AI-driven robotics manipulators for lab automation

Department of System Innovation, Graduate School of Engineering Science

Associate Professor Weiwei Wan

Researchmap https://researchmap.jp/weiweiwan?lang=en

Abstract

This work develops a system that employs a 6-DoF collaborative robot to autonomously operate a pipette for liquid dispensing in biochemical applications. The system includes two main components: (1) a specialized end-effector for holding and triggering manual pipettes, (2) hand-mounted cameras for recognizing racks and correcting positioning errors. The two main components enable the robot to autonomously operate a pipette as well as exchange tips for handling multiple types of liquids. Experimental validation shows that the system, with additional help of motion planning, could achieve high precision and flexibility for low-frequency, high-repetition liquid dispensing tasks. This system is deployed beside the RIKEN Plant Phenotyping System (RIPPS) for screening chemicals and genomes. Research scientists at RIKEN saved much effort and ensured correctness in their research activities. They also reached interesting scientific conclusions with the help of the developed system. The system do not require significant infrastructure changes and is expected to facilitate more general laboratory activities that require flexible liquid handling.

Background & Results

Liquid handling is a widely seen task in laboratories and requires much carefulness and patience. Conventionally automatic liquid handling machines require a large amount of space and are not suitable for handling small amounts and large varieties of liquids. To solve this problem, we develop a flexible liquid dispensing system by using collaborative robot and AI methods. Specifically, we used a Vision Transformer to determine errors, and thus ensured that the pipette shaft can be accurately inserted into the liquid-drawing tip. Additionally, we developed automated recognition and segmentation neural networks that utilize images captured by cameras mounted on the robot end-effector to identify objects in the environment or segment the environment. The recognition and segmentation allowed precise targeting of specific objects. In the plant research on RIPPS, the robot can identify and segment each leaf and perform liquid dispensing on different parts of the plant, such as the stem, the largest leaf, and other designated locations. Users may also freely drop a rack of tips and provide a well plate of different liquids in front of the robot. The robot could recognize the racks, exchange tips, and handle liquids sequentially according to human specifications.

Significance of the research and Future perspective

The system developed in this study remarkably improves the efficiency and accuracy of handling small volumes of diverse liquid types, thereby alleviating the workload of laboratory researchers and facilitating scientific experimentation and data collection. Future work will focus on exchanging pipettes. The ultimate goal is human-like pipetting – A robot with a standard hand picks up different pipettes for varying liquid handling.

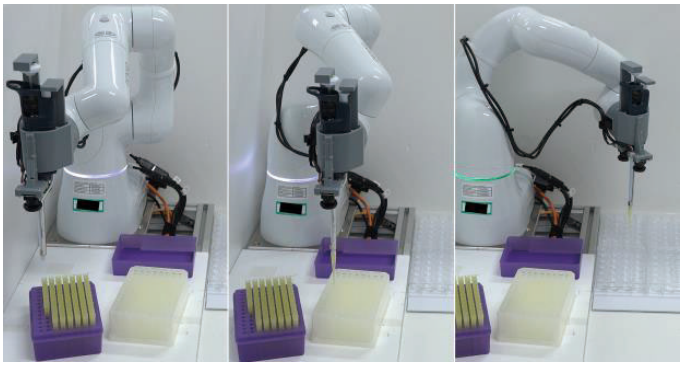

Fig. 1 Liquid handling using the developed robot system

Fig. 2 Hand mounted camera

Fig. 3 Liquid and genome screening in plant experiments

Patent

Treatise Zhang, Junbo; Wan, Weiwei; Tanaka, Nobuyuki et al. Integrating a pipette into a robot manipulator with uncalibrated vision and TCP for liquid handling. IEEE Transactions on Automation Science and Engineering (TASE). 2024, 21(4), 5503-5522. doi: 10.1109/TASE.2023.3312657

URL

Keyword lab automation, robotic manipulator, AI