Human Centered Study of Strawberry Picking Behavior for Intelligent Harvesting Robot

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I. INTRODUCTION

Strawberries, highly valued both commercially and for consumption, are predominantly cultivated in controlled environments like greenhouses. Despite these advantages, human labor remains a significant factor in strawberry production costs, especially during harvesting. To address this, there is a growing interest in developing strawberry harvesting robots. However, detecting strawberries poses challenges due to leaf shading, overlapping, and plant structure interference. Enhancing the visual object detection system is crucial for accurate and real-time detection. Given the vulnerability of strawberries to damage due to low mechanical strength during harvesting, we propose a stem-based harvesting method and plan to develop an efficient motion planning approach for the robot manipulator [1][2]. The goal is to enable the intelligent robot to navigate autonomously, picking strawberries with improved efficiency and minimal damage, thus transforming strawberry harvesting processes.

II. LITERATURE REVIEW

Various motion planning methods are explored for optimizing the efficacy of strawberry picking.

A. Traditional Algorithms

Artificial potential field algorithms necessitate the entire workspace for sampling and may stop path searching due to inflection points. A* algorithm speed diminishes with increasing degrees of freedom (DOF) and obstacle complexity. The Improved Rapidly exploring Random Tree (RRT*) algorithm addresses these issues in high-dimensional spaces but incurs high computational time and generates zigzag paths, which pose challenges for motion of the manipulator. [3],[4]

B. Fuzzy logic

Fuzzy logic enables a smooth path and swift decision-making [3]. However, path optimization depends on rule quality, potentially leading to inefficiencies. Careful rule refinement is crucial for effective fuzzy logic-based path planning.

C. Hybrid motion planning

To overcome the drawbacks of traditional algorithms and stand-alone fuzzy logic in motion planning, researchers commonly employ a hybrid approach. By combining both methods, they aim to leverage the respective advantages of each and enhance overall efficiency [3].

Based on the literature review, we selected RRT* as the traditional algorithm to integrate fuzzy logic for our hybrid motion planning method. Initially, our investigation sought insights into human hand behavior during strawberry picking.

III. METHODOLOGY

A. Experiment design

A total of 35 strawberry-picking experiments were conducted, involving seven distinct individuals. Each participant executed five distinct approaches, each based on varying hand orientations. Figure 1 illustrates the five distinct approaches used by each individual during the experiments.

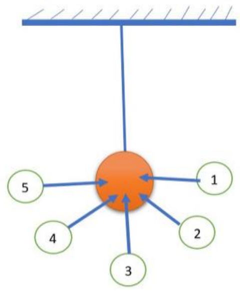

Figure 1 – Five distinct approaches.

The experiments were carried out with restrictions: participants used only their right hand, and the distance between the sample model and the human remained constant throughout the experiment to maintain consistency and control for and reliable analysis of the collected data.

B. Data collection of joint angles

This study focuses on analyzing the right shoulder, right elbow, right wrist, and right-hand joints. We established the Kinect Version 2 Camera with Vitruvius Library to collect joint angles data by modifying existing code for the selected right-hand joints, as illustrated in Figure 2.

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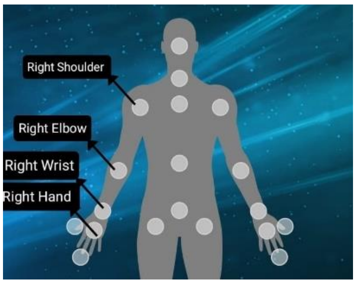

Figure 2 – Chosen joints of right hand.

IV. Analysis and Results

This study involves recording 15 joint angles reading per second for each joint and finding mode values on each second, revealing the most frequent angles.

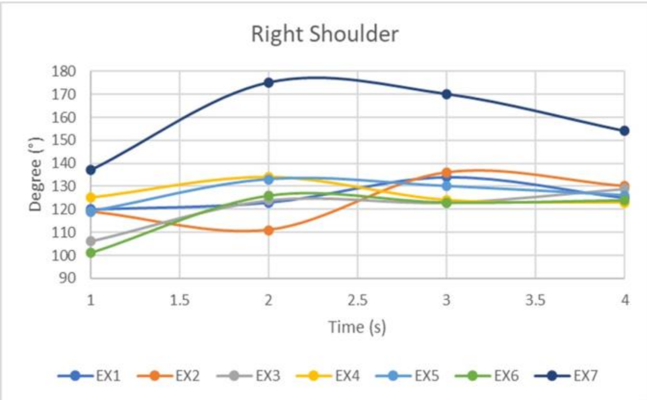

Figure 3 – Hand Orientation 1_Right Shoulder

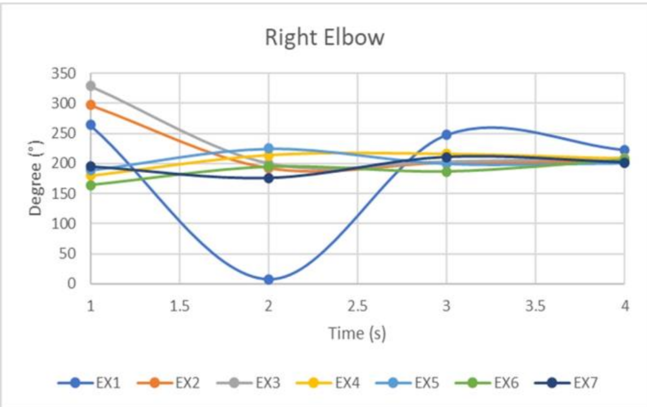

Figure 4 – Hand Orientation 1_Right Elbow

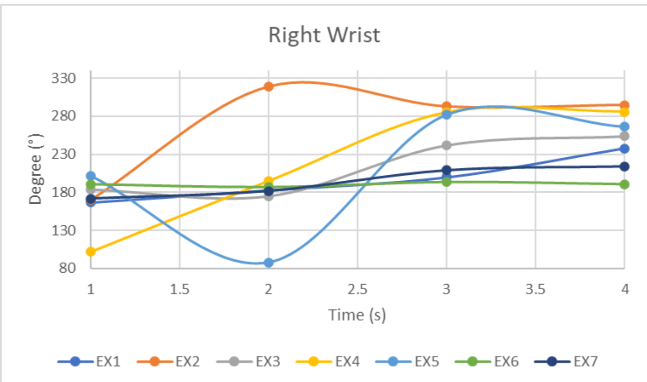

Figure 5 – Hand Orientation 1_Right Wrist

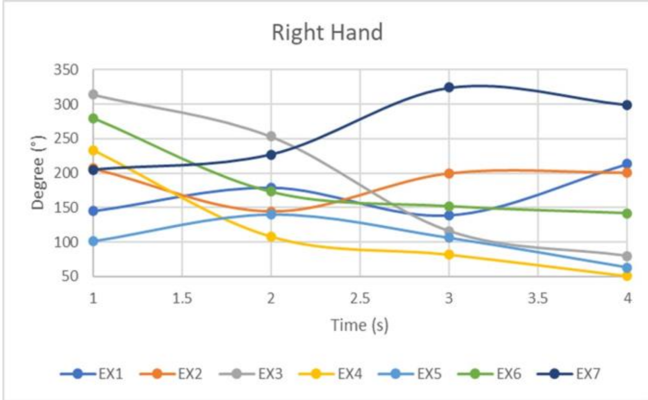

Figure 6 – Hand Orientation 1_Right Hand

Above figures 3-6 illustrate angle variations over time for each joint in hand orientation 1. Right Elbow and Right Shoulder joints are mostly same joint angle variation for approach of all individuals in hand orientation 1.

Similarly joint patterns were identified in the analysis of the other four right hand orientations.

Hand Orientation	Joint Patterns
1	Right Elbow, Right Shoulder
2	Right Elbow
3	Right Elbow
4	Right Elbow, Right Wrist
5	Right Elbow

Table 1 – Joint patterns for distinct hand orientation.

V. Conclusion

According to the human centered study, the Right Elbow joint angle be as a key indicator of common human hand behavior. Potential use of Right Elbow joint parameters to map human hand’s paths and define the hand's workspace. This insight gives foundation for mimicking the identified workspace in the design of an Intelligent harvest robot.

VI. References

[1] Kurpaska, S.; Bielecki, A.; Sobol, Z.; Bielecka, M.; Habrat, M.; Smigielski, P., "The Concept of the Constructional Solution of the Working Section of a Robot for Harvesting Strawberries.," Sensors, p. 17, 2021.

[2] Seungmin Woo, Daniel Dooyum Uyeh, Junhee Kim , Yeongsu Kim , Seokho Kang, Kyoung Chul Kim , Si Young Lee , Yushin Ha , and Won Suk Lee., "Analyses of Work Efficiency of a Strawberry-Harvesting Robot in an Automated Greenhouse," Agronomy, p. 20, 2020.

[3] Hentout, A., Maoudj, A. and Aouache, M. (2022) A review of the literature on fuzzy-logic approaches for collision-free path planning of Manipulator Robots - Artificial Intelligence Review, SpringerLink. Available at: https://link.springer.com/article/10.1007/s10462-022-10257-7 (Accessed: 23 October 2023).

[4] W. Shi, K. Wang, C. Zhao, and M. Tian, “Obstacle avoidance path planning for the dual-arm robot based on an improved RRT algorithm,” MDPI, https://www.mdpi.com/2076-3417/12/8/4087/htm (accessed Oct. 23, 2023