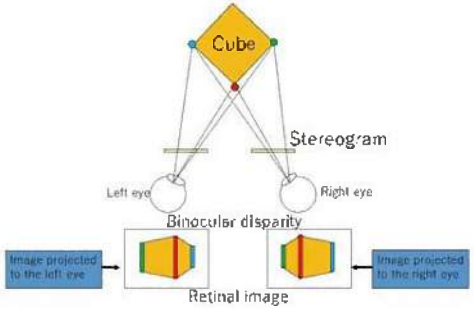
Elucidation of visual information processing in three-dimensional stereoscopic space

Our research is aimed at elucidating the visual characteristics of how **depth perception** and **numerosity perception** are processed in three-dimensional space. Humans process various physical stimulus attributes (e.g., distance, depth, color, and numerosity) of objects in **3D space** in everyday life. It is generally believed that human perception accurately reflects the attributes of physical stimuli, but perception and physical stimuli do not always coincide. We measure human sensations when we observe an image or other object, and investigate how the processing in the brain is carried out based on the relationship between the physical stimulus and the measured response. To better understand the information processing carried out in the brain, we use psychophysical, physiological, and computational methods of measurement to study this processing. VR, AR and MR are technologies that make use of the visual characteristics of 3D space, and they are being widely used in entertainment (such as 3D movies and 3D games) and medical AR.



Schematic diagram of the difference in retinal images when observing a cube

About Researcher

AIDA Saori, Dr. Eng.

Dr.Eng., 2014, Tokyo University of Marine Science and Technology

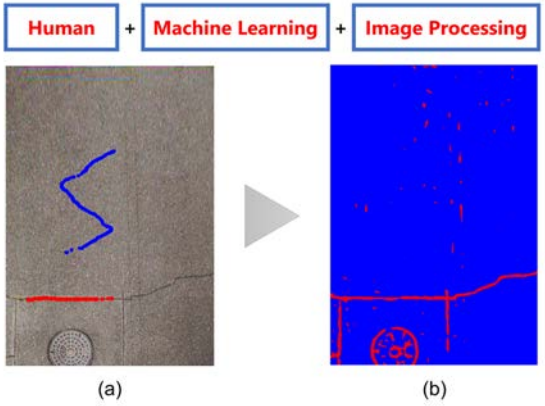
WEB ➢ http://www.vip.csse.yamaguchi-u.ac.jp/en/index.html

Research into Pattern Recognition Theory and Practical Algorithms for Application to Real-World Problems

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 (including deep learning). We are currently engaged in the following research:

1) Development of a machine vision system for visual inspection of infrastructures, such as 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) Generally, the construction of deep learning models requires a large amount of training data. The high cost of data collection and precise labeling are key issues for practical applications. To address these issues, we are also developing methods to build systems using **small data** and ambiguous information, using human-computer interactive processing based on image processing and pattern recognition techniques.



Example of “interactive image processing”: training of crack detection model, and result of crack detection using trained model.

About Researcher

FUJITA Yusuke, Ph.D.

Ph.D., 2008, Yamaguchi University

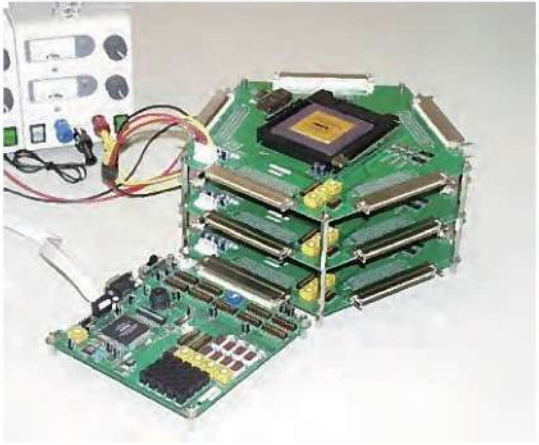
Dependable and High-Performance Parallel and Distributed Systems

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.



Prototype of a self-reconfigurable parallel system

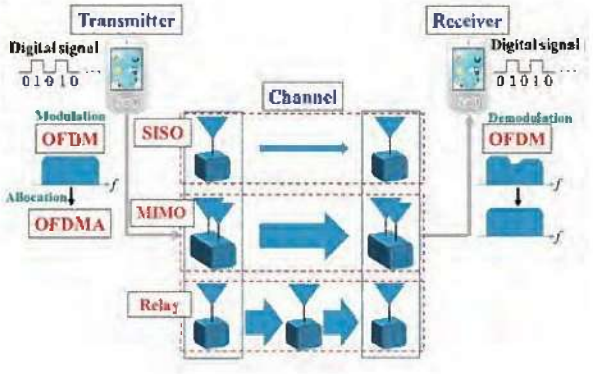
About Researcher

FUKUSHI Masaru, Ph.D.

Ph.D., 2002, JAIST (Japan Advanced Institute of Science and Technology)

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.



Flow figure showing modulation, allocation, antenna and propagation for wireless communications

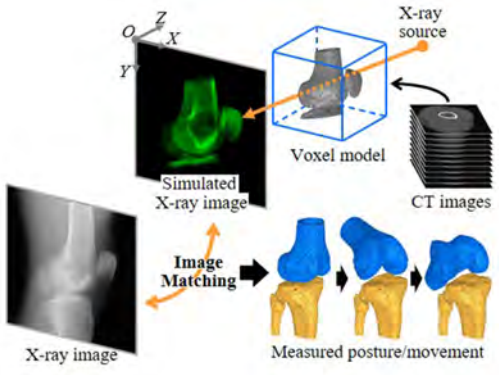
About Researcher

IDA Yuta, Ph.D.

Ph.D., 2013, Hiroshima City University

Kinematic Analysis of *in Vivo* Joints in the Field of Orthopaedics

Human joints have great mobility and stability and are capable of various activities. Osteoarthritis is a frequent cause of pain and functional disability. Patients with osteoarthritis often choose to undergo total joint arthroplasty to relieve pain, improve functions, and become active again. In the field of orthopaedics, ***in vivo* joint kinematics** are measured to quantify the six-degree-of-freedom motion of joints of pre- and post- total joint arthroplasty. We are developing a kinematic analysis technique that applies the **model-image registration methods** using medical images such as X-ray images and CT images. This kinematic analysis technique measures joint kinematics by using image matching on **digitally reconstructed radiographs** created using CT images or artificial joint models to objects in X-ray images. We measure joint movements of the shoulder, hip, and knee joint kinematics during daily life and sports, and provide feedback to evaluate and improve orthopaedic surgery. This research may support the introduction of a clinical joint kinematics examination in the near future.



In vivo joint kinematics is measured with model-image registration methods that use medical images

About Researcher

IKEBE Satoru, Dr.Eng.

Dr.Eng., 2016, Kyushu Sangyo University

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.

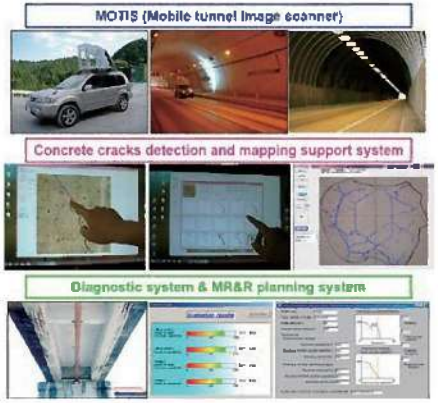
1) Inspection: inspection support system, MOTIS (mobile tunnel image scanner) (Keywords: crack pattern extraction, digital image processing, inspection vehicle, interactive genetic algorithm)

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**.



Our research concept and related software and devices

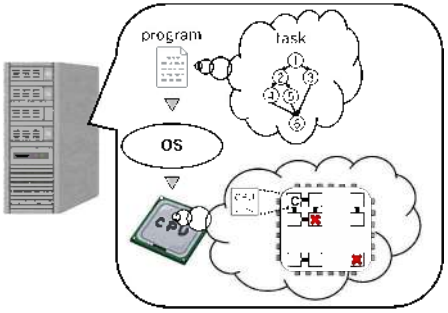
About Researcher

KAWAMURA Kei, Dr.Eng.

Dr.Eng., 2000, Yamaguchi University

Fault-tolerant Parallel and Distributed Systems

Parallel and distributed systems consisting of a large number of processing units (computers, processors, etc.) are used everywhere from very large scale systems such as supercomputers, which mainly perform scientific calculations, to small scale systems such as multi-core processors, which are embedded in PCs and smartphones. In such systems, when failures and faults occur during their manufacture or when running, the entire system will be prevented from working properly. Accordingly, dealing with these problems is an important and fundamental issue. To solve them, we are working on **fault-tolerant routing methods** and **task mapping methods**. The goal of our research is to achieve a parallel and distributed system in a scale in the thousands on a single VLSI chip. We would like to contribute to the development of a more convenient society by embedding this chip in all kinds of devices and using it as computational infrastructure to achieve many new services.



Execution of a program on a many-core CPU that contains faulty cores

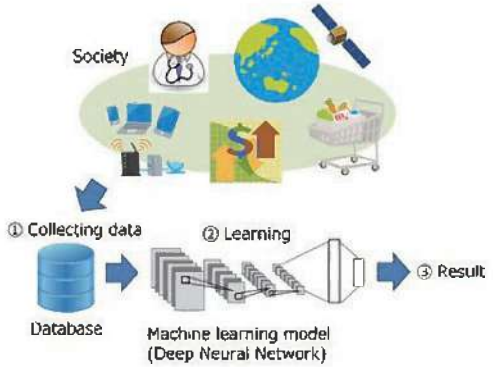
About Researcher

KUROKAWA Yota, Dr.Eng.

Dr.Eng., 2021, Yamaguchi University

Study on Machine Learning Algorithms for Big Data Analysis

Research into **machine learning** has been actively conducted in fields such as image recognition, and machine learning has shown better recognition accuracy compared to human beings. In this research, decision support systems and anomaly detection systems have been developed by applying **deep learning** and machine learning algorithms. In detail, we are developing **computer-aided diagnosis systems** for detecting diseases from medical images, and fast **anomaly detection** systems for finding disaster-stricken areas from satellite images. Generally, to obtain high detection accuracy using machine learning (including deep learning), a large number of training data with annotation is needed. However, we cannot always obtain such databases with a sufficient number of annotated data. Therefore, we are also developing unsupervised learning algorithms that do not need annotated data and semi-supervised learning algorithms that use the limited number of annotated data efficiently. We are aiming to achieve machine learning systems that can be easily used in various environments.



1. Building databases. 2. Training machine learning model.
3. Trained model is used for prediction, detection, decision making, etc.

About Researcher

MABU Shingo, Ph.D.

Ph.D., 2006, Waseda University

WEB ≫ http://www.nn.csse.yamaguchi-u.ac.jp/english/

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**.

Figures: an image captured by a left-side camera (upper left), the ground truth of the distance map (upper right), distance maps computed by a conventional method (lower left), and our method (lower right).

About Researcher

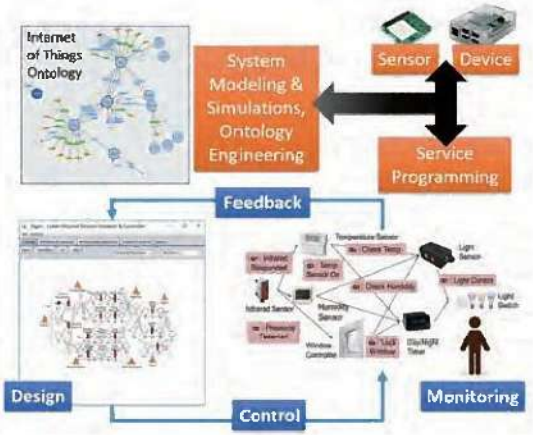
MIZUKAMI Yoshiki, Dr.Eng.

Dr.Eng., 1998, Yamaguchi University

Research and Development of Internet of Things Service Deployment Technology for the Smart Society

We focus on research and development of Internet of Things (IoT) technology. In the society of the future, autonomous services such as smart homes, self-driving vehicles, healthcare, and smart grids will be in enormous demand. In order to meet society's constantly changing needs, rapid service deployment is required. Cyber-physical systems are the foundation of IoT, where our everyday lives will be supported by diverse interconnected devices, sensors, and actuators. Any device should be able to interoperate in any IoT environment in order to provide services to the user.

We are working on the design and implementation of a framework for IoT services that can be deployed anytime and anywhere. Our laboratory focuses on: (i) research into service design and development methodology based on formal approaches such as system modeling, ontology engineering, and simulations; (ii) development of an IoT service deployment framework that consists of design, control, monitoring and feedback; (iii) implementation of IoT systems and the development of software tools for visual service programming and computation analysis. We constantly implement new design theories and IoT technology based on the latest trends and needs.



We are developing an IoT service programming system and rapid deployment framework consisting of design, control, monitoring, and feedback.

About Researcher

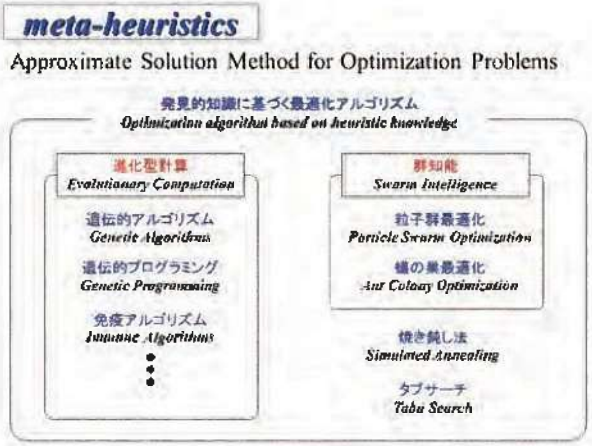
MOHD ANUARUDDIN Ahmadon, Dr. Eng.

Dr. Eng., 2017. Yamaguchi University

WEB ⁄ www.ss.csse.yamaguchi-u.ac.jp

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.



Approximate solution method for optimization problems

About Researcher

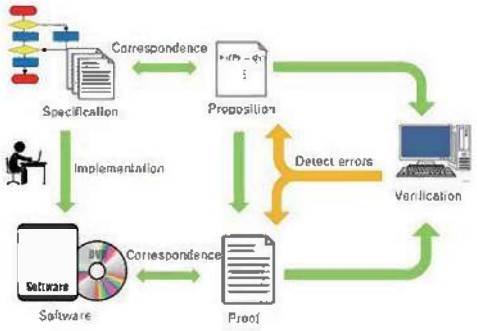
NAKAMURA Hideaki, Ph.D.

Ph.D., 1996, Yamaguchi University

Studies on Proof Assistant Systems

My research interests include **proof assistant systems**. Mission critical systems like e-commerce transactions are required to be highly reliable because a defect may have a large negative impact on our society. Currently, in order to prevent software bugs, a number of manual reviews and a variety of software tests are conducted in the software development process. However, in principle, it is impossible to completely eliminate software bugs through this manual work. Proof assistant systems assure the correctness of mathematical proofs written in a formal language. According to the Curry-Howard correspondence, mathematical propositions and proofs are logically equivalent to software specifications and implementations, respectively. Therefore, proof assistant systems can also be used as a tool to ensure that software programs behave as they are specified. Our typical research topics are as follows:

1) Assistant tools such as IDEs and documentation generators;
2) **Search algorithms** and system development for formalized libraries;
3) **Automated reasoning** using machine learning;
4) Design of specifications and description languages;
5) Logical correspondence between software and mathematics.



Flow of software verification with proof assistant systems

About Researcher

NAKASHO Kazuhisa, Dr.Eng.

Dr.Eng., 2013, Shinshu University

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.

This is a visual illusion discovered in my laboratory. Please estimate the angle that is composed of the leftmost solid line on the road shoulder and the dashed line.

About Researcher

OSA Atsushi, Ph.D.

Ph.D., 2005, Yamaguchi University

WEB ≫ http://web.cc.yamaguchi-u.ac.jp/~osaa/index-e.html

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

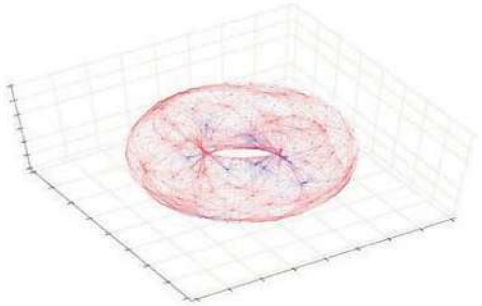
About Researcher

SAEKI Tetsuro, Ph.D.

Ph.D., 2000, Yamaguchi University

Intelligent Systems Inspired by Computation in the Brain toward Sustainable Development

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 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 elucidating **the mechanisms of computation in the brain** from **computer simulations** of signal transmission and plasticity in neural circuits. Moreover, we have a particular interest in the improvement of artificial neural networks and the development of intelligent systems for disaster management as the application fields of the computation mechanism.



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

WEB ≫ http://www.ncc.csse.yamaguchi-u.ac.jp/

Computer Graphics and Its Applications

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.

A scene of a rainy urban street depicting raindrop-induced splashes

About Researcher

TADAMURA Katsumi, Dr.Eng.

Dr.Eng., 1995, Hiroshima University

Development of Emergency Management Information System and Preparedness Education Program

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.

My research has focused on topics concerning system development and developing an actual exercise program for disaster preparedness

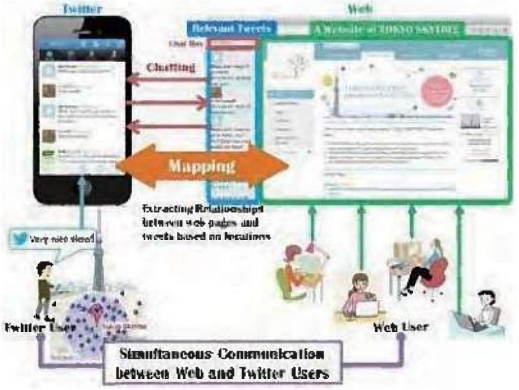
About Researcher

TAKIMOTO Koichi, Ph.D.

Ph.D., 1993, Yamaguchi University

A Cross-Media Social Communication and Search System

Two primary methods are used to obtain information using Internet services: search engines (SEs) and social network services (SNSs). While SEs have the advantages of highspeed searches and high data coverage, they also have the disadvantages of the absence of immediate updates and exibility. Moreover, communication via SNSs can enable us to provide updates immediately because they can be updated with current information. Moreover, flexibility can be maintained because users can freely troubleshoot with other users. However, responses obtained can be time-consuming and may have lower knowledge coverage than SEs. Therefore, we aim to develop a **Cross-Media Social Communication and Search System** that combines the advantages of both Web search and social communication. The system provides a communication function for users who browse the same page or SNS users whose SNS messages are related to a page, thus enabling real-time communication over heterogeneous media. Therefore, users will efficiently search important pages using relevant SNS messages and immediately obtain useful information from pages and other users via the communication function. Our system contributes to information retrieval, collaboration and cross-media communication.



Cross-media communication system between Web and Twitter.

About Researcher

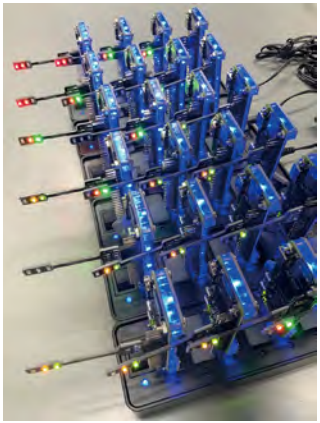
WANG Yuanyuan, Ph.D.

Ph. D., 2014, University of Hyogo

WEB ≫ http://www.wie.csse.yamaguchi-u.ac.jp/wang/

Research and Development of Cyber Security System to Defense the World with Botnets

We are advocating for, and working to research and develop, an innovative cybersecurity system called the **Botnet Defense System (BDS)**. The Mirai botnet, which emerged in 2016, exploited vulnerable IoT devices and has attacked Amazon, Twitter (currently known as X), and others, causing them to shut down their services. Since then, Mirai and its derivative botnets have continued to cause damages worldwide. Based on the concept of "fighting fire with fire," BDS uses **botnet technology** for defensive purposes. Specifically, BDS builds a white-hat botnet and then commands and controls the botnet to eliminate malicious botnets. In addition, BDS incorporates mechanisms inspired by the **biological immune system** to autonomously eliminate newly emerging malicious botnets. Our goal is to break the cycle of attack and defense and put an end to this perpetual battle.



Prototype of Botnet Defense System (BDS)

About Researcher

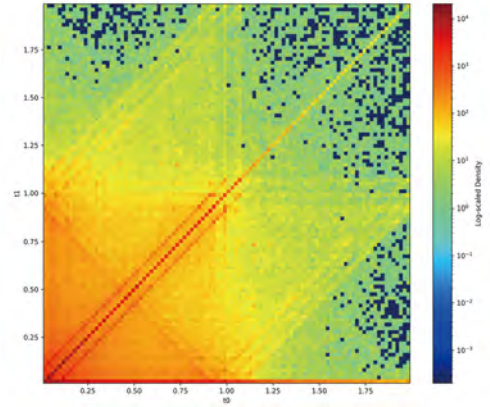
YAMAGUCHI Shingo, Dr.Eng.

Dr.Eng., 2002, Yamaguchi University

WEB ≫ https://ds0n.cc.yamaguchi-u.ac.jp/~shingo/

Mechanisms of Large-Scale Collective Behaviors

Modern society is becoming increasingly complex, and teamwork has become a crucial element for societal development. Therefore, factors that enable **effective teamwork** have become a hot topic for many previous studies. The current research aims to elucidate the factors that enable efficient teamwork, especially in the context of online crowdsourcing communities. Specifically, the researcher utilizes data on large-scale group behaviors to quantitatively analyze the **personal characteristics** of team members (e.g., age, gender, political affiliation) and the **social networks** among team members, and investigate their correlation with the outcomes of group behaviors. The potential findings, which are based on real-world data related to production and management activities, have the potential to make significant contributions to various fields. In particular, they can provide valuable insights for the industrial sector, especially in areas such as organizational management and team building. By understanding the dynamics of effective teamwork, industries can optimize their operations and achieve greater success.



Probability of collaboration between users in online communities. Red indicates a high probability of collaboration.

About Researcher

YANG Kunhao, Ph.D.

Ph.D., 2021, The University of Tokyo

WEB ≫ https://www.researchgate.net/profile/Kunhao-Yang