical rotor

The vibration is caused in the situation that the mechanical resonant frequency is less than the motor's maximum operating...
frequency or the fluctuation's frequency of the load. We analyze the problem and propose appropriate control methods both by simulation and experiment.

**<5> Slip control in electric vehicles**

This research gives an analytical result of the rapid variation of slips between wheels and road surfaces, and proposes a novel Traction Control System (TCS) of EVs to suppress the rapid variation of slips.

**Keywords**

- Computer-aided circuit analysis methods
- Simulation algorithms and methods of power electronic systems
- Digital processing methods of high-voltage measuring system
- High-efficiency control methods of power electronic systems
- Vibration suppression methods of motor drive system
- Efficient motor drive methods
Prof. Akihiro AMETANI, Naoto NAGAOKA, Yoshihiro BABA
Power System Analysis Laboratory

http://istc.doshisha.ac.jp/course/electrical/lab_17.html

Research Topics

- Analysis of phenomena and characteristics in lifelines/infrastructure systems:
  Intelligent buildings, wind-power generation, electric railroads, solar-power generation, etc.

- Analysis of transient/steady-state phenomena in electrical/electric systems

- Developing numerical analysis methods and modeling methods for transient/steady-state phenomena:
  Fourier/Laplace transform, EMTP, numerical electromagnetic field analysis, etc.

- Different types of modeling methods, transient/steady-state characteristic research: cars, railway, airplanes, lithium-ion batteries, transformers, electrical appliances, semiconductor elements, measuring instruments, machinery lifetime estimation, etc.

Research Contents

<1> Introduction

Virtually most of the lifelines (water lines, railroads, telecommunications, etc.) and infrastructure (buildings, roads, etc.) of modern society run on electricity. If electricity were shut off, water would not run when the water taps were turned on, building doors would not open, ATMs would shut down, cell phones would not recharge, and their base stations would stop transmitting before that anyway. The technologies of "electrical energy as a power source" and "electrical signals for telecommunications and control" are indispensable to modern society.

The Power System Analysis Laboratory conducts research related to the electrical energy (electrical power) that supports lifelines and infrastructure. Its ultimate goal is stable supply of electrical power. Electrical power systems must therefore be designed, built, and operated with "safety," "high reliability," "efficiency," and "economic considerations" in mind. Since electrical power systems are also very large systems, however, it is not possible to fully verify them through experimentation. The main topics of our laboratory are the development of numerical analysis methods for electrical power systems and the development of numerical models for power equipment to be used in this. Fig. 1 shows an overview of our research topics.
<2> Modeling

Insulation levels in electrical power systems are dictated by the voltage of switching surges generated by breakers and lightning surges caused by lightning. It is therefore important to predict overvoltage precisely when designing economical electrical power systems. To do this, we first need very precise numerical analysis models to represent power equipment. Our laboratory develops models of different equipment used in electrical power systems.

The primary components of transmission and distribution systems are the overhead power lines and cables, which are distributed-parameter lines. In overhead power lines with considerable length, which are affected by earth, wave propagation characteristics have frequency characteristics. In cables, sheaths are thin, so their propagation characteristics also are a function of frequency. Our laboratory has devised numerical analysis models that consider the frequency dependence of these homogeneous lines with great precision. We are also developing a finite-length line model that considers grounding and vertical conductors, as typified by steel towers, which must be treated as non-homogeneous lines. When developing these models, we conduct theoretical electromagnetic field analysis and develop functional approximation method suited to represent line models; we then conduct measurements using scale models to confirm the precision of the analytical model. We are also developing devices that measure high voltages precisely without contact by applying the induction characteristics of multi-phase distributed-parameter lines.

Substations are built by organically combining an array of equipment such as transformers, bus lines, breakers, and arrester.

Models of these are widely available for low-frequency domains, but we are developing the broadband numerical models needed for surge analysis. Since this equipment has nonlinear voltage-current characteristics, these characteristics must be adequately expressed in model development. For breakers, it is particularly necessary to consider arc characteristics, which are a discharge phenomenon. The model developed by our laboratory can take these characteristics into account with an extremely simple function and has notably short calculation times. The model developed by our laboratory was also improved jointly with Mr. Ichiro FUJITA of the Plasma Application Laboratory, and we developed a discharge lamp model that has achieved good results. A paper on this model was presented and awarded a prize at a conference.
Steel towers and substations are grounded, but surge analysis that has been performed in the past has virtually ignored the frequency characteristics of ground resistance. Through theoretical analysis and actual measurements, we are elucidating the transient characteristics of grounding impedance and developing a model.

**<3> Transient and steady-state analysis**

Analysis that uses the models described above is conducted in the time domain and frequency domain. Since electrical power systems are extremely large, their analysis programs must be versatile. Our laboratory is developing a system analysis program in the time domain jointly with the U.S. Department of Energy. This program is called the Electromagnetic Transients Program (EMTP) and is used around the world. We have developed a highly precise numerical forward/inverse Laplace transform method in analysis of the frequency domain and also have a generalized Frequency-domain Transient phenomenon analysis Program (FTP) that applies it. Harmonics have suddenly become a problem in recent years with the spread of equipment driven by power electronics technology. Harmonic currents that flow through electrical power systems can cause damage to the transformer facilities of power consumers and have even been reported to cause bodily harm. To prevent such accidents, there is an urgent need to estimate harmonics and develop rapid countermeasures. Our laboratory has developed a simple and precise harmonics estimating program, proposed an effective measure to deal with harmonics by making transformer connections multi-phase, and is currently applying it in many electrical distribution systems in buildings.

Intelligent buildings have problems with malfunction or breakdown of IT and other equipment caused by induction generated by harmonics in electrical distribution systems and lightning surges. The study of harmonic induction damage focuses on measuring induction voltage and current after damage occurs and has barely considered induction caused by lightning surges, which are transient phenomena. Not surprisingly, countermeasures are generally based on experience, and induction has not been systematically estimated or countermeasures devised. Our laboratory has proposed analysis methods to clarify these EMC problems within intelligent buildings which have complex structures.

**<4> Analysis of maglev train systems**

Maglev trains are being developed with the goal of building a new trunk transportation network because of the limits of the transportation capabilities of the Tokaido Shinkansen. Their power systems are the first systems to make wider use of high-capacity inverter equipment, so one of our topics is the analysis of such new electrical power systems. In addition to this, the routes currently being planned are prone to lightning strikes, so lightning countermeasures are required for these train systems to be highly reliable. Our laboratory is conducting analysis of the characteristics of inverter-driven electrical power systems and of lightning surges while also taking part in the design of a new transportation system.

**<5> Machinery lifetime estimation**

Insulation breakdown in power equipment is one factor in preventing stable supply of electricity. If it were possible to constantly ascertain the condition of equipment installation and exchange equipment before it broke down, power outages could be further reduced. At our laboratory, we are developing a method of detecting minute partial discharges occurring within equipment and estimating the remaining service life of equipment by processing this information. To detect partial discharges, we measure partial discharge current while also measuring the sound vibration that occurs with it. We combine this measurement data with a model that expresses the high-frequency characteristics of equipment, especially transformers, and apply it to estimating the lifetime of insulators. We also apply information processing methods, such as neural networks, to increase estimating precision.

**Keywords**

- Electrical power systems
- Computer simulation
- Modeling
- Distributed-parameter lines
- Transient phenomena
- EMTP
- Electromagnetic field analysis
- High-frequency/fast transient measurement
- Lifetime estimation
- Harmonic
Research Topics

- Developing software for electromagnetic-wave circuit element design
- Developing electromagnetic-wave circuit elements using genetic algorithms
- Research on transmission and leakage characteristics of waveguides for integrated planar circuits
- Research on passive circuit elements (filters and multi-port circuits)
- Research on microwave and optical-wave interactions
- Research on millimeter-wave leaky-wave antennas
- Research on different types of horn antennas
- Research on planar circuit antennas
- Research on multi-beam/movable beam antennas
- Developing visualization technologies for electromagnetic phenomena
- Other topics in the areas of microwaves, millimeter-wave circuits and aperture antennas

Research Contents

The High-frequency Engineering Laboratory researches an array of issues involving superhigh frequency electromagnetic waves, from microwaves to optical waves. We conduct both theoretical research-mainly computer-driven numerical analyses-and experimental research-mainly measurement of various characteristics using network analyzers, etc. We research an array of topics, some of which are listed above.

Keywords

- Microwave device
- Millimeter-wave device
- Optical device
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Electrical Machinery & Apparatus Laboratory

http://se.doshisha.ac.jp/subject/electrical/lab/electrical08.html
Prof. Mami MATSUOKAWA
Laboratory of Ultrasonic Electronics
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Research Topics

- Fabrication of multifunctional ZnO piezoelectric films by magnetron sputtering.
- Nondestructive evaluation of thin films by Brillouin light scattering.
- Laser ultrasonics
  - Nondestructive and noncontact evaluation of small cracks
- Thermoacoustics
- Elastic wave propagation phenomena
  - Simulation and theoretical studies
- Development of ultrasonic transducers

Research Contents

The Laboratory of Ultrasonic Electronics has started as "Laboratory of Acoustics and Measurements", simultaneously with the establishment of Faculty of Engineering at Doshisha University. Our research attitude is always based on the "Experimental study" and "Originality", which are the most important points of view for the Engineers. The laboratory changed its name when the faculty of engineering moved to the new campus "Kyotanabe". After this movement, our research area has dramatically spread and connected to the "Frontiers" of the science and engineering, making use of the interesting characteristics of "Ultrasonics".

World collaborating laboratories

University Pierre et Marie Curie (Paris, France), Ecole Centrale de Lille (France), Washington University of St.Louis (USA), University Paris 7 (France), Ecole Superior Physique et Chimie Industrielle, Paris (France) etc.

Keywords

- Ultrasonic Electronics
- thermoacoustics
- piezoelectric device
- Opto-acoustics
- nondestructive evaluation
- medical electronics
Prof. Motoi WADA, Toshiro KASUYA, Yasuyuki KIMURA  
Applied Physics Laboratory  

Research Topics

- Theory and experimental simulation of bow shock formation
- Laser spectroscopy of atoms and molecules in higher energy states
- Diagnostics of high-energy particle beams
- Biomedical applications of atmospheric plasmas
- Numerical simulation and experimental studies of sputtering due to low energy ions

Research Contents

- Hollow cathode glow discharge
- Arc transition from glow discharge
- Oxygen plasma in a multi-cusp plasma device
- Double layer formed in strong grad B field
Applied Physics Laboratory is being developing variety of plasma devices for dry processes. Glow and arc discharges create plasmas as environments suitable for producing new functional materials like carbon nano tubes and titanium oxides. Plasmas also serve as sources of various ions with their energy precisely controlled to achieve specific reaction. Ions extracted from plasmas with very low energy can form films of quality better than other preparation procedures.

Our laboratory participates in various research programs related to magnetically confined thermo nuclear fusion plasmas. Negative ions of hydrogen (H-) easily lose an extra electron through collisions with photons and other particles even after they acquire kinetic energy necessary to heat up a nuclear fusion plasma. Study on H- density measurement in a magnetic multi-cusp device indicates a scenario for further enhancing the efficiency to produce, extract and focus the H- beam. The high-energy beam of hydrogen formed by electron detachment from H- delivers energy to a plasma confined in a strong magnetic field.

Deeper understanding of the fundamental plasma physics obtained from the laboratory's research helps to find the most effective way to realize a plasma for advanced applications. Many devices at Applied Physics Laboratory creates plasmas for one to learn plasma physics as well as plasma application technologies. Experience in producing plasma through many different methods together with prediction obtained by computer simulation software cuts down the cost and time to develop a complicated plasma device.

We participate in many joint research programs conducted with other research institutes. These include National Institute for Fusion Science, Japan Atomic Energy Research Agency, Advanced Institute for Science and Technology, RIKEN and many universities in Japan as well as abroad.

**Keywords**

- high energy physics
- plasma material interaction
- plasma sputtering
- ion beam
- nuclear fusion
- plasma diagnostics
- negative ion
- plasma enhanced CVD
- computational plasma physics
Research Topics

- Nonlinear waves and soliton theory
- Development of integrable numerical algorithms
- Nonlinear integrable systems based on system of orthogonal functions

Research Contents

In the Laboratory of Applied Mathematics, we are conducting research on applied mathematics based on nonlinear integrable systems (continuous systems, discrete systems, and ultra-discrete systems), computational mathematics (numerical analysis and computer algebra system), geometry, and other fields for better understanding the mathematical structures at work deep inside physics and engineering.

<1> Generally, it is difficult problem whether nonlinear differential equations have solutions. However, nonlinear equations called soliton equations can be shown to be integrable, and moreover they are known to have many types of solutions. Also, one characteristic of nonlinear integrable systems is the ability to configure discrete integrable systems with a discretized spatial axis or time axis while keeping their solution structure. In this laboratory, we are researching nonlinear integrable systems.

<2> Numerical algorithms are the most important tools in conducting numerical analysis and computer simulations. When the recurrence formula for numerical algorithms is treated as a discrete dynamical system, there are many algorithms with desirable properties, and it has been shown that these are equivalent to discrete soliton equations. Soliton equations were originally proposed as a physics model for nonlinear waves, and soliton theory serves as a bridge to physics, mathematical engineering, and computer science. In this laboratory, we are striving to develop new, powerful numerical algorithms based on the ideas of nonlinear integrable systems.

<3> Nonlinear integrable systems are known to have a wide variety of characteristics. One of the most important is Hirota bilinear forms. The method of finding multiple soliton solutions using Hirota bilinear forms is called “Hirota’s direct method.” The direct method is an extremely powerful tool in the theory of nonlinear integrable systems. In recent years, the relationship between system of orthogonal functions and nonlinear integrable systems has been important problem. In this laboratory, we research integrable systems based on system of orthogonal functions.

Keywords

- Applied mathematics
- Mathematical engineering
- Nonlinear integrable systems
- Soliton theory
- System of orthogonal functions
- Numerical algorithms
- Computer simulation
- Discrete dynamical systems
- Ultra-discrete dynamical systems
In our laboratory we are researching technologies related to system configuration, wireless transmission, and radio wave propagation in various wireless communications systems. In particular, we aim to advance mobile communications by researching fundamental technologies such as wireless security, coding technologies, next generation mobile communications systems/technologies, radio wave propagation, and wireless measurement technologies. Our goal is to contribute to the realization of future multimedia mobile communications. Researches on these items are carried out by investigating new methods and technologies and evaluating their effectiveness with computer simulations and indoor/outdoor wireless experiments.

Our major research themes are the technologies in the fields of mobile communications and other wireless communications described below.

<1> **Wireless encryption/security, coding technologies** in order to realize safer, even more reliable communications

<2> **Next generation mobile communications system/technologies** in order to realize communications that are easy for users to use at even higher speeds and lower costs

<3> **Radio wave propagation, wireless measurement technologies** in order to establish reliable and economic service areas and to eliminate/avoid interference from other cells and wireless communications

<1> **Wireless encryption/security, coding technology**

In wireless communications, all information is naturally transmitted with wireless channels in the air. Different from wired signal transmission where the transmission point and reception point are connected by a cable and the signal only propagates in a limited range, in wireless signal transmissions reception locations basically cannot be limited. There are security risks present in wireless signal transmission such as information eavesdropping, unauthorized usage of wireless networks, and falsification. Wireless LAN security, which has recently become a problem, is a typical example of this. For the problem, our laboratory is focusing on a method to share a private key between sending and receiving devices to prevent information interception/leakage by encryption. The principle of the method is based on the reversibility (reciprocity) and locality of wireless channels. By the method, a private key is shared between sending and receiving devices without transmitting key information over wireless channels. For this method, we run computer simulations that assume the propagation environment and qualitatively evaluate its performance.

In addition, we are also conducting research on error-correcting codes as a technology to improve transmission reliability of wireless communications. In particular, centered on a combination with adaptive modulation and adaptive coding technologies, we are working to research and develop new error-correcting codes suited to recent broadband wireless communications.

<2> **Next generation mobile communications system/technology**

In the mobile communications field, in continuation of the first generation (1G) analog automobile telephone system, the second generation (2G) early digital mobile communications system, and the third generation (3G) communications system advanced in high speeds and international standards, currently research and development of the so-called fourth generation (4G) of the mobile communications system is moving forward. In the fourth generation system, instead of a concept where a single large system comprehensively supports the entire environment and services, a concept where multiple systems are split up according to the usage environment or application, for example cellular communications to cover wide areas and wireless LANs suited to high-speed transmissions, is envisioned. The general idea is to call this collection of multiple systems “4G.” A large increase in transmission capacity is also necessary with the personalization and ubiquity of wireless communications. The implementation of broadband
transmissions is a fundamental technological challenge in 4G mobile communications. As is symbolized by the expression "anywhere, anytime, and with anyone," a major issue is also implementing technologies so as to provide easy-to-use and user-friendly communications at low prices.

For these problems, our laboratory is researching and developing next generation wireless transmission technologies, software-defined radio, and wireless ad hoc communications. Research on the next generation wireless transmission technologies is fundamental research about how to conduct broadband wireless transmissions within limited frequency resources. Specifically, OFDM, MC-CDMA, MIMO, CDMA, adaptive modulation, and other topics are our research subjects. For these methods we are formulating new technologies, qualitatively evaluating their performance by computer simulations and verifying their effectiveness. Software-defined radio implements signal processing of radio equipment by software, until now done by hardware, the result is that wireless transmission methods can be changed by changing software. In order to implement the 4G system concept of splitting multiple systems according to usage environment and application, this is essential as a terminal-side technology. In particular, in order to constantly maintain an optimal system selection, simultaneous access to multiple (two or more) wireless systems with a single wireless circuit is deemed necessary, and we are working on research for the circuit configuration of software-defined radio terminals that implements this.

With the aim of also implementing future systems that are easy-to-use at low costs, we are advancing research on wireless ad hoc technology. Wireless ad hoc technology is a concept that attempts to implement information transmission by relaying it with terminals. For example, dead zones in cellular mobile communications systems can be eliminated by efficiently utilizing terminal relaying, and as a result, it makes the construction of economic wireless networks possible. In our laboratory we are specifically researching the wireless methods/multiplexing technologies suited to implementing wireless ad hoc.

<3> Radio wave propagation, measurement technology in wireless communications

When thinking about cellular telephone systems, for example, the installation location of base stations and as a result deciding how many base stations to install is a major issue in constructing cellular networks. In other words, there are problems such as dead zones where radio waves don't reach, making the supply of communications impossible, if the distance between base stations is too large, but on the other hand if base stations are densely installed, the dead zones are reduced but the cost of wireless network infrastructure construction increases. To resolve these issues, it is important to establish propagation models to precisely estimate propagation characteristics such as propagation loss, multipath delay characteristics and so on in a radio channel. In this way it is possible to design an optimal wireless network. In recent years, many forms of wireless communications have been developed such as wireless LAN local communications and UWB and RF-ID short distance communications. It is also important to construct propagation models for respective environments to establish these systems. In our laboratory we are researching these propagation models.

The research technique in our laboratory is mainly computer simulations, but eventually the evaluation and verification of wireless communications by wireless experiments using radio waves is necessary. For this we are also working on investigating and developing wireless experimentation techniques. For example, in an environment where interference exists, performance evaluations are conducted with actual radio waves emitted for the technologies developed in the laboratory, our private key sharing method for example, and along with research on those evaluation technologies, the effectiveness of the formulated technology is verified.

**Keywords**

- Mobile communications
- Modulation/Demodulation
- Coding
- Multipath fading
- Coded modulation
- Adaptive modulation
- Adaptive equalization
- Code Division Multiple Access (CDMA)
- Orthogonal Frequency Division Multiplex (OFDM)
- Wireless security
- Private key
- Wireless LAN
- MIMO
- MC-CDMA
- Software-Defined Radio (SDR)
- Mobile ad hoc
- Radio wave propagation
- Wireless measurement technology
- Anti-interference technology
Research Topics

- Optical properties of compound semiconductors and their application in laser and MEMS technology
- Improving organic EL device functions and elucidating device physics
- Realizing higher performance of organic thin-film solar cells

Research Contents

Many photonic devices are used around us. We often see them in lighting devices, displays of mobile phones and digital cameras, and solar cells, etc. With the start of fiber-optic Internet service for the consumer market, people now see that light is used in telecommunications. Telecommunications use lasers, photodetectors, modulators that place information in light, and amplifiers that boost light intensity.

Photonic devices are already in widespread use, but demand for them is expected to continue growing with the advent of ubiquitous computing society. Accordingly, performance of photonic devices must improve, while the device must also become lower cost and smaller. To meet these needs, it is not sufficient to only boost the performance of the photonic devices already in use. We also need to develop new ideas that arise from investigations into the properties of new materials.

In light of this situation, the Laboratory for Photonic Devices seeks to "find materials and principles that will be useful in people's lives." To this end, we are studying the optical properties and fabrication technologies of new compound semiconductors and organic materials while exploring possibilities of high-performance photonic devices with new functions. We are divided into the three groups listed below, with one student in charge of each topic. Therefore, each student must learn everything needed for their topic, from ways to fabricate samples to evaluation methods. Students must also study programming technology for automating measuring instruments and calculation technology for theoretical evaluation of experimental data. These are technologies and knowledge that are sure to come in handy after students enter society.

Some of the keywords that appear often in these topics are "thin films," "quantum wells," the "nano" prefix and "quantum dots." These are collectively termed "nanotechnologies;" they attempt to apply new phenomena that occur in very small new substances, in the nanometer range, to new photonic devices.

1. Inorganic compound semiconductor group

This group is evaluating the basic physical properties of antimony-nitrogen compound semiconductors, new materials that are so far little studied. We are studying these materials because they may make it possible to create photonic devices that can cover a broad
range of wavelengths from deep ultraviolet to far infrared. Once their basic properties are elucidated, the group will try to fabricate multiple quantum wells and quantum dots from these new materials and fabricate light emitting diodes and optical modulators.

2. Organic low-molecular semiconductor group

Progress has been made in applying organic small molecules to displays, etc., but there is much that still remains unclear about the mechanisms of electron transport and emission properties in devices. One particular possibility is that we may be able to greatly improve emission properties and develop new emission mechanisms by creating nanostructures such as multiple quantum wells that combine different materials. We are also researching ways to fabricate nanowires, which will enable nanometer scale wiring that can make organic integrated circuits a reality.

3. Organic polymer semiconductor group

Organic polymers are effective for reducing the costs of devices because materials can be developed using simple manual procedures. In our group, we research ways to more simply achieve the emission properties of low-molecular materials by incorporating low-molecular materials into polymer materials. We are also developing new emission mechanisms that incorporate nanoparticles, fine metal particles, carbon nanotubes and the like to develop devices that emit ultraviolet and infrared rays.

**Keywords**

- Light-emitting device
- Photodetector
- Sensor device
- Quantum effect device
- Compound semiconductor
- Organic EL
- Organic thin-film solar cell
- Process technology
- Optical nonlinear material
- Nanostructure
- Quantum dot
Research Topics

- Mechanical properties of ultrafine grained materials fabricated by severe plastic deformation.
- Fabrication of nanocrystalline metal matrix composite by electrodeposition
- Studies on properties of grain boundaries by model bicrystal

Research Contents

Metallic materials for practical use are polycrystalline materials, containing crystals of various orientations. The boundaries between these crystals are called "crystal grain boundaries, or interphase boundaries" and these are closely linked to the strength and corrosiveness of the material. At our laboratory, we focus on phenomena related to "crystal grain boundaries and interphase boundaries," and basic research is conducted on the following main research themes relating to model materials, practical materials, and ultrafine grain materials.

I. Basic research on the structures and properties of crystal grain boundaries

One property of crystal grain boundaries is that they raise the strength of metallic materials (Hall-Petch effect). However, in high temperature or corrosive environments, cracks develop or spread at the crystal grain boundary, which can actually weaken the material and lead to grain boundary embrittlement. At this laboratory, through experiments and computer simulations using model bicrystals and tricrystals, we analyze the structure and energy of crystal grain boundaries and conduct researches on following topics about the relation with grain boundary corrosion and corrosion fatigue.

- Basic research on corrosion fatigue of high purity copper bicrystals
- Molecular dynamics structural analysis of crystal grain boundaries
- Characterization of grain-boundary triple-junctions
- Measurement of grain boundary corrosion potential by Scanning Vibrating Electrode Technique (SVET)

II. Grain refinement by severe plastic deformation and material properties

It is possible to refine the crystal grain of metallic materials using intense plastic working; this is called "severe plastic deformation." With severe plastic deformation, ultrafine grain materials, in which the crystal grain is refined to 1 micron (1/1000 of a millimeter) or smaller, can be produced as bulk materials. Ultrafine grain materials are markedly stronger than regular materials with a crystal grain diameter of 10 microns or greater. However the mechanisms of crystal grain refinement and deformation, and corrosiveness are poorly understood, and this is a field of great engineering and scientific interest. We are using ECAP (one method of severe plastic deformation) to study various metallic materials such as copper, aluminum, and silver.

- Corrosion behavior of ultrafine grain copper and aluminum
- Stress corrosion cracking of ultrafine grain copper and brass
- Effect of purity and stacking fault energy on the stability of ultrafine grain material structures
Formation and deformation structures of copper single crystals during ECAP

Application of ECAP to stainless steel sheets (texture control and ridging of stainless steel sheets)

III. Basic research on superplastic deformation

Multiphase alloys such as two-phase stainless steel and two-phase brass are known to display superior superplasticity. Two-phase alloys have in-phase crystal grain boundaries and interphase boundaries formed from different phases; the latter comprise over 80% of all boundaries. We aim to elucidate the mechanisms of interphase boundary sliding using synthetically produced interphase ($\alpha/\beta$) bicrystals.

- Boundary sliding behavior in interphase ($\alpha/\beta$) brass
- Elucidation of interphase boundary sliding and mechanisms of superplastic deformation in two-phase ($\alpha+\beta$) brass

Commissioned/collaborative research

We conduct the following commissioned research on practical materials:

- Assessment of corrosion resistance and stress corrosion cracking in austenite stainless steel pipe rolled thread
- Establishment of methods of stress analysis and a fatigue life prediction formula and life extension for bellows-type expandable pipes

Keywords

- Single crystal
- Bicrystal
- Nanocrystal
- Crystal grain boundary
- Grain boundary energy
- Corrosion
- Stress corrosion cracking (SCC)
- Corrosion fatigue
- Deformation behavior

Prof. Tatsuya TANAKA
Applied Materials Engineering Laboratory
http://istc.doshisha.ac.jp/course/mechanical/lab_26.html

Research Topics

- Basic research on forming high-tensile steels for automobiles
- Research on improving heat-resistance and impact strengths for environmentally-conscious, natural long-fiber reinforced Poly Lactic Acid (PLA)
Research on 3D, high-viscosity, thermohydraulic analysis in a twin-screw extruder

Research on optimal weight minimization of massage chairs

Research on forming resin foams for automobile aluminum honeycomb sheets

**Research Contents**

The Applied Materials Engineering Laboratory conducts research on materials processing. The fields of research can be broadly categorized into (A) metal processing, (B) polymer processing, and (C) applied materials processing. Research activities in these fields require a sound basic knowledge of viscoelastic dynamics, plastic dynamics, continuum dynamics, and plastic processing. Whether using metals or polymers, the major processing methods involve either exploiting high-strain-rate deformations or repeated deformations to plastically process metals in solid form in a mold, or heating materials above their melting point and exploiting the fluidity of the material to rapidly inject (cast) it under high pressure in a mold.

In addition to basic experiments to elucidate the deformation and flow mechanisms, we apply finite element method (FEM) and difference method software (CAE analysis) to establish theories to assist engineering applications.

The basic philosophy of this laboratory is to conduct "research on forming environmentally friendly materials (materials with low environmental burden).” While "environmentally friendly material” is difficult to define strictly, research topics are selected according to keywords such as "Recycling," "Functionality," and "Lightness," etc. However, industrial materials that match these keywords are not necessarily easy to process; in fact, most such materials are difficult to process. Consequently, our research topics center on materials which are significant from the material research viewpoint, but requires thorough research on the forming technologies for their industrial application.

**Keywords**

- High-strain-rate plastic processing
- Shock wave
- Inelastic constitutive equation
- Incremental forming
- Semi-solid molding
- Nano-crystal
- Natural-fiber-reinforced plastic
- Carbon-fiber-reinforced plastic
- Injection molding
- Extrusion molding
Research Topics

- Fatigue mechanisms and new systems for high durable and ecological polymer composites.
- Crack growth and interactions mechanisms in mechanical structure.
- Development of advanced composite materials with high performances and properties for industrial applications.
- Power transmitting mechanisms for CVT (Continuous Variable Transmissions) using metal and conventional V belts.

Research Contents

We believe, our laboratory is ahead in some branches of technology for developing new ecological polymer composites, high durable carbon fiber composites, novel structural system of CVT transmission with superior property and other effective concept for mechanical designs. Relating to our studies, at least ten papers are published annually in not only major domestic journals but also in a number of international journals.

Our laboratory has some collaboration with several companies to conduct specific researches related to the above subjects. We have also special subjects supported by the National Science Fund provided by the Ministry of Education, Culture, Sports, Science and Technology, Japan. Co-sponsorships with industry are welcomed as long as the results will be published in the future. International students are also welcomed. Do not hesitate to contact us.

Details of research subjects are:

- Study on Improvement Method of Strength for Eco-composites using Natural Bamboo Fiber
- Surface Treatment Method of Bamboo Shoot Skin Fiber for BFRP
- Development of Advanced Carbon Fiber Composites using Micro Fibrillated Cellulose.
- Development of Bamboo Fiber Paper with High Specific Strength and Stiffness
- Novel Approach in Evaluation of Fatigue Damage Progression of Woven Fabric Composites under Cyclic Loading.
- Development of Novel Carbon/Carbon Composite (Carbon Fiber Reinforced Carbon Composite) with Added Fine Carbon Fiber
- Study on Assist Device with Advanced Structure in Standing up for Welfare.
- Development of Low-cost Car-Clutches Using Short Glass Fiber Reinforced Phenol Composites.
- Study on Power Transmitting Mechanisms of Metal V-belt type CVT
  - Change of Pitch Line -
- Improvement of Power Transmitting Efficiency of Metal V-belt type CVT.
- Estimation of power Loss and Prediction of Shifting Gradient Considering Elastic Deformation of Blocks of Metal V-belt type CVT
Noise Generation Mechanism of One-piece Type Brake Disc used in Motorcycle after Alternation of Braking and its Release.

Development of Mechanical New Power System for Vehicle Driven by Plural Motors Connected in Series with CVT

Crack Propagation due to Cyclic Impact Loading and Local Deformation in Rubber Conveyor Belt for Civil Engineering.

Keywords

- Mechanics of Materials
- Structural Engineering
- Linear and Hyper Elastic Mechanics
- Strength and Fracture Mechanics of Composites Materials
- Crack and Damage Mechanics
- Mechanics of Power Transmission Systems
- Continuous Variable Transmission (CVT)
- Finite Element Method (FEM)

Prof. Jiro SENDA,
Spray and Combustion Science Laboratory
Major Research Topics

- 3D spray structure measurements using holography
- Construction of a hydrogen energy network and development of high-efficiency hydrogen engines
- Design of high-efficiency, low-emission combustion method using spatio-temporal combustion control by multi-stage fuel injection
- Numerical simulation of spray combustion process by LES and determining the internal structure by Rayleigh scattering
- Basic research on forming CVD semiconductor layers using flash boiling spray
- Research on high-efficiency, thermoelectric-conversion cogeneration systems
- Design proposals for environmentally symbiotic town blocks


“1. Optical measurement”
involve the use of various laser-based, leading-edge optical measurement technologies for the highly accurate, non-contact measurements of fuel vapor, chemical species, temperatures, and concentrations inside engines to facilitate the spray combustion process.

“2. Fuel research”
includes the development of practical hydrogen-diesel engines, next-generation biofuels, and new methods for fuel reforming. In particular, the proposal of fuel-design theories including LCA, and of high-efficiency, low-emission spray combustion methods.

“3. Spray research”
is a systematic approach to engine spray research, including modeling of cavitation in nozzles, the disintegration process, and the spray process.

“4. Chemical reactions and combustion research”
includes the highly accurate numerical simulation of soot particles in the combustion field using chemical reaction dynamics; research on the application of a low-emission combustion method, homogeneous charge compression ignition (HCCI), to diesel engines; and the elucidation of new combustion methods by fuel design techniques.

“5. Numerical simulation and modeling”
includes integrating the previously developed spray-wall impinging model and flash-boiling spray model into a multi-dimensional simulation scheme, and simultaneously advancing research on the highly accurate numerical simulation of the spray combustion process using Large Eddy Simulations.

“6. Applied research”
involves investigating new areas, such as on-board measurements of performance and emission data during diesel vehicle operation; research on cogeneration systems for high-efficiency, thermoelectric-conversion; research on forming CVD semiconductor layers using flash boiling spray; and research on the manufacture of nano-particles.

Keywords
Spray engineering
Combustion engineering
Internal combustion engines
Thermofluid engineering
Optical measurement
Cavitation engineering
Sustainable Urban Design with Optimum Energy Application

Prof. Mamoru SENDA, Kyoji INAOKA
Heat Transfer Laboratory
http://istc.doshisha.ac.jp/course/mechanical/lab_30.html

Research Topics

<1> Research on elucidating various thermal flow characteristics and their engineering applications

<2> Research on dynamic control of thermal flow fields

<3> Research on enhancing the efficiency of systems using waste heat and of thermofluid devices

Research Contents

Topic I

develop aims to clarify various thermal-hydraulic phenomena in laminar and turbulent flows and discover their engineering applications. In practice, this focuses on thermal flow fields including significant engineering elements such as wall turbulence, jet flow, swirl flow, pulsatile flow, flow around wings, and re-attaching flow after separation accompanied by heat transfer, in order to investigate the structure of the flow field and temperature field, identify phenomena with potential engineering applications, and develop thermofluid equipment. For example, an object placed in a turbulent flow results in unsteady vortices shedding downstream. These vortices carry both momentum and heat. This results in a flow field with unsteady large-scale vortex motions added to the turbulent components. The thermal flow field resulting from this mutual relationship is complex. For detailed investigation of such complex thermal flow fields, laser-based velocity measurements (LDV, PIV) and temperature measurement (LIF) are performed to create a thermal-flow-field database and enhance understanding of these phenomena.

Topic 2
involves research on the effectiveness of positioning artificial devices in a thermal flow field. In order to investigate the flow mechanisms, small actuators positioned in the flow field are operated to reduce the size of the circulation region of flow with inferior heat transfer or are applied to the flow field around a wing to help avoid stalling at high angles of attack.

**Topic 3**

encompasses research to enhance the performance of thermofluid devices that use waste heat, such as cogeneration systems. In practice, the research includes pilot testing of the Rankine cycle to recover waste heat from engines, proposing a new expander, and developing new dynamic heat exchangers and heat-exchanger elements using superfine metals.
The Fluid Engineering Laboratory is divided into two groups, Group A and Group B, which both cooperate and compete with each other.

The leader of Group A is Prof. Jiro MIZUSHIMA. The interest of Group A is observing, analyzing, and researching the motion of fluids from a wide range of viewpoints. Particular attention is focused on the instability of fluid flows and turbulence transition. Instability of fluid flow results in sudden changes in flow pattern symmetry. Flow instabilities can temporally result in oscillatory fluid motions that may cause objects to oscillate. The flow stability theory can be applied to artificially create such flow patterns and control the resulting oscillations. Conversely, machines can be controlled by deliberately generating oscillations in a fluid flow.

The research topic currently tackled by Group A are as follows:

<1> Structural analysis of turbulent combustion fields
We are surrounded by many types of combustion phenomena, from internal combustion engines to domestic gas stoves. The carbon dioxide and nitrogen oxides they generate are known to have serious detrimental effects on the environment. The laminar flamelet model is widely used for research on combustion phenomena. It uses steady laminar diffusion flames to simulate the instantaneous local flame structure in turbulent fields. However, despite their importance, adequate attention is not paid to characteristic turbulence effects such as increased area and thickness of the reactive surface and promotion of the chemical reaction due to turbulent diffusion. This research involves direct numerical simulations and visualization testing using methane to clarify the dynamic behavior of the combustion field and to elucidate the mutual interactions between the large-scale vortex structure and chemical reactions in jet diffusion combustion.

<2> Flow instability and flow transition between two coaxially rotating discs

The flow between two coaxially rotating disks models the flow inside a computer hard disk unit. It is investigated by testing, numerical simulations, and analysis.

<3> Numerical simulation of flows in a suddenly expanding and contacting channel

Numerical simulations of flows in a suddenly expanding and contacting channel are compared with the results from flow stability theory.

<4> Stability of Hagen-Poiseuille flow

Linear theory indicates that the Hagen-Poiseuille flow is stable. We investigate the stability of Hagen-Poiseuille flows using numerical simulations and non-linear flow stability theory.

<5> Flow instability and flow transition past a sphere, cylinder, or array of cylinders

We determine steady solutions for the flow past a sphere, cylinder, or array of cylinders and investigate the linear stability to determine the bifurcation structure of the solution.

<6> Flow transition past two cylinders

Numerical simulations and testing to investigate the transition to oscillatory or deflecting fluid motions in a flow past two cylinders: one parallel and one perpendicular to the flow direction.
<7> Generation of suction vortices in vertical shaft pumps

We are attempting to optimize and reduce the size of the bellmouth inlet that is generally used in an axial flow pump. Joint research with Torishima Pump Mfg. Co., Ltd.

<8> Eddy structure in backstep flows

Numerical simulations of flows in a suddenly expanding channel are compared with the results from flow stability theory.

<9> Genesis mechanism of bathtub vortices

When fluid flows out of a container with a small flow outlet, a bathtub vortex is generated near the outlet. We conduct testing and numerical simulations to investigate the genesis mechanism and structure of bathtub vortices.

<10> Ekranoplans

Ekranoplans exploit the Wing-In-Ground effect to generate huge lift. As this effect is obtained over land and water, the Ekranoplan shows promise as an intercontinental transport medium of the future. We are undertaking testing on model Ekranoplans.

<11> Basic research on wind-energy power generation

Despite the enormous research and practical implementation of wind-energy power generation in Europe and the USA, it is not yet common in Japan. We are attempting to develop small, domestic wind generators, rather than large industrial-scale systems.

<12> Development of model wind-powered cars that can move upwind

Is it possible to make a car that can move upwind? This is a purely academic exercise and is not intended to create practical applications.

<13> Development of fluid-based toys

We are developing toys that exploit the properties of fluids, particularly oscillation phenomena in fluids. We are also developing musical instruments that exploit the sounds generated in a fluid.
The leader of Group B is Prof. Hiroshi YAMAGUCHI. The main subject of interest of Group B is the research on engineering flows of complex fluids. Smart fluids are fluids that detect changes in the ambient environment to offer self-control and other functions. Group B undertakes basic research into their flow behaviors and characteristics in the flow field and is investigating their industrial potential. Currently known smart fluids (vague as their definition may be) are fluids sensitive to external electromagnetic fields, such as magnetic fluids, electrorheological fluids, and plasmas; and fluids that automatically change flow to match the external environment, such as body fluids and special polymer solutions.

Our current research focuses on complex fluids, such as magnetic fluids, non-Newtonian fluids, and supercritical CO2.

The major research topics are as follows:

- Solar Rankine system using supercritical CO2
- Ultra-low-temperature heat-pump system using CO2 gas-solid two-phase flow
- Development of mixed-phase flow parameter measurement methods using magnetic fluids
- Elucidation of noise-generating mechanisms in a pressure regulation valve upstream of a hydraulic valve
- Research on fluid friction reduction methods using magnetic fields
- Research on the properties of heat-transport devices using temperature-sensitive magnetic fluids
- Development of magnetic refrigerator using magnetic particle suspension
- Research on couplings using magnetic fluids
- Research on improving efficiency of magnetohydrodynamic (MHD) power generation using low-melting-point metal alloys
- Research on the rheological characteristics of Bingham fluids and their applications to pipe design
- Research on heat transfer characteristics of magnetic fluids flowing through a porous medium

<1> Magnetic fluids

In addition to sensitivity to magnetic fields, magnetic fluids exhibit changes in apparent viscosity and apparent specific gravity (magnetic buoyancy) when subjected to a magnetic field and also exhibit the magnetocaloric effect. The Fluid Engineering Laboratory focuses on the properties of magnetic fluids and undertakes basic and applied research on magnetic fluid behavior to find applications in power generating devices, heat-transport devices, and measuring instruments.

**Characteristics of heat transport by boiling two-phase flows of magnetic fluids**

Mixing a fluid that has a lower boiling point than the mother liquor into a magnetic fluid creates a magnetic fluid with a lower boiling point than before. Such non-azotropic temperature-sensitive magnetic fluids exhibit a significant drop in magnetism due to temperature increases in the room-temperature range (temperature-sensitive magnetism). The magnetic body force difference due to this property and the air-lift pump effect due to the boiling of the low-boiling-point solution can be used to control fluid flow in the
Development of mixed-phase flow parameter measurement methods using magnetic fluids

Unlike a general fluid flow, a mixed-phase flow contains mixed solid, liquid, and gas phases. Such flows are important in the nuclear engineering, civil engineering, petroleum engineering, and mechanical engineering fields. For example, gas-liquid two-phase flows occurring inside an atomic reactor cause complex changes in heat transfer characteristics. Understanding such phenomena requires measurements of parameters such as the flow rate and volume ratio of each phase.

This research project aims to establish a new mixed-phase flow measurement method using the sensitivity of magnetic fluids to magnetic fields and the principle of electromagnetic induction. The advantages over current measurement methods are low cost, convenience, and maintenance-free operation. Currently, we have achieved the measurement of the void ratio and bubble speed in gas-liquid two-phase flows, identification of flow patterns in gas-liquid two-phase flows, and measurement of the solid-phase concentration in solid-liquid two-phase flows. In the future, we aim to further enhance the sensitivity and expand the range of application of this method.
Characteristics of magnetic-field-controlled energy-conversion MHD power generation

In magnetohydrodynamic (MHD) power generation, an electromotive force is generated due to Faraday's law of induction when a conductive working fluid cuts through the magnetic field in a flow channel with electrodes arranged as shown in the diagram below. This project aims to create a cogeneration system using a conductive magnetic fluid as the working fluid. This conductive magnetic fluid uses the magnetic fluid researched for heat-transport devices as the mother liquor. The project involves testing to evaluate the system's generating capacity and numerical simulation of the working fluid flow in the generator channel.

Magnetic refrigerator using magnetic particle suspension

This research aims to apply the magnetocaloric effect (the phenomenon of a magnetic body heating when a magnetic field is applied and cooling when the magnetic field is removed) to refrigeration devices. Such refrigeration methods are kind to the environment, as no Freon or other greenhouse gases are used. Many institutions are researching magnetic refrigeration using solid magnetic bodies. However, our research focuses on magnetic refrigeration using magnetic particle suspension (liquid magnetic medium like a magnetic fluid).
Heat transfer properties of magnetic fluids due to natural convection

This project researches the magnetic natural convection using temperature-sensitive magnetic fluids that can be controlled using magnetic fields and temperature. In a heat-transport device using temperature-sensitive magnetic fluids, buoyancy and magnetic body forces affect the flow behavior, and strong temperature dependency of magnetization is shown. For this reason, temperature-sensitive magnetic fluids are thought to be ideal for convection in the zero gravity of space or in the low gravity on the surface of the Moon. We are using testing and numerical simulations to investigate the effects of magnetic fields on the heat-transfer properties of temperature-sensitive magnetic fluids.

<2> Environmentally friendly energy-conversion systems using natural refrigerant (CO2)

Recently, in an attempt to protect the environment, considerable research has been undertaken into energy-conversion systems using natural energy, such as solar and wind energy, to generate electricity. This project uses the boundless energy (heat) of the Sun and uses CO2 as a natural refrigerant to enhance the efficiency of a Rankine cycle system that generates electricity and usable heat. This system uses the carbon dioxide in a supercritical state at high temperature and high pressure. As our understanding of the properties in this supercritical state is still incomplete, we are investigating the properties of supercritical CO2 in addition to research into the overall system.

Solar Rankine system using supercritical CO2

Recently, in an attempt to protect the environment, considerable research has been undertaken into energy-conversion systems using natural energy, such as solar and wind energy, to generate electricity. This project uses the boundless energy (heat) of the Sun and uses CO2 as a natural refrigerant to enhance the efficiency of a Rankine cycle system that generates electricity and usable heat. This system uses the carbon dioxide in a supercritical state at high temperature and high pressure. As our understanding of the properties in this supercritical state is still incomplete, we are investigating the properties of supercritical CO2 in addition to research into the overall system.

Ultra-low-temperature heat-pump system using CO2 gas-solid two-phase flow

Conventional refrigerators use Freon or hydrochlorofluorocarbons as the refrigerant. The destruction of the ozone layer and global warming are becoming increasingly serious, and the refrigerant Freon is one cause of these environmental problems. Research and development is being conducted on natural refrigerants that have a low environmental load. This project undertakes basic research into the fluid-dynamic behavior of a carbon dioxide solid phase formed in liquid carbon dioxide inside a cylindrical heating tube, and its heat transfer properties.

In practice, the liquid carbon dioxide undergoes isentropic expansion in an expansion valve and its temperature drops due to the Joule-Thomson effect. As a result of the decrease in temperature, dry ice particles precipitate out and then sublimate and steal heat from the surroundings.
Keywords

Group A (Prof. Jiro Mizushima)
- Flow stability
- Chaos
- Turbulence transition
- Fluid engineering
- Combustion fluid engineering
- Wind-energy power generation
- Pump

Group B (Prof. Hiroshi Yamaguchi)
- Magnetic fluids
- Gas-solid two-phase flow
- Mixed-phase flow
- Supercritical
- CO2
- Lattice Boltzmann Method
- Heat transport
- MHD
- Turbulence
- Flow analysis / computer simulations
- Flow calculation

Prof. Katsuya Hirata, Jiro Funaki
Laboratory of Fluid Mechanics
http://istc.doshisha.ac.jp/course/mechanical/lab_32.html
Research Contents

The Laboratory of Fluid Mechanics undertakes research, both basic and applied, on the fluid behaviors and properties in various systems, as follows.

<1> Flow-Induced Vibrations

Proposal, development, and investigation of simple new oscillators (identification of oscillation range including low Reynolds number range, oscillation characteristics within the range, critical Reynolds number, etc). Elucidation of mechanisms generating various flow-induced vibrations, such as fluidity oscillators, flip-flop jet nozzle and bluff-body flutter in a uniform flow, identification of their oscillation region and oscillation limits, and research on their applications and control.

![Fig. 2(a)](image1.png)  New type of 2D fluidic oscillator tool

![Fig. 2(b)](image2.png)  Sequence of streamlines

<2> Flow between Rotating Disks

Various flow phenomena arise near a floppy disk or other rotating disk due to the boundary conditions and the Reynolds number. We are currently conducting research and analysis to clarify the flow between two coaxially rotating disks.

![Fig. 4](image3.png)  Flow pattern tool

<3> Computational Fluid Dynamics

Development and improvement of analysis methods for various hypothesized flow fields, including difference methods, vortex methods, and discrete singularity methods. Verification of the simulated results is performed using the test results and visualization data.
We conduct research on 2D cavity flow with sinusoidal oscillation of the boundary to enhance the efficiency of diffusion and mixing as well as research on the effects of gravitational oscillations on natural convection and research on fluid sloshing as basic research on the promotion of heat dispersion due to forced oscillation of a container.

As basic research on solid transport, we conduct research on rotational and non-rotational flows in round pipes and near round pipe inlets, research on solid-liquid mutual interactions that are important when suction-lifting solids, and research on annular ejectors that are attracting attention as simple constructions for jet pumps.

High-Reynolds-number flows and flow-induced vibrations are often characterized by separating flows. The Laboratory of Fluid Mechanics conducts research on flows around two-dimensional bluff bodies and wake vortices behind three-dimensional bluff bodies.

Steady flows, which appear near an ultrasonic sound source in addition to the sinusoidal oscillations, are known as acoustic streaming or ultrasonic flows. They are expected to find applications in gravity-free spaces. We conduct computational simulations to elucidate these flows near various-shaped sound sources.
Other research on thermal flow characteristics in fuel cells, automotive catalytic converters, and etc.

Keywords

- Fluidic oscillator
- Flow between two rotating disks
- Computational fluid dynamics
- Slow flow
- Ejectors
- Siphon
- Flow-induced vibrations
- Flutter
- Shear layer control
- Acoustic streaming
- Fuel cell
- Automotive catalytic converter

Prof. Takayuki KOIZUMI, Nobutaka TSUJIUCHI
Motion and Vibration Control Laboratory
http://istc.doshisha.ac.jp/course/mechanical/lab_33.html

Research Topics

- Vibration and noise reduction in electrical appliances and mechanical equipment
- Dynamics of automobiles, motorcycles, and heavy construction machinery
- Robot dynamics and control
- Human body modeling and dynamic safety analysis
- Matching evaluation of sporting goods to the human body and human dynamics

Research Contents
The Motion and Vibration Control Laboratory conducts research and development on new technologies and new methods through analytical approaches, numerical simulations, and experiments of a wide range of phenomena associated with dynamics and their control.

Familiar examples include vibration reduction in fully automatic washing machines through whirling vibration analysis in the spin cycle during dehydration and optimization of the support system; development of analytical methods for vibration transmission paths and contribution factors for sound suppression in automobiles; establishing subjective preference evaluation methods for ride comfort. Also this evaluation is being applied to optimize the pulse of large motorcycles. A robot hand using pneumatic actuators created at this laboratory as artificial muscles is being combined with biological information recognition technology for myoelectric signals to develop new prosthetic hands and assisting devices, due to its good affinity with the human body (Fig. 1). As human dynamics, we are developing numerical simulations of the infant body and conducting various experiments to ensure safety in the event of collisions or accidents in order to develop new types of safety device (Fig. 2). We also undertake matching evaluation of golf clubs to the human body and the analysis of muscle loads during Nordic walking.

Prof. Eiichi AOYAMA, Toshiki HIROGAKI
Manufacturing System and Design Laboratory
http://istc.doshisha.ac.jp/course/mechanical/lab_35.html

Research Topics

- CAD/CAM, Industrial Robot and Machine Tool Integrated System
- Control of Automatic Guided Vehicle and Industrial Robots and Machine tools
We focus on automation and sustainable technology in the manufacturing fields, including new product design, life cycle assessment, machine control, machining process control and computer aided manufacturing.

(1) CAD/CAM, Industrial Robot and Machine Tool Integrated System

- Control of working plate with a dual arm robot
- Reverse generation using photometric stereo method with industrial robot
- CAM system for five-axis controlled machine tool

(2) Machine control of Automatic Guided Vehicle (AGV) and Data mining

- Autonomous controlled AGVs based on traffic system: traffic system
- Manufacturing system with data mining

(3) Integrated Life Cycle Assessment of Energy, Design and Green Manufacturing Technology
(4) Design and Quality Control of Gear Powertrain Considering Human Engineering for Hybrid Vehicle

- Integrated desktop size machine tools, robots and diode laser heat source
- Green manufacturing based on bamboo growth

(5) Manufacturing of MEMS for Electronics Device and Electric Automobile

- Design method considering Human Engineering
- Gear quality control with IR vision

Keywords
- Manufacturing System
- Design System
- Computer Numerical Control
- Machine Tools
- Industrial Robots
- Automation
- Life Cycle Assessment
- Machining Process Control
- Green Products
Research Contents

Topic I
Involves research to grasp the characteristics and improve the performance of machine elements such as stepless gearboxes, bearings, and linear guides. In practice, we are developing force control mechanisms and positioning mechanisms incorporating traction drives that are attracting attention as stepless gearboxes, optimizing the design of fluid dynamic bearings used in hard-disk drives, developing ultra-precise actuators that perform positioning through minute adjustments to the hydrostatic bearing supply pressure, and developing linear guides that permit the stable and low-friction movement of objects.

Topic II
Involves research on property evaluation of diamond-like carbon (DLC) films and fine-particle peened films that are attracting attention as high-performance films. In practice, we undertake the development of heat-resistant DLC films and research into the tribological characteristics of films peened by fine molybdenum disulfide particles. We use X-rays and neutron beams to investigate the composition and structure of films and make detailed examinations of their effects on tribological characteristics in order to search for the optimal film formation conditions.

Topic III
Involves the development of superior new materials with enhanced mechanical properties and sliding characteristics. In practice, this includes the development of new composition-controlled magnesium alloys, development of high-strength natural-fiber-reinforced composite materials using ethylene plasma polymerization, development of carbon-fiber composite materials, and improving the adhesion of copper plating by low-temperature plasma treatment.

Keywords
- Tribology
- Lubrication engineering
- Machine elements

Prof. Masanori TAKAOKA, Shigeo KIDA
Physics Laboratory
http://istc.doshisha.ac.jp/course/mechanical/lab_39.html
The Physics Laboratory aims to educate students to apply logical thought processes based on scientific knowledge to analyze familiar complex phenomena and to be able to think creatively. Therefore, the students’ research topics are diverse, with each student conducting projects to clarify the physics of phenomena that interest them.

Fluid phenomena such as waves and vortices that we experience in everyday life follow deterministic equations and exhibit complex and diverse motions due to non-linearity and high degrees of freedom.

As we can note from Da Vinci sketches, physics has a long history of attracting researchers from diverse fields who have developed a magnificent body of theory. However, uncharted areas of research still remain and the new concepts of soliton and chaos have appeared. Finding solutions to difficult problems that have remained historically unresolved requires a new integrated approach through multidisciplinary joint research that fully exploits the features of today’s information age.

Our current topics of interest include the following.

1. **Self-organized structure and cooperative phenomena in disordered systems**
   Despite the overall disorder of the system, structures can appear spontaneously. The elements can also accumulate into an organization with a single function. We are attempting to physically elucidate why systems or nature shows a preference for such structures and why each element plays a role.

2. **Statistical theory of macroscopically disordered systems**
   Statistical theories supporting the solution of the complex fluctuations and the population of solutions are effective in multi-dimensional chaos, mixing, and turbulence. It is important to pursue these statistical laws, to clarify their dependence on macroscopic conditions, and to what degree they are independent.

3. **Stability and pattern dynamics**
   When control parameters are changed, the regular patterns (solutions) can become unstable and branch to new solutions, making a transition to a more complex (disordered) state.

4. **Nonlinear wave phenomena**
   The linear phenomena of reflection, refraction, interference, diffraction, and scattering are known for waves such as light, ripples and sound. However, the consideration of nonlinear effects leads us to an extensive range of phenomena from regular waves like solitons to complex waves such as the wind-driven turbulent waves typical in the ocean.

5. **Interaction between flow and objects**
   The movement of an object through a fluid, such as a curving and flying ball, and movement of a fluid through an object, such as flow through a pipe or the flow of water in a bay, is of industrial importance as well as academic interest.

6. **Geophysical fluid dynamics and environmental problems**
   The movement of a fluid within the atmosphere and ocean are well known as the convection, ocean currents and waves. Noise and the dispersion of pollutants are known as environmental problems. These are important issues that are closely related to our everyday lives.

7. **Singularities and the existence of solutions in nonlinear partial differential equations**
   Knowledge of the mathematical properties of governing equations, such as the Navier-Stokes equations, is extremely important for a physical understanding. For example, see "millennium prize problems."

8. **Emergent functions of organisms and cooperating groups**
   As represented by organisms, the properties and functions of an organization depend on the arrangement and combination of the components. We investigate the mechanism and applications of such emergent function.
9. Mechanism of environmental adaptation

Organisms change and evolve through interactions with the environment. They have become optimized by accumulated learning. We undertake numerical evaluations of the mechanisms of environmental adaptation.

Keywords

- Fluid phenomena
- Macroscopically disordered system
- Statistical theory
- Self-organization
- Cooperative phenomena
- Stability
- Pattern dynamics
- Non-linear wave
- Vortex dynamics
Research Topics

Elucidating the earth's magnetic field variation and obtaining magnetic records of climate changes

Research Contents

One of the characteristics of global environmental issues is that materials and energies generated by human activity can cause disturbances to natural systems, which might constitute threats to human existence. Carbon dioxide and CFCs, for example, while not toxic themselves, give rise to major changes in the earth systems, which in turn make people anxious and bring troublesome problems to our life. Studying nature and change of the earth system is indispensable to understanding the global environment issues.

On the basis of earth science, the Earth System Science/Environmental Magnetism Laboratory conducts research of analyzing, evaluating and modeling climate and geospheric environment changes. Rocks and sediments of seas and lakes contain magnetic minerals such as iron oxides or iron sulfides that bear ferri- or antiferromagnetism. Just as magnetic tapes and floppy disks store every sort of information, magnetic minerals in rocks and sediments can record the ancient earth's magnetic fields as natural remanent magnetization. Paleomagnetism is a branch of the earth science: to decode the record of the earth's magnetic fields, to date rocks or sediments based on the magnetic polarities, and to understand continental drift or tectonic movements. On the other hand, composition, concentration and grain size of the magnetic minerals can tell us the provenance and transport of sediments, which leads to clarifying the natural environments at the time of deposition, and hence hydrologic or climate changes; this discipline is called environmental magnetism. Global environment and tectonics research based on magnetic measurements is presently used for a wide variety of samples and is expected to contribute greatly to our understanding of the global environment and its near-future state. The sedimentary record is not only an archive of planetary and human history, but also a target of our intellectual challenges exploring the unknown world.

<1> Environmental change analysis using the magnetic properties of sediments

We obtain the magnetic properties of sediment samples from seas and lakes and interpret the data on how the magnetic properties are related to environmental and climate change. We conduct time series analysis and factor analysis on magnetic properties data, perform geographic information system analysis, and try to model the material transport and detect quantitative environmental indicators.

<2> Paleosecular variation, paleointensity change, and the history of geomagnetic polarity reversal

Geomagnetic polarity reversal is a simultaneous phenomenon occurring on a planetary scale, which constitutes a global isochronous horizon. In addition, geomagnetic secular variation and changes in geomagnetic field intensity are effective for dating and correlation of strata in higher resolution and are used widely in studying climate change and human evolution. They also provide important clues to understand the dynamics operated in the deeper part of the earth.

<3> Formation and development of the Japanese Islands based on remanent magnetization measurements

Paleomagnetic directions are essential clues for reconstructing ancient positions of lithospheric plates, land blocks and small rocky formations, and also provide valuable information on the development of the Japanese Islands. Focusing on widespread tephra that
deposited simultaneously in a short period, one can compare remanent magnetization acquired at the same time over a vast area, which allows us to detect crustal movements that took place in the Quaternary Period.

Keywords

- Earth systems
- Environmental magnetism
- Rock magnetism
Research Topics

- Elucidating changes in the ground surface environment
- Elucidating climate change
- Analysis of mountain, river and coastal environments
- Element dynamics and cycling in the atmosphere, hydrosphere and soil
- Impact assessment of atmospheric fallout (yellow sand, acid rain and pollutants) on the ground surface environment
- Changes in the composition of precipitation and dustfall
- Elucidating ancient environments as recorded in sediments and soils of East Asia region

Research Contents

Earth's surface biosphere consists of various zones such as the lithosphere, pedosphere, atmosphere, hydrosphere, etc. Looked at closely, various elements such as minerals, living things, water and air are found to be closely related to each other to form natural cycling systems. When elements originating from human activities in the human sphere are added, cycling systems become altered or destroyed, causing regional or even global environment problems that come back to affect the human sphere.

To elucidate the cycling systems that are intertwined with various types of regions, elements and phenomena, it is necessary to collect and analyze data on each element in both the natural environment zone and human activity zone.

In this laboratory, we aim to understand the processes of formation and change in natural environmental systems on various time and space scales as well as understand the process of material cycling between systems. We furthermore seek to establish observation, survey and analysis methods for conservation, countermeasures and assessment while creating new environmental conservation and anti-disaster technologies.

Keywords

- Global environmental changes
- Mountain, river and coastal environments
- Stratigraphy
- Sedimentology
- Paleoclimatology
- Biogeochemistry
- Soil inorganic chemistry
- Material cycling
- Environmental geology
• Isotope ecology
Research Contents

A template of “foods and living places” provided by forest ecosystems
Hiroshi TAKEDA, Professor

My research uses the concept of a template of “food and living places” that plants provide in a forest ecosystem as an approach to explain forest biodiversity. The functions and structures of forest ecosystems are maintained by interactions between plants and decomposers.

Producer plants in forest ecosystems

Through the process of photosynthesis, plants in a forest ecosystem produce a menu of foods and living places as resources. Just as food, shelter and clothing are critical to the lives of humans, food (energy) and living places of the living creatures in the forest are critical in our understanding of ecosystem biodiversity.

Soil decomposer system

A certain percentage of the organic matter produced by trees in forest ecosystems is used by consumer animals. As a result, the earth’s vegetation is preserved. As organic matter withers and dies, it is decomposed by decomposer microorganisms and animals in the soil decomposer system. The result is that nutrient substances are recycled between plants and the decomposer system.

<1> Research on mechanisms of forest ecosystem decomposer systems
Focusing on the interrelationship among leaf litter, decomposer microorganisms and soil animals, research is being conducted on the form of decomposition of leaf litter, residual amounts of nutrients in the soil, and the form of nutrient supply by soil moisture. This research is taking place at Kyoto University Ashiu Experiment Forest, Kyoto University Kamigamo Experiment Field and Mt. Tanakami in Shiga Prefecture, among other places.

<2> Behavior of rootlets in soil and role of soil animals

Research is being done on the amount of rootlets supplied to the soil decomposer system as well as the behavior of rootlets, at Kamigamo, an evergreen seasonal forest in Thailand, in mountain forests and in plantations of sugi (Cryptomeria japonica). Manipulative experiments to clarify the functions of soil animal community structures are being done at Kamigamo, while research into rootlets is taking place in the Thai forest. In particular, as for soil animals, I am prescribing manipulative experiments to elucidate their functions.

<3> Tree module mechanism in forest ecosystems

At Kyoto University Kamigamo Experiment Field, Mt. Tanakami in Shiga Prefecture and Ashiu Experiment Forest, I am researching forms of behavior in module units consisting of branches, leaves and sprouts in major tree species in order to reveal the mechanism of forest regeneration and maintenance.

<Conservation ecology>

Endeavoring to conserve endangered plant species and restore ecosystems
Shigeyuki MITSUTA, Associate Professor

<1> Basic survey of flora of Kyoto Prefecture

This year the focus is especially on surveying for wetland plants and the Tango Peninsula.

<2> Conservation of endangered plant species

Subjects of this year’s efforts (party in brackets is the requesting party)

- Kamigamoshida (Asplenium oligophlebium Baker), Momiji charumeruso (Mitella acerina) [Kyoto Prefecture]
- Asaza (Nymphoides peltata) [Yawata City]

<3> Exotic plant survey and ecological evaluation [Kyoto Prefecture]

As one of the Ministry of the Environment’s “Endangered Species Conservation Promoters,” I continue to conduct surveys in order to write a new all-Japan red data book. My motto is “Abundant nature within the urban environment. Abundant culture within the farm town environment.”
Research Topics

(Books, papers, etc. on recent environmental issues)

- Globalization and Environmental Destruction (in English)
- Verification of the Theory of Ozone Layer Depletion over the South Pole by CFCs (Part 1: Doubts) (in Japanese)
- Globalization and Muslim Armed Groups in the Philippines (2) (in Japanese)
- Aren't Adults Trying to Deceive Children? / The Story of Global Warming (in Japanese)
- Beyond Science (co-authored book) (in Japanese)
- Globalization and Environmental Destruction (in Japanese)
- Relation between Carbon Dioxide Increase and Global Warming (in Japanese)
- Study of Effectiveness of Wind Power Generation (in Japanese)
- Verification of the Theory of Carbon Dioxide as the Main Cause of Global Warming (Part 1: General Study) (in Japanese)
- Thinking about the "Reality" of Environmental Issues (book) (in Japanese)
- Enantioselective Addition of Diethylzinc to Aldehydes in the Presence of Chiral Hydrazine and Imine Ligands (in English)

Research Contents

Environmental issues have become a topic of concern among the general public, and government and enterprises have begun to endorse so-called "eco-friendly action" for the sake of the environment. But what is the "truth" of these environmental issues and measures? Surprisingly, it is no exaggeration to call this a matter of struggle for hegemony among industrialized nations in world politics and economics—or so I believe.

At the Human and Environmental Studies Laboratory, we seek to determine the essence of environmental issues and their countermeasures that are talked about so much and try to find a direction for our species to go in the future. This could reveal errors in our current environmental measures. We also hope to suggest directions that are truly and scientifically correct. This would be for the benefit of people in weak positions around the world but also for all those creatures that do not have a voice.

Keywords

- Essence of environmental issues
Research Topics

<1> New energy systems for environmental restoration and conservation in Lake Biwa and the surrounding areas

<2> "Hydrogen energy systems" and the "ammonia economy"

<3> Creating new functional materials
   - Creating functional rare earth-transition metal alloy films
   - Forming carbon films by electrochemical processes
   - Producing functional micropowders by plasma induced electrolysis

<4> High efficiency conversion of thermal energy to electric energy

Research Contents

<1> New energy systems for environmental restoration and conservation in Lake Biwa and the surrounding areas

In response to the desire for "hydrogen energy systems" as eco-friendly energy systems, there has been development of methods for producing, shipping/storing and using hydrogen effectively. The electrolysis of water is an outstanding method of producing hydrogen, in part because it can use solar and other renewable forms of energy. The superiority of the water electrolysis process is further enhanced by the effective utilization of the oxygen produced from the anode. From this standpoint, we are conducting basic research on the water electrolysis process that can be kill-two-birds-with-one-stone solution, namely directly electrolyzing water from Lake Biwa at the bottom of the lake to get hydrogen with the cathode while simultaneously using the oxygen evolved from the anode to prevent oxygen deficiency in Lake Biwa. Research is also proceeding on processes for effective utilization of the hydrogen produced from the cathode.

<2> "Hydrogen energy systems" and the "ammonia economy"

To achieve a hydrogen energy system, it will be necessary to establish the basic technology to use "ammonia" as a key material for the storage, transport and use of hydrogen. On the other hand, ammonia is used not only in fertilizer and chemicals, but also increasingly in applications as a reducing agent of NOXs and heat transfer medium. If ammonia can be positioned as a key material of a cooperative system for both industrial application and hydrogen energy system, it is possible to built "ammonia economy" as a new economic system. To turn this idea into reality, we have proposed a new method-"electrolytic synthesis of ammonia under atmospheric pressure," which is simple, has low energy cost and can be used in place of the conventional Haber-Bosch process, and we are proceeding with the research and development of this method.

<3> Creating new functional materials

We have proposed a novel method of creating a wide variety of new functional materials, including "rare earth-transition metal alloy films," "carbon films," "nano-powders" and so on, with an electrochemical process using molten salt as a reaction medium, and have proven the possibility of such a method. An overview is given of a few examples below.

Creating functional rare earth-transition metal alloy films

When nickel or cobalt are used as cathodes and cathodically polarized in molten salt containing rare earth ions, various rare earth-transition metal alloy films are formed on the cathodes. In addition, when the obtained films are used as anodes and anodically
polarized in molten salt, the morphologies and compositions of the obtain film can be precisely controlled by electrolysis conditions (applied potentials, current densities, molten salt compositions, etc). By using this method, it is possible to obtain the desirable composition and porosity of the alloy films. The lab is working to create various types of alloy films with the goal of expanding applications of this technique to magnetic, electrode and catalytic materials and microreactors.

**Forming carbon films by electrochemical processes**

When copper or aluminum are used as cathodes and cathodically polarized in molten salt containing carbonates, various carbon films are formed on the cathode surface. The structure of this film is controlled by electrolysis conditions such as substrate materials, applied potentials, current densities and so on. Our research is trying to understand more quantitatively the relationship between the conditions of electrolysis and the structures of the obtained carbon films, and is furthermore seeking out the optimal conditions for getting carbon films suited to individual applications, such as electric double layer capacitors, batteries and moreover catalysts. We are also working on the electrochemical formation of carbonaceous composite films with the objective of achieving new functions.

**Producing functional powders by plasma induced electrolysis**

Molten salts containing metal ions are used as electrolytes for plasma induced electrolysis. When a voltage of DC 200 V is applied between the anode and the cathode whose tip is positioned above the bath surface, a plasma is induced between the cathode and the melt under 1 atm of Ar to produce the corresponding metallic powders in the melt. Once the atmosphere is turned to plasma, the electric current can flow continuously even with just some tens of volts, so that the microparticles are produced continuously. Using this principle, functional micro- or nano-particles of various metals and compounds are possible to produce, which are suited to individual applications like magnetic recording media, photocatalysts, pigments, battery electrodes, electrochemical capacitors, catalysts and so on.

<4> "Hydrogen energy systems" and the "ammonia economy"

The development of a process for high efficiency conversion of thermal energy to electric energy is a much desired goal. One energy conversion device that could potentially fulfill this need is a "thermally regenerative fuel cell," which combines fuel cell electricity generation with a pyrolysis process of reaction products. Thermodynamic calculations have been shown that the energy conversion efficiency of a "lithium-hydrogen thermally regenerative fuel cell" using molten salt as an electrolyte would be increased by lowering the operating temperature of fuel cell and elevating that of pyrolysis reactions. Also, when attempting to achieve this, it will be necessary to develop metal film electrodes with excellent permeability to hydrogen atoms and corrosion resistance to hot molten salt and liquid metal lithium. While keeping mindful of these various factors, the laboratory is exploring and developing low-temperature molten salts and working to develop composite metal film electrodes with both hydrogen permeability and corrosion resistance.

The laboratory is pursuing research and development to make these technical seeds fit for practical use. At the same time, academic research is being continuously conducted on chemical and electrochemical reactions with molten salt with the aim of discovering new reactions leading to the creation of advanced techniques for new materials and new energy processes.

**Keywords**

- New energy
- Energy chemistry
- Environmental electrochemistry
Major Research Topics

<1> Rechargeable metal hydride - air batteries

<2> Smart anodes for electrowinning, electroplating, water electrolysis, and waste water treatment water

<3> Highly sensitive and selective biosensors using intelligent electrodes

Research Contents

<1> Rechargeable Metal Hydride - Air Batteries

A zinc-air battery is well known as a commercially available metal-air battery, which is used for a power supply of hearing aid and has some attractive properties such as no limitation on the capacity of the positive electrode and a high theoretical energy density, since the active mass of the positive electrode is oxygen in air. However, commercially available metal-air batteries are limited to be a primary zinc-air battery, and no rechargeable metal-air battery has been developed, except mechanically rechargeable zinc-air batteries, although many efforts have been done to realize a secondary metal-air battery. One of the reasons is a difficulty to develop a bi-functional air electrode enabling oxygen reduction and evolution reversibly. For example, the air electrode of a zinc-air primary battery consists of catalyst/carbon mixed material, and carbon is consumed when the battery is recharged due to generation of carbon dioxide.

On the other hand, we have developed a new bi-functional air electrode consisting of nickel, PTFE, and pyrochlore-type oxide, Bi₂Ir₂O₇-z, and have demonstrated that the air electrode has a good reversibility for oxygen reactions and a high durability for charge-discharge cycles up to 2000 cycles. We have been also trying to develop a new class of secondary air battery with the bi-functional air electrode and focusing on hydrogen storage alloys as the negative material in combination with an alkaline electrolyte, as shown in Fig. 1.

![Fig. 1 Configuration of MH-air secondary battery](image)

This secondary air battery is expressed as an MH-air battery, which has a cell configuration analogue to Ni-MH battery where the nickel oxide electrode is replaced with the air electrode. The reactions of this battery are expressed as follows (→ discharge, ← charge):

Positive electrode: O₂ + 2 H₂O + 4 e → 4 OH–

Negative electrode: 4 MH + 4 OH– → 4 M + 4 H₂O + 4e

Total reaction: O₂ + 4 MH → 4 M + 2 H₂O
The battery has a high theoretical energy density more than 1,000 Wh/kg, and the EMF is 1.22 V. Our recent studies have been demonstrating that the current efficiency and the utilization of MH are higher than 90% and the projected energy density is more than 400 Wh/L. A good cycling performance has also confirmed. The battery is expected as a promising candidate for use in electric and hybrid vehicles, solar and wind power storages, and power supply to mobile devices.

<2>Smart anodes for electrowinning, electroplating, water electrolysis, and waste water treatment

Industrial electrolysis including electrowinning and electroplating of metals, water electrolysis, waste water treatment and etc. consumes a large amount of electric power, and the energy consumption depends on the voltage of the electrolytic cell, in which the electrolyte is usually an aqueous solution and the anode's reaction is oxygen or chlorine evolution. A low potential anode is much important for energy saving of industrial electrolysis, and our developing smart anode can promote the anode's reaction and reduce oxygen or chlorine evolution potentials. The anode consists of a mixture of IrO2 and Ta2O5 formed on a titanium substrate, which is prepared by thermal decomposition of a precursor solution. The anode is similar to those known as DSA, but is quite different from commercially available DSA, because IrO2 in the coating is amorphous. We have been revealing that amorphous IrO2-Ta2O5/Ti anodes has lower potential for oxygen or chlorine evolution than commercially available DSA or lead alloy anodes; for example, the amorphous oxide anode can reduce oxygen evolution potential by 0.55 V for zinc electrowinning compared to the lead alloy anode, which corresponds to 18% energy saving. In addition, the amorphous oxide anode prevent some unwanted side reaction simultaneously occurring oxygen or chlorine evolution such as MnOOH deposition in zinc or copper electrowinning, PbO2 deposition in zinc or copper electrowinning and in copper foil production, and CoOOH deposition in cobalt electrowinning. The prevention of such unwanted side reactions is valuable to prolong the anode's lifetime, eliminate the maintenance of the anode to remove the oxide deposits from the anode's surface, and suppress the contamination of minor components in the cathode's product. Therefore, our developing anode is a smart anode which can distinguish the wanted and unwanted reactions from each other.

<3>Highly sensitive and selective biosensors using intelligent electrodes

Compositional analysis of blood and urine is critical to illness diagnosis and health management, and electrochemical biosensors are one of the tools that can be used for such analysis. These operate by quantifying components from electric current values when oxidizing or reducing the intended component with an electrode. Compared to other methods that use chemical reactions or optical absorption measurements, biosensors offer greater sensitivity and more compactness of equipment. Blood and urine, however, contain many components that resemble each other, which means that it is not so easy to detect just the intended component with an electrode. Even electrodes with a high sensitivity to a certain component do not function sufficiently as sensors unless there is a large gap between that sensitivity and the sensitivity to interfering components. Besides, to make a biosensor respond only to a certain component is important not only for sensitivity but also for controlling deterioration of the electrode over time. "Intelligent electrodes" with the function to distinguish responses have demonstrated the ability to meet these requirements of biosensors. Presently our laboratory is developing intelligent electrodes intended to be applied to various biosensors, including glucose sensors.

Keywords
- Rechargeable MH-air batteries
- Smart Anodes
- Industrial electrolysis
- Biosensors
- Energy Saving
Research Topics

<1> Spectra and Green's function properties of differential operators, with a focus on Schrodinger operators (particularly non-self-adjoint operators) and Sturm-Liouville operators

<2> Asymptotic behavior of solutions of Lotka-Volterra and other equations

Research Contents

At our laboratory, we are researching differential equations particularly by applying functional analysis. Many problems that appear in physics and engineering can be solved using mathematics. A large number of these problems can also be solved using calculus. For example, Newton used calculus to solve problems in differential equations to demonstrate Kepler's law, that is, "the planets orbit the sun in an elliptical path with the sun at a focus." There are also many types of differential equations, and our research deals with such differential equations.

Keywords

- Differential equation
- Integral kernel
- Functional analysis
- Banach space
- Spectrum
Research Topics

At the Computational Mathematics Laboratory, the primary focus of our research is numerical analysis of differential equations. To be more precise, we are interested in the individual topics and related fields described below.

1. **Discrete-variable methods for large-scale, stiff differential equation systems**

   Time-dependent partial differential equations, including Navier-Stokes equations, can be reduced to large-scale time-marching ordinary differential equations by discretization of space variables (with finite difference or finite element methods, etc.). These large-scale systems actually exhibit stiffness, and numerical solutions are difficult to find for many of them. For stiff systems we are studying the feasibility of parallelism for Rosenbrock formulas, which is equipped with an automatic generation of the Jacobian matrix of the system, as well as for Runge-Kutta formulas (described below).

2. **Parallel algorithms**

   Obtaining significant numerical results in mathematical modeling yields an enormous amount of calculations. To overcome these difficulties, an introduction of parallel computation can be a breakthrough. Manipulating implicit Runge-Kutta formulas for large-scale stiff systems can attain parallelism, and we are actually studying this performance using various supercomputers. Parallel algorithms require a fundamental look-up on basic theoretical properties such as convergence, stability and so on, and their computational complexity must be re-examined.

3. **Geometric discrete-variable methods**

   The Hamiltonian systems that often appear in the formulation of physical phenomena feature to be symplectic, that is, they preserve an intrinsic quantity called the symplectiness. The feature is also expected to be kept in discrete-variable methods, but the frequently-used numerical solutions are readily shown not to be symplectic. The fact inspires a development of new methods. This structure-preserving method is now called the geometric method. Since many symplectic methods are implicit, an in-depth study related to (2) above is also necessary.

   The figure below shows the simulation results for the motion of a vortex appearing in the analysis of fluid motion on a plane called the vortex method. The equation of motion is a special Hamiltonian system, and if the symplectic discrete-variable method is not used, it cannot be tracked for an extended period of time. We constructed discrete-variable methods with the G-symplecticness and checking their calculation results.

4. **Discrete numerical solutions of stochastic differential equations**
Phenomena that involve time-dependent probability events are mathematically formulated with stochastic differential equations, which raise many issues that must be solved in their simulation. We are studying topics such as pseudorandom number generators that simulate the standard stochastic process known as the Wiener process on a computer, convergence of the discrete-variable method and its convergence speed, and numerical stability of discrete-variable solutions.

<5> Discrete-variable solutions of delay-differential equations

Analytic solutions of delay-differential equations that appear in control engineering, population dynamics theory, and other fields present more difficulties than typical differential equations, and discrete approximation solutions are required in simulations. We are studying discrete-variable methods, particularly criteria of their numerical stability, and engaged in research on implementation issues and phenomena modeled by difference-differential equations.

Research Contents

We are currently studying computational mathematics with a focus on numerical analysis. Numerical analysis is a field of mathematical science that can be defined as "the mathematic theory of designing, analyzing, and evaluating numerical algorithms." In many aspects of science and technology, the process of mathematical modeling is repeated, which involves building a mathematical model for analyzing a certain phenomenon using the power of computers, and obtaining qualitative and quantitative data about these problems from the simulation results to open up new knowledge. Most mathematical models are expressed in terms of differential equations, but it is impossible to directly solve differential equations on a computer, and therefore solutions through discretization or approximation are necessary. Creating new algorithms enables us to solve previously unsolvable problems or solve problems thousands of times faster than before, and for this reason, numerical algorithms are critically important for model simulations.

Newton, Euler, and other prominent mathematicians in history have contributed to numerical analysis, and with the widespread use of computers today, many more problems are being challenged. Our research ranges from the foundation of this field to its real applications.

Keywords

- Numerical analysis
- Ordinary differential equation
- Mathematical modeling
- Numerical algorithm
- Parallel computation
Main Research Topics

<1> Stability of ordinary differential equations/difference equations and price-adjustment equations:

Michio Morishima (1977) performed numerical calculation of price-adjustment difference equations for price equilibrium of two commodities in order to estimate the eventual stability. Iterative calculations were performed on the relative price (%) of one commodity, and 25,000 to 30,000 were plotted. (Fig. 1)

<2> Fuzzy differential equations/optimization:

The curves of solutions for fuzzy differential equations which show ambiguous information are drawn from left to right (Fig. 2). The solution methods for bridge optimal location problems with fuzzy hourly traffic volumes (round numbers) of A, B, C, D, Ln, and Rm will solve variational inequalities (Fig. 3).

<3> Chaos/fractal analysis:

The wings of the Gumowski-Mira are the focus on research into the nature of chaos and randomness (Fig. 4)
<4> DNA computing:

The properties of the chemical reactions of four types of DNA bases are used and optimization theory is applied for devising new computing principles.

<5> Rough information image processing analysis:

Redundant information occurs when image processing data is handled in a significantly large space. The objective of this research is to develop algorithms with faster computing speeds to take advantage of the large number of zero values even though the number of computing increases.

Research Contents

The average rate of change can be calculated by taking the displacement of an object as minute changes over time. The limiting operation can be used to obtain the differential (coefficient) from the average rate of change. We are engaged in research that applies this differential concept to various fields.

The purpose of our research is analysis of the stability and chaos (complex behavior that is difficult to predict) of trajectories for ordinary differential equations where differentiation is considered on a continuous time axis and difference equations at discrete times and then applying these results. In particular, our aim is to apply these results to price stabilization analysis in economic theory.

Also, when the environment surrounding people is modeled, information analysis is needed that incorporates ambiguous meanings (fuzziness) such as "roughly, about" if objectively performing numerical analysis of subjectivity and skilled and experienced intuition.

We are also involved in the analysis of fuzzy differential equations that have ambiguity and research into the fuzzy optimization such as bridge location problems that take into account ambiguous road traffic volumes.

Keywords

- Fuzzy differential equation
- Fuzzy optimization
- Qualitative theory of ordinary differential equation
- Chaos/fractal analysis
- Price adjustment difference equation
- Optimized DNA computing
- Sparse decomposition and wavelet transformation
Research Topics

<1> Maximum likelihood decoding of two-dimensional codes using a Groebner basis
The Ikegami-Kaji algorithm that performs two-dimensional maximum likelihood decoding using a Groebner basis requires too much computational time to be of practical use. In view of this problem, in this research we consider whether a Groebner basis of the ideal necessary for maximum likelihood decoding can be derived from combinatorial properties of the codes. Such an attempt might lead to the opening of a new vista on the mathematical structure of codes and the mechanism of maximum likelihood decoding.

<2> Groebner basis and the problem of network optimization
In many cases, the problem of network optimization can be formulated as an integer programming problem. Consequently, based upon this problem, a toric ideal can be defined. We investigate the relationship between generators or Groebner bases of such toric ideal and network structures.

<3> Various problems of combinatorial optimization in bioinformatics
In the field of bioinformatics, various combinatorial optimization problems occur that are also of interest from an optimization problem perspective. By formulating such problems as integer programming problems, we study their mathematical structures.

Research Contents

Optimization refers to the process of either maximizing or minimizing an objective function under a given set of constraints. As such, it represents a typical research topic in applied mathematics. Optimization problems are of two types: a continuous optimization problem in which the treated variable takes continuous values, and a discrete optimization problem in which the variable takes discrete values. Our laboratory is principally devoted to the study of discrete optimization problems, in particular, integer programming problems, in terms of their mathematical structures and from a mathematical point of view. The keyword is either toric ideal or lattice ideal. The tools we use are the Groebner bases of an ideal in the polynomial ring. Specific discrete optimization problems that we are pursuing and that are of considerable interest include the graphical network optimization problem, the problem of maximum likelihood decoding in error correcting codes, and various combinatorial optimization problems in bioinformatics.

Keywords

- Optimization problem
- Discrete structure
- Formula manipulation
- Groebner basis
- Toric ideal
- Error correcting code
- Bioinformatics