What if your wheelchair could help you eat?

Discover the Future of Assistive Tech

Introduction

Mealtime is a fundamental part of daily life, yet for at least 195 million in India and 1.8 million in US alone, it requires assistance, which can impact feelings of dignity and independence. To address this profound challenge, a collaborative team from the University of Washington and Cornell University has developed a groundbreaking robot-assisted feeding system designed to empower users.

This system is built from the ground up on three core principles:

Safety, Portability, and User Control. Unlike stationary systems, this entire setup—including a sophisticated robot arm, cameras, and compute hardware—can be mounted on and powered directly by a person's own wheelchair, making it a truly portable solution for everyday life. Control is placed directly into the hands of the user via a custom web app, which allows them to operate the robot using the assistive technologies they are already familiar with, like chin joysticks or head-activated buttons.

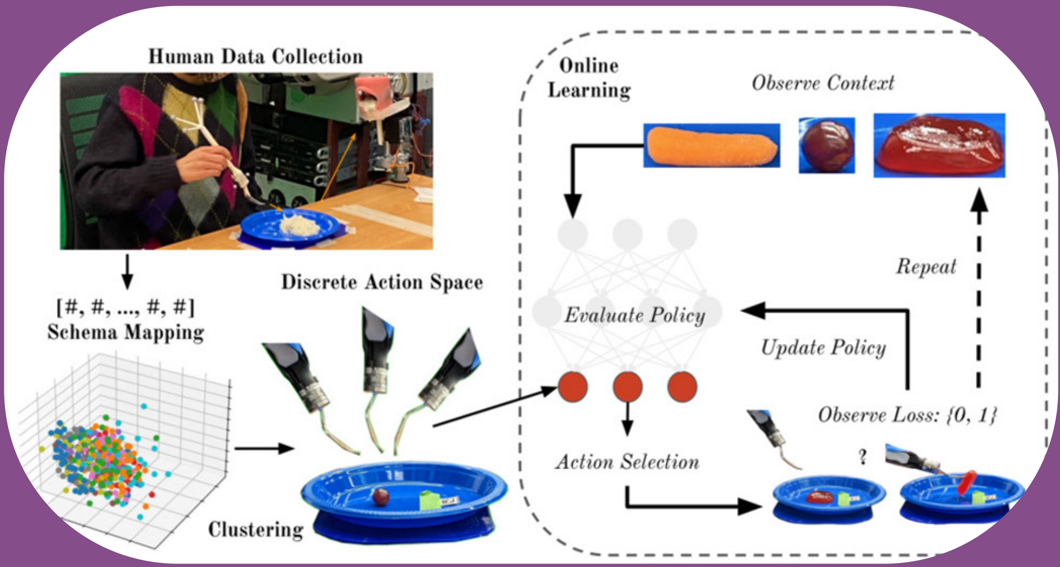
The system's intelligence shines in its two primary functions. For bite acquisition (picking up food), it uses an advanced multi-modal online learning approach. By analyzing human motions, it learns a diverse set of actions for skewering and scooping, allowing it to tractably adapt to new and unseen food items. For the delicate task of bite transfer, it employs real-time mouth perception and physical interaction-aware control. Using a combination of cameras and a force-sensing fork, the robot can safely navigate to the user's mouth, adapt to voluntary and involuntary movements, and react appropriately to the physical interaction of a bite.

Crucially, this technology was not developed in a vacuum. It was co-designed with community researchers and has been validated through numerous studies with end-users who have conditions such as Multiple Sclerosis, Spinal Cord Injury, and Spinal Muscular Atrophy, ensuring it is a practical and empowering tool built for those it is intended to serve.

three fascinating things I learned from this paper

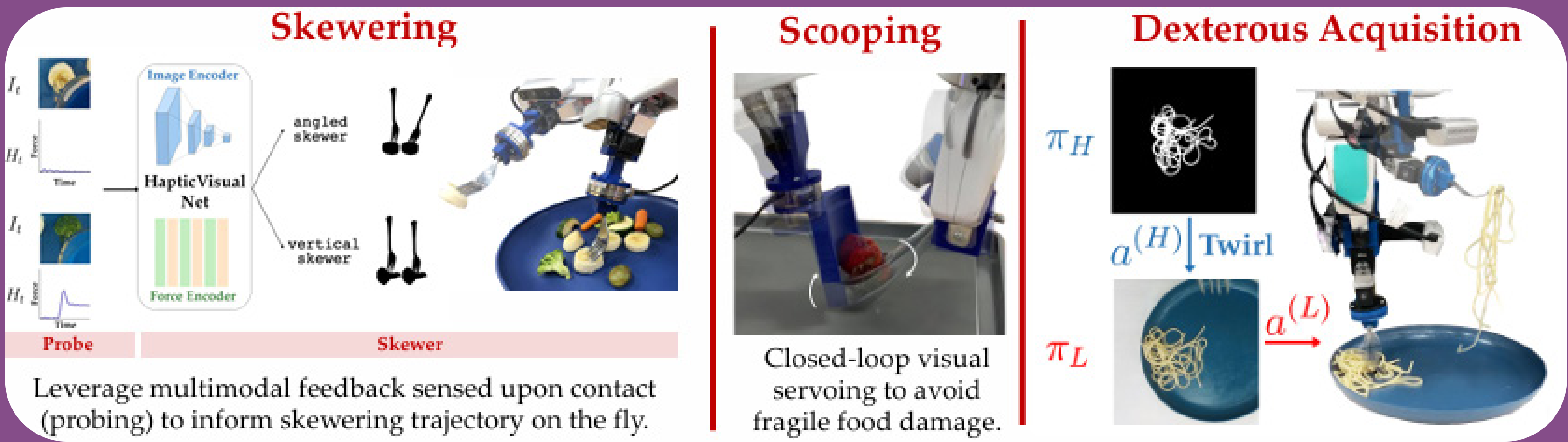
The Discrete Action Space

To make the complex problem of learning how to acquire food more manageable, researchers developed a discrete action space. Rather than having the robot try to invent a motion from a nearly infinite set of possibilities, the team first collected a library of expert examples by recording approximately 500 human acquisition trajectories. Using a machine learning technique called **k-medioids clustering**, they analyzed this human data to identify the most representative and effective motions. This process resulted in a curated menu of 11 distinct actions that encompass a wide range of proven techniques, from wiggling inside food to a novel tilting motion that helps food fall onto the utensil. By creating this "greatest hits" menu, the robot's learning task is dramatically simplified: it just needs to learn which of these 11 proven actions is best for the specific food it sees, allowing for much faster and more tractable adaptation.



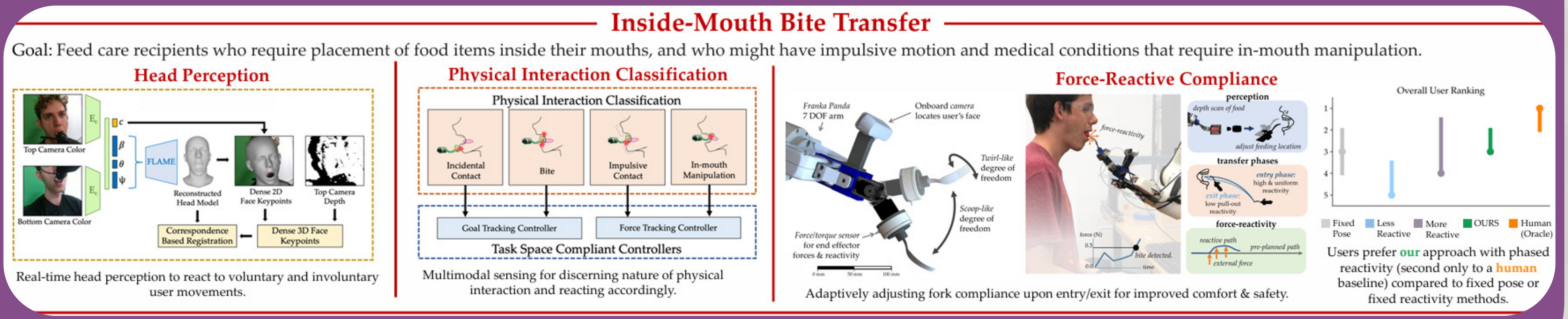
26-Dimensional Interpretable Acquisition Schema

The 26-dimensional interpretable acquisition schema is a structured framework designed to serve as a comprehensive blueprint for any single robotic fork motion. This schema functions like the "DNA" of an action, where each of the 26 dimensions represents a specific, human-understandable (interpretable) characteristic of the movement, such as the fork's approach angle, wrist rotation, penetration depth, and applied force. By precisely defining the values across these 26 parameters, the system can mathematically capture and differentiate between a wide variety of nuanced techniques observed in human data, including skewering, scooping, and twirling. This detailed schema creates a rich, continuous action space that provides the foundational language necessary for analyzing and replicating complex, real-world utensil skills.



Haptics: Feeling the Food

When a robot's task is to physically interact with a person's mouth, ensuring safety and a gentle touch is paramount. This is where haptics, the robot's "sense of touch," becomes indispensable. The system's custom fork is equipped with a 6-DOF ATI Nano25 force-torque sensor that wirelessly measures forces, providing rich sensory feedback. This sense of touch is critical for two distinct phases. First, during bite acquisition from the plate, the robot uses force data to learn why an action succeeded or failed, helping it adapt to new foods. More critically, during the bite transfer to the user, this haptic data is combined with vision in a multimodal sensing approach. This allows the robot to feel the delicate, physical interactions with the eater, discerning an accidental bump from an intentional bite. This ability to feel is what enables the robot to react appropriately and ensure the user’s safety and comfort.



This post is based on the incredible work presented in the paper:

"An Adaptable, Safe, and Portable Robot-Assisted Feeding System"

This research is a collaborative effort between:
University of Washington
and
Cornell University

Key Researchers:
The work was led by a large team, including principal investigators Tapomayukh Bhattacharjee (Cornell) and Siddhartha S. Srinivasa (UW) , and lead student authors Ethan K. Gordon (UW) , Rajat Kumar Jenamani (Cornell) , and Amal Nanavati (UW).

Publication:
The paper was published in the
Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction (HRI '24).

Learn More & Dive Deeper:
To explore this project further, visit their official websites:
robotfeeding.io
emprise.cs.cornell.edu/bitetransfer

Summary and Design by: Ranveer Bhura