Autonomous Robotics Packaging Ready Meal in Conveyor Production Line

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Abstract

Food automation technology has become increasingly important in industrial and scientific research, especially in a social distance of pandemics. In this paper, we investigate the robotic motion planning and grasping for the food, which is non-rigid, nonpattern, and soft since the food is challenging to pick. Moreover, in automation, the process has to be organized on time since the automation uses the conveyor production line. This paper contributes three points: online motion planning while the production line conveyor operates. The second is real-time non-pattern food segmentation. The third is grasping non-rigid, nonpattern, and soft objects of food. Additionally, the robotics grasping also proposes the finishing decorating spaghetti packaging by rolling the spaghetti while the conveyor moving which is our novel proposed.

Keywords: Robotics, Pick-and-Place, Food Automation.

1. Introduction

Nowadays, technology has played an increasingly important role in facilitating human life and work. Technology development has been utilized rapidly and widespread in agriculture, medicine, and automation in the recent decade. That mainly focuses on developing renewable energy considering the environment and helping to reduce pollution problems. The industry has continually improved and set in terms of tools, equipment, and electrical appliances rapidly since the technology of Artificial intelligence, Machine Learning, and Robotics are researched and developed pervasively.

Recently, the robot has been widely and extensively applied to improve the quality, performance, and precision in a production factory. Additionally, one popular function of robots is assembling various parts. The robot would pick the component to assembly in this process, typically called pick-and-place. The critical point in this process is that the robot needs to be assigned to the position and orientation of the robot and the picked object since the robot would be programmed and instructed to move from pick position to place position.

The manipulator robot is controlled by joint position; however, we usually manipulate the robot in Cartesian space. Therefore, we calculate the inverse kinematic (IK) from the cartesian space to the joint space. The robot is

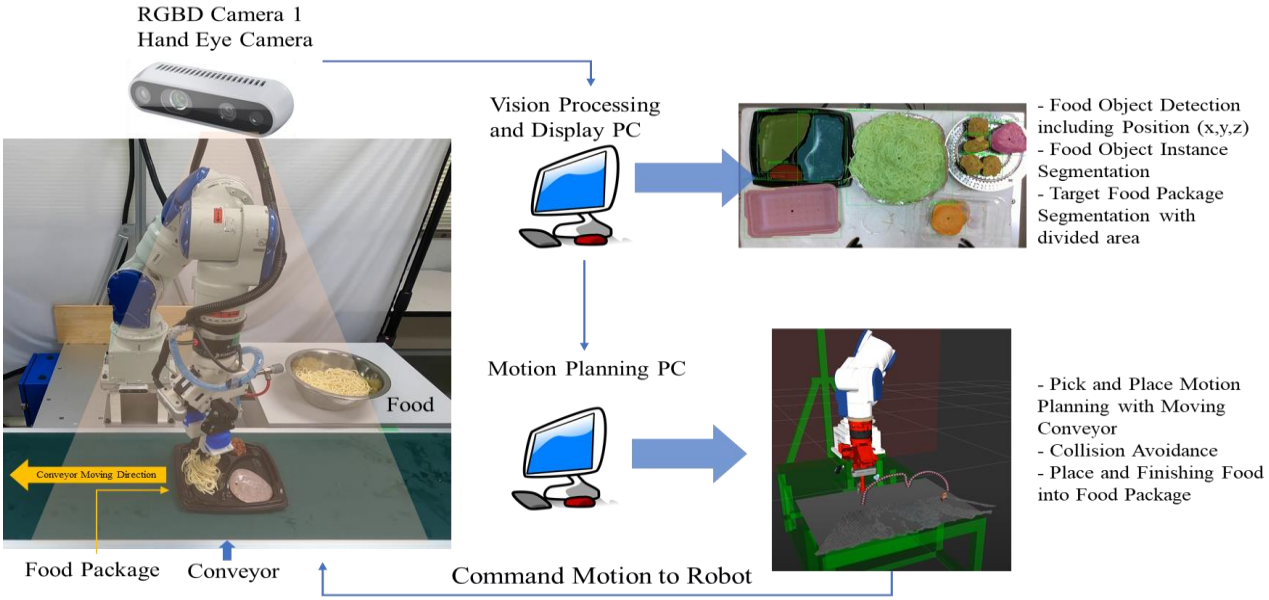

Fig. 1. The overview system of the proposed scheme includes a robot, RGBD camera, PCs, Foods and Conveyor

required to plan the trajectory according to the environment, such as avoiding the collision or moving to the target. The recent motion planning method is the Open Motion Planning Library, which is popular, reliable, and fast for solving the trajectory motion in various movements such as robot arm motion, vehicle, drone.

In this paper, we propose and contribute the robot automation for food packaging that can generate the robotics motion according to the food and moving container on the conveyor. Then we apply the planned move to the actual robot motion. Besides, this system uses Trac-IK for kinematic[1], and OMPL[2] for path planning based on ROS. Fig. 1 shows the overview of our proposed, which consists of the robot, food container on moving conveyor, and the food tray which contains the preparing food for packaging.

2. Approach

In this section, we explain the overview system, including robot hardware configuration, Conveyor, food instance segmentation, food package segmentation with the divided area, And the robot placing the food into the food package and finishing.

2.1. *Food Automation Setup with Conveyor*

Our proposed food automation setup consists of the robot, conveyor, food tray, food container package, and camera. The robot is used to operate the pick and place task and support the vision system since the camera is installed on the end-effector of the robot. The conveyor is utilized to move the food package to the robot then the robot would assembly the food into the container. For the vision system, we installed the RGBD camera into the robot to perceive the position of food in the tray and the food package on the conveyor. For the image processing system, we use one PC to operate the deep learning architecture to extract the segmentation and position of foods. Additionally, we use the second PC to manage the robotics motion planning for picking and placing the food into the package. The hardware system

Fig. 2. The example image of food and package instance segmentation includes three section areas of the package, spaghetti, Ham, chicken fries, rice ball.

configuration is shown in Fig 1.

2.2. *Foods and Package Instance Segmentation*

Firstly, we implement the Foods Instance Segmentation for the perception to detect and segment the food area and extract the position. We introduce the deep learning architecture of Cascade Mask R-CNN, implemented with PyTorch[3]. The backbone is ResNet-50. Our detection can detect the foods such as chicken fries, Ham, rice balls, spaghetti. We also implemented the food package divided into three section areas. We used this method to detect the food area in the color image after extracting the position using point cloud since we installed the robot's RGBD camera. The example of food and package section areas segmentations are shown in Fig.2.

2.3. *Robot Trajectory and Motion*

Since the robot knew the hand motion trajectory, we can then plan the motion according to the workspace constraint and the trajectory. Firstly, we set the home pose to initialize the robot joints to prepare a starting position to move following the trajectory. The robot will plan motion using the Open Motion Planning Library (OMPL) and Trac-IK inverse kinematic when the robot gets the new trajectory from the demonstration. In this implementation, we utilize the MoveIt tool with Robotics Operation System to organize motion planning and collision protection among the workspace environments. After the robot could detect the food and the package on the conveyor, the robot would move following the planned motion. Moreover, placing the food into the packing on the moving conveyor, we introduce the finishing process for spaghetti to allow the spaghetti not messy by making the robot roll the spaghetti while the conveyor moves.

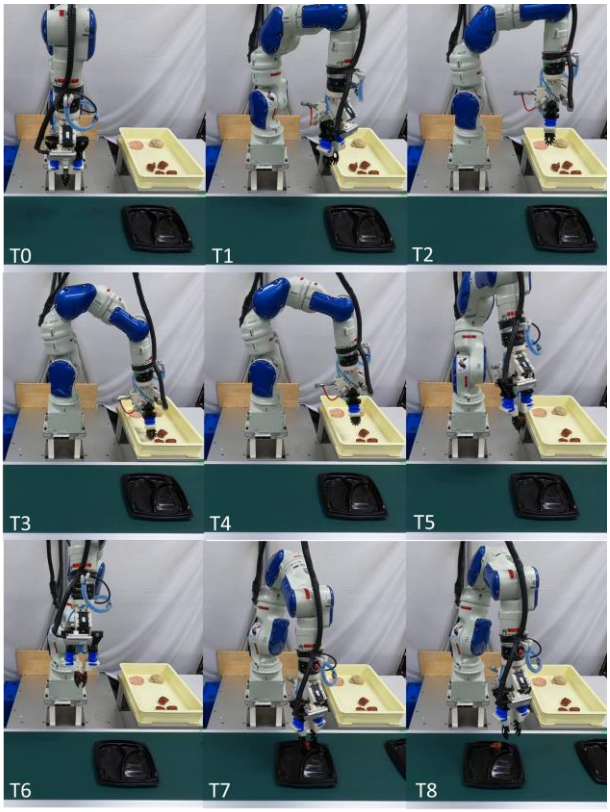

Fig. 3. The robotics motion of chicken fries pick and place with moving conveyor.

2.4. *Experiment Setup*

We use the industrial robot with 7 degrees of freedom and a soft gripper tool of end-effector for the hardware configuration system since we aim our robot to grasp various food. For robot control and motion planning system is implemented in the desktop PC. Additionally, we implement the image procession in another PC based on Deep learning Instance Segmentation. The robot is mounted on the robot base station with the camera mounted at the robot's end-effector in the experiment setup. We also calibrate the camera position translation to the robot position and orientation. Finally, the conveyor is set up in front of the robot.

3. Experiment and Results

The robot performs the food packing with a moving conveyor in this experiment. The robot would perceive the food and container position and then make a pick and place motion. After that, the robot will grasp the food into the package according to the speed of the conveyor.

First, the robot assembly the ready meal package by picking the chicken fries in the food package on the conveyor. Fig. 3 shows the robot assembling the chicken fries into the food package. Second, the robot assemblies ham to the food package, which is the same method of assembly chicken fries, except the robot would switch the tool by rotating the actuator at the end-effector to be a vacuum pad. The robot assembling Ham is represented in Fig. 4. Finally, the robot assemblies

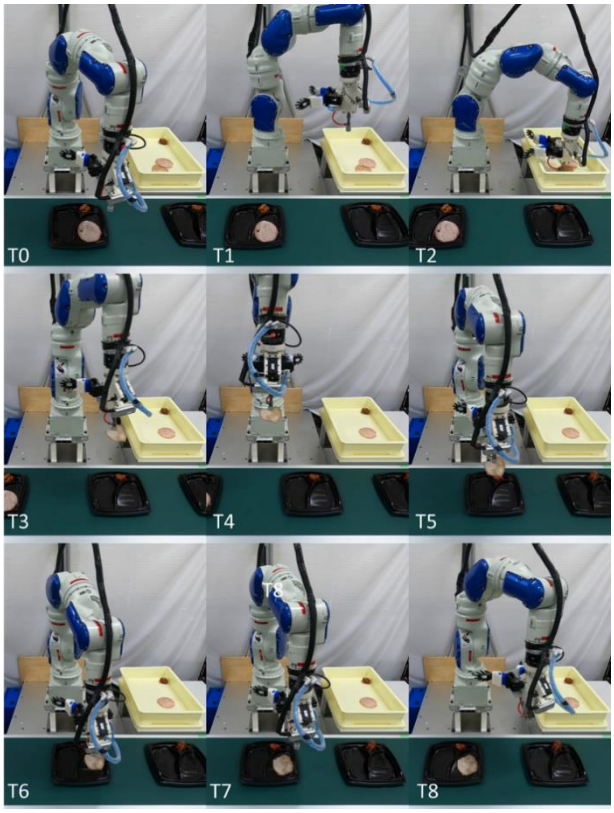

Fig. 4. The robotics motion of Ham pick-and-place with moving conveyor.

spaghetti, as shown in Fig. 5. However, in this process, the robot adds a finishing process by rotating the end-effector tool to roll the spaghetti, making spaghetti look in shape, as shown in Fig 4 from T8 to T9.

4. Conclusion

We introduce the robot food packaging in automation with the finishing process. We present and implement the robot framework of autonomous robot motion generation by perceiving the foods and the package moving on the conveyor using deep learning-based food and package instance segmentation based on Cascade Mask-RCNN. The robot could succeed in the food packaging especially assembling spaghetti with finishing process to keep it in shape while the conveyor moves.

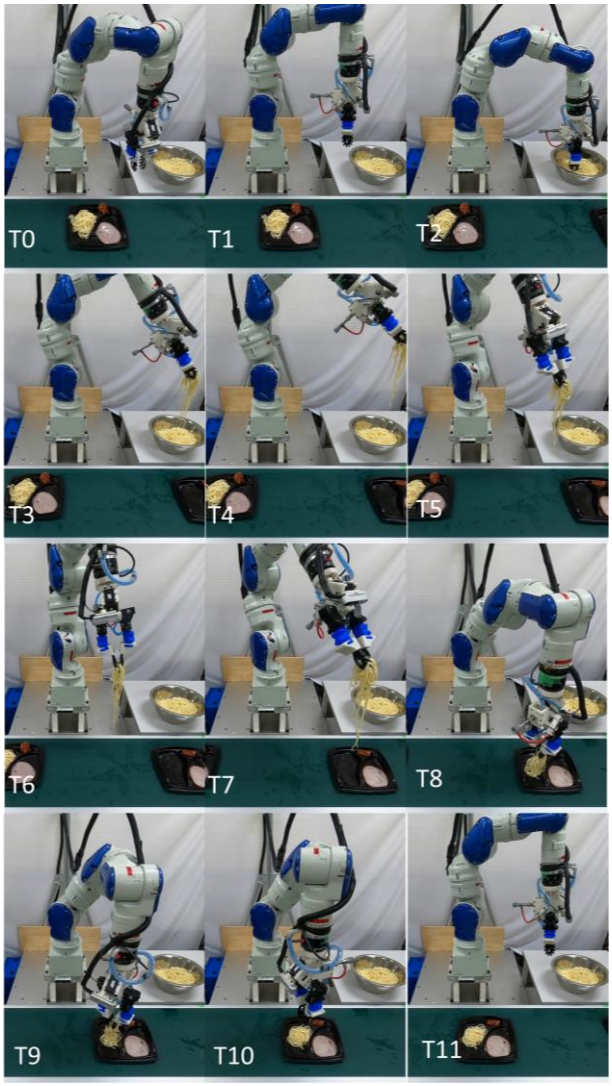

Fig. 5. The robotics motion of spaghetti pick and place with moving conveyor.

Acknowledgments

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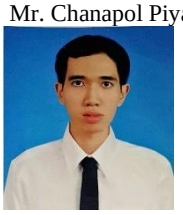

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