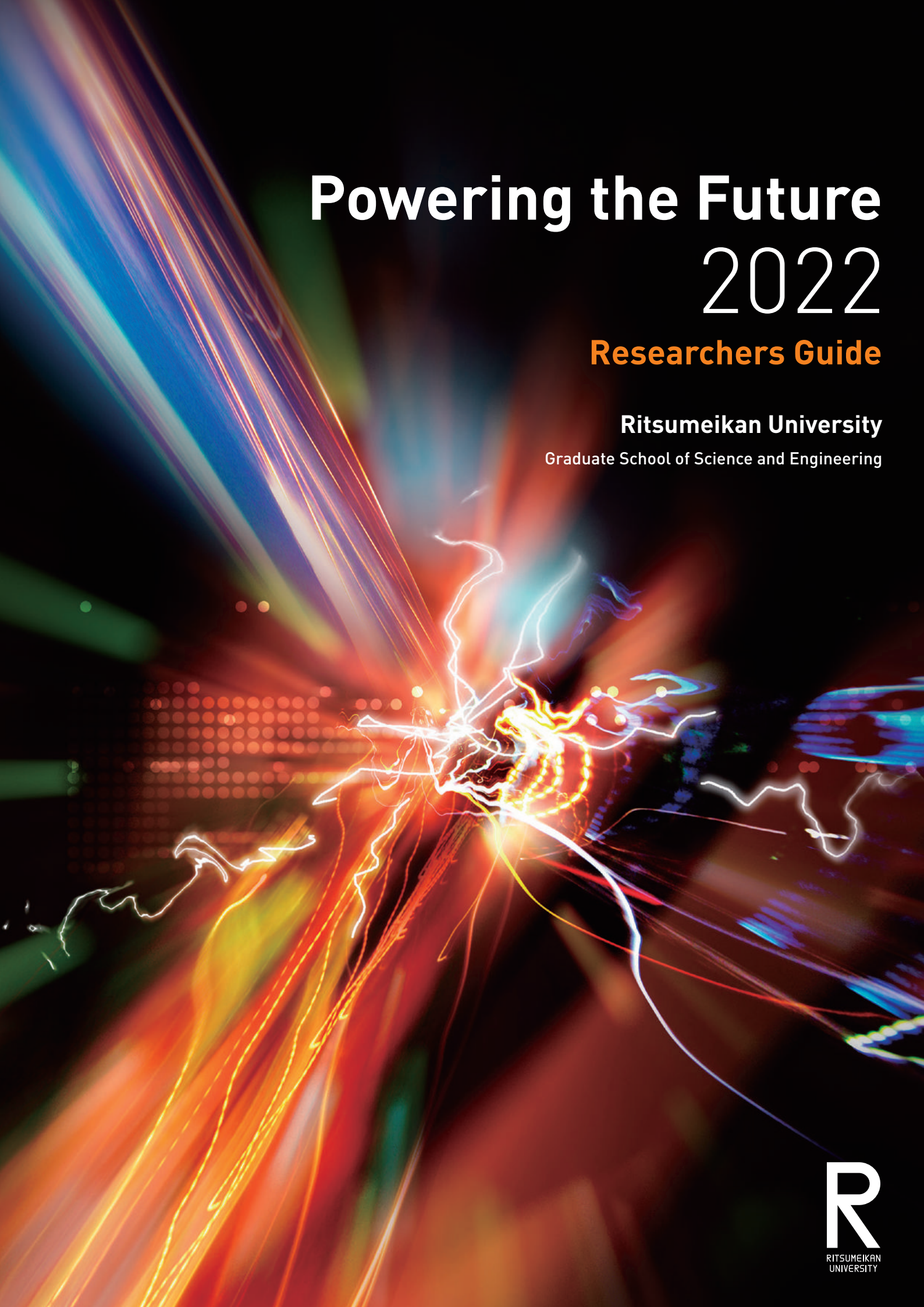


# Powering the Future 2022

## Researchers Guide

**Ritsumeikan University**

Graduate School of Science and Engineering

RITSUMEIKAN UNIVERSITY

# Message from the Dean

Shigeru TAKAYAMA, Dean

Welcome to the Graduate School of Science and Engineering, Ritsumeikan University!

The Graduate School of Science and Engineering, Ritsumeikan University is dedicated to high quality education and high-level research. We concentrate to produce the professional and innovative human and intellectual resources required in today's competitive, technological and global society. Through our education and research activities, we help people to realize a better life, to increase the quality and productivity of services and products, to decrease communication barriers and to support vibrant, knowledge-based economies.

Scientists and engineers are researchers, inventors, and innovators. They find practical solutions to real problems, tackling ever-increasing global challenges. And the requisite knowledge of math and science is but one critical component on the road to becoming the discoverer of a new device, method or technology to solve the world's complex problems.

The Graduate School of Science and Engineering, Ritsumeikan University is the best platform to challenge and inspire you to work towards the realization of a peaceful world and to raise the quality of human life. Various experiences and diversities will cultivate you into a high skilled engineer who produces and participates in the modern society. You will be expected to be an architect in the modern society based on novel technological infrastructures characterized by Internetworking, Broadband Communication, Big Data Mining, Artificial Intelligence, Large Capacity Transportation, Natural Interface, Smart Mobile and Security. The scale of modern society has been spreading from Local and National to Global, and now takes steps to towards Space. The accelerated dynamics have resulted in a connected society, and are hoped to help realize a constantly harmonized society. From this view point, also, you will be expected to be a technical solution provider of Sustainable Development Goals who realizes real international and universal harmony through global partnership.

The Graduate School of Science and Engineering, Ritsumeikan University covers four kinds of major: 1) Advanced Mathematics and Physics, 2) Advanced Electrical, Electronic and Computer Systems, 3) Advanced Mechanical Engineering and Robotics, 4) Advanced Architectural, Environmental and Civil Engineering. Many professionals, associated researchers, well trained staffs and senior students work creatively and innovatively with various kinds of original equipment and apparatus in many sophisticated facilities. They keep strong and world-wide partnerships with industries, institutes, universities, academic societies and foundations through research collaboration. Continuously, all researchers are expected to give academic presentations at international conferences and workshops to distribute their contributions world-wide. In these majors, Master and Doctoral programs are prepared according to your career path. Our students, researchers and alumni are paid close attention to so many companies and organizations in industry; engineering, construction, pharmaceutical, agriculture, finance, trade and so on. Their business style is cooperative, innovative and global.

The Graduate School of Science and Engineering, Ritsumeikan University is on a beautiful campus, Biwako-Kusatsu Campus (BKC), which is placed on a small hill near Lake Biwa in Shiga prefecture. You can find BKC around the center of the islands of Japan on a map. BKC is designed as a sophisticated university campus for education, research, sports and volunteer projects. The scale is over 600,000 meters squared. Total students number over 15,000 including foreign students from over 20 countries. It is easy to access Kyoto from BKC in just 30 minutes and Osaka in 60 minutes. You can enjoy precious experiences getting in touch with Japanese traditional culture and impressive sightseeing spots in addition to learning, studying and working at BKC.

It is our principal mission and objective to provide undergraduate and graduate students various kinds of academic and research opportunities which are truly challenging, engaging, fascinating, and reflective of the creative and innovative spirit.

It is my pleasure and privilege to push myself along with our students, faculty, research staffs, alumni, and academic friends to continue the momentum of realizing the goals and potential of the Graduate School of Science and Engineering, Ritsumeikan University and to engage with the next generation of engineering innovators at BKC.

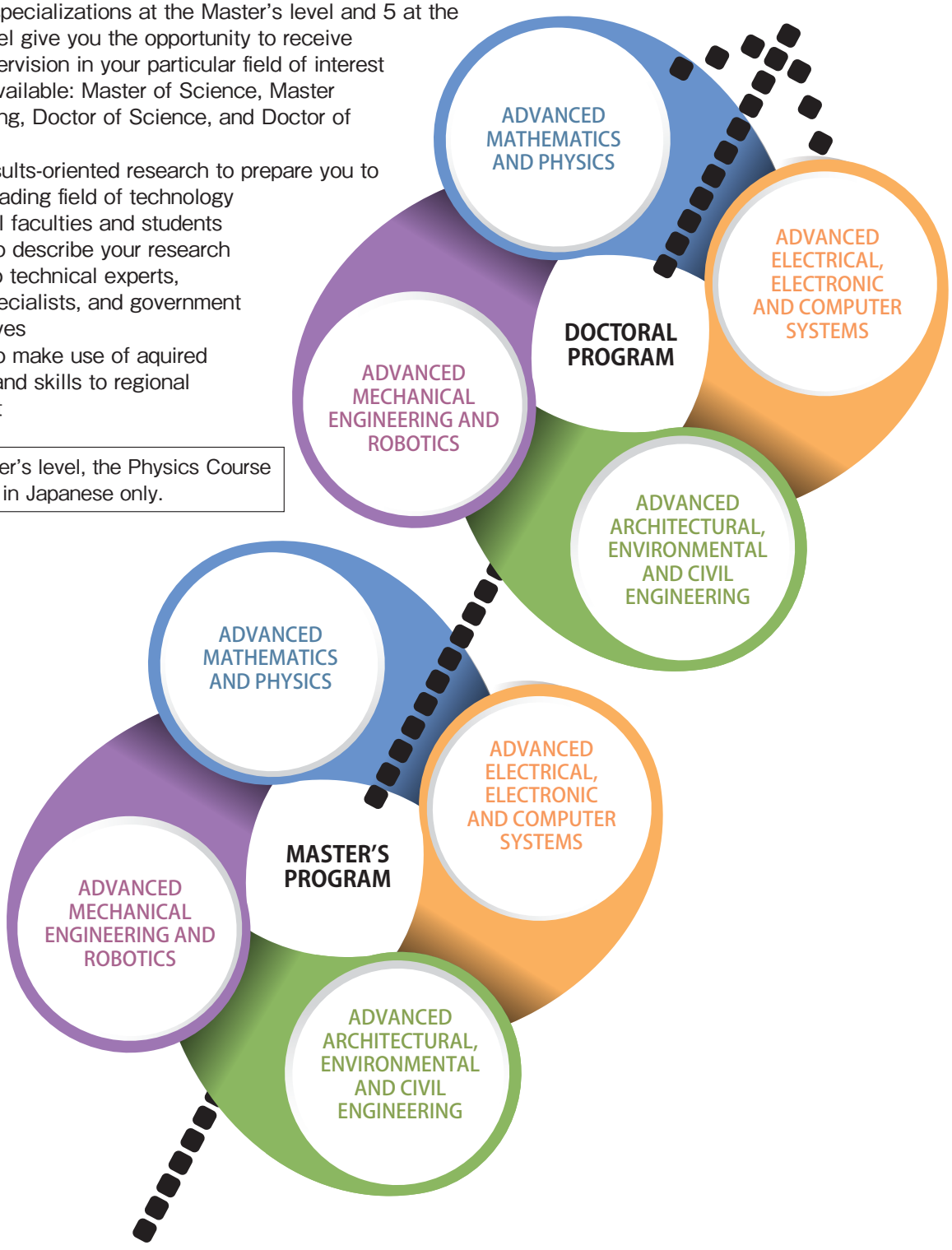
With thanks.

# Specialized Research Opportunities to Meet Your Goals

Craft your own research path under supervision in a specific field to meet your practical goals.

- All courses and research supervision in English
- 9 research specializations at the Master's level and 5 at the Doctoral level give you the opportunity to receive focused supervision in your particular field of interest
- 4 degrees available: Master of Science, Master of Engineering, Doctor of Science, and Doctor of Engineering
- Practical results-oriented research to prepare you to excel in a leading field of technology
- Multinational faculties and students
- Learn how to describe your research effectively to technical experts, industrial specialists, and government representatives
- Learn how to make use of aquired experience and skills to regional development

※ At the Master's level, the Physics Course is available in Japanese only.



# List of faculty members

# Major in Advanced Mathematics and Physics

**Master's Program** **Mathematics Course**

Mathematics and physics require an exceptionally high level of versatility in comparison to other academic fields within science and engineering. In terms of education and research, mathematics and physics continue to become essential elements of the ever expanding range of academic fields.
These areas are not limited by a scientific framework, but are highly related to all fields, including anthropology, medicine, biology, sociology and economics studies, as these various fields are interrelated and have contribute to each other's development. Examples of this phenomenon include the role that mathematical sciences has played in the fields of finance and information security, as well as the collaboration of physics and engineering fields in energy issues and nanotechnology.
**At the Master's level, Physics Course are available in Japanese only.*

**Doctoral Program**

***Mathematics Course***
The mathematics course provides advanced interdisciplinary education and research in the field of mathematics. This course aims to incorporate engineering, information studies, and other fields through the expansion of algebra, analysis, and other applied fields.

***Physics Course***
The physics course provides a wide range of education and research at an exceptionally high level in the field of physics. From theoretical physics to solid-state physics, from basic scientific fields to nanoscience, doctoral students pursue the interdisciplinary fields of physics systematically at a deep level.

# Mathematics Course

Research/Development Areas
Stochastic process and its application, financial mathematics and its application

## Professor / AKAHORI, Jiro

My interest lies in probability theory, financial mathematics and the various fields that are related to them. This involves various subjects that include abstract mathematics as well as its applications; stochastic differential equation on topological groups, quadratic Wiener functionals and infinite dimensional Lie algebras, the pricing of financial derivatives, sustainable economic growth problems, and so on. These research projects also involve a number of postgraduate students. International exchanges take active place with guests frequently visiting my laboratory from all over the world, from whom we can all learn a lot. The number of foreign students at our laboratory is also increasing while some of our students occasionally get sent to foreign universities. We also frequently have the opportunity to travel overseas to attend academic society meetings. Graduates from our laboratory often enter professions in the banking industry.

Commemorative laboratory photo

Research/Development Areas
Structure analysis of von Neumann algebras

## Associate Professor / AOI, Hisashi

As we live in a three-dimensional world the idea of "four-dimensions" can be quite challenging but it is considered quite routine in mathematics, with well developed arguments for it in place. However, contrarily enough five-dimension or six-dimension worlds appear to have been taken for granted.
My interest is in the "infinite dimensional" world that could be considered to exist at the beyond of "finite-dimensional" worlds where phenomena considered impossible in a finite-dimensional world could occur. The subject of "operator algebras" can be considered something that "acts" on this marvelous world. The study of this is classified as "analysis"; however, it is also closely related to algebra and geometry. In the real world quantum mechanics and knot theory etc are also related to it.
This field is comparatively new in mathematics and has a lot of unknown problems, thus making it a challenging research subject.

Research/Development Areas

Semi-classical Analysis of Schrödinger Equations

## Professor / FUJIIE, Setsuro

Semi-classical analysis is an asymptotic analysis where the Planck constant appearing in the Schrödinger equation is regarded as a small parameter. Under certain conditions, quantum mechanics is expected to approach classical mechanics in the semi-classical limit (Bohr's correspondence principle). The asymptotic distribution of eigenvalues or resonances created by a bound or semi-bound state, respectively, is closely related to the existence and the geometry of "trapped" trajectories of the corresponding classical dynamics.

This problem is an extension of the famous question "Can one hear the shape of the drum?" (M. Kac), which examines the relationship between the geometry of a bounded domain and the asymptotic distribution of eigenvalues of its Dirichlet Laplacian.

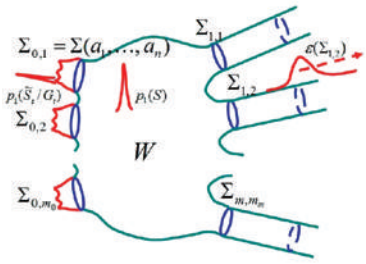
The useful WKB method consists of constructing an asymptotic power series solution globally with respect to the Planck constant. This power series diverges and the asymptotic form changes discontinuously when passing through turning points or caustics. This so-called Stokes phenomenon is a key to solve the above problem.

Research/Development Areas

Application of gauge theory to V-manifolds and its three-dimensional manifold in the same boundary

## Professor / FUKUMOTO, Yoshihiro

Homologically the same boundary groups configured with whole three-dimensional homological spheres are an important subject of research related to the unsolved expectation of triangles being divisible by high-dimensional manifolds, however, very little is known about the structure except the fact that it is a finitely generated Abelian group. My research involves homologically the same boundary invariants in seeking structures that particularly include the integer lifting of classic Rochlin invariants by applying gauge theory to V-manifolds. Gauge theory can be used to extract topology information from nonlinear partial differential equations describing the field (particle) on the manifold. I focus on the contribution made by the singular point of a V-manifold and configure the integer lift of an Ochanine invariant based on elliptic genus and unbound algebra related to the same boundary of the three-dimensional manifold and the functor in a certain type of zone with a commutative ring in order to consider the relationship between basic group, homological algebra and gauge theory more.




Application of gauge theory to topology

Research/Development Areas

Amusing number theory

## Professor / KAGAWA, Takaaki

I specialize in number theory, and recently in particular classifying elliptic curves found in real quadratic fields. The cue to why I began to be interested in number theory was a book entitled "Fermat's last theorem" that was written by my instructor Norio Adachi while I was at university (Waseda), and why I began to be interested in elliptic curves is that elliptic curve theory was used to solve Fermat's last theorem. One of the great charms of number theory is its concreteness. Quadratic fields and elliptic curves are concrete and can be easily put into practice; however, they still involve lot of unsolved problems. My aim is to quickly solve those problems, and hence I hope students can be helpful.

Research/Development Areas

Stochastic Analysis, Monte Carlo Methods, Stochastic Differential Equations

## Professor / KOHATSU-HIGA, Arturo

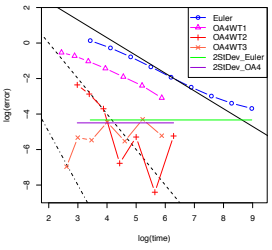
My research interests are centered on various applied and theoretical aspects of simulation for stochastic systems which evolve with time.

In particular, we are interested in stochastic equations of different types. These equations may have various applications in finance, engineering and physics. One of the challenges consists in studying their theoretical properties of these methods and obtaining efficient simulation methods. Therefore students working with me may do either theoretical studies related with these problems or simulation studies which have a strong mathematically oriented theoretical basis. We sometimes also try to test newly proposed simulation methods and find some theoretical basis to explain their behavior. The goal is to obtain fast and accurate methods that can be used in various practical problems and therefore there is a strive to achieve some generality over particularity.

Usually, students working on simulations will be proficient in C programming or other similar languages such as scilab, octave, R or python. On the theoretical side, we request basic knowledge and interest in either probability theory, stochastic process or Monte Carlo methods.

Our students, usually interact with the group of mathematical finance where they can also experience the direct feeling of applications to real problems. Therefore our group is very active, we encourage discussions between students, visitors and professors. We have frequent seminars, many times given by visitors from various countries and backgrounds therefore achieving a high scientific interaction which promotes learning and the spread of information.

We also encourage communication in foreign languages due to the multi-culturality of our group.



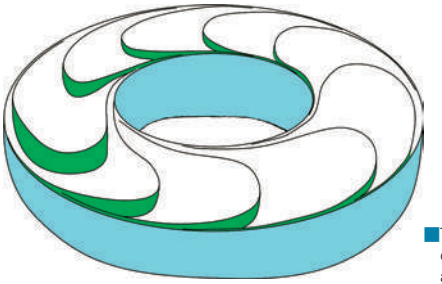

This graph shows the performance of various approximations schemes. The so-called Euler scheme is the traditional method. The other methods are the ones proposed by our team. The higher the slope the more accurate the method is.

Research/Development Areas

Differential topology, Foliation theory

## Associate Professor / NOZAWA, Hiraku

A river can be regarded as a bundle of flow lines. Foliations are abstract generalization of such geometric structures. Namely, a foliation on a space is a decomposition of the space into spaces of smaller dimension. I am interested in the geometry and topology of foliations. They have been studied in these 50 years originally motivated by the research on partial differential equations and dynamics on 2-dimensional spaces. The relation of foliation theory to 3-manifolds, group actions and differential geometry is also actively studied. I am investigating global geometric properties of foliations from the viewpoint of cohomology and characteristic classes. The goal of my recent research is to understand mysterious phenomena on foliations called “rigidity”, which means that certain special foliations with large symmetry have distinguished dynamical properties.



The picture of a section of the Reeb foliation on a donut-like space.

Research/Development Areas

Operator Algebras and Operator Theory

## Professor / OSAKA, Hiroyuki

Functional analysis which is the abstraction of mathematical models for use in revealing their essence is the main subject of this laboratory; however, recently, various graduate level research that includes mathematical physics, braid theory, topology, partial differential equations and probability theory are also taking place. We are also working on graduate level research linked to educational material for use in for junior high and high school education.

Operator algebras, which is known as “an infinite dimensional linear algebra”, is the research subject. Banach space theory was introduced by Stefan Banach and developed as an extension of a function space on a compact metric space. In particular, we are working on the classification problem of C*-algebras generated by inserting an algebraic structure within them.

Recently we have also been working on a problem connected to a monotonically increasing function that is applicable in economic theory and achieving a new result for Jensen’s inequality, which is a generalization of the arithmetic and geometric means that are presumably so familiar to high school students.

$$\varphi\left(\frac{\sum a_i x_i}{\sum a_i}\right) \leq \frac{\sum a_i \varphi(x_i)}{\sum a_i} \quad i = 1, 2, a_i = 1, x_i > 0, \varphi(x) = -\log(x)$$

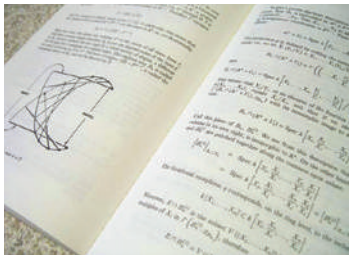
Both the arithmetic and geometric means can be derived using the above expression. Have a go at calculating them!!

Research/Development Areas

Algebraic geometry

## Professor / TAKAYAMA, Yukihide

Dr Takayama’s main research interest is algebraic geometry in positive characteristic, which covers many interesting phenomena that are quite different from the phenomena covered by algebraic geometry in characteristic zero such as complex algebraic geometry and complex differential geometry. For example, Kodaira vanishing theorem and Bertini’s theorem of hypersurface intersection play important roles in complex algebraic geometry. However, these theorems do not generally hold in positive characteristic. In addition, we do not yet know how Hironaka’s theorem of resolution of singularities, which is also a fundamental result in complex algebraic geometry, holds in positive characteristic. This means that geometry in positive characteristic is much more complex or in a way richer than complex algebraic geometry and presents many interesting research problems. Dr. Takayama’s approach to this field involves the use of commutative ring theory and methods generally employed in algebraic geometry in characteristic zero.



Text used in seminars. Research on higher dimensional geometry that fully utilizes advanced algebra.

Research/Development Areas

Theory of integrable systems, geometric mechanics, dynamical systems theory, and related geometries

## Associate Professor / TARAMA, Daisuke

The researches of Daisuke Tarama focus on dynamical systems, geometric mechanics, and related geometries, such as differential geometry, particularly symplectic geometry and Poisson geometry, as well as algebraic and complex analytic geometry.

Daisuke Tarama has mainly been studying the finite-dimensional integrable systems, particularly (generalized) free rigid body dynamics, or equivalently the integrable geodesic flows on Lie groups with respect to a left-invariant metric of a large class. Through the symmetry and the singularities of the systems, one sees their interesting aspects in relation to not only dynamical systems theory and Lie theory, but also such different mathematical disciplines as symplectic geometry, Poisson geometry, and, algebraic and complex analytic geometry, as well as mathematical analysis of differential operators, when one considers corresponding quantum systems. For such finite-dimensional integrable systems, he has investigated the dynamical behavior around the equilibria (singularities), the analysis of (quantum) differential operators with Lie group symmetry, and the associated algebraic varieties, such as elliptic fibrations and K3 surfaces.

Daisuke Tarama also aims at expanding his research scope towards applied mathematics and physics in symmetry and singularities, trying to carrying out geometrical and globally analytical studies on wider phenomena in such areas as natural sciences, data science, and engineering.

Research/Development Areas

Linear differential equations in complex domains/singular perturbation, spectrum, Stokes phenomenon

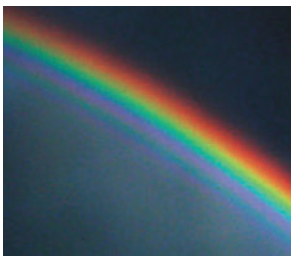
## Associate Professor / WATANABE, Takuya

The subject of our research is to study the spectra (eigenvalues, quantum resonances etc) which relate the quantum mechanics and the classical mechanics. Differential equations which describe typical phenomena have beautiful structures in a mathematical sense. Hence the basic methods in analysis (complex analysis, functional analysis and Fourier analysis) play important roles for problems in Mathematical Physics.

The students of our laboratory learn deeply such basic techniques selected according to their interests.

Recently we investigate differential equations including a small parameter (singular perturbation). Its keyword is “Stokes phenomenon”. In order to understand it, we have to treat the differential equations in the complex domain.

This fact implies that studying natural phenomena require the advanced mathematical technique and interests us in Mathematical Physics.



A supernumerary bow can sometimes be seen inside rainbows.
This is explained by “Stokes phenomenon” of an Airy’s differential equation.

Research/Development Areas

Probability theory and numerical analysis

## Associate Professor / YASUTOMI, Kenji

The study of modern probability theory.

If the “result” that can be obtained is limited (two sides of a coin toss or the throw of a dice etc) the probability of each “result” primarily considered, however, the obtainable “result” will be non-countable and unlimited, in that the probability of each “result” in the limited case results in a contrariety, even if a value could be set for the probability.

Modern probability theory resolves this dilemma by abstracting the concept and measuring the size, thus enabling probability that is non-countable and has unlimited “results” to be considered. However, that abstraction does result in a new dilemma: the existence of an assembly for which the size cannot be measured.

As revealed above probability theory is an interesting research subject. It is also an interesting mathematical field that has the aspect of being actually applicable in various parts in society by being linked to statistical methods.

Mathematics can be pondered anywhere there is a blackboard and chalk or paper and pencil.

# Physics Course



Research/Development Areas

Structure formation and dynamics of soft matter

## Professor / FUKAO, Koji

Soft matter involves systems with original structures and dynamics of the medium scale between macro scale and micro scale that have hierarchical structures in the rich time space of micro to macro. For example, macromolecules, colloids, liquid crystal, emulsions, and powders etc are all soft matter. Research on each of the type matters has been conducted for some time now, however, in recent years attempts are being made to collectively describe them as soft matter in understanding their physical phenomenon. We are promoting research with an interest in glass transformations, structural formations resulting from crystallization, glass dynamics, dewetting phenomenon, and the dynamics of ionic liquids etc of the macromolecules involved in the phenomenon.

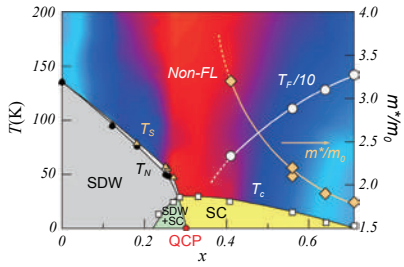
Impedance analyzer used in a dielectric relaxation spectroscopy method that enables dynamics measurements in wide time areas.

Research/Development Areas

Search for high-temperature superconductors and novel quantum phases

## Professor / IKEDA, Hiroaki

In the technological development, designing innovative materials is crucially important. However, it remains difficult to design desirable materials from purely theoretical prediction. This is because complex physical systems may exhibit behavior that cannot be understood only in terms of the laws governing their microscopic constituents, as indicated by P.W. Anderson. For example, superconductivity is a phenomenon that shows quantum-mechanical effects on a macroscopic scale. Here we need its own fundamental principles, largely different from the laws governing individual electrons. In our group, we work on clarifying curious physical properties in some topical magnetic/superconducting materials based on the electronic structures, and constructing new theoretical concepts. In addition, we aim to make predictions of novel properties and new quantum phases, and design new high-temperature superconductors from the long-term perspective.




Phase diagram in the iron-based superconductor $BaFe_2(As_{1-x}P_x)_2$, discovered in 2008 (K.Hashimoto et al. Science 336, 1554 (2012)). Superconducting phase(SC) appears in close proximity to the spin-density wave phase (SDW). QCP indicates a quantum critical point.

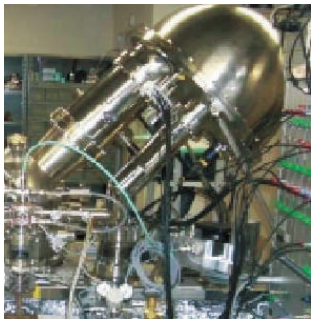
Research/Development Areas

Electron spectroscopy and elucidation of materials physics related to electron spin

## Professor / IMADA, Shin

Characteristics of a material are decided often by the characteristics of electrons in that material. For example, glass is transparent because electrons in glass do not absorb light. Electrons revolve around the nucleus as they rotate themselves. The latter rotation is called “spin”. The reason why iron becomes a magnet is that electrons in iron tend to have spin with the same direction. Electron spin causes many other interesting phenomena. For example, some metal becomes an insulator when its temperature is changed. The goal of our research is to elucidate the mechanisms of such phenomena related to electron spin.

In order to unveil the electronic states in materials, we perform experiments both at the campus and facilities such as SPring-8. Main experiment is “photoemission,” which measures the energy of electrons emitted from a material under application of ultraviolet light or x-ray.



High-resolution photoemission apparatus, which precisely measures electrons escaping from a sample.

Research/Development Areas

Earthquake source physics and seismic wave propagation

## Professor / KAWAKATA, Hironori

Earthquakes are awful phenomena that may cause terrible damage to our infrastructures. On the other hand, however, plain fields and basins have been formed owing to faulting associated with earthquakes. Also, active faults provide us ground water. Beautiful nature in Japan has been partly made by activities of the earth such as earthquakes. Since we are living in Japan, where a lot of large earthquakes occur, we must survive earthquakes in exchange for great natural benefits. Then, it is essential to understand earthquakes and active faults.

When, where, how large and how do earthquakes occur? Are the earthquake sizes determined in advance? How do rocks in the earth behave when seismic waves pass through? In our laboratory, we are approaching to such fundamental problems on earthquake physics and seismic wave propagation by means of laboratory experiments, field observations and seismic waveform analyses.

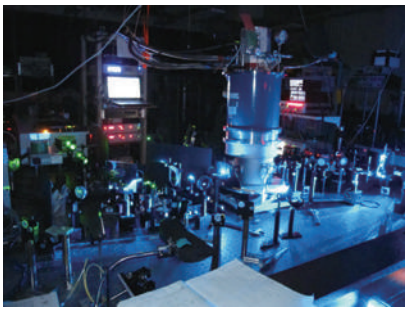
Granite sample on the way to fault formation. White part is a fault trace that will be a final rupture plane.

Research/Development Areas

## High-precision laser spectroscopy on the elementary excitations in dielectrics/ ferroelectrics

### Professor / KOREEDA, Akitoshi

In dielectrics, most of the energy is transferred by the motion of the atoms, or by the “phonons”, the quanta of the sound wave in matters. The phonons play important roles in ferroelectricity and in the thermal dynamics in dielectrics. In particular, some ferroelectric crystals allow the heat to become a “wave”, rather than to allow it only to diffuse as we experience usually. We use ultrafast laser sources to excite a “coherent wave of heat” in certain ferroelectric crystals. We also use an ultra-high (kHz) resolution stimulated Brillouin spectrometer to unveil the phonon linewidth in crystals and glass-forming materials at cryogenic temperatures. The high-resolution spontaneous Brillouin light scattering method is used, for example, to investigate the “fractal dynamics” in ferroelectric single crystals.



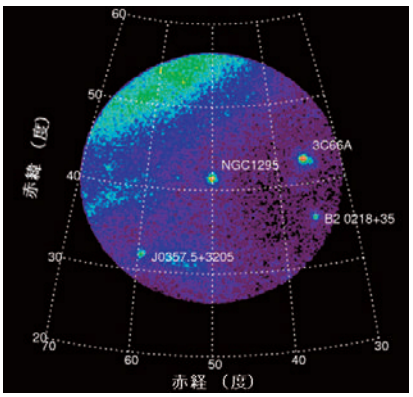
The optical system that excites the coherent wave of heat, and an optical cryostat for 0.3K spectroscopy.

Research/Development Areas

## Particle acceleration in the Universe, Origin of cosmic rays

### Professor / MORI, Masaki

We are exploring the high-energy Universe, which cannot be seen in optical light, with gamma-rays. Gamma-rays are emitted from high-energy objects in the Universe, such as supernova remnants, pulsars and pulsar nebulae, and active galactic nuclei. Electrons and protons are accelerated to high energies in these objects and produce gamma-rays via interaction with surrounding radiation and matter. Gamma-rays are the best probe of particle acceleration in the Universe since they travel straight and are not deflected by magnetic fields. In addition, the annihilation of dark matter particles could be detected by gamma-rays. Also we are operating a 60cm optical telescope in the BKC campus to explore time-varying astrophysical objects.



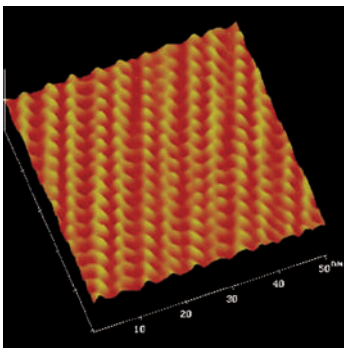

Gamma-ray intensity map around the Perseus cluster of galaxies observed by the Fermi Gamma-ray Space Telescope

Research/Development Areas

## Phase transitions and interface phenomenon in the mesoscopic region

### Professor / NAKADA, Toshitaka

Science in recent years has been clarifying a lot of enigmas, from the micro world that includes subnuclear particles to the macro world that includes cosmic space. However, in the medium that links micro to macro, or nanometer world (a few to several hundred arranged atoms or molecules) there is a lot of interesting phenomenon whose mechanisms have yet to have been clarified. At our laboratory we focus on how atoms and molecules gather together, break up or react in various materials, regardless of being organic and inorganic, or more concretely the phase transformation process and interface phenomenon. For example, we target metallic quantum dots created on semiconductors, ultra-thin films created using a single organic molecule layer, and the crystals of proteins etc. We research changes in atomic/ molecular alignment using the latest microscopes and analyzers by creating the materials ourselves.




Microscopic photograph of protein crystal. Molecules have a regular arrangement.

Research/Development Areas

## Hypocenter-proximate monitoring to mitigate seismic risk

### Professor / OGASAWARA, Hiroshi

During 2009-2015 I chaired a project “observational studies in South African mines to mitigate seismic risk” in a JST-JICA program for or Science And Technology REsearch Partnership for Sustainable Development (SATREPS). Having been appointed as a dedicated research professor, I spent lots of time in South Africa to monitor earthquakes (2>M) at the closest proximity at depths from 1km to 3.4km from the surface. These can be attempted only at South African gold mines in the world. Since 2016 International Continental Scientific Drilling program with UNESCO as a liaison member has funded our research to collaborate with researchers not only from South Africa but also from US, Germany, Switzerland, Israel, India, and Australia. Ongoing drilling is to intersect the M5.5 aftershock zone in 2018.
We couldn’t foresee the 2011 M9.0 earthquake (Tohoku earthquake). We try our best to demonstrate how seismology can contribute to mitigate seismic risk in South Africa.

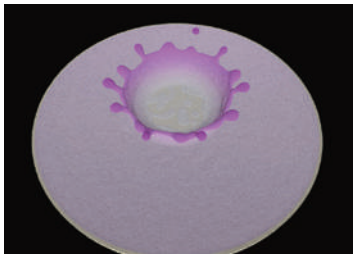
A shaft tower of the Mponeng mine of largest gold production in South Africa.

Research/Development Areas

## Numerical Studies for Understanding Chaotic Motion of Atoms in a Nanoparticle

### Professor / SHIMIZU, Yasushi

Every physical system is constantly changing its state both at a microscopic and a macroscopic scale.
In particular, nonlinearity in a dynamical rule often brings a highly complicated behavior to the system. In fact, during the time evolution of the nano-sized system, one can experimentally and numerically find a wide variety of individual and collective motion which seems to be originated from nonlinearity in the evolution rule.
For example, Au nanoparticles are known to change their shape continuously even below melting point. Such an isomerization process is a typical case where the large fluctuation dominated by nonlinearity in dynamics plays a primary role for the transition as a whole.
The main interest of our research group is to understand a complicated motion of the constituent atoms and molecules from the viewpoint of dynamical systems theory with the help of numerical simulation.
One of our goals is to give a firm theoretical basis for the understandings of microscopic mechanisms behind the complicate behaviors which can be experimentally observed in various phenomena.



A particle simulation of the so-called milk-crown phenomenon (by N. Fukada) : A visualization often gives a physical intuition for the understanding of the complicated behaviors.

Research/Development Areas

## Superstring theory and unification theory of elementary particles

### Professor / SUGAWARA, Yuji

Elementary particle theory could be a field of science aiming at a unified description of elementary particles, which are the source of all matter and interactions, also searching for an answer to a fundamental question: 'how did our universe begin?'.
Establishing the unification theory for elementary particles is the long-held dream of theoretical physicists, however, the journey until completion remains long. Superstring theory has been expected to be the most hopeful candidate of unification theory including the quantum gravity, which is still incomplete. Therefore, Superstring theory has been actively researched as a cutting-edge area in theoretical physics all around the world.
At this laboratory, we are researching elementary particle physics, mainly focusing on Superstring theory, as well as deeply related topics in cosmology and the physics of black holes.

Laboratory seminar scene

Research/Development Areas

## Synchrotron-radiation excitation physics

### Professor / TAKIZAWA, Masaru

We are exploring functional materials through atomic-orbital-controlled excitation by synchrotron radiation (SR) in the SR Center.
SR is very powerful light ranging from infrared light to ultraviolet light to x-ray. At the SR center in this campus, we easily access this useful light. Selecting an appropriate light through a beam line from SR, an element-specific excitation is realized, such as C, N, O in organic materials, Si in semiconductors, Mn, Fe, Co, Ni in magnetic devices, and so on. So, we can obtain the information of the element we want to know in the functional materials.

In addition, a polarization of SR light leads to an atomic-orbital-specific excitation. This enables us to know the orientation of the functional atomic-orbital.

Synchrotron radiation source (red building) and beam lines in the SR Center

Research/Development Areas

## Biological and Nonequilibrium Physics

### Professor / WADA, Hirofumi

Our group focuses on understanding mechanisms underlying different forms and motions found in the natural world (including our daily life), with much emphasis on microbiology, plants, and other biological systems. Our research is mainly theoretical, and different physical approaches such as nonequilibrium physics, continuum mechanics of fluids and solids, softmatter physics, and pattern fomation dynamics, are all employed to understand biological systems and other macroscopic natural phenomena. Our research style finds a particular importance on a close link with experimental results, so we often work together with physical and biological experimetalists in other groups.

A unique structure in a twisted string or rubber band, called "plectoneme", encompasses the mechanics ranging from a telephone cable to morphologies of microorganisms to supercoiled DNAs in living cells.

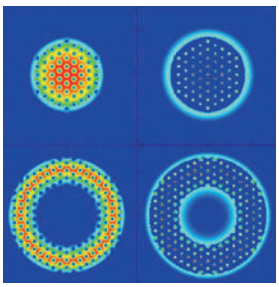
Research/Development Areas

Quantum field theory from micro to macro

## Professor / YABU, Hiroyuki

Anywhere a physical quantity corresponds to a point of space such as an electric field or magnetic field is referred to as a field, and the motion described using quantum field theory. The theory is a basic way of understanding nature, from the micro world that includes nuclei, subnuclear particles and atomic molecules through to the macro world that includes the mechanism of the universe. Field theory is a basic method used in thinking about the symmetry of the natural world, and can reveal the beauty behind it.

It can also suddenly appear in the macro world through phenomenon such as superfluidity and superconductivity. At this laboratory the problem of symmetry in the world of subnuclear particles and nuclei and a new quantum state of matter such as the Bose condensation state of atomic gases are theoretically worked on using field theory and with basic research on application in new technology such as gamma lasers.



The vortex lattice (theoretical calculation) created by a number of quantum vortexes in a Bose-Fermi mixed condensate. The left one is the vortex of the Bose particle condensate and right one the Fermi particle trapped by the core of the vortex. In the below figure a huge vortex (Giant Vortex) has formed in the center.

# Major in Advanced Electrical, Electronic and Computer Systems

**Master's Program** **Electrical, Electronic and Computer Systems Course**

Modern electrical engineering plays a significant role in everyday life, as exemplified by society's dependence on devices and technologies such as satellite communications, broadcasting, medical systems, electricity, traffic systems, energy conversion technology, computers, A/V systems, and mobile phones. The proliferation of solar energy generation and the use of laser optics in high-speed communications, optical recording, and optical input/output demonstrate the increased relationship between electrical and optical engineering, as well. This program allows students to deepen their knowledge in these fields and apply their research to meet society's increasing demand for, the development of high-performance and large-scale electrical/information systems for use in automobiles, home information appliances, communications, micro miniature medical devices, and other technologies that cannot be realized solely with software.

**Doctoral Program**

The Doctoral Program in Advanced Electrical, Electronic and Computer Systems provides advanced interdisciplinary education and research in electronic and electrical engineering fields. Students gain advanced systematic knowledge of a wide range of fields, from applied systems, device materials, and information communication, to basic and applied research on solar and laser optics as well as information engineering.



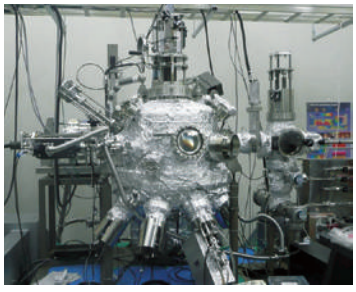
## Electrical, Electronic and Computer Systems Course (Electrical and Electronic Engineering)

Research/Development Areas

Cutting-edge semiconductor electronics for the 21st century

### Professor / ARAKI, Tsutomu

The appearance of a new semiconductor known as gallium nitride resulted in blue light emitting diodes, white light emitting diodes and the Blu-ray Disc, completely changing our lives. If we can now extract the full potential of this semiconductor we will be able to create new optical/electronic devices that will solve important problems in the 21st century, which encompass energy, the environment, health and medical care etc. For example we can expect long-life light sources with less power consumption, solar cells of extremely high conversion efficiency, highly-efficient inverters that will support battery car technology, small and high power UV light sources for sterilization etc. Our laboratory is promoting global cutting-edge research from the fabrication of semiconductor materials through to evaluating their properties of and creating devices while obtaining support from the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Economy, Trade and Industry in order to realize semiconductor electronics that suit the 21st century.



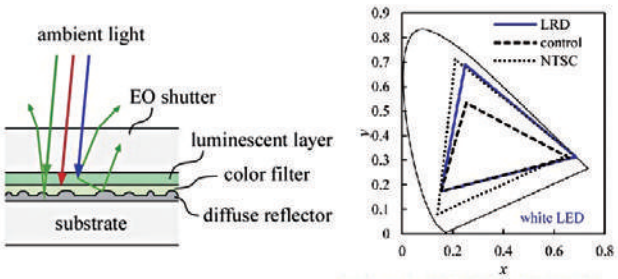
■Molecular beam epitaxy equipment for fabricating semiconductor materials being controlled at the atomic level.

Research/Development Areas

Electronic and photonic devices and their applications for image information systems

### Professor / FUJIEDA, Ichiro

Visualizing the invisible leads to discoveries and propels our understandings on nature. A beautiful picture takes our breath away. There is no need to reiterate the importance of electronic systems that handle images. Image sensors and displays are essential parts for human interfaces, contributing to the evolution of our social life of information. These devices are based on electronic and photonic materials, which also provide solid foundations for radiation detection, energy harvesting, and other important systems. This laboratory focuses on such materials, devices and systems. Our recent interests include a Luminous Reflective Display (LRD): by utilizing ambient light with luminescent materials, bright, vivid images are displayed.



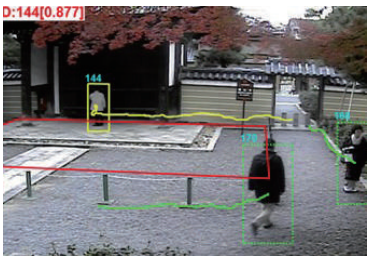

■Photoluminescence allows one to display bright and vivid images. A solar cell can be placed below luminescent layers for harvesting energy from ambient light.

Research/Development Areas

Machine intelligence for a safe and secure society

## Associate Professor / FUKUMIZU, Yohei

Information processing systems with advanced intelligence technologies such as machine learning, as well as signal processing systems based on multimedia technologies, will contribute to a safe and secure society. In this laboratory, we conduct research on informatics technology that largely utilizes the power of software while still being based on hardware processing. Our research projects include a video processing system for a street- or storefront-mounted surveillance camera that provides a cognitive ability comparable to a human, making it possible to identify suspicious behavior; a non-invasive medical diagnosis system to process the inner body sound signals acquired with high-sensitivity microphones to detect signs of lifestyle diseases such as arteriosclerosis and heart disease in everyday life; and an image quality improvement system that uses computers to sharpen camera images degraded by darkness, backlight, mist, dust, and so on.



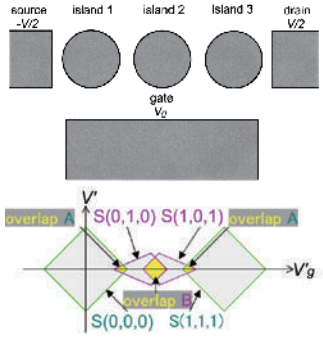

An experimental result of the intelligent camera finding the suspicious individual.

Research/Development Areas

Theoretical study on the behavior of single-electron devices

## Professor / IMAI, Shigeru

Integrated circuits (IC) that perform advanced information processing in PCs are composed of a large number of transistors that are a few dozen nanometers in size and control the transfer of electrical charge bearing information. Single-electron transistors and other single-electron devices are ultimate devices that can control transfer of individual electrons with the smallest charge by means of their property of repelling each other. Single-electron devices can treat each electron as an information carrier and dramatically improve the degree of integration while reducing the power consumption of ICs. We are carrying out theoretical research on the behavior of multi-dot single-electron devices, each of which has a single-common-gate that can be easily fabricated.



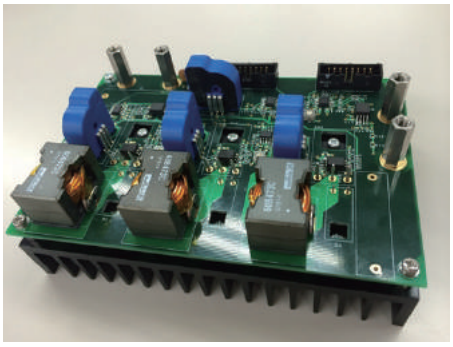

The structure of a triple-dot single-electron device with a single-common-gate (top) and its stability diagram that represents the state of electrons within the device (bottom).

Research/Development Areas

Power electronics for power system applications

## Professor / KAKIGANO, Hiroaki

Power electronics is deeply related to electric power generation, storage, supply, and usage. Therefore, it plays an important role to utilize the electrical energy efficiently. Our laboratory researches power electronics applications in power supply systems for high stability, high quality and high efficiency. The examples of the research subjects are as follows: 1. Study on dc system and its components, 2. Study on power converters to make good use of next-generation power devices, 3. Study on modular multilevel converter for HVDC transmission. Through those research activities, students enhance deep understanding of power electronics and power system engineering, who will contribute to create future renewable power society.



Interleaved dc-dc converter with SiC MOSFET

Research/Development Areas

Intelligent power electronics

## Professor / KAWABATA, Yoshitaka

Power electronics are essential in critical quality-of-life technology used in air conditioners, laundry machines, fluorescent lamps etc in addition to various industries, electrical power itself, new energy sources such as solar cells and fuel cells, and battery powered cars and trains. Power electronics concerns technology used to convert and control electric energy and ensure efficient use of it, thus contributing to solving energy and environmental problems, and hence you will be assured of having a worthwhile career after entering the workforce. In more detail we are involved in the following activities. (1) Studying the basis of electronic circuits through fabrication tests of the I/O peripheral circuits of microcomputers and electronic circuits such as drive circuits. (2) Studying the basis of real-time control while creating control software in the C-language in order to control inverters and electric motors using DSP and RISC microcomputers. (3) Studying the basis of control while establishing a system using the famous software of MATLAB and SIMULINK.

The study of technology that can be utilized in society through research while carrying out experiments by operating the model of a few kW such as with inverters and electric motors using microcomputer control.

Research/Development Areas

Satellite positioning and its applications

## Professor / KUBO, Yukihiro

Satellite navigation/positioning systems based on artificial satellites such as American GPS, Russian GLONASS, European Galileo, Chinese BeiDou, Indian IRNSS and Japanese QZSS are collectively called GNSS (Global Navigation Satellite Systems). In this laboratory, we are focusing on various research areas related to GNSS positioning algorithm and its applications, such as, PPP (Precise Point Positioning), INS (Inertial Navigation System)/GNSS integration for land vehicle such as cars and trains, ionosphere modeling, image processing in navigation and pedestrian navigation in smartphones. For example, INS is an autonomous navigation system based on inertial sensors (accelerometer and gyroscope). With the development of MEMS technologies, the inertial sensors have been much easier to be utilized. However, the sensors have large unknown noises and/or biases. Therefore, the noises and/or biases are tried to be removed by integrating with GNSS through Kalman filter. In addition to GNSS, the map matching technique is often utilized for the car navigation systems. In this laboratory, we are trying to extend the map matching technique to the train positioning system based on the INS/GNSS integration.

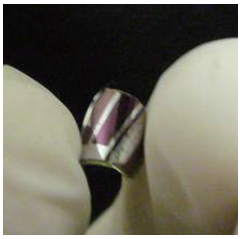
Experimental mobile GPS positioning using a rail line scene (at the Hikone station of the Ohmi Railway)

Research/Development Areas

High efficiency solar cell and PV system

## Professor / MINEMOTO, Takashi

Energy crisis and environmental pollution is now serious global concern in 21st civilization life. Photovoltaics have gathered much attention as clean energy. Solar cell is semiconductor device which convert sunlight directly to electricity. In our laboratory, we are working on thin-film compound solar cells which have great potential on low-cost fabrication and high energy conversion efficiency. Our research covers broad spectrum of solar cell development, such as theoretical device design (modeling), thin film deposition, crystal growth, and device fabrication. Our main task is “proof-of-concept” for new material and new device structure; especially we are working on chalcogenide material and earth abundant semiconductors. Also, our activity includes flexible and light weight solar cells by new fabrication approach. To realize further popularization of PV, we are working on field test of PV modules and also promoting collaborations with companies and government.



Flexible Cu (In,Ga) $Se_2$ solar cell.

Photovoltaic modules installed at Techno-complex.

Research/Development Areas

Synthesis, elucidation of electro or optical properties, and device application of semiconductor nano materials. Graphene and atomically thin layered mateerials. Energy conversion, or saving devices. Sensor application. Quantum device.

## Associate Professor / MOURI, Shinichiro

We are studying “Ultimatically thin layered materials” such as graphene or MoS2, which are expected to be candidates for future optic or electronic devices. Unusual material properties are emerged due to quantum confinement effects or symmetry breaking effect, in these meterials composed of atomically thin structure. Futhermore, van der Waals stacking of these meterials also provide variety of unique material properties. We would like to fabricate next generation energy conversion devices or information devices using these materials. Novel quantum structure will be fabricated by van der Waals expitaxy and material properties are elucidated using various microscopes.

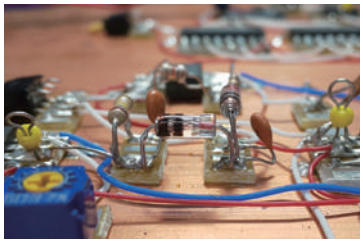
Optical microscope image of the atomically thin semiconductor MoS2.

Research/Development Areas

Innovative analog circuit architecture in the 6G era

## Professor / NOSAKA, Hideyuki

Waves include electromagnetic waves such as radio waves and light, sound waves, and gravitational waves. There are millimeter waves and terahertz waves in the boundary area between radio waves and light, and their use in smartphones and IoT has been considered in recent years. In order to utilize this undeveloped frequency, a new technology “wave engineering” that flexibly controls waves is important. For example, controlling the phase to form a beam in the desired direction or switching to a better wavelength in the propagation environment. In our laboratory, we are researching innovative analog integrated circuits for freely controlling the frequency, phase, and amplitude of waves. Through this research, we aim to realize high-speed wireless communication that can be connected without interruption, and to realize sensing and imaging such as food analysis, lesion analysis, and space exploration. In the 6th generation mobile communication system (6G) era, the area of information communication extends not only on the ground but also in the sky, underwater, and space. We will enrich our lives with circuit technology.



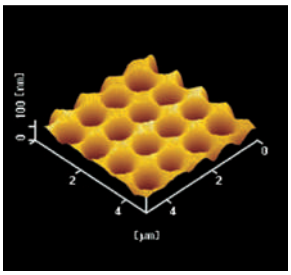
Principle confirmation board of phase-locked loop by new topology

Research/Development Areas

Application of interactions of light and electrons to engineering

## Professor / NUMAI, Takahiro

Photonics/Quantum-Electronics is a research field that deals with interactions of electromagnetic waves and materials. The aim of our research is to create new devices and systems by controlling the interactions of light and electrons. Our major research themes are nano-scale process technology, semiconductor lasers, imaging devices, and optical fiber communication systems.In the research of the nano-scale process technology, we have developed room-temperature imprint lithography that allows us to copy fine patterns, which were formed on a mold, to a surface of resin on a substrate, at room temperature.
In the research of the semiconductor lasers, we have proposed and theoretically analyzed a new ridge structure, which can emit a laser beam with the fundamental transverse mode up to a high light-output. In the research of the imaging devices, we have discovered a structure, which can control the peak wavelength and spectral width independently. In the research of the optical fiber communication systems, we have proposed and analyzed several schemes to reduce four-wave-mixing noises, which are caused by the third-order optical nonlinear effect in the optical fibers.



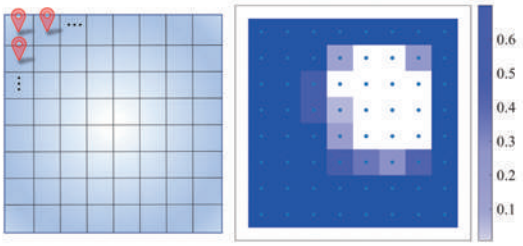

Fabricated pattern by room-temperature imprint lithography

Research/Development Areas

Analysis, design, and control of cyber-physical systems

## Associate Professor / OKANO, Kunihisa

Cyber-Physical Systems (CPSs) are systems in which physical/mechanical devices and information processing and communication are closely connected. We study CPSs from a viewpoint of systems and control engineering. As emerging low-cost devices equip with communication functions, it is now easy to collect various information about systems. This enables us to use such information to operate systems that were once isolated from each other. The amount of information collected and transmitted will continue to increase exponentially in the future. Therefore, it is important to establish technologies to select the necessary information from the vast amount of data. What kind of information is essential to accurately grasp the system's state? What level of accuracy is required to control a system? We are addressing these questions based on systems and control methods.



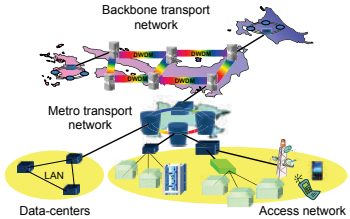

Measuring the gas concentration in a room (left). The right figure shows the importance of measurement spots derived by a mathematical model.

Research/Development Areas

Optical fiber communications technology and its application

## Professor / SANO, Akihide

Optical fiber communication is a key technology that supports the massive growth of Internet traffic. During the last three decades, transmission capacity per fiber has been increased five orders of magnitude. Our laboratory has been established on April 2017, and we are working on optical fiber communication system technologies and its applications. Our research target covers various aspects of optical communication systems such as long-haul optical transport networks, optical access networks and data-center networks. The transmission performance of long-haul transport networks has dramatically increased by digital coherent transmission scheme. However the attainable per-fiber capacity is fundamentally limited by fiber nonlinearity, and thus one of main topics in our laboratory is nonlinear compensation techniques to overcome this limitation. We are also focusing on advanced modulation-detection schemes to realize high-speed and low-cost interfaces, and working on optical performance monitoring technique that is indispensable for providing highly-reliable communication services.



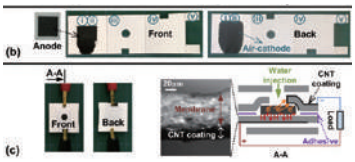

Configuration of optical communication networks

Research/Development Areas

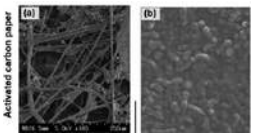
High-performance energy exchange devices and energy harvesting devices

## Professor / TAGUCHI, Kozo

Nowadays, energy and environmental crisis have become a severe problem. Sustainable energy resources are believed to become an effective solution for this issue. We are developing high-performance energy exchange and energy harvesting devices with a focus on sustainable materials and methods. Our group is working on various projects, such as biofuel cells (BFCs) and dye-sensitized solar cells (DSSCs). BFCs are electrochemical systems that utilize bacteria to convert chemical energy directly to electricity. Its operation principle is based on sustainable biological processes. We are developing some exciting BFCs, such as floating type, soil-based type, and hybrid type. Also, DSSCs, which can convert sunlight directly to electricity, are actively developed. We focus on improving high-quality photoanode and counter electrode by synthesizing novel but low-cost materials. Quasi-solid and solid DSSCs are also investigated to improve its practicality. With accumulated knowledge and inventions in the fields, our lab is collaborating with companies to promote the introduction of research results to the market.




Paper-based microbial fuel cell



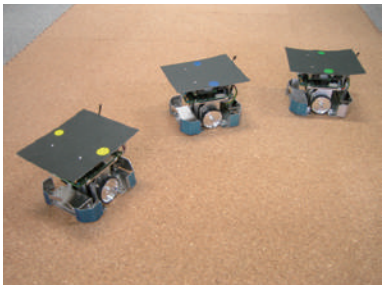

SEM images of the biofilm anodes

Research/Development Areas

Systems and control theory and its applications
Modeling, estimation, and control of large-scale networked systems

## Professor / TAKABA, Kiyotsugu

Dynamical systems arising in various engineering problems in modern society are getting increasingly huge and complex, and exhibit a large-scale network structure consisting of a number of sub-systems. Examples of such systems are power grids, sensor networks, formations of mobile vehicles, etc. Mathematical model-based methodologies are essential to guarantee stability and high performance of large-scale networked control systems under various constraints. Against this background, we conduct research and education on systems and control engineering aiming at the development of practical and expansible methods for modeling, estimation, and control of large-scale networked systems. Our research interests include robust design of networked control systems, synchronization of sensors or electro-mechanical systems, formation control of mobile vehicles, etc.



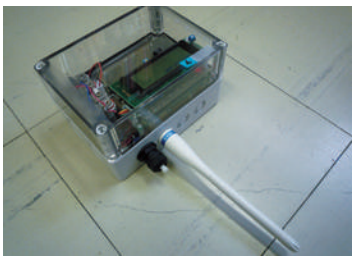
Formation control of a group of mobile robots

Research/Development Areas

Development of measurement systems by autonomous sensor node network

## Professor / TAKAYAMA, Shigeru

Wireless sensing network systems is the key technology in advanced measurements under the conditions in large fields, with multiple parameters, and in dangerous or destructive environment. The system is designed as a remote, collaborative, cooperative system consisting of multiple sensors and measuring instruments, and communication devices. The aim of the sensing system laboratory is (1) to construct an autonomous sensing node, which integrates sensors, a micro-processor system and a communication device and (2) to realize a flexible, robust and dual communication sensing network. As concrete applications, the laboratory staff have been working on (1) forecasting landslides at hills around mountain areas, (2) monitoring the flow speed and direction of dangerous rivers, (3) monitoring the dynamical physiological parameters in daily life and (4) monitoring human flow in densely populated areas.
From the viewpoint of social evolution, our staff work to design and construct practical systems and devices by combining the dual aspects of hardware and software.



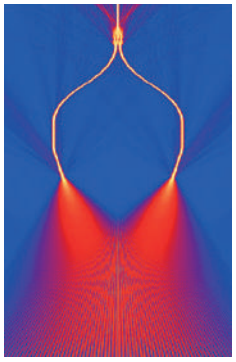
Example of configuration of sensory node that is the constituent element of a slope failure monitoring network

Research/Development Areas

Optical signal processing and its application to optical communication and sensing

## Professor / TAKIGUCHI, Koichi

The capacity of optical communication is being steadily increased, which brings significant benefits to our lives including broadband services of the Internet. However, the signal processing utilizing electronic circuits causes the limit of processing speed and large power consumption in the optical communication. The information photonics laboratory was just established in April 2012, where we aim at research on optical signal processing based on photonic nanotechnology, diffraction, interference, and non-linear optical effect in optical waveguides and fibers. We pursue technology that can process optical signals directly in the optical domain at high-speed and without increasing power consumption. The lightwave also has a feature that enables us to carry out sensitive detection of biological objects and environmental information without disturbing them. By use of this feature and above-mentioned optical signal processing technology developed for the optical communication, we pursue sensitive metrology for biotechnological, medical and environmental fields, and information photonics for multiplexing or fusion of optical sensors.



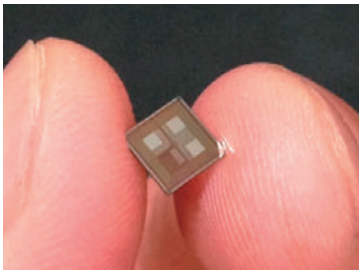
Result obtained with simulation of integrated photonic device.

Research/Development Areas

Nanoelectronics and its applications for bio-chemical sensors

## Professor / UNO, Shigeyasu

Nanotechnology and biotechnology. These disciplines have achieved remarkable progress independently, and now they collaborate to form a new interdisciplinary research area, namely, nanobiotechnology. We aim to contribute to advances in nanobiotechnology through our expertise in electronics. Our research interests include (a) nanoscale integrated CMOS devices and circuits for advanced sensors, (b) biosensors for biochemical molecules and physiological activities, (c) biochemical energy generation and storage. We stress international collaboration with research groups all over the world, and laboratory members are international as well. We enjoy exciting collaborations with experts from wide variety of disciplines not only physics but also chemistry, biology, and medical science. Interested? Then just contact me for more details!



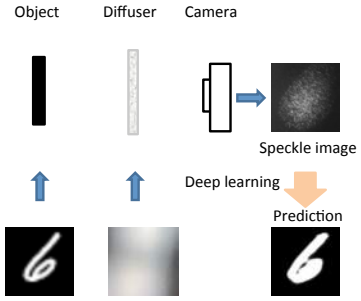
CMOS LSI chip for biochemical molecular sensing.

Research/Development Areas

Photonic application for optical information technology and biomedical imaging

## Professor / WATANABE, Wataru

Light is used in a wide variety of applications including communications, information processing, data storage, energy, healthcare, medicine, and manufacturing. The group engages in fundamental and applied study on photonics, focusing on optics and image processing with the aim to harness light. Our lab focuses on the development and applications of optical microscopy techniques for biomedical imaging. We develop computational imaging systems such as active illumination microscopy, digital holographic microscopy, and lens-less imaging system through diffuse/scattering media. Our research also involves laser micromachining with ultrashort laser pulses such as material processing and micro structuring of optical materials. The group is engaged in interdisciplinary areas of education and research, spanning optics, photonics and imaging.




Prediction of objects through diffusers by deep learning

# Electrical, Electronic and Computer Systems Course (Electronic and Computer Engineering)



Research/Development Areas

Design of battery-less system and its application

## Professor / DOUSEKI, Takakuni

Systems that do not require any batteries would be more convenient in that they would not require any maintenance and can be installed where people cannot reach such as in sensor networks and implantable computers. At our laboratory we are aiming at the research, development and application of a battery-less system that obviously does not require any batteries. In order to realize this research needs to cover the three points of the generation of energy (electricity generation technology), conversion (power supply conversion technology) and consumption (low-power LSI technology). As energy resources the natural energy existing around us such as light, thermal and motion energies need to be utilized. With regard to LSI-related research we are researching new power supply conversion circuit technology to enable stable electricity to be supplied from unstable natural energy sources to internal CPUs and extremely small circuit electric power technology. We have succeeded up to the creation of system but are now promoting the research in cooperation with external companies.

<Example of battery-less system>

Hanger electric generation

Body temperature electricity generation

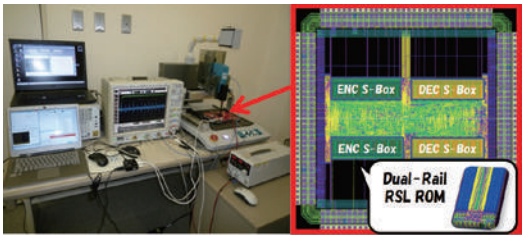
Research/Development Areas

Electronic Devices for Network Application — Security & Application Specific LSI —

## Professor / FUJINO, Takeshi

The secure network communication is the key technology for IoT (Internet of Things). IoT devices are required to have high security and low power consumption. Cryptographic circuits and secure key storage are implemented on IoT devices in order to protect secret information.

Recommended cryptographic algorithms are computationally secure, however, the attacker reveal secret information by analyzing the side-channel information such as power consumption and electro-magnetic field. Furthermore, the attacker could clone security LSIs by analyzing physical information. In our laboratory, we are researching tamper-resistant LSI which protect secret information, and Physically Unclonable Function for anti-cloning. In addition, we are studying in-vehicle security technology such as AI-assisted intrusion detection system and sensor fusion system.



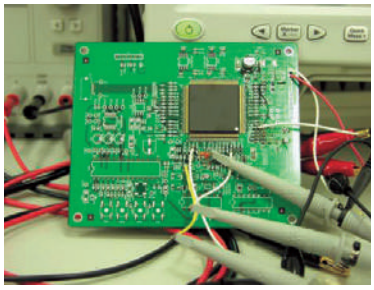

Side Channel Attack and tamper-resistant cryptographic LSI

Research/Development Areas

Optimization Technique for Analog Integrated Circuits

## Professor / FUJITA, Tomohiro

At the analog integrated circuit laboratory we are promoting research that focuses on two points: information processing technology utilizing analog circuits and how the analog circuits are created. With regard to information processing technology we are researching information processing that utilizes complex dynamics such as in a neural network. We wish to realize the information processing doctrine of the brain on an analog circuit. For the problem of how the circuits should be created we aim at establishing automatic design technology carried out by computer. We wish to automate the design flow, which used to rely on the experience of the designer, using an optimization program on a computer. We are also carrying out research on simulation technology that cannot be easily realized using existing technology such as high-frequency circuits used in cell phones and a large-scale digital circuit mixed system.



Research/Development Areas

Intelligent Battery System and Design Optimization

## Professor / FUKUI, Masahiro

Aiming at low carbon society, it is important that smart houses spread for efficient utilization of natural energy sources, e.g., photovoltaic battery. Lithium-ion battery is an important component to construct those systems. We discuss how to formulate the degradation of the batteries, and clarifies the efficient keys to control the cost of battery degradation. Furthermore, mobile systems with lithium-ion batteries have become very popular. Higher performance, longer battery life, and safer operation are required strongly. We are developing an efficient battery management and control system to get the highest performance and highest reliability.

**Battery Smart Sensor for Smart Grid**: In a smart grid, a storage battery is an essential device for electric vehicles and renewable energy. But optimal management of the storage battery is difficult, because of manufacturing variations and degradation. It is important for battery optimal management to understand degradation and characteristics of the battery. So, We propose a battery management by the battery smart sensor. The battery smart sensor is based on IEEE1888 communication standard, and this system monitors a battery voltage, current, temperature and SOC (State-of-charge) on the Web.

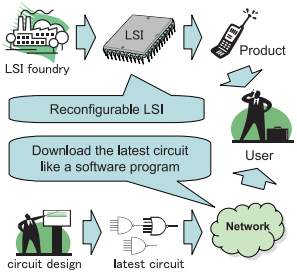
**Practical and Accurate SOC Estimation System for Lithium Ion Batteries**: With the advent of big-scale popularization of secondary batteries, the accuracy as well as the inexpensiveness should be indispensable for measurement systems. Particularly, the SOC (state of charge) estimation is essential for capturing the state of secondary batteries. A precise SOC estimation system is devised by means of EKF (Extended Karman Filter) run on a microcomputer. Compared with the conventional techniques, such as OCV, internal resistance method, current accumulation method, etc., EKF attains higher accuracy. In fact, EKF is a statistical method which minimizes over time the gap between the prediction and the observation, on the basis of the information acquired from observation of the physical variable with SOC dependence, such as OCV and internal resistance.

Research/Development Areas

Flexible hardware and its application

## Professor / IZUMI, Tomonori

Electronic information equipments, such as cell phones, vehicles, artificial satellites, etc., are implemented as complicated systems with hardware and software.
In the traditional sense, hardware (implies a rigid matter) is an electronic circuit which offers the best performance and software (implies a flexible matter) is a computer program whose functionality can be changed by re-loading another program.
Our research theme concerns “reconfigurable hardware” which realizes both the high performance of electronic circuits and the flexibility of computer programs. Reconfigurable hardware would realize adaptive systems such as mobile phones, TV receivers, or wireless network appliances which could be reconfigured automatically to fit multiple standards. It would also realize evolutional hardware which would change autonomously according to the environment and usage. Furthermore, it would contribute to safety maintenance of the systems in dangerous place such as space, deep sea, nuclear facilities, by reconfiguring hardware for update or repair. It might also contribute to ecology by reconfiguring and re-using the system, i.e. reducing the waste.



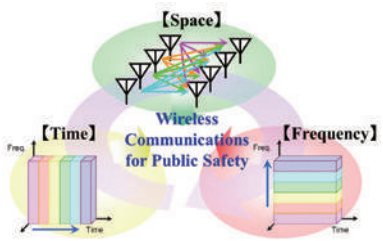

An electronic board equipped with “flexible hardware” (top-right photo) and an example of application “downloadable hardware” (above figure)

Research/Development Areas

Wireless Communication Systems for Public Safety

## Professor / KUBO, Hiroshi

Wireless communications play important role not only for broadband data transmission but also for public safety. Our laboratory is making research on digital signal processing technologies for wireless communications with high quality and reliability in fast vehicle environment and in low received signal power environment. Using digital signal processing technologies in “Time”, “Frequency” and “Space” domains, we focus on robust wireless communication systems for high-speed trains and airplanes at a speed of several hundreds of km’s per hour and communication satellitesat a height of several ten thousands of km’s. We are also making research on visualization technologies for wireless communications in order to support robust wireless communication systems. In addition, we are expanding these digital signal processing technologies not only to wireless communications but also to wired communications (optical communications, metallic communications) and acoustic sensing.




Wireless digital signal processing technologies in “Time”, “Frequency” and “Space” domains

Research/Development Areas

Multimedia data processing LSI-system

## Professor / KUMAKI, Takeshi

Recently, our multimedia environment is developing and changing rapidly.
Furthermore, mobile devices have spread with the rapid development of embedded LSI architecture.
For contributing to the further development of above technologies, our laboratory focuses several novel massively parallel LSI architectures and its applied multimedia systems.
The proposed massively parallel LSI architectures are based on a Content Addressable Memory (CAM), a Single Instruction Multiple Data (SIMD) hardware, etc.
The applied multimedia systems are deal with image data, sensing data, etc.
Latest research topics for realizing effective multimedia data processing are multi-ported and process variability-used CAM, intermittent-sensing image sensor node, highly implementable watermarking, human-like digital image forensics, spy-photo prevention system, hardware Trojan detection and more.

Demonstration scene: international conference and domestic exhibition.

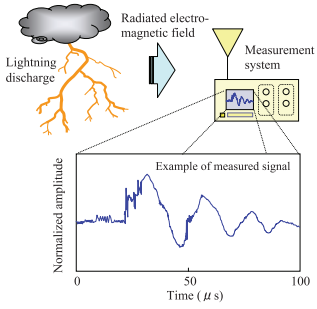
ARM-core and FPGA evaluation board for multimedia system and security camera prototype system.

Research/Development Areas

1. Signal analysis in atmospheric electricity and bioengineering fields
2. Bio-electromagnetic engineering

## Professor / MASUGI, Masao

Our laboratories deal with two research topics: one focuses on the signal analysis in atmospheric electricity and bioengineering fields, and the other focuses on bio-electromagnetic engineering related to the effect of transient electromagnetic waves on bio-systems.
Regarding the former research topic, we measure electromagnetic waves caused by lightning discharges whose occurrence rate is strongly related to global warming effects. The weather data sets are also used to assess the measured data and actual global warming effects. Regarding the atmospheric electricity, we also measure fluctuations of broadcasting waves, which can be effective data for forebodings of big earthquakes. In addition, we analyze the biological signals (e.g., EEG) for the health care management in our daily life.
Then, in the latter research topic, we evaluate effects of transient electromagnetic waves on bio-systems such as plants and yeast fungus. Artificial nerve-cell models are also used to analyze their responses by external electromagnetic waves. We believe that these new approaches will provide a new quantitative measures in revealing the actual effect of electromagnetic waves on bio-systems.




Concept of measuring electromagnetic field caused by a lighting discharge

Research/Development Areas

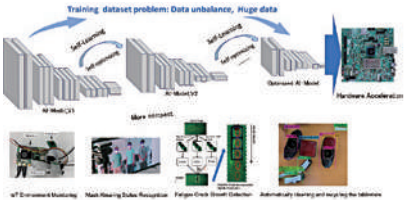
Artificial Intelligence (AI);
AI + High-Performance Computing;
AI + IoT + Industry / Society;
AI + Cultural Heritage Reorganization and Protection;

## Associate Professor / MENG, Lin

AI + High-Performance Computing: We aim to realize the compact AI models by self-learning and self-optimizing for reducing the redundant calculation. Furthermore, we also design the FPGA-based hardware accelerators for realizing the high-performance AI which includes BNN, DNNs, etc. The technologies include AI models design, hardware architecture design (FPGA, SIMD).

AI + IoT + Industry / Society: These topics aim to combine AI and IoT for helping Industrial automation and building a safe and comfortable society. Industrial automation includes Fatigue Crack Growth Detection, Dirty Detection on Egg, etc. Safe and comfortable society creation includes Mask-Wearing Status Recognition and Person Identification, etc..

AI + Cultural Heritage Reorganization and Protection: There have been many ancient documents which contain a large number of potential knowledges, are waiting for being unlocking. In this study, we aim to reorganize and protect the ancient literature by AI and IoT techniques. The technologies include image processing, machine learning, deep learning, database, visualization, and so on.

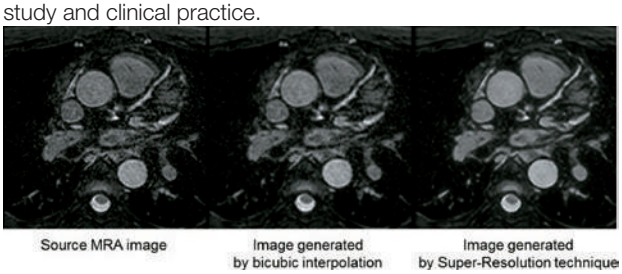



Research/Development Areas

Development of techniques of medical image processing/analysis for clinical practice

## Professor / NAKAYAMA, Ryohei

Our major research efforts have been focused on computer vision and human-computer interaction for medical images. The goal of our researches is to let computers help physicians in the image interpretation process. In computer vision, we have been developing image processing techniques such as a filter bank for enhancing lesions in medical images, a subtraction technique for visualizing lesions, and a super-resolution technique for improving image resolution and image quality. In human-computer interaction, we have been developing a computerized scheme for evaluating the likelihood of malignancy and/or histological classifications on lesion by using pattern recognition and artificial intelligence. We also investigate if the proposed methods are useful for improving the diagnostic accuracy and for reducing the interpretation time in observer study and clinical practice.



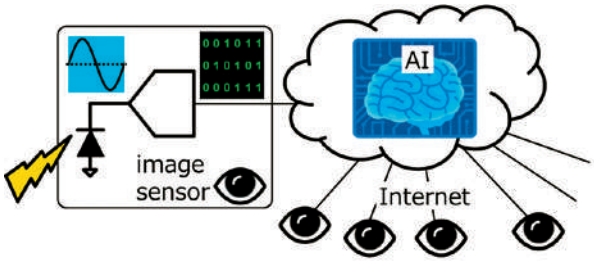

Example of 512x512 source image and 512x512 generated images from the 256x256 input image by a bicubic interpolation and by super-resolution technique.

Research/Development Areas

CMOS Image Sensor Design for IoT Applications

## Associate Professor / OKURA, Shunsuke

In the Internet of Things (IoT) society, massive number of sensor devices will be utilized all around the world in order to connect the physical world to the artificial intelligence (AI) in cloud computing. As we can see our surroundings through our eyes, AI can “see” various environments in the world through image sensors. In the era of this IoT and AI, image sensors should consume ultra-low-power, have information security function, and generate the data suitable for AI. Our lab started in April 2019, and we research the image sensor for the IoT and AI society from wide aspects, including pixel device, sensor circuit, hardware security, and image recognition. We are desingning and implementing CMOS image sensors for the research.




Overview of image sensors, IoT, and AI.

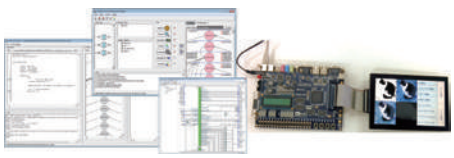
Research/Development Areas

Design Methodologies for Embedded and Cyber-Physical Systems

## Professor / TOMIYAMA, Hiroyuki

A variety of electric and mechanical products (e.g., home and office electric appliances, automotive vehicles, robots and so on) are controlled by computer systems which are embedded in the products. Such computer systems are called embedded systems. Modern embedded systems are connected to the Internet, and with the help of cloud computers over the Internet, they offer sophisticated services to customers. Such embedded systems are called cyber-physical systems or Internet-of-Things. Our vision is to conduct leading-edge theoretical and practical researches on design methodologies for embedded systems and cyber-physical systems. Our current research focuses are on, but not limited to, design automation for embedded systems, parallel processing on manycore architectures, energy optimization for quadcopters, and IoT for smart houses.

Power analysis for quadcopters



Design automation of image processing systems

# Major in Advanced Mechanical Engineering and Robotics

**Master's Program** **Mechanical Engineering Course / Robotics Course / Micro Systems Technology Course**

Mechanical Engineering provides necessary, fundamental support for the manufacturing process, from material development to designing, processing, production, operation, and maintenance. Manufactured items range from large space structures to nanoscale manufacturing. As the relationship between electronics and information sciences continues to grow stronger, mechanical engineering continues to grow beyond conventional boundaries into new frontiers. This Master's Program combines the fields of mechanical engineering, robotics, and microsystems technology in the pursuit of comprehensive education and research.

**Doctoral Program**

The Doctoral Program in Advanced Mechanical Engineering and Robotics provides advanced education and research in the field of mechanical engineering. Students take part in systematic studies of exceptionally advanced fields related to mechanical engineering, robotics, and microsystems technology, including fields that exceed the boundaries of conventional mechanical engineering.

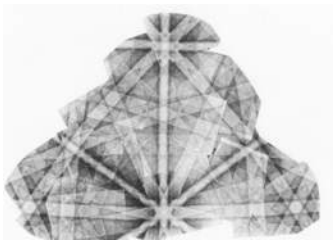
## Mechanical Engineering Course

Research/Development Areas

Development of advanced materials by hetero structure control

### Professor / FUJIWARA, Hiroshi

The mechanical properties of metallic materials are mainly effected by the microstructure. Therefore, the microstructure controll is very important for fabrication of materials with better mechanical properties than conventional materials. This laboratory aims to develop the innovative hetero structure materials by the microstructure contoroll via the powder metallurgy technology. We will develop hetero structure materials with excellent properties and clarify the relationship between their microstructure and excellent properties. Microstructure control from the nano level enables the development of innovative materials. Therefore, we design the optimum hetero structure by analyzing the crystal structure, crystal orientation, etc. by using our original analysis technique with a high-resolution electron microscope. This figure is an electron diffraction pattern obtained by electron backscattering in a scanning electron microscope. Detailed crystallographic information can be obtained by analyzing such geometric figures.



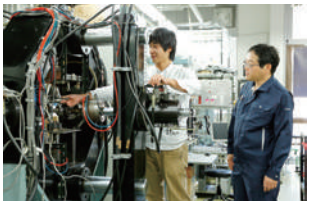
Electron diffraction pattern by electron backscattering of a scanning electron microscope

Research/Development Areas

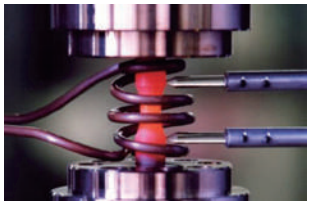
Reliability and strength of materials – Challenges in multiaxial fatigue –

### Professor / ITOH, Takamoto

This laboratory is carrying out many fatigue tests under multiaxial loadings for various materials, such as heat and corrosion registrant alloys used for high temperature component, light weight alloys and super alloys used for aircraft, low melting alloys used for electronic devices, etc. Based on the obtained test results, deformation and fracture behaviors are evaluated. Observations of crack and microstructure, analyses and evaluations of results and numerical analyses are also carried out, and then evaluation of strength and development of design criteria for fatigue strength are studied. For the multiaxial fatigue test, since special test equipment is needed, almost all the machines are the originally designed and fabricated testing equipment. New testing machines are also developed. Thus, the students can study not only materials and strength of material, but also programing of test controlling and hydraulic control system. In this laboratory, most important thing is to enjoy the research work.



Tri-axial fatigue testing machine



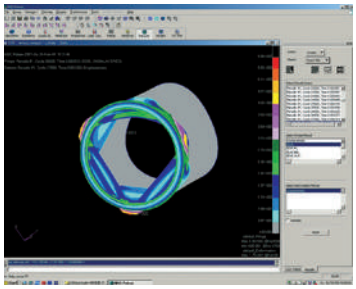
Multiaxial fatigue test of heat registrant alloy

Research/Development Areas

Strength design and soundness evaluations of machine structures

## Professor / KUSAKA, Takayuki

We are involved in the structural design and structural evaluations of the safety and functionality of rapid transportation such as vehicles and aircraft. The crash safety of vehicles and damage detection of aircraft etc are both representative examples of this theme. In particular we are carrying out research using the keyword of “impact phenomenon” and researching the impact resistance of new materials such as carbon fiber reinforced composite materials and shock absorbers that put a folding structure to practical use. We frequently carry out inspections using CAE (a type of computer simulation) in addition to various intensity experiments in our research, and develop test productions. Recently we have also been emphasizing damage diagnosis of architectural constructions and developing a system that can be used to evaluate the generation status of cracks in real time. We have a lot of themes of research that are being promoted in cooperation with car and aircraft manufacturers etc.



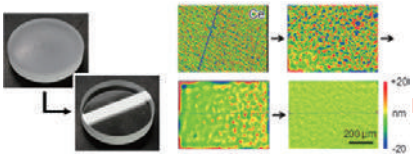
Plastic buckling simulation of shock absorber for vehicle. We are developing a highly-efficient shock absorber using CAE.

Research/Development Areas

Ultra-precision surface processing utilizing physical/chemical reaction

## Associate Professor / MURATA, Junji

Surface processing for functional materials such as semiconductors, ceramics and optical materials is essential to achieve high-performance electronic/optical devices. However, owing to their high mechanical hardness and chemical stability, such materials are generally difficult to be processed by conventional surface machining method. In our research, novel surface preparation method are developed utilizing physical/chemical reactions occurred on the material surface. The physical/chemical reaction including electrochemical, tribo-chemical, and catalyst-enhanced chemical reaction are employed to remove material surface with an atomic/molecular level accuracy, and thus the ultra-precision machined surface can be obtained. Furthermore, functional particles such as multi-component magnetic particles, SPE (solid polymer electrolyte)-coated particles are also developed to polish or etch material surfaces with nano/micro accuracy. By developing new processing methods that offer superior efficiency and accuracy to the conventional machining method, we can contribute to a promotion of the energy-saving and environment-friendly society.



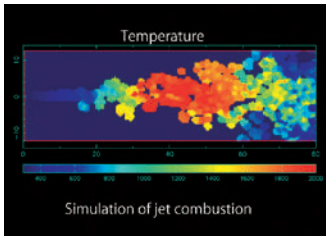
Abrasive-free nano surface processing for optical materials

Research/Development Areas

Development of efficient computational codes and their technological applications

## Professor / OGAMI, Yoshifumi

With the advances in computer technology and development of computational codes for fluid dynamics, solving complex equations has become mainstream. However, there is room for improvement in computational accuracy and time. For example, simulation of combustion in turbulent flows needs to solve hundreds of chemical equations simultaneously, which leads to a huge computational load. Therefore, efficient computational methods are required. In our laboratory, we are developing efficient computational codes for analyzing flow around fixed physical objects (Eulerien method) and as well as flow around moving physical objects (Lagrangian method).
In addition to the development of efficient computational codes, we are working on application of these codes to technological studies such as “noise-reduction of turbulent flow from jet nozzle,” “development of micro gas turbine,” “development of artificial heart with magnetically suspended impeller,” and “flow analysis of moving animals as swimming fishes and flying birds.”



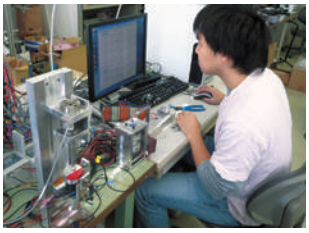

An example of computational code for the Lagrangian method combined with the thermal equilibrium method. With this code, accurate calculation is possible without using hundreds of chemical equations.

Research/Development Areas

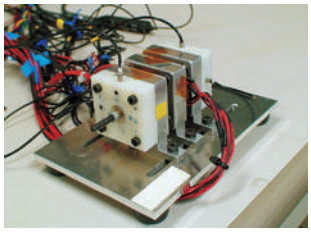
Development of magnetic levitation/ magnetic bearing system

## Professor / UENO, Satoshi

Magnetic levitation/magnetic bearings are used in systems that support objects or rotating shaft without contact through use of magnetic force. It has various favorable characteristics: no friction or abrasions, supports high-speed rotation, low loss, long lifetime, usable in vacuums or in ultralow temperature environments, and supports advanced active control. Currently it is actually being utilized in magnetic suspension trains, turbo-molecular pumps, flywheel energy storages, clean pumps, and blood pumps for artificial hearts etc. We are working at the development of a magnetic bearing smaller than those already existing, the development of a self-bearing motor that integrates magnetic bearings and an AC motor, and the development of a non-contact displacement sensor for use in magnetic levitation etc. We are also developing a magnetic bearing system using a superconductor in addition to the magnetic suspension that uses a normal conduction magnet.



Scene of experiment



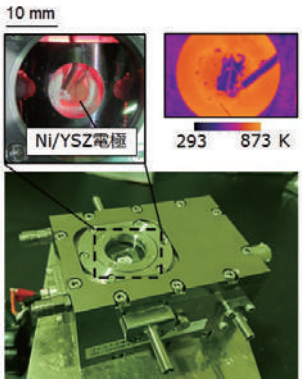
AC motor using small magnetic bearing

Research/Development Areas

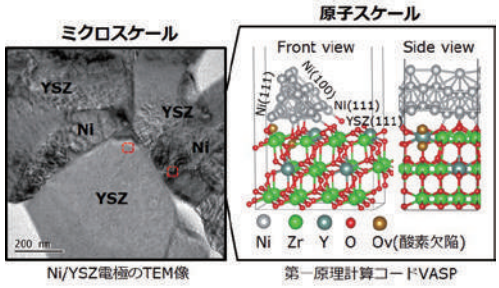
## Fuel cell system and carbon resource conversion for a carbon neutral society

### Associate Professor / WATANABE, Hirotatsu

Our interests are fuel cell system and carbon resource conversion for a carbon neutral society. Fuel cells are an important devices for a hydrogen society and a future of carbon resource conversion. We are trying to visualize reactive-transport phenomena on electrodes and catalysts in fuel cell system at atomic scales, micro scales and macro scales, and develop a novel energy conversion devices.




■Operando analysis of SOFC electrode




■Multi-scale study of SOFC electrode

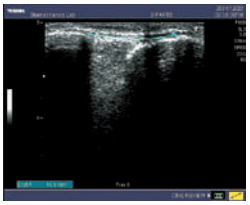
Research/Development Areas

## Clarifying biomechanics through mechanical engineering

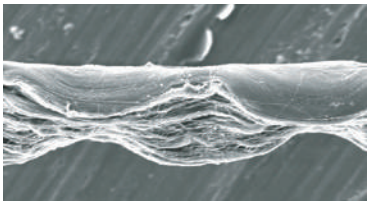
### Professor / YAMAMOTO, Noritaka

We are clarifying the mechanism of vital functions using the material mechanics required in designing vehicles and aircraft that avoid damage in mechanical engineering. In addition we are aiming at developing new medical treatments for disorders that have been untreatable using the accomplishments obtained. We mainly carry out research on tendons and ligaments of the articulatio genus.

Tendons and ligaments are made up of collagen fibers and have a very complicated structure. We are researching the relationship between minute structures and mechanical properties by harvesting fiber fascicles of approximately 100 micrometers in diameter and very fine fibrils of approximately 200 nanometers in diameter obtained the tail tendon of the mouse for use in conducting tensile tests. We also obtain mechanical properties from the relationship between force and extension at that time by capturing the change in shape of the patella tendon that bears the load using ultrasonic diagnostic equipment in order to measure the mechanical properties of the patella tendon in the human articulatio genus.



■Ultrasonic diagnostic image of human patella tendon



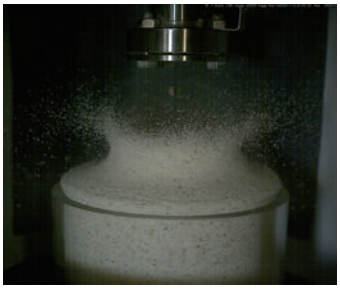
■Electron microscope photograph of fiber fascicle from mouse tail tendon

Research/Development Areas

## Clarification of high-speed impact phenomenon accompanying shock waves

### Professor / WATANABE, Keiko

The high-speed impact accompanying the shock waves is a very interesting research subject in physics because unique phenomena that can never happen under the static and dynamic loading are induced. The main subject is the clarification of fracture and propagation behavior of waves induced by the impact. In particular, we recently focus on the high-speed penetration phenomenon into geological particulate materials such as sands. Since particles are heterogeneity and instability, both behaviors as solid and liquid exist and the three states of matter (solids, liquids and gases) are mixed, phenomena are so complicated and less understood. This is not only basic research of high-speed impact phenomena but research of engineering significance, such as the product development using a non-Newtonian phenomenon, the establishment of planetary exploration technology, the establishment of protection technology against high-speed scattering objects and the development of new excavation technology and geological survey technique.



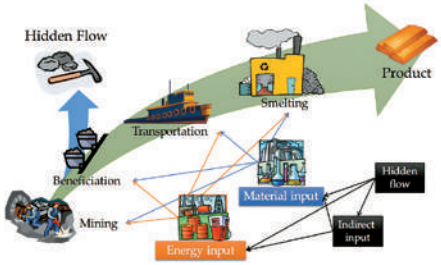
■Behavior of ejecta during high-speed penetration into sands

Research/Development Areas

## Materials Science and Process Engineering supported by Industrial Ecology towards Sustainable Material Supply Chains (Material Logistics)

### Professor / YAMASUE, Eiji

The research interests of our group may be encapsulated as "Sustainable Materials, Processes and Production". Our laboratory is grappling with the development of materials and processes, and their environmental impact assessment from multidimensional (present, past and future; local, domestic, and global) viewpoints. More academically, our research fields consist of natural science (materials science, thermodynamics and transport phenomena, etc.) supported by industrial ecology (material flow analysis, life-cycle assessment, environmental system engineering, etc.), and sometimes experimental archaeology. Current targets are metals (iron, nickel, zinc, copper and related scarce metals), phosphorus and foods, and related processes. With regard to these particular products, we focus not only natural mines but also urban mines that were thought of as waste.




■Concept of material logistics. We optimize the entire material and energy inputs in various different ways through basic natural science supported by industrial ecology.

Research/Development Areas

Environment restoration technology by fluid engineering

## Associate Professor / YOSHIOKA, Shuya

The environment has recently been damaged by human activity. In our laboratory, we study two technologies: environment restoration technology and the technology for the reduction of environmental impact, by means of fluid engineering. Our main focus is to develop such technologies by using a large quantity of micro scale bubbles. This technology makes it possible to efficiently dissolve oxygen in water in the environment on a massive scale. Dissolved oxygen restores the ecological systems and material cycle systems, providing the water environment strong environment-restoration ability. Our field experiments are carried out at testing sites such as lakes and water-storage dams, in cooperation with the local government authority. To support and verify our fieldwork, we perform experiments in our laboratory on campus, which attempt to predict the process of water environment restoration by simulating heat, fluid flow, diffusion, and chemical reaction in the environment.

■Water containing micro bubbles, with the appearance of milky liquid

■Field experiment at Sounoseki-dam (Miyagi Pref.)

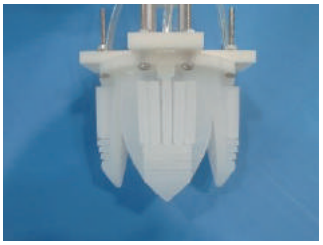
# Robotics Course

Research/Development Areas

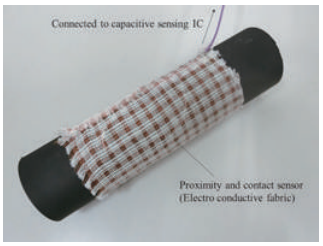
Soft Robotics

## Professor / HIRAI, Shinichi

Soft Robotics Laboratory is investigating robots with novel functions brought by soft materials and its related technologies including soft sensors and actuators. So far, hard materials are mainly used in robotic systems. Contrary, creatures are made of hard and soft materials, suggesting us introducing soft materials into robotics will realize novel functions as creatures. Research topics are 1) Food Manipulation, 2) Soft Sensors, 3) Pneumatic System, 4) Soft Contact, 5) Biomechanical Modeling, and 6) Aerial Operation. Visit http://hirailab.com/ for details.



Soft wrapping gripper for food materials



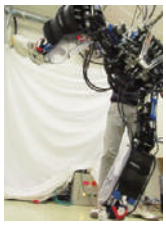

Fabric sensor for tactile and proximity perception

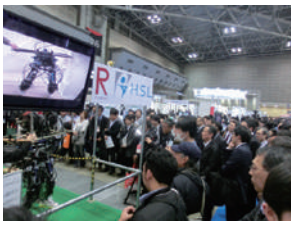
Research/Development Areas

Creating high-performance humanoid robots to explore future robotics

## Professor / HYON, Sang Ho

Humanoid Systems Laboratory (HSL) aims to contribute to our society by creating high-performance humanoid (human-like) systems, focusing on the universal, sustainable methodologies of design, control, and real world operation.
We validate our methods through multi-discipline collaboration. Ongoing research projects include hydraulic humanoid robots that can safely interact with humans, exoskeleton robots that can optimally assist wearer's motion, quadruped walking robots for mobile applications, and low-cost hybrid manipulators or servo-press for industrial applications.





Hydraulic humanoid robot and the live demo at exhibitions

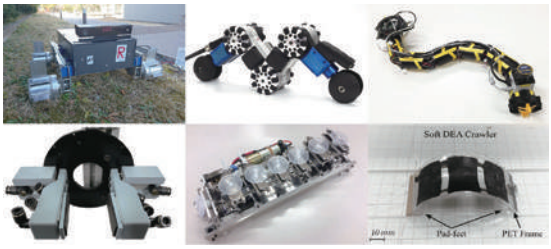
Humanoid technology applied to assist and filed robots

Research/Development Areas

Understanding the dynamic phenomena of life's intelligence of motion and developing environmentally-adaptive robots with novel morphology and functionality

## Professor / MA, Shugen

Nature systems having a body with a large number of degrees of freedom are often considered the ultimate model for intelligence. To confer the performance advantage of animal systems on robotic machines, at this laboratory, we are carrying out the studies on a thorough understanding of the biological systems at both biomechanical and physiological levels and the developments of biomimetic intelligent machines, biologically inspired robots and environmentally adaptive mechanisms with the keywords, 'biomimetics','motion intelligence', 'environmental adaptation', 'flexibility' and 'energy-saving'. Our research topics include – but not limited to – R & D of new types of robots such as snake-like robots and quadruped robots that have a similar body with animals and show the correspondent intelligence, and R & D of field robots such as an amphibious robot that has polymorphic motion modes, including wheeled, legged, paddling and paddle-aided hybrid motion modes.
http://www.malab.se.ritsumei.ac.jp/




Upper left: An amphibious robot, upper middle: An in-pipe robot, upper right: A snake-like robot, lower left: An pneumatic-underdriven gripper, lower middle: A wall- climbing robot, lower right: A soft DEA-driven crawler

Research/Development Areas

Development of medical welfare robot and ultra high-speed robot

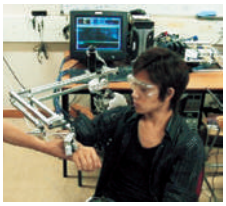
## Professor / NAGAI, Kiyoshi

**1) Rehabilitation robot (international collaborative research with the University of Reading in England)**
We are promoting the rehabilitation robot R4 used for the upper extremities that can be applied during rehabilitation in the acute stage after having suffered apoplexia cerebri in an intercultural exchange with researchers from the University of Reading in England where some of my graduate students and I visit.

**2) Medical robot (collaborative research with Shiga University of Medical Science)**
In order to realize a master-slave robot that can support surgery under MRIs etc we are working on research regarding a motion transfer mechanism that does not get affected by magnetic fields.

**3) Assist robot**
We are promoting the design of a mechanism for an assist robot for support in preventing lower back pain, the design of a control system and research on a distributed force sensor.

**4) Ultrahigh acceleration robot**
We are working on research on the ultrahigh acceleration parallel mechanism NINJA with the aim of realizing 100G and a parallel mechanism that can accelerate equipment on which electronic components are mounted.



Rehabilitation robot R4 (1st model)

Parallel mechanism NINJA

Research/Development Areas

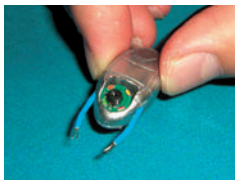
## Highly Functional Small Medical Robots/ Equipment

### Professor / NOKATA, Makoto

We carry out research into medical robots, highly-functional small medical equipment, and rehabilitation equipment in order to improve the quality of our daily lives.

**[Capsule-Robots for diagnostic treatment]**

We design and develop Capsule-Robots that can carry out inspections and provide medical care in the body cavity for a long time. Capsule-Robots move along the surface of internal organs driven by external magnetic fields. We research mechanisms that enable correct positioning in soft internal organs, a diagnosis function, a medical treatment function. We also develop a system that generates a magnetic field for the robots' movement in the body, and analyze the behavior of the Robots by use of movement simulation.



Capsule-Robot for diagnostic treatment with 30x15x8[mm] CCD camera and two forceps

**[Tool for minimally invasive medical treatment]**

We develop tools for use in surgically treating internal organ with minimal damage. We design and fabricate a vascular catheter that includes micro forceps of 1mm in external diameter and a multi-functional endoscopic instrument for laparoscope assisted surgery. Our medical tools have multi-degrees of freedom and rigidity required in surgery even though very small size.

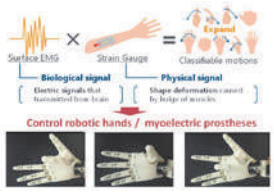
Micro forceps of 1mm in external diameter mounted on the tip of vascular catheter

Research/Development Areas

## Biological and Physiological Engineering / Engineering in Medicine and Biology

### Professor / OKADA, Shima

We have been devoted to biological and physiological engineering. We have five main themes, 1) Development of biomedical sensors, 2) Healthcare monitoring, 3) Brain machine Interface and 4) Development of Sports instrumentation. Additionally, Dr. Shima Okada is an expert on sleep research. We should approach the sleep monitoring with the ambulatory, unconsciousness, noninvasive and long-term monitoring in daily life. Newly critical sensor has to be developed. We focused on the relationship to assess the sleep quality and investigated the body movement measurement technique using video analysis. We successes to monitor sleep stages only using the body movement date obtained from this technique. We applied this technique for assessment of Obstructive Sleep Apnea Syndrome (OSAS) therapeutic efficacy. Apply our technologies for clinical and commercial products. Many of our research area include sleep, but not are limited to only sleep research. Our research key words are Medical, Welfare, Healthcare, Sports and so on.




We propose an advanced motion classification method combined arm-shape-changes with sEMG to classify the detailed motions which is difficult motions to classify using only sEMG signals and to improve the classification accuracy of various hand motions as compared with previous methods.

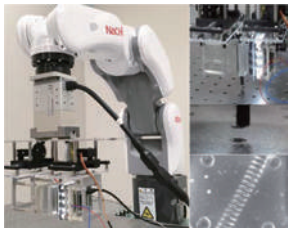
Research/Development Areas

## Vision and tactile sensing for intelligent robots

### Professor / SHIMONOMURA, Kazuhiro

Visual and tactile sensors are important elements for robots to know information about objects and the environment. In our laboratory, we are researching on vision and tactile sensors and their information processing technology, as well as intelligent robots and automation systems based on the sensing technology. Our recent research projects include vision-based control of aerial robots, embedded computer vision systems, tactile sensors with high spatial resolution using cameras, and development of ultra-high speed silicon image sensors etc.

Vision-based control of aerial robot



Tactile-based control of manipulator

Research/Development Areas

## Research and development of assistive technologies for persons with disabilities and the elderly

### Professor / TEJIMA, Noriyuki

We are developing assistive technologies (AT) for use by persons with disabilities and the elderly and doing basic research. We are proud that our laboratory has the most different commercially-available AT found in science and engineering laboratories in Japan and students commence learning from first experiencing the superior points and problems of AT by using and comparing them as research that does not include any hands-on experience frequently becomes merely paper theory. This laboratory is a part of the robotics department; however, we aim at developing useful equipment, even if it is rather low-tech and regardless of high-tech mechatronics equipment. The themes of research includes the development of a safety mechanism for rehabilitation robots, the development of a more comfortable cushion for a wheelchair, basic research on amusement equipment for the elderly, and the development of an earring type input device for tetraplegics etc.

Experimentally produced earring type input device

Scene of experiment where elderly people interact with a radio control toy

Research/Development Areas

Smart control, mechanism, and recognition of robots

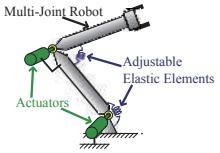
## Associate Professor / UEMURA, Mitsunori

We are investigating smart control, mechanism, and recognition for future robots that perform tasks in unstructured environments. The following are representative research topics.

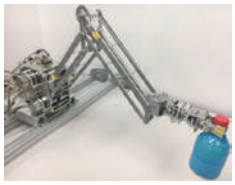
(1) Adaptive optimization of motion and joint stiffness for energy-saving robots
(2) Simultaneous gravity and gripping force compensation mechanism for lightweight hand-arm robot
(3) Wire driven lightweight robots
(4) Standing and walking control of legged robots for high balance ability
(5) Online object recognition utilizing contact between robot and object

Wire-driven lightweight legged robot with high balance ability control

Object recognition utilizing contact




Robot with adjustable elastic elements for energy-saving



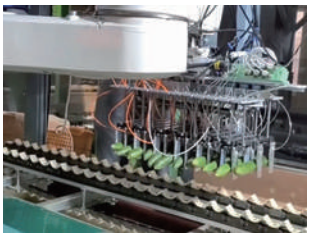
Simultaneous gravity and gripping force compensation mechanism

Research/Development Areas

Research on Robotic systems for improving automation in the food and agricultural industries

## Associate Professor / WANG, Zhongkui

Automation in the food and agricultural industries is still underdeveloped because of the lack of robotic systems capable of efficiently handling food and agricultural products with large variations in shape, size, and mechanical properties. Our research aims at developing effective robotic systems for handling food and agricultural products to facilitate the automation in the food and agricultural industries. Particularly, we focus on developing technologies of soft actuator, robotic gripper, AI based object recognition, ROS/ROS2 based robotic system, and IoT component. By integrating these technologies with open sourced cloud services, we make efforts to build cloud-based robotic systems to maximize the cost performance of the developed systems. In addition, we are dedicated to applying these technologies to real-world applications together with our industrial partners. The figures shown below are two examples of our developed robotic systems.



Robotic system for simultaneously packaging multiple cucumbers

Robotic system for automatic arrangement of tempura for food serving

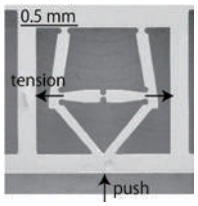
# Micro Systems Technology Course

Research/Development Areas

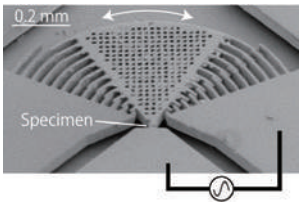
MEMS devices for technology of evaluation/observation

## Professor / ANDO, Taeko

Micro Electro Mechanical Systems (MEMS) technology is one of the most prospective fields for applying the information equipment, industrial equipment, medical field, scientific field, and so on. Our research projects are basic researches for realizing the MEMS devices and micro- or nanometer structures. Characterization of MEMS materials is essential issues to ensure reliability of devices and requires new techniques to overcome difficulties that the target materials are very small.
We have developed new testing method to evaluate tensile strength and fatigue life for microscale and nanoscale specimens. We are preparing the test specimen in MEMS testing devices that you can see in figures. Then tests are performed in electron microscope to observe the aspect in large magnification view (left figure). We are also interested in development of micromachining to achieve a new miniaturized shape and structure. Now we are trying to create a new MEMS field by promoting our research.




Tensile testing device for silicon



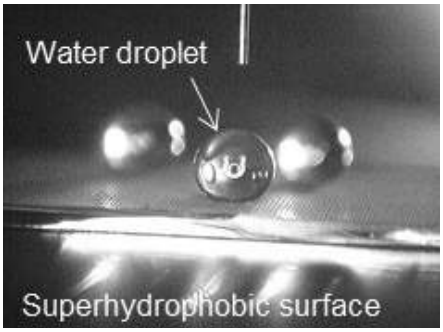

Fatigue testing device for polymer material

Research/Development Areas

Mechanical–electrical material properties of advanced functional thin films

## Professor / KOBAYASHI, Taizo

Our study focuses on the fabrication and investigation of advanced functional surfaces/interfaces through a combination of micromachining technology and mechanical–electrical thin films. Surface properties have higher impact on physical and chemical phenomena at the micro-scale than on those at the macro-scale. Functional surfaces/interfaces have a wide range of potential applications. The design and fabrication of topological surface structures based on micromachining and thin-film growth of advanced functional materials through thermal evaporation, reactive sputtering, and electroplating are studied to fabricate new functional surfaces/interfaces. For example, we are currently working on wettability for microliquid manipulation.




A figure shows water droplets on a superhydrophobic surface with a micromachined topological structure

Research/Development Areas

Creation of new functionality of small machines (MEMS) and their application

## Professor / KONISHI, Satoshi

LSIs (integrated circuits) are incorporated computers and the computers are connected to networks, thus linking information, humans and objects. Small machines originating in LSI technology MEMS (Micro Electro Mechanical (= machine) Systems, called MEMS) are now being spotlighted. My subject of research is MEMS and the world that can be treated using MEMS. MEMS involve an acquisitive field where mechanical and other information that includes biochemical information is dealt with utilizing the minute structure of the LSI chip. Applications have continued to expand: a number of small mirrors that turn ON/OFF the image signal of a display by swinging it, and biotips for catching cells, boring holes, and assembling cells etc. We are recently working on medical applications of MEMS with the aim of contributing to medical care that less burdens patients. An endoscope robot with soft hands has been developed, and we would like to continue working on this field with you.

Remote operation by data glove of micro hand: under deployment in medical application

Research/Development Areas

Analyses and applications of rhythmic system in science and technology

## Professor / TOKUDA, Isao

Rhythmic phenomena, characterized as regular recurrence of pattern in time, are observed in a variety of systems in nature. Examples include rhythms in speech communications, rhythms in music plays, rhythmic walking, rhythmic heart beat, 24 hours biological rhythm, rhythmic flashing of fireflies, firing patterns of neuronal activities, planetary motion, and many others. Ensemble of such rhythmic elements leads to a rich collective behavior such as synchronization. In mechanical engineering, development of mechanical oscillators that can generate stable and precise rhythms provides one of the most fundamental technologies. In our laboratory, we construct mathematical models and experimental devices for rhythmic systems. Our aim is to develop basic theories and advanced applications in science and engineering. Our subjects cover a broad range of research fields from mechanics, robotics, computer science, neuroscience, and circadian rhythm to acoustics and music.

Physical model of vocal folds that can produce voice as human.

Research/Development Areas

## Micro machine design that puts the micro mechanics of solid fluids to practical use

### Professor / TORIYAMA, Toshiyuki

We are aiming at the realization of a micro power source of an ultra-small turbo machine etc. by putting micro machine system technology to practical use. The micro power source has been assumed to be a propulsion engine loaded on an ultra-small flying object. We are implementing element design and test production of centrifugal compressor, a can type premixing hydrogen combustor, a radial flow turbine and gas bearing etc configured with an impeller diffuser based on the thermodynamic cycle required for the propulsion engine. We are also implementing structural fluid design by dealing with the centrifugal force, thermal stress and heat conduction problems from the point of view of solid mechanics and the transonic fluid problem of the low Reynolds number from the point of view of aeromechanics. We are also aiming at resolving the electronic/dynamic behavior of piezoresistant material in which the application of a micro mechanical rate sensor like an acceleration sensor is expected, by applying micro mechanics to it.

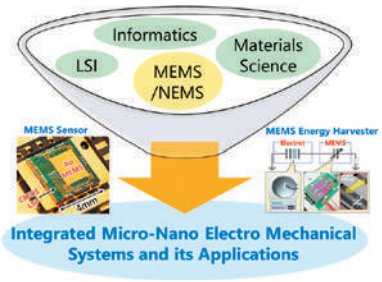
Silicon splitter impeller blade/reaction turbine blade of 10mm in diameter and fluid sealing structure (design point performance of rotation number of 900000rpm: pressure ratio 2, heat-insulating efficiency 0.5) that was experimentally produced by the processing technology with the micro machine system.

Research/Development Areas

## Integrated Micro-Nano Electro Mechanical Systems and its Applications

### Associate Professor / YAMANE, Daisuke

Our research interest is in the integration of micro/nano scale devices utilizing their electrical and mechanical properties. MEMS (Microelectromechanical Systems) and NEMS (Nanoelectromechanical Systems) are key technologies to the development of tiny sensors and actuators for the coming IoT/CPS (Internet of Things / Cyber-Physical Systems) era. Using MEMS/NEMS technology, we aim to realize seamless interaction between micro/nano devices, integrated circuits (e.g. CMOS-LSI) and nano-material properties, which contributes to maximizing the performance of chip-scale sensors, actuators and their integrated systems. Also, with the aid of informatics, we explore new smart applications employing such miniature electro-mechanical devices, enabling physical and digital worlds to be closely intertwined more than ever.




Currently, our research topics are (i) CMOS-MEMS sensors, (ii) MEMS energy harvesters, and (iii) micro/nano devices for secure IoT systems.

Research Concept | Micro Mechatro Systems Laboratory

# Major in Advanced Architectural, Environmental and Civil Engineering

**Master's Program** **Civil Engineering Course / Environmental Systems Engineering Course / Architecture and Urban Design Course**

Human life is not protected by medicine alone. Urban infrastructure also plays a critical role in assuring public safety. There is greater demand than ever before for experts in the field of engineering to work with other fields to solve the environmental problems of the 21st century, and to create a new atmosphere of positive action. With the end of Japan's era of high economic growth and the aging of Japanese society, the country has experienced an outcry for buildings and cities that are not dedicated only to efficiency, but focused on comfort and quality of life features, such as accessibility, as well as environmental considerations.

**Doctoral Program**

The Doctoral Program in Advanced Architectural, Environmental and Civil Engineering provides advanced education and research in the environmental and civil engineering fields. Students take part in systematic studies, from specific theories in civil system engineering, environmental system engineering, management skills development, and environmental policies in social sciences, to interdisciplinary studies of construction design and city design, and develop specialized knowledge and skills.

## Civil Engineering Course

Research/Development Areas

Environment Management and Disaster Mitigation in Forested Areas

Associate Professor / FUJIMOTO, Masamitsu

The number and scale of sediment disasters are increasing due to climate change. Frequent heavy rain and huge typhoons may cause severe disasters such as shallow and deep landslides, and debris flows as well as natural landslide dams across a wide area and they would seriously harm human life and activity. To protect our life and activity, we must understand the risks of sediment disasters and the countermeasures, especially in mountainous areas. In our laboratory, we conduct research on landslide phenomena using several methods, including onsite measurement of subsurface water (soil and groundwater) movement, laboratory landslide experiments, and numerical simulations of rain infiltration/groundwater movement/landslide processes. We are also seeking for effective countermeasures against sediment disasters that consider both conservation of the natural environment and the protection of human life.


Laboratory experiment and numerical simulation of landslide

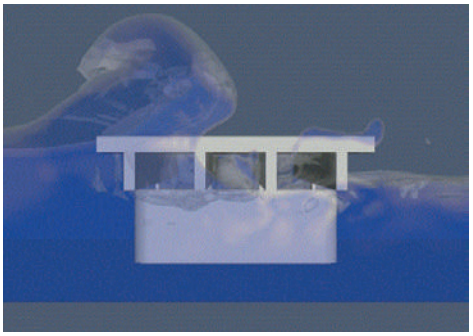
Research/Development Areas

Earthquake Disaster Mitigation of Bridges

Professor / IZUNO, Kazuyuki

As Japan is a highly seismic country, earthquake resistant design technique for infrastructures has progressed. Our laboratory promotes research aimed at protecting people, communities and their culture against earthquakes and other natural disasters.

Bridges are one of the most important infrastructures. Destruction of bridges can significantly compromise logistic operations, not only having a major impact on daily living activities but also delaying reconstruction of suffered area. We conduct experiments and numerical analyses to construct safe and robust bridges against earthquakes, tsunamis and floods to save invaluable human lives.



Simulation of tsunami surging toward a bridge

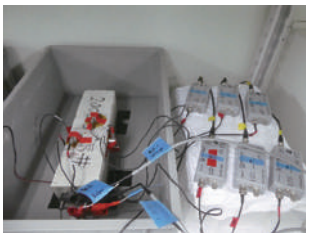
Research/Development Areas

Materials and structures for sustainable infrastructures

## Associate Professor / KAWASAKI, Yuma

Our lab. is mainly engaged in research related to infrastructures and concrete materials. Infrastructures support our daily life in various situations. Sometimes it even protects us from disasters. It protects not only people but also valuable culture and scenery. Appropriate and precise maintenance and management are necessary to ensure the safe and secure use of infrastructure in the future. We are conducting research on a wide range of topics, including damage assessment methods for infrastructure and their components for the purpose of disaster prevention and mitigation and the development of new applications for concrete materials. In particular, we are researching the early evaluation of reinforcing steel corrosion in concrete using non-destructive testing methods and evaluating the fracture process of concrete using slag aggregate. Among the non-destructive testing methods, we use the acoustic emission method.

■AE measurement to clarify fracture mechanism



■AE measurement to monitor rebar corrosion

Research/Development Areas

Design and planning of the urban community

## Associate Professor / KIM, Dowon

The main objective of research is the sharing the best practices of the urban communities` sustainability and its cultural/social identity. For this, a laboratory will focus on the method of analytics, field investigation, and communication tools development, and theorize these practices to transfer to the global context.

Nowadays, the collaboration of the various stakeholders is one of the very important key point for sustainable development in urban design and planning field. A university needs to join this collaboration to scientifically analyze, evaluate and suggest the design process of the urban place. The cultural, social identity and all the infrastructures in urban places are need to be designed with the academic experts. A laboratory will practically join this collaboration process with the engineering analysis tools by integrating the research methods of statistics, social science and geo informational system tools.

Research targeting area will be especially focus on the cities, urban districts and settlements in Japan. But for sharing the knowledge and the practices, a laboratory will definitely find the attractive cities and settlements in any other countries, to achieve the sustainable development (UNESCO's SDGs) and cultural resilience.

■Horikawa, an urban river where the basement of the local community's activity.

■Ponto-cho, the culturally and socially resilient community in Kyoto, Japan

Research/Development Areas

Soil investigation and its application to intelligent earthworks and geo-disaster prevention

## Professor / KOBAYASHI, Taizo

We are working on practical engineering studies related to "Ground" based on our two fields, "Soil mechanics" and "Soil investigation." Our recent activities include (1) hazard assessment of slope disaster using an in-situ investigation system, (2) development of intelligent earthwork equipment, (3) implementation of testing tools to maintenance of soil structures and (4) studies on interactions between robots and lunar/planetary surfaces in space exploration. What and how shall we obtain information of the ground with high uncertainty and heterogeneity? How shall we use that information for construction and maintenance? These are challenging researches that demand deep knowledge of soil mechanics, expertise in testing and sensor technologies, and among others, unique creative power.

■Subsurface soil strength measurement using a miniature borehole testing tool

■Quality assurance testing of soil compaction using a ground penetrating radar

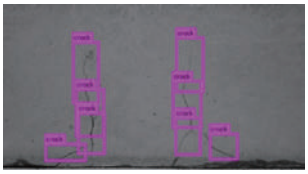
Research/Development Areas

Applied informatics to structural health and safety management

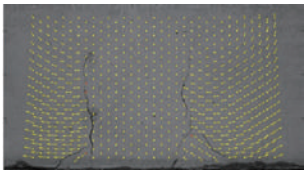
## Professor / NOMURA, Yasutoshi

Recently, monitoring the integrity of the structures accurately and reliably has become extremely important in various fields in order to increase operational lifetime and improve safety. To this end, numerous methods which include structural health monitoring (SHM) systems have been researched. SHM involves the observation of a structure over time using dynamic response measurements, the extraction of damage-sensitive features from these measurements, and the statistical analysis of these features to determine the current state of structural soundness.

Our laboratory is aiming to develop efficient/labor-saving SHM systems for social infrastructures by automating a series of inspection and diagnostic actions through utilization of Artificial Intelligence techniques and IoT systems. The current activities include (1) vibration-based abnormality detection for mechanical system, (2) structural damage localization based on deep learning, (3) quantification based on image correlation for localized damage and (4) structural parameter identification based on data assimilation.



■Damage localization by deep learning



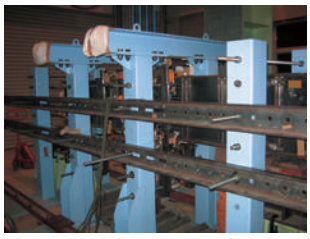
■Damage quantification by image correlation

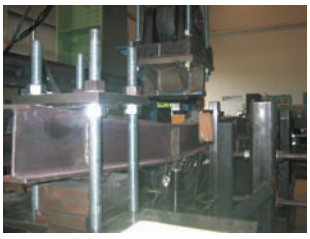
Research/Development Areas

Strength of steel structures, maintenance of steel bridges

## Professor / NOZAKA, Katsuyoshi

At the bridge engineering laboratory we mainly carry out research on the design of steel bridges and their maintenance. For use as data needed to design steel bridges economically we are clarifying the strength of members through experiments and analyses. Through experimental tests, it is possible for us to see and feel the strength of steel members and to get to know a bit about the strength of the structures our lives depend on. Many structures around us have been in public use for long time and some of those have some structural damages. Hence we are researching a method of safely using them for longer through maintenance and strengthening. As one possible method, we are studying the use of carbon fiber reinforced polymer (CFRP) plates. CFRP is light but has much strength and rigidity than steel material, and it has begun to attract attention as an effective material for strengthening and maintenance use in the future.





■Experiment on the strength of a steel girder
(Heavily deformed shape indicates the ductility of steel)

Research/Development Areas

Travel behavior analysis and traffic phenomenon analysis for urban transport planning

## Professor / OGAWA, Keiichi

We are carrying out research on urban transport that encompasses the movement of people in cities along with the movement of bicycles and vehicles on roads. In order to ease traffic congestion in cities and thus traffic jams and accidents the behavior of people moving in cities and the behavior of people driving cars need to be analyzed, and appropriate traffic management policies and road safety practices then considered.
Travel behavior such as with work trips, commuting to school and shopping is implemented by everyone on a daily basis, and thus is a field that involves behavior in everyday life, and therefore a target of research that can take place anywhere in people's daily lives.

■Video recording image used to analyze the movement of vehicles at a crossroad

Research/Development Areas

Creation and management of sustainable cities

## Professor / OKAI, Yuka

It is anticipated that due to depopulation and global environmental issues cities will shrink instead of expanding continuously.In this context, the modern city planning methodologies need to be reviewed to reflect the current status of urbanization, which can therefore contribute to creating rich, dynamic,and sustainable cities.
Our study focuses on the techniques for measuring the shrinking cities and the maintenance technologies in the advanced urbanized societies and advice on how to achieve sustainable cities, which can take advantage of the regional characteristics. We conduct research on the city systems, regional planning, and management systems of the cities that fully utilize participation and consultation offered by diversified bodies, including national and local governments, citizens, and NPOs. We also carry on comparative research on European cities and especially refer to the French cities.

■Lille (France)

Research/Development Areas

Design and city planning for environmental preservation and disaster mitigation in cultural heritage and historic city

## Professor / OKUBO, Takeyuki

The aim of our research is to design the safe and beautiful cities and regions in a composite study field, which incorporates the conservation of cultural heritage and disaster mitigation planning for cities, two areas that have traditionally been implemented separately. In particular, we are carrying out planning research for the revitalization and disaster-mitigation of historic areas related to the activities of "Institute of Disaster Mitigation for Urban Cultural Heritage". We are also committed to making a contribution to society in the creation of beautiful environments with abundant space and water that can be utilized even in case of earthquake triggered fires. This includes the creation of regional disaster mitigation plans for historical city-scapes with the participation of the local communities, the discovery of traditional knowledge of disaster mitigation in history, and effective evaluation by modern science. For example, we are also involved in the water resource development plan for disaster mitigation in the flammable and historical region around Kiyomizu-dera Temple, which is being put into practice by Kyoto-city. Through these kind of projects in Japan and overseas, we are taking part in practical research for making disaster mitigation plans and evaluations by inhabitants and the government for sustainable social services.

■Developed Easy Hydrant System using Stocked Rain Water: it can be operated by single person and equipped in Kiyomizu Historic District by Kyoto Fire Department.

Research/Development Areas

Seeking the ideal situation of a river basin

## Professor / SATOFUKA, Yoshifumi

Rivers are not just for channeling precipitation (rain and snow) down to the mouths of rivers but also for the cycle of various substances. Landslides carried by the flow of a river have generated changes in landforms and created various natural environments through the organic substances that form in mountainous areas and forests. However, people have evolved using the sustenance of rivers since early times and have changed river basins according to their wishes while being occasionally faced by disasters such as floods and sediment disasters. In recent years catchphrases such as protection and conservation of the natural environment have become in vogue and the opinion that the approach to rivers by humans should be controlled as much as possible is growing stronger. At this laboratory we are researching the outflow phenomenon of water and landslides in river basins and how it can change the form of the land. We are also researching a method sophisticatedly balancing human society with the river environments by confirming the effect of such phenomenon on ecological systems and past river development transitions etc.

■Checking the outflow process of water and landslides at the Kusatsu river basin where a new river road was constructed.

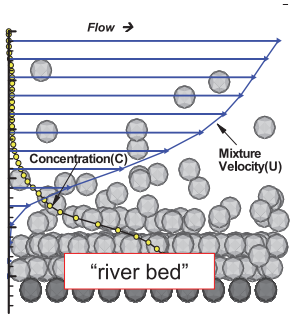
Research/Development Areas

Dynamics of riverbeds during flooding

## Professor / WELLS, John Craig

In the fluid mechanics laboratory, we are building a “nowcast system” to track the 3D distribution of temperature and water currents in Lake Biwa, which is the largest lake in Japan and supplies water for 14M. The system, one of the first “Operational Forecast Systems” of a lake or coastal sea in Japan, will combine available observations of the lake with computer simulations in the same way as Numerical Weather Forecasting, thus exemplifying Data Assimilation, the “Fifth Paradigm of Science”. A feature of this effort is the world’s first application of Acoustic Tomography to a lake, wherein we have obtained strong evidence of currents in the lake’s deep waters, based on small differences in the reciprocal acoustic travel times between pairs of SONAR-type transponders separated about 10 km.

We also study basic processes of sand particle motion on river beds, developing and experimentally verifying highly detailed computer simulations of erosion and deposition (see figure).




■World’s first “bedload DNS” developed at Ritsumeikan University.
In order to clarify bedload phenomenon a “direct” numerical simulation method that can handle heavily-concentrated solid-liquid two-phase turbulent flow, Direct Numerical Simulation; (“DNS”) was developed.

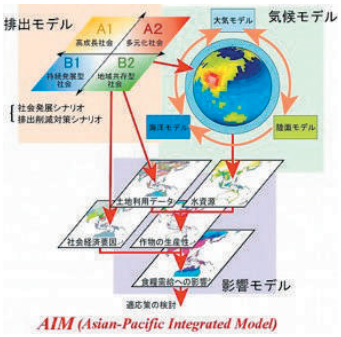
# Environmental Systems Engineering Course

Research/Development Areas

Integrated assessment of global environmental changes

## Associate Professor / HASEGAWA, Tomoko

Our laboratory conducts researches mainly on climate change mitigation, by integrating relevant discipline such as energy, economy, agriculture, land use, and water use into a single platform. We primarily focus on future greenhouse gas emissions, their reduction measures, economic implications of such climate mitigation policies and the economic impact of climate change. Moreover, beyond the climate change issue, to provide solutions to achieve broader sense of sustainable development is the newly focused area in our research field. We cover multi-scale areas spatially temporally. For instance, spatial resolution varies from national, Asia, to the globe and sometimes gridded scale analysis is carried out. The temporally coverage is near to long-term future such as next decade to entire this century.




■An integrated assessment model describing relationships between natural systems and human society

Research/Development Areas

Assessment and design of sustainable resource and waste management systems

## Professor / HASHIMOTO, Seiji

Development of a socioeconomic system that cyclically uses limited earth resources at an appropriate level is an important task to achieve a sustainable society, given an increasing and increasingly wealthy global population. Our laboratory intends to conduct research that contributes to the development of such a socioeconomic system from the viewpoint of a systems analysis approach. Our work will answer the following questions confronting Japan and the world:

- What is sustainable resource and waste management? How should progress to a sustainable resource and waste management be measured and assessed?
- What is the status of material cycles in our society? What will it be in the future? What technological systems of resource and waste management should be developed?
- What are people's attitudes related to sustainable resource and waste management? What social systems such as regulations and incentives should be developed for the formation of sustainable resource and waste management?

■Waste and resource issues are increasingly convergent.

Research/Development Areas

Evaluation and control of air quality/ malodors

## Professor / HIGUCHI, Takashi

Measurement techniques to evaluate air quality and odors, especially using human sense of smell, is studied. In Japan, the use of "olfactory measurement" to assess malodors has been established by legislation, and the purpose of this study is to find the way of its application to comprehensive evaluations of air quality in the environment.

And, a biological treatment system is being developed for use in removing gaseous organic compounds (VOCs or Volatile Organic Compounds), which are major air pollutants currently, and odorants. This equipment is generally known as "biological deodorization" or "biofiltration," and our research is focusing on high efficiency of pollutants removal and on fine control of microbial activity and biomass growth to achieve its practical use.

■Air sample at a spot of roadside is collected. Pollution level of the target air is evaluated using both human noses and instruments.

■A pilot apparatus of biofiltration system for the preparation of its practical use. Unique structures are equipped in gas-flow and filter material (patent has been approved)

Research/Development Areas

Phenomenon analysis for use in formulating environmental management plans and a policy analysis method

## Professor / ICHIKI, Atsushi

Lake Biwa, for example, has a vast water catchment area with 100 or more large and small rivers flowing into it, thus making comprehension of the contaminant outflow and outflow characteristics of the water catchment area necessary in formulating appropriate water management policy to conserve water quality and carrying out concrete facility developments to controlling the outflow load of contaminants. We are therefore clarifying the existing characteristics of contaminants, their behavior characterization that includes generation, accumulation and outflow, and the mechanism of pollution, and working at making inspections and suggestions of appropriate water management policy using policy simulations and an environmental management model. Some concrete research themes are given below.

- Dynamics analysis of contaminating substances/small amounts of harmful substances in urban or agricultural land
- Existing evaluations of urban activity-derived air-pollution substances
- Ecological risk evaluations of small amounts of harmful substance that exist in the environment
- Development of a contaminant outflow management support system for the water catchment area of Lake Biwa and evaluation of its availability
- Water quality formation process for Lake Biwa and its model

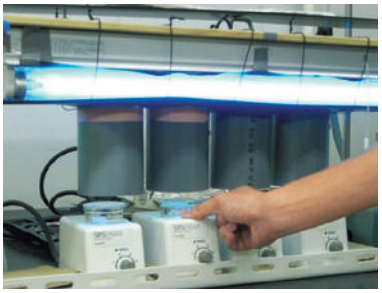
■Scene of river water quality survey from a ship in the Kapuas river in Indonesia

Research/Development Areas

Physicochemical processing method for safe tap water

## Professor / KAMIKO, Naoyuki

Running water is essential in our lives as we are use it for cooking, doing the laundry, bathing, and for drinking.
However, it has recently been discovered that a disease organism called cryptosporidium could be threatening the safety of water. Cryptosporidium gets discharged from infected warm-blooded animals to survive and propagate in another warm-blooded animal within a shell that is immune to disinfectant like chlorine.
Something that cryptosporidium is not immune to though is water being irradiated with ultraviolet light. However, if the amount of ultraviolet light is too small the disinfection process can be insufficient, but if too much is used the equipment or operation can be uneconomical. We are carrying out various inspections for use in the appropriate design and operation of ultraviolet disinfection.



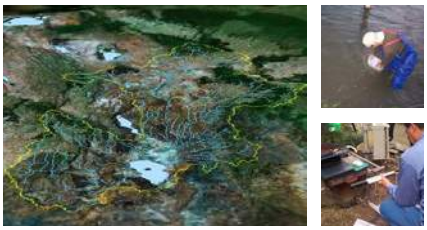
A Petri dish containing micro-organisms is sterilized using an ultraviolet lamp.

Research/Development Areas

1. Impact assessment to water resource and ecosystems by global climate changes
2. Model development and field application of an Integrated Lake Basin Management method
3. Vulnerability analysis of sea level rise, storm surge, and tsunami

## Associate Professor / SATO, Keisuke

There are serious water resource problems in the world. With forecasts of global warming and climate change intensifying in the future, safe and steady water supply will become more difficult for people and industries. It is therefore necessary to propose effective management techniques in our country that rely on the import of food and energy resources. In our laboratory, field investigation from lake Biwa and the Aso basin and experimental measurement of pollution loads are carried out. Moreover, an Integrated Simulation Model of atmosphere-soil-water-sediment has been developed. We use information technology, such as the latest global information obtained from GIS and satellites RS as an applicable method all over the world. Problem structures of water resource are comparatively analyzed in various regions. Additionally, by considering the limitation and environmental capacity in each region, new environmental policies are designed and evaluated quantitatively. Our final goal is to suggest more sustainable water resource management techniques.



A Bird's eye view of lake Baringo basin with GIS and Remote sensing, and a photo of the field investigation

Research/Development Areas

Implementation of intelligent transport systems for sustainable society

## Professor / SHIOMI, Yasuhiro

Transportation systems are one of the most essential infrastructures for our social activities and daily life. However, in densely populated area, traffic congestion, air pollution, traffic accidents and delayed public transportation annoy our daily life, while, in rural area, city area has been widely spreading due to motorization and the city center has been empty. It causes our society to decline sustainability, livability, and eco-friendliness. Our mission is to come up with smart and optimal transportation systems with "intelligence" and to achieve livable society. The fundamental research consists of the following three steps; i) getting better knowledge about the nature of transportation network dynamics, ii) developing methods to acquire these in sights, and iii) using this knowledge to come up with innovative traffic management approaches. The current research topics cover the following area: modeling traffic flow and driving behavior, developing traffic data collection technique and active traffic management systems, and analyzing traffic safety and travel behavior.


(Left) Active traffic management in the Netherlands,
(Right) Traffic survey in Makassar, Indonesia

Research/Development Areas

Wastewater treatment and resource recovery by using microorganisms and aquatic plants

## Professor / SODA, Satoshi

The purpose of our laboratory is to develop technology for wastewater treatment and resource recovery by exploiting the abilities of microorganisms and aquatic plants.

A lab-scale membrane bioreactor for removing persistent chemicals

(1) Design and control of the biological wastewater treatment process

A variety of approaches are used, including the design and operation of the bioreactor, the gene analysis of the microbes, and mathematical models for removing persistent chemicals and toxicants.

(2) Wastewater treatment and biomass production using constructed wetlands

We are surveying the constructed wetlands for treating landfill leachate in Southeast Asia. We are also testing the approach of converting the plant biomass that grows in a constructed wetland into biofuels and biomaterials.

Landfill leachate treatment using lab-scale constructed wetlands

(3) Environmental assessment for developing sustainable wastewater treatment processes

By the introduction of a variety of energy-saving and energy-generating technologies, we are exploring the design of future sustainable wastewater treatment process.

# Architecture and Urban Design Course

**Research/Development Areas**

Urban Design, Urban Planning, Architectural Design, Housing and Community Planning, Pre-Post Disaster Restoration

## Associate Professor / ABE, Toshihiko

In the field of urban design and planning, it's very important to propose the future plan, and build consensus with various stakeholders. We call it "Machizukuri", the collaborative method of urban design and community planning unique to Japan.
For example, we practiced an action research of Machizukuri to promote the restoration plan of Kesennuma City, which was struck by the tsunami by the Great East Japan Earthquake. We held design workshops using 3D models.
And we developed the Pre-Disaster Community-Reconstruction GIS System, in order to prepare for the Great Earthquake that will strike in the near future.
We are conducting practical research through collaboration with locals, various experts and students, widely in society, to develop the methodology of urban design and planning.

■Design workshop with locals using 3D models and CCD camera

■Disaster Restoration plan with small-scale multi-agent projects chains

**Research/Development Areas**

History of Architecture, Preservation of Historical Buildings

## Associate Professor / AOYAGI, Norimasa

Architecture is one of the existing academic fields for a long time among all study domains, therefore, needless to say, the building in our appearance stands on the accumulation of very long history, which creates the Culture of Architecture in our society. In the present age, it is required to understand it deeply and succeed to it without letting the culture disappear.
The study of Architectural History is aimed to expand our understanding of the architectural cultures, and can give a guidance to the contemporary architecture. Besides, existing historical buildings are naturally valuable inheritance to be succeeded since those fabrics convey past cultures.
In the laboratory, we perform investigations into historical architectural documents and practical preservation activities of historic architecture in Japan, mostly Kansai region. In order to achieve the aim mentioned above, it is required to have advanced ability to read, write and speak Japanese language.

**Research/Development Areas**

Architecture/urban environmental engineering, architectural equipment, environment coexistence

## Professor / CHIKAMOTO, Tomoyuki

We are carrying out research on the design of architecture and cities/city blocks that can coexist with the environment, clarifying humans comfort/physiological phenomenon, and the establishment of a low-carbon society.

**(1) Human-clarification of comfort/physiological phenomenon:**
We clarify the comfort and physiological phenomenon people experience through architecture and various spaces in cities in studying the architecture and urban spaces people feel comfortable with.

**(2) Architecture-energy saving efforts:**
We are promoting the development of next-generation air-conditioning/heat source systems that balance energy saving with comfort and an eco-campus in addition to making suggestions on and evaluating new merchant houses in Kyoto utilizing traditional knowledge and environmental coexistence type architecture.

**(3) City-safe city blocks/city designs that take the environment into consideration:**
We are evaluating and researching urban greening and city block designs that lead to control of the heat island affect.

**(4) Earth-aiming at a low-carbon society:**
We are aiming at the realization of being a low-carbon society by establishing a model that incorporates traffic and transportation in addition to architecture and cities.

■Researching reduction of heat island affect by reproducing a city in an experimental wind tunnel laboratory

**Research/Development Areas**

Durability of reinforced concrete structures, Soundness diagnosis technique of infrastructures

## Associate Professor / FUKUYAMA, Tomoko

During service period, buildings made of reinforced concrete are exposed to various deterioration environment. Then, deterioration factors permeate through concrete, reach to a steel bar, and initiate steel bar corrosion. Steel bar corrosion is a major issue for structural performance and durability of reinforced concrete buildings. Many nondestructive electrochemical techniques have been proposed to detect initiation of steel bar corrosion from the surface of the cover concrete. However, measured data sometimes is not in accord with the actual state of corrosion because of the electrochemical properties difference of cover concrete. Hence, our group specializes in characterizing the electrochemical properties of cement-based materials. To tie practical techniques and our research achievement, we are focusing on not only laboratory experiment but also field survey of existing buildings.

■Steel bar corrosion caused by chloride attack

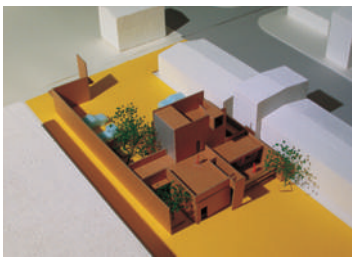
■Field survey at Battleship island known as Gunkan-jima in Japanese (I am the first person on the left in this photo.)

These were photographed with a Nagasaki City's special authorization.

Research/Development Areas
Architectural design process

## Professor / HIRAO, Kazuhiro

The concept and academic field of a “design process” exists with architecture and product design. It is a concept that evolved in the US and Germany in the 1960s, with researches on it having been carried out in the fields of industrial and architecture design.
Design cannot be promoted without a plan and is generally implemented with targets: (1) efficient allocation of time, (2) generation of ingenious ideas, (3) smooth formation of agreement with client/transmission of the intent of the design, (4) expressive presentation etc according to the plan. Performance can be improved by intentionally following these processes toward a specific result. From the methodology given above we focus on the expression technique such as in making sketches and invocation via the means of the imagination that are evolving in the planning field etc and carrying out research on verifying the efficiency of the processes using actual projects and competitions.



■Project model

Research/Development Areas
Light and Lighting, Lighting Design, Day Light Using, Lighting Related Technology

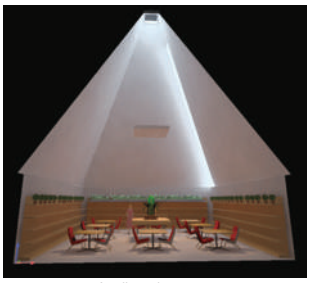
## Professor / HONMA, Mutsuo

What are we living for? What is the meaning of life on earth?
I firmly believe we were born to be happy and content.
If so, how should we live our lives to become happy?

Naturally, I don’t completely know how to live to become happy.

Thus, at this moment in time my policy is to focus on what I can do in moving forward. Our laboratory is studying environmentally designed lighting and related technology with the aim of developing happiness within people.

Let’s join this pursuit of happiness together by studying and creating a suitable environment for a happier life by further developing lighting design and related technology!



April 27th 13:25

April 27th 20:00

■Simulation image “Homage to Casa das Histórias Paula Rego by Souto de Moura”

Research/Development Areas
Analysis of hygrothermal environment of buildings, Evaluation of human sensations

## Associate Professor / LEE, Myonghyang

In recent years, the demand for a highly efficient and comfortable hygrothermal environment has increased. Therefore, it is necessary to consider the heat insulation, air-tightness performance, the indoor residential environmental performance and the equipment efficiency, etc. of the building at the planning phase. In order to create an energy-saving and comfortable living environment, we are researching on the durability of the building, the human health, the energy conservation and the thermal comfort.
The main research themes are as follows;
(1) Effective utilization of the natural energy of the passive and active methods
(2) Proposal of the high performance building for the energy conservation
(3) Dynamic prediction and evaluation of the hygrothermal environment of the whole buildings
(4) Development of the building envelope system for high durability (evaluation of moisture condensation proof)
(5) Evaluation of thermal comfort of the human body
(6) Coupled analysis of the building environment and human sensation of thermal comfort
(7) Optimal operation and installation of high efficiency equipment

■The high performance building utilizing hygrothermal property of red pine plank

Research/Development Areas
Buildings Production, Construction Materials and Structural design

## Professor / MOCHIDA, Yasuhide

In a design process and the construction process of the building, we perform the original actions that are specialized in each. And we continue working hard to adapt to the demand of the times enough. I contribute to the society by building the convenient facilities and unprecedented huge space. Lately, we do not only construct new buildings. The preservation of an old building, the creation of the long-lived building and the consideration to natural environments become important. My present studies relate to the communication and management in the construction. For example, the research and development on method of the earthquake reinforcement including seismic Isolation retrofit. The maintenance by the dry crazing control technology of concrete structures. The development of relays such as a carbon fiber rod using the thermoplastic resin or the high-strength fiber composition laminated lumber. Application of information and communication technology in the quality control of the ground improvement body using electric ratio resistance investigation.

■Production scenery of the carbon fiber rod specimen of the impregnation in thermoplastic resin

■Visit scenery of concrete placing work

Research/Development Areas

Providing new design methodologies for architecture and working on practical architectural projects

## Professor / MUNEMOTO, Shinsaku

The purpose of our laboratory is to provide design methodologies for architecture that are based on human senses and behavior. For many designers it is difficult to explain these ideas clearly. Even though there are already many basic, established theories on architectural planning and design, the conceptualization of a design is primarily based on one's personal sense and knowledge base without obvious evidence. In response to this, our laboratory is trying to incorporate the modeling of human feelings, eye motion and brain activities into design methods for the solution of such problems. We are also working on practical architectural projects and international competitions as another avenue towards developing methodologies for the design of new architecture.

■Discussion of projects making models and drawings

Research/Development Areas

Expansion and sophistication of design through architectural informatics and human science

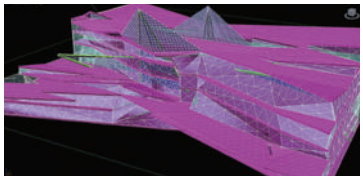
## Associate Professor / YAMADA, Satoshi

**Expansion and sophistication of design through architectural informatics and human science**

My research theme is the "Co-creation of information technology and people in the field of architectural and urban design," with a specialty in architectural informatics. This discipline consists of many elements of information technology, including computer aided design (CAD), computer graphics (CG), extended reality (xR), building information modeling (BIM), geographic information system (GIS), the internet of things (IoT), simulation, data science, machine learning, and deep learning. Each field comprises numerous possibilities and great enjoyment. My research theme is to explore planning methods that include the coordination of these fields.

In the field of artificial intelligence (AI), we are aiming for "co-creation between AI and humans" with AI as a partner for sensibility prediction and design generation. In the xR field, we aim to construct "xR architectural theory" by elucidating the "human science of the xR space" such as human behavior, perception, and cognition in virtual and mixed reality worlds. In the research using IoT, we aim at "dynamic spatial design with spatial OS" in which the space changes according to the storage and prediction of human actions, emotions, and tacit knowledge.

Some of our research and classes are available on our lab page. Please have a look.



■A state of examining and analyzing the design

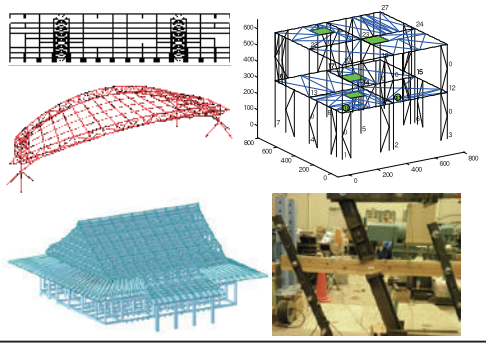
Research/Development Areas

Logical structural design method based on principles of mechanics

## Professor / YOSHITOMI, Shinta

Our laboratory is developing following techniques for analysis and design of building structures based on structural mechanics or principles of mechanics.

(1) Logical structural design method based on structural optimization method to determine shapes, sectional sizes and member placement of building structures.
(2) New vibration control systems and base isolation systems and logical design method for these systems.
(3) Smart techniques for damage detection or health monitoring of building structures.
(4) Methodology to evaluate seismic performance and dynamic behavior of Japanese traditional timber structure based on simulations with detailed 3D models or experimental tests.



# Graduate School Application Information

## Important Dates

| | Regular Admission |
|---|---|
| Application Information Available | Late October |
| Application Deadline | Mid-January |
| Admission Results Released | Early March |
| Scholarship Results Released | Early March |
| Classes Begin | Late September |

Regular Admission: http://www.ritsumei.ac.jp/gsse/eng/fs/apply/application.html/

## Pre-Enrollment Scholarship Details

| Scholarship Provider | Key Qualifications | Benefits | Period |
|---|---|---|---|
| Monbukagakusho (MEXT)<br>University Recommendation Scholarship | Age: Under 35<br>Level: Master or Doctoral<br>Compelling Research Topic | Full tuition covered<br>Round-trip ticket to Japan<br>Monthly living expenses | Generally the standard period of study |

Recommendees for the MEXT University Recommendation Scholarship at this graduate school are chosen from the pool of GSSE Regular Admissions applicants. If you wish to be considered for recommendation for MEXT Scholarship at GSSE, follow the instructions for Regular Admissions procedures at the above website.

## Admission Fee (Academic Year 2022 Entry)

(JPY)

| Category | Type of fee | Fee |
|---|---|---|
| Admission<br>Transfer Admission | Admission Fee | 200,000 |

Note: Payment of the admission fee is required in the year of admission only.

## Tuition for Graduate Schools (Academic Year 2022 Entry)

* Tuition fees may be revised when social factors, such as rapid inflation, have a significant impact on the university.

Updated March 2022
The information in this document is subject to change.

(1) Master's Program

(JPY)

| Graduate School | | | 1st Year | | 2nd Year | |
|---|---|---|---|---|---|---|
| | | | 1st Semester | 2nd Semester | 1st Semester | 2nd Semester |
| Science and Engineering (except for Mathematics Course) | | Tuition | 584,800 | 584,800 | 584,800 | 584,800 |
| | | Total | 1,169,600 | | 1,169,600 | |
| | Mathematics Course | Tuition | 546,600 | 546,600 | 546,600 | 546,600 |
| | | Total | 1,093,200 | | 1,093,200 | |

Note: Students whose duration of enrollment has exceeded the standard period of study will be charged half of the amount of the semester tuition fees in effect for that academic year.

(2) Doctoral Program

(JPY)

| Graduate School | | 1st Year | | 2nd Year | | 3rd Year | | 4th Year and after |
|---|---|---|---|---|---|---|---|---|
| | | 1st Semester | 2nd Semester | 1st Semester | 2nd Semester | 1st Semester | 2nd Semester | Per Semester |
| All Graduate Schools | Tuition | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 250,000 | 100,000 or 25,000 |
| | Total | 500,000 | | 500,000 | | 500,000 | | |

## Application FAQ

### Q1. What are the application requirements?

Requirements differ based on the application process. Please refer to the websites listed on the previous page for the appropriate eligibility criteria, required documents and deadlines.

### Q2. What is the minimum TOEFL®, etc. score required to apply?

There is no minimum requirement, but all applicants are required to submit a certificate from an English language testing agency such as TOEIC®/TOEFL®/IELTS so we can evaluate their language ability.

### Q3. I studied in English for my undergraduate degree. Do I really need to submit a TOEFL®, etc. score?

Yes. All applicants must submit a score from an internationally recognized, standardized English language proficiency test, regardless of their previous academic experience or official language in their home country.

### Q4. Must I specify my desired supervisor before applying?

Yes. All applicants must receive an informal OK for research supervision from their desired supervising professor and write the supervisor's name in the application form, regardless of their application type.

### Q5. How can I view your list of researchers/professors?

Please refer to the Researchers page to browse an index of our researchers/professors at:
http://www.ritsumei.ac.jp/gsse/eng/academics/researchers.html/

### Q6. How can I contact researchers/professors?

If a researcher's/professor's email address is not open to public, please make a request to get in direct contact with them by emailing the Graduate School of Science and Engineering Administrative Office at: se-admw1@st.ritsumei.ac.jp

### Q7. What is the screening procedure like?

Screening is conducted primarily based on submitted documents, but an interview via email/telephone/etc. may be conducted if necessary.

### Q8. Do you have spring semester admission?

The English-language curriculum starts in September. Therefore, we cannot accept applicants for the English-language programs in spring. For details, please see the Admissions Countdown page at:
http://www.ritsumei.ac.jp/gsse/eng/admissions/countdown.html/

### Q9. Is Japanese language ability required?

Since lectures are conducted in English, students are not required to have Japanese language ability. However, some knowledge of the Japanese language would make it easier to transition into living in Japan. Students may also take various Japanese language courses to orient them to day-to-day life in Japan and to aid interaction with other students within their research laboratories.

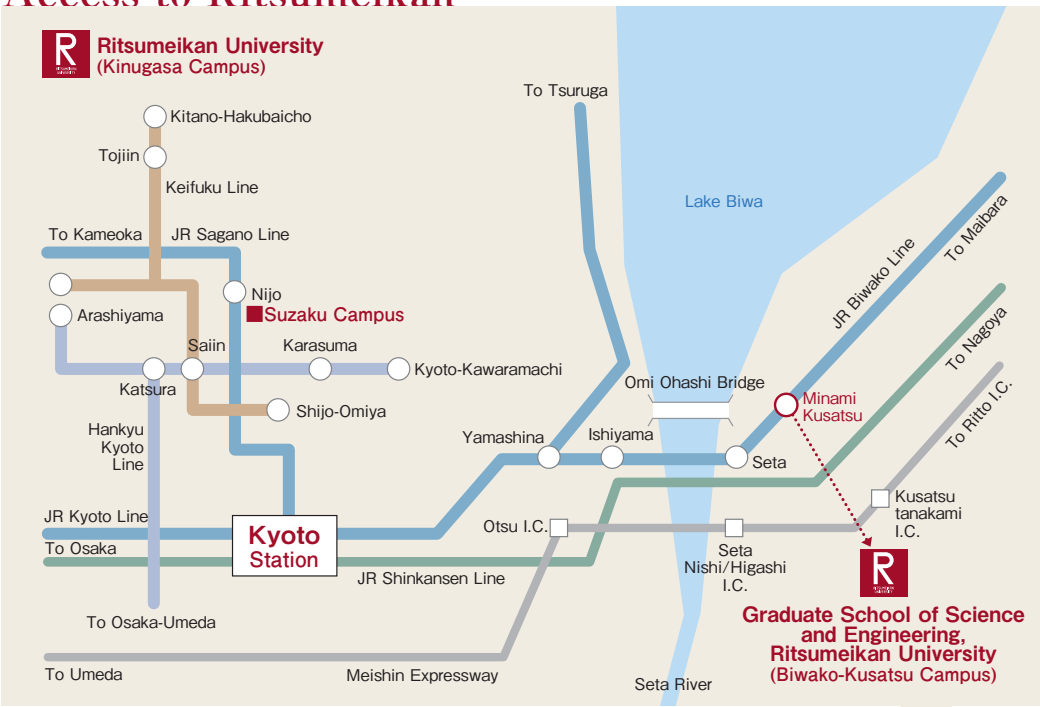
### Q10. Can I review what graduates have researched in the past?

Please refer to the Past Research Topics page at:
http://www.ritsumei.ac.jp/gsse/eng/academics/past.html/

### Q11. If I have other inquiries, who should I contact?

Please send an email to: se-admw1@st.ritsumei.ac.jp

# Access to Ritsumeikan




## To Get to the Biwako-Kusatsu Campus of Ritsumeikan University

### From Osaka or Kyoto

Take the JR to Minami Kusatsu Station ( 50 minutes from Osaka, 20 minutes from Kyoto). Exit the station on the south side ( turning right after passing through the ticket gates). Take an Omi Railways Bus designated as either "Ritsumeikan Daigaku yuki（立命館大学行き）" or "Ritsumeikan Daigaku keiyu Tobishima Green Hill yuki (立命館大学経由飛島グリーンヒル行き)" and get off at "Ritsumeikan Daigaku（立命館大学）"( 8 minutes).

## For More Information

Please refer to the homepage for the latest information on scholarships, housing and other assistance.

**HP: http://www.ritsumei.ac.jp/gsse/eng/**


RITSUMEIKAN UNIVERSITY

**Graduate School of Science and Engineering**
**Ritsumeikan University**

Biwako-Kusatsu Campus 1-1-1 Noji Higashi, Kusatsu, Shiga 525-8577, JAPAN
Tel: +81-77-561-2624
Fax: +81-77-561-2890