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Seven Papers from Mitsubishi Electric's Researchers Accepted at IROS2024

Recognized for the companies' research results at the top conference in the fields of AI and robotics

TOKYO, October 3, 2024 – Mitsubishi Electric Corporation (TOKYO:6503) announced today that seven papers submitted by researchers at its Information Technology R&D Center (Kamakura City, Kanagawa Prefecture) and Mitsubishi Electric Research Laboratories, Inc. (MERL), a subsidiary located in the United States (Cambridge, Massachusetts), have been accepted at IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 2024.

IROS is a leading conference in the fields of AI and robotics, and one of the largest international conferences in the world in the field of robotics. It is cosponsored by the Institute of Electrical and Electronics Engineers (IEEE) and The Robotics Society of Japan (RSJ). In 2024, 47% of papers were accepted out of more than 3,300 submissions. Details of the accepted papers are below, they will be presented during the conference in Abu Dhabi from October 14 to 18. Mitsubishi Electric will continue to work on research and development of cutting-edge technologies with the aim of contributing to a sustainable future.

List of Accepted Papers

-Title
Autonomous Robotic Assembly: From Part Singulation to Precise Assembly
-Authors
Kei Ota (Mitsubishi Electric), Devesh K Jha (MERL), Siddarth Jain (MERL), William Yerazunis (MERL), Radu Corcodel (MERL), Yash Shukla (Tufts University), Antonia Bronars (MIT), Diego Romeres (MERL)
-Abstract
In the current factory setup, automation is achieved by ensuring that any part is sent to a designated position, and then the system integrator generates robot movements to connect these points. This results in high costs each time new parts or products are handled. This study proposes a method that combines force sensors, tactile sensors, and vision sensors to automatically assemble gearbox components (two gears and two shaft) placed in arbitrary positions.

-Title

Domain Randomization-free Sim-to-Real : An Attention-Augmented Memory Approach for Robotic Tasks

-Authors

Jia Qu (Mitsubishi Electric), Shun Otsubo (Mitsubishi Electric), Tomoya Yamanokuchi (NAIST), Takamitsu Matsubara (NAIST), Shotaro Miwa (Mitsubishi Electric)

-Abstract

Adapting models trained in simulation to the real world (sim-to-real) has been a long-standing challenge in the field of robotics. Traditional approaches like domain randomization[1] have shown promise by augmenting the diversity of simulations. However, they suffer from the need for extensive training and dependency on heuristic approaches.[2] To address this, we propose a novel robot learning architecture that learns robust feature representations effective in both simulation and the real world, without the need for domain randomization. Our proposed method minimizes learning costs in simulation while acquiring semantic task-related features that are robust to environmental changes, demonstrating the ability to be deployed directly into the real world in a domain randomization free manner.

-Title

DECAF: a Discrete-Event based Collaborative Human-Robot Framework for Furniture Assembly

-Authors

Giulio Giacomuzzo (Università di Padova), Matteo Terreran (Università di Padova), Siddarth Jain (MERL), Diego Romeres (MERL)

-Abstract

This paper proposes a task planning framework for collaborative Human-Robot scenarios, focusing on furniture assembly. It treats humans as unpredictable agents, while the robot's planner computes optimal actions reactively. The problem is modeled as a Discrete Event Markov Decision Problem (DE-MDP)[3] and solved using Reinforcement Learning to derive the robot's optimal policy. Experiments were conducted in both simulations and real-world human-robot assembly tasks.

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[1] In artificial intelligence training, a method of randomly changing the parameters of the training environment so that the AI can respond to various real-world situations.

[2] Use empirical methods and rules to quickly find approximate solutions when it is difficult or time-consuming to find a complete solution when solving a problem or making a decision.

[3] It is a problem for optimal control of systems in which states transition discretely and stochastically, and is widely used as part of reinforcement learning.

-Title

InsertOne: One-Shot Robust Visual-Force Servoing for Novel Object Insertion with 6-DoF Tracking

-Authors

Haonan Chang (Rutgers University), Abdeslam Boularias (Rutgers University), Siddarth Jain (MERL)

-Abstract

This paper introduces a one-shot method for high-precision robotic assembly, allowing robots to perform insertions from random orientations using a single demonstration image. Combining visual tracking and impedance control,[4] it enables real-time feedback without pre-training. The method is resilient to calibration errors and disturbances in the object in-hand pose, validated through extensive real-world experiments across various high-precision assembly tasks.

-Title

Open Human-Robot Collaborations using Decentralized Inverse Reinforcement Learning

-Authors

Prasanth Sengadu Suresh (University of Georgia), Siddarth Jain (MERL), Prashant Doshi (University of Georgia), Diego Romeres (MERL)

-Abstract

This paper introduces a novel multiagent framework for open Human-Robot Collaboration (HRC), allowing agents to join and exit tasks flexibly. It addresses limitations of closed systems where all agents are present for the entire task duration by enabling concurrent human tasks. The proposed framework generalizes a recent multiagent inverse reinforcement learning method for open systems,[5] showing improved performance over closed systems in both a toy firefighting domain and a realistic human-robot assembly.

-Title

Few-shot Transparent Instance Segmentation for Bin Picking

-Authors

Anoop Cherian (MERL), Siddarth Jain (MERL), Tim K. Marks (MERL)

-Abstract

This paper introduces a data-efficient method for segmenting transparent objects in robotic bin picking using Mask-RCNN. Key innovations include a novel method for generating training images and a scoring method for consistency between predicted segments and ideal templates. Experiments on a new few-shot dataset show that the proposed method improves Mask-RCNN performance[6] by over 14% in mean intersection-over-union accuracy with minimal annotated samples.

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[4] It is a control method in robotics that regulates the relationship between the robot's movement and external forces, allowing the robot to move flexibly in response to external forces.

[5] A system in which there are multiple agents, such as humans and robots, that recognize the situation around them and make decisions and act independently based on the recognized situation.

[6] Metrics to evaluate the performance of image segmentation (the task of dividing an image into multiple parts or segments).

-Title

Disentangled Acoustic Fields for Multimodal Physical Scene Understanding

-Authors

Jie Yin (Shanghai Jiao Tong University), Andrew Luo (Carnegie Mellon University), Yilun Du (MIT), Anoop Cherian (MERL), Tim K. Marks (MERL), Jonathan Le Roux (MERL), Chuang Gan (MIT-IBM AI Lab and UMass Amherst)

-Abstract

This paper addresses multimodal[7] physical scene understanding, where an agent locates fallen objects by inferring properties from impact sounds. It introduces a disentangled acoustic field (DAF) model to capture sound generation and propagation, enabling the agent to create a spatial uncertainty map.[8] This map improves object localization success by suggesting multiple exploration locations. The analysis-by-synthesis framework enhances sound property inference by decomposing and factorizing the model's latent space.

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About Mitsubishi Electric Corporation
With more than 100 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Mitsubishi Electric enriches society with technology in the spirit of its "Changes for the Better." The company recorded a revenue of 5,257.9 billion yen (U.S.$ 34.8 billion*) in the fiscal year ended March 31, 2024. For more information, please visit www.MitsubishiElectric.com
*U.S. dollar amounts are translated from yen at the rate of ¥151=U.S.$1, the approximate rate on the Tokyo
  Foreign Exchange Market on March 31, 2024

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[7] Information from several different types of data or sources (e.g., visual, auditory, tactile, text, etc.).
[8] A two-dimensional map that provides a visual representation of uncertainty about the outcome of a prediction or estimation. Here, the error between the position of the sound source predicted by the simulation and the actual position of the input sound is expressed in color and intensity as an indicator of uncertainty.