



Endeavors & Advancements in Additive Manufacturing for Orthotic & Prosthetic Devices

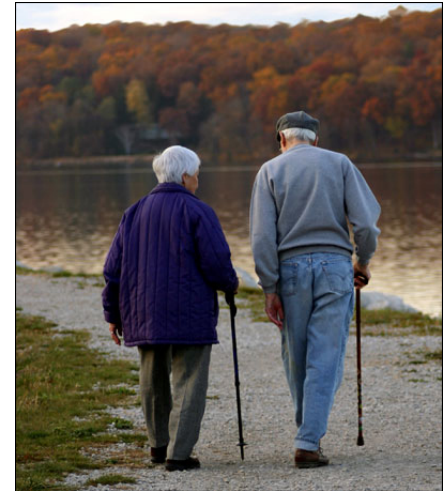
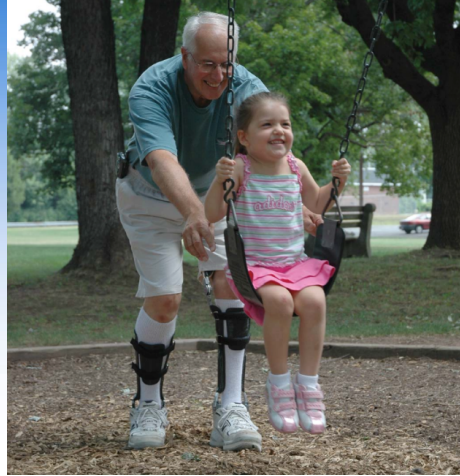
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University of Delaware

*New Frontiers of Bio-Medical Additive Manufacturing, RAMP
MD
March 4, 2016*

O&P devices come in many different types...



So do people...



Enhancing A Patient's Function & Mobility requires:

Personalization

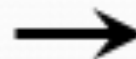
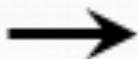
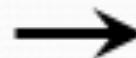
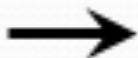


Device Characteristics



Patient's Function &
Needs

Current Design & Manufacturing Method



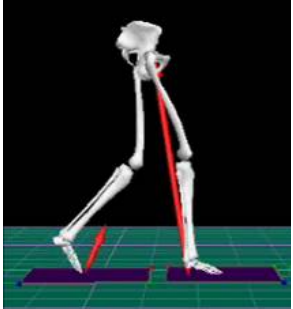
Labor Intensive
Craft-Based
No Quantification
Trial & Error

Rapid Personalization & Manufacturing Method

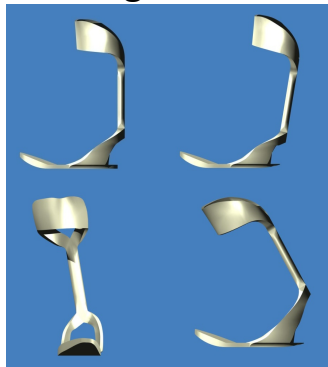
Characterize
Subject Fit



Characterize
Subject Function



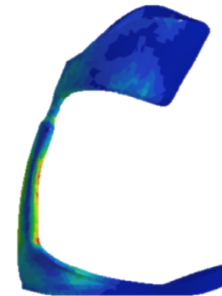
Virtual Orthopedic
Alignment



Fit Personalize
CAD Model



Function
Personalize
CAD Model



Fabricate via
Additive
Manufacturing



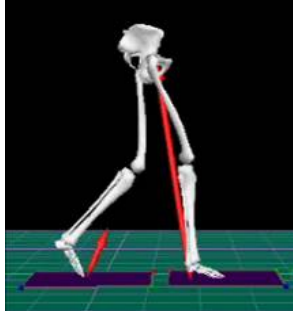
Automated

Rapid Personalization & Manufacturing Method

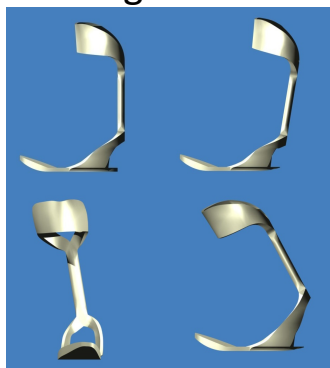
Characterize
Subject Fit



Characterize
Subject Function



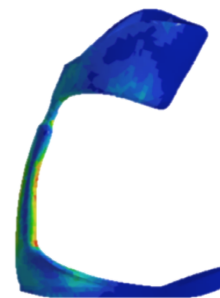
Virtual Orthopedic
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Additive
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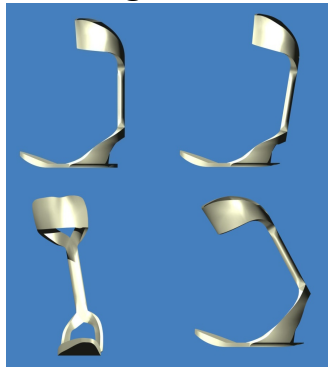


Rapid Personalization & Manufacturing Method

Characterize
Subject Fit



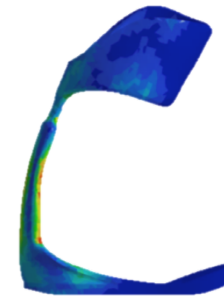
Virtual Orthopedic
Alignment



Fit Personalize
CAD Model



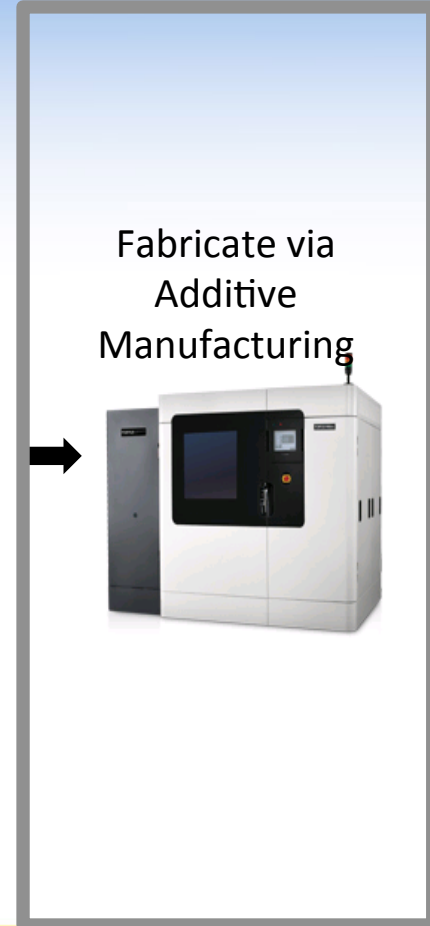
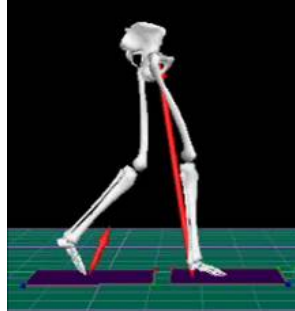
Function
Personalize
CAD Model



Fabricate via
Additive
Manufacturing



Characterize
Subject Function



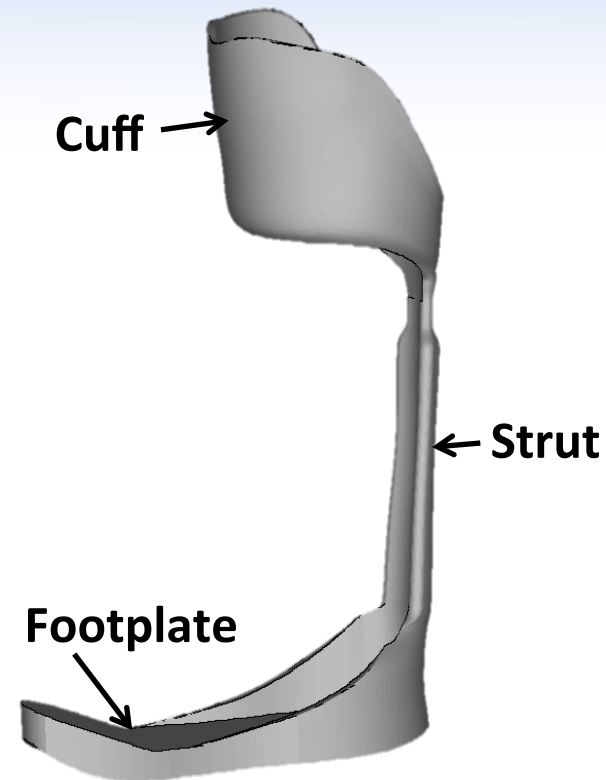
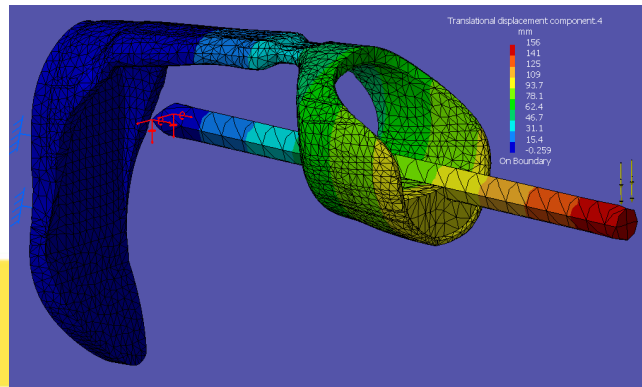
Fabrication

- Need to rapidly fabricate prosthetic and orthotic devices (complex shapes) that are:
 - Fit Personalized → dimensional accuracy with 2mm tolerance
 - Function Personalized → mechanical properties predictable with 5% of target

Load-Bearing, Functional, End-Use Parts.

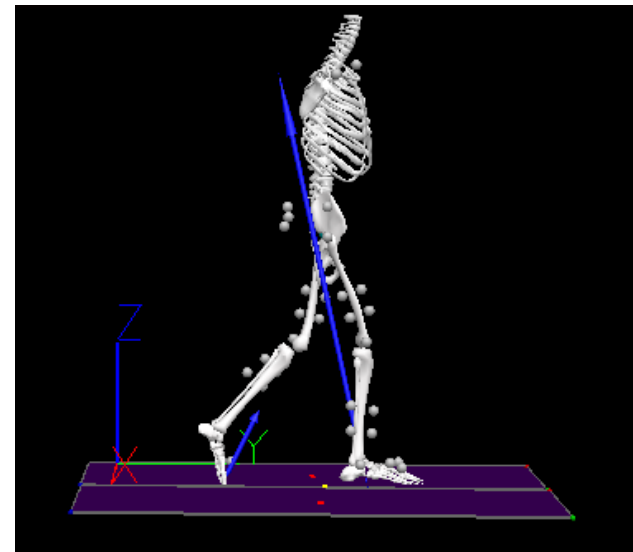
Rapid Personalization & Manufacturing of Ankle-foot Orthoses

- Demonstrated dimensional accuracy
 - SLS in DuraForm® EX Natural Plastic
 - FDM in medical-grade polycarbonate
- Developed method to predictable tune bending stiffness (function personalization)
 - FDM in medical-grade polycarbonate



Rapid Personalization & Manufacturing of Ankle-foot Orthoses

- Using personalized AFOs to:
 - Understand device-musculoskeletal interaction
 - Develop prescription models



Current Limitations & Needed Advancements

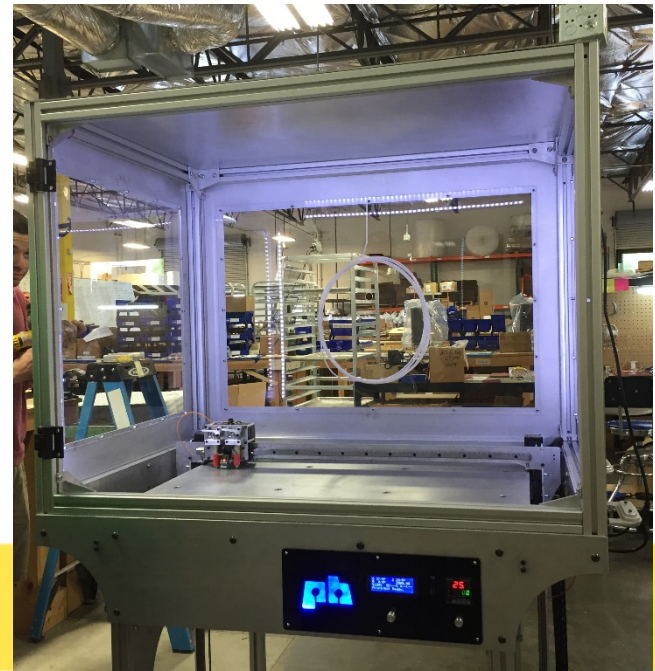
- Clinical implementation limited by materials currently available
 - Mechanical properties highly dependent on material thickness
 - Limited durability



Current & Future Directions

- ADM developed novel **carbon fiber composite** for direct use in additive manufacturing
 - Initial analyses show material provides:
 - **Magnitude improvement in elastic modulus**
 - **Almost twice as strong**
 - Might be **ideal AM material for prosthetic and orthotic devices**

- Purchase custom PrintrBot machine
 - Large build volume (20" x 18" x 12")
 - Heated bed
 - Enclosed build chamber
 - Dual extrusion head



Current & Future Directions

- Working to...
 - Fully characterize mechanical and physical properties of carbon fiber composite
 - Optimize manufacturing paradigm to fabricate personalized, light weight, durable prosthetic & orthotic devices



Additive Manufacturing: Enabling a transformative, personalized medicine approach to orthotic & prosthetic management

