Faculty and Laboratories of Department of Mechano-Informatics

※: Professors denoted by this symbol do not accept new graduate students for the applicable academic year.
[RCAST] denotes the professors of Research Center for Advanced Science and Technology holding adjunct professorship at School of Information Science and Technology.
[IIS] denotes the professors of Institute of Industrial Science holding adjunct professorship at School of Information Science and Technology.

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Hirose-Tanikawa-Narumi Laboratory

Our research laboratory focuses on developing a high level user interface that unites human and computer seemlessly, that is, Cybernetic Interface.
Starting with virtual reality technology (VR), we seek to research and develop such interfaces. The research themes that our laboratory is working on include image-based rendering technology, augmented reality (AR), multimodal/crossmodal interfaces, wearable computers and lifelog.
We are also interested in the contents based on technologies mentioned above. We are working on social projects such as the Digital Museum project, the Digital Public Art project, and the Senior Cloud project.

Virtual Reality and Mixed Reality

Virtual Time Machine
3D World Reconstruction from 2D Photo Images and Videos
Digital Museum and Virtual Archeology
Subjective VR & Reflex-based Interface

3D World Reconstruction from 2D Images

Territorial Virtual Time Machine

Image-based Interaction and Digital Display Case

Subjective VR
by Feedback of Facial Expressions

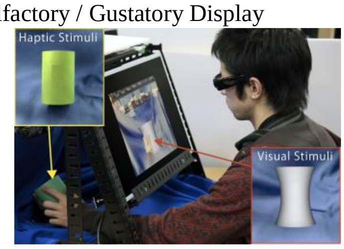
Advanced Human Interface

Multimodal and Crossmodal Interfaces
Crowdsourcing Interface for Elderly People
Lifelog Visualization and Analysis, and Lifelog-based Future Prediction
Behavoir Elicitation Techniques
Digital Public Art

Avator Robot for Seniors' Telework

Olfactory / Gustatory Display

Lifelog-based Future Prediction



Shape Display using Pseudo-Haptics

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Robotics, Dynamics and Control Laboratory

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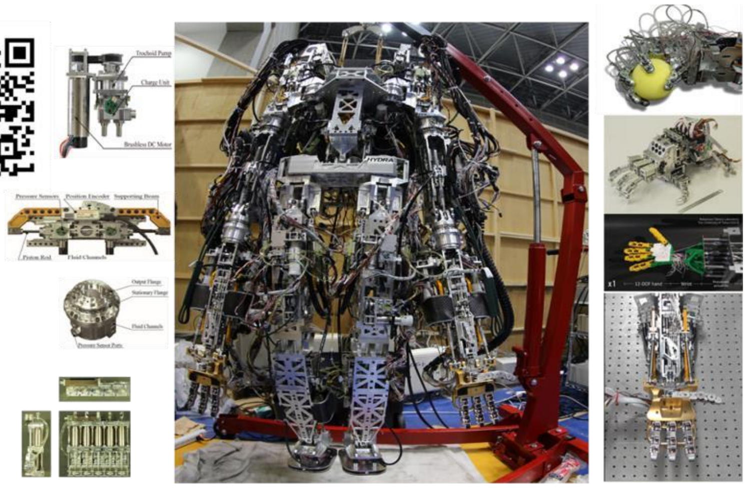
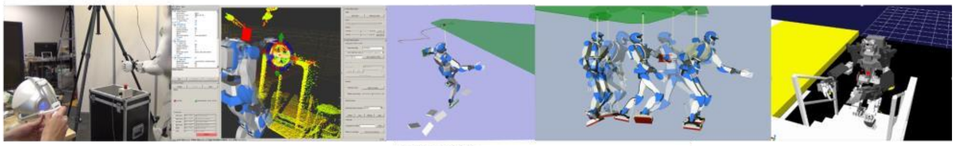
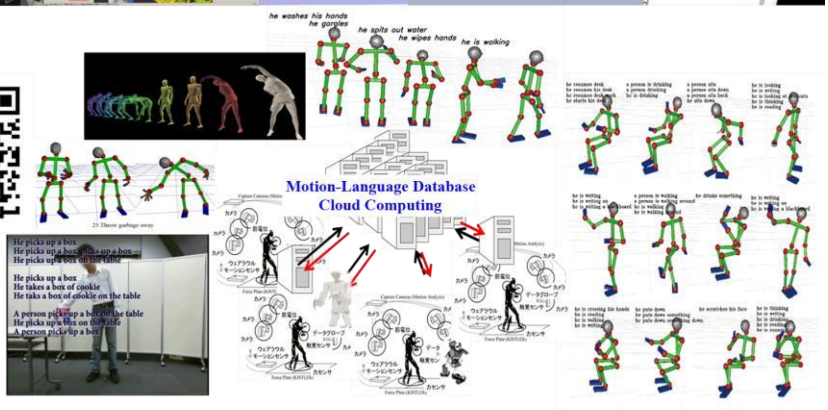
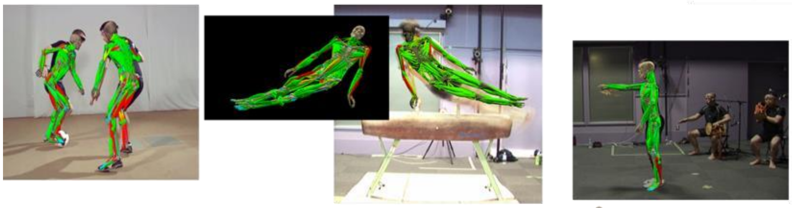
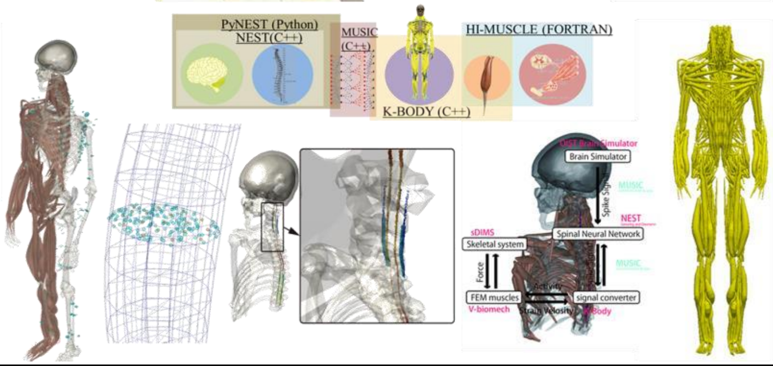
(1) Small Hydraulic Actuators: Force Control, High Pressure and Integration
(2) Humanoid Robotics: from Human Understanding to Motion Control
(3) Human Computation: Wholebody Motion Control by Mouse Brain Model
(4) Human Understanding: Video MoCap, Embodiment, Symbols and Language
(5) Sports Performance Analysis: Individual and Team Analysis by Video MoCap and Computational Biomechanics
(6) Sports Intervenient Training: Sensing, Computation and Data Science











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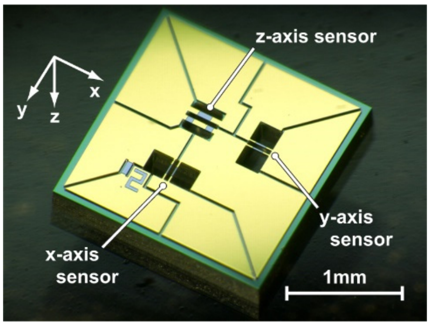
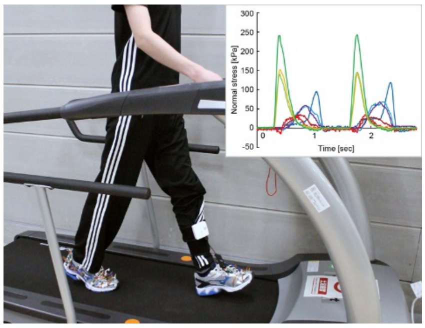
Shimoyama-Takahata Laboratory

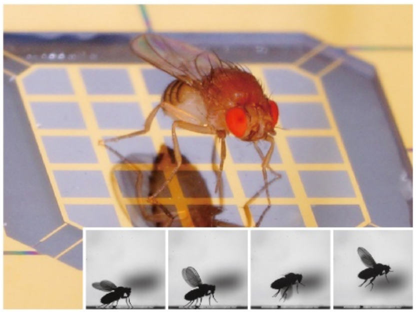
We explore new mechanical systems by prototyping micro-sized devices based on deep analyses of physical and/or chemical phenomena prevailing on micro- or nano-scale. Micro-electro-mechanical systems (MEMS), robotics and information technology have been integrated into the systems. The devices can be applied to widespread fields; in studies of sensing living bodies, for example, the object ranges from a human body to an insect or a single cell. In addition, we have applied the devices to intelligent mechanical systems like robot hands.



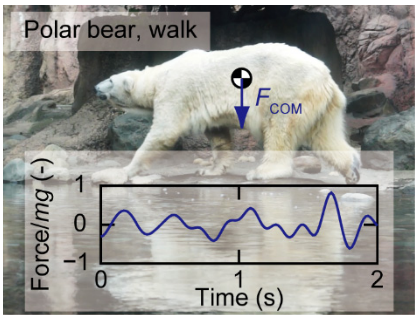
Triaxial tactile sensor to measure a pressure and sheer stresses.



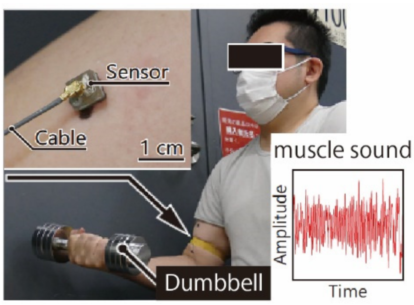
Measurement of the force distribution on the sole of the foot using sensor shoes.



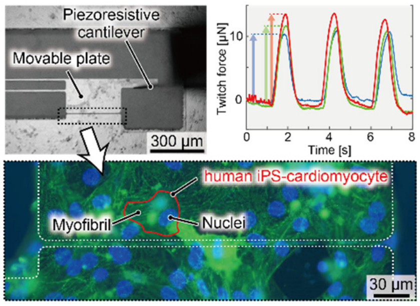
Study on the jumping force of a fruit fly using micro-force-plate.



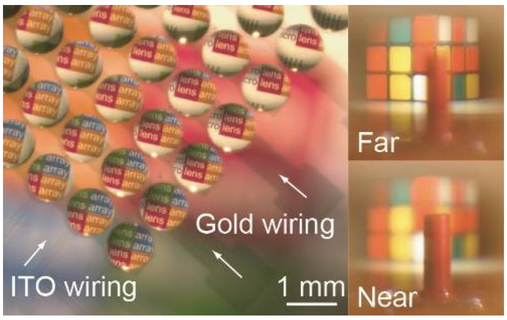
Analysis of animal locomotion from ground reaction forces.



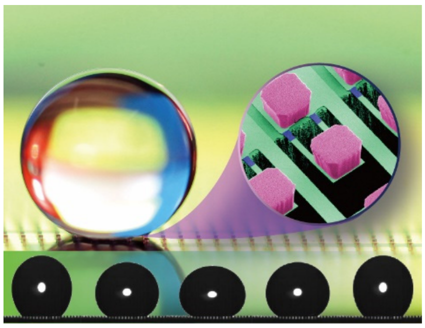
Measurement of mechanomyogram using MEMS sensors.



Realtime twitch force measurement of iPS cell-derived cardiomyocytes.



Varifocal liquid lens actuated by electro static force using liquid encapsulated by polymer thin film.



Viscosity measurement of micro-droplet using force while vibrating the droplet.

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Kanzaki & Takahashi Lab

Research field: The aim of our research is to clarify the basic neural mechanisms for generating adaptive behaviors (or intelligence) using interdisciplinary approaches combining informatics, engineering and biology. As model systems, we use cultured neurons, insect brains and rat brains. Our research deals with investigating bio-machine hybrid systems, and also establishes basic technologies for controlling behavior by external commands to brain functions.

Research Examples：

(1) Understanding of the brain, learning from the brain

■Adaptive robots implemented with insect sensors and neuronal circuits

Achieving adaptability to various environments is one of the essential aims in constructing autonomous systems. Insects display a range of sophisticated adaptive behaviors in response to their environments with their simple nervous systems, therefore, they are good models for understanding adaptability. We have developed insect-machine hybrid systems that enable us to analyze and evaluate insect adaptability by manipulation of interactions between a robot (body), an insect (brain) and its environment (A, B). Throughout the analysis of adaptability using hybrid systems, we can establish models of behaviors and implement them in mobile robots.

(2) Modification of the brain

■Rewiring of the brain

The brain is a rewritable device. Understanding of learning- and microstimulation-induced plasticity as well as neural processing will pave the way for engineering and medical innovations (C). Toward this end, we are also interested in engineering and information science approaches including development of neural interfaces and implementation of multi-variant statistical analyses and information theory.

■Modifications of neural circuits in insect brains by molecular genetics

Genes contain the blueprint of an animal body including sensors and neural circuits. We can understand the function of a neural circuit in the insect brain by genetic modification of neuronal properties (D). An important application of these methods result in the development of “sensor insects” capable to report almost any stimulus of interest.

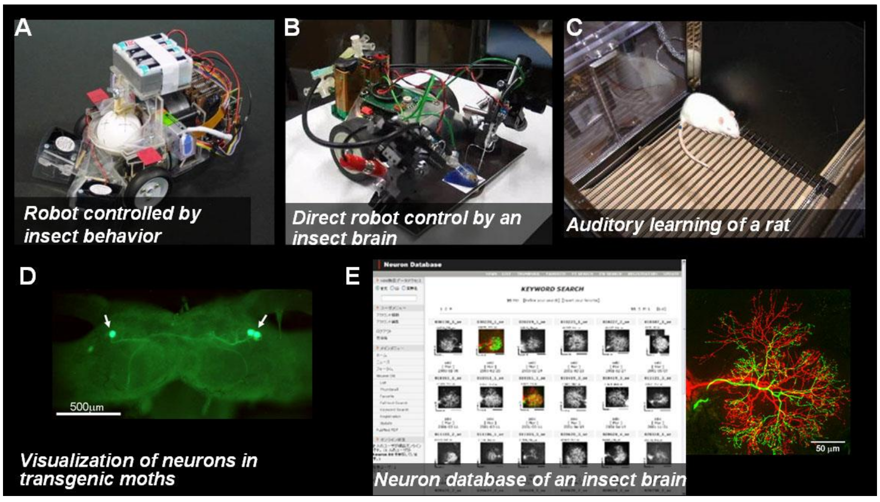
(3) Reconstruction of the brain

■Reconstruction of an insect brain using mathematical models

We have established a database of neurons based on analyses of the insect brain employing various techniques in molecular genetics, morphology, physiology, biochemistry and ethology (E). By integration of the information in the database into a mathematical model, we can understand mechanisms underlying insect adaptive behaviors.

■Neurocomputational chip using dissociated cultured neurons

Neurons cultured in a dish develop self-organized networks. By controlling self-organization, we develop a cultured network to be used as a computational device.



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JSK Robotics Laboratory
(Jouhou System Kougaku Laboratory)

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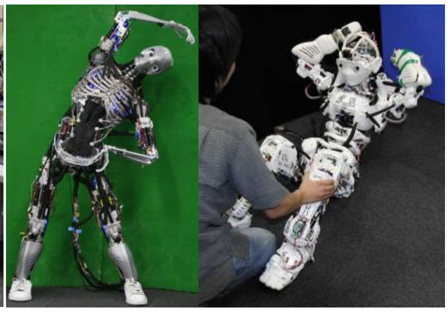
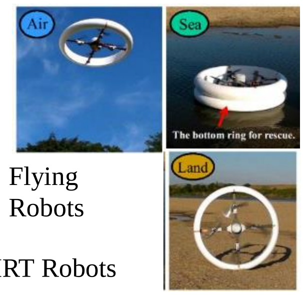
Research in this laboratory is focusing on the fundamental functions and systems necessary for future intelligent robots that will live and work in the daily life field and human society. The members are challenging something new through their own integrated robot systems and learning how to build sustainable systems for the future with each other.

(1) Daily life support humanoid platform : recognition of situations in human life environments, using tools, dishes, tablewares, and appliances, learning from humans, conversation with humans, etc.
(2) Musculoskeletal tendon-driven humanoid : humanlike musculoskeletal body with very many joints and numerous redundant sensors aiming at powerful and supple motions like human, design principle of humanoid body structure, autonomous development of complex sensory-motor system, etc.
(3) Embedded robotics devices: soft flesh or deformable tactile sensor devices, integrated IMU sensors, perception devices, embedded CPU for flying robots, onbody communication LAN system, power system for intelligent robots. etc.
(4) Dynamics whole body control humanoid : integrating high-torque, high-speed motor drive circuit, high-speed 3D recognition system, dynamics whole-body.
(5) IRT (Information and Robot Technology) to support human and aging society: through fusing IT and RT systems, personal mobility robots, affectionate watching appliance are conducted for supporting the future life society
(6) Robot Open Software System : design and development of open-source type intelligent robot for mobile manipulation robot.

Daily Assisteive HRP2-JSK humanoids



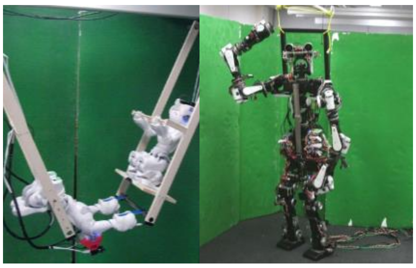
Musculoskeletal humanoids



Flying
Robots

IRT Robots

Soft exterior and interaction



Dynamic whole-body control humanoid

Open software robot : PR2

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Intelligent Systems and Informatics Lab

http://www.isi.imi.i.u-tokyo.ac.jp/

Breakthrough Toward Intelligent Systems in the Real World

Our goal is to achieve intelligent systems that can behave appropriately in the uncertain and complex real world. In order to have a true understanding of the principles of such intelligence, we focus on the physical embodiment, emergent behaviors, developmental processes, and sociality. We carry out investigations into theories, applications, software and hardware to solve those problems.

1. **Origin of Intelligence: Fetus and Infant Developmental Scenario**

   Human fetus simulation (with cortex model, spiking neuron, sensory-motor feedback, tactile sensation, and uterus model), Self-organization of neural network, Baby robot, Cognitive development, Emotion.

2. **Embodied Cognitive Science: Emergence of Behaviors and Cognition**

   Coupled chaos network, Adaptive body image, Tool use, Affordance, Analyzing the "knacks" of human skills, motor learning, motor skills in sports, humanoid robot.

3. **Understanding Human Brain**

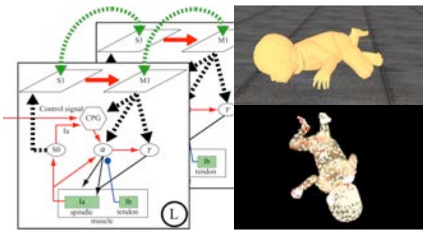
   Time series analysis brain activity, Neural network, Multimodal recognition and learning, Body scheme, Estimation of emotion and intention, Developmental disabilities, Neuro-rehabilitation.

4. **Bio-Inspired Robot and Soft Robotics**

   Bio-inspired mechanism, Biomimetics, Biomechanics, Soft actuator, Printable Robot, Artificial musculo-skeletal system, Human-robot interaction (HRI), Soft UI, shape-changing computer interface, wearable device.

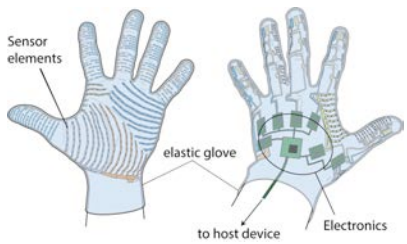
5. **Social ICT**

   Understanding, designing and realization of social systems and services as information systems. Innovation of mental health by combining advanced ICT technologies and clinical psychology.



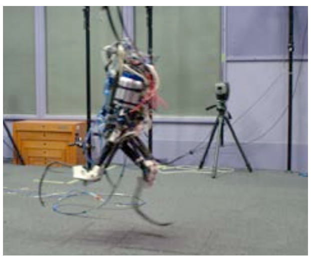
Self-organization of neural system and behavior of fetus and newborn

Baby robot

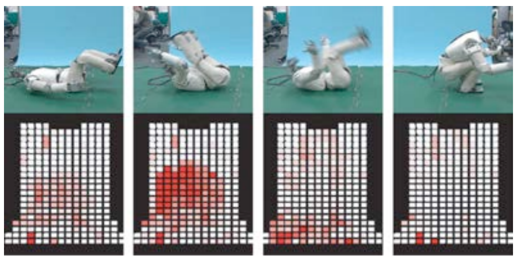


Hand skill copy glove

Human skill copy suit

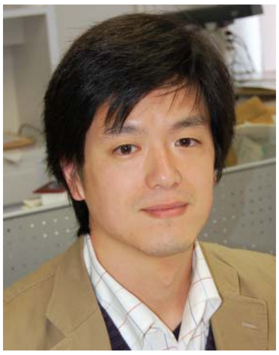


Running Athlete Robot



Roll and rise motion using whole body distributed tactile sensor

Shoji TAKEUCHI
Professor
[IIS]



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Biohybrid Systems

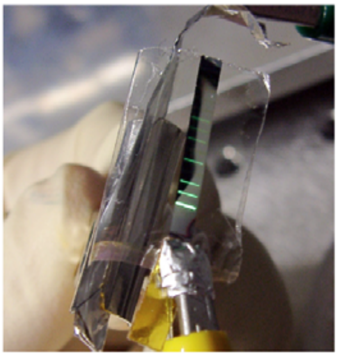
- Shoji Takeuchi Research Group -

Our group focuses on the design and fabrication of bio-hybrid systems that combine bio functional materials with micro/nano devices. Since the size of the bio-molecular motors, such as kinesin-microtubule, is on the order of a few nanometers, they can work as a nano-sized bio functional elements in existing MEMS devices. Micro neural electrodes can be used as the neural interfaces between the living organs and artificial equipments. We are trying to realize such hybrid systems through the micro/nano fabrication technologies. We welcome people from multidisciplinary backgrounds, including mechanics, informatics, biophysics, cell biology, material sciences.

【Research Projects】

IT devices

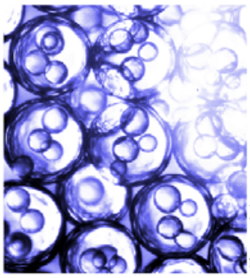
We study on flexible, low-cost displays using organic light emitting diodes.



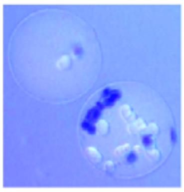
World thinnest OLED display; the thickness is around 6 micrometers.

NanoBiotechnology

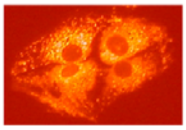
We try to understand mechanism of biomolecules or cells by using microfluidic devices.



Synthesis of cells for understanding "what is the life?", and for medical and pharmaceutical purposes

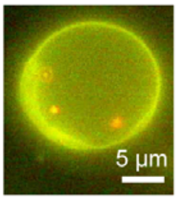


Micro hydrogel beads encapsulating cells for transplantation



Single cell assembly for the advanced tissue engineering

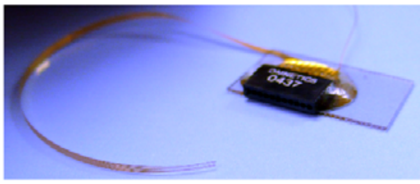
Controlling the shape of cells with microfluidic technologies: bacterial springs



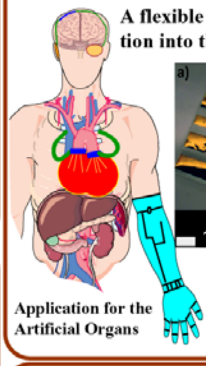
Artificial cells for medical uses

Brain-Machine Interfaces

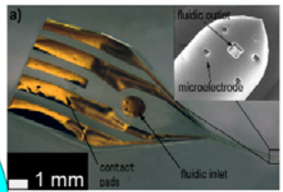
We apply flexible microelectrodes for neural stimulation and recording.



A flexible electrode for the implantation into the spinal cord of a monkey.



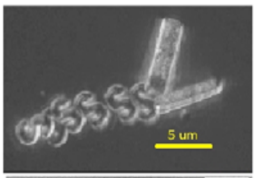
Application for the Artificial Organs

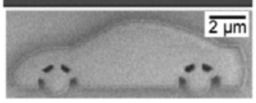


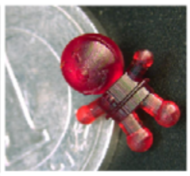
An implantable, flexible microelectrode with microfluidic channels for chemical injection.

Micromachine

We study on the design and fabrication of micromechanism and structures.

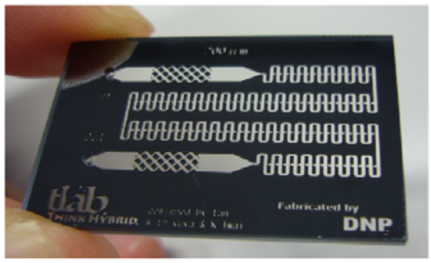






micro humanoid fabricated by micro stereolithography

micro/nano structures driven by biomolecular motors



Lab-on-a-chip systems for the high throughput screening.

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Machine Intelligence

Beyond Human Intelligence Based on Cyber-Physical Systems

Our goal is to invent intelligent systems beyond human intelligence by combining useful but infinite information in the physical space with huge amount of data and powerful computational resources in the cyber space. To tackle this challenging problem, we utilize all resources in the area of computer science including mathematical basis and robotics.

1. **Mathematical Basis for Cyber-Physical Information Processing**
   Information theory, machine learning, data mining, pattern recognition, stochastic/statistical theory, time series analysis, causality analysis, learning theory, feature extraction
2. **Cyber-Physical Information Recognition and Understanding**
   Deep learning, big data, computer vision, image recognition and retrieval, 3D vision, image segmentation, behavior recognition, crossmedia understanding, multimodal recognition, detection of interesting and newsy events, dialog understanding, emotion understanding, natural language processing, speech and music information processing
3. **Contents Creation**
   Sentence generation and summarization of image and video, image generation from sentences, dialog system, automatic article generation system

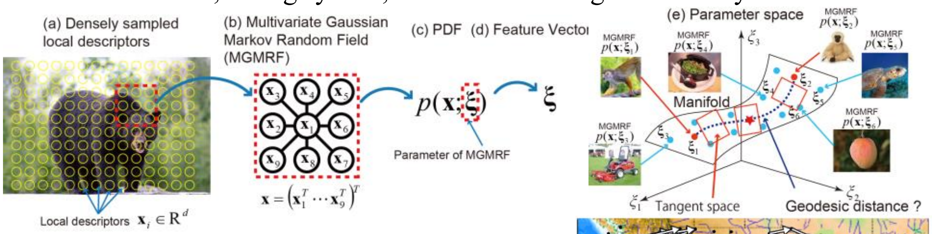


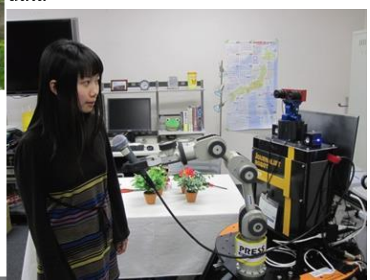
Image feature extraction based on information theory and machine learning

Causal analysis for meteorological data

A silver car parked in a residential street.

A brown horse standing in a lush green field.

Automatic sentence generation system



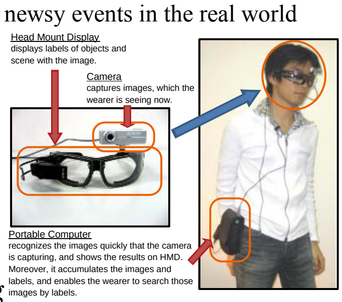
Journalist robot discovering newsy events in the real world

1. oboe
2. flute
3. ice lolly

1. Siamese cat
2. Egyptian cat
3. Ibizan hound

1. diaper
2. swimming trunks
3. bikini

Large-scale image recognition system



Artificial intelligent goggles recording everything you see and enabling you to find missing belongings