2023 IWAMechS

The International Workshop on Advanced Mechatronic Systems

(IWAMechS 2023)

February 26 – February 28, 2023

Karuizawa, Nagano, Japan

PROGRAMME

Organizers:

International Journal of Advanced Mechatronic Systems

Modeling, Identification and Control

International Journal of Human Factors Modelling and Simulation

IEEE Systems, Man, and Cybernetics Society

Tokyo University of Agriculture and Technology, Tokyo, Japan

Ritsumeikan University, Tokyo, Japan

Osaka Institute of Technology, Osaka, Japan

Instructions

Registration Guide:

Arrive at the Conference Venue → Inform the conference staff of your paper ID →Sign your name on the Participants List → Check your conference materials.

Checklist:

1 receipt, 1 name card, 1 printed conference abstract, 1 lunch coupon, 1 dinner coupon.

Devices Provided by the Conference Organizer:

- Laptops (with MS-Office & Adobe Reader)
- Projectors & Screen
- Laser Sticks

Material Provided by the Presenters:

PowerPoint or PDF files

Notice:

- Certificate of listener can be collected from the registration counter.
- Certificate of presentation can be collected from the session chair after each session.
- The organizer will not provide accommodation, so we suggest you make an early reservation.

Contact:

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Advanced Mechatronic Systems

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GREETINGS FROM THE GENERAL CHAIRS

On behalf of IWAMechS2023 Organizing Committee, it is our great pleasure and honor to welcome you all to The International Workshop on Advanced Mechatronic Systems. The workshop is held on February 26-28, 2023 at The Karuizawa, Japan, sponsored by International Journal of Advanced Mechatronic Systems (IJAMechS), Modeling, Identification and Control (MIC Journal), International Journal of Human Factors Modelling and Simulation (IJHFMS), Tokyo University of Agriculture and Technology, Ritsumeikan University, Osaka institute of Technology, IEEE Systems, Man, and Cybernetics Society.

IWAMechS2023 is in conjunction with ICAMechS 2022. It aims to provide a high-level international forum for scientists, engineers, and educators to present the state-of-the-art research and applications in AI design, AI application, and advanced mechatronic systems research. The workshop features keynote speeches given by world renowned scholars.

Karuizawa, a town in the Kitasaku district of eastern Nagano, is a haven for lovers of beautiful mountainous views, serene nature and curious history. Located at an altitude of roughly 1000 meters, the town provides a pleasant escape from the summer heat. With a wide array of seasonal activities, inspiring art galleries, museums and local attractions, Karuizawa has something to light a spark in the imagination of any visitor.

Eight distinguished speakers are invited to give keynote presentations. We would like to present our sincere thanks to the keynote speakers.

We hope that you all enjoy the workshop and beautiful Karuizawa.

Best regards,

General Chair

Lin MENG, Associate Professor, PhD

SOCIAL EVENTS

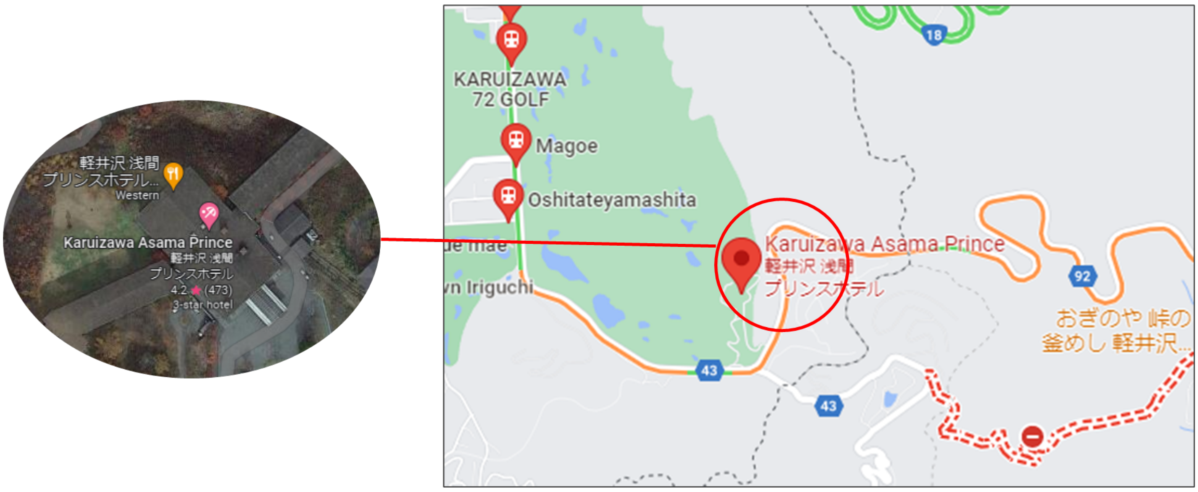
Welcome Reception

Conference Banquet

CONFERENCE LOCATION

Karuizawa Asama Prince Hotel, Nagano, Kitasaku District, Karuizawa, Hotchi, 389-0113 JAPAN

Maps and Transportation



Agenda Overview

Monday, December 27, 2021

Venue: Karuizawa Asama Prince Hotel, Nagano, Kitasaku District, Karuizawa, Hotchi, 389-0113 JAPAN

09:50 - 10:00	**Opening Remark**
	Keynote Speaker 1
10:00 - 10:30	**Prof. Mingcong DENG, Tokyo University of Agriculture and Technology, Japan**
	Title: Current Developments on Advanced Mechatronic Systems at TUAT
	Keynote Speaker 2
10:30 - 11:00	**Prof. Lin MENG, Ritsumeikan University, Japan**
	Title: AI + High-performance Computing and the Applications
	Keynote Speaker 3
11:00 - 11:30	**Prof. Shuhui BI, Shandong Academy of Sciences, China**
	Title: DS Evidence Theory based Multi-model Fusion in Near Infrared Technology
	Keynote Speaker 4
11:30 - 12:00	**Prof. Guang JIN, Tokyo University of Agriculture and Technology, Japan**
	Title: Vibration Control Design for a Nonlinear System based on Operator Theory
12:00 - 13:00	**Lunch Break**

	Ph.D Students Session
13:00 - 13:30	**Ximei LI, Tokyo University of Agriculture and Technology, Japan**
	Title: Nonlinear Vibration Control for a Flexible Arm with Actuator Fault
13:30 - 14:00	**Xuebin YUE, Ritsumeikan University, Japan**
	Title: An Ultra-Lightweight Object Detection Network for Empty-Dish Recycling Robots
14:00 - 14:30	**Break**
14:30 - 15:00	**Yifei GE, Ritsumeikan University, Japan**
	Title: A novel automatic Yolo architecture search model
15:00 - 15:30	**Zhuo LI, Ritsumeikan University, Japan**
	Title: Deep Learning-based Unsupervised Anomaly Detection in Industry
15:30 - 16:00	**Break**
16:00 - 17:30	**Panel Discussion**

Tuesday, February 28, 2021

Venue: Karuizawa Asama Prince Hotel, Nagano, Kitasaku District, Karuizawa, Hotchi, 389-0113 JAPAN

	Keynote Speaker 1
10:00 - 10:30	**Prof. Aihui WANG, Zhongyuan University of Technology, China**
	Title: Control System Design of Lower Limb Rehabilitation Robot based on Human Gait Properties
	Keynote Speaker 2
10:30 - 11:00	**Prof. Xudong GAO, Nanjing University of Information, Science and Technology China**
	Title: Application of Population-based Metaheuristic Methods for Wireless Power Systems
	Keynote Speaker 3
11:00 - 11:30	**Prof. Changan JIANG, Osaka Institute of Technology, Japan**
	Title: Optimal Posture Maintenance Control of 2-link Object with Viscous Joint by Nonprehensile Two-cooperative-arm Robot
11:30 - 13:00	**Lunch Break**

	Students Session
13:00 - 13:30	**Hengyi LI, Ritsumeikan University, Japan**
	Title: Enhanced Mechanisms of Pooling and Channel Attention
13:30 - 14:00	**Jiale REN, Zhongyuan University of Technology, China**
	Title: Controller Design of Rehabilitation Robot and Gait Prediction Based on Human Movement Data
14:00 - 14:30	**Break**
14:30 - 15:00	**Xin WANG, Zhongyuan University of Technology, China**
	Title: Wrist-worn sensor-based Human Activity Recognition by Deep Learning
15:00 - 15:30	**Zhenling SU, Zhongyuan University of Technology, China**
	Title: Development of a Buried Neurostimulator for Free-moving Animals
15:30 - 16:00	**Break**
16:00 - 17:30	**Panel Discussion**
17:30 - 18:00	**Closing Ceremony**

KEYNOTE SPEAKERS

Prof. Mingcong DENG, Tokyo University of Agriculture and Technology, Japan

Prof. Mingcong Deng received his PhD in Systems Science from Kumamoto University, Japan, in 1997. From 1997.04 to 2010.09, he was with Kumamoto University; University of Exeter, UK; NTT Communication Science Laboratories; Okayama University. From 2010.10, he has been with Tokyo University of Agriculture and Technology, Japan, as a professor. Prof. Deng specializes in three complementary areas: Operator based nonlinear fault detection and fault tolerant control system design; System design on thermoelectric conversion elements; Applications on smart material actuators. Prof. Deng has over 580 publications including 195 journal papers, 15 books (or chapters), in peer reviewed journals including IEEE Transactions, IEEE Press (for books) and other top tier outlets. He serves as a chief editor for International Journal of Advanced Mechatronic Systems, International Journal of Human Factors Modelling and Simulation, and associate editors of 6 international journals. Prof. Deng is a co-chair of agricultural robotics and automation technical committee, IEEE Robotics and Automation Society; also a chair of the environmental sensing, networking, and decision making technical committee, IEEE SMC Society. He was the recipient of 2014 & 2019 Meritorious Services Award of IEEE SMC Society, 2020 IEEE RAS Most Active Technical Committee Award (IEEE RAS Society). He is a member of The Engineering Academy of Japan, and Fellow of AAIA.

Title:

Current Developments on Advanced Mechatronic Systems at TUAT

Abstract:

In this talk, current techniques for advanced mechatronic systems at TUAT are shown. In details, for dealing with nonlinear mechatronic system dynamics, cases study on modeling are introduced, which describe the nonlinear dynamics based on fundamental physical and chemical rules. As for the control on the nonlinear dynamics, robust nonlinear control design schemes are employed to guarantee the robust stability and desired performance. Further, operator-based robust nonlinear controls of uncertain wireless power transfer systems, calorimetric power loss measurement system, 3-DoF soft actuator, thermoelectric power generation, micro reactor, DCS based tank process etc. are presented.

KEYNOTE SPEAKERS

Prof. Lin MENG, Ritsumeikan University, Japan

Lin Meng is currently a associate professor at the college of science and engineering at Ritsumeikan University. He received his Ph.D. from the graduate school of science and engineering, Ritsumeikan University, Japan, in 2012. During his Ph.D, he received Japanese Government Scholarship (MEXT). He was a Research Associate from 2011 to 2013, and was an Assistant Professor from 2013 to 2018 in the department of Electronic and Computer Engineering, Ritsumeikan University. During 2015 to 2016, he was a visiting scholar in Department of Computer Science and Engineering, University of Minnesota at Twin Cities, USA. He has published over 280 papers including IEEE TIM, IEEE TSC, IEEE TITS, IEEE IoT J, AIRE, APIN. He received four funding from Japan Society for the Promotion of Science (JSPS) in the past five years. His research interests include computer architecture, parallel processing, image recognition with Artificial Intelligence and so on. He is a member of IEICE, IEE, IPSJ, ACM and IEEE.

Title:

AI + High-performance Computing and the Applications

Abstract:

Artificial intelligence (AI) has made great achievements in multiple domains. However, as the major branch of AI, deep learning (DL) demands an overwhelming amount of hardware resource which has severely impedes the further development and application of the technique. At the same time, research has fully demonstrated that the current deep neural networks (DNNs) are seriously over-parameterized with an enormous number of redundant computations. In view of this, our research aims to realize the high-performance of AI for further popularizing the application of AI in various fields. The high-performance computing of AI involves two phases: software-level and hardware-level. The software level is to automatically generate the optimal DNN models for specific tasks with the redundancies of the architecture automatically swept out. As a result, the optimal networks are more compact and smarter with high efficiency. As for the hardware level, the research is to implement the acceleration of the optimal DNNs by utilizing FPGA. In detail, FPGA provides promising solutions to accelerate DNNs with multiple distinct advantages, including low latency, high-flexibility, etc. In detail, the acceleration of DNNs on FPGA is realized by utilizing the Vitis AI development stack, which is a convenient and efficient tool for deploying and accelerating AI inference on Xilinx hardware platforms including both Edge devices and Alevo accelerator cards. Then, the high-performance DNNs are further applied for cultural heritage reorganization and protection, IoT-based system, Facial Expression Recognition, Tidying Up Tableware, Medical Diagnosis System, Prediction of Metal Deterioration, etc.

KEYNOTE SPEAKERS

Prof. Shuhui BI, Shandong Academy of Sciences, China

Shuhui Bi received the B.Sc. degree in Applied Mathematics from Qufu Normal University in 2002, the M.Sc. degree in Operational Research and Control Theories from Ocean University of China in 2007, and the Ph.D. degree in Control Theory and Control Engineering from Okayama University, Japan in 2010 respectively. Shuhui Bi is currently an associate professor of the school of Electrical Engineering at University of Jinan, China. She has worked as an Associate Professor at Shandong Academy of Sciences. Her research interests include nonlinear system control, filter design of integrated navigation system, evidence theory based multi-model fusion. She co-authored over 70 internationally refereed journal and proceedings papers. She is a member of the IEEE and CAA.

Title:

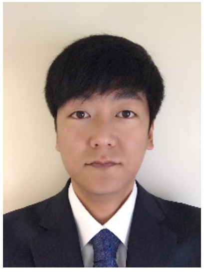
DS Evidence Theory based Multi-model Fusion in Near Infrared Technology

Abstract:

As a non-destructive detection technique, near infrared spectroscopy (NIRS) detection technology has been widely used in the internal quality testing of fruits, which is feasible to detect the sugar or acidity of fruits due to its advantages of fast, non-destructive and pollution-free. NIRS is an indirect detection method that requires modeling to predict the soluble solid content (SSC) based on large amounts of acquired spectral and data. This speech first introduces the application of NIRs on apples, which includes characteristic, detection process and the factors affecting prediction accuracy. Focusing on these factors, the data pre-processing, spectral characteristic wavelength selection, and modeling methods will be discussed. Moreover, the single classification model has seriously limited the prediction accuracy and application, particularly with the hard partition of the instance space. DS evidence theory is adopted to aggregate the predictions of the several models, which provides a flexible framework to represent and reason with uncertainty. Mass function generation was discussed for the fusion model. Experiments proved a much more accurate and intuitive classification was achieved using the improved fusion model. The better applicability was also obtained without the hard partition, compared with the single prediction model. And the improvement can also be applied to the fusion of other prediction models.

KEYNOTE SPEAKERS

Dr. Guang JIN, Tokyo University of Agriculture and Technology, Japan



Guang Jin received the M.S. degree in electrical and electronic engineering and the Ph.D. degree in electrical and information engineering from Tokyo University of Agriculture and Technology, Japan, in 2016 and 2020, respectively. He is currently an Assistant Professor in Department of Electrical Engineering and Computer Science, Tokyo University of Agriculture and Technology, Japan. His research interests include nonlinear control, vibration control.

Title:

Vibration Control Design for a Nonlinear System based on Operator Theory

Abstract:

Recently, vibration control has been a key technology in many engineering fields. The vibration control methods mainly fall into two categories: passive vibration control and active vibration control. From the viewpoint of energy saving, passive vibration control is desirable. However, active vibration control is necessary to suppress vibration more efficiently. More recently, smart materials have been used as actuators in many dynamic systems to realize the reduction in size and weight of actuators. Many smart materials have been proposed, such as piezoelectric elements, shape-memory alloy, and magnetic fluid as actuators. And as sensors, piezoelectric elements and optical fibre can be mentioned. Vibration control using smart materials attracted attention as one of the vibration control methods.

This talk shows nonlinear vibration control schemes for the wing plate system with piezoelectric actuators based on operator theory. This can be applied to the design of the vibration control system using smart actuators with hysteresis nonlinearity for the purpose of realizing the desired vibration control performance. Also, designed schemes can be applied to both single-input single-output (SISO) systems and multi-input multi-output (MIMO) systems. In addition, some simulation and experimental results are shown.

KEYNOTE SPEAKERS

Prof. Changan JIANG, Osaka Institute of Technology, Japan

Changan Jiang received his B. E. degree and M. E. degree from Northeastern University, China in 2003 and 2006, and his Ph.D. degree from Okayama University, Japan in 2009. He worked in Okayama University as a Specially Appointed Assistant Professor (2009-2010), then in SCA Co., Ltd as a JST Researcher (2010-2011). He became a Doctoral Researcher in Kagawa University (2011), after that joined RIKEN as a Research Scientist (2012-2015). He became an Assistant Professor in Department of Mechanical Engineering, Ritsumeikan University (2015-2020). Now he is currently an Associate Professor in Department of Robotics, Osaka Institute of Technology, Japan (since 2020). He also was a Visiting Scientist in Concordia University, Canada for 6 months from September 2017. His research interests include robotics, nonlinear robust control with input nonlinearity, vibration control, modelling of smart material-based actuator, magnetic levitation and active magnetic bearing.

Title:

Optimal Posture Maintenance Control of 2-link Object with Viscous Joint by Nonprehensile Two-cooperative-arm robot

Abstract:

Recently, more researchers have focused on nursing-care assistant robot and placed their hope on it to solve the shortage problem of the caregivers in hospital or nursing home. In this paper, a nonprehensile two-cooperative-arm robot is considered to realize posture maintenance to keep a 2-link object (regarded as a care-receiver) stable on the robot arms. In order to better imitate the care-receiver's body, a 2-link object with viscous joint is developed. After measuring parameters of the 2-link object, the dynamic model of the robot systems including nonprehensile robot and 2-link object is derived based on Lagrange equation. In this model, for describing interaction behavior between object and robot arms in the normal direction, a viscoelastic model is employed to represent the normal forces. Considering existence of friction between object and robot arms, LuGre dynamic model is applied to describe the friction. In this research, considering that fast variance of movement of robot arms may lead care-receivers to feel afraid, uncomfortable, and even pained during holding and lifting-up, an optimal regulator, whose performance can be modified according to the care-receivers' feeling, is designed to control the holding motion of two-cooperative-arm robot. In order to verify the effectiveness of the proposed method, simulation results are shown.

KEYNOTE SPEAKERS

Prof. Aihui WANG, Zhongyuan University of Technology, China

Professor Aihui Wang received the PhD degrees from Tokyo University of Agriculture and Technology in Japan, 2012. He then worked as a postdoc at Bournemouth University in UK between 2014 and 2015. He joined Zhongyuan University of Technology in 2004 as a lecturer, and was then promoted to an associate professor in December 2013, and to a Professor in December, 2021.

Title:

Control System Design of Lower Limb Rehabilitation Robot based on Human Gait Properties

Abstract:

Neurological diseases, limb injuries, and stroke in aging all lead to human lower limbs dysfunction, which seriously affects the quality of human life. Researches on rehabilitation medicine have shown that effective training can promote the recovery or reconstruction of moment function for patients with limb dysfunction. However, the existing robot adopting passive rehabilitation training method does not fit well with the normal movement of the lower limbs, and the manual training and treatment of rehabilitation physicians require a lot of social resources. Therefore, the research on exoskeleton rehabilitation training robots with "humans in the loop" is important to economy and society. The research from the human gait data of normal people based on the lower limb rehabilitation training robot, and obtained the joint angle and torque with the characteristics of human motion by combining with the biomechanical analysis and model construction of human motion, which were used as the reference input signal for the lower limb exoskeleton robot model. After that the controller was designed to realize the humanoid compliant control of the robot. By comparing with several existing human body models and exoskeleton robot control methods, this dissertation analyzes the advantages of the proposed method in robot trajectory following and man-machine fusion. The experiments showed that the humanoid modeling and control method of lower limb exoskeleton robot proposed in this paper were scientific and effective.

KEYNOTE SPEAKERS

Prof. Xudong GAO, Nanjing University of Information, Science and Technology China

Xudong Gao. He received his Ph.D Degree from Tokyo Agricultural and Industrial University in Japan. Now he is working at Nanjing University of Information, Science and Technology, Nanjing, China. He has been engaged in research of control system design for almost ten years, and he has published more than 20 papers in the fields of power electronics modeling and its intelligent control algorithms design. The published papers include 6 SCI magazine papers, 2 Japanese authoritative papers and several international conference papers as first author or corresponding author. He served as the Chairman of the Publicity Committee of the 11th International Conference on Advanced Mechatronic Systems ICAMechS 2021, Member of China Association of Automation, TPC member of 2023 International Conference on Cyber-physical Social Intelligence (ICCSI 2023), and Chairman of the sub-session of ICAMechS 2021.

Title:

Application of Population-based Metaheuristic Methods for Wireless Power Systems

Abstract:

Once the optimization task of specific applications is formulated, the optimal solution can be obtained by either a deterministic programming method (e.g., linear or quadratic programming) or a non-deterministic programming method, i.e., metaheuristic method. The deterministic programming methods need to calculate the gradient and Hessian matrices, which is challenging for most of the optimization tasks in power electronics due to the complexity. Metaheuristic methods serve as a general end-to-end tool that needs less expert experience and is efficient and scalable for various optimization tasks. The metaheuristic methods are generally developed with inspirations of biological evolution, e.g., genetic algorithm by process of natural selection, ant colony optimization algorithm (ACO), particle swarm optimization algorithm (PSO) by simulating biological population in finding an efficient path for foods. By implementing artificial intelligence (AI), power electronic systems are embedded with capabilities of self-awareness and self-adaptability, and therefore the system autonomy can be improved.

Ph.D student Ximei LI, Tokyo University of Agriculture and Technology, Japan

Title: Nonlinear Vibration Control for a Flexible Arm with Actuator Fault

Abstract:

This paper considers a nonlinear vibration control for a flexible arm with the actuator fault using an interactive Shape Memory Alloy (SMA) actuation. The robust stability and tracking performance of the nonlinear vibration control system are obtained by integrating an operator-based vibration controller and multiple feedback loops. Furthermore, the safety and reliability of the nonlinear vibration control system is discussed as an essential part of the control system. In detail, the operator-based vibration controller is to guarantee the robust stabilization for the vibration displacement of the flexible arm. The design of the evaluation construction is to eliminate the non-invertible part of the PI model from the interactive SMA actuator. The multiple feedback loops of operators are to obtain the desired tracking performance of the control system. Further research is conducted on the vibration control system to examine the fault tolerance of actuator faults. The effectiveness and reliability of the proposed nonlinear vibration control are verified by simulation cases under the normal and faulty conditions. In the first case study, the proposed vibration control scheme can quickly control the vibration of the flexible arm with low input power and within 3 seconds under normal conditions. In the second case study, even if the presence of an actuator fault, the proposed vibration control scheme still stabilized the vibration of the flexible arm within 5 seconds by increasing the input power. The results demonstrate that this approach has the ability to tolerate actuator faults.

Ph.D student Xuebin YUE, Ritsumeikan University, Japan

Title: An Ultra-Lightweight Object Detection Network for Empty-Dish Recycling Robots

Abstract:

Due to the workforce shortage caused by the declining birth rate and aging population, robotics is one of the solutions to replace humans and overcome this urgent problem. The emergence of empty-dish recycling robots has alleviated problems such as labor shortages caused by an aging population. The detection and grasp of dishes play a crucial role in empty-dish recycling robots. However, due to the limited resources of edge devices, traditional object detection models require more space to store parameters and higher computational overhead, limiting the development of empty-dish recycling robots. Therefore, we propose an ultra-lightweight dish detection model YOLO-GS for an empty-dish recycling robot. We use the modified CSPDarknet as the backbone structure and design an ultra-lightweight Neck structure for efficient feature fusion. Meanwhile, we design a lightweight Head structure for object classification and bounding box coordinate regression by combining Ghost Shuffle Convolution (GSConv2D) and anchor-free method. We design a dish grasp points extraction algorithm using image processing for the empty-dish recycling robot to grasp the dishes. Finally, TensorRT is used to perform floating-point 16-bit (FP16) quantization on the model, realizing efficient and intelligent detection of dishes on the NVIDIA Jetson Xavier NX. The experimental results show that YOLO-GS achieves 99.380% mean Average Precision (mAP) with a parameter amount of 0.606 M. The inference speed of the TensorRT-optimized YOLO-GS algorithm reaches 31.371 frames per second, which meets the needs of real-time dish detection by the empty-dish recycling robot. The grasp points of various dishes are effectively extracted through the proposed image processing method. The functions of empty-dish recycling are realized and lead to further development toward practical use.

Ph.D student Yifei GE, Ritsumeikan University, Japan

Title: A Novel Automatic Yolo Architecture Search Model

Abstract:

With the rapid development of AI technology, there are many advanced convolution neural networks. How to establish a private and effective Yolo becomes a complex subject. To reduce the complexity of the designing process and facilitate users to design a dedicated network, a novel automatic Yolo architecture search model is proposed. The system includes two modes: automatic training and manual training. In detail, the system enables users to select appropriate training methods to obtain the optimal Yolo model according to their needs. An automatic training service is provided for users. It means that the users only need to click the training button and the system automatically searches for the best Yolo model. Moreover, a manual training mode is presented which enables users to establish a special Yolo architecture with different necks and backbones. Meanwhile, some hyperparameters concerning the training phase could be customed for improving the training process. After training, different evaluation metrics are provided to reevaluate the training results, and then the optimal Yolo model is obtained. The effectiveness of the system is demonstrated by the experiments.

Ph.D student Zhuo LI, Ritsumeikan University, Japan

Title: Deep Learning-based Unsupervised Anomaly Detection in Industry

Abstract:

Currently, deep learning-based anomaly detection has been successful. However, anomaly detection in industry usually presents problems of scarcity of defect samples, annotation costs and lack of prior knowledge of defect. Unsupervised anomaly detection, an important component of anomaly detection, addresses these problems by training only normal samples. Hence, this paper proposes a novel unsupervised anomaly detection architecture, relational knowledge distillation anomaly detection (RKD-AD). RKD-AD contains a teacher model and a student model. The architecture is different between the student model and the teacher model. By learning the architecture information of the teacher model, the student model is better to extract the features. To make better utilization of teachers' knowledge, multiple intermediate features are used in the process of knowledge distillation. Meanwhile, considering intermediate features gives more significant differences compared to using only the last layer of activation values. RKD-AD detects and locates anomalies by the difference between the intermediate activation values of the teacher model and the student model under the input data.

Ph.D student Hengyi LI, Ritsumeikan University, Japan

Title: Enhanced Mechanisms of Pooling and Channel Attention

Abstract:

In nature, optimizing DNNs at the software level is to improve the efficiency of the feature maps filtered by the neural network. In view of this, we make proposals to enhance the representation capability of feature maps. The pooling-function features can be summed up as following two points: First, the feature invariant of the function. By representing the feature maps as approximately small-size invariant, the pooling operation samples the inputs by making the representation of the feature maps approximately invariant to small size with the summary statistic of nearby features. As previous research indicates, for features, invariance to local translation can be a useful property when it is more crucial for whether they are rather than exactly where they are. Second, the down-sample function reduces the redundant information with key features remaining. As a result, the complexity of the network, the floating-point operations (FLOPs), and the memory consumption are reduced. Further, the effect of the over-fitting problem is alleviated and the generalization ability of the network is improved. As a result, pooling has been a vital function for CNNs. However, regardless of the benefits of the pooling, the down-sampling of the function results in information loss more or less inevitably. Based on the max pooling and average pooling, we propose an improved pooling mechanism FMAPooling pooling and a novel channel-attention method FMAttn. Furthermore, the proposals could be easily integrated into various DNN architectures by adding directly or replacing certain structures of DNNs.

Master student Jiale REN, Zhongyuan University of Technology, Japan

Title: Controller Design of Rehabilitation Robot and Gait Prediction based on Human Movement Data

Abstract:

Lower limb dysfunction is a common sequela of nervous system diseases and lower limb injuries, which brings severe inconvenience to patients' life. Systematic rehabilitation training is proved to be effective in recovering patients' motion function. The lower limb rehabilitation robot, as the product of robot technology and medical theory, is a practical aid in rehabilitation medicine. The application of the rehabilitation robot not only improves patients' rehabilitation effect but also relieves medical resources stress.

Nevertheless, although researchers have come a long way in the field of the robot, it is still an intractable issue to enable the lower limb rehabilitation robot to move as human. Focus on this challenge, the research proposes two control methods based on model predictive control (MPC) and extended state observer (ESO). MPC is adopted with the cost function designed to simulate the way people walk. And ESO is applied for enhancing the anti-interference capability to the uncertainty of modeling and external disturbance. Human gait data is utilized as the controller's reference trajectory. The simulation results in MATLAB demonstrate the quick response, high precision, and strong robustness of the proposals.

Furthermore, to improve the human-robot cooperation ability of lower limb rehabilitation exoskeleton robots and the wearing experience of patients, a gait prediction model to predict the gait trajectory of the wearer is proposed. The gait trajectory prediction model is constructed based on convolutional neural network (CNN), long short-term memory network (LSTM), and attention mechanism. In detail, the spatial coordinates of each lower limb joint are used as the input vector, and the outputs are the angles of hip and knee joints which are also used as the feedback input vectors. Experimental results show that the model achieves excellent performance on predicting the movements of human lower limbs. The model has theoretical significance for improving the motion control and operation performance of exoskeleton robots.

Master student Xin WANG, Zhongyuan University of Technology, Japan

Title: Wrist-worn Sensor-based Human Activity Recognition by Deep Learning

With the development of artificial intelligence (AI), wearable sensor-based human activity recognition (WSHAR) has been widely used in many human-centered fields. Recently, new challenges are presented to WSHAR, namely better wearing comfort and higher recognition accuracy, etc. Wrist-worn sensor-based HAR systems are sought after for their convenience and comfort. However, sensor displacement and local information limitation restrict the performance of wrist-worn sensor-based HAR systems in real use. This paper proposes a multi-view features extraction model (MVFE) for wrist activity multi-dimensional data. MVFE consists of three components: spatial attention block, self-attention block and temporal attention block, which extract spatial features, inter-sample features and temporal features from the raw data, respectively. In addition, we pre-train the model using the HAR public datasets (PAMAP2, MHEALTH, etc.) and thus transfer to the wrist data for further training to improve the HAR performance with sensor displacement. Experimental results show that MVFE enables to learn more valuable information from wrist data than the baseline LSTM model, thereby enhancing HAR performance. And the transfer learning-based approach is effectively lower the negative effect of sensor displacement on wrist-worn sensor-based HAR systems. In the feature work, graph neural networks will be considered to extract correlations between sensor channels to further extract deeper features of wrist activity data.

Master student Zhenlin SU, Zhongyuan University of Technology, Japan

Title: Development of a Buried Neurostimulator for Free-moving Animals

Bionic robots that mimic the structure, movement, and behavior of animals in nature have significant potential applications in emergency operations, but robots are still far behind animals in terms of smoothness of movement, flexibility, environmental adaptation, and energy utilization in unstructured environments. Due to advances in neuroscience and brain-computer interface (BCI) technology, many studies have been conducted on controlling animal behavior by connecting the nervous system to electronic devices.

Although attempts have been made to control animal movement wirelessly, most of the current neurostimulators are placed outside the body in a backpack or head insert, which has many inconveniences when used in practice, such as: (1) there is still a transcutaneous connection between the implanted neural interface and the stimulator, which increases the risk of infection at the wound site; (2) the size and weight of the external stimulators are relatively bulky and can interfere with the animals' natural activities and habits; and(3) the animals incur a higher risk of secondary injury due to mechanical stress on the exposed device. To minimize the risk of discomfort and infection in animals while ensuring long-term sustainability, fully implantable devices need to be designed.

For free-moving animals, we have developed a buried neurostimulator that not only generates biphasic current pulses with adjustable parameters through control signals, but also optimizes the material, size, weight, and implantation method of the stimulator, as follows: (1) the neurostimulator uses a flexible printed circuit boards board, which is lighter in weight and can be folded into a shape that is more suitable for subcutaneous implantation. This reduces the "effective" size of the device, which makes surgical implantation easier; (2) the buried neurostimulator overcomes the disadvantages of traditional neurostimulators, such as easy infection and poor concealment; (3) the neurostimulator adopts a modular design, and the components are selected in the smallest package, which not only ensures the electrical effect of the stimulator but also meets its miniaturization design criteria. Finally, we designed experiments to test the performance of the stimulator. The results of the in vitro and ex vivo experiments show that the stimulator not only has excellent stimulation performance, but also has good biocompatibility and stable long-term working performance after being buried in the animal. This not only has positive implications for the practicality of animal robots, but also has some reference value for deep brain stimulation in neurological diseases such as epilepsy.