Designing a Mobile Device Positioning Robotic Arm for Power Wheelchair Users

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***Abstract*—Although portable screen-based devices, such as smartphones and tablets, provide crucial access to communication, information, and entertainment, individuals with upper body motor impairments who use power wheelchairs face significant challenges in positioning and interacting with these devices. While existing solutions, including rigid arm positioners (e.g., Mount'n Mover) and flexible hose-based mounts (e.g., ModularHose), offer some level of adaptability, they remain constrained by issues such as high cost, limited adjustability, and the need for manual positioning. These limitations reduce user independence, particularly for those with severe motor impairments. This workshop paper explores the current landscape of device positioning solutions, identifying critical challenges in stability, reconfigurability, and accessibility. Our analysis highlights a pressing need for automated, adaptive solutions that enhance usability and reduce reliance on manual adjustments. To address this gap, we outline a roadmap for the development of a mobile device positioning robotic arm tailored for power wheelchair users.**

***Index Terms*—accessibility, human-robot interaction, robotic Arm, device positioning, power wheelchair**

I. Introduction and Background

Portable screen-based devices, such as smartphones and tablets, enable access to information, communication, entertainment, and much more. However, people with upper body motor limitations, who use a power wheelchair cannot hold these devices and interact with their screens in the way able-bodied users can [1]. Instead they use different assistive technology, such as eye trackers or switches, to provide input to their devices. The screen of the device, which displays input options for the user and the output of the interaction, needs to be positioned in a way to support the interaction, given the unique needs and preferences of the user.

Several accessibility research mentioned device positioning for the power wheelchair users is a big challenge. For instance, Carrington et al. described that power wheelchair users often have difficulties to use devices due to their upper body motor impairment. They argued that mobile device accessibility could be improved through designs that take into account users' functional abilities and take advantage of available space around the wheelchair itself [2]. Additionally, in their systematic review of Physically assistive robots, Nanavati et al. demonstrated several ADLs that can be assisted by physical assistive robots however, received less attention in HRI research. Assisting in managing screen one of them [3].

This paper explores existing device positioning solutions and outlines a roadmap for HRI researchers to design a mobile device positioning robotic arm for power wheelchair users.

II. Challenges with Current Available Device Positioning Solutions

A. Device positioning system for general population

This section examines the types of device positioning systems available for the general population and the challenges associated with them. Our analysis is based on Amazon product reviews of various commercially available device holders, including the AOCHUAN Gimbal Stabilizer [4], Pictron VIJIM [5], iOttie iTap 3 Magnetic Dash and Windshield Mount [6], and Lamicall Gooseneck Tablet Holder Stand [7].

The primary challenge identified is the stability of base attachments. Many products, including the Lamicall Gooseneck Tablet Holder Stand, suffered from weak base attachments, leading to instability, especially with heavier devices. Another significant issue is the reliability of device attachment mechanisms. Device holders typically used magnetic, spring-based clamps, or non-attached support mechanisms. While magnetic options like the iOttie iTap 3 offered convenience, most relied on clamps that frequently failed to secure devices properly, causing grip failures and usability obstructions. Reconfigurability also emerged as a limitation: many holders lacked full 3D positioning and rotation capabilities. Gooseneck and limited-angle joints often required frequent manual adjustments, as reported by users of the Pictron VIJIM LS08. In summary, current device holders face significant challenges in stability, secure attachment, and adjustability. While motorized options offer potential, they remain hindered by durability and power constraints, underscoring the need for more adaptive, user-friendly solutions.

B. Device positioning system for power wheelchair users

We also examined currently available device holders for power wheelchairs. Through a review of a discussion on device mounts for power wheelchairs in the Assistive Technology Facebook group, we identified several recommended brands: Mount'n Mover [8], RAM (primarily designed for car mounting) [9], ModularHose [10], and Daessy [11].

Our analysis found that Mount'n Mover, RAM, and Daessy provide stable, multi-jointed arm positioners, while ModularHose offers a flexible, bendable hose design that prioritizes adjustability over rigidity. Mount'n Mover, RAM, and Daessy use frame clamp mounting systems for superior stability and durability, with Daessy's quick-release system enhancing ease of use. In contrast, ModularHose relies on spring or screw-tightened clamps, making it more adaptable but less stable.

Device compatibility varies: Mount'n Mover and Daessy support multiple devices, whereas RAM is limited to laptops, and ModularHose requires separate positioners for different devices. Mount'n Mover offers user-specific lock-setters, adjustable plates, and 360-degree swiveling, while ModularHose's rigid structure can be challenging for users with limited dexterity.

A key limitation is the lack of motorized adjustability, except for Mount'n Mover Power Mounts. Manual positioning poses accessibility challenges for individuals with upper body impairments, reducing independence and requiring caregiver assistance. While motorized options improve usability, their high cost and maintenance needs limit accessibility.

Cost remains a major concern. Mount'n Mover, Daessy, and RAM range from $300 to $4,800, with feedback highlighting their rigidity and high price. ModularHose, priced between $36 and $124, received positive reviews but was criticized for difficulty in adjustment, stability issues, and phone clamp breakage. More affordable, adaptive, and automated solutions are needed to enhance accessibility for power wheelchair users.

Ultimately, while all these solutions serve specific needs, the lack of motorization or automation across most available device holders highlights a significant gap in accessibility. For users with upper-body impairments, reliance on manual adjustments can severely limit independence. Addressing these limitations through more user-friendly, automated, and cost-effective solutions is essential to advancing accessibility in assistive technology.

III. Designing a Mobile Device Positioning Robotic Arm for People with Upperbody Impairment

Device positioning is a crucial part of ADLs of people with upper body impairment who use a power wheelchair for mobility. Introducing automation in the space of device positioning for power wheelchair users through robotic arm solutions will require several explorations and research. We list some of the the foreseeable steps that we as HRI researchers can take to get involved in this space :

- Identifying Possible Tasks: There are several screen-based tasks that a Mobile Device Positioning Robotic Arm might support, such as reading (e.g., email, news, social media), watching (e.g., Netflix, Youtube), audio/video communication (e.g., phone, Zoom), typing (e.g., email, text message), playing a game, taking a photo, or showing someone a photo. However, researchers must learn from power wheelchair users with upper body impairments to refine its design. To identify the tasklist we envision the following human-centerd steps:
  - *Contextual inquiry with users:* Researchers should observe and interview individuals with motor limitations to document device usage, past solutions, frustrations, and desired improvements. They will also gather feedback on robotic positioning systems and preferred features.
  - *Interview with assistive technology experts:* Occupational therapists and assistive technology technicians will be interviewed on client device usage, positioning challenges, existing solutions, and their perspectives on robotic positioning systems and feature preferences.
- **Participatory body-storming:** After the preliminary exploration with the target users and AT specialists, researchers need to conduct a body-storming in which participants will explore ideas of how the robotic arm should behave and how they want to control the arm by having a person from the design team emulate the arm.
- **Simulation prototype:** To identify the simplest possible robotic arm configuration that can support the desired device interaction modes, researchers should simulate a robotic arm with human interaction to identify the simplest effective configuration. Animations from the simulation will help gather user feedback on design, positioning, and movement.
- **Physical implementation and evaluation:** Finally, with all the previous learning, researchers need to implement a first version of the system with the designed interface on a real robotic arm and gather further feedback from users who test it.

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References

[1] Motahar, T., Wiese, J. (2024). Investigating Technology Adoption Soon After Sustaining a Spinal Cord Injury. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 8(1), 1-24.

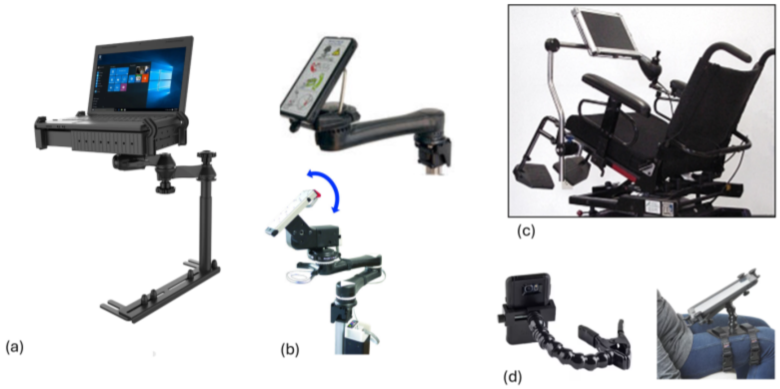

Fig. 1. Example of currently available device holders for power wheelchairs: (a) RAM, (b) Mount'n Mover, (c) Daessy, and (d) ModularHose.

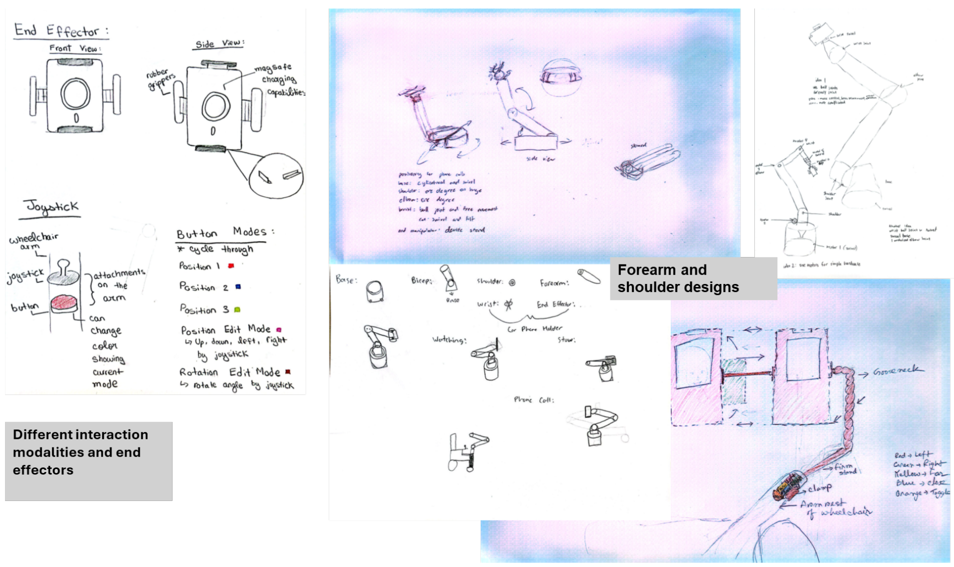

Fig. 2. We conducted a brainstorming and design sketch session with four undergraduate students who are learning to design and fabricate mobile device positioning Robotic Arm for power wheelchairs. During this session, they explored various interaction modalities, end effector designs, and forearm and shoulder configurations. We present a selection of their designs, which are highly relevant to the context of this paper.

[2] Carrington, P., Hurst, A., & Kane, S. K. (2014, April). "Wearables and chairables: inclusive design of mobile input and output techniques for power wheelchair users," In Proceedings of the SIGCHI Conference on human factors in computing systems (pp. 3103-3112).

[3] Nanavati, A., Ranganeni, V., Cakmak, M. (2023). Physically assistive robots: A systematic review of mobile and manipulator robots that physically assist people with disabilities. Annual Review of Control, Robotics, and Autonomous Systems, 7.

[4] "Gimbal Stabilizer for iPhone," https://www.aochuan-tech.com/?variant=42663235715125 (accessed Feb. 9, 2025).

[5] "PICTRON VIJIM Flexible Arm Auxiliary Holding Arm," https://www.amazon.com/Flexible-Auxiliary-Detachable-2-Section-Accessory/dp/B09BJB1YZ2 (accessed Feb. 9, 2025).

[6] "iTap 3 Magnetic Dash and Windshield Mount," https://www.iottie.com/product/itap-3-magnetic-dash-windshield-mount/?srsltid=AfmBOoqd-rJcujRU6ey9AgyKJ1-ks5vIV2RSPsGuoFN8yp8gToHgq3MW (accessed Feb. 9, 2025).

[7] "Lamicall Gooseneck Phone Holder ," https://lamicallshop.com/products/gooseneck-phone-holder?srsltid=AfmBOoqg8Um1FPJN3AOgrbacC-4mtISocdlDLKKDueKelNaoKRaOH6JF (accessed Feb. 9, 2025).

[8] "Choosing a Mount'n Mover Wheelchair Mount ," https://www.mountnmover.com/products/mounts (accessed Feb. 9, 2025).

[9] "RAM® No-Drill™ Universal Laptop Mount," https://rammount.com/products/ram-vb-196-sw1 (accessed Feb. 9, 2025).

[10] "Flexible Mounts," https://www.modularhose.com/ (accessed Feb. 9, 2025).

[11] "DAESSY Mounting System," https://www.daessy.com/dms/indexm.html (accessed Feb. 9, 2025).