SHAPE AND ROLL:

COSMETIC COVER

Jaipur Foot

- Easy to manufacture
- Gives patients the ability to do many of the things they could with an actual foot
  - Running, climbing trees, etc
- Uses simple materials, and coloring can be made to match the native skin color

Photo of Jaipur Foot removed due to copyright restrictions.

Problems with Jaipur Foot

- Lacks toe support
  - Leads to shortened stride
- Use of different materials inside foot can cause deterioration
- Heavy: current design is roughly 800g

Goals of the Shape & Roll Foot

- Incorporate a foot design to resemble the dorsiflexion of a biological foot/ankle in stride
- Reduce the weight of the foot while maintaining the same durability
- Allow for easier squatting

Current S&R Capabilities

Photo of Shape and Roll Foot from Prosthetics Research Laboratory and Rehabilitation Engineering Research Program at Northwestern University Feinberg School of Medicine has been removed due to copyright restrictions.

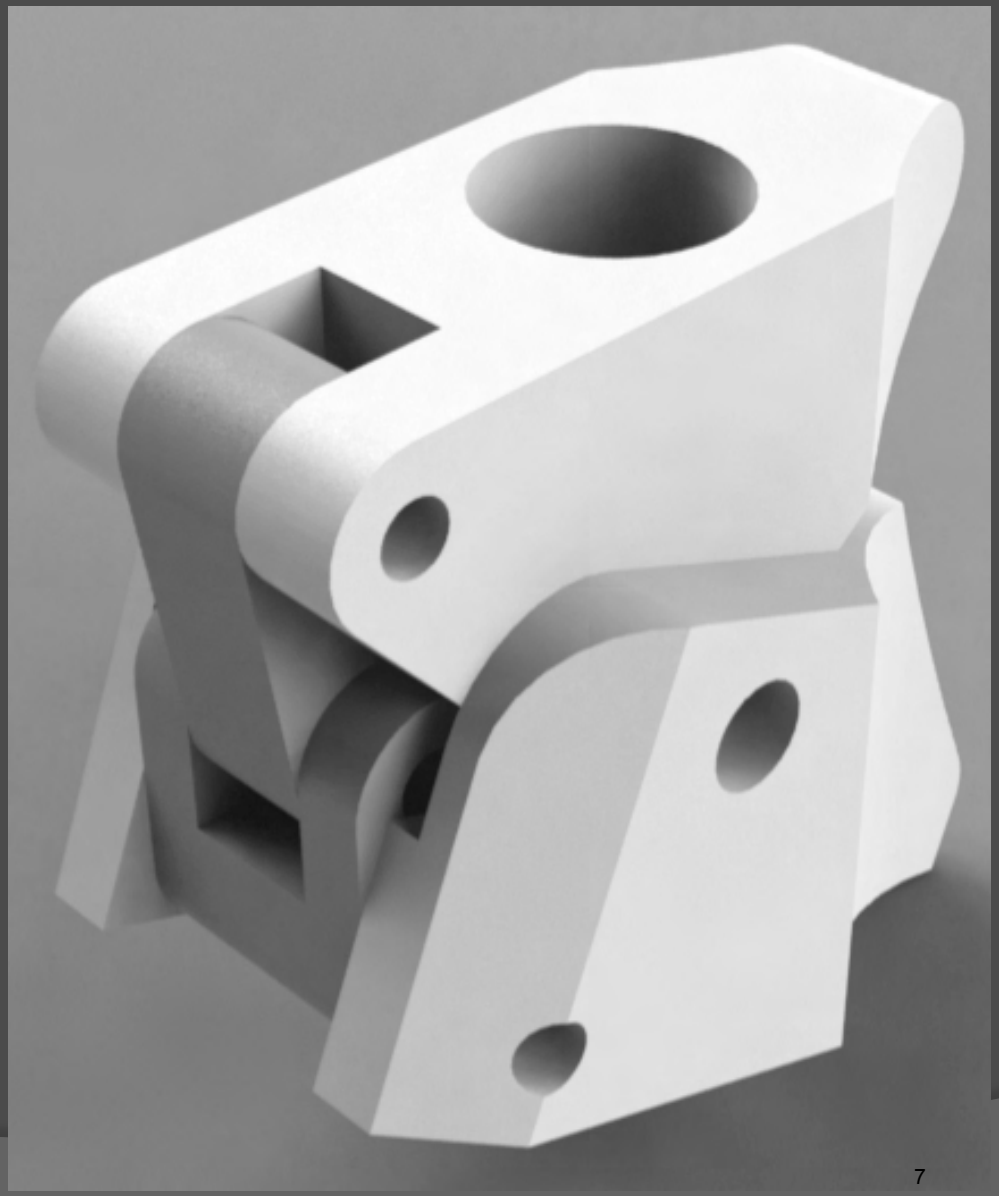
- Closely resembles the roll-over contour of a normal stride
- Far lighter than the Jaipur Foot
- Low in cost

Goals for the Shape & Roll Project

1. Create an ankle design to allow for extreme dorsiflexion while squatting
   - Edward Sung

2. Find a way to make a cosmetic cover for the current S&R Foot
   - Parhys Napier and Nicholas Torgerson

Ankle Joint Design



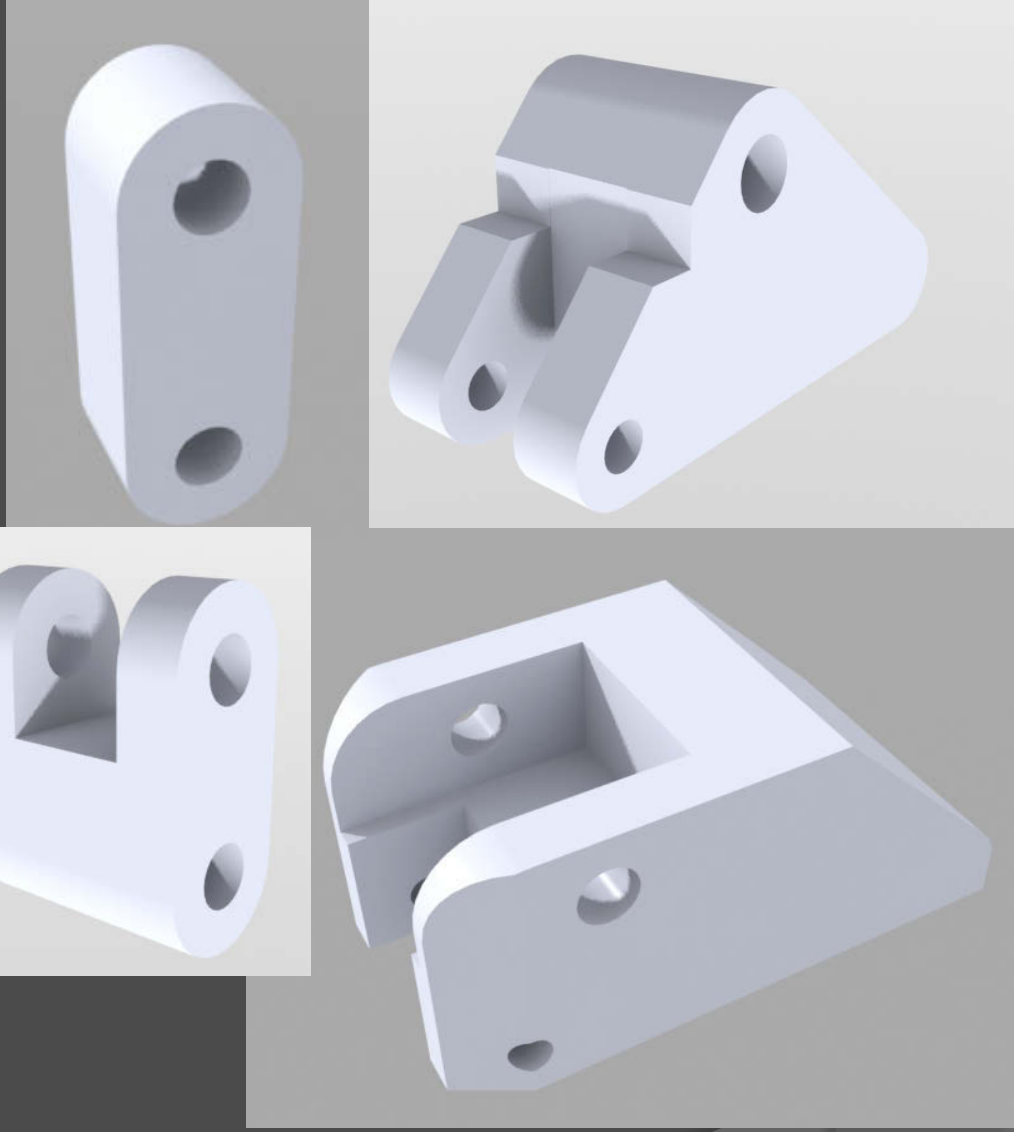
- ~ 25 degrees range of motion
- Material cost < $20
- Labor cost > $50

Process:

- Machine grooves and angled sides
- Sand/grind for aesthetics

Future Plan

- Decide on actuation:
  - Wire
  - Push-pull rod
- Work on interface



Goal 2: Improving the Cosmetic Cover

- Create a mold around the S&R core and form the cosmetic cover directly on top of it (S&R-Jaipur Hybrid)

- Find a lightweight, flexible and durable material for the cosmetic cover

Current Problems

- Previous attempts at S&R feet with cosmetic covers have still been heavy
- One cosmetic shell design was tested by Cornell, but eventually wore out in a couple of months

Methods of Covering S&R

- Make a cosmetic sleeve, and slide the Shape & Roll into it
  - Fill the empty spaces with a foam-like substance
- Create a hybrid Jaipur Foot using the Shape-and-Roll as the core
  - The cosmetic cover is molded directly onto the S&R using a process similar to that of the Jaipur foot

Cosmetic Shell

Advantages:

- Lightweight
- Rapid process
- Inexpensive

Photo of cosmetic shell for a prosthetic foot removed due to copyright restrictions.

Disadvantages:

- Requires filling due to loose-fit
- Not waterproof
- Depending on the material, sleeve can be abrasive on prosthetic
- Not as rigid as hybrid
- Would not allow for a good bond between the keel and the mold

S&R-Jaipur Hybrid

Advantages:

- Completely watertight
- More durable than a shell
- Less chance for wear due to parts rubbing against one another
- One solid foot rather than multiple pieces

Disadvantages:

- Heavy
- Does not allow for squatting

Photos of hybrid Shape & Roll - Jaipur Foot removed due to copyright restrictions.

Hybrid Foot Approach

- Materials in S&R-Jaipur Hybrid
  - Rubber (vulcanized, natural, crepe) – density: 1100 kg/m^3
  - Teflon – density: 2200 kg/m^3
  - Wooden block – density: ~ 650 kg/ m^3
- Want to use a similar approach, but use alternate materials for a lighter foot
- Combined with ankle mechanism, the foot will allow for dorsiflexion

Materials – First Prototype

- Urethane 60
  - Durable, yet also flexible
  - Can buy in bulk
  - Not very toxic
  - ~ $105/gallon (Smooth-On, Inc.)
- Fiber Reinforcement
  - By adding glass fibers to the Urethane 60, we hope to reinforce the foot and make it more durable
  - ~ $9/1’x1’ .01” sheet (McMaster-Carr)

Additional Materials

- Composite Materials
  - Ex: Carbon fiber
  - Pro: Lightweight, extremely durable
  - Con: Potentially damaging to S&R foot
- Synthetic Rubbers
  - Ex: Neoprene
  - Pros: durability over wide temperature ranges; water resistant
  - Cons: price, local availability
- Microcellular Rubber (MCR)
  - Pros: low density; lightweight; soft; high impact absorption
  - Cons: lacks hardness, susceptible to abrasion

Modification for New Ankle Design

- Use a more flexible material to allow full dorsiflexion capabilities during squatting.
- Looking to use a something similar to a sleeve to cover the ankle.
- Sleeve will be integrated into the mold to make one piece.
- Needs to be waterproof
  - Possible material: urethane 40 (~$100/ gallon)

Molding Modification

- Current methods use rubber blocks to fill in gaps around the S&R core
- We plan to use a lighter “filler” to reduce weight
  - Foam similar to the kind used in the toes
  - Microcellular Rubber (MCR)
  - Polymers (like polyurethane)
  - Cork
- Bonding between keel and mold
  - Received feedback on the importance of bonding the keel to the mold (decreases movement and wear)
  - Plan to either use strong adhesive or integrate the keel into the mold as one piece.

Plan of Action

- We hope to order materials and begin prototyping the week after spring break (3/29)
  - Begin testing (durability, amount of flexion, etc.) Collect data/analyze (week of 4/5)
  - Modify the design and any failed materials with alternate materials/improved design (week of 4/12)
  - Make new prototype(s) based off of success of previous prototype and resume testing (finish tentatively week of 4/26)
  - Integrate ankle mechanism with cosmetic mold; test with ankle cover (late April, early May)
- Finish a final prototype by the end of the semester.

EC.722 Special Topics at Edgerton Center:Developing World Prosthetics

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