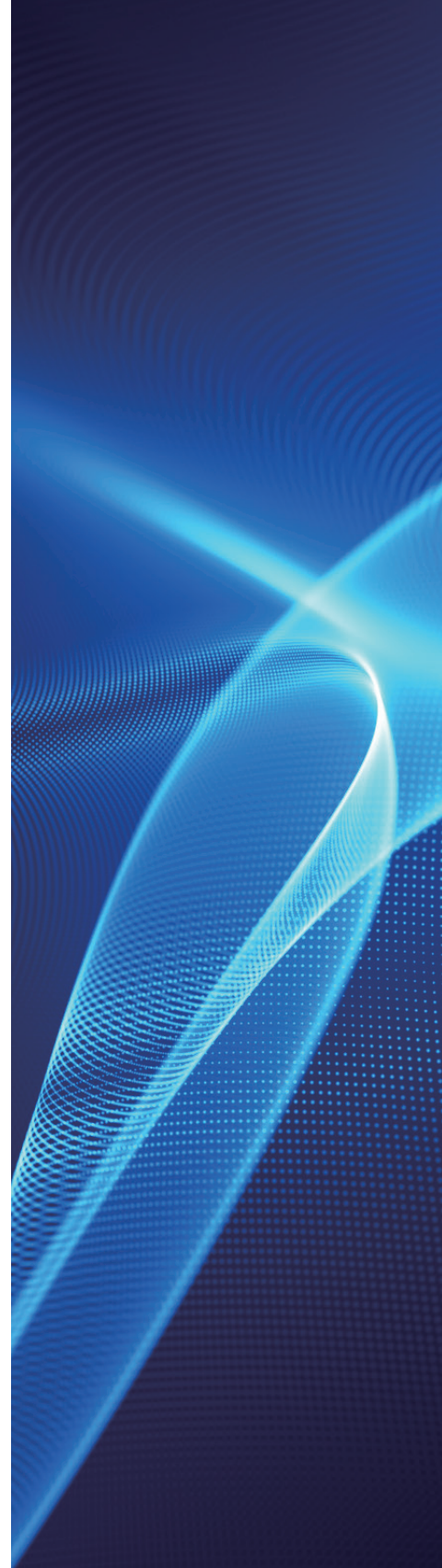


Research Highlights

Fukuoka Institute of Technology
Comprehensive Research Organization



Research Highlights

Fukuoka Institute of Technology
Comprehensive Research Organization

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Study of Remote Sensing Method using Micro-wave and Millimeter-wave

Professor, Department of Information Electronics, Faculty of Engineering

KOGI Yuuichiro

Research Outline

Recently occurring natural disasters are increasing in scale and threatening the lives and properties of citizens. Although early detection of flood and landslide disasters due to localized torrential rain, tsunamis, volcanic eruptions, etc., is extremely important for disaster mitigation, methods for collecting information during nighttime and rainy weather have yet to be established.

Thus, in our research, we are developing an airborne high-resolution imaging radar for observing changes in ground surface to aid disaster mitigation. Research

contents include research and development of imaging radar hardware and establishment of ground surface microvariation detection methods through research on methods for processing the data acquired by the hardware.

So far, we have developed the radar hardware shown in Fig.1, have conducted ground tests (Fig.2) and flight tests, and have succeeded in acquiring radar images of the same level of resolution as satellite photographs (Fig.3).



Fig.1. LiveSAR hardware.



Fig.2. Ground test conditions.

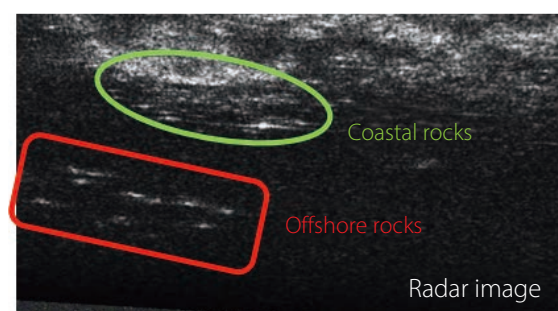


Fig.3. Comparison of satellite photograph and radar image.

Research Field(s)

Instrumentation engineering

Keywords

Radar technology, Tsunami wave gauge, Flood inundation area monitoring, Moving body detection

■ Advantages and Features

- A radar capable of acquiring high-resolution images can be installed on aircraft to enable mobile operation when a disaster occurs.
- Image acquisition in travel correction mode enables acquisition of high-resolution images in near real time.
- Use of high-resolution images enables finer observation of ground surface microvariations.

■ Application Fields

Disaster prevention, disaster mitigation, and moving body detection

■ Patents

Japanese Patent No. 5035782 "Split beam synthetic aperture radar"



Reinforcement Learning-based Driver Modeling for Probabilistic Collision Risk Assessment

Professor, Department of Information Electronics,
Faculty of Engineering

MATSUKI Yuji

■ Research Outline

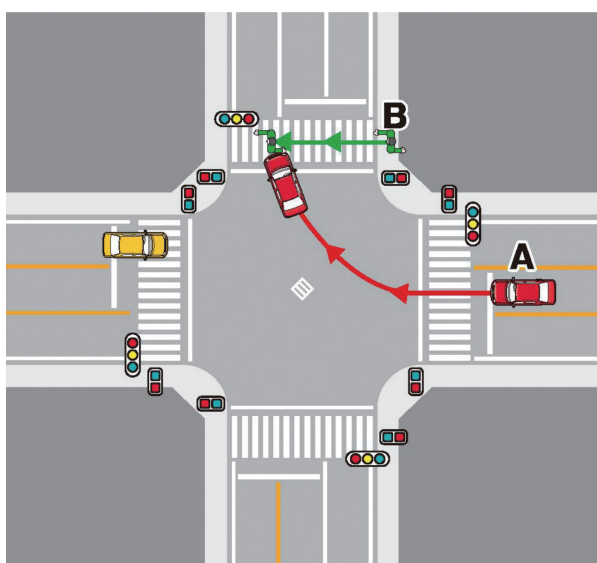
Our research aimed to develop a new method for quantitatively evaluating traffic accident risks at intersections. Driver behavior is extremely complex and was therefore considered difficult to model mathematically. Especially in a complex driving situation such as right-turning, there was a problem in that it was not possible to apply conventional risk assessment methods.

In order to solve such problems, we used reinforcement learning, which is a form of machine learning, to create a driver model of passing through an intersection. In this driver model, a person's visual field characteristics, driving operation amounts, etc., are restricted in the same way as in reality and learning is performed in order to make a right turn toward a destination under

these restrictions.

By using this driver model, it has become possible to simulate the ways in which road environments and traffic environments influence collision risks at intersections.

We are presently planning to create a versatile driver model that would enable assessment of driving risks not just in right turning but in other situations as well. It is anticipated that through this research, the conventionally difficult qualitative assessment of collision risks in complex driving situations will be made possible to aid in driver education and development of safe driving support devices.



◆ Characteristics of right-turn accidents at signal-controlled intersections

- Accidents at signal-controlled intersections occur most frequently during “right turning” of a primary four-wheeled vehicle.
- Accidents occur when both the primary and secondary vehicles enter an intersection in a “green light.”
- A leading cause of these accidents is the “failure to ensure safety” by the right-turning primary four-wheeled vehicle.
- Bicycles or pedestrians beyond the right turn are easily overlooked due to distractions from oncoming

Research Field(s)

Human engineering, Social system studies, Traffic psychology

Keywords

Machine learning, Traffic accidents, Driver model, Collision probability

vehicles.

- During nighttime, bicycles or pedestrians moving in the same direction are often overlooked.

Precautions for avoiding accidents

- A driver of a right-turning four-wheeled vehicle should:
 - Always stop and carefully ensure safety in circumstances where it is difficult to view the opposite traffic lane;
 - Upon seeing an oncoming vehicle, wait until it passes and not take chances; and
 - Before starting the right turn, check safety beyond the right turn and decelerate adequately in front of a pedestrian crossing.
- For their own safety, bicycle riders or pedestrians should:
 - Not be careless just because one has priority but should carefully watch movements of right-turning four-wheeled vehicles until the end.
 - During nighttime, it is important to make one's presence be noticed by turning on a bicycle lamp, etc.
 - Bicycles should travel on the left side of a roadway. Even if sidewalks enable passage of bicycles, one should avoid bicycle travel on a right-side sidewalk and be mindful to travel on a left-side sidewalk.

Fig.: Diagram of accident case circumstances and characteristics of accidents at signal-controlled intersections (sourced from "ITARDA INFORMATION," Institute for Traffic Accident Research and Data Analysis)

Advantages and Features

Conventionally difficult qualitative assessment of driving risks will be made possible.

Application Fields

Safe driving education and development of safe driving support devices



3D Camera: Automatic Three-Dimensional Image Measurement System

Professor, Department of Information Electronics,
Faculty of Engineering

LU Cunwei

■ Research Outline

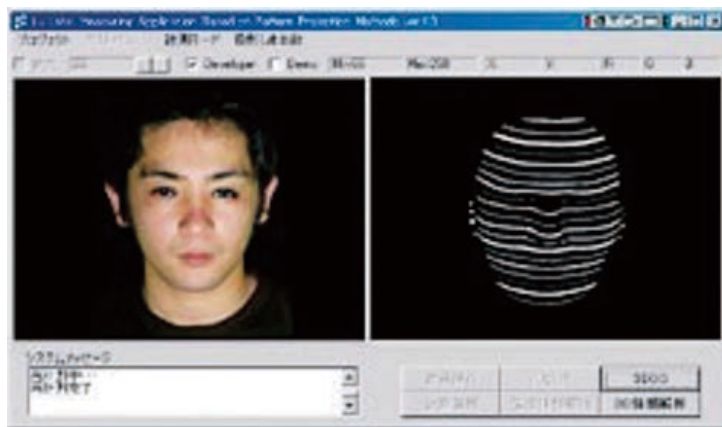
Although only two-dimensional (2D) photographs can be taken with a general digital camera, with the 3D camera developed by our laboratory, three-dimensional (3D) information on surface shapes of measured objects can be acquired using optimal pattern projection 3D image measurement and other patented technologies invented by the researcher

himself. 3D shapes, areas, volumes, spatial distances, etc., of objects can thereby be calculated without contact and in real time.

The novelty and practical utility of these technologies have been verified through joint research with several companies.



Measurement device.



Main screen of measurement software.



Measurement results.

Research Field(s)

Measurement, Quality control,
Image processing

Keywords

3D image measurement

Advantages and Features

- 3D surface shape information of measured objects can be acquired at high speed without contact.
- 3D surface shape information not only of stationary objects but also of nonstationary measured objects can be acquired.
- Application to human body measurement is possible because a laser is not used.

Application Fields

- Product shape measurement, appearance inspection, quality control
- 3D shape acquisition of human bodies, 3D facial recognition, safety and security
- 3D modeling, model generation for 3D printers

Patents

- Japanese Patent No. 4883517 “Three-dimensional measuring apparatus, three-dimensional measuring method, and three-dimensional measuring program”
- Japanese Patent No. 4986679 “Three-dimensional measuring apparatus, three-dimensional measuring method, and three-dimensional measuring program for nonstationary objects”
- United States Patent No. 7,583,391
“Three-dimensional measuring apparatus, three-dimensional measuring method, and three-dimensional measuring program”
- Chinese Patent ZL200580039510.9
“Three-dimensional measuring apparatus, three-dimensional measuring method, and three-dimensional measuring program”
- Chinese Patent ZL200880010126.X
“Three-dimensional measuring apparatus, three-dimensional measuring method, and three-dimensional measuring program for nonstationary objects”
- Hongkong Patent HK1139199
“Three-dimensional measuring apparatus, three-dimensional measuring method, and three-dimensional measuring program for nonstationary objects” and 9 other Japanese patents and 3 other Chinese patents



Research on Novel Phenomena in Quantum Devices

Associate Professor, Department of Information Electronics, Faculty of Engineering

NAKAMURA Taketomo

■ Research Outline

Conventional electronic devices realize their functions by applying electric fields, which control the density and momentum of carriers, such as electrons and holes, in materials. However, new devices that utilize magnetic and/or quantum mechanical effects have come out in recent years. For example, electrons and holes have spins in addition to the charge, and the spins enable us to develop low power consumption devices and non-volatile memory of both high durability and high-speed operation. Also, some materials show phase transition at certain temperatures, and their resistance becomes zero. This is called superconductivity, one of the quantum phenomena, which gives rise to various quantum

effects. Superconductors are not only used as a conducting wire but also as a material for magnetic sensors of ultrahigh sensitivity or high-performance filters, etc. In addition, superconducting devices serve important roles in quantum computers, one of IT's hottest topics.

In our research group, we fabricate novel spintronic and superconducting devices on semiconductors and/or new materials, such as graphene, and measure their physical properties. We also discuss the physics in the devices and the materials, and develop fabrication processes and measurement techniques.

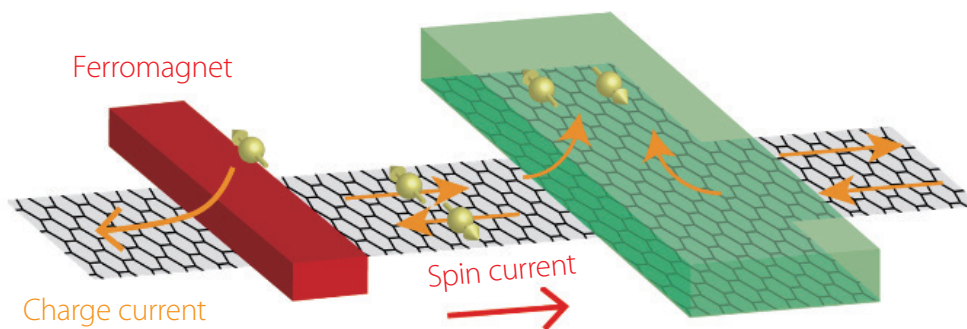


Fig.1. Spin-to-charge conversion on graphene. Spin polarized electrons are injected into the graphene and di used as pure spin current, which carries the angular momentum without energy loss. The spin current is converted to the charge current at the right side, that is, the information is transmitted to the right side without energy dissipation.

Research Field(s)

Superconducting electronics,
Semiconductor devices, Spintronics

Keywords

Superconductivity, Semiconductors,
Spintronics, Two-dimensional systems

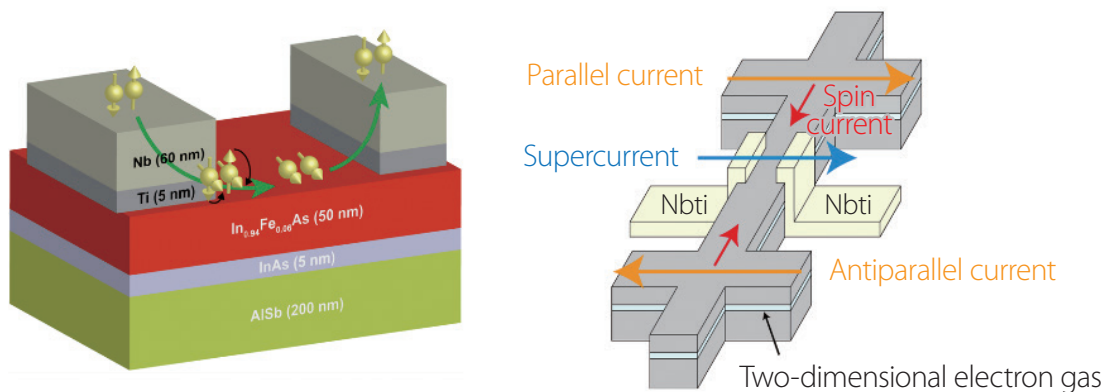


Fig.2. (Left) Schematic image of a superconducting device which generates spin-triplet superconductivity in a ferromagnetic semiconductor and (Right) Schematic image of a method to control the supercurrent using spin current. The spin-triplet superconductivity is one of the key phenomena in super-spintronics, because it carries the charge and spin with zero resistance.

Advantages and Features

Low power, high speed, and high performance devices.

Application Fields

Non-volatile memories, logic elements, superconducting computers, quantum computers



Research on Development and Practical Utilization of Taste Sensors Using Artificial Lipid Membranes

Assistant Professor, Department of Information Electronics, Faculty of Engineering
WU Xiao

Research Outline

In Japan and other countries of the world that are entering the aged society, whereas eating is an act necessary for living, eating tastily serves an important role for attaining joy and happiness. Physiologically, the tastes that a person senses include the five basic tastes of salty, sweet, sour, bitter, and umami and additionally, there are tastes in a broad sense such as astringency

and pungency that stimulate the sense of pain. Lipid membranes are present on the cell membranes of taste cells present on the tongue and inside the oral cavity of a human being and these interact with receptors for taste substances to generate nerve signals for sensing taste.

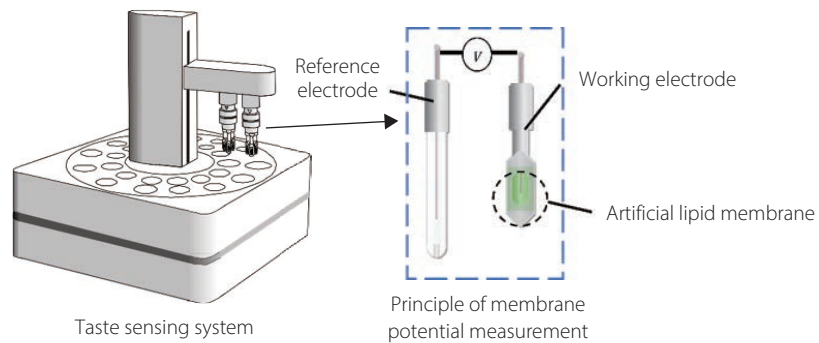


Fig.1. Taste sensor.



Fig.2. Mapping of world beers¹⁾.

Research Field(s)

Sensing devices, Sensitivity measurement evaluation

Keywords

Lipid membrane, Membrane potential, Taste sensor, Global selectivity

In our laboratory, we are engaged in research aimed at development and practical utilization of taste sensors using artificial lipid membranes that imitate biological membranes. An artificial lipid membrane is constituted of a lipid, a modifier, a plasticizer, and polyvinyl chloride and we are aiming at measuring the types and amounts of taste substances present in foods by making use of changes in electrical characteristics of the membranes that occur upon interaction with taste substances.

Although taste sensors are already being put to practical use presently, since these are based on membrane potential measurement, there are issues in measuring neutral or weakly charged taste substances. Thus, in our laboratory, we are engaged in new development of sweetness sensors for sugars and sensors for detecting uncharged bitter substances. We are also examining methods for improving the versatility of taste sensors and solving issues toward practical utilization. These research results are anticipated to be useful in realizing more advanced taste sensing technologies in the food industry and medical field in the future.

Reference

[1] Xiao Wu, Kiyoshi Toko, Taste sensor with multiarray lipid/polymer membranes, Trends in Analytical Chemistry, 158, 116874 (2023)

Advantages and Features

Various receptor membranes of a taste sensor respond selectively to various taste qualities. This property is called “global selectivity.” In contrast to the high selectivity of a conventional chemical/biological sensor to a chemical substance, a taste sensor classifies chemical substances according to taste, not according to individual chemical substances, and has selectivity to taste such as sour and bitter. In our research, we are carrying out joint studies with the Research and Development Center for Five-Sense Devices, Kyushu University.

Application Fields

- Food/pharmaceuticals development
- Quality control of foods and drinks
- Marketing/business globalization of foods and drinks
- Detection of chemical substances in the environment



Analysis of Regulatory Mechanisms for Stem Cell Fate

Professor, Department of Life, Environment and Applied Chemistry, Faculty of Engineering

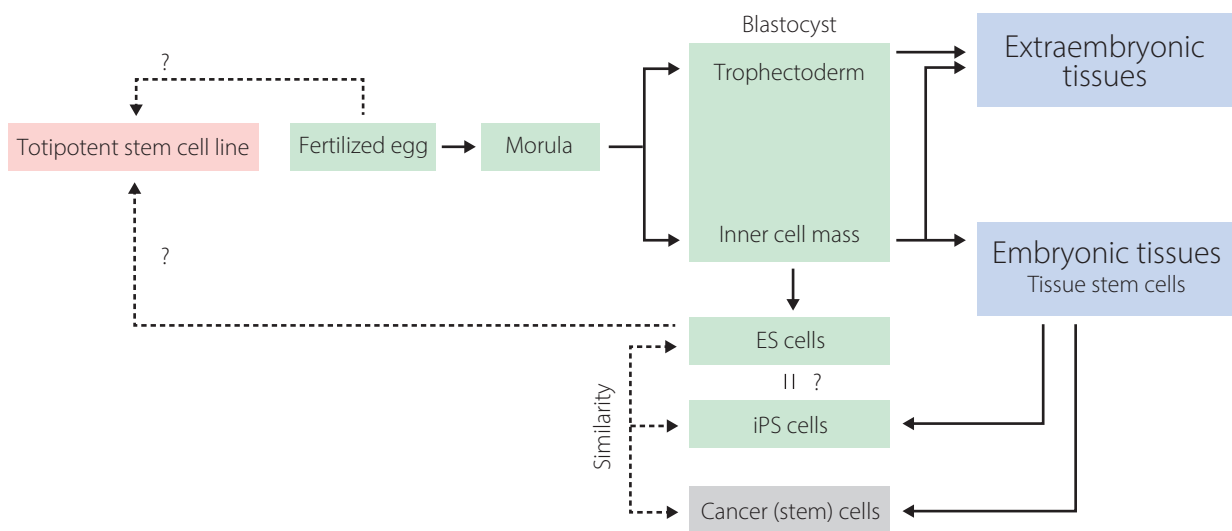
AKAGI Tadayuki

Research Outline

Our human "body" is believed to be composed of around 200 types of cells, totaling in the trillions. This diverse "body" actually originates from just a single cell—the fertilized egg—formed when sperm and egg come together. In simpler terms, this fertilized egg is the fundamental "stem cell" from which all other cells arise. ES cells are cells obtained a few days after fertilization and are known as "pluripotent stem cells". The fertilized egg goes through multiple rounds of cell division, leading to the creation of various tissues and organs that make up the body. Within each tissue, there

are specific tissue stem cells like hematopoietic and intestinal stem cells, which contribute to maintaining and regenerating the tissue. Additionally, as we age, cells within tissues might transform into cancer cells, giving rise to cancer stem cells. In our research, we focus on investigating the mechanisms that control the fate of stem cells, using ES cells (pluripotent stem cells), hematopoietic stem cells (tissue stem cells), and cancer stem cells as models.

Analysis of Regulatory Mechanisms for Stem Cell Fate



Research Field(s)

Molecular cell biology, Stem cell biology

Keywords

Pluripotent stem cell, Hematopoietic stem cell, Transcription factor, Proliferation, Differentiation

■ Advantages and Features

Recent studies have indicated that ES cells (pluripotent stem cells) and cancer cells/cancer stem cells share similar properties. In our research, we concentrated on exploring this similarity with the goal of uncovering novel pathways for regulating stem cell fate. This was achieved through the examination of gene clusters implicated in the oncogenic transformation of normal cells.

■ Application Fields

ES cells (pluripotent stem cells) possess the remarkable ability to differentiate into a diverse array of cells constituting an organism. However, ES cells are incapable of generating placental and extraembryonic tissues. We believe that elucidating the regulatory mechanisms governing stem cell fate would pave the way for the development of "totipotent stem cell lines," capable of giving rise to all cell types contributing to the formation of a complete living organism.



Chemical Exploration by Theoretical Chemistry and Computer Simulation

Professor, Department of Life, Environment and Applied Chemistry, Faculty of Engineering

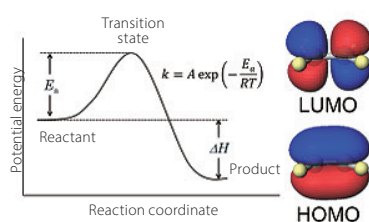
KAMACHI Takashi

Research Outline

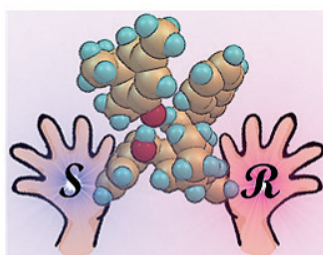
By using methods of computational chemistry, the structure of a molecule, the energy change accompanying a reaction, and other information that cannot be made known by experimental methods can be obtained comparatively easily. The importance of collaboration of computational chemistry and experimental chemistry is thus widely recognized today. Due to dramatic improvements in computers, this trend is accelerating in various fields related to chemistry.

In our laboratory, we are deploying theoretical research based on techniques of reaction mechanism analysis by quantum chemical computation. Thermodynamic data such as heat of reaction, activation energy, etc., that are also important for plant design can be

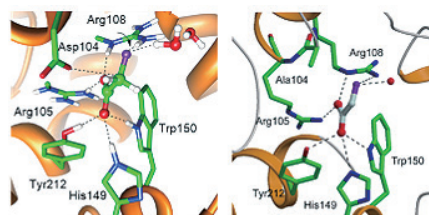
evaluated with high precision and reaction mechanisms can be clarified thereby. Predictions concerning reaction selectivity can also be made based on reaction kinetics and molecular orbital analysis. In recent years, the QM/MM methods have made it possible to apply computational chemistry methods even to macroscopic systems with over 10,000 atoms and realize docking simulations of high precision. This is anticipated for application to drug development. We are presently tackling such challenging themes as software development aimed at rational design of organic molecular catalysts exhibiting high enantioselectivity and catalyst development based on informatics such as machine learning, etc., that are gaining attention currently.



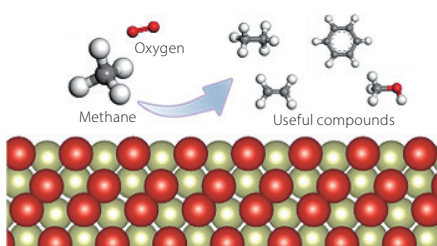
Reaction mechanism analysis.



Rational design of organic molecular catalysts that exhibit high enantioselectivity.



Docking simulation
High-precision docking simulation by QM/MM methods.



Development of methane activation catalyst based on reaction analysis and informatics.

Research Field(s)

Computational chemistry, Catalyst chemistry, Enzyme chemistry

Keywords

Quantum chemistry, Catalyst, Biological reaction, Data science

■ Advantages and Features

Provides solutions to problems that cannot be understood by experiments alone.

■ Application Fields

Wide range of fields including materials chemistry of materials, catalysts, etc., and life chemistry of enzymes, drug development, etc.



Development of Dispersion, Immobilization, and Composite Technologies for Nanoparticles Using Supercritical Fluids

Professor, Department of Life, Environment and Applied Chemistry, Faculty of Engineering
MATSUYAMA Kiyoshi

Research Video 



Research Outline

We are proposing technologies by using characteristics of supercritical fluids (high-pressure carbon dioxide and water) to immobilize nanoparticles and composite nanoparticles on and with porous materials having fine microporous structures. These technologies enable dispersion/immobilization of particles of nanosize and compositing of micro and nanoparticles. By making use of the features of low viscosity, high dispersibility,

and zero surface tension that are possessed by supercritical fluids, compositing and immobilization of nanoparticles, which were considered to be difficult with conventional liquid solvent and mechanical treatments, are made possible and various composite materials are being developed based on concepts such as those shown in the figure.

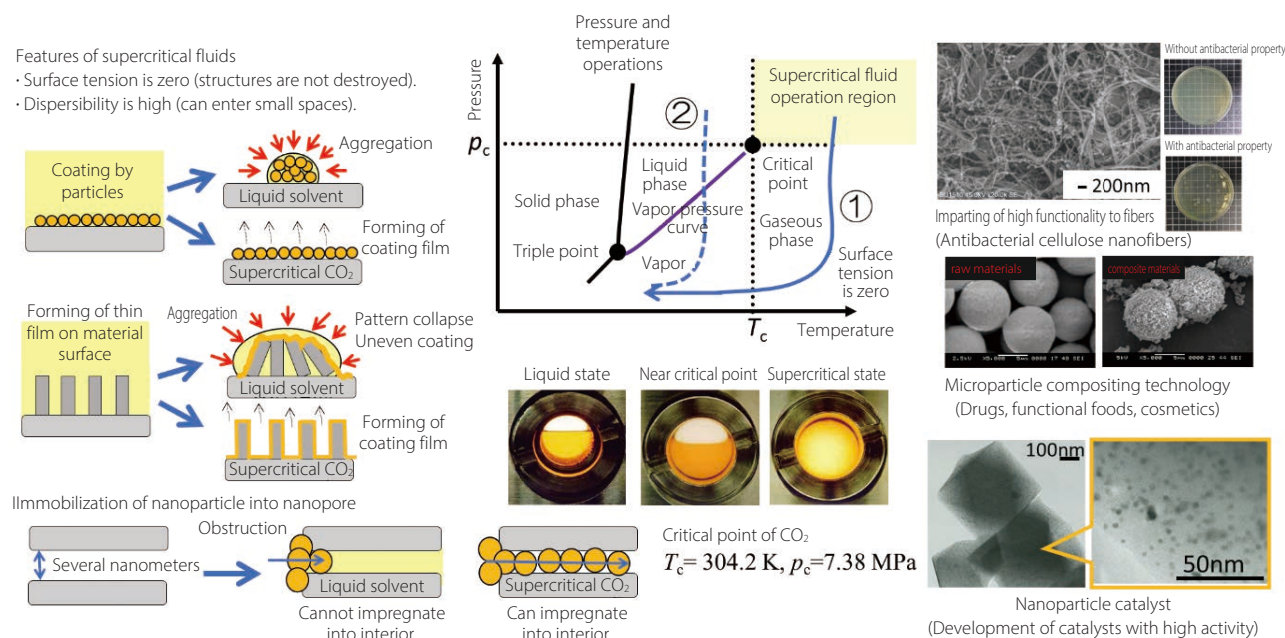


Fig. Development concepts and application examples of functional materials making use of features of supercritical fluids.

Research Field(s)

Catalysts, Cosmetics, Pharmaceuticals, Health foods, Electronic materials, Fibers

Keywords

Nanoparticles, Porous materials, Supercritical fluids, Coating, Composite materials

■ Advantages and Features

- Nanoparticles can be immobilized on porous materials without aggregating.
- Due to being an operation in carbon dioxide or water, there is no worry of residual solvents and applications to pharmaceuticals and foods are possible.
- Dispersion/immobilization/compositing of uniform nanoparticles is possible.
- Porous materials with immobilized nanoparticles of a catalyst, electrode material, etc., can be developed.
- Due to being technologies using carbon dioxide and water, which are harmless to the human body, applications to composite particles of pharmaceuticals, foods, etc., for which residual chemical substances are unfavorable are possible.

■ Application Fields

Technologies using supercritical fluids are extremely useful for development of materials having fine structures such as nanoparticles and porous materials. We are recently involved in joint development through industry-academia collaboration in research themes related to functional fibers, health foods, electronic components, catalysts, cosmetics, porous materials, etc.

■ Patents

- Japanese Patent No. 6208316 "Metal nanoparticle carrying method and apparatus therefor"
- Japanese Patent No. 63202027 "Method for producing porous coordination polymer composites"
- Japanese Patent No. 7017730 "Method for producing catalyst using palladium-ruthenium composite microparticles"
- Japanese Patent No. 7254308 "Method for producing olefin-based resin porous material (phase separation induction + second solvent)"



Development of Sustainable Microbial Control Technologies

Associate Professor, Department of Life, Environment and Applied Chemistry, Faculty of Engineering

OKUDA Ken-ichi

■ Research Outline

Antimicrobial resistance (AMR) is a threat of global scale and it is speculated that AMR-associated deaths may reach 10 million a year by 2050. On the other hand, the development of new antimicrobials has been stagnant and active nationwide involvement is demanded. In order to sustain antimicrobial therapies into the future, it is important to promote, in addition to proper use of antimicrobials, the development of antimicrobials with action mechanisms that are unlikely to induce AMR and research that would enable effective utilization of conventionally-used antimicrobials. Also, a film-like structure called biofilm that is formed by some species of bacteria is being noted as a cause of intractable infection due to exhibiting high resistance to antimicrobials and immune systems and development of effective control methods is being demanded.

Our group has thus far performed large-scale screening of compounds to achieve success in acquiring biofilm inhibitors that suppresses biofilm formation by bacteria. Further, we have found that biofilm inhibitors have an effect of improving the effects of antimicrobials against antimicrobial resistant bacteria. In addition, we have clarified that antimicrobial resistant biofilms can be disinfected effectively by using an antibacterial peptide called nisin that is produced by lactic acid bacteria.

Presently, we are deepening and developing these researches and carrying out research aimed at developing technologies of “control without induction of resistance” (= sustainable microbial control technologies) of AMR and biofilms that are presenting problems in such fields as medicine, foods, environment, etc.

Research Field(s)

**Bacteriology, Applied microbiology,
Microbial control science**

Keywords

**Microbial control, Biofilm,
Antimicrobial resistance**

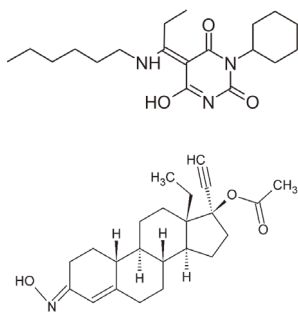


Fig.1. Biofilm inhibitors.

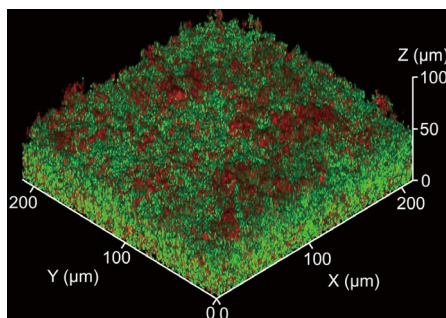


Fig.2. Three-dimensional structure of a biofilm.

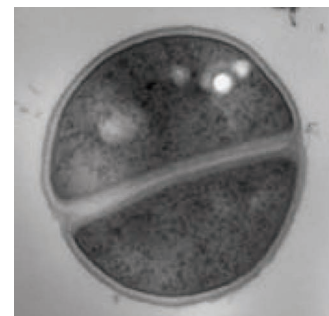


Fig.3. Methicillin resistant
Staphylococcus aureus.

Advantages and Features

Sustainable microbial control technologies that do not induce resistance

Application Fields

Medicine, foods, environment



Selective Separation of Components Contained in Wastes and Ores by Ammonium Salts

Associate Professor, Department of Life, Environment and Applied Chemistry, Faculty of Engineering

KUBO Hironari

Research Video 



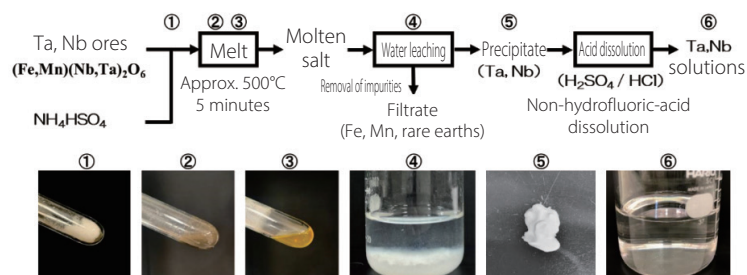
Research Outline

Ammonium salts such as ammonium chloride (NH_4Cl), ammonium hydrogen sulfate (NH_4HSO_4), etc., react selectively with oxides at low temperatures of several hundred °C to form salts. We are proposing recycling of various wastes and smelting process using this characteristic and pungency that stimulate the sense of

pain. Lipid membranes are present on the cell membranes of taste cells present on the tongue and inside the oral cavity of a human being and these interact with receptors for taste substances to generate nerve signals for sensing taste.

1. Smelting tantalum and niobium without using hydrofluoric acid

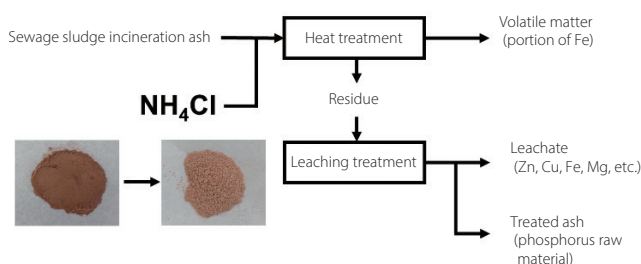
Although liquefying methods using hydrofluoric acid are generally proposed as methods for recovering niobium and tantalum from ores to manufacture niobium oxide and tantalum oxide, hydrofluoric acid is designated as a toxic substance. We are thus proposing a method using ammonium hydrogen sulfate to smelt safely without using hydrofluoric acid.



2. Removal of hazardous components contained in sewage sludge incineration ash

Phosphorus, which is contained in agricultural produce and other foods, is, for example, consumed in the daily life of people to become contained as excrement in sewage and other household wastewater and a large portion of the phosphorus becomes concentrated in sludge in sewage treatment plants.

It is anticipated that if total recovery of phosphorus from sewage sludge incineration ash can be achieved, this would cover much of the phosphorus resource demand in Japan. By using ammonium chloride, we have realized selective recovery of phosphorus from sewage sludge incineration ash, which contains large amounts of impurities other than phosphorus.



Research Field(s)

Metal smelting, Waste recycling

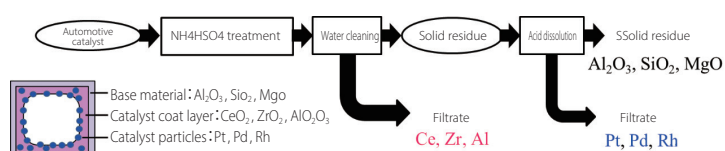
Keywords

Tantalum, Niobium, Sewage, Automotive catalyst, Electric furnace dust, Ironmaking

3. Improvement of platinum group metal recovery rate from automotive catalysts

In automotive catalysts, platinum group metal microparticles are fixed by Al_2O_3 , ZrO_2 , etc., to base material surfaces of honeycomb shape. Since these are poorly soluble in acid, the recovery rates of platinum group metals are lowered.

Ammonium hydrogen sulfate can cause oxides such as CeO_2 , Al_2O_3 , ZrO_2 , etc., to melt in a short time. Therefore, by heat treating automotive catalysts with molten ammonium hydrogen sulfate, the catalyst coat layer can be peeled off and a large portion of the platinum group metal microparticles can be recovered as slurry.



Advantages and Features

- Oxides that are poorly degradable by acid or alkali can be liquefied in a short time at low temperatures.
- Process using ammonium salts that can be considered to be decarbonized.

Application Fields

- Treatment and recycling of wastes and byproducts that contain oxides
- Low environmental load type metal smelting processes from oxide ores

Patents

- Japanese Patent No. 6910690 "Method for liquefying niobium and tantalum"
- Japanese Patent No. 6943409 "Method for treating electric furnace dust"
- Japanese Patent No. 6962536 "Treatment method for steelmaking slag"
- Japanese Patent No. 6987419 "Method for steelmaking"
- Japanese Patent No. 7009008 "Method for treating sewage sludge incineration ash"



Development of Inorganic Nanosheet Liquid Crystals

Associate Professor, Department of Life,
Environment and Applied Chemistry, Faculty of Engineering
MIYAMOTO Nobuyoshi

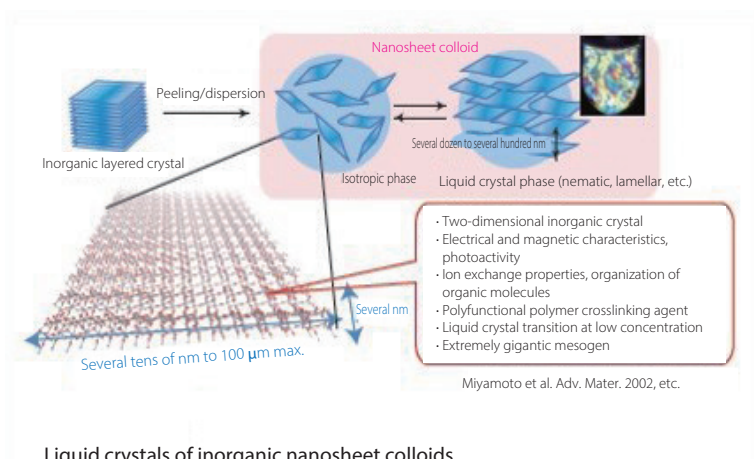
Research Video 



Research Outline

In our research, we have been developing a new type of liquid crystal material called “inorganic nanosheet liquid crystals” (Adv. Mater. 2011, Nature Commun. 2015, etc.). Inorganic nanosheet liquid crystals are obtained from natural clay minerals and various layered crystals prepared by inorganic solid-phase synthesis as raw materials and are synthesized by exfoliation and/dispersing these raw materials in a solvent. The microstructure, physical properties, and functions of the synthesized nanosheet liquid crystals are controlled and can be used in various applications. By utilizing of

functions of the nanosheets themselves (electrical characteristics, charge density, photoactivity, magnetism, luminescence, etc.) control of physical properties of the colloidal state (particle diameter, solvent, counter cation species, and salt concentration), and compositing with various polymers, biomolecules, and organic functional molecules. This research is being carried out jointly with the University of Tokyo, Kyushu University, University of Orléans (France), University of Paris XI (France), the National Institute for Materials Science, etc.



Research Field(s)

**Nanomaterials, Inorganic chemistry,
Liquid crystals, Polymers, Colloids,
Soft materials**

Keywords

**Layered crystals, Nanosheet , Liquid crystal ,
Nano-composites**

■ Advantages and Features

Inorganic nanosheets are highly anisotropic nanomaterials with a width of up to several hundred micrometers and a thickness of approximately 1 nm. Although graphene is receiving attention in particular recently, various other types of nanosheets can be synthesized. Further, our research is distinctive in that we do not only use nanosheets as they are but also proactively use a liquid crystal phase that is an organized structure formed spontaneously upon dispersing a nanosheet in a solvent. Inorganic nanosheet liquid crystals have many advantages such as enabling electronic physical properties unique to inorganic substances to be used easily in comparison to existing organic liquid crystals, being excellent in mechanical and thermal stability, and being easy to use in synthesis of inorganic/organic nanocomposites, etc.

■ Application Fields

- Liquid crystals are already used in a wide range of fields such as display elements, optical shutters, etc., and the same applications are also possible with the new liquid crystals of our research. Inorganic nanosheet liquid crystals can be synthesized from clay minerals, etc., that are inexpensive, harmless, safe, and low in environmental load and can be

considered for application to large-scale light shielding windows, etc.

- On the other hand, liquid crystals are also applicable to nanostructure construction and synthesis of anisotropic materials that are impossible with top-down methods. In particular, there are anticipations for composting with polymers to develop high performance composite materials, etc., that are excellent in gas barrier properties, strength, heat resistance, etc. Applications to sensors and color materials making use of the structural color and stimulation response that are characteristic of liquid crystals are also being explored.

■ Patents

- Japanese Patent No. 7031833 “Method for manufacturing modified inorganic nanosheet and modified inorganic nanosheet”
- Japanese Patent No. 7006885 “Method for manufacturing inorganic nanosheet-polymer composite and inorganic nanosheet-polymer composite” and 4 other Japanese patents



New Interfacial Damage Evaluation Method using Microscopic Raman Spectroscopy Apparatus

Professor, Department of Intelligent Mechanical Engineering, Faculty of Engineering

ZHU Shijie

Research Outline

Although ZrO₂ ceramic thermal barrier coatings are applied to surfaces of superalloys used in such components as gas turbine rotor-stator blades, combustion chamber liners, etc., under actual usage environments, damage such as breakage of the thermal barrier ceramic coating itself, peeling from the superalloy, etc., occurs and since such damage leads to breakage of the turbine, the development of evaluation technologies for ensuring the reliabilities of thermal barrier coatings at the actual structural member level during use is an important issue.

In our research, a microscopic Raman spectroscopy apparatus is used to measure the residual stress inside a thermally generated oxide alumina layer by means of peak shifts in a fluorescence spectrum as shown in the figure. The results are useful for increasing the reliability of coatings to provide coated members that can withstand high-temperature combustion in the future. Indirectly, these would be effective for improving the thermal efficiency of power generation gas turbines, saving fuel, and decreasing CO₂ and other hazardous wastes.

Method for measuring residual stress inside a TGO layer

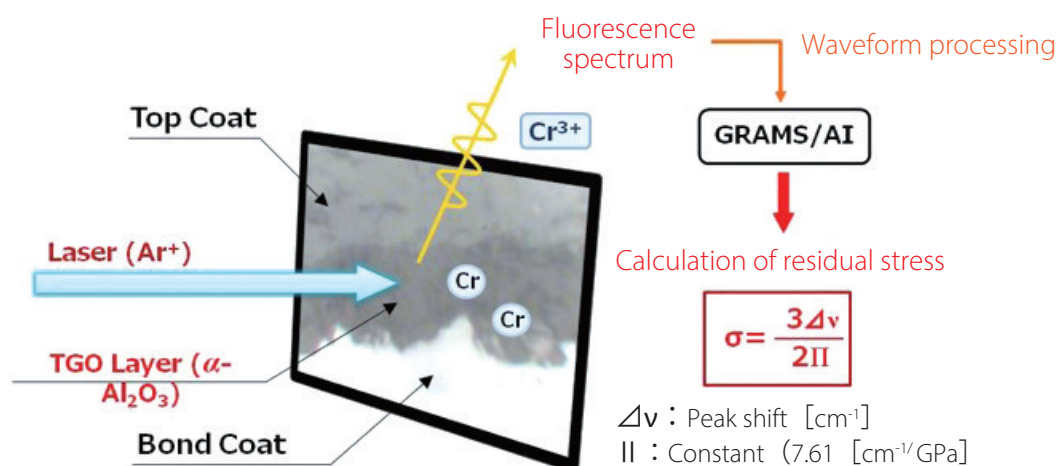


Fig. Principles of fluorescence spectroscopy method for measuring residual stress inside an alumina layer.

Research Field(s)

Mechanical materials, Material mechanics

Keywords

Residual stress, Interfacial damage evaluation method, Thermal barrier coating, Alumina

■ Advantages and Features

The proposed method enables damage information for determining the integrity of a coating to be acquired nondestructively. Since the arrangement is easy, does not require protection as in X-ray methods, and also does not require water or other medium as in ultrasonic methods, the method can be useful as future inspection method for thermal barrier coatings. This evaluation method has such features as being nondestructive, contactless, quantitative, etc., and is one of a kind. It can also be applied to evaluation of Al₂O₃ thin films other than heat resistant coatings.

■ Application Fields

- Gas turbines for airplanes and power generation
- Heat resistant ceramic components for petrochemical industry
- Multilayer structure of metal and ceramics for electronic devices.



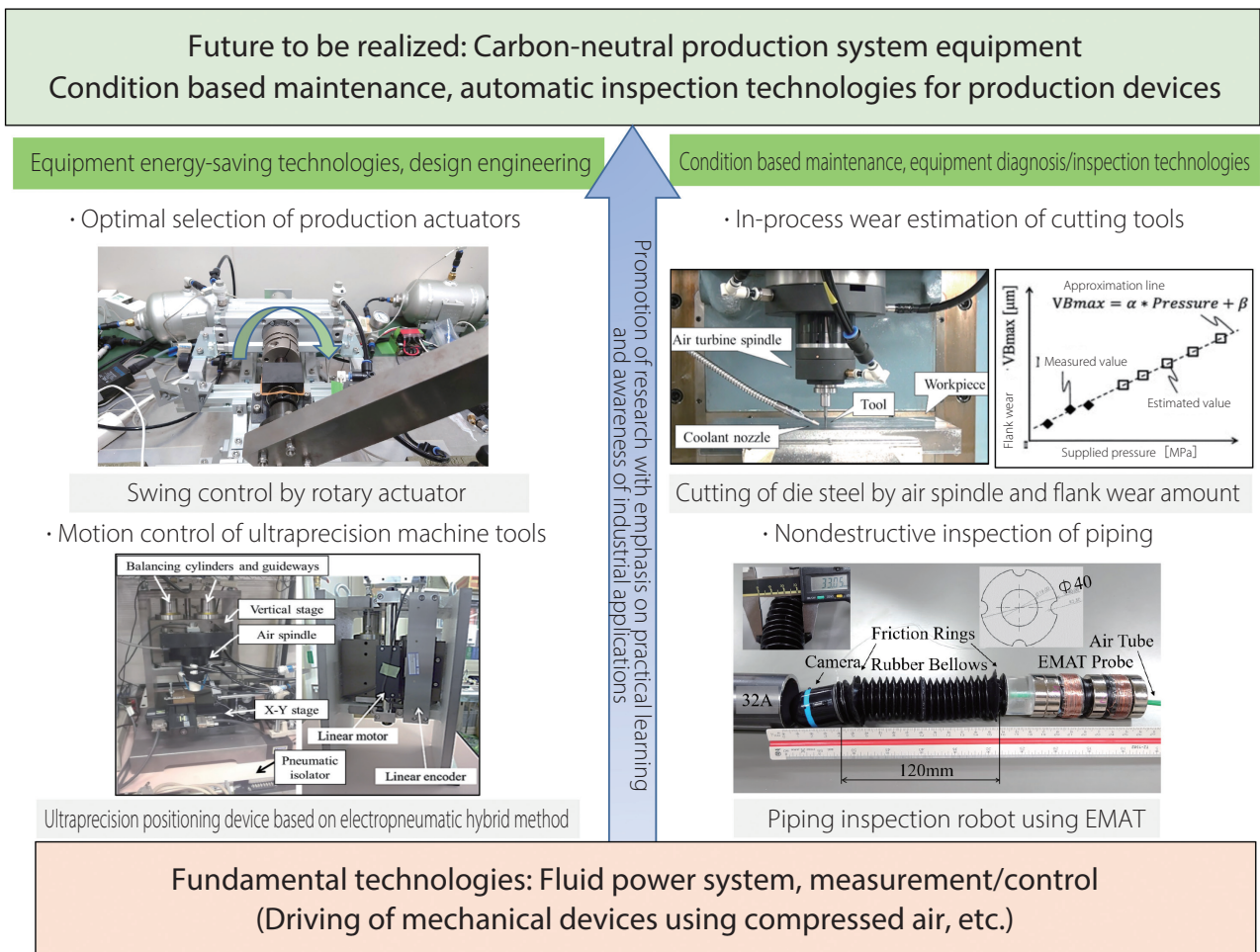
Using Fluid Power to Realize High Functionality in Production Systems

Associate Professor, Department of Intelligent Mechanical Engineering, Faculty of Engineering

KATO Tomonori

Research Outline

In our laboratory, we are deploying such research as shown below based on pneumatic pressure measurement/control technologies.



Research Field(s)

Fluid power system, Measurement/control

Keywords

Pneumatic pressure, Functional fluids, Measurement/control, Production engineering

■ Advantages and Features

With an attitude emphasizing practical learning, we are engaging in research centered on measurement/control of pneumatic pressure and especially recently in research related to optimal selection and control of actuators for production, electropneumatic hybrid ultraprecision positioning devices for ultraprecision machining devices, in-process wear estimation of cutting tools, nondestructive inspection of piping using EMAT and in-pipe traveling robot, artificial muscle actuator driven by gas-liquid phase change, etc.

■ Application Fields

We are promoting research with a keen awareness of industrial applications and the technologies of our research are applicable to situations aiming at realizing condition based maintenance/automatic inspection technologies for carbon-neutral production system equipment/production devices.

■ Patents

- Japanese Patent No. 5822302 “Characteristics evaluation testing device and characteristics evaluation testing method for gas instrument”
- Japanese Patent No. 5843233 “Aerostatic bearing spindle device and machining tool using the same”
- Japanese Patent No. 6195242 “Characteristics evaluation testing device”
- Japanese Patent No. 6638915 “Spindle head elevating/lowering device and machining tool”
- Japanese Patent No. 6905224 “Tool wear estimating method”



Measurement of High Number Density Diesel Fuel Spray Droplets

Associate Professor, Department of Intelligent Mechanical Engineering, Faculty of Engineering

KOMADA Keisuke

Research Outline

Diesel engines are used in freight trucks and vessels due to being high in thermal efficiency and durability and are an important means that supports transport for distribution in island countries such as Japan. Although the EV (electric vehicle) shift is accelerating in the automobile markets of various countries around the world these days, research is also being conducted on next generation biodiesel fuels that are carbon neutral as “another sustainable future”. In a diesel engine, fuel is injected, the fuel is mixed with air, and the mixed gas is combusted/exploded to move a piston to obtain motive power. It is thus extremely important to grasp the characteristics of the injected fuel. However, the fuel spray droplets immediately after injection have characteristics such as the following:

- Velocity of droplets inside the spray can exceed the speed of sound.
- The average droplet diameter is several μm to several dozen μm .
- Droplets are clustered extremely densely (are high in number density).

Therefore, measurement of individual droplets is difficult and there is insufficient measurement data. Numerical simulation results thus cannot be verified and are still low in prediction precision and this is extremely problematic for developing next generation engines.

A laser 2-focus velocimeter (see right figure) that our

group have developed independently has two foci and is capable of simultaneously measuring the velocity and size of a droplet passing between the foci and, due to having a minute measurement volume of the micro scale, is capable of distinguishing individual droplets even in a high number density region. In our research, we are aiming at clarifying the breakup process of spray droplets using the laser 2-focus velocimeter.

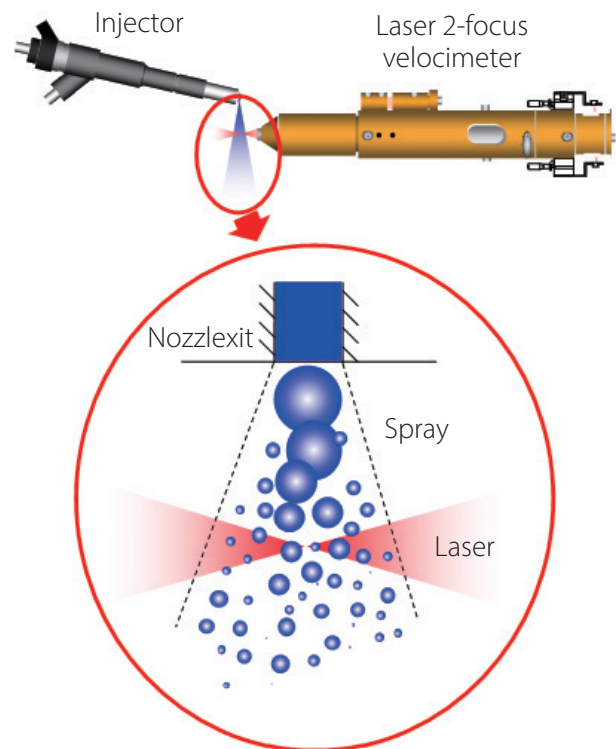


Fig. Image of measurement of spray droplets.

Research Field(s)

**Thermal and fluid engineering,
Multiphase flow, Flow measurement**

Keywords

Diesel engine, Spray droplets, Droplets velocity, Droplets size

■ Advantages and Features

Individual droplets can be measured in a region of extremely high number density inside a fuel spray that was impossible to measure with conventional methods.

■ Application Fields

- Fuel spray of various engines
- Sprays of inkjet printers and coating nozzles



Analysis and Planning of Robotic Manipulation

Associate Professor, Department of Intelligent Mechanical Engineering, Faculty of Engineering

MAKITA Satoshi

Research Outline

With the decrease in working population, robotic automation in industries and support robots in homes are demanded. In order to make robots perform various tasks, "increasing of operation target objects handleable by robots," "enabling object recognition under various conditions," "planning of reliable and secure object manipulation," etc., are required.

In our research, we are engaging in the following themes to advance dexterous robotic manipulation.

- Mechanical analysis to assess reliable robotic manipulation.
- Grasping strategies (caging) based on geometrical constraints for preventing an object from escaping from the hand.
- Object perception for planning of geometrical constraints.
- Operation (pushing, tumbling, etc.) with incomplete grasping where the objects are in contact with the environment.

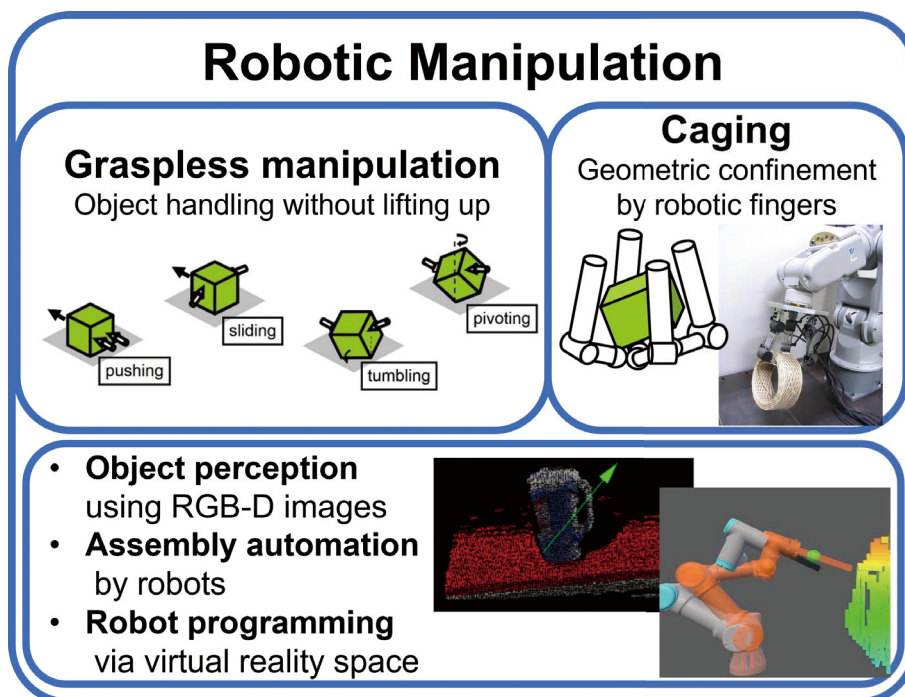


Fig.1. Overview of our studies.

Research Field(s)

Intelligent robotics, Mechanical systems,
Information processing

Keywords

Manipulation, Industrial robots,
Robot hands, Motion planning,
Object perception

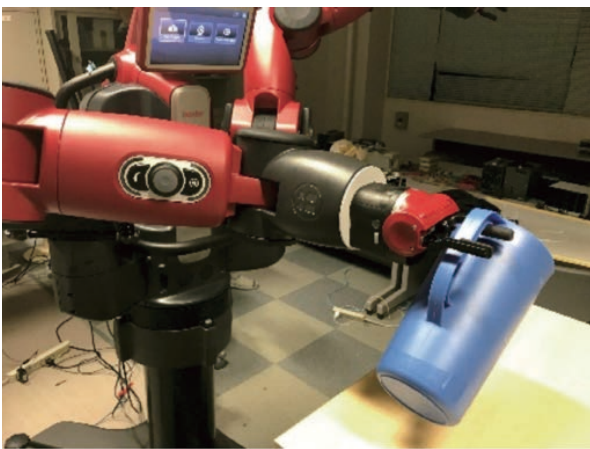


Fig.2. Finger insertion planning for hooking and caging manipulation.



Fig.3. Sash insertion task as a robotic assembly.

Advantage Features

- By taking geometric constraints (preventing of escaping) into consideration, secure object handling can be ensured even with failures of mechanical constraints (dropping of grasped objects by slipping of fingers).
- Even if there is uncertainty in the sensing information, motion planning with tolerance (margins) can be performed.

Application Fields

- Various automation in Production fields (assembly, handling wire harness)
- Support robots in homes where the surrounding environments (lighting conditions, obstacle positions, etc.) often change.



Research on Load Compensation Mechanisms for Manipulators

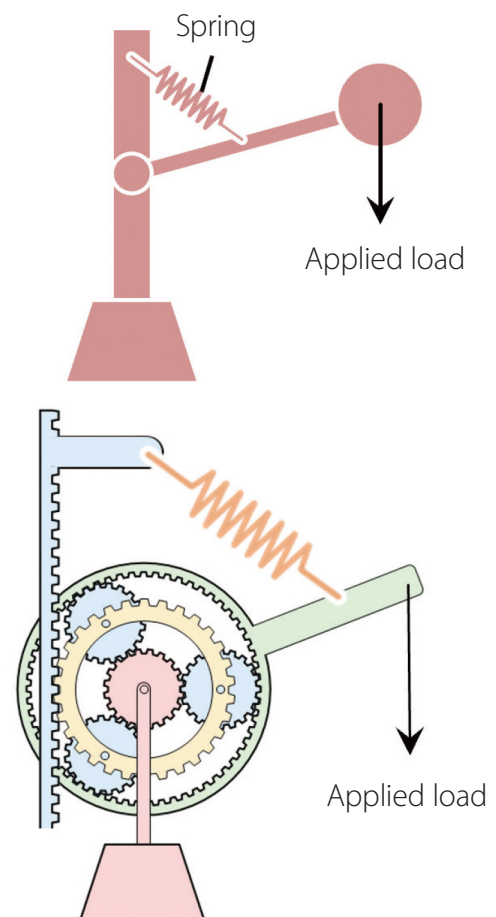
Assistant Professor, Department of Intelligent
Mechanical Engineering, Faculty of Engineering

TAMAMOTO Takumi

■ Research Outline

The load capacity is one of the important capability indexes for manipulators and basically to obtain a large value, the joint torque is increased by increasing the capacity of an actuator, etc. On the other hand, methods of using a mechanism to compensate for the weight of the main manipulator body and the load applied to fingertips have been proposed and these are called self-weight compensation mechanisms and load compensation mechanisms, and in one representative model, a spring is used. These mechanisms are anticipated to contribute greatly to reduction of energy consumption by manipulators. However, there exists a problem in that many of the general load compensation mechanisms cannot accommodate changes in applied load.

In our research, a planetary gear mechanism is used to divide the power of an actuator into power for motion of the joints and power for adjustment of the load compensation force. It is thereby made possible to automatically adjust to a load compensation force that is appropriate for the applied load. After a balanced state is reached, the mechanism can serve as a load compensation mechanism until the applied load changes again.



Research Field(s)

Robotics, Kinematics

Keywords

Industrial robots, Load compensation mechanisms, Planetary gear mechanisms

■ Advantages and Features

Adjustment of the load compensation force can be performed automatically in accordance with the applied load at the manipulator tip.

■ Application Fields

Industrial manipulators, transport robot



Research on Precision Measurement of Current Transport Properties under a Wide Range of Practical Environments and Nondestructive Detection of Performance Bottlenecks in Superconducting Wires

Professor, Department of Electrical Engineering,
Faculty of Engineering

INOUE Masayoshi

■ Research Outline

Superconducting materials, which can carry 100 times or more current than copper and other conventional materials without loss, are being researched for practical use since applications to electric power devices and electric power transmission systems can make large contributions toward building environment-friendly electric power systems and realizing low-carbon societies. In particular, the development of superconducting “wires” is being pursued in and outside of Japan since wires are primary materials used in a wide range of electric power devices and systems. Especially, there are high expectations for high-temperature superconducting wires that can express superconductivity without using liquid helium, which is rare and expensive.

In our laboratory, we are carrying out the precision evaluation of electromagnetic properties and clarification of performance bottlenecks for improving properties of high-temperature superconducting wires.

1. Evaluation of current transport properties of high-temperature superconducting wires under a wide range of practical environments

A liquid-helium-free environment signifies the broadening of operating temperature choices. Therefore, grasping of properties across a wide range of temperatures is essential for the selection of operating

temperature and optimizing of devices. Magnetic field properties are also important for in-field applications that make use of the advantages of superconductivity. We are engaged in precision measurements of current transport properties in such cryogenic temperatures and high magnetic fields.

2. Research on nondestructive detection of performance bottlenecks of high-temperature superconducting wires

High-temperature superconducting wires are constituted of several elements including non-metal elements and it is not easy to form a long and uniform wire. Meanwhile, since a wire is a one-dimensional electrical conductor, a local defect can cause lowering of performance for the entire wire. We are thus also engaged in nondestructive detection of local defects that become performance bottlenecks of the wires. Presently, we are performing combined evaluation using electromagnetic methods and X-ray CT, etc.

Keywords

Superconductivity, Current transport properties, Nondestructive inspection, High magnetic field, Cryogenic temperature

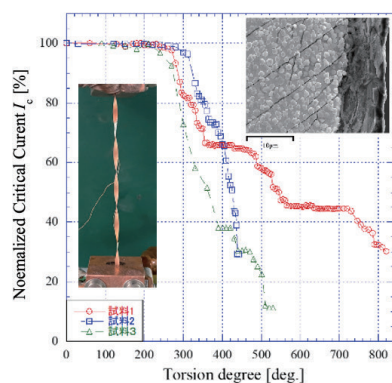


Fig.1. Measurement example of destructive test by twisting of high-temperature superconducting wire.

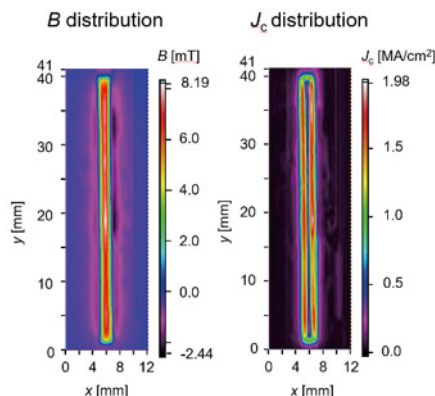


Fig.2. Observation of magnetic field and critical current density distribution in the wire by magnetic microscope.

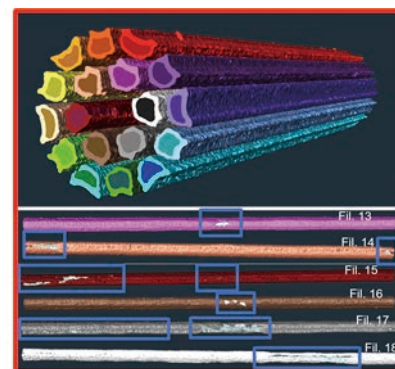


Fig.3. Example of visualization of filament structure in the interior of a superconducting wire by X-ray CT.

Recent research projects

- Grants-in-Aid for Scientific Research: Basic Research (B) (22H02021) principal investigator, Basic Research (S) (19H05617) co-investigator, Basic Research (B) (22H02019) co-investigator, etc.
- NEDO: Project for Research and Development of Advanced Aircraft Systems for Practical Application “Research and Development of next-generation electric propulsion system” (2019 onward) recommission, etc.

Advantages and Features

- Realized current-carrying measurement for a wide range of temperatures and magnetic fields
- Combined evaluation of local electromagnetic field properties and nondestructive internal structure observation of materials with local defects

Application Fields

Although presently, current-carrying property measurement, local electromagnetic property evaluations, and nondestructive inspections of superconducting materials are being carried out, applications to other electric and electronic materials are also possible.

Development of Switched Reluctance Motor Drive System for Electric Vehicles

Professor, Department of Electrical Engineering,
Faculty of Engineering

OHYAMA Kazuhiro

■ Research Outline

1. Research background

A switched reluctance motor (SR motor) in principle lacks a permanent magnet and a coil in the rotor, is simple and inexpensive in motor structure, is mechanically durable, and also does not have the problem of heat generation of the rotor. Although due to having the features of not having the problem of thermal demagnetization of the permanent magnet and enabling operation at high temperature, SR motors have been productized as step motors in the 1950s, they did not become a mainstream of motors due to problems of vibration and noise. In recent years, through advances in simulation technologies and control technologies, improvement propositions based on optimal designs of pole shape and coil, waveform control of the driving current, etc., have been made and SR motors are gaining attention for use in electric vehicles as low-cost, high-reliability motors suited for mass production.

2. Research contents

In our laboratory, development is being carried out in regard to electric vehicle drive systems based on SR motors.

3. Basic structure and operation principles of SR motors

With an SR motor, both the stator and the rotor have salient pole structures and a rotational motion is

created by a continuous magnetic attraction force being generated by supplying a current, based on position information of the rotor, to the coils that are concentratedly wound around the respective stator salient poles. With the SR motor, the rotor is rotated by successively switching the energization of the stator coil approached by a rotor salient pole.

4. Other research

- Research on variable speed wind power generation systems
- Research on small hydraulic power generation systems
- Research on sensorless control of AC machines
- Research on flexible linear actuators

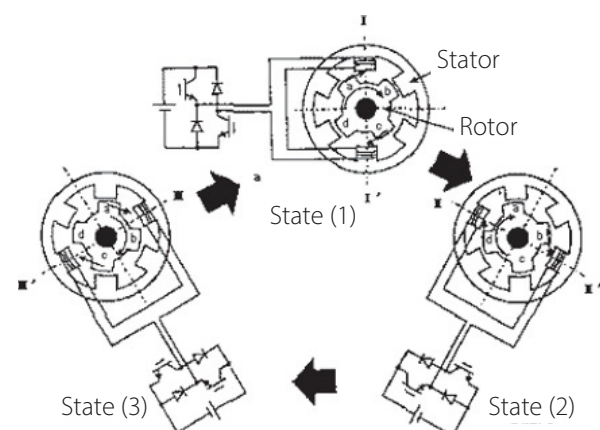


Fig. Basic structure and operation principles of SR motors.

Research Field(s)

**Electric power engineering,
Electric equipment engineering**

Keywords

**Switched reluctance motor,
Electric vehicle, Control system**

■ Advantages and Features

- High in winding efficiency
- Simple to assemble
- Enables high-speed operation
- Enables high temperature operation
- Rotation control is easy

■ Application Fields

- Electric vehicles
- Electric bicycles
- Electric motorbikes

■ Patents

- Japanese Patent No. 5920714 "SR motor drive method and device"
- Japanese Patent No. 6086428 "Method for designing stator and rotor of SR motor and method for manufacturing stator and rotor of SR motor"
- Japanese Patent No. 6086429 "SR motor drive circuit and control method therefor"



Development of Electric Double-Layer Capacitors for Electric Power Storage Using Organic Wastes and These Degradation Diagnosis Technologies

Professor, Department of Electrical Engineering,
Faculty of Engineering

TASHIMA Daisuke

Research Video 



Research Outline

Electric double-layer capacitors, which are maintenance-free batteries with hardly any degradation of electrodes, have come to be noted in recent years and uses, such as effective utilization of regenerative energy of automobiles, etc., are spreading. In our research, we take note of carbon materials used

in the electrodes of electric double-layer capacitors and are developing high-performance electric double-layer capacitors using new carbon materials (e.g. Japanese distilled liquor waste and other organic waste derived materials).

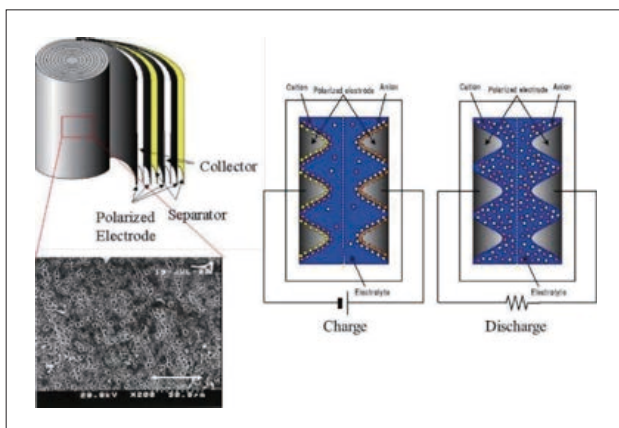


Fig.1. Structure and principles of an electric double-layer capacitor.

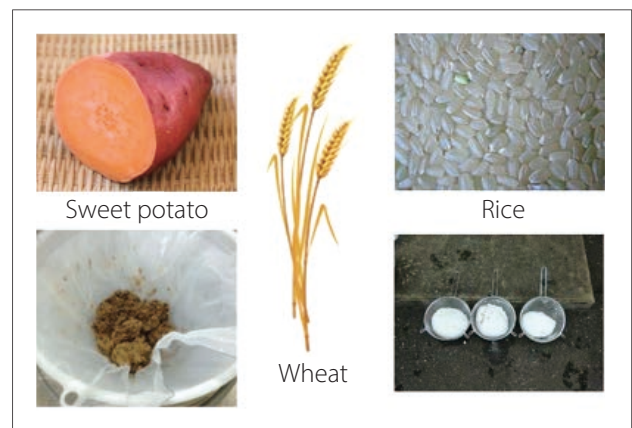


Fig.2. Various Japanese distilled liquor waste.

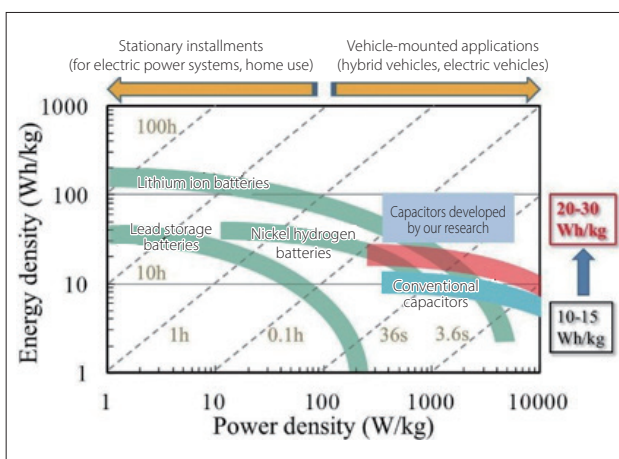


Fig.3. Relationship of power density and energy density.

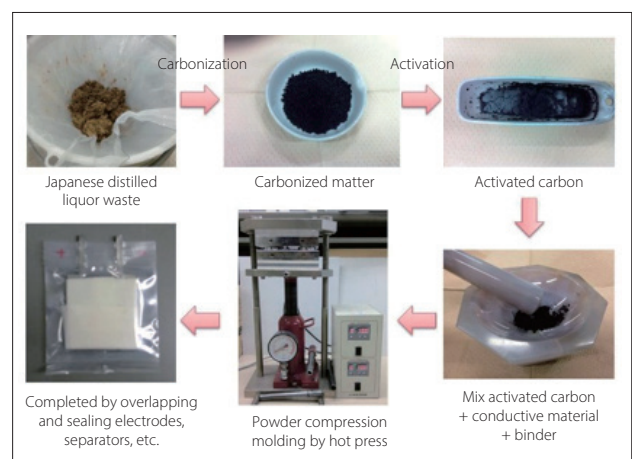


Fig.4. How an electric double-layer capacitor is made from Japanese distilled liquor waste.

Research Field(s)

Renewable energy, Electric power storage

Keywords

Electric double-layer capacitors

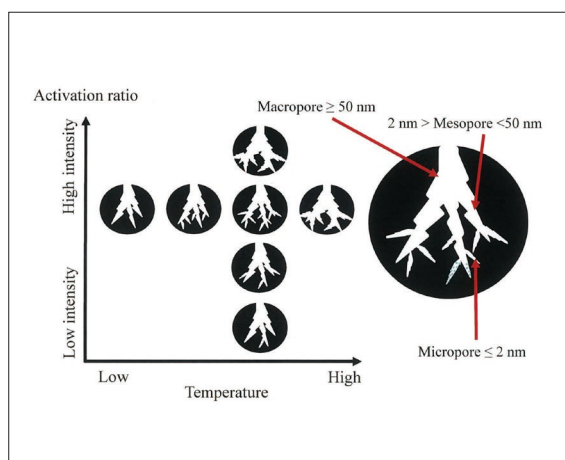


Fig.5. Pore size control.

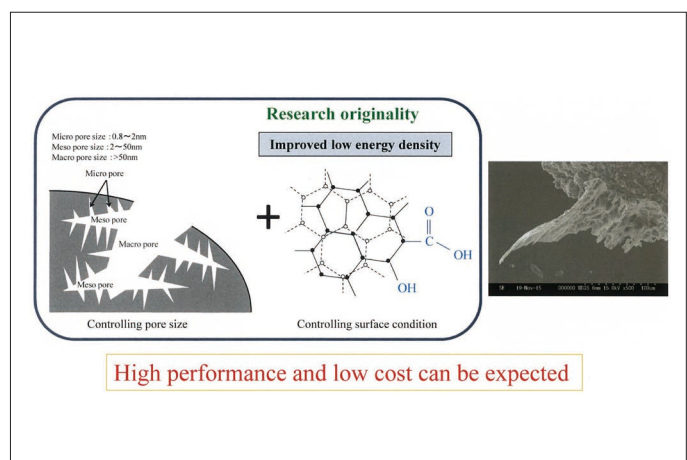


Fig.6. Pore size control.

Advantages and Features

- Low in cost due to using waste material as electrode material.
- Leads to regional vitalization since effective use can be made of unused resources of a region.

Application Fields

- Regenerative energy storage device for vehicles
- Power storage system for homes



Research on Quality Improvement of Thin Steel Plates Using Maglev Technologies

Assistant Professor, Department of
Electrical Engineering, Faculty of Engineering

ENDO Ayato

■ Research Outline

1. Research background

Thin steel plates are widely used in fields mainly involving vehicles and household electric products. Although in a production line for thin steel plates, contact transfer mainly using rollers is performed in a transfer process, there is a problem in that contact with the rollers cause degradation of surface quality such as plating defects and flaws.

In our research, we are studying technologies for holding and transferring thin steel plates contactlessly using magnetic levitation (maglev) technologies as solution methods to the above problem.

2. Maglev technologies for thin steel plates

In our research, we are studying maglev technologies for thin steel plates using a device such as shown in the Fig.1. Electromagnets are positioned in the periphery of a thin steel plate that is the object of transfer and the voltages applied to the electromagnet coils are controlled to make the electromagnets generate appropriate magnetic forces and realize levitation. Also, to achieve levitation without contact of the electromagnets and the thin steel plate, a control method in which the gaps between electromagnets and the thin steel plate are fed back so as to maintain a fixed distance is adopted.

However, maglev control has extremely unstable characteristics. In particular, an extremely thin steel plate with a thickness of 0.30 mm or less deforms due to its flexibility into an extremely complex shape during levitation and enters an unstable state of falling easily. Thus, in order to prevent falling during holding and transfer, we are performing research mainly on clarification of the shapes of thin steel plates and vibration phenomena during levitation, control methods for suppressing the vibration, etc. Also, since flexibility and vibration characteristics change according to the material, size, and plate thickness of the levitated object, we are also examining design methods for maglev systems that are suited for diverse levitated objects. This study examines an appropriate levitation method for thin steel plates. One of the proposed methods is magnetic levitation utilizing gravity (Fig.2). By changing the orientation of the thin steel plate, the effect of deflection is suppressed. However, disturbances caused by transport may affect the levitation stability. We are studying system configurations and control methods that are not affected by transport disturbance. Our research group aims to establish a method of constructing a magnetic levitation system that matches the characteristics of the levitation object.

Research Field(s)

Control engineering, Vibration engineering

Keywords

Thin steel plates, Magnetic levitation, Vibration control

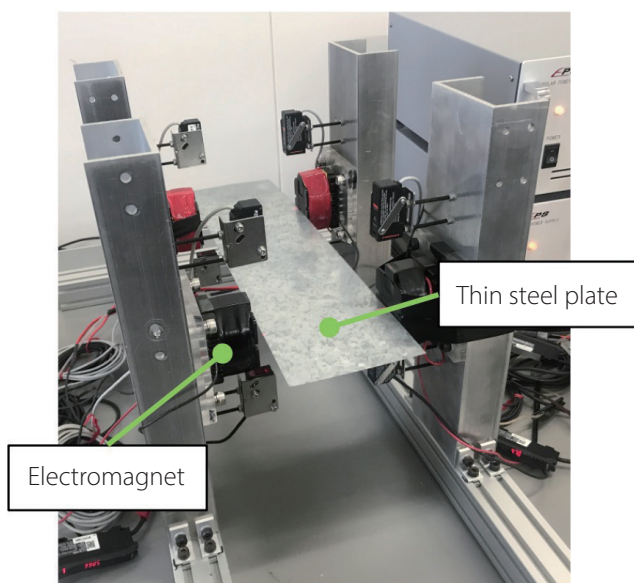


Fig.1. Maglev device for thin steel plate.

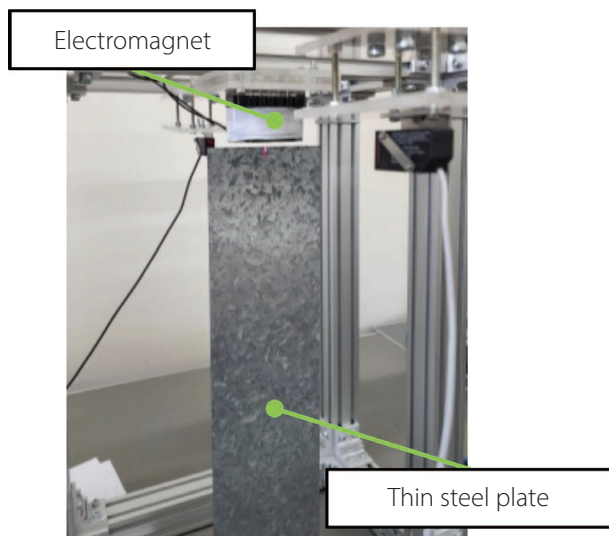


Fig.2. Proposed maglev device utilizing gravity.

Advantages and Features

- Can be used comparatively easily since normal conduction magnetic levitation is applied.
- Due to being contactless, the surface qualities of levitated objects are improved significantly.
- A transfer path of comparatively high degree of freedom can be constructed by using electromagnets.

Application Fields

- Production process for thin steel plates
- Holding and transfer technologies for flexible objects
- Automation and high efficiency of manufacturing lines using steel plates

Research on Molecular Motion in Condensed Systems Using Broadband Dielectric Spectroscopy

Assistant Professor, Department of
Electrical Engineering, Faculty of Engineering

NAKANISHI Masahiro

■ Research Outline

1. Research on molecular motion in liquids

From a microscopic viewpoint, substances are made up of atoms and molecules. A characteristic of liquids is that it flows and can change its shape and this characteristic is derived from the molecules making up the liquid undergoing motion.

In our laboratory, the state of this molecular motion is examined from responsiveness to electric fields.

◆ What is broadband dielectric spectroscopy?

Many molecules have unevenness of electrical charge and are divided into a portion where a + charge is strong and a portion where a - charge is strong (Fig.1). When an electric field is applied to a molecule with such unevenness of charge, the + portion is attracted in the direction of the electric field and the - portion is attracted in the direction opposite to the electric field and the molecule undergoes rotation (Fig.2). The "permittivity" is a physical quantity that indicates the direction in which a molecule becomes oriented and the degree to which the molecule becomes oriented in that direction when an electric field is thus applied. When an AC voltage is applied instead of a DC electric field such that the direction in which the molecule is to be oriented is changed at a fixed time interval, the molecule changes its direction in accordance with the frequency of the electric field. However, there is a limit to the speed at which the molecule can move and if the direction of the electric field is changed faster than

the limiting speed, the molecule becomes unable to follow the direction indicated by the electric field and stays oriented in a random direction. The permittivity in this state should be smaller than that when an electric field of slower frequency is applied. Actually, when the permittivity is observed while gradually increasing the frequency of the electric field, a change from a large permittivity to a small permittivity occurs at a certain frequency. The speed at which the molecule can move is made known from this frequency.

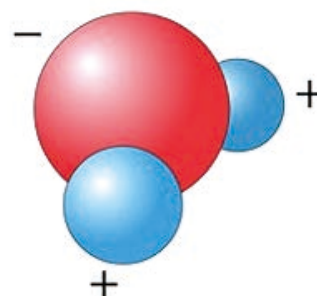


Fig.1. Unevenness of charge of a water molecule.

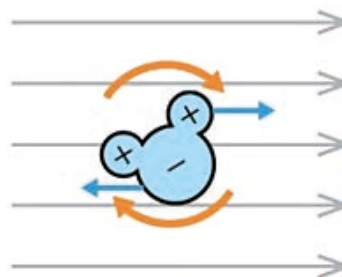


Fig.2. Response of the molecule to an electric field.

Research Field(s)

Chemical physics, Biophysics

Keywords

Molecular motion, Broadband dielectric spectroscopy, Glass transition, Biomolecules, Water, Ice

2. Research on molecular motions of water and biomolecules and orientation motion of water molecules inside ice

Due to water being essential for biological activities, it is considered that the functions of biomolecules such as proteins, amino acids, etc., are supported by water. Through permittivity measurements, we are studying such interactions of water and biomolecules from a viewpoint of molecular motions.

Also, although ice is a solid, water molecules can actually change orientations randomly inside ice. That is, from a point of view of directions of molecules, ice is not a solid but is a liquid. We are studying such motions of water molecules inside ice and impurity effects thereof, etc., through permittivity measurements.

3. Research on glass transition

Plastics in our surroundings are made of spaghetti-like molecules called polymers. These are also actually a type of liquid and is in a continuous viscous state like a rice cake that is soft when it is warm gradually becomes hard as it cools. This is called glass transition. We are examining such sudden slowing of molecular motion by making use of the wide frequency range of dielectric spectroscopy.

Advantages and Features

Although information equivalent to that of dynamic viscoelasticity measurement can be obtained, the features that the frequency range capable of being measured is approximately 10^{10} to 10^{-5} Hz and thus extremely wide, that high sensitivity is provided due to being an electric measurement and that high selectivity is provided are provided.

Application Fields

Often applied to evaluation of materials for capacitors, research on polymer dynamics, rheology, batteries, and aqueous solutions, etc.



Realtime Visualization of Attack Methods

Professor, Department of Computer Science and Engineering, Faculty of Information Engineering

OIDA Kazumasa

Research Outline

1. Research background

Presently, new security vulnerabilities are being discovered on a daily basis. Meanwhile, the progress of new attack technologies that exploit vulnerabilities is accelerating significantly through bug reward programs and hacking competitions. Therefore, according to a report of the U.S. Department of Labor, the demand for information security analysts is predicted to increase by 32% from 2018 to 2028. Virtual environments and isolated sandbox environments for cybertechnology development are effective for learning what can be done with attack codes and how to cope after an attack. On the other hand, for a learner aiming to become a security expert to understand the operation of an attack code on memory, much time must be spent to understand the relevant technologies and source codes.

Thus, our research proposes a system that visualizes the operation of an attack code on memory in real time so that a cybersecurity learner can easily understand attack methods.

2. Outline of attack method visualization system

The system is constituted of two modules: exploit and web-app (Fig.1). Exploit attacks a vulnerable code and at the same time acquires the process information of the code from the memory and sends these to the Firefox browser. Web-app performs processing of the format etc., for displaying the acquired data on Firefox.

Fig.1 illustrates a case where a portion of the stack area on the memory related to the attack is displayed on Firefox. Fig.2 shows the contents on Firefox immediately after an executed Returned Oriented Programming (ROP) attack fails due to a countermeasure of the attack. The description of attack failure and the stack area during the attack are displayed.

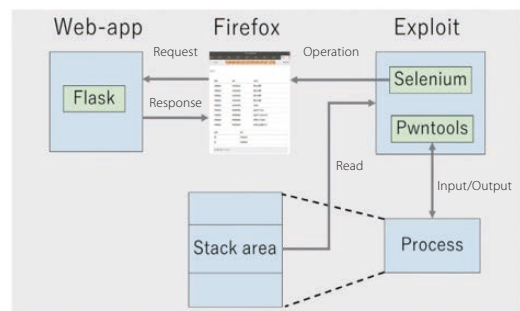


Fig.1. Behavior of the visualization system.

| address | value | comment |
|----------------|------------------|-------------------|
| 0x7ffdc8643160 | 4141414141414141 | Address of name[] |
| 0x7ffdc8643168 | 4141414141414141 | Address of name[] |
| 0x7ffdc8643170 | 4141414141414141 | Address of name[] |
| 0x7ffdc8643178 | 4141414141414141 | Address of name[] |
| 0x7ffdc8643180 | 4141414141414141 | |
| 0x7ffdc8643188 | 4141414141414141 | stack canary |
| 0x7ffdc8643190 | 4141414141414141 | saved ebp |
| 0x7ffdc8643198 | 00007fabb934002b | Return address |
| 0x7ffdc86431a0 | 0000000000000001 | |

| register | value |
|----------|-------|
| RSP | |
| RDI | |


```
The return address is set to the address of function main().
The process terminates and the following statement is displayed:
*** stack smashing detected ***: <unknown>
```

Fig.2. Stack area and attack description on Firefox.

Research Field(s)

Cybersecurity

Keywords

Cyberattacks, Hijacks, Visualization

■ Advantages and Features

The system has three features for efficient and comprehensive learning.

(1) A real execution environment (that is neither simulator nor emulator) for the attack code is provided and the learner can learn while changing the attack code and on/off of countermeasures. The attack method can thus be learned more deeply.

(2) In regard to the attack code, not “what can be done” but “how does it operate” is described at the assembly language level.

(3) Information irrelevant to the attack is removed to improve the efficiency of learning (an actual attack code contains much unnecessary commands).

■ Application Fields

The system is applicable not only for learning by security experts but also for development of attack countermeasures, vulnerability diagnosis, and research on automatic generation of attack codes.



Micro-structured weak X-ray/optical sensor

Associate Professor, Department of Computer Science and Engineering, Faculty of Information Engineering

ARIYOSHI Tetsuya

■ Research Outline

1. Background

Light is classified into X-rays, visible light rays, infrared rays, etc., and these respectively have diverse examples of use including imaging, fluoroscopy, signal transmission, object detection, etc., and photosensors that can perform high-resolution, high-sensitivity, and high-speed processing of such light are being demanded. There is no almighty photosensor that can accommodate all types of light and sensor dedicated to the respective types of light are necessary. In our research, we are proposing various photosensors with microstructures to which micromachining techniques for silicon semiconductors are applied. Silicon is inexpensive, nonhazardous, and offers excellent charge transport properties. Therefore, the long trench photodiode can enhance the detection efficiency for X-rays, and X-rays' detection efficiency of more than 80% has been obtained by irradiating X-rays with a tube voltage of 80 kV from the horizontal direction of the sensor substrate along the length of the trench photodiode. In addition, silicon exhibits intrinsically excellent carrier mobility and long recombination lifetime, enabling rapid collection of signal charge generated by the photoelectric absorption of X-ray photons without loss.

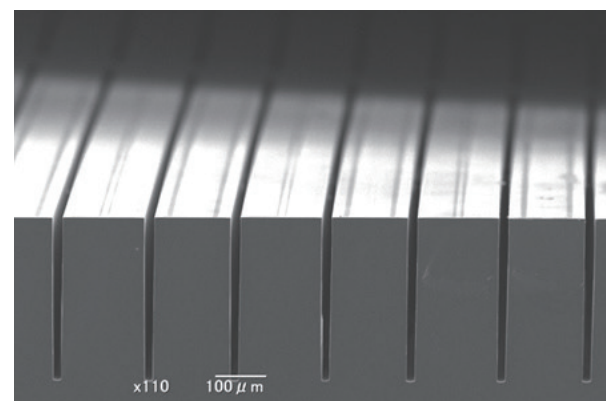


Fig. Deep trenches formed inside a silicon substrate.

2. Outline of photosensors with new structures

The proposed basic photosensors have a deep trench-structure formed inside a silicon substrate as shown in the figure. A photosensor (photodiode) can be formed by making the side walls of the trenches into PN junctions. High-speed, high-sensitivity detection of X-rays and near-infrared light can be realized by making this trench type photosensor long and deep, and by widening the trench width, an optical inspection solution can be injected directly to realize highly efficient photodetection. The two-dimensional array of trench photodiodes in a columnar or cylindrical shape enables detection of near-infrared light with almost 100% light-detection efficiency, which has a transmission power but the penetration length is approximately the depth of the silicon substrate, and two-dimensional near-infrared imaging with one order of magnitude higher contrast than the conventional method.

Research Field(s)

Electronic devices, Electronic equipment

Keywords

X-rays, Photon measurement, Imaging, Integrated circuits, Semiconductors, Microdevices

■ Advantages and Features

By using silicon, which is an X-ray/visible light/near infrared sensor device material, that is low in price, free of environmental load, and easy to process, various microsensor structures suited to the purpose can be prepared by micromachining techniques. X-ray imaging that exhibits a highly sensitive photon counting capability and requires an X-ray amount one digit or more lower than that required by conventional devices, weak light detection at nearly 100% light collection efficiency by 4π geometry measurement, etc., can be realized. We also conceived the idea of enlarging the holes in the trench photodiode and pouring in an ATP wipe test solution to receive isotropically diffusing ATP light emission with a light collection efficiency close to 100%, enabling a sanitary test equivalent to a single bacterial cell.

■ Application Fields

- Element mapping type CT scanner and nondestructive inspection using low-dose X-rays
- Photodetection of trace harmful substances and bacteria in sanitation inspections
- Highly-sensitive quantum type near infrared night vision camera



Elucidation of Brain Computing by Complexity Theory

Assistant Professor, Department of Computer Science and Engineering, Faculty of Information Engineering

YAMAGUCHI Yutaka

■ Research Outline

In our laboratory, artificial intelligence technologies such as deep learning, etc., and neuroscientific knowledge are combined to elucidate the principles of dynamic information processing by the brain and apply

1. Mathematical research on differentiation mechanisms in neural networks

In order to elucidate the process of functional differentiation in the brain from a computational standpoint, we are performing numerical experiments of inducing functional differentiation in a neural network on a computer model(Fig.1). By capturing and changing the flow of information in the network, we are aiming at self-organizationally generating functional modules inside a recurrent neural network and constructing a brain-type information processing model that can be reconstructed flexibly in accordance with tasks.

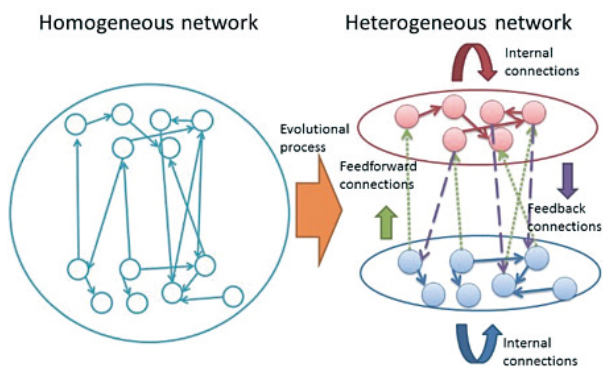


Fig.1. Functional differentiation of a network.

these to artificial intelligence. We are also carrying out research on constructing a deep neural network model having complex dynamics.

2. Research on the role of chaotic dynamics in deep generative models

We are carrying out research on introducing dynamics into deep learning models to expand their capabilities. Using a deep generative model for performing transformation of images, a dynamical system that performs repetitive conversion is constructed to study an ideal generative model that generates diverse images along a deterministic orbit by using chaotic dynamics.

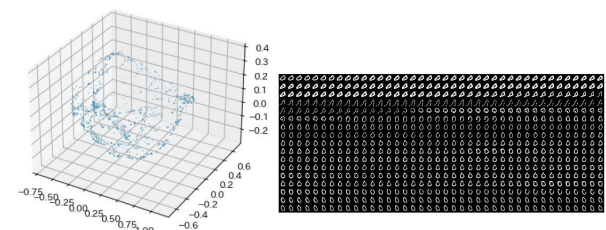


Fig.2. (left) A chaotic attractor in a deep learning model (right) A series of images generated by the model.

Research Field(s)

**Computational neuroscience,
Artificial intelligence**

Keywords

**Neural network, Functional differentiation,
Chaos, Deep learning**

■ Advantages and Features

By analyzing the characteristics of the brain as a complex system and introducing these into AI models, contributions can be made in advancing present AI technologies. A feature of our research is in developing an artificial intelligence model that incorporates neuroscientific knowledge.

■ Application Fields

- Construction of theoretical basis related to bottom-up construction of functional modules in artificial intelligence systems and robots
- Understanding related to the meaning of functional differentiation of the brain in brain science and brain function degradation due to sickness



Japanese Traditional Craft Sharing System Based on Mixed Reality Technologies

Professor, Department of Information and Communication Engineering, Faculty of Information Engineering

ISHIDA Tomoyuki

Research Outline

Traditional craft businesses are of small scale in many cases and although introduction pages, etc., on traditional crafts are made public on the internet, since neither extensive internet advertising nor exhibition in shopping sites is carried out in many cases, there are only limited opportunities for people to see traditional crafts even on the internet. Further, even when one manages to access an introduction page on traditional crafts, since still images or moving images are viewed using a flat display of a smartphone or a personal computer (PC), it is difficult to feel the “excellence of a genuine article” and “deep appreciation” that traditional crafts provide. Thus, in our research, we focused on mixed reality (MR) technologies and developed a virtual traditional craft sharing system for multiusers in real space with which virtual traditional crafts are positioned in real space to make the construction of a virtual room space arranged with three-dimensional computer graphics or virtual reality (VR) equipment (high performance PC, Head Mounted Display (HMD), etc.) unnecessary. With this system, since virtual traditional craft objects are superposition displayed in real space, the shared space is transparent and a user is enabled to recognize just the virtual traditional craft objects. By overlapping the transparent shared space, in which the virtual traditional craft objects exist, with real space, the objects are visualized for the user as being superposition displayed in real space (Fig.1).

Also, with this system, virtual traditional craft objects can be shared among multiple users. An object that a

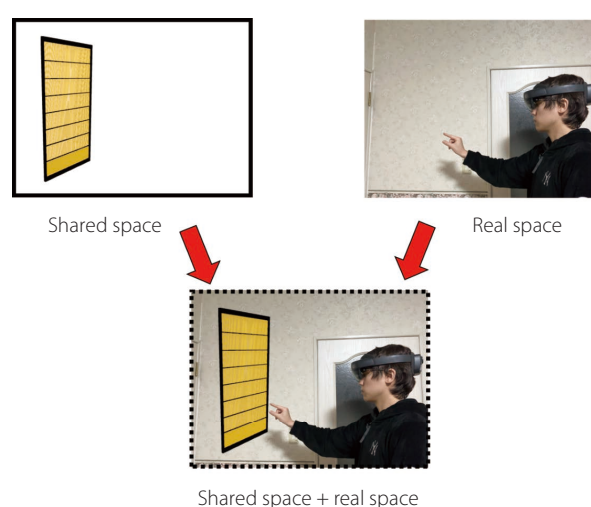


Fig.1. Image diagram of the shared space.

user generates from a list menu of virtual traditional craft objects is also shared with other users and changes in the position, orientation, and size of the object are also shared. A manner in which a virtual traditional craft object is shared is shown in Fig.2. Fig.2 shows a situation where two Microsoft HoloLens2 are used with manipulation of the virtual traditional craft object being performed with one HoloLens2 and the virtual traditional craft object is shared with the other HoloLens2.

Research Field(s)

**Information network,
Social system engineering**

Keywords

**Mixed reality (MR), Space sharing,
Traditional crafts**



Fig.2. Sharing of a virtual traditional craft object.

Advantages and Features

With our system, since a VR room space is not used and virtual traditional craft objects are superposition displayed in a real room space of a user using the system, a more realistic experience is provided in comparison to using a VR room space. Also, by using multiple MRHMDs installed with our system, virtual traditional craft objects superposition displayed in real space can be shared among multiple users.

Application Fields

Although in our research, we handled Tatsuruhama wooden fittings that are produced in Nanao City, Ishikawa Prefecture as contents for the purpose of increasing interests in traditional craft objects from a glocal perspective, we believe that, in addition to traditional craft objects, applications to sales, online shopping, online exhibition, etc., of furniture and household goods using MR technologies are also possible as a future development. We also believe that the remote sharing function of our system can be put to practical use for sharing objects, introducing merchandise, etc., with users in remote areas.



Proposition of Machine Tennis and Game Support by Communication Network

Professor, Department of Information and Communication Engineering, Faculty of Information Engineering

MATSUO Keita

Research Outline

Wheelchair tennis has become widely recognized around the world in recent years and there are cases where it has become socially established as a sport that can be enjoyed throughout life. However, the operations of moving a wheelchair and hitting a ball are difficult for a person without arm strength and the sport has a high hurdle for beginners. We thus believe that an environment that is easy to enter is necessary and are proposing machine tennis.

Machine tennis is tennis using an electric wheelchair (machine) that is specialized for tennis. A specialized machine refers to an electric wheelchair for single person that would never tip over during a tennis game and enables high speed movement while facing an opponent in the court (parallel movement) to be performed easily in various directions (all directions) in order to chase the ball. By using such a machine, a beginner environment can be provided in which a player can chase the ball easily within a tennis court even without having a strong arm strength.

We are also carrying out research for providing a safe environment for players by combining sensors, a communication network, etc. An example of a system for avoiding collision of wheelchairs with each other during a doubles game of tennis is shown in Fig.1. Fig.2 shows a situation in an experiment applying a machine to a badminton game.

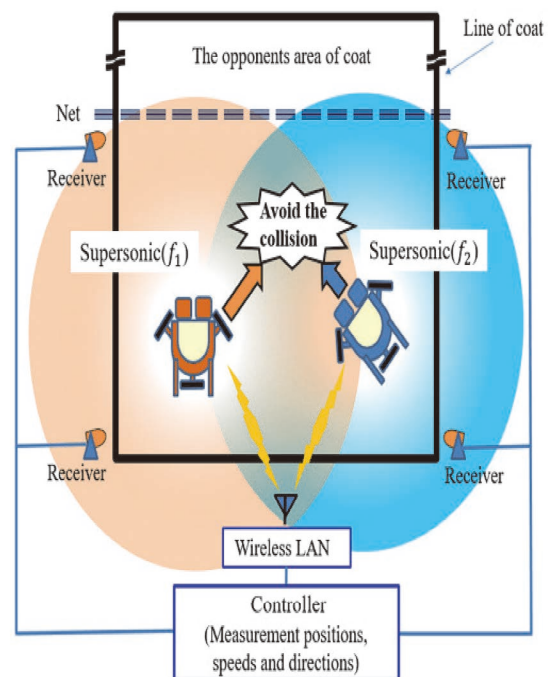


Fig.1. Collision avoidance system using wireless LAN and ultrasonic waves for machine tennis.



Fig.2. Application to a badminton game.

Research Field(s)

Communication/network engineering

Keywords

System control, Robots, P2P, Sensor network

■ Advantages and Features

- Sports using wheelchairs are evolving in various games in recent years. As a representative game using electric wheelchairs, there is “electric wheelchair soccer,” etc., and it is believed that electric wheelchairs will be incorporated and evolve in other games in the future.
- Applications of electric wheelchairs to sports are few in preceding research and issues thereof have not been clarified. By solving problems through our research, contributions can be made so that many people can lead culturally enriched lives through sports.

■ Application Fields

- Application of electric wheelchairs to various sports
- High precision position detecting systems
- M2M



Research on Kinematic Analysis of Artificial Joints and Natural Joints (Medical-Engineering Collaboration)

Associate Professor, Department of Information and Systems Engineering, Faculty of Information Engineering

SHIMOTO Takeshi

Research Outline

Total knee arthroplasty is applied to severe knee joint disorders. By analyzing how artificial knee joints move inside living bodies, detailed diagnosis and development of new artificial joints are made possible. We are thus developing software that enables kinematic analysis to be performed using just X-ray images and are clarifying the kinematics of artificial knee joints in various movements (Fig.1). For kinematic

analysis of natural joints, we developed a kinematic analysis method that applies image correlation using data on bone obtained by CT imaging and X-ray images. By using the devised method, it has become possible to analyze the movements of joints with high precision and comparison of healthy persons and patients and analysis of movements unique to disordered joints are being performed (Fig.2).

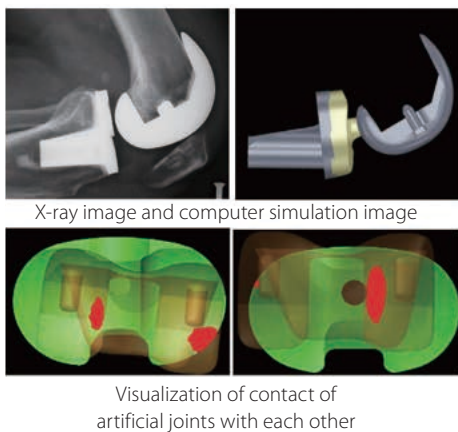


Fig.1. Kinematic analysis of artificial joints.



Fig.2. Kinematic analysis of natural joints.

Study

July, 2018 to December, 2018 Orthopaedic Biomechanics Laboratory, University of Florida, Short-Term Scholar

Research Field(s)

Medical engineering

Keywords

Medical-engineering collaboration, Orthopedics, Kinematic analysis

Major research presentations

- [1] Kozono N, Takeuchi N, Okada T, Hamai S, Higaki H, Shimoto T, Ikebe S, Gondo H, Senju T, Nakashima Y: Dynamic scapulohumeral rhythm: Comparison between healthy shoulders and those with large or massive rotator cuff tear, *Journal of Orthopaedic Surgery*, vol.28, No.3, pp.1-7, 2020.
- [2] Kozono N, Okada T, Takeuchi N, Hamai S, Higaki H, Shimoto T, Ikebe S, Gondo H, Nakanishi Y, Senju T, Nakashima Y: Dynamic kinematics of the glenohumeral joint in shoulders with rotator cuff tears, *Journal of Orthopaedic Surgery and Research*, vol.13, No.1, doi: 10.1186/s13018-017-0709-6, 2018.

Awards

- [1] Best Presentation Award: KUZUSHIMA Kodai, SHIMOTO Takeshi, GONDO Hirota, and HIGAKI Hidehiko: Comparison of movements during shoulder joint elevation before and after arthroscopic rotator cuff repair, The 50th Student Graduation Research Presentation Conference of the Japan Society of Mechanical Engineers Kyushu Student Council
- [2] Presentation Encouragement Award: HASHIMOTO Kazunori and SHIMADA Noboru: Kinetic Analysis of Biological Shoulder Joint Using Medical Images, the 24th Student Conference of the Kyushu Section of the Institute of Electronics, Information and Communication Engineers

Advantages and Features

- We are carrying joint research in medical-engineering collaboration with the School of Medicine, Kyushu University to bring about new knowledge for future medicine and patients.
- We are carrying out research with involvement with medical researchers and clinical doctors while making use of the respective strengths of engineering field researchers and medical field researchers.

Application Fields

- Development of artificial joints suited to the lifestyle of Japanese and experimentation for pharmaceutical application
- The obtained knowledge is applied to surgical methods and diagnoses.



Psychophysiological Measurements of Mental States from Parameters of Indoor Environment

Associate Professor, Department of Information and Systems Engineering, Faculty of Information Engineering

TAMURA Kaori

Research Video 



Research Outline

Comfortable indoor environments are required for our life. Many types of factors determine a comfortable indoor environment, such as physical (e.g., heat, air, light, sound), chemical (e.g., chemical substances, odors), psychological (e.g., mood, preferences), and physiological factors (e.g., brain activity, autonomic nerve activity). Subjective assessments have been used widely to evaluate indoor comfort. Our lab focuses on brain response to reveal indoor comfort from physiological activity.

We have been working on several research projects on the effect of thermal and olfactory factors on indoor comfort with some collaborators. We have research technology to measure Electroencephalograms (EEG), subjective assessments, and behavior data for our project.

1. Effect of indoor wind direction on mental states

In this study, we compared indoor comfort between the environments with/without wind by measuring EEG whose related band with mental load and burden. We compared the two settings that were controlled using a household air conditioner with airflow or a radiant cooling and heating system without airflow to assess the effect of indoor wind on mental states and EEG responses. As a result, we reported the increase of specific EEG bands related to cognitive load under the environment with direct airflow. Our investigation will contribute to establishing a new scale to evaluate indoor comfort using physiological activity. We reported the results in Scientific Reports.

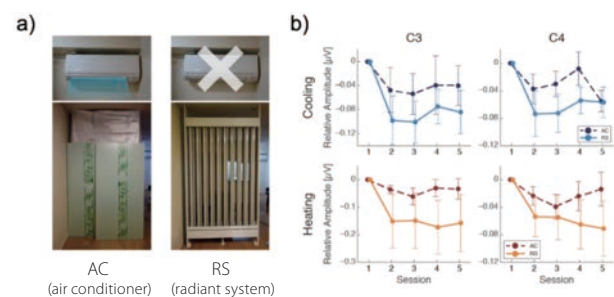


Fig.1. a) Cooling and heating system. b) Beta of EEG activity related to cognitive load.

Research Field(s)

Biomedical engineering, Biological information measurement, Neurophysiology

Keywords

Sensory information, Brainwaves, Comfort, Cognition

2. Indoor olfactory effect on color-working memory

To investigate the effect of odor on indoor working, we measured behavioral and EEG data during a color working memory under the presentation of citrus odor: decanal. The results indicated that decanal presentation inhibited memory precision and EEG response related to attention for orange color memory. We suggested the probability that an odor can inhibit attention engagement to visual information related to the presented smell. This study was reported in PLOS ONE. We have been working on a related project of color-odor association.

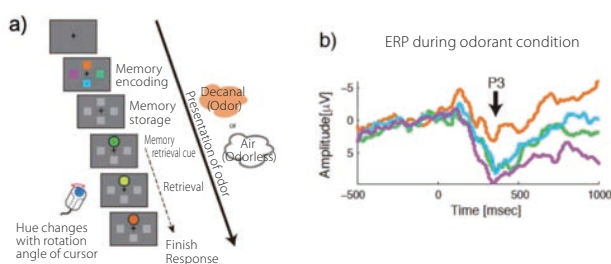


Fig.2. a) Color working memory trial procedure during odor presentation. b) Brainwave response for respective color working memory retrieval during odor presentation.

Advantages and Features

Subjective evaluations can be varied from many types of factors. Several sensations (e.g., olfactory and thermal sensations) sometimes are difficult to express verbally. Introducing physiological measurements such as EEG will contribute to the quantitation of indoor comfort and sensation.

Application Fields

- We can measure physiological parameters under various thermal environments, regardless of the heating/cooling system.
- Preference and pleasantness of odors could be quantified.
- We can measure physiological responses, including EEG, for other types of sensations.



Integrated Research on Wearable Health and Mobile Health for Health Management

Assistant Professor, Department of Information and Systems Engineering, Faculty of Information Engineering

LEE Jihyoung

Research Video 



Research Outline

1. Research ideas

- Enjoy daily health management while listening to music or while performing exercise!
- Enjoy watching outdoor sports while listening to game commentaries on the Olympics and other sports translated to mother tongues and while protecting one's body, especially from "heat stroke"!
- Assist health management of older adults using hearing aids!

2. Research contents

Our research is focused on health management, etc., in daily life and during exercise and is aimed at developing a "smart ear monitor system" that acquires various bioinformation (body temperature, heart rate, tension/stress conditions [1]) from an "external auditory canal sealing type earplug for the ear (earpiece)," can be used for "self-health management" by performing checks through a smartphone or other mobile recording equipment, and yet also used as an earphone.

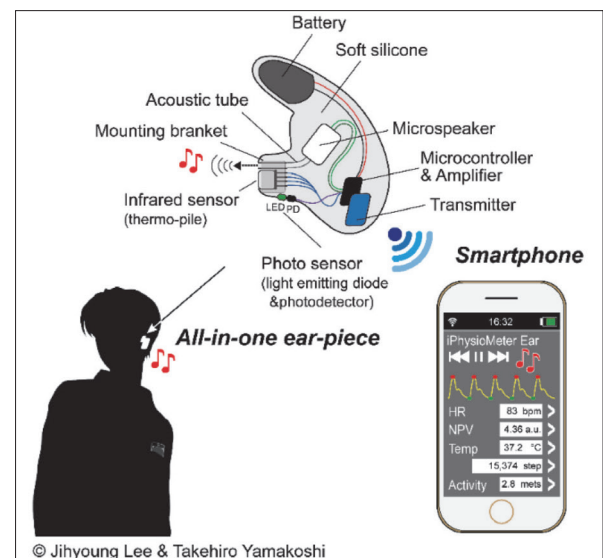


Fig. Image of smart ear monitor system.

Reference

- [1] J. Lee, K. Matsumura, T. Yamakoshi, P. Rolfe, N. Tanaka, K.H. Kim and K. Yamakoshi, Validation of normalized pulse volume in the outer ear as a simple measure of sympathetic activity using warm and cold pressor tests: towards applications in ambulatory monitoring, *Physiol. Meas.*, 34(3), 359-375, 2013.

Research Field(s)

Bioinformation measurement system engineering

Keywords

Wearable healthcare, Mobile healthcare

■ Advantages and Features

- Conditions of the body can be checked easily using an earphone in one ear and further, by using a smartphone, linked operations with applications for music, translation, etc., are also possible.
- Can be used not only by athletes but by spectators as well.
- Onsite check of tension/stress conditions can also be performed.

■ Application Fields

- Sports health science research
- Sports industry
- Welfare industry



The Resolution of Optimization Problems using Mathematical Programming and its Applications

Professor, Department of System Management,
Faculty of Information Engineering

SONG Yu

Research Outline

1. Research on staff scheduling problems

Staff scheduling problems, represented by nurse rostering in hospitals, are extremely complex problems that involve multiple work shifts (such as day shift, night shift, and semi-night shift, etc.), various working forms (full time, part time, etc.), and skill levels (veteran, rookie). And they are further complicated by related laws and legal regulations.

In this research, we utilize various mathematical programming techniques to generate rosters that clear restrictions and improve staff satisfaction (Fig.1).

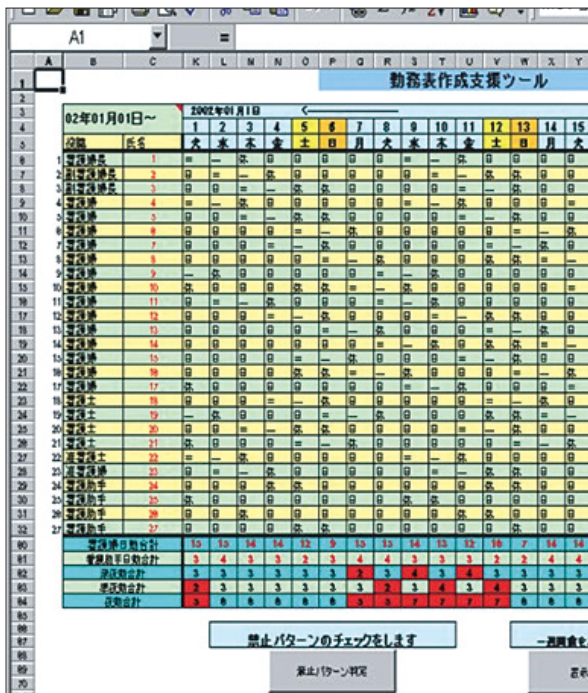


Fig.1. Nurse rostering supporting tool.

2. Research on optimal facility location problems

In this research, we utilize mathematical programming techniques to explore how to efficiently position public facilities and service facilities to enhance user convenience and satisfaction (Fig.2).

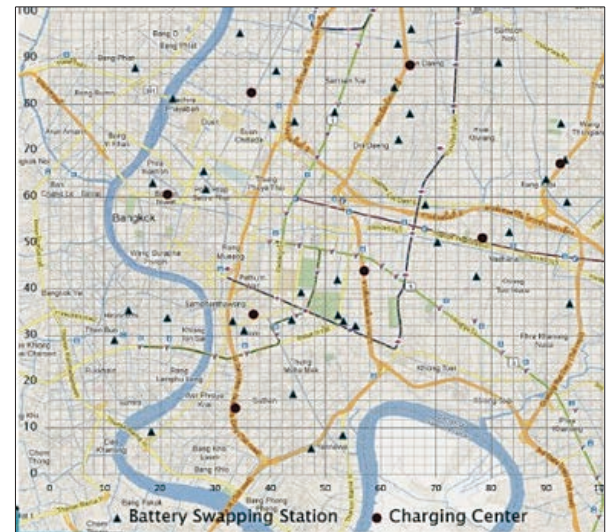


Fig.2. Optimal location of EV battery replacement stations.

Research Field(s)

Operations research, Industrial engineering

Keywords

Mathematical programming, Optimization problems, Working schedule preparation, Optimal facility location-allocation

■ Advantages and Features

Research of 1.: Staff scheduling: For onsite use, interfaces such as web apps, mobile apps, and Excel, are provided as necessary to enable easy use by anyone.

Research of 2.: Optimal facility location problems: Applicable to various cases such as public facilities, company services, etc.

■ Application Fields

Research of 1.: Preparation of staff rosters for call centers, hospitals, restaurants, factories, etc.

Research of 2.: Optimal location problems of libraries, hospitals, schools, hydrogen stations, etc.



Anatomy of Beauty: Visualization of Attractiveness Factors by Image Analysis

Professor, Department of System Management,
Faculty of Information Engineering

FUJIOKA Hiroyuki

■ Research Outline

Historical Context:

Historically, the concept of beauty and attractiveness has been a subject of fascination and study across various cultures and societies. Philosophers, artists, and scientists have long sought to understand and define what makes something beautiful. However, with the advent of the digital age and the proliferation of visual media, there's an increasing need to quantify and analyze beauty in a manner that's both objective and scalable.

Modern Challenges:

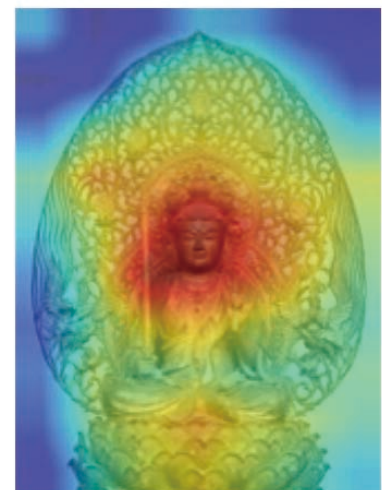
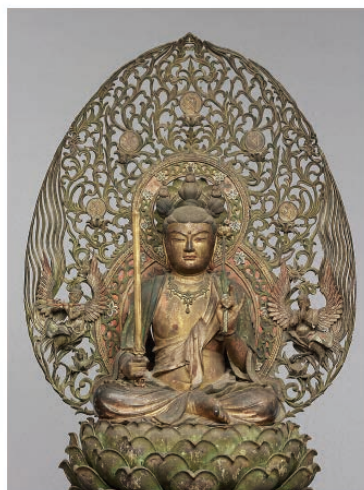
In contemporary times, industries ranging from advertising to product design are investing heavily in understanding consumer preferences and what appeals to them aesthetically. Yet, the subjective nature of beauty poses significant challenges. Traditional methods of gauging attractiveness, such as surveys or focus groups, often come with inherent biases and are not always scalable or consistent.

Our Approach:

This research aims to bridge this gap using advanced AI technologies. We are focused on the quantitative visualization of attractiveness factors of beauty through image analysis. By leveraging a convolutional neural network (CNN) and combining it with questionnaire survey results, we can

effectively visualize the intricate factors that play a role in aesthetic evaluations. This innovative approach not only provides insights into the subjective world of beauty but also offers a standardized method for aesthetic evaluation across various domains.

A prime example of the application of our approach is our ongoing study on Buddhist statues. These statues, revered for their spiritual significance and artistic craftsmanship, present a unique challenge in understanding the elements that contribute to their perceived beauty. By applying our AI-driven methodology, we aim to decipher the specific attributes and nuances that make these statues captivating to observers. This endeavor not only deepens our understanding of traditional art forms but also showcases the potential of our approach in diverse settings, from historical artifacts to modern aesthetics.



Research Field(s)

Information engineering

Keywords

AI, Deep learning, Beauty, Attractiveness factors, Visualization

In addition to the research, we have been actively involved in providing technical guidance to private enterprises, promoting the use of AI technologies and digital transformation (DX). My hands-on experience in assisting businesses with their AI and DX initiatives further emphasizes the practicality and applicability of the research in real-world scenarios.

■ Advantages and Features

In the rapidly evolving world of AI and image analysis, our research stands out as a pioneering effort to understand and quantify the concept of beauty. The unique blend of technology and aesthetics has led to several distinctive features and advantages that set our work apart:

Objective Evaluation: By using AI, we ensure an unbiased and objective evaluation of attractiveness factors, eliminating human biases.

Deep Insights: Our combination of CNN and image analysis dives deep into the nuances of beauty, providing detailed insights that were previously inaccessible.

Versatility: The technology is not limited to one domain and can be applied across different industries, making it a versatile tool for aesthetic evaluations.

Innovation: Our approach is at the forefront of combining AI with aesthetic evaluations, paving the way for future research in this area.

■ Application Fields

The implications of our research extend far beyond the academic realm. In today's market-driven world, understanding consumer preferences and aesthetics can be a game-changer for businesses. Recognizing this potential, our research offers valuable insights and applications in various fields:

- **Product Development:** Assisting in creating designs and packages that are more attractive and resonate with the target audience.
- **Branding Enhancement:** Evaluating brand logos and refining branding strategies based on objective data.
- **Advertising and Marketing:** Creating advertisements that are more appealing based on objective evaluations.
- **Construction and Design:** Supporting designers in understanding the aesthetic preferences of their target audience.



Layered Networks, Equilibrium Dynamics, and Stable Coalitions

Associate Professor, Department of System Management,
Faculty of Information Engineering

FU Jing

■ Research Outline

An important aspect of network dynamics that has been missing from our understanding in various applied settings is the influence of strategic behavior in determining equilibrium network dynamics. Our main objective here is to say what we can regarding the emergence of stable club networks - and therefore, stable coalition structures - based on the stability properties of strategically determined equilibrium network formation dynamics.

A club network consists of three primitives: a set of players, a set of clubs, and a set of arc labels. In our network model, a player's club membership is represented by a labeled directed arc from the node representing the player to the node representing the club. The arc label, which must be feasible for that player in that club, indicates the action chosen by the player to be taken in the chosen club. Thus, a player establishes a directed connection by choosing a club and a feasible club action. The set of all such player-specific directed club connections is the player's club network. At each of infinitely many time points, players, in light of the prevailing state and club network, are free to noncooperatively alter their club memberships as well as their corresponding club action profiles in accordance with the rules of network formation. We will assume that after players have altered their own club networks, each player receives a stage payoff, a function of the prevailing state-network pair, then given the prevailing state and the new club network chosen by the players, a new state is

generated in accordance with the law of motion. We will assume that players, in making their membership-action choices through discrete time, seek to maximize the discounted sum of their expected future payoffs. In particular, we will assume that players in forming their club networks, play a discounted stochastic game of club network formation in which they seek to choose stationary Markov perfect membership-action strategies that maximize the discounted sum of their expected payoffs. Taken together, the players' noncooperative network formation strategies determine a network formation process.

In addition to constructing a discounted stochastic game model (i.e., a DSG model) of club network formation, we show that our DSG of network formation possesses a stationary Markov perfect equilibrium in players' membership-action strategies and identify the assumptions on primitives which ensure that the induced equilibrium Markov process of layered club network formation satisfies the Tweedie Stability Conditions (2001). As a consequence, the equilibrium Markov network formation process generates a unique decomposition of the set of state-network pairs into a transient set together with finitely many basins of attraction. Moreover, we show that if there is a basin containing a vio set (visited infinitely often set) of club networks sufficiently close together, then the coalition structures across club networks in the vio set will be the same.

Research Field(s)

Game theory

Keywords

Club networks, Stable coalition structures, Discounted stochastic games, Stationary Markov perfect equilibria.

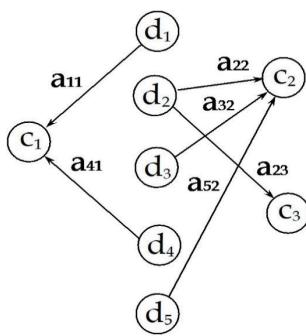


Fig.1. Time Allocation.

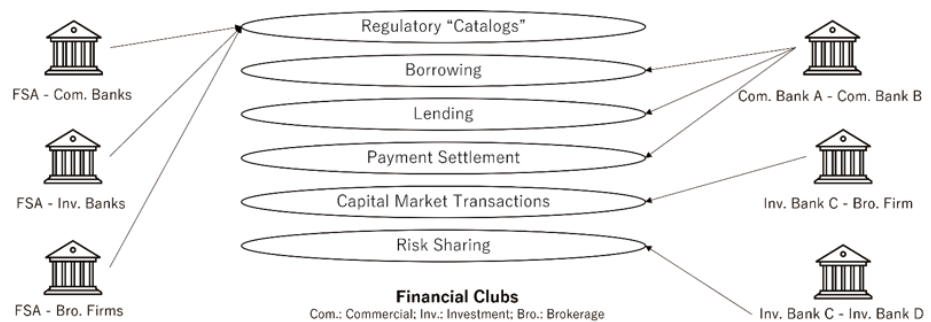


Fig.2. An Example of Financial Club Network.

Advantages and Features

By integrating into the analysis of network dynamics the essential role played by the strategic behavior of players in the network formation process, our work here can be thought of as a first work on the strategic dynamics of layered networks.

Application Fields

As a running example we consider a DSG over time allocation networks (Fig. 1). We show that because players' payoff functions are naturally affine over the convex, compact feasible set of time allocation networks, players' stationary Markov perfect equilibrium network formation strategies are bang-bang. Thus, rather than diversifying their club time across several clubs, each player in each state spends all club time in one and only one club. Moreover, we show that all that is required for the

equilibrium time allocation process induced by players' stationary Markov perfect bang-bang time allocation strategies to satisfy the Tweedie conditions is for the state space to be compact and the conditional densities over coming states to be continuous in the current state and time allocation network for almost all coming states (i.e., except potential coming states having probability zero of occurring).

Another typical application is in short-term financial club network formation process (Fig. 2). The emergence of stable club networks could help in determining how best to remedy, via policy interventions, shortfalls in the endogenous incentives of institutions to form networks that minimize systemic risks, maximize resiliency, and thereby allow investable funds to flow to their socially optimal uses, creating productive investments where they matter.



Ecosystem Evaluation for Conservation of Aquatic Ecosystems and Sustainable Utilization of Aquatic Resources

Professor, Department of Socio-Environmental Studies,
Faculty of Socio-Environmental Studies

INUI Ryutei

Research Video 



Research Outline

1. Development of models to predict distribution of aquatic species

For conservation of aquatic species, it is necessary to know their distribution and habitat. We not only clarify the distribution and habitat of various aquatic species by field surveys, but also predict the distribution of aquatic species using GIS.

2. Determination of distribution and biomass of aquatic species using environmental DNA

In waters, there is present DNA derived from inhabiting living organisms and this is called environmental DNA. In our laboratory, environmental DNA analysis is used in

biological surveys to accumulate information on the distribution, biomass, population, and genetic information of aquatic species.

3. Development of a method for determining the distribution of brackish water species using deep learning

We are developing a method that uses deep learning to analyze images of tidal flat surfaces to predict what species are present in those images. The completion of this method will make it possible to survey tidal flats in a short period of time and with good reproducibility.

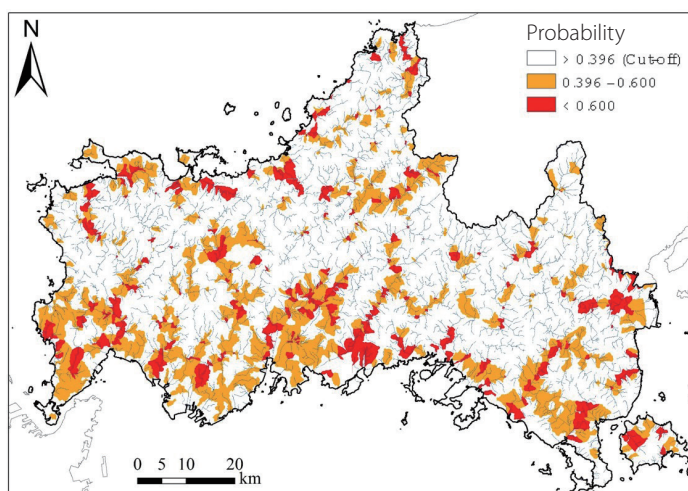


Fig.1. Potential habitat map of the alien plant *Egeria densa* in Yamaguchi Prefecture.

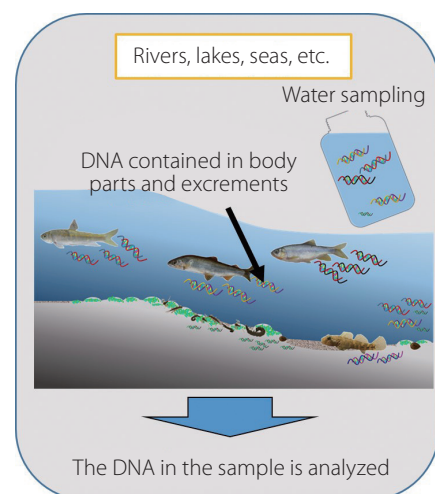


Fig.2. Image of environmental DNA and how water is sampled.

Research Field(s)

Aquatic environmental studies, Ecology and civil engineering, Fish ecology

Keywords

Ecosystem, Rivers, Coasts, Tidal flats, Brackish zone, GIS, AI, Deep learning

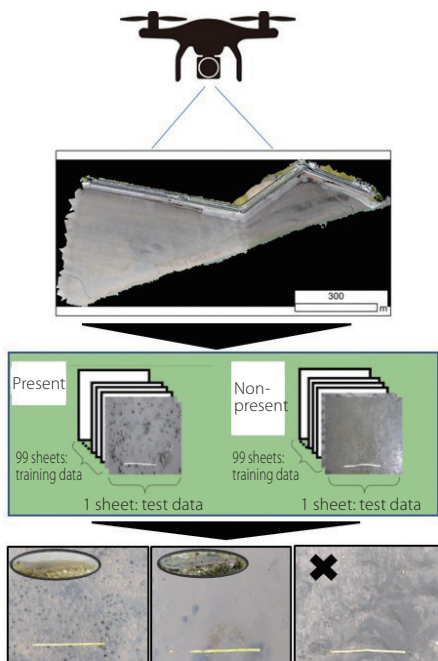


Fig.3. Image of determination of the distribution of brackish water species using deep learning.

Advantages and Features

As information necessary for conservation of living organisms, the information obtained conventionally by direct collection and environmental measurements in the field is insufficient in many cases due to restrictions in time, finance, and labor. By combined use of a distribution prediction model, environmental DNA, and deep learning by AI, it becomes possible not only to cover the limits of the conventional methods but also to make evaluations from a comprehensive viewpoint and obtain vast amounts of data.

Application Fields

River management, coastal zone management, aquatic resources management



Social Area Analysis of Urban Living Environments

Associate Professor, Department of Socio-Environmental Studies,
Faculty of Socio-Environmental Studies

UESUGI Masaya

■ Research Outline

In our laboratory, we are analyzing the urban living environment and associated behavioral and awareness factors of residents from relationships with distribution of resident characteristics according to small district units such as postal code districts. Specifically, the geographic information system (GIS) and statistical methods are used to clarify geographical differences in public safety, traffic behavior of residents, awareness regarding earthquake resistance of homes, etc., and to examine improvement policies in accordance with the neighborhood characteristics. Also, in order to understand the resident characteristics in small district units, we use geodemographics data in which neighborhoods of Japan are classified according to multiple social area types (neighborhood types such as district with a large number of young people living alone, district with a large number of wealthy middle-aged and older adults, district in which aging is progressing, etc.) based on the resident characteristics.

1. Research on physical and social environmental factors of burglaries in residential areas

The crime incidence data according to neighborhoods that are made public by local governments are used to examine how the occurrences of crimes such as residential burglary differ according to proportion of detached housings, proximity to a major road, as well as social area type of a district and to specify neighborhoods where anti-crime measures are to be

stressed in accordance with the modus operandi of crime.

2. Research on neighborhood factors that predict traffic behaviors of individuals

Person Trip Survey data that capture the trajectory of a person in one day are used to examine how the traffic means selection of an individual in daily life activities such as commuting and shopping differ according to social area type apart from personal attributes and to evaluate the possibility of policy induction for converting transportation mode from automobiles to train.

3. Research on public enlightenment of earthquake resistance of homes

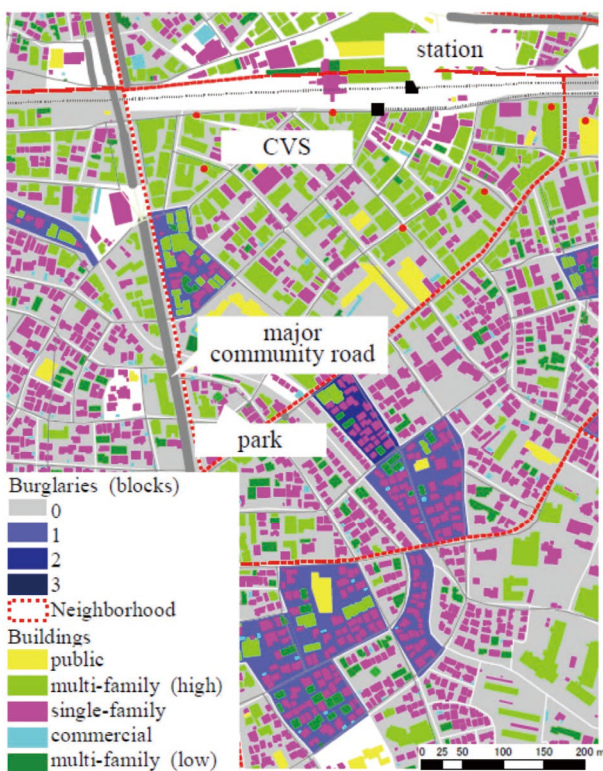
We investigate residents' awareness of earthquake resistance and information media used by residents in the process of home improvement using questionnaires. Additionally, we evaluate differences in trends according to social area type of residences to specify effective enlightenment measures and targets thereof for information provision by local governments in relation to earthquake-resistant reinforcements.

Research Field(s)

Urban geography, Urban planning,
Spatial information science

Keywords

Geographic information system (GIS),
Geodemographics, Living environment,
Regional policies



Crime opportunities at block level.

Reference

Masaya Uesugi, Kimihiro Hino (2015) Block and neighborhood level determinants of residential burglary in Japan. KAGIS Fall Conference 2015 & International Symposium on GIS, 35-36.

Advantages and Features

- By linking multifaceted neighborhood characteristics with conventional statistical/survey data, these regional trends can be understood according to small district units.
- In terms of policies, since targets can be specified in accordance with regional characteristics according to small district units, efficiency can be achieved with limited financial and human resources.

Application Fields

Widely applicable to database with geographical information such as regional statistical data and questionnaire survey data that include address information of respondents.



Clarification of Damage Expansion Mechanisms and Future Prediction of Floods

Associate Professor, Department of Socio-Environmental Studies,
Faculty of Socio-Environmental Studies

TAI Akira

■ Research Outline

In recent years, torrential rain disasters are occurring practically every year in Japan and especially in Kyushu, damage including human damage has been occurring successively as in the north Kyushu torrential rain of July, 2012, the north Kyushu torrential rain of July, 2017, the torrential rain of July, 2020, etc. Further, in the IPCC Sixth Assessment Report, it is reported that there is a high possibility for extreme weather such as increase in frequency and intensity of heavy rainfall to increase globally in the future due to the influence of global warming.

In our research group, we conduct field surveys immediately after flood disasters in various places and

perform computer simulation based on the data to clarify disaster expansion mechanisms of floods. Also, a probabilistic evaluation of future changes in precipitation was performed using a large-scale ensemble climate prediction database to demonstrate that in accompaniment with air temperature rise, the annual maximum hourly precipitation for the entirety of Kyushu will increase and that regional differences are seen in changes in torrential rain. Further, we are using climate prediction data to predict runoff volumes during torrential rains at class A river basins in the Kyushu area by runoff models and are examining characteristics of changes in rainfall and river flow in accompaniment with global warming.



Fig.1. Situation of disaster survey. (Hitoyoshi City, 2020)

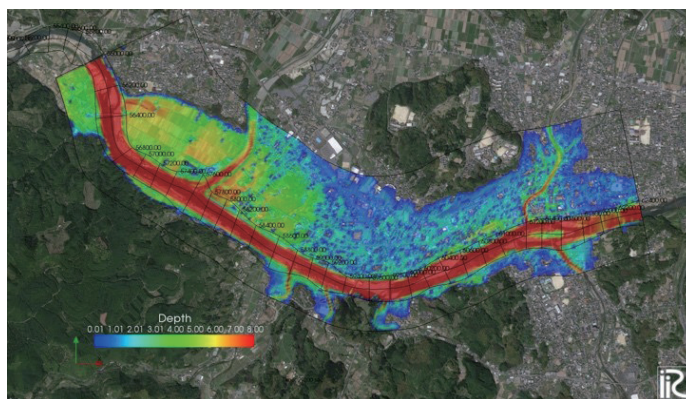


Fig.2. Simulation of inundation. (Hitoyoshi City, 2020)

Research Field(s)

Disaster prevention engineering,
River engineering, Coastal and ocean
engineering

Keywords

Floods, Torrential rains,
Numerical simulation, Global warming

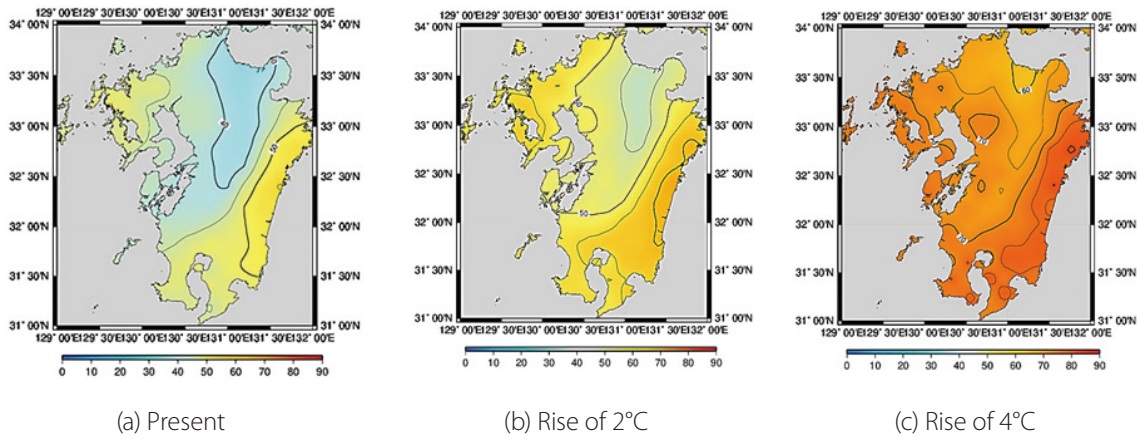


Fig.3. Distribution of maximum hourly precipitation (once in 50 years) in Kyushu.

Advantages and Features

Reproduction of circumstances of floods that have actually occurred and floods that could occur in the future on a computer can be put to use in various measures.

Application Fields

Important information for considering appropriate evacuation guidance and land use for future floods is provided.



Research on Support for Prevention of Functional Disabilities of Older Adults by Physical Activities Including Exercise

Professor, Center for Liberal Arts

NARAZAKI Kenji

Research Video 



■ Research Outline

1. Research background

With the arrival of the super aging society, the prevention of functional disabilities (leading to long-term care needs) of older adults and the realization of elongation of healthy life expectancy are recognized as urgent social issues. In studies in and outside Japan that have targeted middle-aged and older adults up to now, it has been reported that the onsets of lifestyle-related disease, dementia, etc., that can become disorders causing the need for long-term care are suppressed by increasing physical activities in daily life. The possibility that some of such disorders is suppressed by reducing sedentary behavior in daily life, regardless of the amount of physical activities, has also been indicated.

2. Research contents

Based on the above background, in our laboratory, we have set up the hypothesis that “by increasing daily physical activities and reducing sedentary behavior of middle-aged and older adults, the subsequent risks of the need for long-term care are reduced” and are carrying out exercise epidemiology studies for obtaining evidence regarding the hypothesis and exercise physiology studies for clarifying exercise conditions that are effective for reducing need-for-care risks and can be implemented safely.

(1) Exercise epidemiology studies

Through joint research with the Laboratory of Health and Exercise Epidemiology of Kyushu University (Professor KUMAGAI Shuzo), we are carrying out studies on the relevancy of daily life physical activities, sedentary behavior, and physical strength at certain points in the lives of locally residing older adults persons and subsequent certification of long-term care needs. Also, through joint research with the Health Promotion Research Center, Institute of Community Medicine, Japan Association for Development of Community Medicine (Researcher NOFUJI Yu), we are carrying out studies on the relevancy of the living environment and physical activities including exercise and sedentary behavior of locally residing middle-aged and older adults (Fig.1).



Fig.1. Situation of an exercise epidemiology study (investigation meeting).

Research Field(s)

Exercise epidemiology, Exercise physiology

Keywords

Public health, Exercise prescription, Long-term care needs

(2) Exercise physiology studies

Through joint research with the Laboratory of Exercise Physiology, the Faculty of Sports and Health Science, Fukuoka University (Professor TANAKA Hiroaki), we are carrying out studies on the disability prevention effects brought about by exercises of comparatively low intensity such as jogging, cycling, etc., (Fig.2).



Fig.2. Situation of an exercise physiology study (experiment).

Advantages and Features

Research findings that are helpful for planning, practice, and assessment of regional measures aimed at disability prevention such as exercise classes and various activities, etc., targeted at older adults can be obtained.

Application Fields

- Public health studies
- Geriatrics
- Health science



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