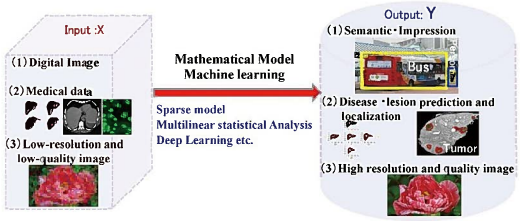
Advanced machine learning and perception technology for intelligent image understanding systems

Our research mainly focuses on developing the generic and core technology of artificial intelligence (AI) for enabling machines to mimic cognitive functions (such as learning and problem solving capabilities) through which humans interact with the surrounding environment. One of the important issues in modern AI systems is how to find the inherent structures hidden in large amounts of collected data and give new insights about the collected data for possible tasks. Instead of using mathematical and statistical models for data analysis, we study data-driven models for exploring the inherent representations and hidden regularities from huge collections of data, and aim to develop advanced machine learning and perception techniques by imitating the hierarchical model of vision processing in the human brain. With the explored machine learning technology, we are also committed to researching various applications, such as image/object recognition and understanding, image super-resolution, medical CAD systems with image analysis, and hyperspectral image analysis. We also work on real applications of machine learning-based AI techniques and pursue close cooperation between academia and industry.



The schematic concept of image understanding, intelligent CAD and image super-resolution

About Researcher

HAN Xian-Hua, Ph.D.

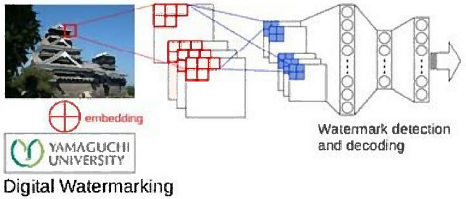
Ph. D., 2005.9, University of the Ryukyus

WEB ≫ http://mlp.sci.yamaguchi-u.ac.jp/index_EN.html

Statistical Mechanical Informatics

Information processing models, e.g. neural network models and information hiding models, are investigated using statistical mechanics. Prof. Kawamura studies memory capacity in an associative memory model (a type of neural network) and channel capacity in digital watermarking. These quantitative evaluations are required for theoretical approaches. Even though the applications of these models appear to be different, they share a similar mathematical structure, or Hamiltonian. Therefore, both types of models can be analysed within the same theoretical framework of statistical mechanics. Moreover, optimal algorithms can be derived from the Hamiltonian for novel information processing models.

Recently, he has been working on a digital watermarking method, which can prevent digital content, e.g. images, from being modified illegally. A watermark is invisibly embedded to protect the image. To detect and decode the watermark from a tampered image, a method based on statistical mechanics can achieve good performance. The goal of his research is to develop a watermarking method that is robust against image processing, i.e. compression, cropping, scaling or rotation.



Schematic diagram of digital watermarking: a watermark is embedded into a photo, and then it can be detected and decoded by a neural network.

About Researcher

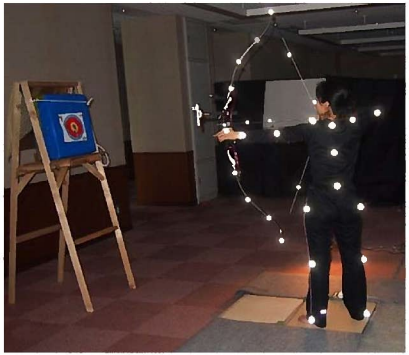
KAWAMURA Masaki, Ph.D.

Ph. D. , 1999, University of Tsukuba

WEB ≫ http://www.sci.yamaguchi-u.ac.jp/en/sci/staff/mkawamura-en?set_language=en

Skill Science/Brain Computing/Biological Cybernetics

Our nervous system is capable of acquiring various motor skills to accomplish movement tasks via learning. Prof. Nishii is trying to reveal the hidden motor skills behind our consciousness using data science methods. In addition, he is investigating the brain mechanism that discovers these skills, the method of finding essential information from the enormous number of sensory signals and that of exploiting the abundant degrees of freedom of our body, by constructing theoretical models.



Analysing the motor skills of experts.

About Researcher

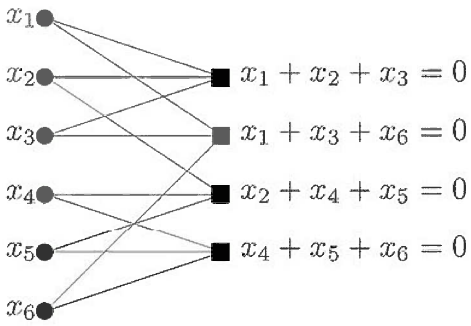
NISHII, Jun,Ph.D.

Ph.D. ,1996, The University of Tokyo

WEB ≫ http://bcl.sci.yamaguchi-u.ac.jp/~jun/

Analysis of Error Correcting Codes

Error correcting codes are one of the fundamental techniques used to correct errors in digital data. Error correcting codes are widely used in digital communication systems and data storage systems, e.g. wireless communication, Ethernet, hard disk drives, flash memories and Blu-ray discs. Therefore, studies of error correcting codes contribute to realising reliable communication and storage systems. Prof. Nozaki researches error correcting codes and their theory, namely coding theory. In particular, his research focuses on graph-based codes, i.e. low-density parity-check codes and their variants and iterative decoding algorithms. His main objectives are (1) to propose efficient encoding and decoding algorithms, (2) the analysis of those encoding and decoding algorithms, (3) to analyse the performance of error correcting codes, (4) the construction of high-performance error correcting codes and (5) to propose reliable and efficient information systems via the use of codes. His research interests are not only in coding theory but also in its applications, e.g. network systems, communication system, information theory, information security and graph theory.



Bipartite graph representation of a linear error correcting code.

About Researcher

NOZAKI Takayuki, Dr.Eng.

Dr. Eng., 2008, Tokyo Institute of Technology

WEB ≫ http://comm.sci.yamaguchi-u.ac.jp/indexe.html

Quality Improvement of Images and Videos Based on Intelligent Image Processing Techniques

Digital image/video processing techniques in diverse studies and application fields have been examined. In particular, the importance of techniques concerning quality improvements of images and videos has been increased according to the wide spread use of various digital equipment. Prof. Suetake works on a variety of problems in image and video quality improvement covering both theory and applications. His areas of research include: "colour barrier-free transforms," "colour transforms for elderly persons," "blind deconvolution," "fast color2gray," "colour transfer," "video halftoning," "inverse halftonoing," "image denoising," "image dehazing," "image enhancement," "image sharpening" and "image super resolution". His ultimate goal is to improve human quality of life via the development and use of advanced image processing technologies. He is the author of more than 100 papers in a number of journals and the author of more than 150 conference papers.

An example of image dehazing results: (left) before processing and (right) after processing.

About Researcher

SUETAKE Noriaki, Ph.D.

Ph.D. , 2000, Kyushu Institute of Technology

WEB ≫ http://www.ic.sci.yamaguchi-u.ac.jp/teachers/index_suetake_eng.html

Brain Computing and Its Applications

Our research is in the area of human brain-based information processing systems, which include the modelling of human brain functions, e.g. self organisation and networking of brain nerves, modelling of human sense organs, brain function-based intelligent systems, neural networks, chaotic systems and brain type signal and image processing.

These topics include a wide range of application areas concerning artificial intelligence, e.g. realisations of new information processing systems for next generation computers, bio-mimetic sensing systems, artificial sense organs and the intelligent control of vehicles.

Brain type signal and image processing has been successfully and concretely applied to the diagnosis of medical CT, MRI and ultrasonic images, the realisation of medical diagnosis systems of arteriosclerosis in coronary arteries and the analysis of eye fundus images. This is, so to speak, a realisation of inference and decision making in the brains of human medical doctors.

Modelling and analysis of the functions of the human brain.

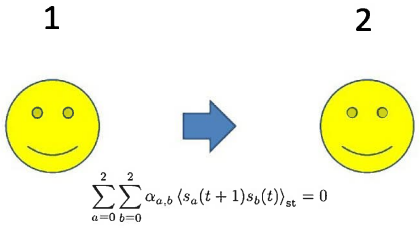
About Researcher

UCHINO Eiji, Professor.

WEB ≫ http://www.ic.sci.yamaguchi-u.ac.jp/index.html

Complex Systems Science

In order to develop mathematical methods for understanding complex systems, my research covers the **glassy behavior of non-equilibrium systems**, and the **economic value of information**. Related to the first topic, I investigate (1) the glassy behavior of trajectories in anomalous diffusion, (2) the deceleration of evolution in population genetics, and (3) the bounded rationality in game theory. With regard to the second topic, I investigate (4) the effects of insider information in game theory, and (5) the computational power of markets in terms of information science.



Relation of payoffs unilaterally enforced by one player in repeated games

About Researcher

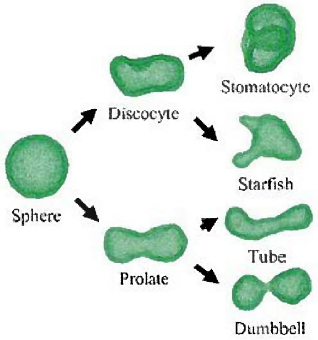
UEDA Masahiko, Ph.D.

Ph.D., 2015, Kyoto University

WEB ≫ https://researchmap.jp/masahikoueda/?lang=en

Molecular Simulations of the Phase Behaviour of Soft Matter

Molecular simulations, such as molecular dynamics simulations and Monte Carlo simulations, are one of the most powerful tools to investigate the microscopic state of materials at the molecular level and are applied to a wide variety of research fields. My research interest is in studying the behaviours of soft matter like polymer chains, surfactants and liquid crystals. Self-organisation and molecular recognition, which are observed in biomolecular systems, are the focus of my studies. Recently, I have focused in particular on the shape changes of vesicles composed of lipid molecules. Vesicles have a closed surface with a bilayer structure and form various shapes; they may be spherical, prolate, oblate, stomatocyte-like or starfish-like. Moreover, the vesicles change their shape according to external stimuli. These shape changes are very important for understanding of the various phenomena observed in living cells, such as cell motion and proliferation. Therefore, I investigate the mechanisms of the shape changes of vesicles using molecular simulations.



Shape changes of vesicles obtained in our simulations.

About Researcher

URAKAMI Naohito, Ph.D.

Ph. D. ,1999, Kanazawa University

WEB ≫ http://www.mms.sci.yamaguchi-u.ac.jp/~urakami/index-e.html