Hamster Mouse

Report #1

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DISCLAIMER

EXECUTIVE SUMMARY

The Hamster project is more than just an engineering project; it symbolizes a transformational vision for redefining the landscape of stroke rehabilitation via the use of technology and human-centered design concepts. At its core, the initiative reflects a dedication to meeting the critical demand for accessible and effective rehabilitation treatments for stroke victims. Recognizing the financial limits and logistical problems that those receiving traditional treatment frequently encounter, the Hamster team set out on a mission to democratize access to physical therapy by building a portable robot that is convenient, affordable, and effective. By breaking down barriers and delivering treatment directly into patients' homes, the initiative hopes to enable people to take charge of their recovery path and restore their freedom and mobility.

The process of envisioning and designing the Hamster the device was defined by rigorous diligence and unrelenting commitment to perfection. The team has used iterative procedures to enhance and optimize every element of the device's design and functioning since the beginning of development. The chassis and casing, for example, were painstakingly designed to optimize ergonomics, durability, and simplicity of use, resulting in a smooth and intuitive user experience. Meanwhile, the motors and batteries have been evaluated to assure peak performance, efficiency, and dependability. Furthermore, the microcontroller code was developed using complex simulations and algorithms to provide accurate motor control and navigation capabilities, improving the device's overall efficacy and user experience.

Looking ahead, the Hamster project is set to have a huge influence on stroke recovery, providing a beacon of hope for patients and healthcare workers alike. Using a collaborative and multidisciplinary approach, the team is dedicated to pushing the frontiers of innovation and quality to create a genuinely revolutionary solution. Beyond engineering, the initiative exemplifies understanding, compassion, and a commitment to improving the lives of stroke survivors. As the initiative evolves and progresses, it has the potential to not only revolutionize rehabilitation techniques, but also inspire hope and resilience in the hearts of countless people throughout the world.

In addition to its technological accomplishments, the Hamster project exemplifies a culture of collaboration and inclusion that transcends beyond the engineering field. Recognizing the varied nature of stroke rehabilitation, the project regularly consults with healthcare experts, caregivers, and stroke survivors to ensure that their voices and views are included in the design process. The initiative aims to establish an open discussion and collaboration culture to build a comprehensive and patient-centered approach to rehabilitation that addresses not only physical obstacles but also emotional and psychological well-being. Furthermore, the initiative aims to promote awareness and de-stigmatize the debate around stroke recovery, fostering a culture of empathy, understanding, and support in communities. Through these collaborative efforts, the Hamster project hopes to not only produce breakthrough technology solutions but also to promote a more compassionate and inclusive society in which every individual could succeed and overcome hardship.

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1 BACKGROUND

Included in the background will be information on the Hamster project description, project deliverables, and overall success metrics. The project description will introduce the client's entire project idea and explain why this project is significant beyond the engineering phenomena. This will contain all budgetary requirements and fundraising strategies. The deliverables section of this chapter will include the project's significant components, such as client and course needs. The success metrics section of the chapter will go over how the team defines success for our project and how it will be measured.

1.1 Project Description

The Hamster Project seeks to create a dynamic solution to assist stroke patients in their rehabilitation process. The development of a motorized robot resembling a mouse, meant to aid physical rehabilitation activities for people with reduced movement after a stroke, is central to this project. The device's mobility enables effortless operation on any tabletop surface, which is convenient for patients. Beyond its practicality, the initiative has substantial social ramifications, with the potential to reduce the financial burden associated with stroke therapy by providing a more cost-effective alternative. Furthermore, by allowing outpatient therapy and reducing in-house patient visits, the idea simplifies the rehabilitation process while simultaneously increasing patient autonomy. With a $1000 budget, our team plans to raise extra funds through family donations and material sponsorships from local businesses such as Elemental Motors in Flagstaff, assuring the project's success. In accordance with the capstone class requirements, each team member is expected to contribute a minimum of 10% of the project's budget. Our team has pledged to raise $100 to satisfy this responsibility. We want to get crucial components like as motors and microcontrollers by leveraging the assistance of family and developing relationships with local businesses, notably Elemental Motors. We want to achieve the Hamster Project's goals through effective resource allocation and community cooperation while sticking to cost limits and optimizing impact.

1.2 Deliverables

The Hamster Project requires many deliverables that must meet both the client's expectations and the capstone course's criteria. The customer has set precise parameters that are directly related to the project's ultimate design, aiming for a tiny, lightweight robot capable of reaching a speed of 1 m/s, exerting 10 N of force unidirectionally, and generating 5 Nm of torque. Furthermore, the gadget must function for at least 30 minutes on a single charge while staying highly portable. The inclusion of a non-functional screen acts as a proof of concept, improving the overall user experience for stroke patients in rehabilitation. These severe standards demonstrate the client's determination to ensure the device's efficacy in assisting patients' rehabilitation journeys.

In parallel, the capstone course imposes its own set of requirements, focusing on cooperation, project management, and effective communication. The course's objectives include demonstrating a fair division of effort among team members, ensuring that each contributes proportionately to the project's success. Furthermore, the capacity to communicate current work and strategically plan future tasks is critical, allowing for a methodical approach to project execution. Given the project's continuance into the next semester, flexibility becomes critical since the goals and needs of both the course and the customer may change over time, forcing occasional schedule modifications to stay on track with project objectives. Through rigorous coordination and attention to course requirements, the team seeks to effectively manage these multiple challenges, eventually producing a robust and impactful solution for stroke recovery.

1.3 Success Metrics

To be considered successful, the Hamster Project must meet certain essential criteria, as specified by both the client's expectations and the capstone course's requirements. First, the gadget must meet all design parameters, such as size, weight, speed, force output, torque, and battery life. These characteristics function as quantifiable standards against which the device's performance will be measured. Testing methods will be devised to evaluate the device's functioning, including rigorous testing of its movement capabilities, force exertion, and endurance. Calculations will be performed to ensure that the device satisfies the stated standards, including exact measurements of speed, force, and torque output compared to predefined thresholds. Furthermore, the inclusion of a non-functional screen acts as a conceptual element to improve user experience, offering an extra layer of validation to the design. While its functioning is not the major priority, its incorporation into a device design is crucial to achieving customer expectations. As a result, proper integration, and placement of the screen within the device will be examined throughout the testing and assessment phases.

In addition to technical performance, the project's success will be measured by the team's adherence to project management principles and successful teamwork. This includes a fair division of labor among team members, timely completion of duties, and initiative-taking communication to resolve any issues or setbacks experienced during the project's lifespan. The team's ability to give progress updates and clearly define upcoming tasks displays their competence for project planning and execution. The Hamster Project's success will be evaluated by its ability to meet or surpass the specified design criteria, pass stringent testing processes, and exhibit excellent project management and cooperation. By satisfying these objectives, the project will not only meet the client's expectations, but also demonstrate the team's ability in offering a feasible solution for stroke recovery.

2 REQUIREMENTS

In this chapter there will be three main subsections presented. These subsections include the customer requirements, the engineering requirements, and the house of quality created from the prior sections. The customer requirements section will include a list of all provided requirements from the client to date and how they are defined. The engineering requirements will be introduced in a list that is quantified and provides targets regarding each requirement. Lastly, these prior two sections will be placed into a QFD where comparisons and rankings of each requirement will be provided.

2.1 Customer Requirements (CRs)

Provided is a list of the customer requirements from the initial proposal and feedback from meetings.

- Size – the client wants the device to be small enough that it is portable and can move over the surface of a desk.
- Speed – the device will need to be able to reach a speed of up to 1 m/s in any direction. This is to allow for the device to keep up with a patient's hand speed.
- Force – must be able to produce a force of up to 10 N to the patient's hand in any direction or 5 Nm of torque about the vertical axis.
- Internal Friction – when motors are not being used the device must be able to be moved with less than 5N of force.
- Backlash- when motors are off the device must not move more than 0.1mm.
- Run Time – device must run for at least 30 minutes on a single charge.
- Interface: device must be able to receive commands from a computer and send its position back to the computer in (x, y) coordinates.
- Screen – there must be a touch screen that is at least four inches on the device.
- Cost – total production of the device must be <$500.
- Microcontroller – client prefers Raspberry Pi to be used due to faster processing speeds.
- Ease of Use – should not require more than a number for the force being applied and a direction.
- Comfortable – the device should be comfortable in a patient's hand.

2.2 Engineering Requirements (ERs)

Below is the list of engineering requirements chosen based on the customer requirements stated in section 2.1.

- Motor Output (kW) – the motor must be able to produce enough rotations per minute to meet speed requirement of 1 m/s.
- Battery Life (kW hr.) – needs to last with three motors and the other electrical components at least 30 minutes.
- Size (ft) – < 1ftx1ftx1ft
- CPU Speed (s) – need the microcontroller to be able to send commands quickly so there is minimal delay in the movement of the robot. (16 MHz)

- Weight (lb.)- the device should not weigh more than 8 lbs. to allow for patient to be able to move it easily.

2.3 House of Quality (HoQ)

Quality Function Deployment

Project title: Hamster
Project leader: Joe Lopez
Date: 1/30/2024

+	.	-
Positive	No correlation	Negative

	1: low, 5: high Customer importance rating	Technical Requirements (How's) → Customer Requirements - (What's) ↓	Motor Output (kW)	Battery Life (kW*hr)	Size (in)	CPU Speed (s)	Weight (lbs)	Weighted Score	Human PT	Neofect Smartboard	Saebo Flex
1	5	Must move 10N	9		5		3	85	9	0	5
2	4	Handheld		3	9		9	84	0	3	8
3	5	Moves 1m/s	9				4	65	0	0	0
4	1	5N*m=Torque	9					9	9	0	2
5	2	Bidirectional Communication				9		18	0	6	0
6	3	Cheap	5	5	5	5	6	78	1	2	4
7	4	Comfortable		5	8		4	68	4	8	5
8	3	Ease of use		7	6	4	4	63	6	8	6
9	3	Rechargable w/ 30 minute battery life		9		2		33	0	7	0
		Technical importance score	114	95	126	51	117	503			
		Importance %	23%	19%	25%	10%	23%	100%			
		Priorities rank	**3**	**4**	**1**	**5**	**2**				
		Target	10N & 1m/s	30 Minutes	<12 in^3	16MHz	<5lbs				

Figure 1: Hamster Project House of Quality

The Quality Function Deployment (QFD) is used for finding the importance of the customer requirements and how each technical requirement relates to it. The customer requirements are labeled on the left and are given by the client regarding what they want to see in the product and each one is weighted from 1 to 5 with regards to importance. The technical importance are quantitative measurements that are used to determine how each customer requirement will be met. The technical requirements are numbered from 0-10 regarding their importance to each of the customer requirements, a blank space means a zero. Above the technical requirements, there is a triangle used to show how different technical requirements relate to each other. At the bottom of the QFD the ranking of requirements is made using the customer ratings and the technical importance values, the totals are calculated to show which technical requirement is the most important. Finally, to the far right, there is a comparison of similar products showing how each of them scores using the customer requirements.

3 Research Within Your Design Space

3.1 Benchmarking

Several innovative systems stand out in the field of system-level benchmarking for state-of-the-art rehabilitation devices such as the Hamster project due to their new techniques and improved functionality. One notable device is ReWalk Robotics' Exoskeleton, which is known for its advanced design that allows people with lower limb problems to walk freely. The ReWalk Exoskeleton, which incorporates innovative sensing technologies and easy control mechanisms, establishes an elevated level for mobility-assistance systems used in rehabilitation. Another notable device is Ekso Bionics' EksoGT, distinguished by its intuitive user interface and adaptable robotic technology, providing tailored rehabilitation programs for stroke survivors and persons with neurological disabilities. Furthermore, the Kinova Robotics Jaco Assistive Robot excels in providing upper limb support and assistance, with precise control capabilities and ergonomic design elements geared to improve the rehabilitation experience for people with limited dexterity.

Benchmarking efforts at the subsystem level are directed on analyzing certain components and capabilities that are critical to the Hamster device's performance and usability. This includes comparing various subsystems, such as motor systems, control interfaces, and feedback mechanisms, to industry standards and best practices. Motor systems, for example, are evaluated using parameters like as torque production, efficiency, and dependability to guarantee optimal performance in providing mobility aid to stroke patients. Similarly, control interfaces are assessed for their intuitiveness, responsiveness, and adaptability to meet varied user demands and preferences. Furthermore, feedback mechanisms, such as sensory feedback and user feedback interfaces, are evaluated to determine their usefulness in giving real-time input and increasing user involvement throughout rehabilitation sessions. The Hamster project intends to create a robust and user-friendly rehabilitation support device by integrating innovative technology and features via rigorous subsystem-level benchmarking.

Images and sources for the devices described above will be included in the appendix at the end of the report.

3.2 Literature Review

3.2.1 Joseph Lopez:

[1]J. Brackenridge, L. V. Bradnam, S. Lennon, J. J. Costi, and D. A. Hobbs, “A Review of Rehabilitation Devices to Promote Upper Limb Function Following Stroke,” *Neuroscience and Biomedical Engineering*, vol. 4, no. 1, pp. 25–42, Mar. 2016, Available: https://www.ingentaconnect.com/content/ben/nbe/2016/00000004/00000001/art00006

The initial source makes a substantial contribution to the fundamental knowledge of our team's effort, which is focused on constructing a tiny robot to assist stroke patients with upper limb rehabilitation. This source investigates existing gadgets on the market built for comparable objectives, offering useful insights into the present landscape of assistive technology for stroke rehabilitation. As our team is still in the early phases of the project, this material is an important reference point, providing a full overview of the features, functions, and limits of existing devices. Analyzing these proven solutions can help us uncover market gaps while also refining our project goals and design concerns. Furthermore, the source acts as a baseline for assessing the efficacy of our future robotic rehabilitation solution, leading us through the development process to assure innovation and improvement over existing alternatives.

[2]P. Weiss, M. Heldmann, A. Gabrecht, Achim Schweikard, T. M. Münte, and E. Maehle, "A Low Cost Tele-Rehabilitation Device for Training of Wrist and Finger Functions After Stroke," *A low cost tele-rehabilitation device for training of wrist and finger functions after stroke*, Jan. 2014, doi: https://doi.org/10.4108/icst.pervasivehealth.2014.255331.

This source is especially useful for our team, which is in the initial stages of designing a small robot to help stroke patients with rehabilitation, with a focus on improving fine motor skills in fingers and smaller appendages. The source digs into the world of low-cost rehabilitation gadgets designed for stroke sufferers, giving light on novel solutions that focus on the precise movements of tiny limbs. Given the nascent stage of our research, this source becomes an invaluable resource, giving insights into cost-effective alternatives and prospective design considerations for our robot rehabilitation equipment. Understanding the tactics and technologies used in existing low-cost gadgets enables us to make educated decisions while designing and developing our robot, assuring both affordability and efficacy. As a result, the source acts as a strategic guide, assisting our team in overcoming the complexities of developing a feasible and accessible solution for stroke patients who require rehabilitation for their fingers and tiny appendages.

[3]T. Georgiou, S. Holland, and Janet, "Wearable haptic devices for post-stroke gait rehabilitation," *Open Research Online (The Open University)*, Sep. 2016, doi: https://doi.org/10.1145/2968219.2972718.

This source proved to be an excellent value to our team during the initial stages of our project, which focuses on the construction of a tiny robot to aid stroke victims in their recovery. This source, which focuses primarily on wearable stroke rehabilitation devices, explains breakthroughs and applications in the sector, providing relevant information that can affect the trajectory of our research. Because our team is still in its early phases, the knowledge obtained from this source serves as a critical basis for comprehending the growing landscape of wearable technology designed specifically for stroke recovery. By investigating the features, user experiences, and efficacy of wearable devices, we acquire a thorough grasp of the technology's potential and difficulties. This knowledge will help guide our design decisions and ensure that we include features that are in line with current trends in wearable stroke therapy equipment. In effect, this source acts as a compass, guiding us through the intricacies of incorporating wearable technology into our tiny robotic system for improved stroke patient rehabilitation.

[4]L. Riek, *Healthcare robotics*, vol. 60, no. 11, Oct. 2017, doi: https://doi.org/10.1145/3127874.

This source emerges as a critical resource for our team as we begin the basic steps of constructing a tiny robot designed to support stroke sufferers in their recovery journey. While not solely concerned with stroke rehabilitation, the site offers useful insights by diving into various medicinal robots and their interactions with patients. This broader viewpoint enables our team to gain expertise from many uses of robotics in the medical profession, resulting in a more nuanced understanding of how patients interact with robotic systems. Examining patient reactions to a variety of medicinal robotics beyond stroke therapy gives a comprehensive perspective that can help us fine-tune our tiny robot design. Understanding the intricacies of human-robot interaction, even in circumstances unrelated to stroke rehabilitation, provides our team with important insights into user experience, trust, and flexibility. Thus, this source serves as a strategic basis, improving our understanding of the larger landscape of medical robotics and aiding in the mindful creation of our little robot for stroke patient help.

[5]J. Duval *et al.*, "Designing Spellcasters from Clinician Perspectives," *ACM Transactions on Accessible Computing*, vol. 15, no. 3, Apr. 2022, doi: https://doi.org/10.1145/3530820.

This source stands out as a useful value to our team, which is now in the early phases of developing a tiny robot to help stroke victims with their rehabilitation. The source demonstrates a novel method by explaining a virtual reality game intended for rehabilitation, with an emphasis on incorporating fun and accessibility into the rehab process. In the initial stages of our research, this information serves as an inspiring benchmark, revealing insights into how technology, especially virtual reality, might be exploited to make rehabilitation entertaining and accessible. By investigating the success and user experiences related with the virtual reality game, our team receives a new perspective on how to improve the user engagement component of our tiny robotic solution. As a result, the source not only broadens our understanding of rehabilitation methodologies, but also inspires creative ideas for incorporating enjoyable elements into our robot's design, potentially leading to a more positive and participatory experience for stroke patients during their rehabilitation journey.

[6]C. Axel *et al.*, "Engineering Rehabilitation: Blending Two Tool-supported Approaches to Close the Loop from Tasks-based Rehabilitation to Exercises and Back Again," *Proceedings of the ACM on human-computer interaction*, vol. 7, no. EICS, pp. 1–23, Jun. 2023, doi: https://doi.org/10.1145/3593229.

This site is useful to our team as we traverse the initial stages of constructing a tiny robot to assist stroke victims in their rehabilitation process. The focus on a tabletop robot that engages patients in rehabilitation by completing simple activities, some of which are robotically aided, provides useful information for our study. In the early phases of our project, learning how a tabletop robot has been used to aid rehabilitation gives a concrete example of incorporating robotics into therapeutic exercises. The source acts as a template, allowing our team to learn critical lessons about task design, patient engagement, and the effectiveness of robotic aid in rehabilitation settings. By investigating the tabletop robot's accomplishments and obstacles during patient engagement, our team learns practical knowledge that can be used to drive design decisions and develop the capabilities of our little robot. As a result, this source acts as a fundamental reference, leading our team in the construction of a robot that not only aids stroke victims in their rehabilitation, but does so using effective and patient-centric techniques.

[7]Dharmaraja Selvamuthu and P. Tardelli, "Partial Observed Fluid Queue Model for Rechargeable Batteries," *Partial Observed Fluid Queue Model for Rechargeable Batteries*, May 2020, doi: https://doi.org/10.1145/3388831.3388856.

This source is a great complement to our team's early-stage study into constructing a tiny robot to aid stroke victims throughout their recovery. While the source focuses on rechargeable batteries and their discharge methods across devices, it is important for our study since it draws attention to the vital topic of power supply. Understanding the complexities of rechargeable batteries is critical for our little robot's long-term operation at this stage of the project. As a result, this source is an important starting point for our investigation into the technical requirements, efficiency, and potential issues related with power management. By looking into the details of how rechargeable batteries discharge charge, we get insights that can help us make decisions about which battery technology to use, energy efficiency concerns, and the overall design of our robot's power system. Finally, this source helps provide the framework for the development of a dependable and effective little robot that may smoothly integrate into stroke patients' rehabilitation processes.

3.2.2 Jared Hemauer:

[1] John Ryan C. Dizon, Alejandro H. Espera, Qiyi Chen, Rigoberto C. Advincula,Mechanical characterization of 3D-printed polymers, Additive Manufacturing, Volume 20, 2018, Pages 44-67

This information on 3D printing polymers and material testing procedures might be quite useful in the development of the Hamster robot. By providing insights on the qualities and best uses of various 3D printing polymers, the source may advise material selection for different robot components, assuring compatibility and performance. Furthermore, knowing various loading types and testing procedures enables thorough evaluation of the mechanical characteristics of 3D printed components, ensuring they fulfill the necessary criteria for strength, durability, and resilience in the context of stroke therapy. Finally, utilizing this source can improve the entire design, functioning, and dependability of the Hamster robot, hence increasing its usefulness in supporting stroke patients with their rehabilitation requirements.

[2] E. Macdonald et al., "3D Printing for the Rapid Prototyping of Structural Electronics," in IEEE Access, vol. 2, pp. 234-242, Dec. 2014

This research discusses 3D printing structural electronics and proposes a unique technique that has the potential to improve the Hamster robot development process. By 3D printing electrical components directly into the robot's construction, the Time to Market (TTM) might be drastically decreased, simplifying the manufacturing process, and speeding up product iterations. While the technology is still in its early phases of development, end-use applications show promise for improving the usefulness and efficiency of the Hamster robot, opening the way for future advances in stroke rehabilitation technology. Using the ideas from this article, the Hamster project might include innovative structural electronics into its design, providing a more integrated and efficient solution for supporting stroke victims with their rehabilitation needs.

[3] C. Wang et al., “Trajectory tracking of an omni-directional wheeled mobile robot using a model predictive control strategy,” Applied Sciences, vol. 8, no. 2, p. 231, Feb. 2018. doi:10.3390/app8020231

This source, which provides a full explanation of driving mecanum wheels with a model predictive control (MPC) method, is extremely useful for the creation of the Hamster robot. Implementing MPC improves the robot's mobility and accuracy, which is critical for treating stroke patients with individualized rehabilitation programs. Understanding and implementing this sophisticated control technique might increase the Hamster robot's capacity to navigate various surfaces and perform complicated maneuvers, thereby enhancing its usefulness in assisting patient rehabilitation. Using the ideas mentioned in this source might result in a more complex and powerful robotic platform, built to address the unique demands of stroke rehabilitation with more accuracy and precision.

[4] K. Shabalina, A. Sagitov and E. Magid, "Comparative Analysis of Mobile Robot Wheels Design," 2018 11th International Conference on Developments in eSystems Engineering (DeSE), Cambridge, UK, 2018, pp. 175-179

This site discusses several wheel kinds and layouts, such as omni and mecanum wheels, and provides useful ideas for improving the Hamster robot's design. Understanding the unique properties and appropriate applications of each wheel type allows the project team to make educated judgments about wheel selection and integration into the robot's design. Insights into conventional and caster wheels broaden the project's scope, enabling for personalized solutions that match the unique mobility and maneuverability needs of stroke therapy situations. Using the information from this source, the Hamster project may develop a well-rounded robotic platform that effectively navigates varied surfaces while offering appropriate aid to stroke patients on their recovery trip.

[5] J. Inthiam and C. Deelertpaiboon, "Self-localization and navigation of holonomic mobile robot using omni-directional wheel odometry," TENCON 2014 - 2014 IEEE Region 10 Conference, Bangkok, Thailand, 2014, pp. 1-5

This source, which provides navigational algorithms for controlling and monitoring a robot with three omnidirectional wheels, is extremely useful in the creation of the Hamster robot. By using these algorithms, the robot's movement may be tuned for accurate control and navigation, which is critical for supporting stroke patients in rehabilitation activities. Understanding and using these algorithms into the robot's control system allows for efficient mobility across a variety of surfaces, improving the Hamster device's overall utility and efficacy. Using the data from this source, the project team can develop a robotic platform capable of providing targeted and precise help to stroke patients during their recovery process.

[6] Centiva, “Driving Mecanum wheels omnidirectional robots,” roboteq, https://www.roboteq.com/applications/all-blogs/5-driving-mecanum-wheels-omnidirectional-robots (accessed Mar. 15, 2024).

This source contains use cases and control techniques for mecanum wheels, which are critical for improving the Hamster robot's design and control system. Understanding various uses and tactics for operating mecanum wheels allows the project team to adjust the robot's mobility capabilities to the demands of stroke therapy. Implementing appropriate control techniques improves the robot's agility and adaptability, allowing it to navigate different surroundings and make precise motions that are critical for supporting patients during rehabilitation activities. Using information from this source ensures that the Hamster robot can give efficient and precise assistance to stroke victims during their rehabilitation.

[7] I. Siradjuddin et al., “A General Inverse Kinematic Formulation and Control Schemes for Omnidirectional Robots,” 2021

This source, which provides a generic Inverse Kinematic Formulation for driving omni-directional wheels, is extremely useful for the creation of the Hamster robot. Understanding the mathematical fundamentals of managing omni-directional wheels allows the project team to create more efficient and precise control algorithms for the robot's mobility. Implementing these formulas improves navigation and mobility, allowing the Hamster robot to help stroke patients in rehabilitation activities more accurately and effectively. Using data from this source allows the project team to develop a robotic platform capable of providing targeted and dependable assistance to persons undergoing stroke rehabilitation.

3.2.3 Rylee Horney:

[1] M. K. Parai, B. Das, and G. Das, “An Overview of Microcontroller Unit: from Proper Selection to Specific Application,” vol. 2, no. 6, 2013

This source provides the appropriate steps when determining what type of microcontroller to use in a device. Included in the paper is a table providing manufacturers of these components and a list of commonly used microcontrollers and their features.

[2] J.-D. Warren, J. Adams, and H. Molle, Arduino Robotics. New York: Springer, 2011.

This book can be used to give a general overview of building a robot as well as examples of robots that have been made. It will be an especially useful tool for the team since the book provides information regarding sensors, batteries, microcontrollers, and other components that go into a robot. It can also answer any questions that may arise throughout the process of designing and manufacturing.

[3] J. Collins, S. Chand, A. Vanderkop, and D. Howard, “A Review of Physics Simulators for Robotic Applications,” *IEEE Access*, vol. 9, pp. 51416–51431, 2021, doi: 10.1109/ACCESS.2021.3068769.

The source above provides knowledge in relation to simulating our robot behavior before building is complete. The journal article discusses which of the various tools that are out there for simulating provide the best features for the robot that may be in question. This source will be useful for any team members that may want to understand more about how our robot will move and if there are any concerns that need to be resolved.

[4] “13.3.2. Controllability of Wheeled Mobile Robots (Part 1 of 4) – Modern Robotics.” Accessed: Feb. 03, 2024. [Online]. Available: https://modernrobotics.northwestern.edu/nu-gm-book-resource/13-3-2-controllability-of-wheeled-mobile-robots-part-1-of-4/#department

[5] “10.1. Overview of Motion Planning – Modern Robotics.” Accessed: Feb. 03, 2024. [Online]. Available: https://modernrobotics.northwestern.edu/nu-gm-book-resource/10-1-overview-of-motion-planning/#department

For both sources [4] and [5] these videos provided by Northwestern University are very applicable to the team’s project. They discuss how to mathematically solve for the motion of the robot. Very specifically the videos talk about the kinematics of omni directional wheels in a triangle format such as the team has designed. Furthermore, when the coding process begins to get the robot moving these concepts will provide an incredibly detailed understanding on how to get the robot to move.

[6] V. C. Pinto *et al.*, “Comparative Failure Analysis of PLA, PLA/GNP and PLA/CNT-COOH Biodegradable Nanocomposites thin Films,” *Procedia Engineering*, vol. 114, pp. 635–642, 2015, doi: 10.1016/j.proeng.2015.08.004.

The information provided in this source allowed for the team to perform calculations for the strength of the material due to the applied stress that is expected in the testing phase of this project.

[7] “New Arduino Tutorials - YouTube.” Accessed: Feb. 03, 2024. [Online]. Available: https://www.youtube.com/

This playlist of YouTube videos has provided the basic knowledge needed to get started with an Arduino board. As the coding engineer for this project this resource has been immensely helpful with learning how an Arduino works and how the coding language works. These videos provide useful background information regarding why the Arduino processes information a certain way. These tutorials will be immensely helpful in the future when needing to refer to a guide as to why a certain piece of equipment may not be working.

3.2.4 Keenan Keams:

[1]Zdzislaw. Gosiewski and Zbigniew. Kulesza, *Mechatronic systems and materials III*. Stafa-Zurich, Switzerland: Trans Tech Publications, 2009.

This resource gives a thorough overview of robotic system applications and research, including industrial, micro, and mobile robots. With thorough chapters on sensors, Arduinos, controllers, and other related topics, it provides unique insights into the various facets of robotics technology. The book's extensive coverage of sensor integration, control methods, and overall system design might help to influence the creation of the Hamster robot.

[2] Mordechai. Ben-Ari and Francesco. Mondada, Elements of Robotics, 1st ed. 2018. Cham: Springer Nature, 2018. doi: 10.1007/978-3-319-62533-1.

This book contains a wealth of information about undergraduate and graduate studies in robotics. The book discusses several types of distance sensors and laser scanners, as well as linear and nonlinear mapping sensors. It also contains significant information on robotic motion and odometry.

[3]C. A. Jara, J. A. Corrales Ramón, C. A. Jara, and J. A. Corrales Ramón, Robotic Platforms for Assistance to People with Disabilities. Basel: MDPI - Multidisciplinary Digital Publishing Institute, 2022.

This book discusses how rehabilitation robots grew in the hospital sector during and after the COVID-19 epidemic. Many patients were unable to schedule rehab sessions because to the pandemic, which limited the number of available institutions. Many patients began to employ rehab robots to assist them meet their rehabilitation training goals. It made things easy for rehabilitation physicians and patients throughout the epidemic.

[4] Y. Hsieh, C. Wu, K. Lin, G. Yao, K. Wu, and Y. Chang, “Dose–Response Relationship of Robot-Assisted Stroke Motor Rehabilitation,” Stroke, vol. 43, no. 10, pp. 2729–2734, Oct. 2012, doi: https://doi.org/10.1161/strokeaha.112.658807.

The journal paper describes a study of stroke patients requiring intermediate rehabilitation, which began with 362 eligible participants. However, after satisfying certain requirements, the research sample was restricted to fifty-four participants. The patients were placed into three groups: high-intensity robotic-assisted therapy (RT), low-intensity RT, and control treatment. Following the trial, medical personnel evaluated the patients and found that those who received high-intensity RT recovered faster than the other groups. This study implies that intense robot-assisted treatment might be useful in aiding recovery in stroke patients with intermediate rehabilitation demands.

[5]K. Lo, M. Stephenson, and C. Lockwood, "Adoption of robotic stroke rehabilitation into clinical settings: a qualitative descriptive analysis," International journal of evidence-based healthcare, vol. 18, no. 4, pp. 376–390, 2020, doi: 10.1097/XEB.0000000000000231.

The article describes hospitals that are undertaking case studies on robot-assisted rehabilitation, such as using exoskeleton robots to help with joint mobility or end-effector devices to target extremities like hands and feet. Patients from public and private institutions took part in the trials. The combination of exoskeleton robots and end-effector devices demonstrates robotic technology's adaptability in supporting rehabilitation efforts in a variety of healthcare settings, potentially providing individualized solutions for patients with various demands.

[6]Ozhan Ozen, Karin A. Buetler, Laura Marchal-Crespo, and Laura Marchal-Crespo, "Promoting Motor Variability During Robotic Assistance Enhances Motor Learning of Dynamic Tasks," Frontiers in neuroscience, vol. 14, 2021, doi: 10.48350/151814.

This paper investigates whether motor variability during robotic aid influences motor learning for dynamic tasks. The patient was instructed to swing a virtual pendulum and strike oncoming targets with the pendulum ball. There were two Model Predictive Controllers (MPC) that applied the ideal aiding forces to the end-effector or to the virtual pendulum ball to further lower the assisting forces.

[7] Electrical Technology, "What is the Main Difference Between AC and DC Motor?," ELECTRICAL TECHNOLOGY, Jun. 12, 2020. https://www.electricaltechnology.org/2020/06/difference-between-ac-dc-motor.html

The page explains the differences between AC and DC motors, stating that AC motors use Alternating Current, have higher output power, and require direct input. DC motors, on the other hand, use Direct Current and may be driven by batteries, cells, or solar energy. They offer a wide range of speed control possibilities. This clarification aids in understanding the unique properties and uses of each motor type, allowing for more informed decision-making throughout the design and implementation stages of projects like as the Hamster robot.

3.3 *Mathematical Modeling*

3.3.1 Battery Life – Joe Lopez

Peukert's Law is written as the equation illustrated in the graphic below, where it is the amount of time in hours, H represents the discharge time in hours, C is the capacity rating (about 1800 mAh), I identifies the discharge rate in amps, and K represents a constant. The customer's expectation that the device would function for at least 30 minutes on a single charge resulted in calculations suggesting an estimated battery voltage of 1.2 Volts, confirming the gadget's operating endurance within the time range indicated by the client.

$$t = H\left(\frac{C}{IH}\right)^{k}$$

Figure 1: Perkurt’s Law

3.3.2 Moment Upon a Beam on a Support – Joe Lopez

Using the SkyCiv website, I modeled the hand region as a beam supported by the robot's base, resulting in a moment equation of 0.081 N-m. In accordance with our sponsor's parameters and intended force direction, I chose a distributed load of 10 Newtons, applied uniformly over one side of the beam. This meticulous calculation assures not just structural integrity but also compliance with specifications, demonstrating our dedication to designing a dependable stroke rehabilitation aid equipment. The picture below depicts a visualization created using Skyciv.

Figure 2: Moment calculation visualization

3.3.3 Omni-directional Wheel Control Using Vectors – Jared Hemauer

Each vector equation refers to a wheel and is used to calculate the speed at which each wheel must move for the robot to proceed in the desired direction. The variables in the equation are Vr: the direction the robot must go in, alpha(α): the angle between Vr and a specified reference vector, omega(ω): the angular velocity, and L: the distance between the center of mass and the center of the wheel. Vw: the rotational speed necessary to move the wheel in the desired direction. A picture is presented below for reference.

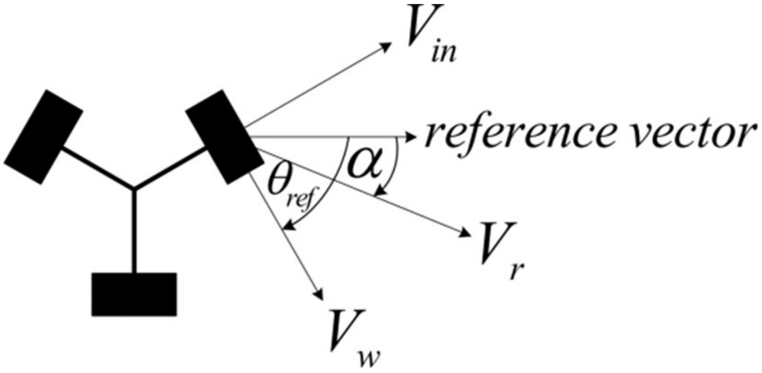


Figure 3: Omnidirectional wheel control visualization

3.3.4 Motor Speed Calculations – Jared Hemauer

Understanding the required rotational speed to attain our desired velocity of 1m/s is critical in determining the best motor for our application. Motor speed calculations use the planned velocity and wheel radius to calculate the needed rotational speed in revolutions per minute (rpm). By taking these parameters into account, we may select an appropriate motor that satisfies the project's speed requirements, resulting in optimal performance and usefulness. Using the formula RPM = (V * 60) / (2 * π * r), where V represents velocity (1m/s) and r represents the radius of the wheel (29mm), we get an estimated RPM value of 329.3rpm. This calculation allows us to accurately determine the motor rotational speed required to produce the target velocity, ensuring efficient performance and smooth integration into the project.

3.3.5 Shear Deformation of PLA Filament – Rylee Horney

Several essential characteristics must be considered while doing engineering calculations for PLA filament shear deformation. For a given shear force (V) of 10N, cross-sectional area (A) of 2.03 mm², length (L) of 127 mm, Young's modulus (E) of 4.107 GPa, and Poisson's ratio (v) of 0.332, the shear deformation (θ) may be calculated using the equation θ = (V * L) / (G * A), where G is the shear modulus of elasticity. The calculation G = E / [2 * (1 + v)] yields a value of around 1.54 GPa. Substituting the provided values into the shear deformation equation provides a result of around 4.06 nm. These calculations give useful insight into the mechanical behavior of the PLA filament under shear stresses, which can help with the design and optimization of structures or components made from this material. A better graphic representation of the work is provided here.

$\theta = \frac{V \cdot L}{G \cdot A}$, $G = \frac{E}{2(1+v)} = 1.54GPa$, $\theta = \frac{(10N)\cdot(0.127\ m)}{(1.54\ GPa)\cdot(\ 0.00203m^2)}$, $\theta = 4.06\ nm$

3.3.6 Instruction Execution Time – Rylee Horney

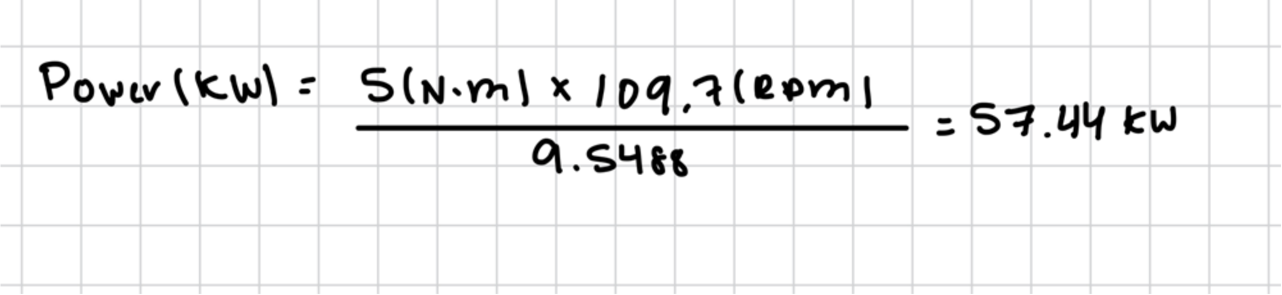
In engineering calculations of instruction execution time, the parameter Texec reflects the time necessary for instructions to be executed. It is defined as Texec = 1/fcpu, where fcpu is the microcontroller frequency in Hertz. This computation gives critical information about the temporal features of instruction processing within the system. Furthermore, when it comes to power consumption, the equation P = fcpu x I calculates the power consumed by the microcontroller, with I being the device's current need. By examining these metrics, engineers may efficiently analyze the microcontroller's efficiency and performance characteristics, influencing design decisions and improving system operations for increased functionality and energy economy.

3.3.7 Power of the Motor – Keenan Keams

In engineering calculations of motor power, many essential characteristics are used to estimate the motor's power output. The equation P = IE connects power (P) to voltage (E) and current (I), giving a basic grasp of the motor's electrical power consumption. For example, multiplying amperage (I) by voltage (E) provides power output in watts (P), as shown by the formula 6A * 18V = 108 Watts. Power may also be estimated using mechanical characteristics like force and distance over time. To determine how much power is necessary for motor operation, multiply force by distance and divide by time. Importantly, knowing the link between power and energy, where one watt equals one joule per second, allows for a thorough knowledge of motor performance in terms of both electrical and mechanical components. These calculations are critical for optimizing motor selection and guaranteeing efficient operation within the project's specifications and limits. Note that this computation is currently a work in progress owing to very recent changes in the project.

3.3.8 Power Torque Calculation – Keenan Keams

Understanding the link between rotational speed, torque, and power output is critical in engineering power torque calculations when selecting an appropriate motor to satisfy the project's needs. Previous calculations found the wheel's rotational speed to be 329.3 RPM, with each wheel moving at around 109.1 RPM. Torque and wheel RPM are crucial elements for calculating power output. Once the power output has been calculated, it is vital to choose a motor that works at the needed power and RPM, which is 70-80% of its full power capability, to guarantee dependability and durability. Engineers may use these calculations to make educated judgments about motor selection, maximizing performance while maintaining within project restrictions. Below is an image of the work.



$$\text{Power (kW)} = \frac{5\,(\text{N}\cdot\text{m}) \times 109.7\,(\text{rpm})}{9.5488} = 57.44\ \text{kW}$$

Figure 4: Power Torque calculations visualization

4 Design Concepts

4.1 Functional Decomposition

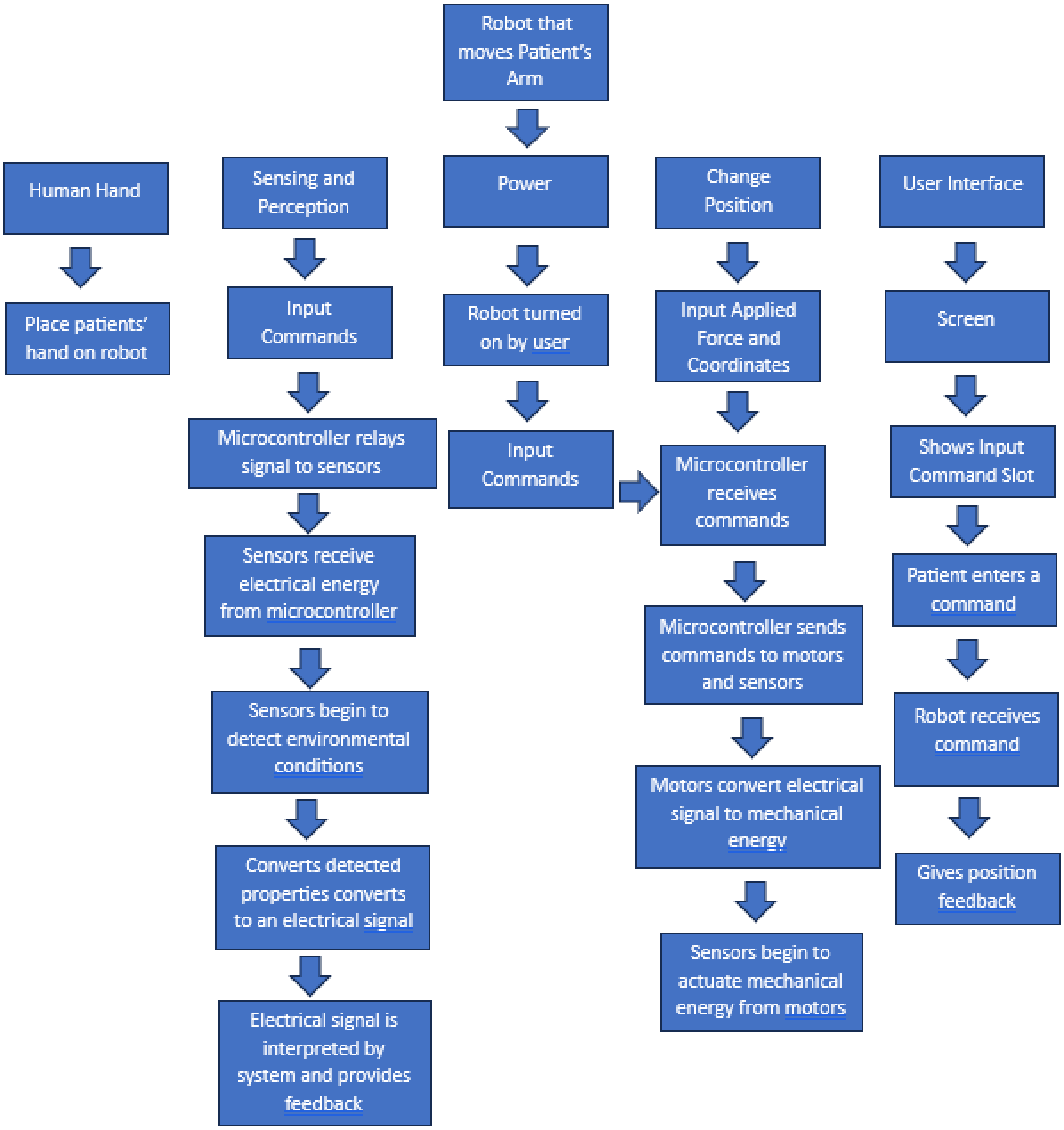


Figure 5: Hamster project functional decomposition

In Figure 5 is the functional decomposition chart for the hamster project. This chart is a flow model to show the main functions needed to fulfill the projects final task. This chart starts with our outcome of the robot moving a patient's arm. Then the subfunctions are in the second row. These subfunctions are broken down into how they will be processed and how they correlate to each other. This functional decomposition model is important for our project because it allows for the team to understand the flow of energy in the robot. This model also breaks down each function into smaller functions that will then help us when it comes time to building and coding the robot.

4.2 Concept Generation

4.2.1 Hand Attachment System – Joe Lopez

Exploring several attachment approaches for our gadget, we discovered that the Velcro strap concept is both affordable and simple to use, although it does require two hands and may cause discomfort for certain users. The friction fit style is easy and uses soft materials, however it may not produce a snug fit. Alternatively, the air compression fit is the best fitting alternative, but with certain structural problems. Robotic claws provide automated fitting but pose safety risks if the motors fail. Finally, while the clamp approach is cost-effective and simple, it may not provide the requisite snugness. Each approach has specific benefits and downsides that must be carefully considered to provide maximum effectiveness and user pleasure. The chosen sub-design was the Velcro strap.

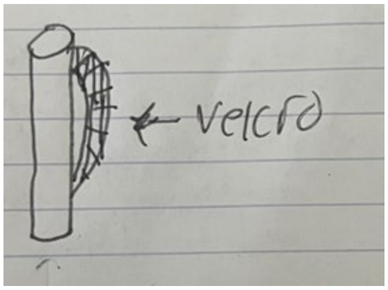


Figure 6: Velcro strap drawing

4.2.2 Wheel Selection and Layout – Jared Hemauer

Several choices were investigated during the concept development phase of wheel selection and layout for the Hamster project robot to enhance mobility and control while balancing cost and complexity. One alternative involved using three omni-directional wheels, which offered cost-effectiveness and excellent mobility but might provide programming issues. Another concept proposed four omni-directional wheels positioned at angles to improve power, but at a greater cost and more programming complexity. Alternatively, mounting four omni-directional wheels on the sides might increase power, but this would limit horizontal mobility and be more expensive. Despite their higher cost, mecanum wheels emerged as a popular alternative because to their superior control and simplicity of programming. Finally, using two regular wheels and one caster wheel was judged cheap and simple, but provided limited movement. By carefully analyzing the advantages and disadvantages of each concept, the team hoped to find the best wheel arrangement to efficiently satisfy the project's objectives. The team chose to use three omni-directional wheels in a triangular arrangement. Below are images for clarity.

Figure 7: Omni-directional wheel

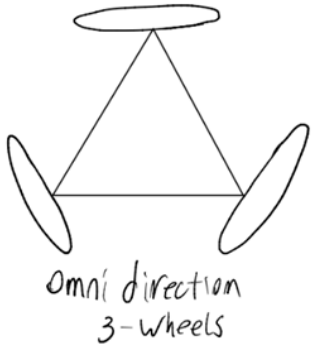


Figure 8: Wheel layout

4.2.3 Chassis Design – Rylee Horney

During the concept generation phase of the chassis design for the Hamster project robot, numerous possibilities were considered to fit the project's components while keeping space limits and compliance with the overall design. The square base emerged as a candidate owing to its capacity to accommodate all components while leaving enough area for a screen. However, concerns were expressed that its size would be too huge for a desk. The spherical base, on the other hand, was thought to be compatible with a three-wheel design, however fitting all components within would be difficult. The dome base was noteworthy for its compatibility with robotic fingers, albeit its height when compared to other designs was a disadvantage. The H base was praised for its economical use of materials, although challenges with internal fittings and additional costs owing to the need for four wheels were observed. Finally, the triangular foundation was considered adequate for a three-wheel design, despite the restricted interior space. After carefully considering these possibilities, the team attempted to choose a chassis design for the Hamster project robot that combines functionality, space usage, and cost-effectiveness. The design chosen was the square base chassis. Below is a picture for clarification.

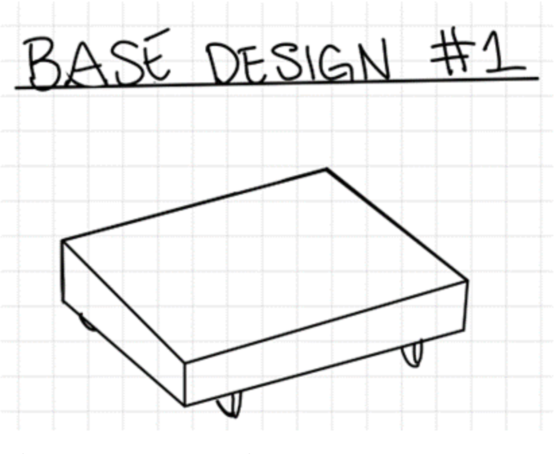


Figure 9: Base Design

4.2.4 Screen Placement – Keenan Keams

During the concept creation phase of screen location for the Hamster project robot, several possibilities were investigated to maximize user experience while balancing durability and cost. One alternative was a screen holder with a separate base on top, which allowed for flexible viewing angles while reducing strain on the user's eyes and neck. However, there were worries about the risk of breakage and increasing costs. Alternatively, incorporating the screen directly into the device was proposed to save components and money, but there were disadvantages such as potential arm occlusion and higher pressure on the user's eyes or neck. Another possibility was to install the screen on top of the gadget, which would save money but provide similar user strain concerns. A screen holder with a bracket was also considered for flexible viewing angles and compatibility with both right and left-handed users, but there were worries about breakage and complexity. Finally, a screen with a side holding arm was considered for more flexible adjustment choices, although concerns about device length and wear over time were expressed. By carefully examining these possibilities, the team hoped to choose a screen layout design that prioritized user comfort and functionality while minimizing potential downsides. The chosen screen positioning was at a 45-degree angle, as indicated in the figure below.

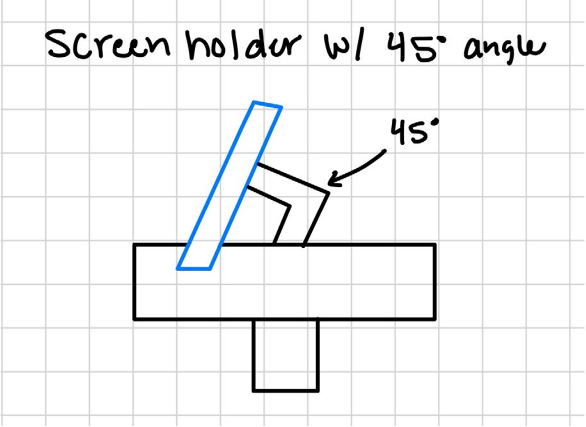


Figure 10: Screen placement design

4.3 Selection Criteria

The Hamster Project's idea selection criteria were based on engineering needs and prioritized features critical to the device's operation and usability. Each criterion was quantitative and related directly to the project's goals. The criteria included:

1. Ease of Use: The most significant factor is the device's ease of operation, setup, and maintenance. Quantification might entail determining the number of steps necessary to activate and use the gadget successfully.
2. Cost-Effectiveness: Cost was the second most significant factor, reflecting the project's budget limits. Quantification entailed determining the total cost of materials and manufacturing processes for each design choice.

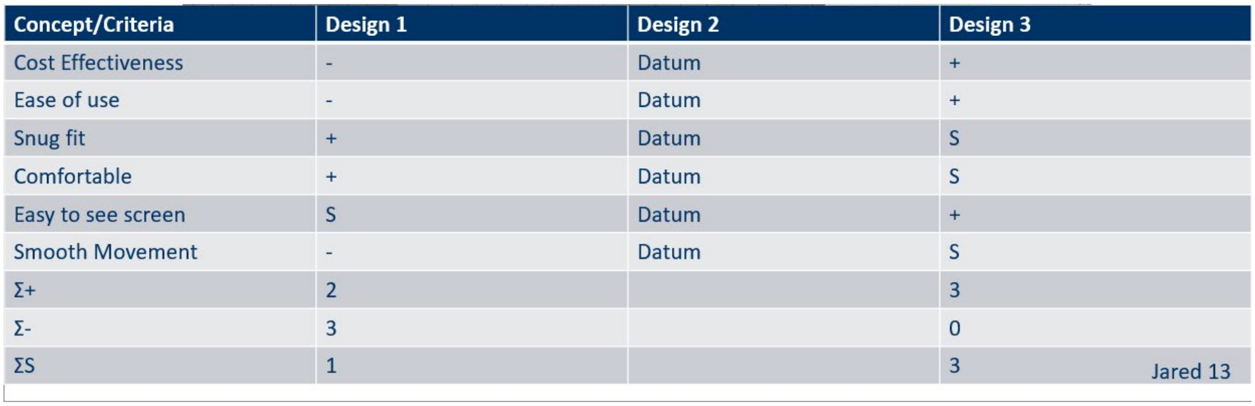
3. Comfort: The third criterion prioritized the device's ergonomics and user comfort while usage. This might be quantified by user surveys and ergonomic studies.
4. Snug Fit: Ensuring a snug fit for the item was rated fourth, demonstrating the significance of stability and security while in use. Quantification may entail examining dimensional measurements and tolerances to achieve a correct fit on the users hand.
5. Screen Visibility: This criterion examined how easy it was to view the device's screen, which contributed to user involvement and feedback. Quantification entailed assessing screen size, brightness, and location to achieve maximum visibility.
6. Smooth Movement: The device's movement was rated sixth, emphasizing the necessity of fluid motion during use. Quantification might entail running tests to determine friction, resistance, and overall movement quality.

Design three emerges as the best option among the finalist ideas for the Hamster Project, excelling in both structural integrity and user comfort. Through extensive moment calculations performed on important junctions, such as the connection between the beam and chassis, design three exhibits greater appropriateness for the required 10 N of force, providing robust performance without compromise. Furthermore, design three's ergonomic considerations make it ideal for attachment to the patient's hand, which corresponds closely to the client's requirement for maximum treatment efficacy. Design three stands out as the most practical and successful stroke rehabilitation aid option because to its emphasis on usefulness, structural stability, and user safety. Design three satisfies the project's objectives while maximizing usability and decreasing danger for stroke patients, thanks to meticulous engineering research and user-centered design.

4.4 Concept Selection

4.4.1 Pugh Chart:

In our Pugh chart study, we used design two as a baseline to compare all other designs. This decision was purposeful, as design two performed averagely across all assessed metrics, giving it an appropriate baseline for analyzing alternative possibilities. Design one was regarded the least favorable, obtaining a score of -1, while design three stood out with a score of +3. This good score suggested that design three outperformed design two in numerous critical areas, prompting us to choose it as the preferable alternative for further development.



Concept/Criteria	Design 1	Design 2	Design 3
Cost Effectiveness	-	Datum	+
Ease of use	-	Datum	+
Snug fit	+	Datum	S
Comfortable	+	Datum	S
Easy to see screen	S	Datum	+
Smooth Movement	-	Datum	S
Σ+	2		3
Σ-	3		0
ΣS	1		3

Jared 13

Figure 11: Pugh Chart

4.4.2 CAD:

The fundamental design of Hamster mk2 remains unchanged, with some enhanced features. The base plate will be manufactured of a tougher plastic rather than PLA, or it may be converted to aluminum if more strength testing is finished. The motors have been chosen as steppers, especially a 350 RPM Premium Planetary Gear Motor, and we are employing motor brackets to keep them secure. The wheels are 100mm omni-directional, with metal cores for added robustness. The middle box's cover is detachable, allowing you to access electronics and batteries. The handle features a hollowed-out middle that allows cables to go through it and connect to the screen. An image of the current CAD model is shown below.

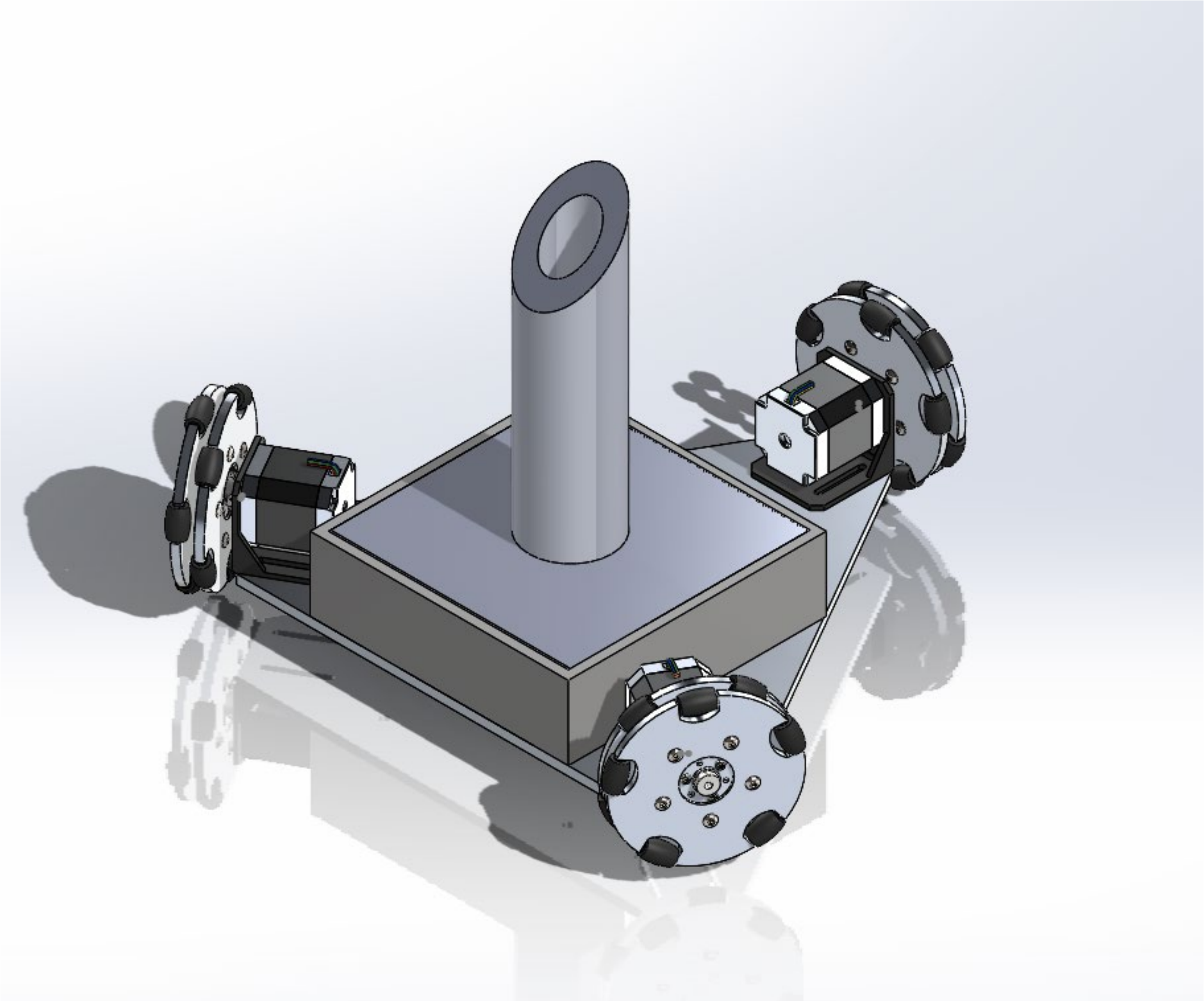


Figure 12: Current CAD model

5 CONCLUSIONS

The Hamster project aims to create a portable robotic device specifically designed for stroke therapy. The project's critical objectives are price, simplicity, and efficacy, with the goal of making cost-effective physical therapy choices available to stroke patients. The project's ultimate solution calls for the development of a motorized robot that resembles a mouse and is intended to aid stroke sufferers in their recovery. This gadget has an easy-to-use UI and simple control mechanisms that allow for tailored therapy sessions. Additionally, the gadget is portable, allowing for easy transfer and usage on any tabletop surface. With its durable design and innovative functionality, the Hamster project aims to revolutionize stroke rehabilitation by providing an inexpensive and convenient solution that allows patients to take charge of their recovery.

Throughout the semester, splendid work has been made toward achieving the Hamster project's objectives. Key accomplishments include the completion of the device's conceptual framework, the identification of appropriate motors for propulsion, and continued research into battery technologies to assure a sustainable power source. In addition, significant work has been put into the creation and improvement of the microcontroller's code, which allows for accurate control of motor operations and navigation. Furthermore, collaborative relationships with healthcare experts and stakeholders have been formed to guarantee that the device efficiently addresses the different requirements of stroke victims. Overall, the semester has resulted in the effective progress of the Hamster project, taking it one step closer to its ultimate objective of changing stroke therapy via innovative technology and caring care.

As the semester concludes, the Hamster project exemplifies the power of multidisciplinary collaboration and creativity in tackling challenging healthcare concerns. The project's progress has been distinguished by thorough research, rigorous design considerations, and a firm dedication to improve the lives of stroke sufferers. While substantial progress has been achieved in the creation of the gadget, the trip is far from complete. Moving ahead, the project team is committed to developing and optimizing the Hamster device to assure its efficacy, cost, and usability. Furthermore, the initiative acts as a catalyst for wider talks about the convergence of technology and healthcare, encouraging future generations of entrepreneurs to push new boundaries in rehabilitation and beyond. With ongoing dedication and a shared goal of compassionate care, the Hamster project is positioned to have a long-term effect around stroke rehabilitation, providing hope and healing to individuals and communities across the world.

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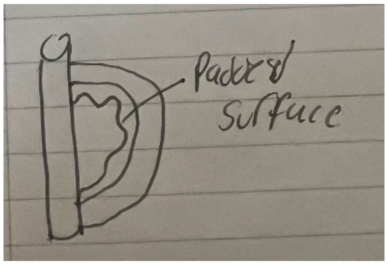
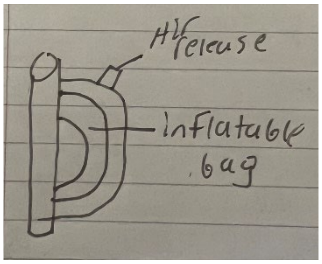
7 APPENDICES

7.1 Appendix A: Other Sub-designs Concepts

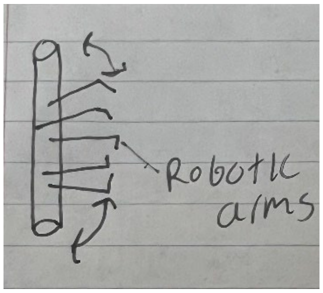
Friction fit hand attachment system:



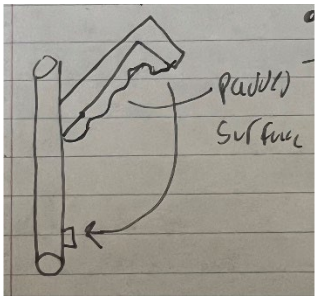
Air bag hand attachment system:



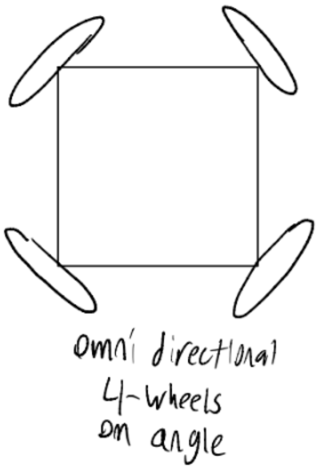
Robotic claws hand attachment system:



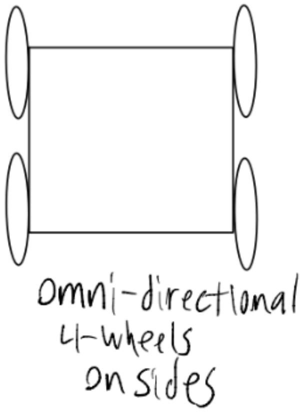
Clamp hand attachment system:



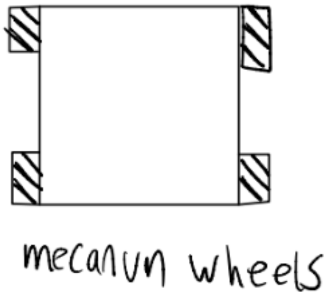
Omni-directional wheels four layout:



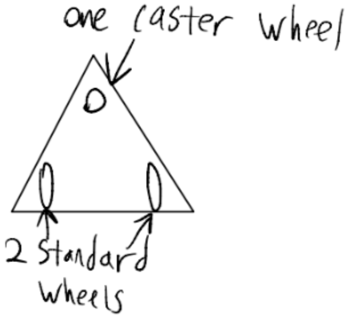
Omni-directional wheels four on side layout:



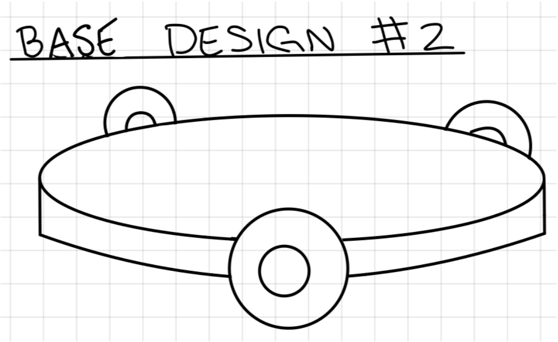
Mecanum wheels layout:



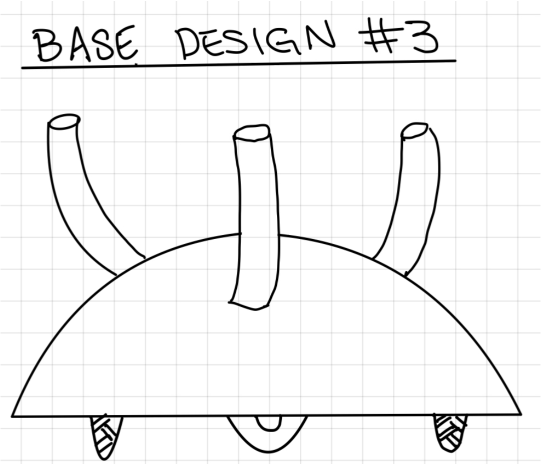
Two standard wheels and one caster wheel:



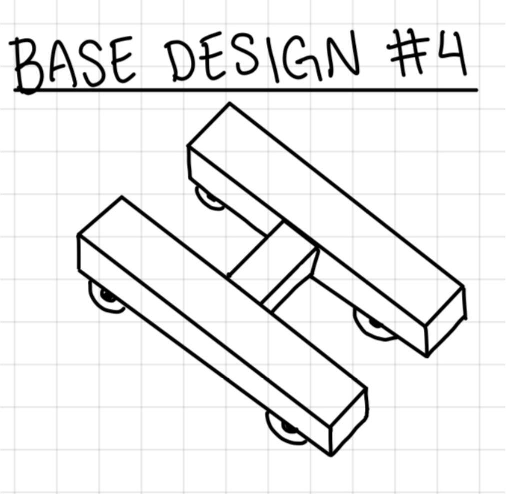
Round base design:



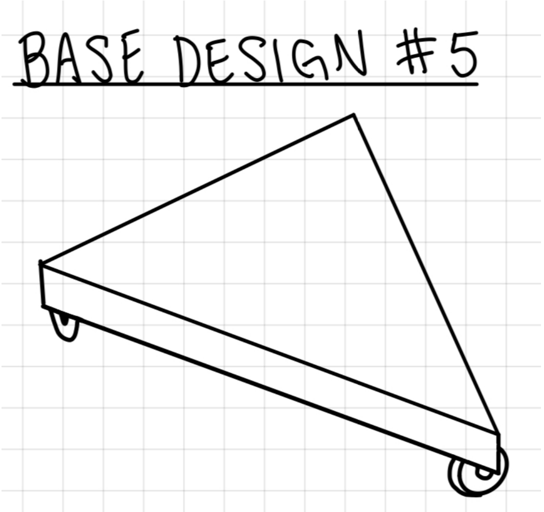
Dome base design:



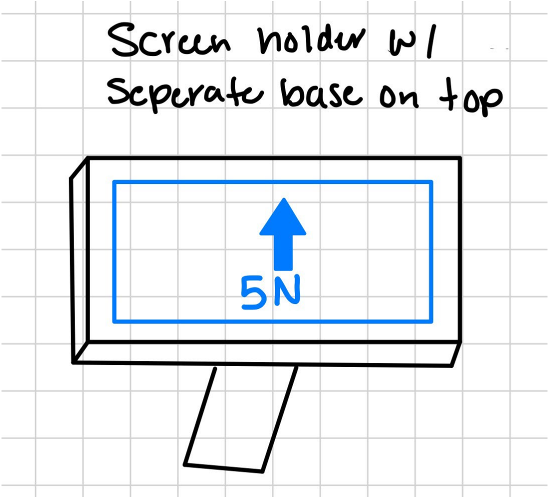
H base design:



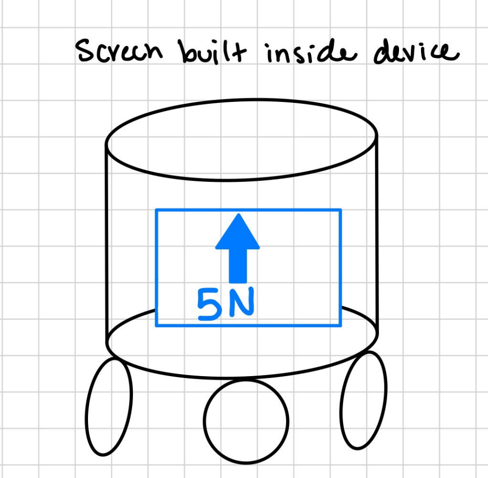
Triangle base design:



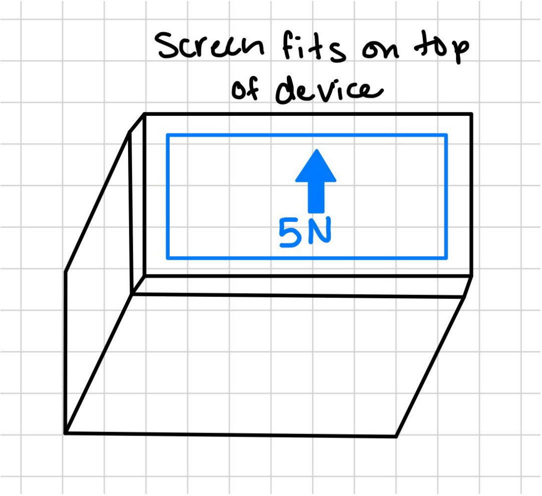
Screen holder on top design:



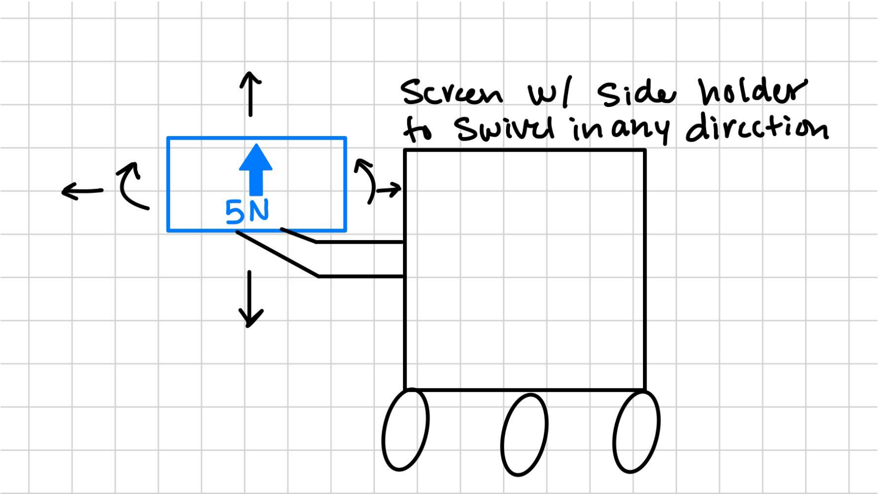
Screen built onto device:



Screen on top of device:



Screen on side of device:



7.2 Appendix B: Benchmarking sources and images

[1]"Lifeward - Redefine Possible," *Lifeward*. https://golifeward.com/ (accessed Mar. 16, 2024).
[2]"EksoNR - The Next Step in NeuroRehabilitation," *Ekso Bionics*. https://eksobionics.com/eksonr/
[3]"Robotic arm," *Kinova - Assistive Technologies*. https://assistive.kinovarobotics.com/product/jaco-robotic-arm

Rewalk device:

Ekso Bionics' Ekso GT:

Kinova Robotics' Jaco Assistive Robot: