Digital traction with Japanese finger sleeves

Progress Report 6

Client: Mr. Pape Samb

Advisor: Dr. Justin Williams

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Team:

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Problem Statement

Design a device that allows for precise digital control and support of the components of the human hand through the use of an universal buckle strap design that will be mounted onto a stand that can be utilized both on a bed clamp design and a wheeled stand design. This device will be designed to allow for controlled and stable traction during relevant procedures so that proper positioning of the hand can be attained with minimal manual effort.

Brief Status Update

The team split into two groups to focus on the two aspects of the design – the finger sleeve and the mechanical stand portion. These teams conducted basic research on their areas, identifying and making preliminary material, parts, and dimensions choices. The team met to discuss progress within sub-divided teams and coordinate interdesign aspects of the device.

Weekly/Ongoing Difficulties

- None to report currently

Current Design

- None to report currently

Materials and Expenses

- None to report currently

Summary of Past Week Accomplishments

- Ilia Mikhailenko
  - Designing an attachment mechanism for the bed clamp portion of the device. This includes several design ideas as well as a design matrix to select between them
  - Met with my subteam to discuss progress on the design of the mechanical component of our prototype and determine the steps we'll need to take moving forward
- Nathan Hansen
  - Constructed testing protocol for tensile durability and slippage of the finger sleeve.
- Nathan Klauck
  - Met with BSAC to discuss various topics including the possibility of a virtual BME 200 class, and rediscuss the training throughout the curriculum.
  - Updated and incorporated research regarding testing and results as well as the discussion sections of the preliminary report into notebook
  - Conducted calculations regarding ideal dimensions of a wheeled stand to prevent tipping
  - Brainstormed Idea for Bed clamp design
- Ben Willihnganz

    - Performed research on ballistic nylon, a potential material for the finger sleeves
    - Brainstormed ideas for how to make the finger sleeve come together, with its attachment pieces
- Mariamawit Tefera
    - Researched and documented potential material we need to purchase for our first prototype
- Sam Dudek
    - Researched and documented the possible techniques to join the nylon and Velcro straps together
    - Documented and discussed a possible way to conduct testing on our sleeve portion during the show and tell two weeks from now

Upcoming Team and Individual Goals:

The current team goals include furthering individual research and considering design ideas to move forward with.

- Ilia Mikhailenko
    - Work with the subgroup to finalize a design for the restraint arm get parts ordered for the restraint arm by the end of next week.
    - Check in with the other team to ensure they are making progress and will be able to finalize a design by next week so we are on track to have a sleeve fabricated for the show and tell.
- Nathan Hansen
    - Begin construction of finger sleeve prototypes.
    - Conduct preliminary testing on prototypes to test if protocol is sound.
- Nathan Klauck
    - Prepared for BSAC exec meeting
    - Further designs
    - Further research and calculations regarding designs
- Ben Willihnganz

    - Talk to someone at the Makerspace about how to cut our fabric in the most effective way possible
    - Begin fabrication of first prototype
    - Test materials for strength and ability to be sanitized
- Mariamawit Tefera
    - Decide on which exact parts we need to use and their prices
    - Get the first few pieces ordered
- Sam Dudek
    - Meet with subgroup to communicate with maker space workers to finalize materials, how we go about joining materials, and creating the outline for fabrication of our prototype
    - Research impacts of sterilization on nylon and other research on our materials we plan to use

Activities Timesheet

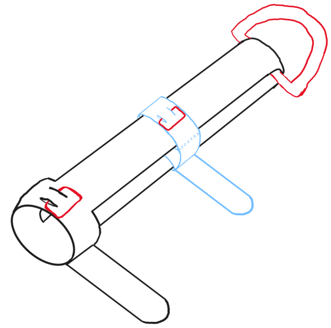
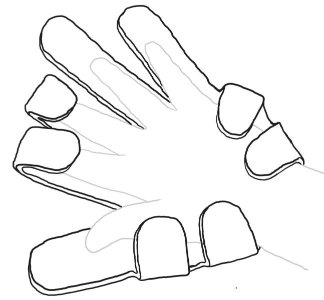
Team Member	**Time for the Week**	**Total Time for the Semester**
Ilia Mikhailenko	3	24
Nathan Hansen	3	24
Nathan Klauck	6	24
Ben Willihnganz	5	22
Mariamawit Tefera	6	25
Sam Dudek	4	22

Preliminary Project Timeline:

Task	Sep			Oct					Nov				Dec	
	12	19	26	3	10	17	24	31	7	14	21	28	5	10
Project R&D														
Brainstorm	x	x	x											
Research	x	x	x	x	x	x								
Prototyping						x								
Testing														
Deliverables														
Progress Reports	x	x	x	x	x	x								
Prelim presentation			x											
Final Poster														
Meetings														
Client	x		x											
Advisor	x	x	x	x	x	x								
Website														
Update	x	x	x	x	x	x								

Design Matrices:

Finger Sleeves

Design Criteria	Weaved Design		Adjustable Velcro Design		Hand Immobilizer	
						
Safety (25)	5/5	25	4/5	20	2/5	10
Ease of Fabrication (20)	2/5	8	5/5	20	4/5	16
Cost (20)	3/5	12	5/5	20	2/5	8
Ease of Use (15)	5/5	15	4/5	12	3/5	9
Comfort (10)	4/5	8	3/5	6	5/5	10
Reusability (10)	2/5	4	4/5	8	2/5	4
Total (100)	72/100		86/100		57/100	

Criteria 1: Cost (25)

- **The cost of the design reflects both the raw material price and the overall affordability of manufacturing. Since hospitals and clinics often need multiple devices, keeping costs low is a priority.**
- **Design 1: Weaved Design — This design scores well on cost. The woven material is inexpensive and widely available, but it requires shaping and tailoring into the correct size and form, which adds moderate expense.**
- **Design 2: Adjustable Velcro Design — This design scores the highest because Velcro and supporting materials are cheap, standardized, and easy to produce in bulk. Minimal shaping or customization reduces overall costs.**

- **Design 3: Hand Immobilizer — This design is more expensive due to its layered foam and flexible metal structure. The additional material and complexity make it less cost-effective than the other two options.**

Criteria 2: Reusability (25)

- **Reusability refers to the number of times a device can be applied, cleaned, and maintained before it becomes unsafe or unusable. This is important to reduce waste and maximize long-term value.**
- **Design 1: Weaved Design: This design scores lowest in reusability. Its woven material can fray, stretch, or lose elasticity over repeated uses and sterilizations, reducing durability over time.**
- **Design 2: Adjustable Velcro Design: This design has the highest reusability. Its straps can be adjusted to fit multiple patients, and the overall construction is durable enough to withstand repeated cleaning and use. The main drawback is eventual Velcro wear, though replacement is simple.**
- **Design 3: Hand Immobilizer: This design has moderate reusability. While it is sturdy, the foam padding degrades with repeated cleaning and use, limiting its long-term durability.**

Criteria 3: Safety (traction) (15)

- **The safety of the design depends on the overall safety for both the patient and physician. This includes both the level and method of traction and dispersion of forces. The weight of this criterion is because safety of all parties needs to be included, as there are procedures being done.**
- **Design 1: This model, which is already commonly used, disperses the force throughout the finger due to its weaved material and keeps the finger steady by use of gravity.**
- **Design 2: This model has two velcro straps which could center too much force on certain parts of the finger, and velcro could eventually wear out.**
- **Design 3: This model has more pressure points around the hand and wrist, which could lead to patient discomfort considering most of the procedures using digital traction are small hand/wrist fractures.**

Criteria 4: Ease of Fabrication (15)

- **Ease of Fabrication refers to the ease of taking available parts and compiling them into our desired product. This was rated in the middle for importance as although any easily fabricated design is important for prototyping and possible future production, the designs cost and reusability play a larger role in the validity of the product.**
- **Design 1: This design requires a multiple size approach and thus requires individual construction for each. Additionally, the conversion of the mess into a cone like shape for application isn't easily achievable, and thus was rated the lowest of the designs**
- **Design 2: This design involves a simplistic manipulation of the material used with a few minor parts and was thus rated second highest for its category**

- **Design 3: This design requires only a foam layer and a flexible metal material beneath, or can be purchased in a similar form and was thus rated the highest for ease of fabrication**

Criteria 5: Ease of Use (10)

- **The ease of use both depends on the ease of applying the finger sleeve to the patient, but also its ease of use in a multitude of different medical procedures. The weight of this criterion is relatively small because this is already the more simple part of the design, and once it is on, there is not much adjustment needed.**
- **Design 1: This design easily slips onto the finger and grasps back on utilizing gravity and its weaved nature, provides tension and leaves space for operation on the finger, hand, and wrist.**
- **Design 2: This design, although it has no restrictions in procedures it can be used in, requires manual tightening and adjusting by the physician.**
- **Design 3: This design is very easy to strap in initially, but would be very difficult to use in certain applications. This includes castings, any wrist procedure, and more.**

Criteria 6:Imaging Compatibility (10)

- **Imaging Compatibility refers to how easy the design is to construct with components that are compatible with basic imaging techniques like MRI. This was rated the lowest as although this feature is valuable, it isn't necessary for our prototype.**
- **Design 1: This design involves a completely MRI safe design, with the metal hook being easily swapped for a compatible metal if necessary and was thus rated the highest.**
- **Design 2: This design is also MRI compatible with the only portion at risk being the supporting metal hook. The only reason this was rated slightly lower is due to the difficulty to switch the hook for a compatible metal if necessary, making it slightly less compatible**
- **Design 3: This design requires a flexible metal attached to the back of a foam and thus is not ease to replace and requires a more specific compatible metal and was thus rated the lowest**

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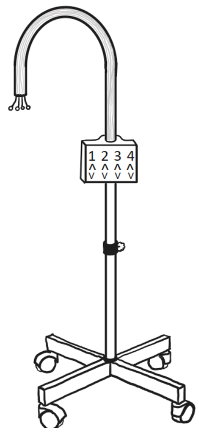
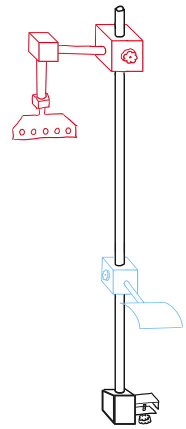
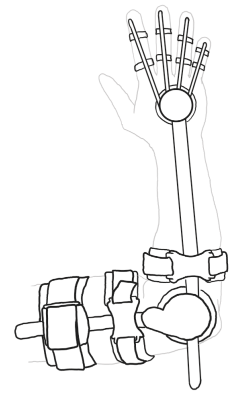
Mechanical/ Frame

Design Criteria	Standing Platform	Bed Clamp & Restraint	Extension Brace

						
Ease of use (25)	4/5	20	5/5	25	3/5	15
Cost (20)	4/5	16	5/5	20	2/5	8
Reusability (20)	4/5	16	5/5	20	2/5	8
Safety (15)	3/5	9	4/5	12	3/5	9
Ease of Fabrication (10)	5/5	8	4/5	4	2/5	10
Versatility (10)	4/5	8	3/5	6	2/5	4
Total (100)	81/100		87/100		54/100	

Criteria 1: Ease of use (25)

- **One of the sole purposes of our design is to reduce manual labor and effort a surgeon puts forth in surgery. For this reason, the ease of operation quickly and effectively is the most important aspect of our mechanical design.**
- **Design 1: The Standing Platform design is effective in ease of use because of its simplicity. This design has very few moving parts and the majority of the mechanism is put inside of the structure itself, but the wheels and multi-use aspect of the design could cause confusion and take away valuable time preparing for procedures and making adjustments.**
- **Design 2: The Bed Clamp and Restraint design is the most effective in ease of use because of its similarity to preexisting devices. It is/ common for surgical equipment to clip or screw onto the side of the operating table, so most surgeons and residents will be familiar with this concept. This design is also very easily adjusted making fine tuning simple and efficient.**

- **Design 3: The Extension Brace receives the lowest score in ease of use because of the manual effort it takes to apply the compression forces and difficulty in getting the patient in the device. This design also almost entirely covers up either the front or the back of the hand making procedures on the sides of the wrist more difficult and clunky.**

Criteria 2: Cost (20)

- **The cost of the design reflects raw material price, manufacturing complexity, and overall affordability for hospitals to purchase and use.**
- **Design 1: Standing Platform — Moderate cost. Materials are not expensive, but added wheels and control components raise manufacturing costs slightly.**
- **Design 2: Bed Clamp & Restraint — Lowest cost. Simple design with standard components makes it inexpensive to produce and assemble.**
- **Design 3: Extension Brace — Highest cost. Requires more complex parts, precision hardware, and replaceable padding, increasing expense.**

Criteria 3: Reusability (20)

- **Reusability is important because hospitals and surgical centers require devices that can withstand repeated sterilization and use across multiple patients. Also, the more durable and easier to clean the device, the more cost-effective and sustainable it is in practice.**
- **Design 1: The Standing Platform design has moderate reusability. While the solid structure and plastic components can endure repeated use, the wheels and moving parts may wear down with time and constant sterilization, which reduces its long-term durability compared to simpler designs.**
- **Design 2: The Bed Clamp and Restraint design scores the highest in reusability. Its simple construction, lack of fragile moving parts, and ability to be easily cleaned and sterilized make it highly suitable for long-term repeated use in clinical settings.**
- **Design 3: The Extension Brace has the lowest reusability. The manual compression components and high-contact areas with the patient's hand and wrist may degrade more quickly with repeated sterilization, while the complex setup makes it more prone to wear out.**

Criteria 4: Safety (15)

- **The safety of this design depends on the safety for both the patient and physician. This includes its stability, dispersion of forces, and more. The weight of this criterion has to do with safety being relevant for all parties involved, every physician and patient who comes into contact with the device.**
- **Design 1: This design disperses the forces well by using gravity on the hand. Its problem is stability, it is possible that the wheels could move during procedure, and if there is too much tension, the control box could fail and disconnect from the mounting post.**
- **Design 2: This design's clamp at the bottom is its only clamp for stability. This could become a problem if the patient's arm becomes too heavy or the tension provides too much force, leading to failure.**
- **Design 3: This design's main problem happens to be its dispersion of forces. It has too much contact with the patient's hand and wrist, which is precisely the site of most of the procedures that need digital traction.**

Criteria 5: Versatility (10)

- **The versatility of the design depends on its ability to be used in a multitude of different operations or procedures. The weight of this criterion has to do with the fact that our client has stated the need to use it for multiple procedures.**
- **Design 1: This design, with its addition of wheels and multiple points of adjustment, is very versatile. Its one drawback is its lack of adjustment to the angle of attachment at the very top.**
- **Design 2: This design has many areas to adjust the patient's arm which allows it to have many different applications, but is limited by its need to lock directly to a hospital bed.**
- **Design 3: This design gets a lower score because although it applies tension, it does not leave ample room for different operations. This includes things like casting, where they need space to get around the entire wrist.**

Criteria 6:Imaging Compatibility (10)

- **The Imaging Compatibility of the designs is graded on how adaptable they are to being used in different imaging devices, specifically MRI compatibility.**
- **Design 1: The Standing Platform design is fairly suitable for imaging. The body of the device could primarily be built out of a strong plastic material that is good for imaging. In addition to this, the ability for the device to be used standing , sitting, or laying down, allows for numerous possibilities as far as different imaging devices.**
- **Design 2: The Bed Clamp and Restraint design struggles as far as imaging goes. Its metal frame and body could be made of MRI safe metals, but the lack of adjustability and mobility reduces many imaging possibilities.**
- **Design 3: The Extension Brace is most suitable for imaging. This device is unique in that it can stand alone as it does not rely on gravity for the application of tension. This allows the device to be directly inserted into different hand, wrist, and arm imaging devices. The lack of a “clunky” body helps this device tremendously.**