Intro duction to the Mobile Robotics Lab (OTA Lab) 2024

Research into Artifacts, Center for Engineering (RACE),
School of Engineering,
The University of Tokyo

Hongo Campus,
7-3-1, Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

URL: http://otalab.race.t.u-tokyo.ac.jp

Members

Professor	Jun Ota
Posdoc Researcher	Kohei Kaminishi, Ryota Takamido, Tetsuya Hasegawa
DC Students	Fan Zeng, Yuichiro Omura, Shigeki Tanaka, Jiaxi Lu, Xiaotian Zhang, Jianqiang Chen, Kei Hoshino
MC Students	Johann Darboven, Xiyu Hou, Sho Okazaki, Keita Kamiya, Kenta Hayakawa, Moichi Ishikawa, Ritsuki Nishizawa, Souta Kawawaki, Yuta Totoki, Gong Jingze, Sihyeon Song
Undergraduate Students	Hokuto Akasaka, Masao Kihara, Jun Hashimoto
Special Audit Student	Jessica Ye
Sectary	Ayako Nakamura, Mika Yagi

Research Topics (OTA Lab)

We have been studying multiple mobile robot systems since 1989. We consider intelligent systems as consisting of three factors: (a) multiple robots or intelligent machines (multiple agents), (b) human-beings who operate or cooperate with multiple agents, and (c) working environments. Now we deal with “design of robotics system”, “design of large-scale production/transport systems”, and “human analysis, service, and hyper-adaptability science” based on motion planning methodology, evolutionary computation, control theory, and so on. Our final target is to establish design methodology of multi-agent systems including artificial agents, humans and working environments through clarifying the underlying structure and function in the intelligence and mobility (mobiligence) of these agents.

Current Research Topics

Multi-agent system and robot system design

- Fast motion planning algorithm considering the dynamic characteristics of swarm AGVs
- Proposal of a general-purpose algorithm of split delivery vehicle routing problems for multiple agricultural machines
- Robot system arrangement using experience-based hierarchical optimization methods
- Measurement pose optimization for joint offset calibration with a hand-eye camera
- Stepwise large-scale multi-agent task planning using neighborhood search

Human support robot system, human demonstration-based robot system, and manufacturing system design

- Learning difficult robot motion from human demonstration collected via a single RGB camera
- Automatic action recognition algorithm for industrial manual workers with human skeleton and object information
- Development of a nursing skill training system based on manipulator variable admittance control
- Learning from human hand demonstration for wire harness grasping
- Development of virtual reality system for identification of specific expert skills in refinery inspection task with explainable AI
- Description method and failure ontology for utilizing maintenance logs with FMEA in failure cause inference of manufacturing systems
- A framework to support failure cause identification in manufacturing systems through generalization of past FMEAs

Human analysis and embodied-brain system science

- Modeling standing postural control in Parkinson's Disease patients
- Estimation of foot center of pressure information using smartphone sensors

The acceleration of search in motion planning considering the dynamic characteristics of swarm AGVs

This study addresses the challenge of efficiently planning conflict-free paths for Automated Guided Vehicles (AGVs) in automated production and logistics environments, a task known as the Multi-Agent Path Finding (MAPF) problem. The conventional method [1], based on Conflict-based Search (CBS) [2], has been effective but struggles with long computation times, especially as the number of AGVs increases or in constrained spaces. To overcome these limitations, the study proposes integrating greedy search techniques and machine learning into the CBS framework, aiming for faster computation without sacrificing planning quality. Specifically, it replaces A* search with either a weighted version or a machine learning-enhanced version and substitutes best-first search with beam search. A novel machine learning model (Fig.1 left) predicts heuristic values for path planning, trained on simulation data from AGV operations. This approach demonstrated a reduction in computation time and the number of top expanded nodes, maintaining high-quality motion planning. Fig. 1 shows a comparison of the proposed method against traditional approaches, highlighting the efficiency gains and effectiveness of incorporating machine learning into AGV path planning within complex logistical settings. These improvements highlight the potential of machine learning to enhance the efficiency and effectiveness of AGV path planning in complex logistical settings.

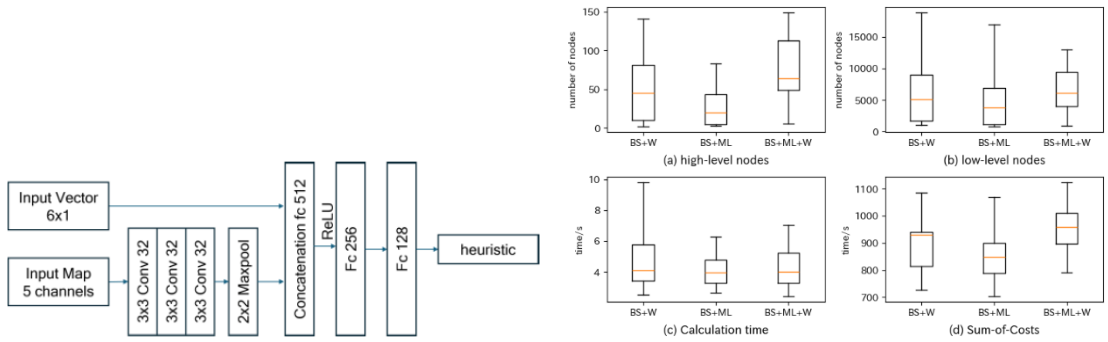

Fig. 1 Left: Proposed Model, Right: Simulation Results (BS: Beam Search, ML: Machine Learning, W: Weighted A* Search)

Keywords: Automated Guided Vehicle, Motion Planning, Multi-Agent Path Finding

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Proposal of a General-purpose Algorithm of Split Delivery Vehicle Routing Problems for Multiple Agricultural Machines

In recent years, there has been growing attention towards smart agriculture to enhance the efficiency of agriculture[1]. Farmers utilize multiple agricultural machines to work on several fields. In this process, it is necessary to decide (a) the assignment of tasks to agricultural machines for each field, and (b) the touring route of each agricultural machine for the fields they are responsible for.

Although various methods have been proposed in previous studies to address this problem, it is not clear which method is appropriate when conditions are specified according to the individual situation of a farm, leading to a lack of versatility in the dispatch system. Furthermore, in each method, hyperparameters (parameters set from outside that affect the algorithm's operation or performance) are empirically given, making it difficult to say that the full potential of each method has been utilized. For these reasons, the development of a versatile task allocation system has not been achieved. Therefore, this study aimed to develop a general-purpose task allocation system for agriculture.

In order to reach this objective, we developed a versatile task allocation system and verified its effectiveness. The results of the simulation are shown in Table 1. It was demonstrated that the simulated annealing method performs well for small agricultural field scales, while local search methods are superior for large scales with short calculation times, and the values of hyperparameters suitable for the scale of the agricultural field were derived. Going forward, further experiments will be conducted targeting more agricultural field conditions and metaheuristics to further develop a versatile agricultural task allocation system, including the extraction of features necessary for selecting the appropriate algorithm.

Table 1. Best optimization methods and hyperparameter combinations according to farmland size and maximum calculation time

Farmland size	Max calculation time (sec) 1	10	100	1000
large	Local search	Local search	Local search	SA (Initial temperature, Cooling rate) =(25, 0.999)
medium	ACO (Evaporation rate, Initial pheromone, Secreted pheromone) =(0.9, 10, 0.1) etc.	SA (Initial temperature, Cooling rate) =(25, 0.99999)	SA (Initial temperature, Cooling rate) =(25, 0.9999)	SA (Initial temperature, Cooling rate) =(25, 0.999)
small	SA (Initial temperature, Cooling rate) =(25, 0.999)	SA (Initial temperature, Cooling rate) =(50, 0.9999)	SA (Initial temperature, Cooling rate) =(25, 0.99999)	SA (Initial temperature, Cooling rate) =(25, 0.999)

Keywords: Smart agricalture, Multi-agent system, Split delivery vehicle routing problem, metaheuristic

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Robot System Arrangement Using Experience-based Hierarchical Optimization Methods

Industrial robots perform various tasks such as welding, assembling, spraying, and transportation in practical industrial environment. Although the motion planning or motion planning of the industrial robots are mostly focused on to improve the working efficiency, it is also highly influenced by the arrangement of the robot environment components, such as the base, conveyors, sensors, objects, and robots, during the execution of these tasks. Moreover, if the environment of a robotic system changes, the robot's motion must also change, even if it performs the same task, leading to significant changes in its tact time or energy efficiency. Therefore, the location and arrangement of the robotic environment significantly impact industry efficiency, and to enhance the productivity of a robotic system, it is crucial to have a proper setup of the robot system environment, along with planning effective robot movements.

However, most of conventional studies focused on the motion planning or path planning among those two aspects, hence, there is few studies which developed the algorithm to identify both optimal motion and environment arrangements. Therefore, this study proposed the new optimization methods for industrial robotic system which can facilitate both robot motion and environment arrangements' optimization. Specifically, to address the difficulty of combined optimization problem of motion planning and environment arrangement, we used hierarchical algorithm [1] and experience-based method [2-3]. The former is to decompose the complicated problem into more simple ones to reduce the calculation cost, and the latter is to reuse the past solutions in similar optimization problem to find optimal solution faster, and we introduced two experience-based method for both motion planning and environment arrangement part.

To verify the effectiveness of the proposed method, we conducted the simulation experiment with a pick and place robotic system (Figure 1). In the experiment, the optimal robot motion from pick position to the place position, and positions of conveyors are calculated and compared with conventional techniques. Figure 2 shows the results of the experiment. As shown in Figure 2, we can solve combined optimization problem faster than conventional methods though our proposed method (left plot in Figure 2). Based on the results of this study, we will add further improvements on the proposed method.

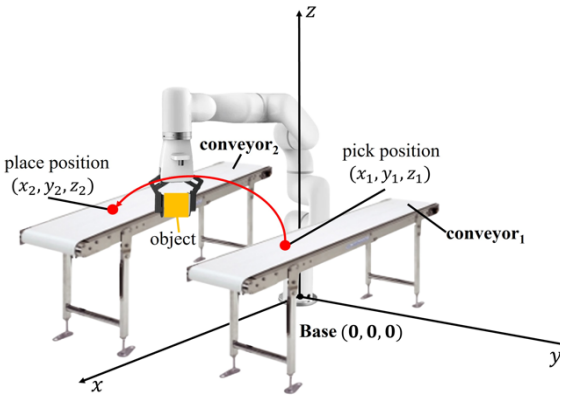

Figure 1. Schematic image of the typical pick and place robotic system.

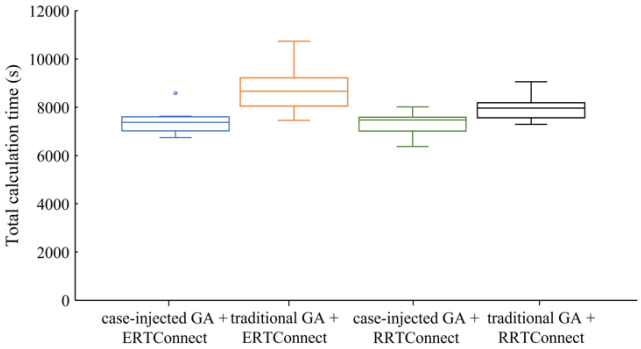

Figure 2. Boxplot of path length of four combinations of method.

Keywords: Robot motion planning, Environment arrangement, Experience-based optimization

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Measurement Pose Optimization for Joint Offset Calibration with a Hand-Eye Camera

Accuracy of the robot motion manipulation is critical aspects for industrial manufacturing, since industrial robot arm owes various delicate works, such as assembling and welding. Hence, calibration of the robotic arm is very important processes for the practical industrial situations. In this regard, robotic manipulators' motion accuracy can be affected by several factors, such as manufacturing tolerance, set-up errors, and wear and tear. While online teaching can ensure that manipulators coincide with the desired and actual motions, it can be a lengthy and resource-intensive procedure. Offline teaching with robot calibration can reduce the cost of online teaching, but joint offset calibration is essential for accurate motion. Several methods for calibration have been proposed, including using specialized equipment to constrain the end-effector or tracking a laser pointer. However, joint angle offsets can account for up to 90% of the RMS value of the error, and joint offsets often change with daily use, making calibration an ongoing challenge.

To address this challenge, researchers have proposed using a single camera and a marker on the ground for calibration. However, the accuracy of pose estimation using this method is lower than laser tracking because of physical constraints. Therefore, in this study, we propose a new method for determining optimal measurement poses using a hand-eye camera and a marker. Based on the previous observability index O1[1], we proposed a new index Ov1 to evaluate the effect of the error in the pose estimation based on the camera images on the offset calibration. The offset calibration with the marker measurement at the poses, which obtained the optimization to maximize the proposed index, realized higher accuracy than other approaches. Figure 1 and 2 shows the comparison of the optimized pose for calibration by the hand-eye camera. As shown in these figures, the calculated poses from our proposed method are different from the one calculated from the method of previous study. Based on the results of this study, we will add further improvement into the proposed method to achieve higher precision which can be applicable in the practical situations.

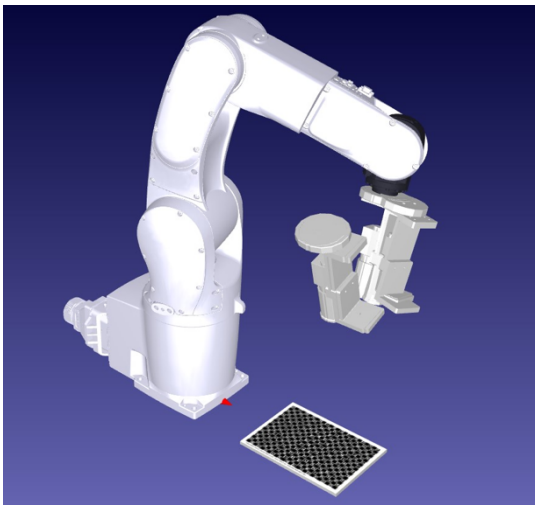

Figure 1. Optimized poses by the method of previous study [1].

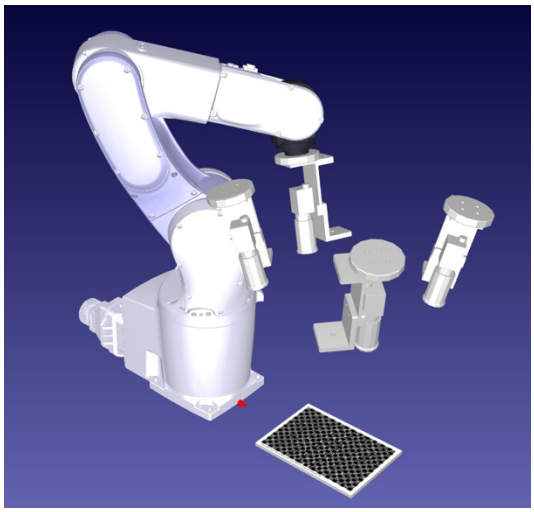

Figure 2. Optimized poses by our proposed method.

Keywords: Calibration, Measurement pose optimization, Hand-eye camera

References

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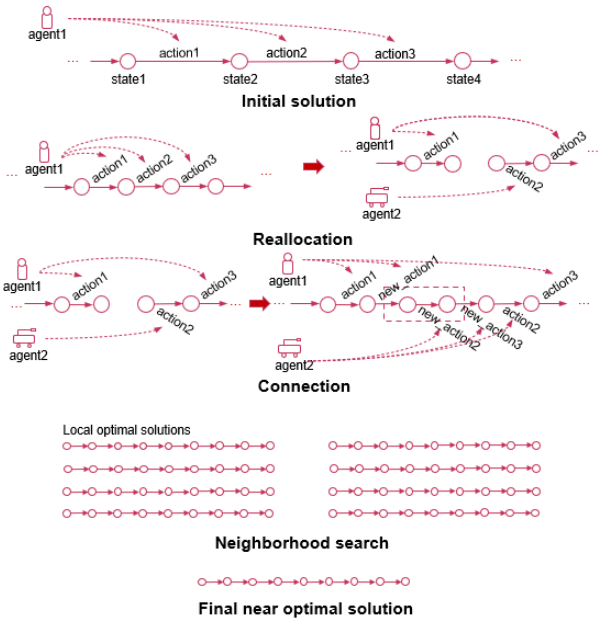
Stepwise Large-Scale Multi-Agent Task Planning Using Neighborhood Search

Multi-agent task planning aims to obtain a solution that can achieve goals using a group of agents by maximizing the overall performance of a system. This is a fundamental problem common in various fields, including robotics, transportation, logistics, and manufacturing. In terms of domain description, the STRIPS-style language [1] is often utilized because it allows the world to be described using predicates, which are statements that can be either true or false. Although this language facilitates scaling up to solve highly complex problems by adding more states and actions, the search space for finding solutions grows exponentially with the number of predicates. Bylander [2] reported that such planning problems are PSPACE-complete and more difficult to solve compared to the NP-complete problems. We present a stepwise method for solving multi-agent task planning problems in large-scale STRIPS-style problems described by the Planning Domain Definition Language (PDDL) [3] within a realistic time frame. While existing planners [4, 5] can promptly solve problems containing only a small number of agents, addressing large-scale problems efficiently remains a challenge. Our method solves this problem by initially achieving the goals of the given problem using a minimum number of agents and then iteratively refines the solution through reordering and partially reallocating actions to other agents. During the local refining process, the reordering and reallocating may disrupt the original logical connections between adjacent actions, so our proposed method reconnects them by searching for optimal connections using a plangraph. The time complexity of obtaining a new solution using the connection of adjacent actions is linearly related to the length of the solution, which reduces the complexity to a polynomial level. The pursuit of realizing an optimal solution is abandoned since developing scalable and quick algorithms to realize optimality is not plausible. The refining process adopts a neighborhood search approach, treating reallocated and reordered solutions as neighbors. Additionally, tabu search is employed to iteratively escape the local optimal solution and ultimately obtain a near-optimal solution.



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Learning difficult robot motion from human demonstration collected via a single RGB camera

Demonstration-based learning has achieved great success in the area of robot motion planning. In this process, a human demonstrator shows ideal motions in the target task using some demonstration techniques, such as kinesthetic teaching, in which human operators directly contact and move the robot end-effector [1], or teleoperation, in which human operators indirectly move the robot through the controller and some other devices [2].

In this study, we propose a new demonstration-based motion planning method that can facilitate difficult motion planning problems in cluttered environments by using only human motion data collected via a single RGB camera as demonstration data [3]. Since existing methodologies in this research area require expertise in robot systems or robot motion planning, using such a simple measurement system (a single RGB camera) to facilitate robot motion planning is worthwhile from the viewpoint of the practical application.

Figure 1 shows an overview of the proposed method. As shown in Figure 1, the human demonstrator first shows the ideal motion in the target task in front of the RGB camera, and the motion is recorded as image data (Figure 1(a)). Then, the three-dimensional human skeleton information is extracted from the recorded image using skeleton recognition software, which serves as the demonstration data for robot motion planning. The extracted skeleton data is converted to the robot motion through the optimization process and saved as the motion template (Figure 1(b)-(e)), and then used as the demonstration data for solving difficult motion planning problems as shown in Figure 1(f). The point of this approach is that the extracted human skeleton data includes a large amount of noise, which decreases the reliability of the demonstration data. Hence, it cannot be directly used as the "strict solution" of the robot motion planning problem. To address this issue, we specifically introduce the path modification and adaptation process to fit the primitive robot motion generated from unreliable human demonstration data to the new environment. The results of simulation experiments showed that our proposed method can solve difficult motion planning problems significantly faster and with a higher success rate than the state-of-the-art motion planner.

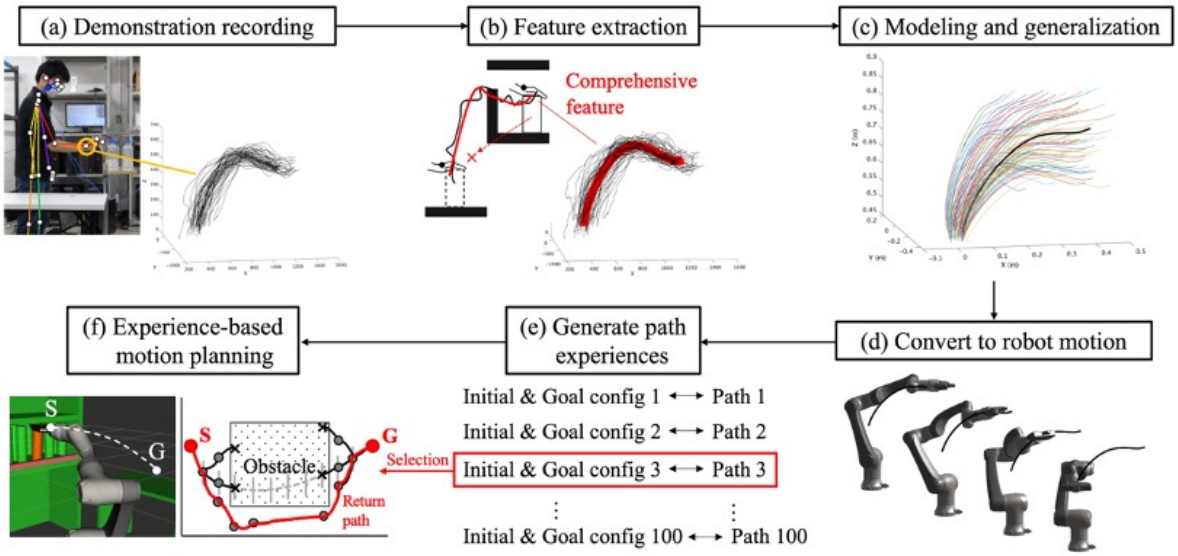

Figure 1. Overview of the proposed method. (a) Recording human motions and skeleton extraction, (b) Feature extraction from noisy human motion data, (c) Modeling extracted features, (d) Convert to robot motion, (e) Motion database development, (f) Motion planning based on the developed database./

Keywords: Learning from Demonstration (LfD), Motion Planning, Skeleton Recognition

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Automatic action recognition algorithm for industrial manual workers with human skeleton and object information

Time and motion studies, which involve dividing a worker's actions into several micro-actions, are a fundamental analytical technique in industrial engineering (IE). Through this analysis, we can identify redundant parts of the worker's actions and make improvements based on it [1]. However, the problem with this approach is that it takes a large amount of time since it is usually performed by human analysts by hand. Therefore, to address this problem, we developed an automatic action recognition algorithm for industrial manual workers.

Although there are a huge number of studies that have tried to develop human action recognition algorithms [2], there are a relatively small number of studies that have dealt with human action in industrial situations. This is because, in the context of industrial manual workers, object and human-object interaction information must also be considered to recognize the worker's action. For example, although the action of reaching for an object and transporting an object are similar in terms of human kinematics, we can clearly discriminate between them in terms of the interaction of the objects. Therefore, to address these issues, we developed a specific algorithm which can deal with the human object interaction information.

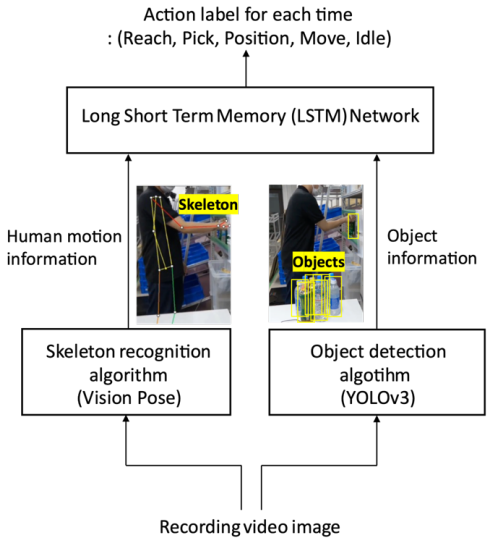

Figure 1. Overview of the proposed algorithm.

Figure 1 shows the overview of the proposed algorithm's architecture. The input of the network is the image data of the human motion in the target task. This data is sent to both the skeleton recognition algorithm and object detection algorithm, and we get both human skeleton and object position (bounding box) information. Then, each data is input to the LSTM network, a type of machine learning technique for processing time series data, and the algorithm finally obtains an action label for each time sequence. Hence, by processing human motion information and object information, we can consider the interaction between the human and the objects.

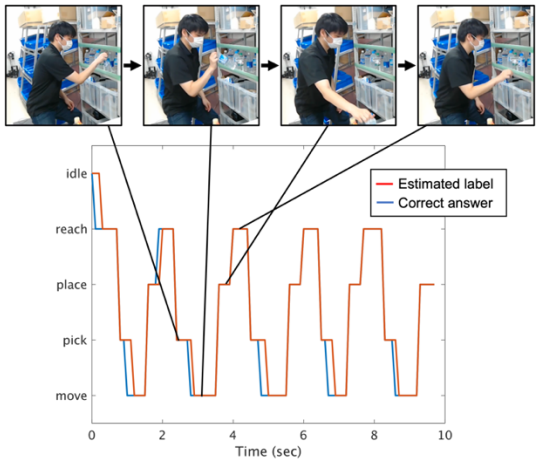

Figure 2. Results of the experiment.

To verify the effectiveness of the proposed algorithm, we conducted an experiment. In the experiment, a participant performed a picking and placing task by moving target objects from a shelf to a desk, or vice versa. The motions of the participant were recorded by a RGB video camera. Figure 2 shows the results of the experiment. As shown in Figure 2, we can describe the participant's action well at each time sequence and it bring us some insights to improve the process. From Figure 2, we can identify motions that can be performed relatively quickly (good action) and those that take relatively longer (redundant action). The mean accuracy of recognition for this experimental task is around 90%. Since we only verified the performance of the proposed recognition algorithm in an experimental environment, we plan to verify it in more practical situations in the future.

Keywords: Action Recognition, Object Detection, Industrial Engineering, Time and Motion Study.

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Development of a Nursing Skill Training System Based on Manipulator Variable Admittance Control

Due to the recent aging society and shortage of nursing experts, the use of robot-based skill training systems is an emerging topic in nursing education, as many innovative robotic systems have been developed to simulate real patients, offering a safe and self-directed platform for nursing students to learn and practice their skills. Among these training systems, several human patient simulators (HPS) [1-3] have been proposed to simulate the patient's performance during patient transfer; however, without an entire motion model and control strategy, most HPS show limited effectiveness in simulating actual patient behavior.

Herein, this work presents a novel patient transfer training system that has the potential of improving the practical skills of nursing students [4]. The reason we set the patient transfer skill as the target of our system is that it is one of the highest risk motions which causes both patient and nurse's injury among many nursing skills, hence improving the novice's skill of patient transfer contributes to reduce the injury in the practical situation. The procedure of development our training system is as follows. First, we propose a simplified force model for patient transfer motion to estimate the contact force in the absence of wearable sensors (Figure 1). We then reveal the correlation between the nurse's force and patient's motion during the transfer through the utilization of the variable admittance model. Finally, we demonstrate the feasibility of the proposed patient transfer training system by performing several experiments on a UR10e robot. To the best of our knowledge, this system is the first patient transfer skills training system that simulates force interaction between nurse and patient using a collaborative robot.

Figure 2 shows the example of the training of the patient transfer motion with proposed training system. As shown in Figure 2, the patient can train and learn the transfer motion through the system. We anticipate that our proposed system will be an effective aid for student nurses to learn patient transfer skills. We believe that this innovative approach can make a contribution to the field of nursing education, addressing the current challenges of inadequate resources for nursing education.

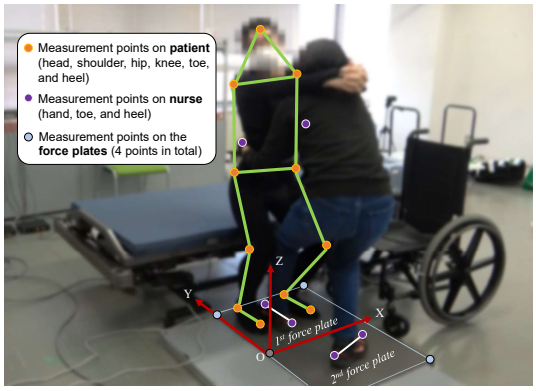

Figure 1. Modeling interaction between the patient and nurse.

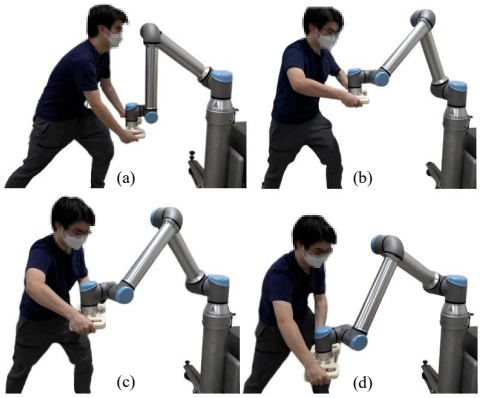

Figure 2. Example of the training with proposed system.

Keywords: Robot patient, Modeling of human motion, Nursing education

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Learning from Human Hand Demonstration for Wire Harness Grasping

In recent years, the automation of bin picking in factory has made significant strides. The automation of rigid objects, such as metal components, has been successfully implemented by leveraging 3D data [1]. However, for deformable objects like wire harnesses, where the object's pose is uncertain, practical implementation is challenging. In most cases, manual intervention remains predominant.

To overcome this problem, we propose a system wherein human operators teach a robot wire harness grasping actions through hand demonstrations. The process involves capturing human grasping of the wire harness and instructing the robot based on RGB-D images to learn the human grasped location and grasping posture. We notice that human tends to grasp specific regions with characteristic structures of wire harnesses. In order to learn such information, we propose a method to build a dataset for neural network training with few shot images. We form the problem as instance segmentation and augmentation of the training dataset is achieved by overlaying wire harness images onto various backgrounds.

Next, the obtained point cloud of grasping locations is aligned with the point cloud from the demonstration instances through point cloud registration. Using such information, the robot transfers the wire harness grasping pose during the demonstration to the current scenes.

We evaluated the accuracy of grasping location segmentation and the success rate of wire harness grasping in real experiments. Future work may include testing different types of wire harnesses, increasing the number of wire harnesses in the box, and dealing with targets near the corner.

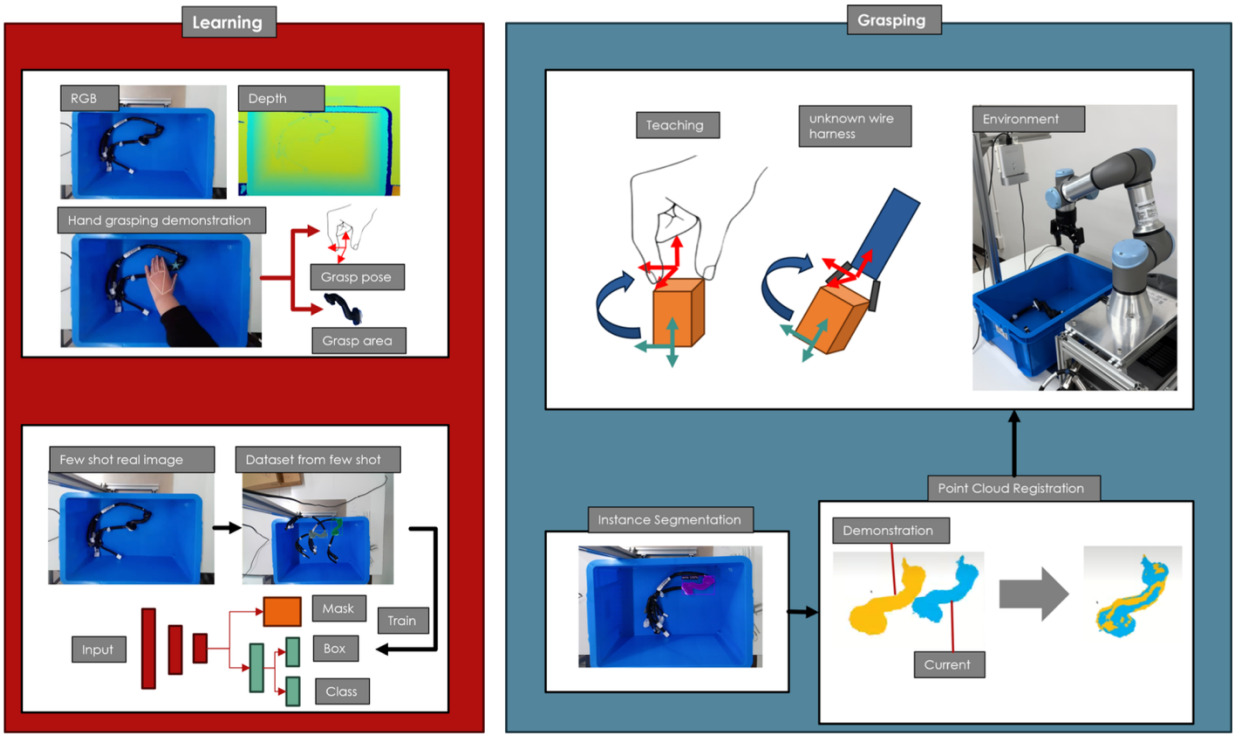

Fig 1. Overview

Keywords: Grasping, Learn from demonstration, Wire harness detection

References

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Development of Virtual Reality System for Identification of Specific Expert Skills in Refinery Inspection Task with Explainable AI

Refinery inspection is the fundamental meintenace task that expert inspectors move around the vast reifinery area and try to find any defects or sign of it. Since even the slight defects will cause serious accidents in later, it owes a critical role for safety management of the refinery. Therefore, to achive the more stable and safety refinery operation, it is important to investigate how expert inspectors can find such a small defects in a vast refinery area, and how different their inspection behavior from novice's one, namely, identification of the expert inspection skill is a critical aspects for refinery safety management.

From above background, in a previous work, a Virtual Realiry (VR) system is used to collect data of both experts and novices inspectors, and clarify the differences between them [1]. As a results, they revealed that expert inspectors tend to set their head in more effective position for finding the defects (e.g., lowerer position for leakage inspection). However, the problem of these previous studies in the lack of temporal and spatial specificity of the expert's skill. Namely, since most of existing studies compared the mean value of the entire inspection process by appling statistical analysis methods, i.e., it is unclear "when" and "where" the expert skill was observed in the entire working processes, and this makes difficult to teach the specific skills for novices.

Therefore, to solve the above issue, in this study, we proposed new analytical framework of the refinery inspection skill which based on the Explainable-AI (XAI) technique [2]. XAI is a kind of analytical technique in the mechine learning filed which tries to visualize and explain the reason for generating the specific out such as prediction or classification. Since it can identify the most important part among wntire time series input data, we adopt this framework for solving lack of specificity problem.

In our proposed method, Covolutional Neural Network (CNN) with Class Activation Map (CAM)[3] are used for classification of the data of inspection behavior into two labels (experts vs novices), and visualize the reason for it. Figure 1 shows the example of obtained results from our analysis. The graph shows the head positions of the participants, and the colors indicate their contribution to the prediction results. As shown in this figure, through the visualization of the CAM architecture, we can identify the specific expert skills such as "the expert inspector tend to gaze from lower angle than novices in this equipment". Hence, by comparing one's own actions with those of skilled operators while inspecting similar objects, we believe that the system can encourage novice workers to make specific improvement plans. In the future, we will develop the educational training system based on this results.

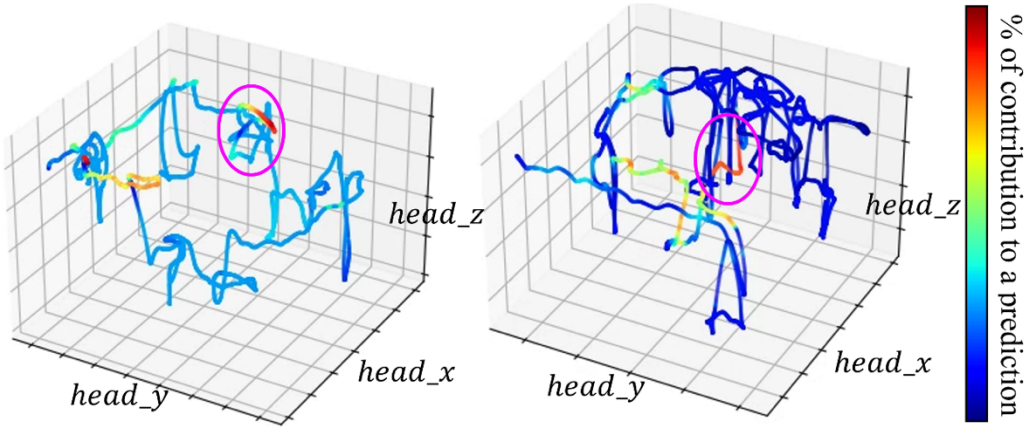

Fig 1. Examples of visualization of the basis for skill discrimination by CAM.

Keywords: Expert Skills, VR, Machine Learning, XAI, CAM

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Description Method and Failure Ontology for Utilizing Maintenance Logs with FMEA in Failure Cause Inference of Manufacturing Systems

To maintain and enhance the efficiency of manufacturing systems, investigating the causes of failures is crucial. However, this task is challenging for non-experts without knowledge or experience. Therefore, various support methods utilizing past failure analyses conducted by experts have been considered. Until now, failure cause inference using existing Failure Mode and Effect Analysis (FMEA) has been widely conducted. However, the inference results from FMEA have shown low consistency with the candidates of causes enumerated by experts for the same failure. This is because during maintenance, experts focus on more detailed aspects than those covered by FMEA, suggesting the necessity of utilizing maintenance logs, which are actual records of maintenance activities, for failure cause inference. Maintenance logs contain more detailed information than FMEA, but they lack uniformity in terms of description quantity and format. Additionally, while FMEA analyzes the structure of the target system hierarchically, resulting in a clear hierarchy of described failures, maintenance logs lack consistency in terms of which hierarchy to focus on when describing failures. Due to these reasons, current maintenance logs make it difficult to extract the necessary causal relationships for failure cause inference, making reuse challenging.

In this study, we propose a method of describing maintenance logs in a reusable format and an ontology based on the knowledge of experts to organize the described failures. By combining maintenance logs with FMEA, we aim to improve the quality of inferring the causes of failures in manufacturing systems.

To use in conjunction with FMEA, we propose a method to describe maintenance logs by extending FMEA. By describing causal relationships between failures and relationships between failures and functions, each description in FMEA and maintenance logs is represented as an instance of "FMEA+Maintenance logs ontology". Additionally, within the domain ontology representing concepts in manufacturing systems, we construct a "Failure ontology" that represents the knowledge of experts regarding failures. Failures are represented using the "Condition" class to express the conditions to be achieved, the "fail_Condition" to associate failures with the conditions they compromise, and the "happen_in_Action" to associate failures with the processes in which they occur.

To validate the proposed method, we compared inference using FMEA and maintenance logs, employing our approaches, with inference solely based on FMEA, as done in the former study [1]. We evaluated the inference outputs using two metrics: precision and recall, by comparing them with the failure cause candidates enumerated by experts for the same failures. As a result, employing the proposed method, inference augmented with maintenance logs achieved a precision of 0.79 and a recall of 0.47, respectively 7.5 times and 4.5 times higher than inference based solely on FMEA. This suggests that the description method for maintenance logs and the failure ontology are effective in improving the quality of failure cause inference. However, within the outputs, there were instances of word combinations such as "stopper unreadable" that are not feasible in manufacturing systems. This indicates the inadequacy of the domain ontology and suggests the need for further enhancement in the future.

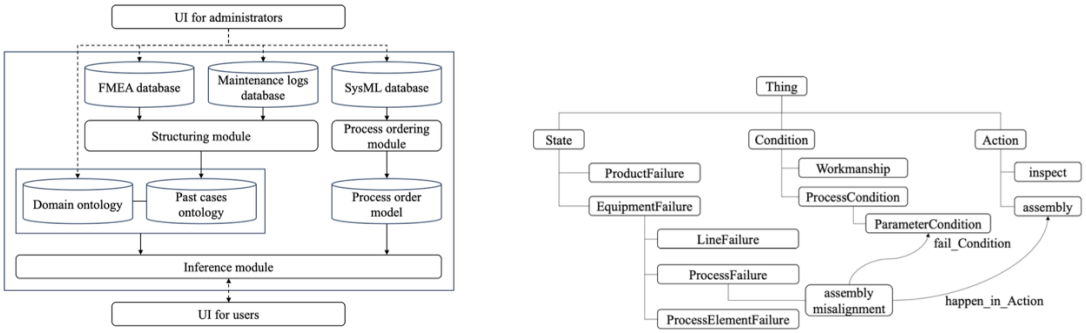

Fig1 Left: Overview of the proposed framework, Right: The failure ontology

Keywords: Manufacturing system, failure cause identification, FMEA, Maintenance log, Ontology

References

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A Framework to Support Failure Cause Identification in Manufacturing Systems through Generalization of Past FMEAs

Inspection and maintenance of manufacturing systems require experts who are familiar with the system's structure and potential defects that may occur. It is a concern in the Japanese manufacturing industry that the shortage of experts makes identifying the defect causes and maintenance activities difficult in the future. A practical approach to compensate for the lack of engineering skill is to refer to the past failure analysis that experts have conducted to identify the causes of failures and repair them.

In this study, we proposed a framework for reasoning possible causes of failures in manufacturing systems based on the past FMEAs (Failure Mode and Effect Analyses) analyzed for various manufacturing systems. The framework generalizes past FMEA descriptions using a combination of classes and properties in the domain ontology of manufacturing systems. The framework searches the possible causes of given failure from the generalized FMEA descriptions through the narrowing down process to consider the possible cause that satisfies the process in the target manufacturing system represented by the partial-order model generated from SysML diagrams. The comparison between the causes inferred by the proposed framework and by skilled experts for three typical failures in the manufacturing system and the interview with them about the plausibility of the inference results showed that more than 73 % of outputs were valid failure causes.

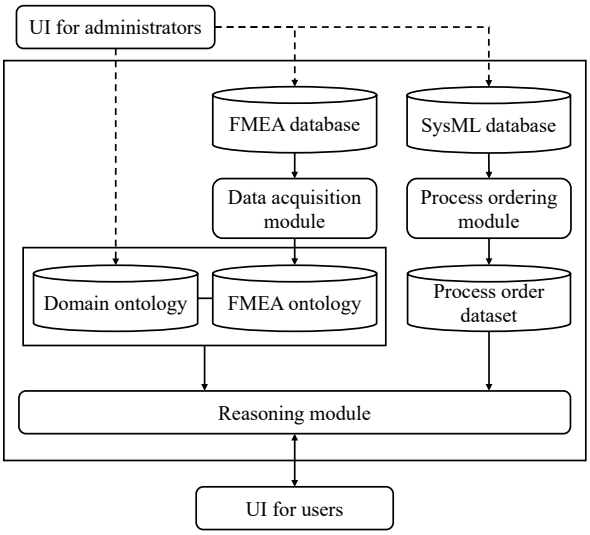

Fig 1. Examples of visualization of the basis for skill discrimination by CAM.

Keywords: Fault Cause Identification, FMEA, Ontology

References

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Modeling Standing Postural Control in Parkinson's Disease Patients

Parkinson's disease (PD) is one of the neurodegenerative diseases known to cause postural control deficits and a distinctive standing posture, referred to as abnormal posture. Increased muscle tone is thought to play a role in this abnormal posture, but accurate measurement of muscle tone during standing is not easy, and the relationship between muscle tone and abnormal posture is not fully understood. Abnormal posture can lead to dysphagia and back pain, which significantly affect patients' quality of life (QOL). Therefore, it is important to elucidate the mechanisms behind these abnormal postures and postural control disorders and to establish effective treatment methods.

We aim to elucidate the mechanisms behind abnormal postures and postural control disorders in PD patients by performing forward dynamics simulations of postural control using computational models. In our previous research, we developed a neural controller model capable of controlling a musculoskeletal model with numerous muscles and degrees of freedom in the joints. This neural controller model takes into account the function of descending pathways that are important for maintaining standing posture. By adjusting control parameters based on data obtained from Parkinson's patients, we have investigated the relationship between muscle tone and abnormal posture. We are also using these models to investigate how dopamine, a neurotransmitter in the brain, is involved in the control of standing posture.

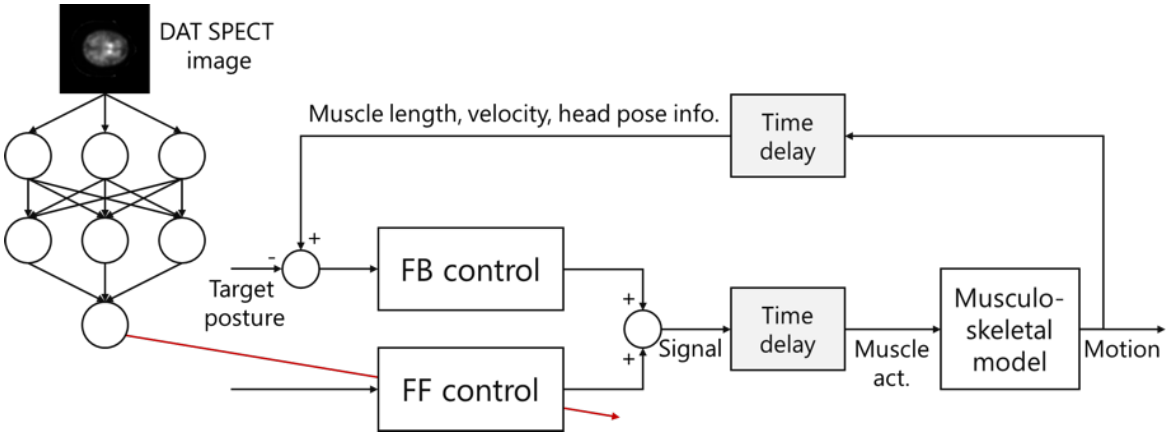

Fig 1. A neural controller model of standing postural control considering dopamine function.

Keywords: Parkinson's disease, Abnormal Posture, Muscle Tone

References

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Estimation of Foot Center of Pressure Information Using Smartphone Sensors

There are a growing number of reports on the effectiveness of postural control training in restoring motor function. One of the most commonly used pieces of information in such training is the Center of Pressure (CoP) of the foot. Many studies have demonstrated the effectiveness of postural control training based on CoP information. Force plates are often used to measure CoP. However, force plates are not widely available and are expensive. Therefore, we aim to estimate CoP displacement using only the sensors of smartphones, which are commonly used in everyday life, for more accessible postural control training.

We used one-link and two-link inverted pendulum models to compare CoP estimates from smartphones with actual force plate measurements. The results confirmed that these models could estimate CoP displacement, and in particular showed that the two-link inverted pendulum model had superior performance. In the future, we plan to develop a smartphone app that can perform such postural control training in practice and verify its effectiveness.

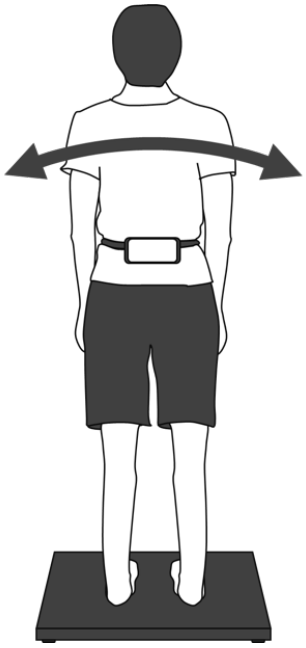

Fig 1. CoP estimation in standing posture with a smartphone worn at the waist.

Keywords: Postural Control, Smartphone, Center of Pressure

References

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