Development of A Remote Controlled Robotic System Combined ROS 2 and IoT

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Abstract

In this paper, we propose a tele-operated robotic system combined Robot Operating System (ROS) 2 and Internet of Things (IoT), aiming to solve labor shortage problem in Japanese food industry. The proposed robotic system consists of a ROS 2 based motion control module, a You Only Look Once (Yolo) V5 based object recognition module, and an Amazon Web Service (AWS) based cloud computing module. To show the effectiveness of the proposed robotic system, several typical pick-and-place tasks were conducted for handling three fruit samples such as apple, orange, and strawberry. These food samples could be successfully grasped and placed to desired destinations using the proposed robotic system.

Keywords

ROS 2, IoT, Remote Control, AWS, pick and place, object recognition

1. Introduction

In Japanese food industry, the labor shortage caused by the aging society has become a social problem [1]. To address this problem, various robot systems have been proposed [2, 3, 4, 5, 6, 7, 8]. However, certain levels of expertise are required to operate these robotic systems [9] [10]. A possible solution is to use the remote control strategy to simplify the operating processes. Current problems in remote control robotic systems include network reliability and security [11], system integration and compatibility [12], and increased costs due to various types of food products. Therefore, in this study, we propose a remote control system combined ROS 2 and IoT. ROS 2 is an open-source software framework designed for the development of robotic applications. It provides a structured environment that simplifies the process of creating complex and robust robot behavior across a wide variety of robotic platforms. IoT changes manufacturing by connecting smart devices and systems to enhance efficiency and innovation. It integrates advanced technologies such as machine learning and big data, enabling predictive maintenance and operational optimization. IoT not only improves productivity but also fosters new business opportunities in the industrial sector. The proposed robotic system combines the ROS 2 and IoT,

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which possesses a series of merits, such as remotely control of typical robotic pick-and-place tasks, requirements of less trained labors, reducing costs related to system changes, and so on.

2. Remote Control System Structure

Figure 1 depicts the diagram of the proposed remote control robotic system. The proposed system consists of a robotic motion control module, an object recognition module, and a cloud computing module.

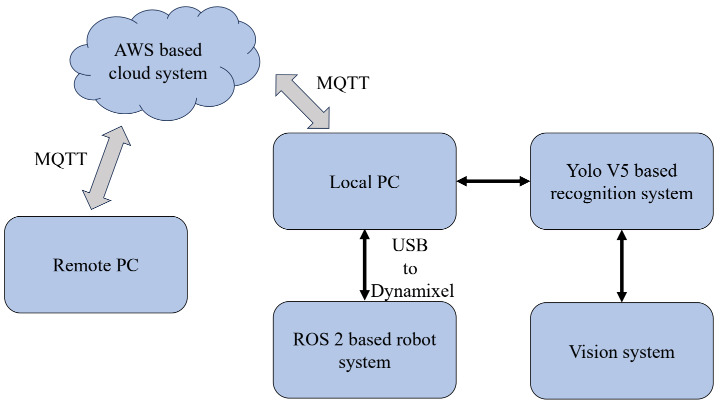


Figure 1: The diagram of the remote controlled robotic system combining ROS 2 and IoT.

The robotic motion control module utilizes the MoveIt 2 package of ROS 2 for robotic motion control. which includes a series of useful functions, such as motion planning, manipulation, three-dimensional (3D) perception, kinematics, control, and navigation[13]. The desired control commands was transmitted via USB to Dynamixel protocol between the local PC and this module.

The object recognition module utilizes the Yolo V5 for object detection. Yolo is a state-of-the-art, real-time object detection algorithm. The bounding boxes of the target object can be predicted via a single neural network, and be classified with certain probabilities. Using Yolo, real time object detection could be realized due to its fast process rate. In addition, YOLO also has high detection accuracy with few background errors [14]. Although other versions of Yolo packages can be used, this time we selected Yolo V5 in our preliminary experiments.

The cloud computing module utilizes the AWS for communications between remote PC and local PC via Message Queuing Telemetry Transport (MQTT) protocol. AWS offers a broad set of Internet of Things (IoT) services that allow devices to connect to the cloud and interact with other devices and cloud applications. The AWS IoT Core is a managed cloud service that enables connected devices securely interact with cloud applications and other devices. It can support billions of devices and trillions of messages, and can process and route those messages to AWS endpoints and to other devices reliably and securely [15].

3. Experiment

To show the effectiveness of the proposed system, several pick-and-place tasks were conducted for handling a series of food samples, such as apple, orange, and strawberry.

3.1. Experimental Setup

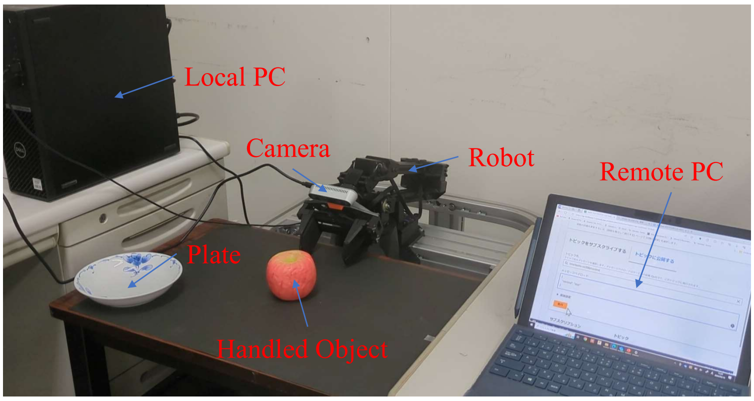


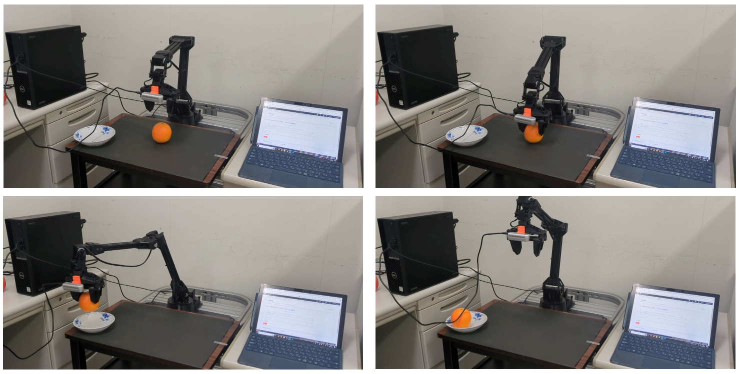
Figure 2: Experimental setup for pick-and-place tasks using the proposed remote control system.

Figure 2 shows the experimental setup for the pick-and-place tasks. A five degree of freedom (DoF) robotic manipulator (ViperX 300, Trossen Robotics) was used to pick the target object and to place it to the desired plate. A RealSense depth camera (RealSense D435i, Intel) was used to capture the information of the handled object for recognition. The handled object was recognized using Yolo V5, the 3D coordinates of which was acquired and sent to local PC as the desired target for motion planning. The motion planning of the robotic manipulator was achieved based on MoveIt 2, which planned a desired trajectory using the 3D coordinates obtained from the recognition system for the pick-and-place task. The entire task was controlled by remote PC based on AWS via MQTT protocol. Three food samples were selected for the pick-and-place tasks. They are plastic samples of apple, orange, strawberry. The physical parameters such as size and weight of these samples are provided in Table 1. We conducted three times experiments for each food sample to obtain the statistical results.

3.2. Experimental Results

Figure 3 shows the experimental results related to the pick-and-place tasks. As shown in Figure 3(a), the apple could be successfully picked up and be placed to the desired plate. The recognition confidence of the apple was 0.88, and the successful rate of this pick-and-place task was 100%. Similarly, as shown in Figures 3(b) and (c), both orange and strawberry samples could

(a)



(b)

(c)

Figure 3: Pick-and-place tasks using the proposed system: (a) pick-and-place the apple, (b) pick-and-place the orange, and (c) pick-and-place the strawberry.

be successfully picked up and be placed to the desired plate. The corresponding recognition confidences were 0.90 and 0.70, and the successful rates of these tasks were 100%, as shown in Table 1.

Table 1
Physical parameters of food samples and experimental results in terms of success rate and recognition confidence.

Handled object	Size[mm]	Weight[g]	Successful rate	Averaged confidence
Apple	$76.9 \times 76.0 \times 65.2$	112.3	100%	0.88
Orange	$78.1 \times 76.8 \times 76.2$	100.3	100%	0.90
Strawberry	$28.7 \times 28.7 \times 45.4$	13.9	100%	0.70

4. Conclusion and Future work

In this study, we developed a remote controlled robotic system combined ROS2 and IoT. The proposed system was successfully applied for typical pick-and-place tasks. A series of food samples could be successfully picked up and be placed to desired destinations using the proposed system. In the future, we would like to conduct the pick-and-place tasks using actual food products. Furthermore, monitoring is commonly required for the remote control system. However, the current system could not remotely monitor the sensor data from the robot side, which will also be solved in our future study. In addition, it is believed that hardware resources of the proposed system could be reduced by utilizing the resources of cloud services and performing calculations such as recognition and trajectory calculations on the cloud side.

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