About Researcher
FUJITA Yusuke, Ph.D.
Ph.D., 2008, Yamaguchi University

Our research interest is in novel pattern recognition and machine vision techniques as well as industrial and medical applications. We develop new technology and methods for pattern recognition and analysis in applied domains that include computer vision, image processing and machine learning. We are currently engaged in the following research:

1) Development of a **machine vision system for visual inspection** of concrete structures and road surfaces. Our proposed methods would be used to detect and measure defects on surfaces using image processing and pattern recognition techniques. They would contribute to greater efficiency in high-precision measurements in visual inspection. Our techniques can be applied to various methods of visual inspection.

2) Development of a **medical diagnosis support system**. We are working to develop new pattern recognition methods for medical image analysis and bioinformatics. The purposes of our research are the identification of important factors and quantitative evaluation for medical diagnosis. The development of a medical diagnosis support system will help improve diagnostic accuracy.

About Researcher
FUKUSHI Masaru, Ph.D.
Ph.D., 2002, JAIST (Japan Advanced Institute of Science and Technology)

Nowadays, parallel computing systems are indispensable infrastructure in various fields in scientific research and product development, and parallel processing is a key technique to fully exploiting their computing power. Our research goal is to realize dependable and high-performance parallel and distributed systems that can continue working efficiently even when faults and failures occur. We are currently interested in the following subjects:

1) **Parallel computing systems on VLSI chips**: we are focusing on Network-on-Chip (NoC) technology to realize future parallel VLSI systems. Our research interests include self-reconfigurable systems, partially-reconfigurable systems, fault-tolerant packet routing, and NoC router architecture with fault tolerant technologies.

2) **Distributed computing systems over the Internet**: we study mechanisms to realize dependable and highly-efficient Volunteer Computing (VC) systems using idle computing resources connected to the Internet (e.g. our PCs). We are also working on high-performance VC server architecture, Web-based VC systems, and a job scheduling scheme for dependable computing.

3) **Application software and hardware**: we also study parallel algorithms for various applications including image processing and application-specific systems using hardware devices such as FPGA and GPGPU.

Detection and classification of cracks on concrete structures using video recorded with mobile devices.

Prototype of a self-reconfigurable parallel system
My research interest is in statistical pattern recognition and its applications to medicine. Areas of focus include bioinformatics fields such as the diagnosis of cancer, image recognition, and the design of a smart computer support system. Specific examples are as follows:

1) Prediction of early recurrence of liver cancer
Liver cancer has a high likelihood of recurrence despite complete surgical resection and is thus known as an intractable cancer. If postoperative recurrence of cancer is correctly predicted for each patient as a form of personalized medicine, effective treatment can be carried out. We try to predict the recurrence of liver cancer with high accuracy through blood tests.

2) Detection of gastric cancer
Gastric cancer is a completely curable cancer when it can be detected at its early stage. Thus, it is important to detect gastric cancer early, which is done through a form of cancer screening known as gastroscopy. Unfortunately, about 20% of gastric cancers are reportedly missed. We are working to develop a gastric detection system that uses a hyperspectral camera.

The aim of our research is to develop computer-aided diagnosis systems for individualized medicine by using clinical medical images such as CT images and microscopic images. The merit of computer-aided diagnosis systems is that they diagnose lesions in medical images in an objective and universalistic manner. To achieve this goal, we focus on the following three areas of research: (1) image analysis to understand internal human bodies and diseased organs, (2) image-based computer simulation to understand the dynamic function of organs, and (3) development of image processing algorithms for more precise analysis.

The pictures on the right half of the page show students discussing the precision of image registration (left) and computers for image processing (right). In the left picture, ante-mortem and post-mortem CT images are registered using anatomical landmarks and a deformation method for quantitative evaluation of changes after death. We expect this research to lead to the development of a method for investigating the cause of death and a method for evaluating the effectiveness of treatment.
Research on Modulation, Allocation, and Antenna and Propagation for Wireless Communications

Our research interest is digital modulation, resource allocation, and antenna and propagation for wireless communications. In recent years, information and communication techniques have come to require low-power systems and large communication areas and low-power systems. To achieve these demands, our laboratory is currently focused on the following three fields: 1) Digital modulation (e.g. OFDM (Orthogonal frequency division multiplexing)); 2) Resource allocation (e.g. OFDMA (OFDM access)); 3) Antenna and propagation (e.g. MIMO (Multiple-input multiple-output), and cooperative and relay communications). These techniques find application in current wireless communications such as mobile communications and wireless local area networks (WLAN). We are especially focused on antenna and propagation techniques as with massive MIMO, device to device (D2D), and coordinate multi-point (CoMP) will be very important in the next generation standard of wireless communications. Our research employs such tools as MATLAB, LabVIEW and NI USRP to investigate system performance for the proposed method.

Simulation Analyses and Control of Stochastic Systems

Our research interests include the stochastic analysis and control of stochastic lumped- and distributed-parameter systems. The five main subjects of our research are as follows: 1) mathematical analysis and control of infectious disease spread; 2) stochastic bifurcation of predator-prey systems; 3) mathematical analysis of the food chain; 4) stochastic modeling and simulation analysis of physical and chemical phenomena; 5) mathematical analysis of pattern formation. Actual phenomena almost always include random fluctuation, and sometimes this fluctuation has a great influence on the phenomena. Hence, stochastic modeling and the analysis of the various kinds of phenomena play an important role. We throw light upon the hidden characteristics of the phenomena by using computer simulations.
Innovation and Improvement in the Fascinating Field of Computing

We investigate the fundamentals of computing and calculation to propose new applications. We deal with a wide range of theoretical computer science fields including automata and formal language theory, algorithm design, and computational complexity. We are recently focusing on the following themes:

1) historical computing mechanisms, such as a) an automata-theoretic model of Japanese reading of ancient Chinese texts, which is a push-down automaton equipped with a mechanism for regarding any stack substring as a single character, b) a modified Rule of 72, called “Rule of $0.7 + 3r$”, which is an approximated calculating trick of the expo, log, and trigonometric functions whose accuracy is guaranteed to be under 1% over the whole domain.
2) mild context-sensitive grammar models such as “pattern context-free grammar” which is a context-free grammar equipped with a mechanism for duplicating subtexts already produced, similar to “pattern expression” for regular expression.
3) a wide area of algorithms such as a) the row-and-column-subtotal-first 2D apportionment scheme whose solutions are uniquely if any and its complexity is not known to be in polynomial-time but its inverse problem is quite easy, b) off-line invader game wherein the shapes of interceptors and invaders are assumed to be, for example, points or vertical or horizontal line segments.

Development of Life-Cycle Management Systems for Infrastructure

My research interests are in the development of bridge and tunnel management systems using advanced information processing technologies. My research focuses on the following topics.

1) Inspection: inspection support system, MOTIS (mobile tunnel image scanner) (Keywords: crack pattern extraction, digital image processing, inspection vehicle, interactive genetic algorithm)
2) Evaluation and diagnosis: performance evaluation system, remote image diagnostic system for existing infrastructure (Keywords: load carrying capability, durability, life-cycle performance, artificial neural network, fuzzy logic, neuro-fuzzy hybrid expert system, visual inspection)
3) Planning: maintenance (MR&R) & rebuild planning system (Keywords: genetic algorithms (evolutionary algorithms), multi-criteria optimization, decision making)
4) Data stock & data mining: bridge management database system, development of data-mining tools for bridge management (Keywords: data-mining, rough sets theory, cloud computing)

My research team not only proposes new methods but also develops practical software and inspection support devices.
As a member of the Laboratory of Bio-Information Processing System Engineering, the focus of my research is on intelligent computing, which includes such subjects as theories of artificial neural networks, fuzzy mathematics, evolutionary computation, and swarm intelligence. Research currently underway is as follows:

1. Brain Computer Interaction (BCI);
2. Time Series Forecasting;
3. Swarm Learning;
4. Development of an Autonomous Robot;
5. Integrated Model of the Brain with Multiple High-Order Functions.

We are also researching machine learning and complex systems with a view to developing intelligent systems.

“The purpose of the brain is to acquire algorithms automatically. The output is just a way to achieve this purpose.” (G. Matsumoto, 1940-2003)

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Classification process of diffuse lung diseases include segmentation of target regions, extraction of image features, and classification by image features.
The number of devices being connected to the Internet has seen a dramatic increase in recent years. Various kinds of systems such as smartphones, home appliances, and cars are connected to the network and working cooperatively. However, due to the complicated interactions between such a large number of systems, problems will occur in the future that cannot be predicted through current knowledge. Our research focuses on intelligent architectures for predicting problems that will occur with high probability in the future and detecting potential malfunctions, using data mining algorithms to discover a large number of rules that can explain system behavior.

To realize the above architectures, we will need to develop new data mining algorithms that can discover new rules from huge databases. We are also researching how to apply evolutionary computation to data mining. Evolutionary computation is based on the evolutionary mechanism of living things in the natural world, and our research seeks to achieve highly efficient rule extraction, where individuals (programs) that can discover important rules become smarter with successive generations.

My research interests include algebraic sequence design and its application in communications. In consideration for a certain communication system, we clarified required sequence properties, including mathematical bounds, and constructed certain kinds of optimal sequences for achieving the bounds. Correlation properties indicating the degree of the similarity between sequences are a particular focus and play an important role for constructing spreading spectrum communication systems. Proposals we have made include real valued bent functions, which can construct interesting sequences, complex Hadamard matrices and their factorization related to fast Fourier transforms over finite fields, and sequence sets with a zero correlation zone called ZCZ codes. We are currently working to propose excellent CDMA (code division multiple access) schemes utilizing a newly defined bent ZCZ code, the Hadamard transform, and block coding and channel estimation techniques. These will meet the needs of various applications including a high performance remote control system to move many control units at the same time and mobile wireless network systems to dynamically link mobile units like robots and vehicles.
Our current research interests include pseudo-noise (PN) sequences and their applications. The PN sequence is a signal similar to noise. Its ideal auto-correlation function is an impulse and its ideal cross-correlation function has all zero values. Our research is currently focused on the following five themes: 1) Evaluate the performance of and implement an optical wireless code-division multiple access (CDMA) system using light-emitting diode (LED) elements, 2) Design compact code generators and compact digital matched filters for PN sequences, and implement them on field programmable gate array (FPGA) devices, 3) Evaluate the performance of a unified communication and ranging system based on a spread spectrum (SS) system using a PN sequence with an ideal aperiodic auto-correlation function, 4) Design and evaluate the performance of a multi-input multi-output (MIMO) system using a PN sequence; and 5) Design and evaluate the performance of digital watermarking using a PN sequence.

A Computational Algorithm for Accurately Estimating Distance Using Camera-Captured Images

Animals or human beings estimate the distance to observed objects by using normally-developed binocular eyes. Two images are captured by their eyes, transmitted to the brain, and then processed to obtain the distance. Although the computational procedure involved has yet to be conclusively researched in the field of brain science, many engineering researchers are proposing binocular vision algorithms so as to implement computer vision on a camera-based system for robots and vehicles. Other approaches for estimating distance with millimeter-wave radar or ultrasonic wave sensors seem to also show promise, but the advantages of binocular vision include estimating distance in a wide field of vision using relatively simple devices, as well as analyzing scenes based on captured images. Our group is studying a simple but practical binocular vision algorithm for accurately estimating distance in which the possibilities of different distances at each image pixel are calculated in a parallel computation. Other interests of our group are handwritten character recognition, signature verification, object detection, and similar image retrieval.
In the engineering field, there are many problems that require optimization. My research interest involves constructing metaheuristic algorithms that seek to achieve optimization and that imitate, on computers, the action and behavior of living things. Constructed algorithms can be used to solve various engineering problems. For example, in ant colony optimization, it is possible to identify the shortest route to food by imitating the action of the ant. When there are few routes, it is easy to identify the shortest route. However, when the number of waypoints and possible routes increases, it is difficult to find the shortest route in a practical amount of time. Optimization using metaheuristics is used to solve such problems.

Evolutionary Algorithms for Optimization and Their Application to Engineering

In the engineering field, there are many problems that require optimization. My research interest involves constructing metaheuristic algorithms that seek to achieve optimization and that imitate, on computers, the action and behavior of living things. Constructed algorithms can be used to solve various engineering problems. For example, in ant colony optimization, it is possible to identify the shortest route to food by imitating the action of the ant. When there are few routes, it is easy to identify the shortest route. However, when the number of waypoints and possible routes increases, it is difficult to find the shortest route in a practical amount of time. Optimization using metaheuristics is used to solve such problems.

Computer Simulation of Fusion Plasmas

The computer simulation of tokamak plasmas is crucial to predict the performance of future fusion reactors and to analyze mysterious phenomena in present-day large-scale and high-beta tokamak experiments. For this purpose, the parallel utilization of supercomputers equipped with huge numbers of operating cores will be critical. We have developed Gpic-MHD, which is gyrokinetic PIC (particle-in-cell) code for MHD (magneto-hydrodynamics) simulation. The main target of Gpic-MHD is the research of MHD-like phenomena with kinetic modification in tokamaks. Gpic-MHD employs OpenMP for thread parallelism and MPI (message-passing-interface) for process parallelism. The particle and domain decompositions are used for process parallelism. In order to use multi-core systems and/or accelerators like Intel Xeon Phi coprocessors with many-core architectures and GPUs (graphics processing unit) like NVIDIA Tesla, the development of high performance algorithms for thread parallelism is very important. The present aim of our research laboratory is to explore the high performance algorithms of Gpic-MHD for state-of-the-art super computer systems.
A Fusion of a Brain Computer Interface and Robot with Learning, Memory and Reasoning Systems

We have so far focused on the development of an intelligent software system that mimics the brain information processing involved in the learning, memory, and reasoning systems present in people. Our research currently involves incorporating into robots numerous labeled learning, memory, and reasoning systems for implementing various purposes and, by using a brain computer interface (BCI) and only operating the labeled corresponding tasks, having the robot autonomously behave to achieve the intended purpose. The products of this research will be very beneficial to aging societies when the robots develop greater intelligence. However, BCI communication accuracy has yet to reach level that will allow for practical use in applications. The current challenge involves improving the sophistication of EEG recognition accuracy.

Investigation of Vision Mechanisms and Their Applications to Imaging Technologies

My research interests lie in understanding the information processing mechanisms in the human vision system and the development of their applications. My particular focus concerns visual illusions. For example, when taking a photo, you might notice differences between the objects in the photo and those in real life. I have observed cases of faraway mountains that look very big in real life appearing very small in photos. This difference is caused by our brain overestimating the sizes of faraway objects more than objects in photos. We might see moving objects in video appear clearer than individual scenes with the video is paused. This motion sharpening is also caused by our brain. I have researched how to cause visual illusions like these in our system of vision. I have also applied an understanding of how our perception of size depends on distance and of motion sharpening to develop a new, more realistic computer graphics technology and a new image processing technology to clearly display images for diagnostic endoscopy.
The Effect of Direction in Masking Sound for Evaluating Speech Privacy

In recent years, importance has been attached to achieving speech privacy in open spaces for purposes that include oral consultations near waiting rooms of small-scale clinics, tax-payment consultations at tax offices, coursework consultations in school classrooms, and legal aid services in temporary booths. This study focused on masking speech with meaningless steady noise in order to achieve speech privacy. To examine the influence of direction in masking noise for evaluating speech privacy, we conducted a psychological experiment in which both speech and a masking noise are presented to subjects from different directions in order to assess their perceived degree of speech privacy. These results suggested that the relationship between speech and masking noise direction have a profound effect on evaluating speech privacy.

Situation of psychological experiment

About Researcher

SAEKI Tetsuro, Ph.D.
Ph.D., 2000, Yamaguchi University

Toward Development of an Intelligent System Inspired by Computation in the Brain

The goal of our research is the development of an intelligent system inspired by computation in the brain. The brain has the capability to solve problems that are not yet easily solved by computers. We believe that the brain can provide clues to methods for dramatically improving the functions of computational systems. The brain is a computational system where computation is implemented in a neural circuit. In a neural circuit, the various types of neurons are wired together. Information is processed through the circuit and stored by changing the structure of the circuit through synaptic plasticity. We are therefore now trying to understand the mechanisms of computation in the brain by elucidating the mechanisms of signal transmission and plastic change in neural circuits from computer simulation. We have a particular interest in the relationship between the anatomical structure of a neural circuit and rhythmic neuronal activities organized through synaptic plasticity in neural circuits.

Artificial neural circuit where two types of neurons (red and blue points) were distributed on torus surface and wired to other neurons

About Researcher

SAMURA Toshikazu, Ph.D.
Ph.D., 2009, Keio University
Our research interests focus mainly on the following two themes: (1) Development of methods for synthesizing highly photo-realistic landscape images in computer graphics; (2) Development of a prototype of an evacuation drill simulator that uses walk-throughs in virtual spaces that simulate a large-scale earthquake hitting an urban area.

The latter consists of the following elemental techniques:

(a) A simulation method for estimating damage done to buildings by earthquakes; (b) A simulation method for creating distributions for rubble resulting from collapsed buildings; (c) A method for creating 3D renders of urban areas hit by large-scale earthquakes by using the results of (a) and (b); (d) A method for simulating earthquake-induced fire spread that takes into account damage done to each building; (e) A simple method for rendering building fires (specifically smoke and flames blowing out from windows) from a specific viewpoints.

My research explores effective ways of raising public awareness and education for disaster risk reduction concerning natural and man-made disasters. My interests also involve the study of interactive approaches for disaster information/communication tools and management procedures for improving organizational incident response processes, as well as knowledge management in organizations and cultivating responsible behavior. We have also developed disaster response training and exercise programs for disaster preparedness in many regions and local governments as social action efforts. The major themes of my research and support for social action efforts are as follows:

1. Development of an interactive disaster simulation system for education concerning natural disasters such as earthquakes, floods and landslides. 2. Development of application software for disaster preparedness education. 3. Development of an Emergency Management Information System (EMIS) for use on cellular phones or tablets for local governments. 4. Proposal of effective emergency management tabletop exercise and drill plans for local governments as social action efforts.
Software Reliability and Modeling

Many people currently use one or more of the many available software services based on cloud computing with big data. Database and cloud software are frequently used as the main software components in systems for cloud computing with big data. Open source software such as OpenStack and Eucalyptus are also frequently used in cloud computing to achieve unified management of data, low cost and easy-maintenance, and simple operation. Database software such as Hadoop and NoSQL is embedded with cloud software. Our research group has developed three-dimensional application software for reliability assessment. We then used the ActionScript programming language to implement three-dimensional spaces in the software tool we developed. This tool will be useful for assessing the software reliability of the characteristics of big data on cloud computing. Our developed software will be of particular use in the development of mobile applications. Software managers will be able to use this tool for cloud computing anytime and anywhere due to the high portability of mobile applications.

Theory and Its Applications to Evolvable Parallel, Distributed, and Autonomous Systems

Our research interest is in the area of theory, especially Petri net theory, and its applications to parallel, distributed, and autonomous systems. Human society’s activities, robots’ cooperative behaviors, biological phenomenon can be regarded as parallel, distributed, or autonomous systems. Such systems are characterized by dynamic evolution. We are working to develop a new theory system by combining various approaches such as Petri net theory, process mining, multi agent technique, process algebra, supervisory control, and model checking. We also are developing systems that evolve based on the theory of systems. The systems we have developed are: a system which models a business process as a Petri net and supports its evolution (shown in the upper part of figure); a system named Éclair, which supports the development of safe and efficient elevator systems (shown in the lower part of figure); and a system which analyzes signaling pathway in biological systems by model checking.