Research on AR system for industrial robot introduction

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Abstract

In recent years, labor shortages in small and medium-sized enterprises (SMEs) have become a serious issue, and the demand for automation by robots is increasing. Another challenge is the high cost of introducing industrial robots. In order to reduce the introduction cost, we are developing an AR system with the aim of providing robot introduction support to SMEs. The AR system developed enables the display of the robot's movements on the AR screen of a smartphone by communicating with ROS while developing Google's ARCore in Unity. In this paper, we describe the system configuration and evaluate the application of an AR application that enables AR simulation and intuitive GUI operation to check the safety range at the time of robot introduction.

Keywords: AR, Factory Automation Robots, ARCore, Unity, ROS

1. Introduction

In recent years, labor shortages in small and medium-sized enterprises (SMEs) have become an increasingly serious issue. In the food service industry in particular, automation using robots is expected to improve productivity in order to solve labor shortages. However, the introduction of robots is costly in terms of design, parts, and other costs. For small and medium-sized enterprises (SMEs) that do not have abundant funds, the high cost is a major barrier to the introduction of robots. This study utilizes Augmented Reality (AR) technology, which displays virtual information that does not exist in real space on a display via a camera such as a smartphone or AR glasses. In other words, a virtual robot model is operated in AR to check the actual food preparation and safety range in a factory.

This eliminates the need to set up an actual robot in a factory and check its operation, and is expected to significantly reduce the cost of introduction, including design and system integration costs.

In this study, we developed an AR application for small and medium-sized enterprises (SMEs) to check the safety range of robots when they are introduced. In addition, we assumed that the users of this application would be people who are not familiar with robot development. Based on these assumptions, we developed an application that is easier to operate and more user-friendly, and we describe its evaluation and verification.

2. Software Overview

2.1. *AR System Configuration*

Three main technologies were used to develop the AR application. We used ARCore SDK for Unity to use ARCore, a software for AR development, on Unity for application development. Fig. 1 shows a schematic diagram of the AR system.

Fig. 1. AR System Configuration

2.2. *AR Application*

The application developed in this study is to operate a real robot after AR simulation. The flow of the application is shown in the following order (a), (b), (c), and (d) in Fig. 2.

(a) Object selection screen

Select the type of solidified food to be grasped, the number of pieces, and the location of the container to be used for serving.

(b) AR simulation screen

The coordinates of the object to be grasped are acquired from the RGB-D camera mounted on the tip of the actual robot, and projected onto the AR.

(c) Real robot start screen

After the simulation is completed, a button for the actual robot operation appears. After pressing the button, the actual robot performs grasping and serving.

(d) End screen

After the actual robot completes grasping and serving, a text informing the end of the operation is displayed on the AR.

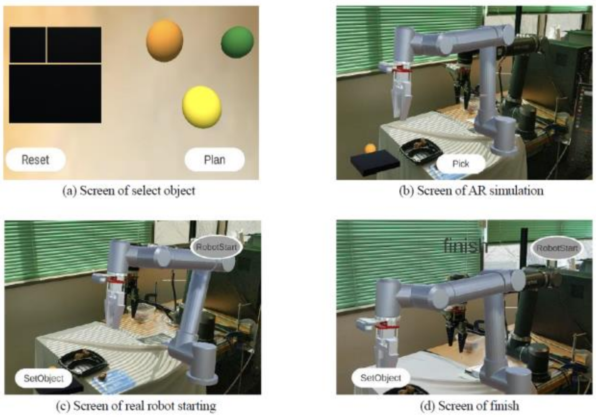


Fig. 2. Screen of AR application

3. Robot System

3.1. *Robot Configuration*

The appearance of the robot used in this study is shown in Fig. 3.1 and Fig. 3.2. Since this robot is required to perform the same tasks as a human in a food factory, a 6-axis vertically articulated robot with a shape similar to a human arm and a high degree of freedom of movement was used. An RGB-D camera for object recognition and a gripper for grasping are mounted on the tip of the robot. This gripper can be opened and closed by stepper motor control to realize the grasping of solidified food.


Fig. 3.1. Appearance of the robot

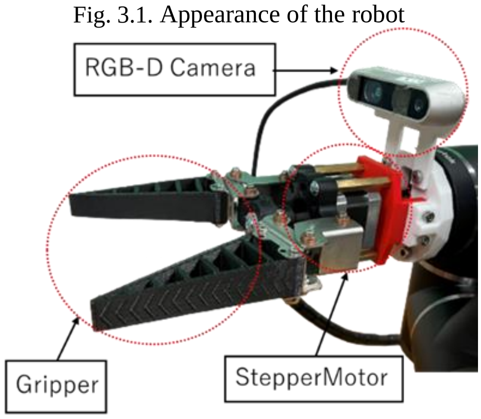


Fig. 3.2. Detail of the gripper

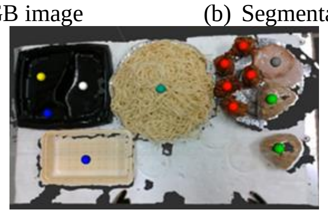
3.2. *System Configuration*

The position of the solidified food must be identified during the gripping and serving process. An object recognition system was used. First, the RGB information of the object is acquired from an RGB-D camera mounted on the tip of the robot, and instance segmentation is performed. The coordinates of the center of gravity in two dimensions are calculated for the generated segmentation image. Furthermore, 3D center-of-gravity coordinates are obtained by acquiring depth information for the object.

In addition, a microcontroller is used to control motors from a PC to open and close the grippers. Fig. 4 shows the image obtained from the RGB-D camera and the processed image.

(a) RGB image

(b) Segmentation image



(b) Gravity center points

Fig. 4. Image from RGB-D camera

4. Experiment

4.1. *GUI Evaluation Experimen*[1]

Ten subjects were asked to use the application from (a) to (d) according to the application flow described in 2.2. The subjects were divided into two groups of five each. Group A was given detailed instructions on how to operate the application, while Group B was asked to use it without being told how to operate it. The subjects who completed the operation to the end were considered successful, and the percentage of successful subjects in each group was investigated. The results are shown in Table 1.

Table 1. Operation result of application user

	Successful	Total	Rate of successful [%]
Group A	5	5	100
Group B	3	5	60

4.2. *Virtual robot motion time measurement*

We considered the time aspect in the process of simulating the developed application. Compared to direct operation by code on the ROS that controls the virtual robot, operation by GUI requires a human operator to give operation instructions for each movement, resulting in a difference in operation time. In addition, the communication between the AR and the ROS also causes delays. In the process of (a) and (b), which simulate the robot motions in 2.2, we performed 10 measurements each for GUI operation in AR and direct operation in ROS, and the fastest, slowest, and average values are shown in Table 2.

Table 2. Measurement result of operation time

	GUI input	Directly input
Fastest[s]	20.95	13.13
Latest[s]	24.49	16.79
Average[s]	22.11	14.68

4.3. *Discussion*

Experiments 4.1 and 4.2 were conducted to evaluate the usability of the developed application.

From 4.1, it was found that although the application can be used by explaining how to operate it, it is difficult to use for people who use this application for the first time. In particular, the largest number of users failed in the process of serving the virtual grasping object on the simulation screen. It is expected that the number of failures in this process will be reduced by developing an application that does not accept the next operation command while the virtual robot is in operation.

In 4.2, since both PCs controlling the virtual robot are the same, the operation time is theoretically the same. However, in addition to the time between GUI operations and the communication time between AR and ROS, the time required to recognize the image to make the virtual robot appear on AR was found to cause a significant delay. The average time was 16.98 seconds when the above effects were suppressed. In particular, GUI operation on the object selection screen contributes to shorter operation time compared to direct input.

The robot can be operated by GUI, and the robot can be operated without being near the control PC.

5. Conclusion

In this study, we developed an AR system that can visualize robot motions on a smartphone. In addition to the visualization, we also developed an application with higher usability. The effectiveness of this system in introducing robots was confirmed.

References

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