Active Feeding System using a General-purpose Manipulator

Daehyung Park, Yuuna Hoshi, Harshal P Mahajan, Wendy Rogers , Charles C. Kemp

***Abstract*— General-purpose manipulators have the potential to provide assistance for activities of daily living such as feeding. However, the complexity creates challenges in providing assistance to people with disabilities. We present a proof-of-concept robotic system for assistive feeding that consists of a PR2 from Willow Garage, visually-guided autonomous behaviors, and various user interfaces. We evaluated our system with 9 able-bodied participants and 4 people with disabilities. All participants successfully ate selected food using the system and reported high rates of success for the autonomous assistance.**

I. INTRODUCTION

Feeding is an essential activity of daily living (ADLs) for staying healthy. However, people with disabilities (ex., quadriplegia) often have difficulties feeding themselves without caregivers due to paralysis or muscle weakness. For their independent feeding, a number of feeding devices have been introduced: arm supports or feeding robots. These specially designed devices often provide *passive feeding* assistance that requires a user's upper-body or -limb movement, so these are unavailable to people with severe motor impairments. Alternatively, in this work, we use a general-purpose manipulator as a robotic-feeding system to extend the assistant capability using its high-dof system and a variety of sensors.

II. OUTLINE OF SYSTEM

We present a proof-of-concept robotic system for assistive feeding improved from our previous work [1]. The system consists of a Willow Garage PR2, visually-guided autonomous behaviors, and two user interfaces. Our feeding system contributes to the adoption of the general-purpose manipulator as an assistive robot for people with more impairments. Unlike other platforms, our system provides *active feeding* assistance for users who cannot move their upper body by autonomously delivering a user-selected food inside the estimated mouth location. We also increased the accessibility of the system by providing graphical- and gesture-based interfaces for diverse needs.

Figure 1 shows the configuration of our robot-assistive feeding system using a PR2 robot, which consists of an omni-directional mobile base, a 1-DoF telescoping spine, and two 7-DOF back-driverable arms. We run the PR2 on Robot Operating System (ROS) Indigo. The system can perform three independent tasks: scooping (or stabbing), feeding, and wiping. A user can command a preferred task via a web-based graphical user interface or gesture-based user interface.

D. Park, Y. Hoshi, H. P. Mahajan, and C. C. Kemp are with Georgia Institute of Technology, Atlanta, GA. W. Rogers is with University of Illinois Urbana-Champaign, IL. *D. Park is the corresponding author deric.park@gatech.edu.

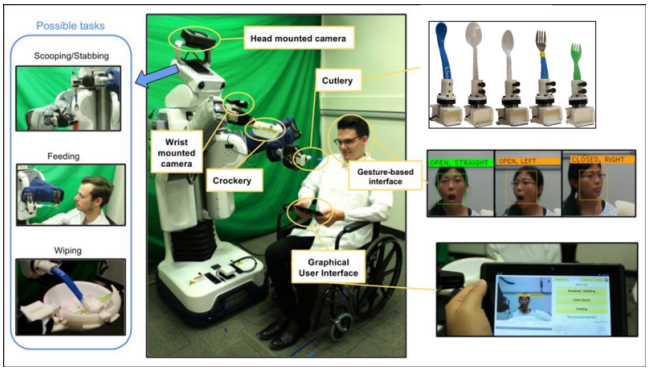

Fig. 1: The outline of a robot-assisted feeding system.

For the scooping, the system finds the best scoopable (or stabbable) location using a head-mounted RGB-D camera, Microsoft Kinect V2, to scoop a spoonful of food in a bowl held by its right arm. For the *active feeding*, the system estimates the user's face and mouth pose by mounting an Intel SR300 RGB-D camera on the top of the right wrist. In addition to the cameras, the system runs various sensors to check anomalous behaviors during the tasks.

III. EVALUATION & CONCLUSION

We evaluated the robot-assisted feeding system with able-bodied participants and people with disabilities. As a step towards use by people with disabilities, we recruited 9 able-bodied participants and performed 96 feeding executions per person in our laboratory from April 30th to May 12th, 2017. We also designed a long-term evaluation to observe the system's daily assistance capability. The author conducted a total of 428 feeding executions for 22 days between April 3th and July 28th, 2017. Finally, we conducted evaluations with 4 people with disabilities in and out of the laboratory. The participants also answered post-experiment questions (five-point Likert type questionnaire items) after the experiment.

Throughout the evaluations, our robot-assisted feeding system successfully fed foods to both able-bodied participants and people with disabilities. Participants agreed that the system comfortably, successfully, and safely provided feeding assistance with an easy-to-use interface. Overall, our results suggest that it is feasible for general-purpose manipulators to provide feeding assistance.

REFERENCES

[1] D. Park, Y. K. Kim, Z. Erickson, and C. C. Kemp, "Towards assistive feeding with a general-purpose mobile manipulator," in *IEEE International Conference on Robotics and Automation - workshop on Human-Robot Interfaces for Enhanced Physical Interactions*, 2016.