Robotics

Robotics
Robotics

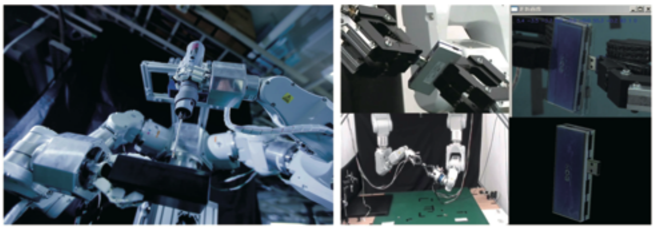
Distinguished Prof.
Kazuhiro Kosuge

Assist.Prof.
Jun Kinugawa

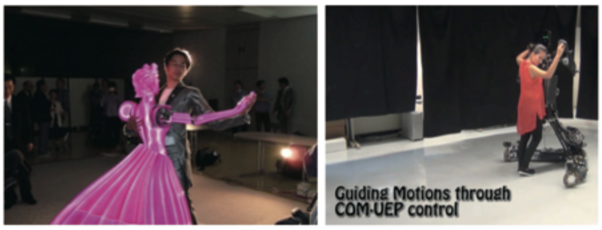
Kosuge/Kinugawa Laboratory

Robot Systems,
Systems Robotics

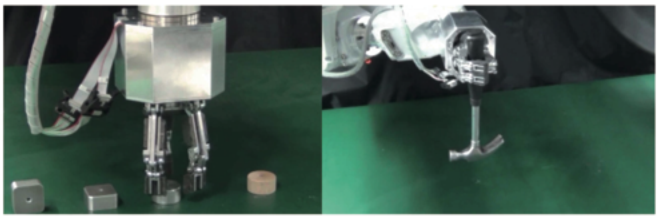
http://www.irs.mech.tohoku.ac.jp/?page_id=258



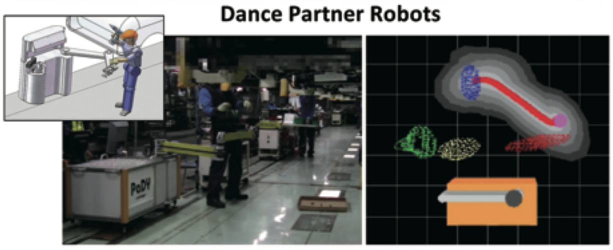
Universal Manipulation



Dance Partner Robots



Universal Robot Hand



Co-worker Robot PaDY

Systems Robotics

A robot consists of devices such as sensors, actuators, and mechanisms, and software/hardware to integrate them to create desired intelligent behaviors of the robot in its real working environment. Systems Robotics research provides a general framework for designing a robot with desired functions based on scientific and theoretical research backgrounds taking implementation/integration issues of the robot in the real environment. We first define a service/services provided by the robot we are planning to develop as a sustainable business model, then develop fundamental technologies required for the service/services and create the robot by integrating them.

Co-worker Robot PaDY

PaDY(Parts/tools Delivery to You Robot) is a co-worker robot developed for vehicle assembly processes in automotive factories where a worker attaches several parts to a vehicle assembled. PaDY delivers necessary parts and tools to a worker when he/she needs them. PaDY learns where the worker works in the vehicle body coordinates, and how the worker moves from one working position to another working position in real-time. PaDY plans its motion for delivering the necessary parts and/or a tool form the working bench to the predicted next worker's working position based on the real-time position of the worker and delivers them to the worker.

Dance Partner Robots

A dance partner robot is a robot research platform for human-robot interaction. Two types of the dance partner robots have been developed so far. One is a dance partner robot, whose key technology is to predict the behavior of the humnan partner. The other is a dance teaching robot, which teaches its partner how to dance based on a progressive dance teaching scheme. These robots have provided us a lot of new findings relating to human-robot interaction, which have been applied to real-world applications.

Universal Manipulation

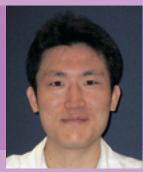
Industrial robots have been used for more than sixty years. The industrial robot control technology is still based on the invention of teaching and playback concept invented in 1954 by George Devol. To use the robot, its user needs to customize the robot, such as design of an end-effector to grasp the part, parts feeder system of the parts, a fixture, sensors, programing of the robot, etc. The goal of this research is to develop a customization free and a program-free robot system.

Universal Robot Hand

For universal manipulation, we need a general purpose robot hand, which could handle different parts without any customization. In real production systems, we could not use anthropomorphic robots hand designed for realizing human like hand, because of several issues of the hand, such as cost, robustness, etc. The goal of this research is to develop a universal robot hand, which is applicable to real assembly processes handling different shpaes of objects without any customization.

Robotics
Robotics

Arai(sho) Laboratory



Assoc.Prof.
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System Robotics Laboratory

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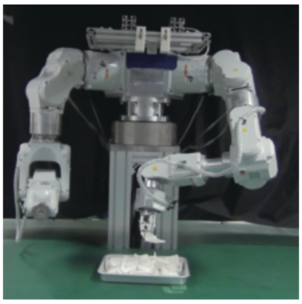
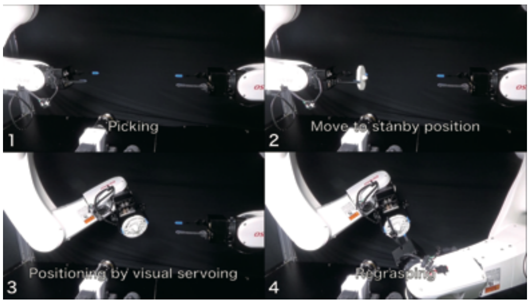
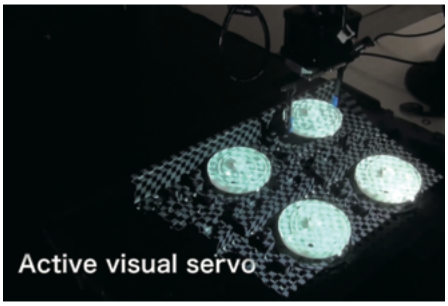


Bin Picking Robot



Re-grasping by visual Servoing



High Accuracy Positioning via Active Visual Servoing

Developments of robotics towards Fourth Industrial Revolution!

Nowadays, it is important to monitor the states of the entire factory and link the data with services inside and outside the factory via an internet connection. Towards Fourth Industrial Revolution, intense competitions for technological development among countries and corporations are taking place all over the world. Current automated production systems are facing the problem of the huge integration costs for the establishment of the production lines and short down-time due to the daily troubles. To solve these problems, we are focusing on a technology of the robot system that integrates key technologies of robotics such as 3D measurement, robot vision, and visual servoing. Furthermore, we are working on the formulation of control theory for multi-agent systems and the analysis of the behavior of the model organism based on the robot vision technologies.

Bin Picking Robot

The automated production lines require machines to pick up the piled up objects one by one (bin picking) and to supply them to the assembly robot in a constant pose. Currently, these tasks are done by humans or machines called parts feeder, though it is common sense in the robotic field that the bin-picking robot is necessary for automated production. In our laboratory, we research on “three-dimensional measurement”, “pose estimation”, “grasp planning”, “motion planning”, and “visual servoing”, which are key technologies of bin picking robots.

Active Visual Sevoing for high accuracy manipulation

Grasping, handling, and aligning object are fundamental motions for humans, though these basic motions are relatively difficult for robots. Despite the development of various robots, none of them have yet to be put into practical assembling tasks in automated lines. To overcome the problems, we propose a key technology called Active Visual Servoing that enables precise robot manipulation by applying deep learning and three-dimensional measurement technology to control theory for positioning.

3D measurement based on deep learning and spare modeling

We are working on developing a technology for high-accuracy 3D measurement for objects with metallic luster and semitransparent objects, which were difficult until recent. To achieve fast, precise, and robust 3D measurement, we propose a novel method for 3D measurement by introducing technologies of deep learning and sparse modeling. Our goal is to develop a measurement device based on the proposed method that can be used practically in the manufacturing field.

Multi-agent system

Control theory for the multi-agent system has been researched in our laboratory. We aim to develop an algorism for fast and optimal sensor scheduling when using a network of sensors as an observer that compose multiple various sensors. We also research on energy sufficient controls and field sate estimation technology for a long-term field exploration by multiple autonomous mobile robots.

Hayashibe Laboratory

Prof.
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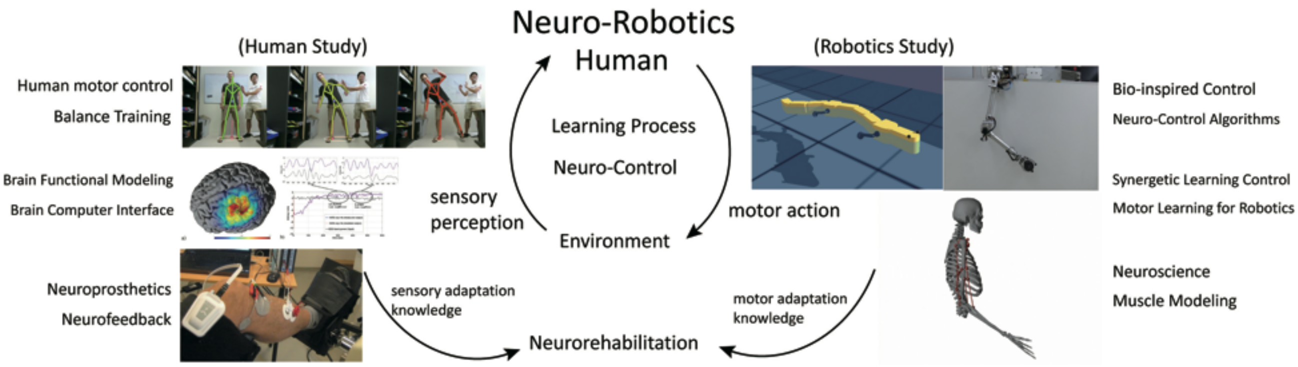
Robot Systems
Neuro-Robotics

http://neuro.mech.tohoku.ac.jp/



Neuroscience for Robotics, Robotics for Neuroscience

Recent era is referred as the century of robots and AI. However, especially in terms of adaptive interaction with the real-world environment, there are still many things we should learn from human advanced motion control and sensory functions. In this lab, we investigate toward a deep understanding of human environmental adaptation, with the approach of both engineering and brain science. Therefore, we study on motor control and learning mechanism at a level that can be explained by brain science with robotics technology. We work on Neurorobotics: neuroscience for robotics and robotics for neuroscience. We also aim for neurorehabilitation inspired by Neurorobotics.

Human adaptive control and learning mechanism

It is no exaggeration to say that humans have acquired the best environmental adaptability in the animal kingdom due to their motor learning ability to cope with unknown environments. We are focusing on the learning control loop of sensorimotor systems, which is how humans process sensory inputs from the environment and what learning algorithms can calculate correct motor output from sensory inputs. We study on balance and gait control both experimentally and computationally.

Modeling and identification for bio-signals and functions

We develop biological signal analysis related to exercise, modeling of biological functions including muscle to brain, and identification technology for considering individual differences. By analyzing the efferent motor information such as myoelectric potential and analyzing the brain perception state when applying afferent sensory feedback, we analyze the motor-sensory synergy by performing multidimensional signal analysis. We aim at quantitative evaluation of sensory motor function.

Redundant joint control and motor learning in vertebrates

Not only humans but also vertebrates adapt to the environment by producing appropriate motor outputs of the limbs and redundant joints. This is possible because it has a neural circuit that expresses basic rhythms related to movement, such as walking, in the lower levels of the central nervous system, and has a mechanism to generate and modify motor output. We are conducting research on the expression and memory of time-series motion patterns using neural networks.

Development of robot technology for neurorehabilitation

The efficiency of neurorehabilitation is an important issue for Japanese society, which will face a super-aging society in the future. Stroke, in particular, increases with age and affects motor control and coordination functions. We are studying processes related to motor learning from brain signal processing and sensory feedback by neurosensory stimulation on the peripheral side, and aim to construct neurorehabilitation that maximizes the effects of motor learning.

Robotics
Department of Robotics

Owaki Laboratory

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Robot System
Neuro-robotics

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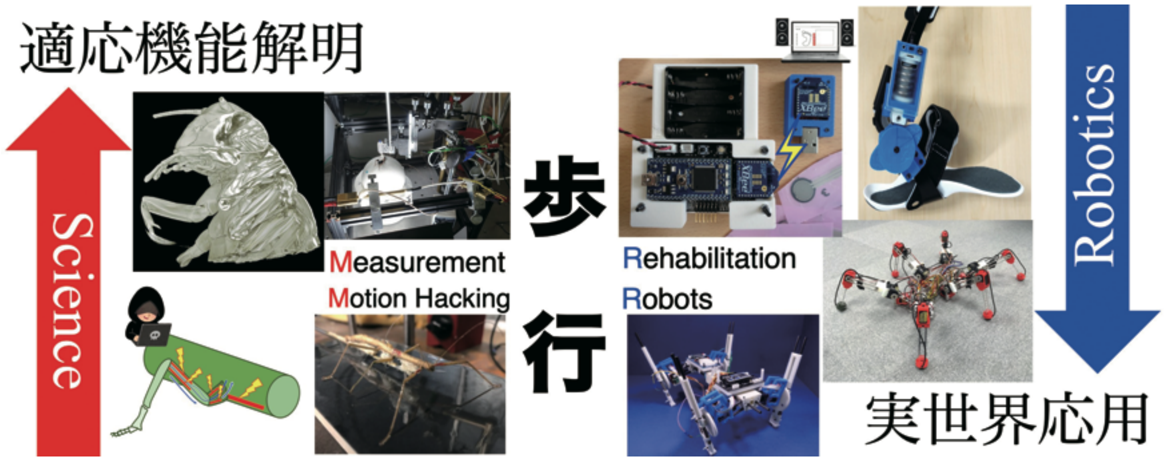

Understanding Adaptation Mechanism in Animal Locomotion and its Applications

Animals, even insects which have limited numbers of neurons, exhibit surprisingly adaptive locomotion against unpredictable situations, e.g., unknown environments or sudden bodily accidents. In this Lab., by focusing on “walking”, which is a fundamental ability for locomotion, we aim to understand the scientific principles and to implement them into real-world applications. Here, we study bi-directional research topics, e.g., (1) understanding motor control mechanism in insect locomotion for designing robots and (2) developing innovative technologies/robots for neuro-rehabilitations/neuroscience researches, by using sophisticated engineering approaches.

Measurement of insect walking

Even after leg amputation, insects exhibit adaptive walking in response to their remaining body morphologies. Here, we aim to elucidate the adaptation mechanism before and after leg amputation from the viewpoints of robotics and engineering, by using simultaneous recording of leg movements with high-speed camera and muscle activities with electromyography.

Neuro-rehabilitation Inducing Brain Plasticity

Here, we consider that understanding the neural mechanism underlying long-term brain plasticity on body representation with motor disfunctions is the key for establishing the effective neuro-rehabilitation techniques. To this end, we develop novel rehabilitation technologies that enable interventions to body representation and then apply them to clinical trials for patients on Tohoku University Hospital towards social implementation.

Motion Hacking -Control of Insect Walking-

Not only measuring insect walking, this research aims to understand intrinsic neural mechanism for adaptation by externally “controlling” insect walking with engineering approaches. Here, we proposed “Motion Hacking” method, which can externally hack leg motions via electrostimulations for muscles.

Resilient Robots That Can Adapt to Bodily Accidents

Even cutting-edge robots are weak against unpredictable environments and accidents, whereas animals generate adaptive behaviors against such unpredictable situations by fully utilizing their remaining functions. Here, we aim to apply the ingenious adaptation mechanism for developing “tough” and “resilient” robots that can reproduce adaptive behaviors in the real world similar to animals.

Robotics
Robotics


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Hirata/Weng/Salazar Laboratory

Robotic System
Smart Robots Design

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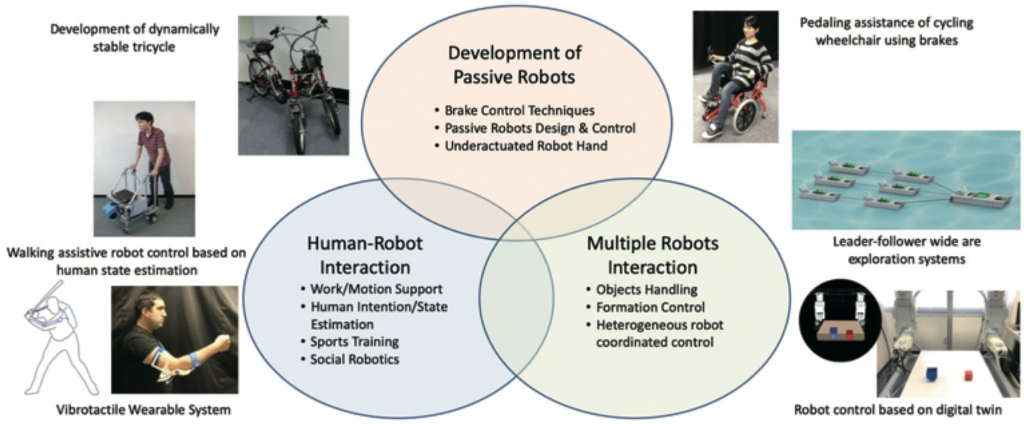

A new type of robot that cannot move by itself

The main goal of our laboratory is to create and develop novel passive robots enabled with state-of-the-art robotic technology to guarantee the user's safety in Human Robot Interaction. Most of the systems developed in our laboratory do not have their own driving force from motors, but their mobility rather relies on an external force. Our assistive robots are designed to support users when they need it or in case they are in a dangerous situation. As a result, people feel don't feel like they depend on the robot, they feel that they can move freely and independently. Under the same concept, we are developing haptic devices (using vibration) to convey the desired motion direction to users and help them train sports efficiently by themselves. Furthermore, we are conducting research and development of a wide-area exploration system using multiple passive robots for efficient exploration of earthquake disaster areas, volcanic areas, oceans or other planets.

Support systems for the elderly and disabled (human-robot interaction

We have developed passive robots' motion control technology for robotic walkers, cycling wheelchair robots, object transportation robots (i.e. mobility cart system), as well as haptic systems that can be used for rehabilitation, sports training, and virtual reality. Besides, we are also conducting research in estimating the user's state and motion intention by measuring user's motion in real time.

Sports training system using vibrotactile stimulation (human-robot interaction)

We are currently developing technologies to effectively train sports in a short time by conveying users the appropriate motion direction using multiple vibration stimuli. The proposed systems range from haptic wearable systems to haptic sports equipment (e.g., rackets, golf clubs). In addition, we want to use this technology to enhance the perception for elderly and disabled people so that they can enjoy sports despite their reduced capacities.

Social robotics (human-robot interaction)

As technology develops and the demand for incorporating robots into human society increases, the research field of social robotics to study the coexistence between humans and robots is becoming important. This can be called a "robot sociability problem". In the future, in order to develop new human-friendly robots, we will not only conduct research from an engineering perspective, but also conduct interdisciplinary research with other fields including robot ethics and robot law.

Wide-area exploration system using multiple robots (multi-robot interaction)

In this area, we propose using an active system with a driving force (e.g., robot, ship, crane, etc.) towing multiple passive robots equipped with sensors in order to efficiently survey earthquake disaster areas, volcanic areas, oceanic area or another planet's surface in a short time. We study how to use part of the driving force to realize steering and controlling those passive robots into a formation for exploration. This realizes a low-cost and efficient wide-area exploration system.

Robotics
Information Sciences

Okatani/Suganuma Laboratory

Prof.
Takayuki Okatani

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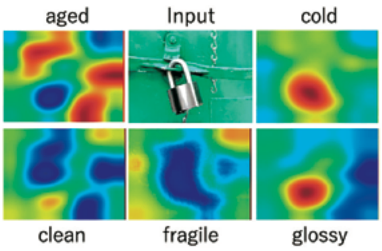
Masanori Suganuma

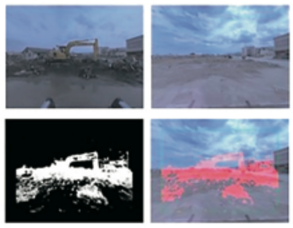
Intelligent Robotics, Image Analysis

http://www.vision.is.tohoku.ac.jp/us/home/



Recognition of surface qualities

Visual Question Answering



Four-dimensional modeling

Computer Vision: From Image Sensing to Deep Learning

We study computer vision and related fields such as image processing, machine learning, or natural language processing. The goal of computer vision is to build a machine intelligence that can capture, recognize, and make a decision on various visual phenomena, from image sensing to semantic recognition. Towards this goal, we work on both theoretical and practical problems in computer vision, such as material recognition, urban scene modeling, deep neural networks, probabilistic graphical models, artificial network for neuroscience, visual fashion analytics, or attribute perception in natural language.

Recognition of Surface Qualities

We are studying methods for recognizing the surface qualities of an object from its single image. By surface qualities we mean a variety of sensations that humans receive for the surface of an object, such as smoothness/roughness, glossiness, and bumpiness. We believe that the surface quality of an object can be represented by a set of such attributes, which form a comprehensive concept (called Sitsukan in Japanese) in the human brain in a mutually connected manner.

Artificial Intelligence Based on Deep Learning

Deep neural networks have achieved good performance on various problems such as image recognition, low-level image processing, and language modeling. We are studying deep learning techniques from basic and practical perspectives. For example, we proposed a new training method for deep neural networks with normalized kernels.

Four-dimensional Modeling

Since right after the occurrence of the Great East Japan Earthquake on March 11th, 2011, we have been periodically capturing the images of the disaster areas in the north-eastern Japan coastline by using a vehicle having a camera on its roof. The motivation behind the periodic image capturing is to archive not only the damages of the areas but also the process of their month-by-month recovery or year-by-year reconstruction.

Visual Analysis of Fashion

We are working on visual analysis of fashion images based on computer vision. Specifically, we try to build a machine intelligence that can recognize fashin images as humans do. To this end, we propose a method which learns a probabilistic model of the combination of outfits and items using a large amount of web data.

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Assoc.Prof.
Kazunori Ohno

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Robotics
Graduate School of Information Sciences

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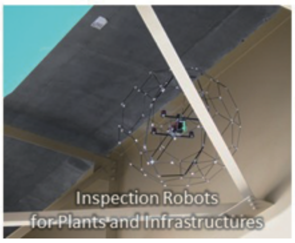
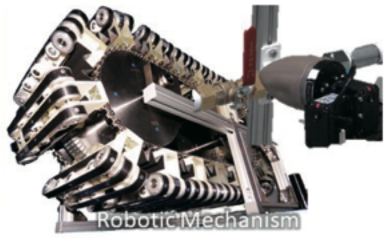
Information and Applied Technology, Human-Robot Informatics

https://www.rm.is.tohoku.ac.jp/englishtop/





Study on Rescue robots and Cyber-enhanced rescue canines

Prof. Tadokoro opened a new academic field on search and rescue robotics after he experienced the Han - Shin Awaji Earthquake disaster in 1995, and our laboratory has been acting as a world center of this filed. Especially, Quince, a search robot with high mobility in confined spaces, was applied for Fukushima Daiichi nuclear disaster after the 2011 Tohoku earthquake, and it contributed to the cold shutdown of the nuclear reactor. Besides, Robo-scope, a serpentine robot to explore damaged buildings, was also applied for the nuclear disaster to investigate inside the damaged nuclear plant. Recently, high-tech suits worn by search and rescue dogs attract attention as innovative technology. The sensing and environment recognition technologies developed for rescue robots are applied to the suits, and the suits can automatically detect the clues of victims and transmit information on disaster sites and victims to rescue workers.

Study on autonomous driving and scene recognition

Our laboratory has studied on robust technologies for autonomous driving and scene recognition in harsh environment such as bad weathers (heavy rain, snow, and fog). Fusion of LiDAR and GNSS enables to conduct 3D mapping and localization. Probabilistic robotics and machine learning are used for data fusion and scene recognition. Our techonologies are used in real applications such as autonomous outdoor carriers in Toyota Motor East Japan and fire-fighter robot sytem in petrochemical complexes.

Study on Active Scope Camera

Our laboratory has been studying thin serpentine robots to move actively by applying new actuation mechanism. We have developed Active Scope Camera, video scope camera that can move by itself with the developed actuation mechanism, aiming for exploration in narrow spaces in disaster sites. We won the best award of the commissioner of the Japanese Fire and Disaster Management Agency and the Japanese Robot Award in 2008.

Inspection Robots for Plants and Infrastructures

Our laboratory has been developping inspection robots for industrial plants and infrastructures such as bridges and tunnels on the basis of technologies we evolved for search-and-rescue robots to work at hazardous places for humans. As of 2019, we are developping a drone with a spherical shell that can inspect narrow spaces in bridges, a tracked vehicle for plant inspections, and a welding robot for industrial sites.

Robotic Mechanism

Our laboratory are systematically working on extreme mechanisms including the omnidirectional drive mechanism with the spherical omnidirectional wheel "Omni-Ball" as a starting point. From the creation of the principle idea of the mechanism, we are also working on a series of realization processes such as actual machine design and prototyping. Also, as an application of the robotic mechanism, we are working on a mobile robot platform and robotic gripper in a disaster area.

Robotics
Graduate School of Information Sciences

Konyo Laboratory

Assoc.Prof.
Masashi Konyo

Information and Applied Technology,
Human-Robot Informatics

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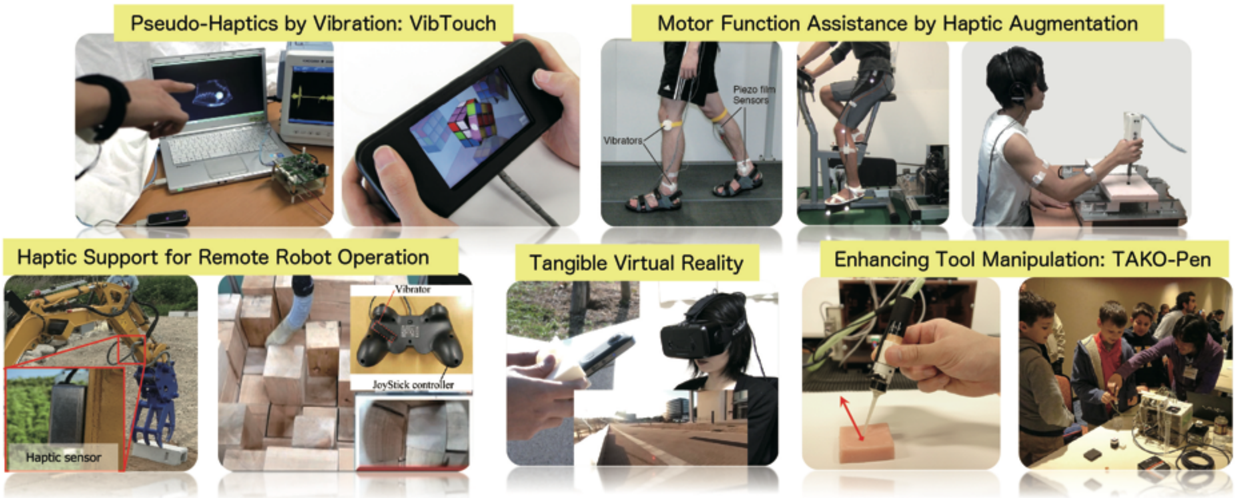

Haptic Interfaces for Human Support and Advanced Robotic Applications

Haptics is all things related to our sense of touch and body sensory functions. Creating haptic feedback for humans and robots contributes to enhancing our communication and physical capabilities. Our missions are to reveal unknown functions of human haptic sensory systems and to create innovative technologies by reproducing and improving the human haptic capabilities.

Haptic Interface for Mobile Information Devices

A pseudo-haptic representing method called VibTouch enable us to use haptic feedback on mobile information devices anywhere. VibTouch can represent force-like feelings such as friction, inertia, viscosity, and elasticity, which are based on sensory illusions induced by vibrotactile stimuli. Our technologies realize a highly intuitive experience for human-computer/machine interactions.

Motor Function Support by Haptic Augmentation

Older people often lose motor functions not only due to the decline of muscle but also the loss of sensory functions. We are investigating cutaneous sensory mechanism related to the motor functions and creating new sensory enhancing technologies. Our technologies target on new welfare devices such as a gait support system, efficient rehabilitation therapy, and sensory transportation for prosthetic limbs.

Haptic Support for Remote Robot Operations

Remote operations in extreme environments require not only the robot capability but also operators' performances in operation and decisions. We offer a haptic transmission technology by combining a vibration-based sensing method for detecting collisions on a robot body and vibrotactile feedback methods for the operator. Notably, we have developed remote operation systems for snake-type robots and construction robots for the ImPACT "Tough Robotics Challenge" Program.

Haptic Mechanism for Tool Manipulations

Humans can perceive external forces applied on a grasping tool based on skin pressure distribution at multiple contact areas during grasp. We have developed a pen-type pseudo-haptic interface using suction pressure stimulation on each skin. Our technology realizes to represent forces in 6-DoF directions and to enhance the detected force by reproducing cutaneous activities at the contact area.

Prof.
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Yuki Suzuki

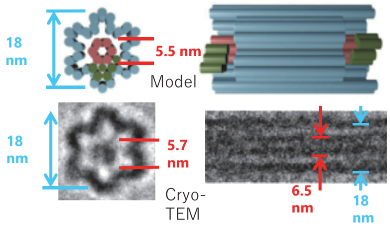
Murata/Kawamata/ Suzuki Laboratory

Molecular Robotics

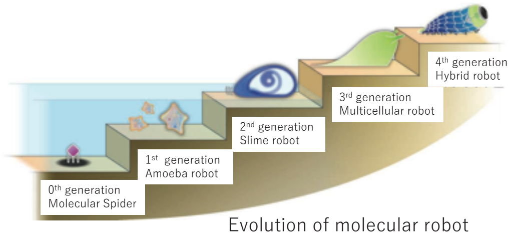
http://www.molbot.mech.tohoku.ac.jp/eng/index.html

Molecular Robotics-A new manufacturing paradigm

- Manufacturing based the principle of life
  Able to design biopolymer sequences by computer to construct a functional system
- Compact and eco-friendly manufacturing
  Able to create all parts of system using a polymer synthesizer (mother machine).
- Ultra information-intensive manufacturing
  We are aiming at constructing a new systemic theory to describe the design of each layer of the molecular system



DNA-origami module (Stacking no. control)



Evolution of molecular robot

Diagram of enzymatic DNA computer
(Universal Strand Generator)

Toward the establishment of molecular robotics

This laboratory is the first laboratory in Japan advocating “molecular robotics”. We are aiming to establish a method to construct a “molecular robot” by designing each molecule as a component and assembling them as a consistent system. Research into molecular systems is a breakthrough for extending robotics to the world of molecules. The technology developed here will be the fundamental technology has a great impact both academically and industrially. A wide range of applications such as a super drug delivery system, programmed stem cell culture, environmental monitoring, and nucleic acid medicine are expected.

What is DNA nanoengineering?

DNA is a very promising molecule not only for the genetic information of life but also as a programmable material for making various artifacts. By properly designing the base sequence of DNA, we can freely control the shape of a DNA molecule and also the interaction between the DNA molecules. DNA nanoengineering is a technology that utilizes these properties to create complex nanostructures and various molecular devices including molecular computers.

Nanostructure made of DNA

The technology for assembling nanostructures using chemically synthesized DNA with a specified base sequence is rapidly advancing. A technique called DNA origami is typical, which enable us to design molecules with extremely complex shapes using a computer. In our laboratory, we are working on the development of artificial membrane channels using DNA origami, artificial flagella thrusters, molecular stepping motors, DNA gels that respond to light and so on.

DNA computing

When the complementarity between DNA sequences is used properly, a reaction can be created in which the concentration of certain DNA corresponds to a result of cirtain logical operation. This can be used to create a molecular computer that includes hundreds of logic gates. Our laboratory has developed a system that outputs DNA molecules of a specific sequence in the programmed order, a discrete reaction space on the gel and so on.

Big success in international biomolecular design competition!

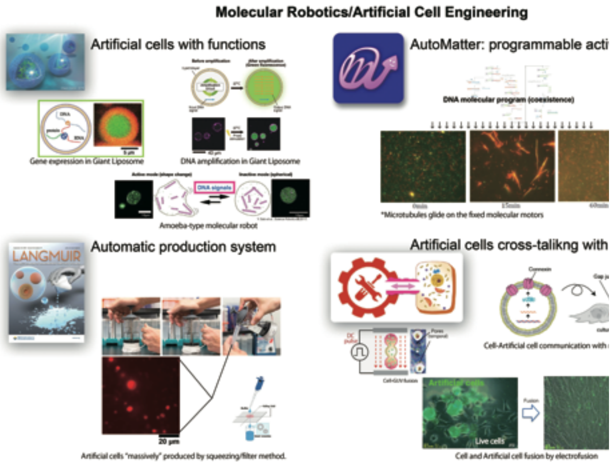
The International Biomolecule Design Competition (BIOMOD) is a student contest sponsored by the University of California. A team of students from around the world will participate in the competition for unique designs of biomolecules such as DNA and proteins. In 2018, the Tohoku University team won the grand prize in the design of a deployment structure by DNA Origami. A student team from our laboratory will participate again this year.

Nomura Laboratory

Assoc.Prof.
Shin-ichiro NOMURA

Nanosystem

https://sites.google.com/site/smnomuralaboratory/



MolecularRobotics and Artificial Cell research

Molecular Robotics/Artificial Cell Engineering

The artificial cell is a molecular robot with a compatible function with a live cell, designed molecular systems as a unit of micro cellular-structures. Modern cells have indispensable structures and functions: genes, compartments, metabolism, and replication. Design, synthesis, and implement them work as a system is the key to artificial cell engineering. Another key is programmability. Every machine, including molecular robots, must work as written in the program. Through to creation of the artificial cell, our research group aims to provide potentially applicable molecular systems for medical, environmental, materials, and biotechnology.

Artificial cells with functions

The micrometer-sized lipid compartment is a useful microcapsule as an artificial cell's body. We can install various functional/reactive chemical soup to the capsule, such as DNAs, RNAs, proteins, catalysts, total gene expression system, motor proteins, DNA logic gates, etc.
Some of them used for understanding and revealing of the special function of micro-compartment and some used as a shape-shifting molecular robot showing an amoeba-type motion.

Automatic production system

In the biomolecular world, the complex structures are not created one by one but are assembled together by self-assembly that depends on the affinities. As is the same, in the artificial cell compartment also assembled from their component molecules automatically. Usually, one makes only several mL amounts used for experiments, but we have reported a mass production method. We aim their production of the artificial cell itself would become comparable to the growth of natural cells.

AutoMatter: programmable active matter

When the swarming behavior of molecular robots works as individually programmed by a human, they can be called “Auto-Matter”(coined word by our group). We aim to control such active matters as desired by connecting digital electronic devices and molecular devices. We are tackling the challenge of controlling molecular robots driven by motor proteins using molecular computers in situ. In the near future, molecular and electronic signals would be linked to control molecular swarms.

Artificial cells cross-talikng with live cells

Artificial cells, with their comparable size to the live cells, are expected to work as the "caretaker" at the same scale as the natural one. We are designing "channels" transporting specific molecular signals through the biomembrane. We also found that artificial cell structure itself also can be used as the one-time container for cellular delivery by using the electro-fusion method. Their biocompatibility leads the way to some application in the bioengineering field.

Prof.
Shuji Tanaka

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Robotics
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Nanosystem
Smart System Integration

http://www.mems.mech.tohoku.ac.jp/index_e.html

Fig. 1 Integrated bus-networked tactile sensors installed on robot hand

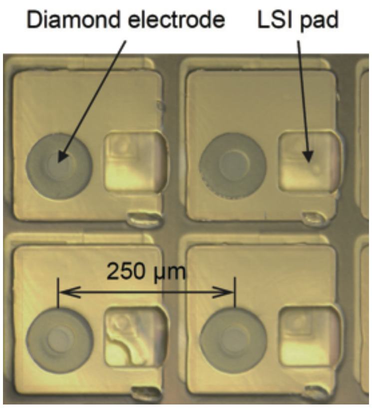


Fig. 2 Integrated biosensor array with diamond electrodes on LSI

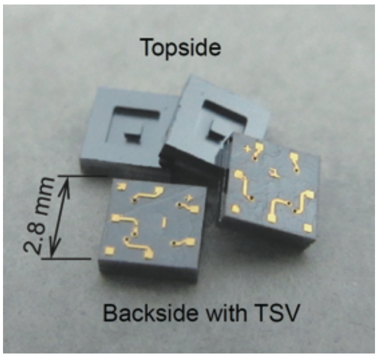


Fig. 3 MEMS-LSI integration platform with TSV

Development of MEMS for various applications

Our core competence is MEMS (Micro Electro Mechanical Systems) technology, which is widely used for inertial sensors, pressure sensors, microphones, frequency control devices etc. Recently, MEMS are getting more important for wireless communication, automated control, healthcare, medical diagnosis, energy saving etc. To answer such requirements, we are developing CMOS-integrated tactile sensors, acoustic wave filters, piezoelectric ultrasonic transducers, advanced gyroscopes, biosensors and so on in conjunction with wafer-level packaging technology, piezoelectric thin films and original process tools. We are eager in industrial and international collaboration.

Sensors for robots, automated vehicles and health care systems

Integrated bus-networked tactile sensors (Fig. 1) are being developed to cover the whole body of robots. A lab-designed LSI is integrated with a MEMS-based 3-axis force sensor by metal-based wafer bonding. This sensor system allows us to install many sensors on a robot with less wires. Advanced MEMS gyroscopes for automated vehicles, robots and VR systems, biosensors for quick medical screening (Fig. 2) and ultrasonic transducers for range finding and biometrics are also being developed.

Wafer-level hermetic packaging and integration technology

Wafer-level packaging is a key for the miniaturization and reliability of MEMS and a source of cost competitiveness in market. We have a variety of wafer-level hermetic packaging technology and know-how for different applications. We also have rich experiences in the integration of heterogeneous devices and materials like LSI and MEMS (Fig. 2 and 3). Our customers can find their best solutions with us in terms of wafer-level packaging and integration.

Frequency selection and control devices for wireless systems

The shortage of frequency resource below 6 GHz for wireless communication is more critical in a coming IoT (Internet of Things) society. Modern frequency selection and control in smartphones is relying on surface and bulk acoustic wave (SAW and BAW) devices, and the demand for high-performance SAW and BAW devices are rapidly increasing. We are developing advanced SAW and BAW devices and RF MEMS switches for 5G and the next generation wireless systems.

To industrial customers looking for a MEMS R&D partner

We are willing to support MEMS industry in research and development based on a lot of technology, know-how and literature accumulated for a long time in Tohoku University. We can propose multiple styles of research and development, from the proof of concept using small substrates to device prototyping using 4-6 inch wafers, depending on R&D phase and available resource in each company. Consultation about MEMS technology and business are being accepted anytime from companies.

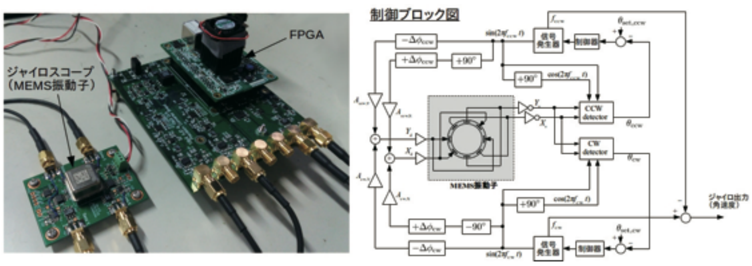
Robotics
Robotics

Tsukamoto Laboratory

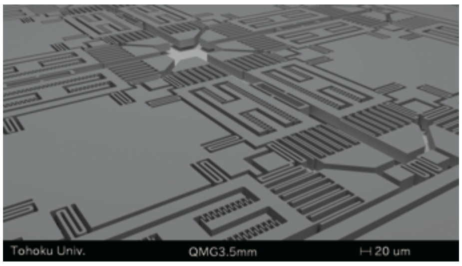
Assoc.Prof.
Takashiro Tsukamoto

Smart System Integration
Chair of Nanosystem

http://www.mems.mech.tohoku.ac.jp/



Control system diagram for high precision MEMS gyroscope



Silicon resonator for MEMS gyroscope

High performance MEMS sensors for better life

We are developing high performance sensors and sensing systems based on MEMS (Micro Electro Mechanical Systems) technique. We are mainly focus on performance enhancement and miniaturization of these devices, as well as fabrication technique to develop the devices. Not only device itself, but also development of sensor systems using micro-processors and FPGA (Field Programmable Gate Array) is our interest.

High Performance MEMS Gyroscope

Gyroscope is one of the important device for our daily life. In near future, MEMS gyroscope become more and more important for autonomous driving, control of robots and drones, etc. We are developing a frequency modulated (FM) and rate integrating (RI) gyroscope, which can solve a lot of problems of current MEMS gyroscope.

Micro Thermal device

For high heat flux cooling or refrigerating of micro device, we are developing MEMS thermal devices. High thermal dissipation can be achieved by evapolation and condensation at microscale. Using this technique, thermal rectifier (thermal diode) was developed. In addition, infrared thermal detector using MEMS technique was also developed.

High power and precise MEMS acuators

MEMS actuator can usually generate small actuation force. Some material such as PZT can generate strong actuation force, however, the precise position control is difficult due to the stability and temperature dependency of the film property. To overcome these problems, feed-back controlled actuator with integrated position sensor is under development. This technology is also applicable for another type of actuators, such as electro-thermal actuators.

Mobile bio-sensing system

To detect the allergen contained in daily meal, a mobild bio-sensing system is under development. The system utilize an Aptamer, kind of DNA, to specifically detect the allergen. The detection result is read-out by optical way. The optical system and electronics as well as disposable sheet containing the aptamer was developed.

Robotics
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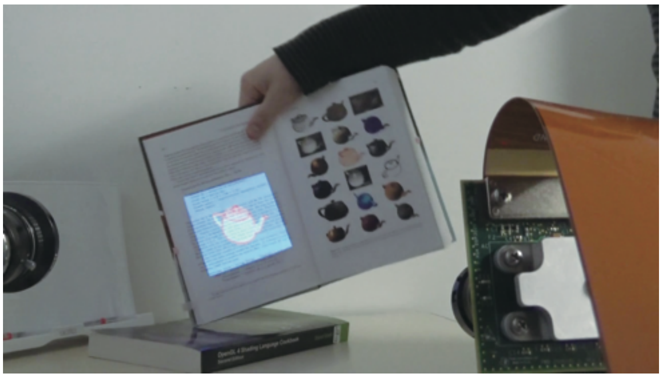
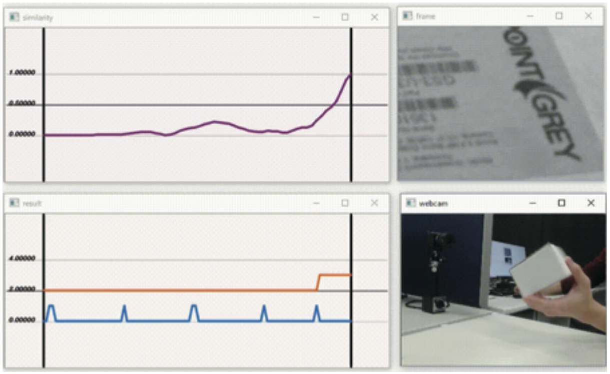


Full-color projector capable of low-latency projection mapping



Touch operation detection by classifying small vibrating motion in images

High-speed vision systems and their applications

We investigate high-speed real-time vision systems that operate at a frame rate significantly higher than conventional vision systems, and pursue their applications by combining them with other sensing and active lighting techniques. As part of this research direction, we are developing high-speed projector-camera systems that can project and capture image patterns at hundreds to thousands of frames per second. They can be applied to 3D shape measurement at a high frame rate and novel technologies to present video contents. We also study new user interaction techniques that utilize the high-speed vision systems to react to quick movement of objects.

High frame rate image measurement

High frame rate vision is a powerful tool for measuring moving objects in general. While retaining the advantages of visual measurement such as the ability of non-contact sensing, it also achieves real-time measurement of fast movements that cannot be captured by existing technologies. By combining them with other sensory information, we are also working on, for example, identification and classification of different moving objects and materials.

Development of high-speed projectors

By combining video projectors and vision systems, a variety of visual representations such as projection mapping become possible. Aiming at allowing low-latency interaction between a projector and a camera, we are developing a high-speed projector capable of projecting thousands of frames per second. Our architecture has a distinct feature that video contents supply and geometric control applied to them are separated, which enables fast adaptation without imposing a load on host PCs.

User interaction based on high-speed visual information

Projection-type information presentation to turn every surface around us into graphical displays is gaining attentions as a means of work and life support in offices, homes, and manufacturing sites. We conduct research and development to achieve video projection mapping that adapts to fast movements of objects and users in the real environment without delay, and dynamic computer-human interaction techniques based on such movement information.

Applications of robot vision to challenging tasks

Real problems in industries and sports sometimes pose significant challenges for robot vision technologies. In particular, we are working on automatic detection, positioning, and tracking problems in highly difficult conditions such as measurement and handling of flexible wire harnesses and sheet-like materials, and movement measurement of high-speed spinning golf balls without relying on logos and markers.

Robotics
Department of Robotics

Kanamori Laboratory

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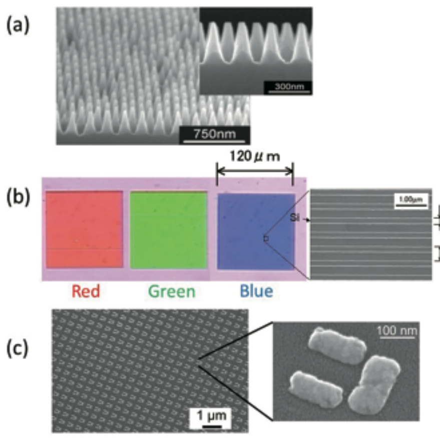
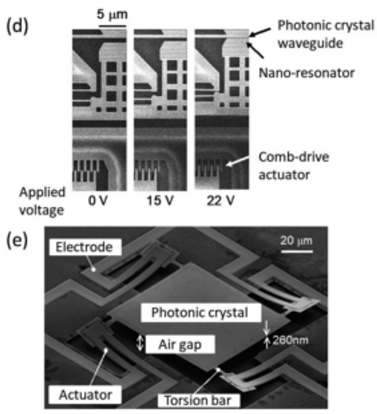
Informative Nanosystems

http://db.tohoku.ac.jp/whois/detail/fbe3bc4c0f557bf49e4f1b3bd22d8c67.html



(a) Anti-reflection structures. (b) Structural color filters.
(c) Electromagnetically induced transparency metamaterials.



(d) Switching add/drop filter.
(e) Variable reflectance filter.

Innovative optical control: metamaterials, biomimetic photonic devices

Metamaterials are artificial optical materials with subwavelength structures smaller than the incident wavelength as unit elements, and it is known that various optical responses that do not exist in nature such as negative refractive index can be realized. In Kanamori laboratory, studies on fabrication technologies of metamaterials, mechanical reconfigurable metamaterials, application of metamaterials, and so on have been conducted. In addition, we are developing highly efficient nano-optical devices using biomimetics. In order to realize ultra-low-loss nano-photonic devices, we are developing novel smoothing technology for silicon surfaces.

Biomimetics: structural colors and moth eye structures

The color of the peacock's bright feathers is due to structural color generated by nanolattices. The structural color filters enable a variety of colors. Subwavelength periodic structures are formed on Moth-eyes. By mimicking this structures, reflectance of silicon has been reduced by a factor of 100, and the light extraction efficiency of light-emitting diodes has been improved by about 60%. We have also developed inexpensive manufacturing technology using nanoimprint.

Metamaterials: toward innovative optical control

Metamaterial is a structural artificial optical material, and its unique electromagnetic mode depends on the structure. Therefore, metamaterials enable innovative optical function and electromagnetic wave control on demand. We have developed electromagnetically induced transparency metamaterials, novel metamaterials having Fano resonance, metamaterial absorbers, metamaterial sensors with integrated photodiodes, and mechanical reconfigurable metamaterials.

Active control: movable nano-photonic devices

Photonic crystals have fine periodic structures in the order of wavelength of light and function to block and confine light. We have developed a wavelength selective filter that controls the optical coupling efficiency of photonic-crystal's nano-resonator and a variable reflectance filter that controls the light blocking characteristics by controlling the position of photonic crystals with high accuracy using micro-actuators.

Development of novel surface smoothing technologies

Dry-etched silicon surfaces are rough, causing device characteristics to deteriorate and optical loss. We have developed novel surface smoothing technologies that control ultra-precise surface deformation caused by self-diffusion of silicon surface atoms in a high-temperature hydrogen atmosphere. We realize ultra-low-loss nano/micro optical devices and silicon micromechanical parts with excellent mechanical strength.