Robot Motion Generation for Precise Scooping of Powders Material based on Recognizing 3D Functional Attributes of Spoons

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Abstract— **We propose a robot motion generation method for scooping a desired amount from a heap of food powder using various kinds of spoon. In this paper, the desired amount of the powders material is converted to volume based on density values, and the inner trajectory, which is the spoon's passing through the powders material heap, is generated geometric calculations based on recognition of the spoon's functional attributes and a cone model approximating the powders material heap, obtained using a depth sensor. The spoon's outer trajectory for the target food, which is the spoon's motion before it enters and after it leaves the target food, is determined by fusing the "common motion trajectory model" and the functional attributes of the spoon. The final robot trajectory can be generated by integrating the inner and outer trajectories.**

Keywords— **Robot Motion Generation; 3D Functional Attributes; 3D Point Cloud Processing; 3D Sensing; Robots;**

I. INTRODUCTION

In recent years, realizing useful cooking robots is strongly required because serving robots have begun to be deployed in restaurants. For cooking robots, appropriate robot motions such as scooping or stirring food materials are required. Previous studies have proposed methods in which robots manipulate granular ingredients by using machine learning [1][2]. However, this approach has a significant practical problem, the cost of collecting the data for machine learning. In this paper, we propose a method to generate robot motion even if the spoon and target material heap have various sizes and shapes.

II. PROPOSED METHOD

The schematic diagram of the proposed method is shown in Fig. 1. The method generates both (a) an inner trajectory and (b) an outer trajectory. (a) is the path when the spoon travels through the food material heap, and (b) is a path before and after the spoon's inner trajectory.

Step1 : The inner trajectory

First, point cloud data of the target food heap, obtained with a depth sensor, is approximated as a cone model. Second, the radius and height of the model are calculated. Third, 3D shape of the spoon and its functional attributes are recognized [3]. Finally, the spoon's inner trajectory for the target food is generated by using these data.

Step2 : The outer trajectory

In order to calculate the outer trajectory, the common motion trajectory model is utilized. The model represents the qualitative trajectory of various spoon-like tools, and it can be converted to a quantitative trajectory to be transferred to the robot by using the sensed 3D shape and the functional attributes.

Step3 : Robot motion trajectory generation

The final robot motion is generated by integrating the inner and outer trajectories calculated in Steps 1 and 2.

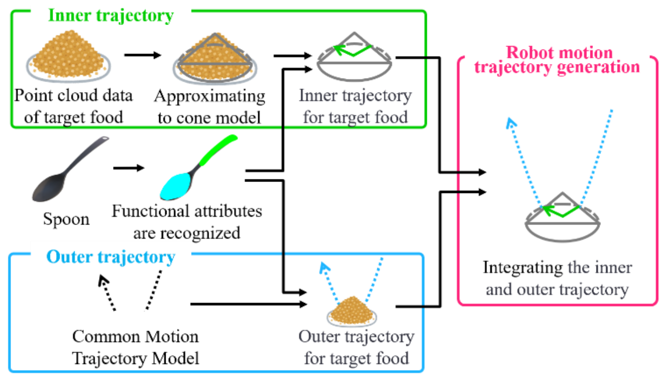

Fig. 1. Flow of proposed method

III. EXPERIMENT RESULTS

In this experiment, 30 motions were generated for each combination of three kinds of spoons and three powder material heap shapes. A total of 270 motions were thus evaluated. Fig. 2 shows histograms of actually scooped weights by our method when we assigned 1.50[g] as the target amount to the system. The achieved mean value was 1.51[g] and standard deviation was 0.58[g], demonstrating that our method is effective for automated robot motion.

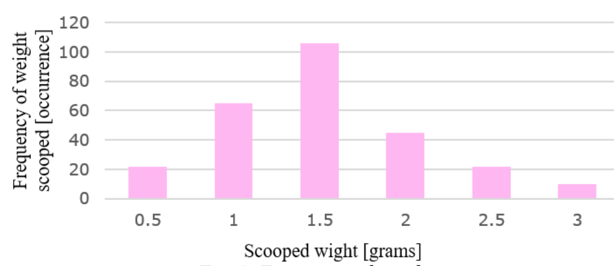

Fig. 2. Experimental results

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