Learning about and Designing Physical Assistive Technology for Upper-body Motor Impairment Individuals

By

Mililani Rosare

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HCI MS Capstone Project Proposal

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Abstract

Many individuals use laptops or desktops daily for various everyday tasks and activities, but sometimes individuals with upper-body motor impairments may struggle due to their physical assistive technology, such as adaptive mice, specialized keyboards, and more. Additionally, there is a gap in knowing about physical assistive technologies, struggles with current tools (i.e., limited customization and personalization, accessibility, lack of standardization, etc.), and suggestions for tools specifically to laptops and desktops. For my capstone project, I would like to explore how we can improve or develop new tools for these individuals. Previous studies have explored various input tools that are used; however, I will be focusing on mouse and keyboard input modalities, while using a website on a laptop or desktop. To gather results, I plan on distributing a survey, followed by an observation and semi-structured interview to learn about their physical assistive technologies and more. I hope to provide a list of insights, guidance for design and development, and suggestions that can leverage other researchers' work about learning and designing physical assistive technologies for individuals with upper-body motor impairments.

1 Introduction and Background Information

Individuals with upper-body motor impairments use various accessibility tools when using technology, such as laptops and desktops. Experiencing upper-body motor impairments may affect different parts of upper extremities, such as arms, hands, fingers, or a combination. This can influence the ability to use a laptop or desktop with various tools: mouse, keyboard, and more. To my knowledge, there is little research on what is accessible for individuals with upper-body motor impairments. Previous studies for individuals with upper-body motor impairments have explored customizable/personalized wearables [1,9], assistive robotics [11], virtual reality hand function rehabilitation [7], but there is a gap in knowledge about what physical assistive technology are used, how people might struggle with current tools, and suggestions for improvements when using a laptop or desktop.

Individuals with upper-body motor impairments struggle with click-and-drag, multiple key functions (i.e., shortcut keys), combination of key and mouse functions (i.e., clicking on hyperlinks), and more when using a laptop and desktop [10,12]. There are many physical assistive technology alternatives when interacting with a laptop or desktop, such as mouse and keyboard input modalities. A study on mouse input analyzed mouse movements through multi-directional point and click interaction tasks to improve input and interaction techniques [6]. Understanding various tools when using a laptop or desktop may help to inform improvements for the design and development of accessible technology.

This work will focus on learning and suggesting improvements to current physical assistive technologies, specifically mouse and keyboard modalities, on a laptop or desktop for individuals with upper-body motor impairments during website navigation. Current issues with physical assistive technologies include compatibility problems, customization limitations, a lack of universal standards and more. To address these challenges, it is essential to foster collaboration among users, designers, and developers in order to collectively build tools that ensure accessibility for these individuals. Exploring websites as opposed to application facilitates the observation of challenges and successes associated with mouse and keyboard input modalities. Focusing on websites is relevant for understanding physical assistive technology, as websites often entail frequent updates, flexible interactions, and diverse click and navigation options which emphasize the challenges and benefits posed by website navigation for individuals relying on mouse and keyboard inputs. To garner more information on this topic, I will be using mixed methods of a survey, observation, and semi-structured interview. Acquiring findings for my research may provide further insight and guidance for how to design and develop physical assistive technologies that provide access to laptops and desktops for upper-body motor impairment individuals.

2 Motivations and Goals

2.1 Problem/Purpose and Significance

To address the challenges faced by individuals with upper-body motor impairments there exist issues rooted in the lack of knowledge regarding various physical assistive technologies, current challenges, and potential recommendations for improvements when utilizing a laptop or desktop during website navigation.

2.2 Research Questions

The research questions I would like to explore for my project are:

- RQ1: What barriers are there with current physical assistive technologies for those with upper-body motor impairments when using a laptop or desktop?

For this question, I plan to investigate current physical assistive technologies used by people with upper-body motor impairments. I will explore what input modality preferences they have when using a laptop or desktop.

- RQ2: What expectations do users have for physical assistive technologies when using a laptop or desktop?

Many previous studies have underscored the challenges associated with upper-body motor impairments experience, revealing limitations in areas such as fatigue, limited fine motor control, lack of customization, learning curve for new technologies, and more. Similar to the first research question, I plan to investigate previous and current struggles users have when using physical assistive technologies, such as mouse and keyboard input modalities. For example, learning why the individual stopped using other input modalities would be valuable to my research. Then explore users' expectations for physical assistive technologies when using a

laptop or desktop and explore potential enhancements that may improve their daily activities and tasks with current devices. This will allow me to create a list of future improvements to these physical assistive technologies that researchers can explore for future studies.

- RQ3: How can we enhance existing technology to offer improved accessibility for individuals with upper-body motor impairments when using laptops and desktops?

Through the results of this study, I plan on listing preferences, needs, effective input modalities, barriers, satisfaction, availability, integration, and more. These findings will guide future researchers in how we can provide more accessibility needs to suit those with upper-body motor impairments.

2.3 Research Objectives

My objective of this project is to learn more about how individuals with upper-body motor impairments use physical assistive technologies, specifically mouse and keyboard modalities, when using a laptop or desktop. After gaining insights on the challenges faced by these individuals, my focus will shift towards proposing and implementing improvements for mouse and keyboard input modalities on laptops and desktops to enhance their overall user experience. There are various previous studies that explore different accessibility tools, but none to my knowledge that talks about how to improve physical assistive technology for people with upper-body motor impairments when using a laptop or desktop. Through my project, I plan on distributing a survey about physical assistive technologies, suggestions, improvements, and more, followed by an observation of the participant using a website utilizing a mouse and/or keyboard, and concluding with a semi-structured interview for a more in-depth insight about how tools are used.

2.4 Potential Contributions and Benefits

From my findings, researchers can know more about what physical assistive technologies are available and helpful when using a website on a laptop or desktop for those with upper-body motor impairments. This research may also be helpful background information to those who are interested in creating tools accessible to people with upper-body motor impairments. Additionally, this study will leverage future studies for physical assistive technologies for individuals with upper-body motor impairments.

3 Prior Work

3.1 Types of Input Used by Individuals with Upper-body Motor Impairments

When individuals with upper-body motor impairments use laptops, desktops, and mobile devices, there are various types of inputs to perform tasks, navigate to webpages, and more. The different types of inputs mentioned by Li et al. are touch, voice-based, eye-based, head-movement, face-based/mouth-based, and other inputs [8]. Preference for and utilization of inputs depends on the type of diagnosis of motor impairment. Results of this study show voice and touch are the most preferred input. Furthermore, multimodal input may offer

opportunities that complement each individual. Another study explored which input (mouse, touchpad, and touchscreen) was most effective for Malaysian individuals with motor impairments' browsing performance [5]. Results showed that mouse input performed the fastest and had a faster average browsing time, compared to a touchpad and touch screen. The choice of input modality can depend on a specific task. Learning about what types of inputs is helpful to know which are used more than others and if there are preferences when using the various inputs. From this, I aim to investigate a commonly utilized physical assistive technology – specifically, the mouse – while also exploring keyboard input.

3.2 Exploring the Use of Mouse and Keyboard Inputs

With laptops and desktops being used every day, both mouse and keyboard input modalities serve as essential accessibility tools, facilitating navigation within computing environments. The combination of these modalities offers an alternative for individuals facing voice challenges due to upper-body motor impairment. Andreas et al. developed a personalized mouse and keyboard to compare the functionality and performance with a mouse and QWERTY keyboard [2]. This study revealed that a personalized mouse had a higher throughput, three times higher than a commercial mouse, while error rates on the alternative keyboard are comparable than those on a QWERTY keyboard. A throughput is a metric determined by the tasks' difficulty and time needed to click on targets measured in bits/s. Having a higher throughput for a mouse allows to transmit more data packets or information frequently and quickly to a computer, reduces input lag, and allows for better precision. Andreas et al. also found that the alternative keyboard demonstrated a slower typing speed. Andreas et al. suggests the general functionality of the alternative keyboard can still be improved.

Another study explored a co-design approach with 26 designers and 3 motor impaired designers to create a new keyboard and mouse and understand the lived experiences of physical disabilities in relation to human interface devices [3]. Cossovich et al. designed a workshop to facilitate collaboration and creative problem-solving in groups led by 3 facilitators. Collaboration between the participants was intimidating at first for people with motor impairments when working with non-disabled designers, but they were soon able to work alongside each other to come up with solutions and sharing opinions knowing the support from the team. Cossovich et al. identified the need for a larger wired sensor to enhance accessibility and reduce complexity, advocating for a more transparent process for input and output. While keyboard and mouse are used together to navigate through programs, websites, and more, I want to focus on how an individual with upper-body motor impairment navigates through a website while using mouse and keyboard input modalities.

Lastly, a lab study with 32 participants, 16 identifying having upper-body motor impairments and 16 without disabilities, compared touch and mouse input, input performance, and discussed the differences with those who have motor impairments and those without through input tasks [4]. Findlater et al. found that while touchscreen input had advantages over a mouse in terms of speed, the benefits in terms of lower error rates were only observed for users without motor impairments. Meanwhile, tapping interaction is a common technique used

on touchscreen devices and plays a pivotal role in this study. The study underscores the need for enhancements for tapping accuracy, especially considering the various gestures (i.e., tapping vs. swiping) on touchscreen when compared to non-touch screen modalities, like a mouse and keyboard. However, not all individuals have access to touchscreen laptops and desktops, due to cost, traditional input, learning curve and more. Therefore, while touchscreen has its advantages over a mouse, mouse input is more traditional and is commonly used by those with motor impairments.

4 Methodology

4.1 Plan of Work

The methodology I would like to use in my study is mixed methods: survey, observation, and semi-structured interview.

4.1.1 Survey Conduction

For the survey, I aim to gather responses from 20 participants with upper-body motor impairments. The survey is designed to explore how these individuals use physical assistive technologies, what limitations they experience with current or previous physical assistive technologies, what suggestions they have for physical assistive technologies, and more. I will post the survey to various social media channels, local Rochester communities, and local veteran offices to ensure a broad reach to the target audience. Topics covered in the survey will revolve around demographic information (i.e. type of motor impairment, daily technology use, etc.), physical assistive technology usage, limitations and challenges, suggestions, satisfactions, Likert scale ratings, and open-ended responses.

4.1.2 Observation & Semi-structured Interviews

After the survey, I plan to observe 2 – 5 participants as they interact with a website using a laptop or desktop, utilizing either a mouse and/or keyboard input modalities. Subsequently, will use semi-structured interviews to explore the challenges they encounter while utilizing these tools and gather insightful suggestions for potential improvements. Participants are required to have either one of the tools. The tasks I plan to observe during website navigation will depend on the availability of a keyboard and/or mouse for the participants. Once the two websites are selected, I will ask the participants to follow tasks, while observing the completion of the task, time to finish tasks, movements of the mouse, keyboard accuracy, and struggles. After the observation, I will ask participants questions regarding their experience, challenges, suggestions, comfort and accessibility, tool's impact on their daily lives, and any additional comments or insights. This process will be conducted in-person to gather and analyze observation tasks with Zoom recording for interview transcript and video recording of the screen. Observing in-person will show how the participant is using their hands and device(s). Additionally, capture any non-verbal cues and subtle gestures that may be happening during the tasks. If I am unable to observe the user in-person, I will use Zoom as it still remains valuable for gaining insights into how these individuals navigate their devices. Zoom will allow

for real-time screen sharing, enabling participants to share their screen, think-aloud, demonstrate interactions, and discuss challenges encountered when using a mouse and/or keyboard. However, I will prioritize getting participants in-person for the observation and interview process. The recruitment for this would be individuals from local Rochester communities, veterans, or participants who opt in for the interview from the survey and have availability to keyboards and/or a mouse. Participants without access to a mouse or keyboard input will be excluded from the observation, as it is not feasible to provide these tools to all participants. Time allotted for observation and semi-structured interviews will be scheduled for an hour, 15 minutes for observation and 30 minutes for the interview portion.

4.1.3 Data Analysis

Once data is collected from the survey, I will analyze what physical assistive technologies are being used by people with upper-body motor impairments. I want to learn how many individuals use a given tool and why. Then, I will add interview questions about their general experience using physical assistive technologies, challenges and limitations, current setup, daily activities while using a laptop and/or desktop, accessibility, and more. Afterwards when all data is collected from the observation and semi-structured interviews, I will analyze the data using the thematic analysis approach. For the survey, I will be using a quantitative analysis to summarize the frequency and distribution of physical assistive technologies usage and explore relationships between variables (i.e., certain assistive technologies and challenges). These methods will provide insight into the challenges and needs of individuals with upper-body motor impairments in the context of physical assistive technologies.

4.2 Challenges or Barriers

My biggest challenge for this study is recruiting participants for the survey, observation, and semi-structured interviews. While it is possible to gather a variety of participants from the survey through social media channels, gathering significant data for my research is challenging due to the uncertainty of having enough participants. However, to address this barrier, I plan on reaching out to local Rochester communities (Rochester Rehabilitation, Rochester General Hospital, The Center for Rehabilitation, University of Rochester Medical Center, etc.) and veterans office that help individuals with upper-body motor impairments, along with posting to various social media channels. There are also challenges in the observation process, as participants with mouse and/or keyboard input modalities may only participate in-person rather than through video call based on their availability to laptop and/or desktops.

4.3 Limitations

There are few limitations for my study, most of them being specific to the allotted time of a semester. A limitation in my study is limiting two physical assistive technologies during the observation process: mouse and keyboard input modalities. While there are many tools that are used by people with upper-body motor impairments, there is not enough time to investigate all tools currently available and provide suggestions and improvements. Additionally, time also limits the number of participants I can gather for both the survey and observations/semi-structured interviews. Furthermore, if the observation and semi-structured

interviews are conducted through Zoom, it may be hard to gather details about struggles and challenges individuals with upper-body motor impairments may struggle with due to the limitation of the video calls. I will only be able to view their screen, rather than observing the interaction of the individual using the physical assistive technology. However, conducting on Zoom is still beneficial as it can reduce the observer effect, accommodate participants, lead to more natural behaviors, capture for later analysis, time efficient, accessible, and more. Lastly, I am focusing on laptops and desktops over all other types of technological devices that could potentially be used by these individuals, such as phones, tablets, and more. These technology devices may provide similar or different findings that can help leverage future studies for individuals with upper-body motor impairments.

4.4 Deliverables

Once all the data is collected, I will compile a list of physical assistive technologies, which can be found from survey findings and see if there are newer findings compared to previous studies. In regard to the observation and semi-structured interviews, I will compile a list of struggles using mouse and keyboard input modalities, along with other information mentioned during the interview process. Moreover, results from this work will inform suggestions for other researchers on how we can improve current mouse and/or keyboard input modalities to improve or create newer tools that can help those with upper-body motor impairments.

5 Timeline for Proposed Work

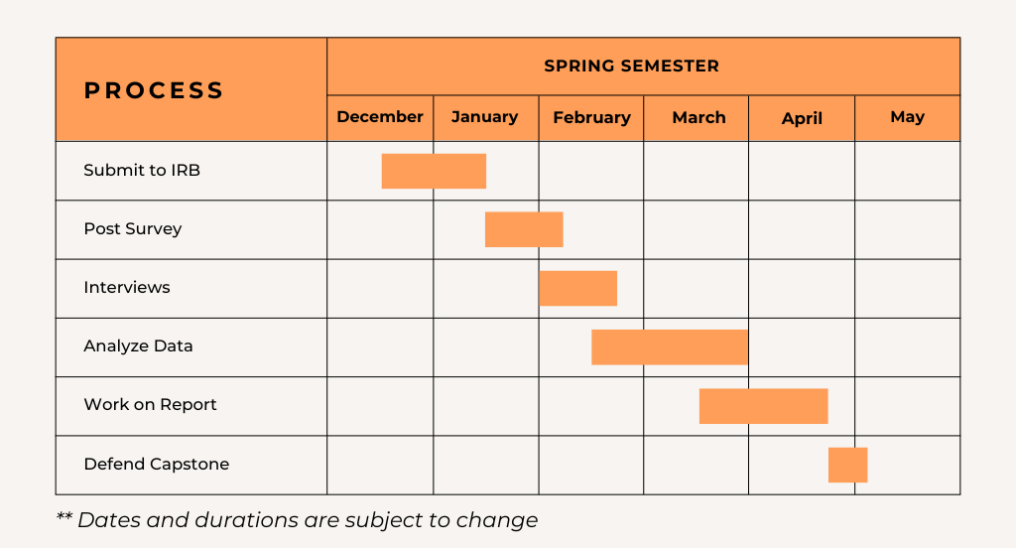

Figure 1. Proposed capstone timeline

I plan on submitting the IRB in mid-December. Afterwards, during mid-January once receiving IRB approval, I will be posting the survey. While the survey is still live, I will begin to conduct interviews. Each step of the process is planned to be around 3 to 4 weeks.

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