Study in Spoons

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Abstract

The Assistive Dexterous Arm (ADA) is an assistive robot that people with upper-extremity mobility impairments can use to eat a meal. In the past, this system has focused on fork-based feeding. In this work, we investigate the challenges introduced when transitioning ADA from fork to spoon use. While spoons may improve perceived safety by eliminating sharp tines, they can also place greater demands on food acquisition and transport, making the system more sensitive to motion instability, spillage, and utensil geometry. Through evaluation of the system and an interview with a community researcher, our preliminary results highlight the importance of treating spoon-based feeding as a distinct design space when building assistive robotic feeding systems that meet the needs of real users.

CCS Concepts

• **Human-centered computing → Participatory design; Accessibility technologies**; • **Computer systems organization → Robotics**.

Keywords

assistive technologies, community-based participatory research, speculative design, robot-assisted feeding

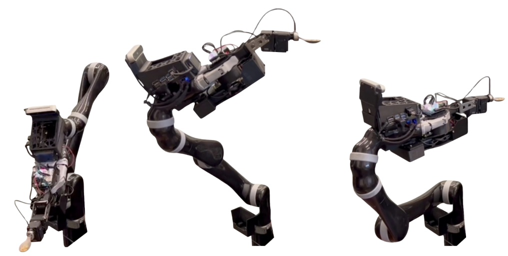

Figure 1: Articutool Balancing Spoon During Transport

1 Introduction

Eating is a fundamental human experience. For many people with motor impairments, however, accessing a wide variety of foods independently can be challenging. Although assistive feeding systems have made progress toward supporting independent eating, challenges, including reliably acquiring food, maintaining consistent bite sizes, and avoiding spillage, still remain [1–3].

Prior work with the Assistive Dexterous Arm (ADA) robot has focused on the task of acquiring solid food with a fork [4]. Following a successful two-week deployment of our ADA arm for fork feeding [4], we recognized the need to expand capabilities to include a wider variety of foods, particularly those that require a spoon, such as soups, yogurts, and other soft foods. Spoon feeding introduces additional complexity beyond that of a fork, including the balancing of volume, trajectory, and consistency (Figure 3). With this, factors that humans manage effortlessly by hand become a failure-prone process for a robot, where spillage or unsafe motions are real concerns. This shift highlights the need to examine how utensil choice shapes system behavior and user experience.

To address these challenges, we developed the Articutool (shown in Figure 1), a modular, untethered 2-DOF wrist that decouples fine-grained utensil control from gross arm transport, helping maintain stable spoon orientation and reducing spillage. Building on this functionality, this paper shifts our focus from technical development to user experience and qualitative outcomes. We investigate the transition from fork to spoon feeding and present early findings from an interview with a participant (CR), an individual with quadriplegia who often works with us as a community researcher to bring lived experience with motor disabilities to our research team. We outline their likes, dislikes, and specific concerns regarding spoon-feeding functionality, exploring topics such as volume control, utensil handling, and safe transport. This work examines the successes and pitfalls of current designs from a user perspective, guiding the next phase of development toward more functional, safe, and comfortable robot-assisted feeding.

2 Selected Related Work

Prior work has developed a variety of feeding systems [5], including older ones such as the Winsford Feeder [6], the Robot Arm Work Table [7], and the Handy 1 [8], as well as more recent systems like the Neater Eater [9] and Obi [10]. Many of the commercial

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feeding systems listed use spoons, but cannot be customized to user preferences as extensively as a system such as ADA. We focus on the process of developing spoon-feeding for ADA specifically, due to the wide difference in robotic systems.

3 Methodology

We conducted a qualitative evaluation with one participant (CR), a quadriplegic adult male. He has previously used the ADA system [4, 11], but not the new Articutool addition. We conducted this interview over Zoom to avoid requiring CR to travel, focusing on showing videos of researchers eating with the Articutool that highlighted both the successes and failures of the current system. Rather than focusing on isolated bites, the videos showed multiple consecutive bites from the same bowl to capture the experience of using the system over the course of a meal. These videos, along with structured interview questions, were used to prompt feedback, observations, and requests from CR.

3.0.1 Granular Foods. We first evaluated spoon feeding using a granular food to probe the system's ability to reliably scoop small, solid items. For the video setup, the robot scooped pecans from a standard bowl using the Articutool with a standard spoon tip attached. We varied the amount of food in the bowl across trials to represent different stages of a meal.

During the video creation process, we made several observations. When the food volume in the bowl was low, the robot struggled to acquire meaningful portions, often lifting only small amounts of food with each scoop. Our current food detection procedure uses Segment Anything [12] to segment an image of the contents of the bowl or plate into pieces of food. The user then selects a piece via our custom web application, and the robot approaches the detected centroid [13, 14]. Using the fork, this procedure allowed us to spear the center of a bite of food, giving the fork a more stable grasp on the bite. However, with the spoon, the segmentation software detects the entire contents of the bowl as one segment on each bite, causing the spoon to scoop from the same area repeatedly, creating a pit in the bowl. Because the surrounding food did not flow to fill the space, once most of the pecans within this area were removed, the robot was unable to acquire pecans for additional bites.

While recording videos to demonstrate the system to CR, we temporarily mitigated this issue by manually shaking the bowl to redistribute the food, or by refilling the bowl to record multiple scoops in a row. However, these strategies are not practical for users with upper-extremity motor impairments.

Prior to meeting with CR, we considered several design directions to address this issue. One approach is to introduce randomized or distributed acquisition points rather than repeatedly targeting a single centroid to avoid creating a pit. Another is to actively redistribute food within the bowl before scooping, for example, by gently pushing or raking food together with the spoon to form a larger, more scoopable cluster before executing the scooping action. Finally, adjusting the spoon to a shallower angle could reduce digging into the food and instead promote surface-level scooping.

3.0.2 Viscous Foods. We conducted trials with yogurt to explore spoon performance with viscous foods. Our setup used the Articutool to acquire yogurt from a standard bowl, with repeated trials to observe the volume of yogurt acquired as well as number and quantity of spills. This setup allowed us to examine the relationship between utensil angle, arm movement, and food adhesion, and how these factors impacted spillage of viscous foods on a user.

We observed that the viscosity of the yogurt introduced additional challenges, causing food to adhere to the underside of the spoon or remain unevenly distributed across its surface, increasing the likelihood of delayed drips during transport. In contrast to fork feeding, where successful acquisition was the primary goal, spoon feeding introduces the complication of moving to the mouth without spilling (Figure 3).

To address this challenge, we identified several potential solutions to discuss with CR. These included introducing a wiping motion along the edge of the bowl after acquisition to remove excess yogurt at the bottom of the spoon and adding a plate-like attachment beneath the spoon to catch drips during transport.

3.0.3 Liquid Foods. Lastly, we explored scooping liquids. We anticipated that transporting liquids would require the most precise spoon control, as liquids are more prone to spilling/splashing. Liquid spillage also poses greater risks in some cases, such as when feeding a hot liquid like soup.

To investigate, we conducted trials of the robot acquiring several scoops of tomato soup from a standard bowl. We observed three primary challenges. First, small amounts of liquid occasionally sprayed or dripped from the spoon during acquisition and transport. Potential solutions hypothesized include smoothing the robot's motion to reduce small vibrations of the spoon and adding a brief pause after acquisition, while the spoon remains above the bowl, to allow liquid to settle before transport.

Second, we had designed a vertical scooping motion that worked for granular and viscous foods, but when tested on liquids, this motion did not acquire a full spoonful in each pass. In this scoop, the spoon enters the liquid from above at a near-vertical angle and lifts a portion of the soup along this trajectory. This approach is limited because the spoon cannot reach the sides or bottom of the bowl due to the current proximity of the spoon to the Articutool's motors, which collide with the bowl. One solution considered was modifying the spoon utensil design to increase clearance between the spoon body and the motors, allowing for deeper or angled scoops.

3.0.4 Other Observations. During our experiments, we experienced frequent path planning errors. After performing a scoop, the robot was often unable to find a viable path to the user's mouth due to the constraints introduced by having to keep the spoon level. When these failures occurred, the robot returned to a hard-coded "above bowl" position to prevent additional spillage, which required the bowl to remain in a fixed location on the table. To support this during evaluation, we marked the optimal bowl position with tape.

We also noted that the robot occasionally exhibited odd movements, such as raising the arm above the head, reaching around the side of the wheelchair, or using inconsistent trajectories between bites. To prevent these potentially alarming motions, we considered further constraining the robot's range of motion to more predictable paths and adopting a strategy in which the robot repeats previously successful movements to move food from the bowl to the user's face, thereby reducing variability and path planning failures.

3.1 Interview Materials and Protocol

To gather qualitative insights on the feeding videos, we conducted a structured interview with CR via Zoom. Our goal was to gather feedback on ADA's performance and to identify priorities for addressing observed challenges. In preparation, we first reviewed the recorded videos of the spoon-feeding trials for granular, viscous, and liquid foods. For each video, we brainstormed targeted questions designed to elicit feedback on key aspects of the feeding process, including utensil handling, food acquisition effectiveness, spillage, and overall safety and comfort for potential users. The challenges we had identified up until this point included: occasional large arm motions during transport, path planning failures, spillage, and small quantities of food acquired per scoop.

We compiled these materials into a Google Slides presentation, which organized the videos alongside the corresponding discussion questions to guide our conversation. The interview lasted approximately one hour, during which CR provided insights on which issues were most critical to prioritize and offered suggestions to address these issues.

4 Interview

4.1 Food Access and Utensil Preference

CR emphasized that spoon feeding is necessary to access many foods that fork-based systems cannot support, including soup, cereal, and yogurt. He also noted that while some foods (e.g., Chex Mix) could technically be eaten with a fork, a spoon would often be preferred, stating that "a spoon is just easier."

4.2 Perceived Safety and Motion Comfort

Compared to fork feeding, CR thought that he would feel more comfortable with a spoon, explaining that forks felt "a lot scarier with pointy ends coming at your face." However, this comfort depended heavily on predictable and controlled robot motion. When shown videos featuring odd movements, including overhead arm movements, he remarked that he "would have kill-switched immediately," indicating that these motions substantially reduced his sense of safety.

4.3 Spillage, Cleanliness, and Transport Distance

Spillage during transport, especially with liquids, was a major concern for CR. He suggested that having "something underneath the food" would improve his sense of security, either through a guard beneath the spoon or by placing the bowl closer to his face. We discussed how people typically eat closer to their body than an arm's length away, and that reducing transport distance could decrease spillage, limit alarming arm motions, and prevent food from becoming cold. CR also noted that positioning the bowl beneath the face could help catch drips from the chin. Notably, he disliked the idea of a spoon-wiping motion on the bowl to reduce drips, noting that it would add unnecessary time to each bite.

4.4 Utensil and Bowl Design Preferences

When discussing potential solutions to the pit created by scooping granular foods, we came to the conclusion with CR that the simplest option was rotating the scooping motion to enter the bowl at different points. CR also shared his idea to use a clip-on plate guard, or a plate with one high side, to enable the robot to push granular foods against the side of a plate rather than scooping from a deep bowl, sharing that this is an assistive device that is already commonly used. CR also supported our idea of elongating the spoon design to create more distance between the spoon and the Articutool motors, which would enable more dexterous and successful scoops of liquid. Finally, CR expressed a preference for a deeper spoon capable of acquiring larger bites, reducing the number of feeding actions per meal, and emphasized that utensil functionality was far more important to him than appearing as a regular dinner spoon.

4.5 Key Themes

Across the interview, CR's feedback consistently emphasized three priorities: safety, driven by predictable motion and reduced risk of spills, cleanliness, particularly minimizing drips during transport, and efficiency, supported by shorter transport distances and larger bite volumes. We use these themes to understand the system's current limitations and guide future design directions.

5 Discussion

In this section, we revisit the challenges initially identified during our trials and refine them based on CR's feedback. The interview provided important context for understanding how these challenges affect his overall eating experience.

5.1 Unpredictable Arm Motions

As noted, we found that the added constraints to the robot's path led to sometimes dramatic motions of the arm. Spurred by CR's comments, one of our main next goals is to provide predictable, contained motions of the arm to achieve a safe and comfortable user experience. This could be addressed by training learning-based models to prioritize a small set of safe, preferred paths, particularly given that the robot repeatedly moves between the same resting position and a fixed feeding pose in front of the user.

5.2 Balancing Spills and Speed

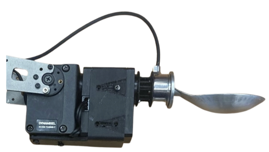
CR emphasized that eating speed was important to him. As a result, he disliked spoon-wiping motions on the bowl, which led us to discard our initial bowl-scraping solution. Based on our conversation, we instead plan to focus on the two options suggested by CR: a retractable guard under the spoon to collect drips, and moving the bowl location closer to the user's mouth to reduce large transport motions and keep drips located over the bowl. We will begin with adjusting the bowl location as a quicker first step to try, as this only requires changing some preset robot positions and reconfiguring actions, rather than designing a new mechanical part. We will study the tradeoffs and potential benefits of moving the food source closer to the user. While this option could cause some social discomfort (blocking the user's view or having robot movement very close to the user's face), the reduction in travel distance would likely reduce the risk of spillage.

5.3 Path Planning Failures

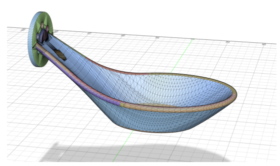
Delays caused by path planning failures were not shown in the videos presented to CR, as this was not our main focus. However, given CR's emphasis on feeding speed, minimizing these failures is an important future direction, as more reliable planning would reduce interruptions and wait time during feeding. This further supports using learning-based methods to focus on stable and repeatable transport paths.

5.4 Small Scoops

During testing and interviews, the robot's difficulty in acquiring full scoops emerged as a key concern, as CR noted that smaller bites increased overall meal time. Although we initially worried that a larger or unconventional spoon might negatively affect the social experience of feeding, CR emphasized that functionality mattered most to him in this area. This feedback expanded our ideas of acceptable utensil designs and motivated the development of an elongated spoon to improve acquisition.



(a) Current spoon tooltip design



(b) Initial draft of an elongated spoon design

Figure 2: Comparison of current spoon tooltip on the Articutool and an initial draft of an elongated spoon design.

A main limitation of the current system comes from existing hardware design. Because conventional spoons are designed around human wrist dexterity rather than robotic kinematics, directly reusing the standard spoon shape constrains acquisition and stable transport in assistive feeding systems. While the new Articutool offers significant improvements in balance and movement capabilities, its current structure prevents the deeper diving angles needed for effective scooping, especially when the volume of food or liquid in a bowl is low. Resolving this problem requires a hardware-focused design change to increase the robot's reach into a bowl. For this, we will design and test a spoon with a longer, permanent bend or angle in the handle (Figure 2). We hypothesize that this new structure will compensate for the Articutool's bulk, allowing the spoon bowl to reach deeper into a bowl without the Articutool's structure colliding with the rim of the bowl (which can cause spills and decreases the robustness of the system).

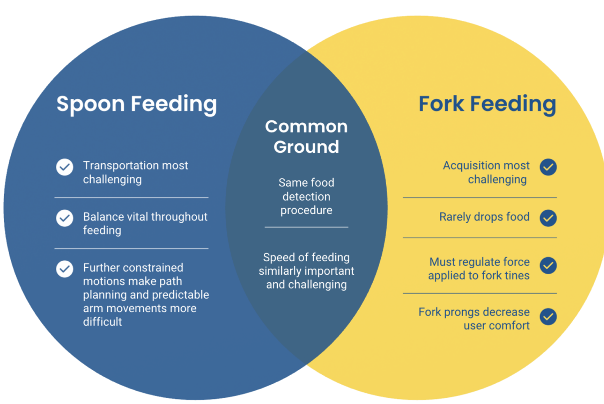


Figure 3: Spoon vs Fork Feeding Venn Diagram

We will also integrate and test assistive plate guards or structured lips on the bowl/plate, as suggested by CR. This is a solution often used in occupational therapy [15] and directly addresses the problem of collecting granular foods without resorting to over-engineered robotic motions. We will explore movements that push foods against the guards on the rim of the dish to allow for scooping larger volumes even when food volume in the dish is low.

Our ultimate goal is to develop a system that can reason about the physical space surrounding the system, including the geometry of the bowl, the density of the food, and the current food level. This will allow the robot to move beyond pre-programmed actions and adapt its scooping motion dynamically (e.g., switching from a deep central dig to a "counter-lever" or edge-scoop motion) to maximize food acquisition from any dish, which will enable a fully flexible and robust feeding assistant. Methods like reinforcement learning can help the robot improve scooping and transport motions to best fit the foods it is working with and help it generalize to new, unseen food types and dishes without the need for more code.

6 Conclusion

In this work, we examined the transition from fork to spoon-based robotic feeding on ADA through feedback from a community researcher. This feedback helped us better understand how to make our system more effective and usable. This exploration showed how simply switching to a new utensil can shift both user experience and system demands, bringing forward constraints and challenges that are less apparent in fork-focused designs (Figure 3). Rather than viewing spoon feeding as an extension of existing approaches with a fork, our findings suggest the need to reconsider design priorities to better support stability, safety, and user comfort. By working closely with a community researcher, this work demonstrates how user-centered evaluation can guide the development of assistive feeding technologies that better match everyday eating needs.

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