

Cyber-Physical Design and Additive Manufacturing of Custom Orthoses

Albert Shih

Professor

Mechanical Engineering,

Biomedical Engineering,

Integrative Systems + Design

University of Michigan at Ann Arbor

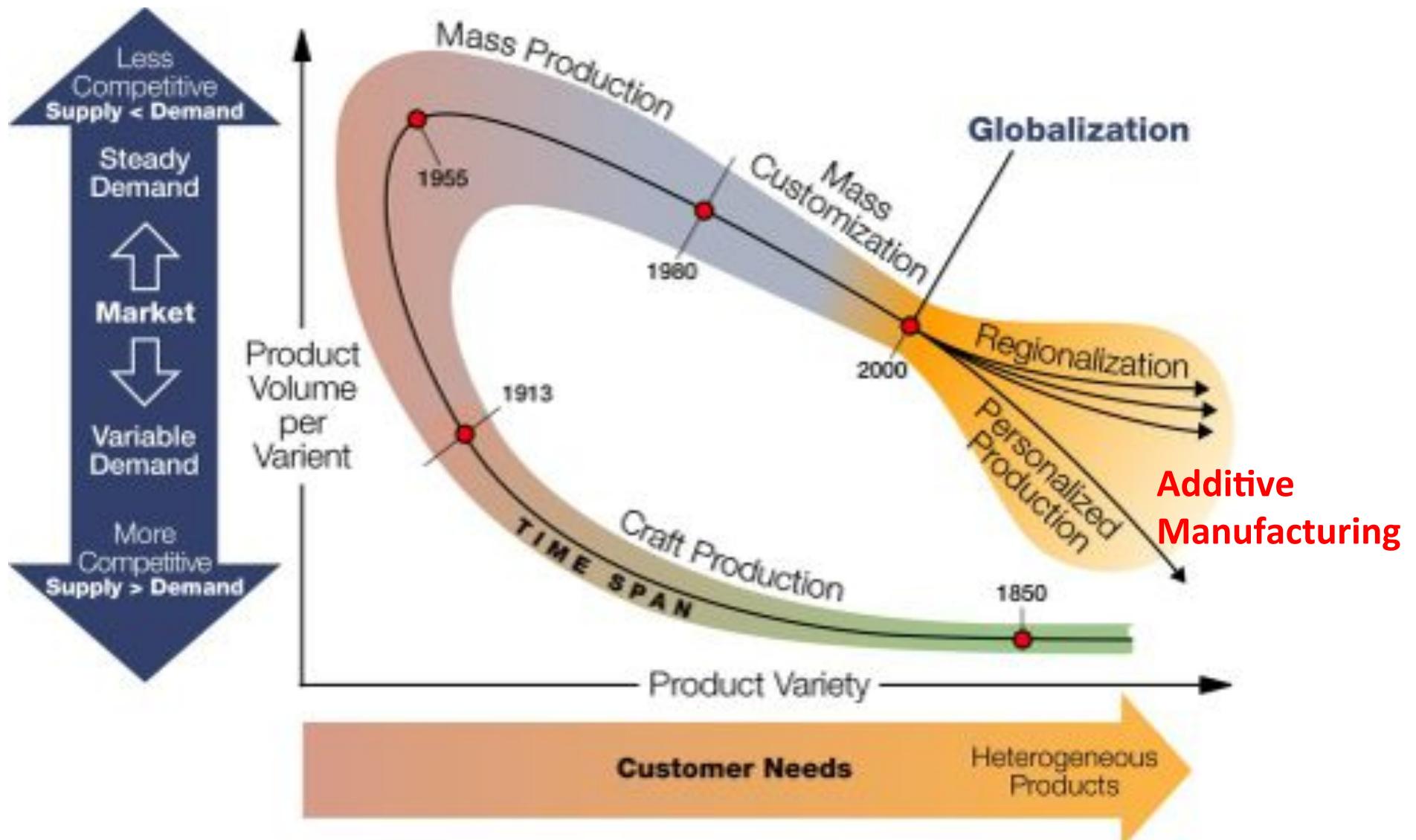
NSF Workshop: Additive Manufacturing for Health
March 17, 2016 Arlington VA



Topics

- Large-Scale Manufacturing of Custom Products
- Custom Orthosis and Prosthesis
- Cyber-Physical Design and Additive Manufacturing at the University of Michigan Orthotics and Prosthetics Center (UMOPC)
- Soft Material Additive Manufacturing
- Education: Hands-On, Video-Enhanced 3D-Printing Course

Large-Scale Manufacturing of Custom Products: the Paradigm Shifted by AM



Custom Orthosis and Prosthesis: Current Manufacturing Practice for Ankle-Foot Orthoses (AFO)

Negative impression



Modification



Trim and finish



Plaster molding



Vacuum forming



Custom Orthosis and Prosthesis: Cyber-Physical Design and Additive Mfg of AFO



Mfg System

Research:

- * Scheduling
- * Ergonomics
- * Quality
- *

Material/ Process::

- * FDM of short carbon-fiber in Nylon



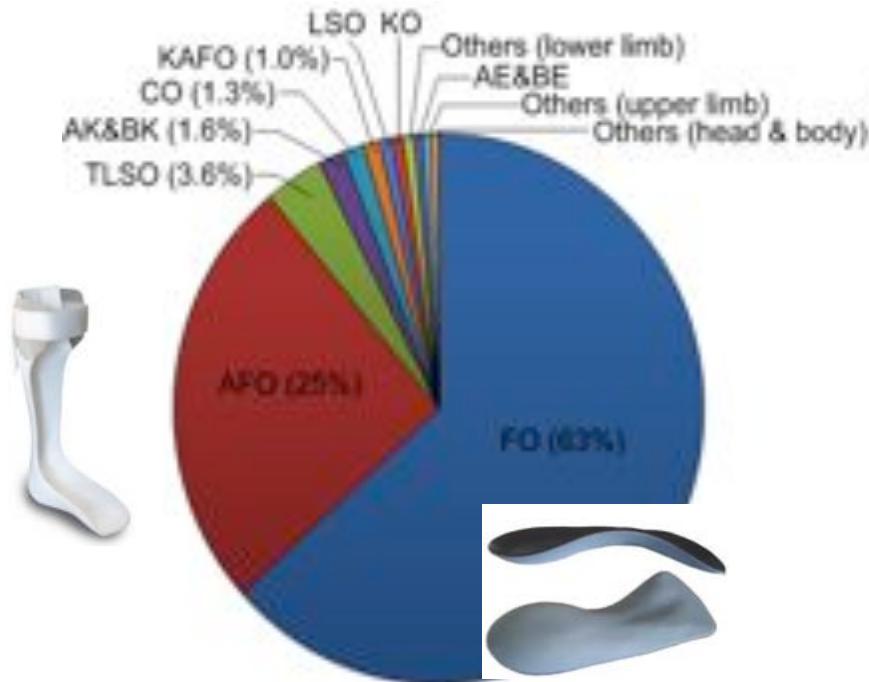
Software:

- * Interactive web-portal
- * Model-based design
- * Security
- *

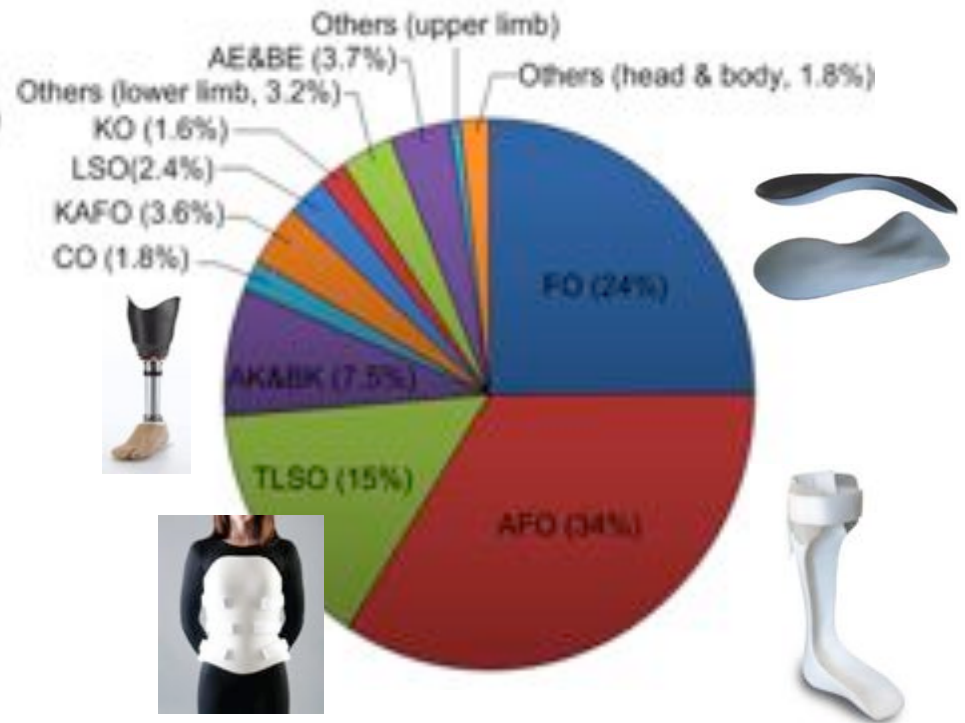
Trends of Orthoses and Prostheses

- In the United States,
 - 5 million in 2011
 - Projected to reach 10 million by 2020
- A study at UM Orthotics and Prosthetics Center for 2013

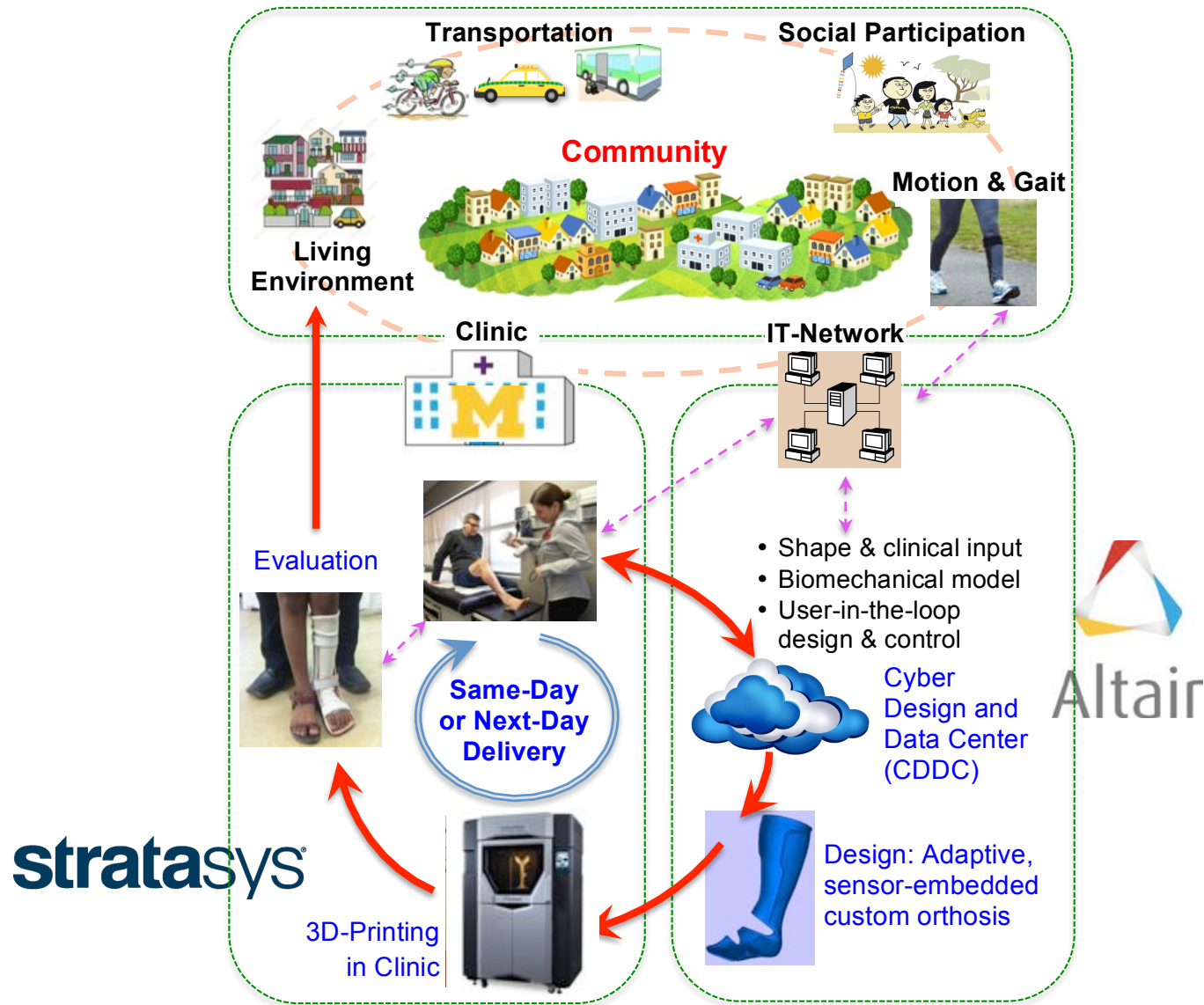
Quantity



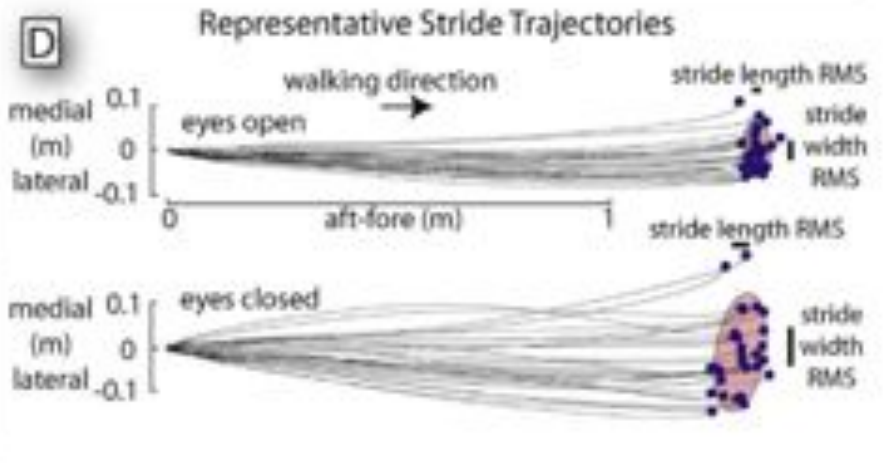
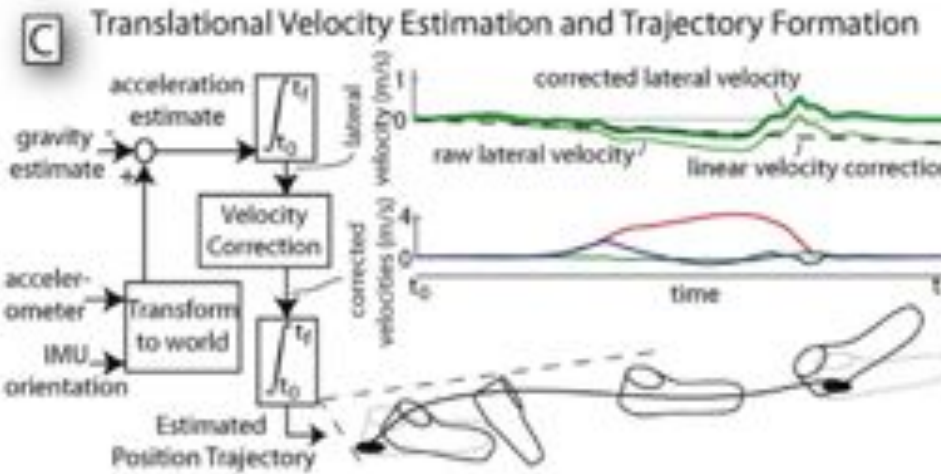
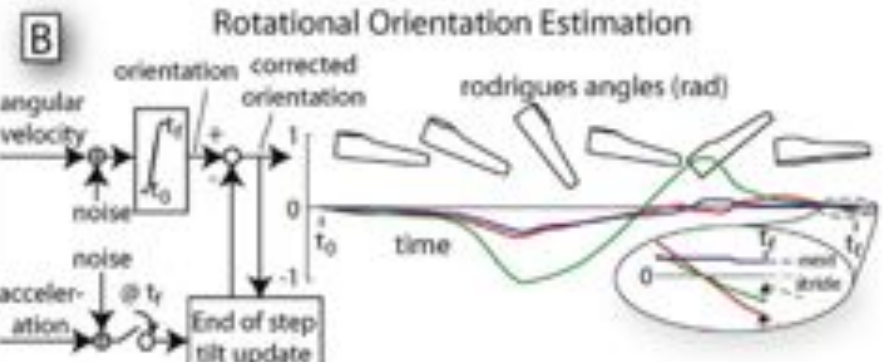
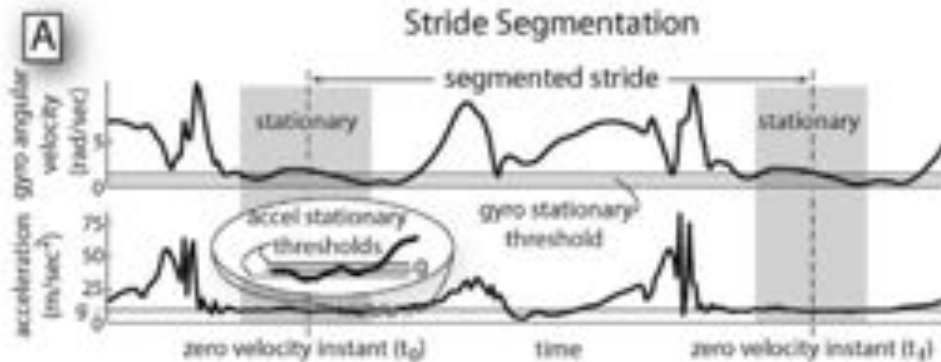
Revenue



Custom Orthosis and Prosthesis: Cyber-Physical Design and Additive Mfg (NSF PFI:BIC & Cybermfg)



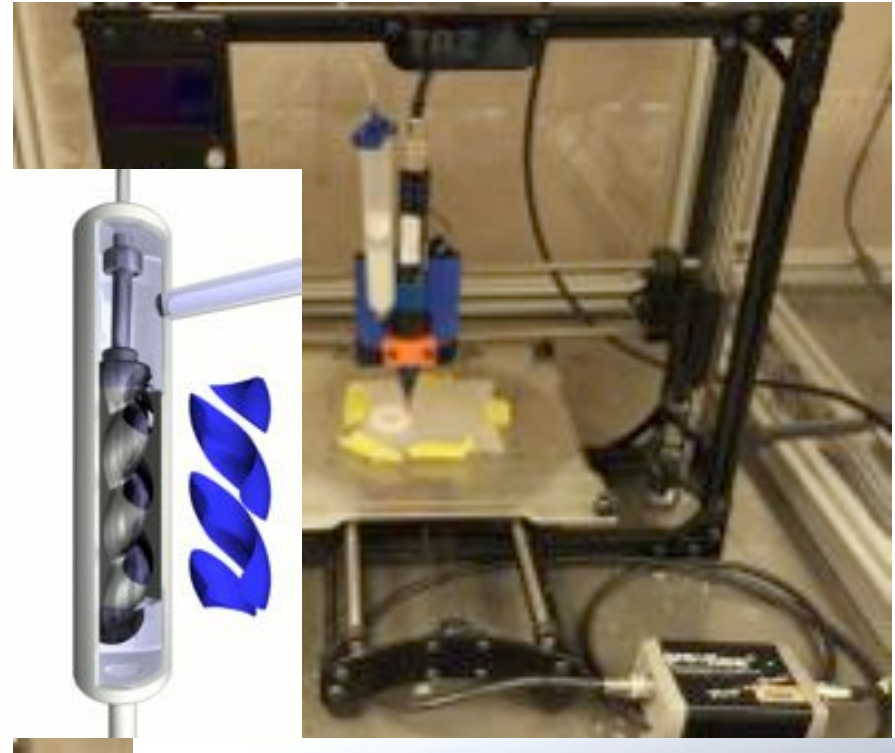
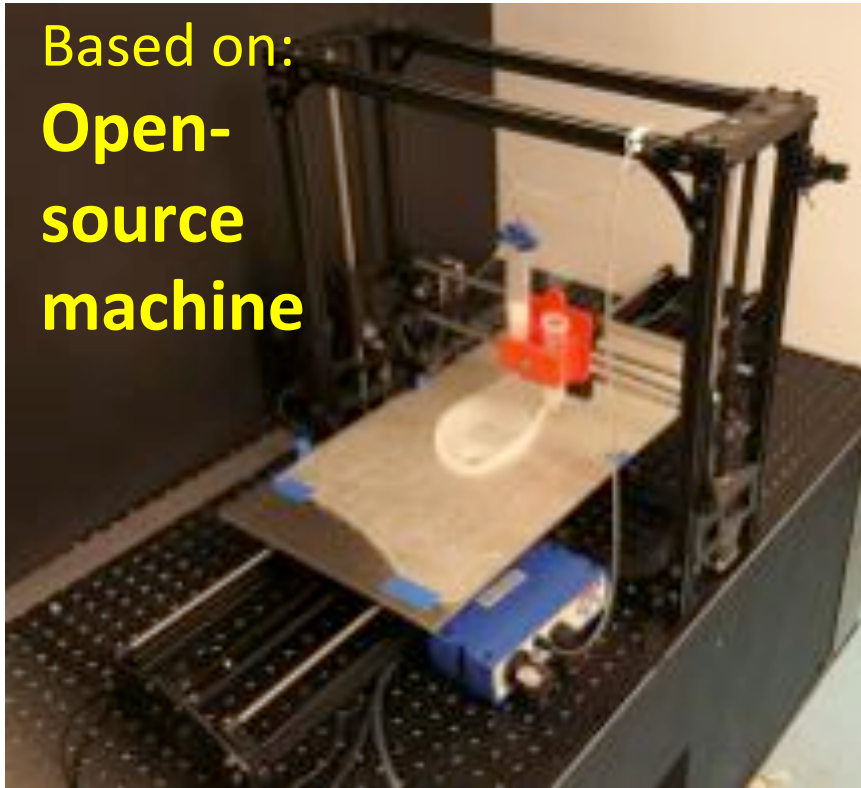
Custom Orthosis and Prosthesis: Cyber-Physical Design and Additive Mfg (NSF PFI:BIC)



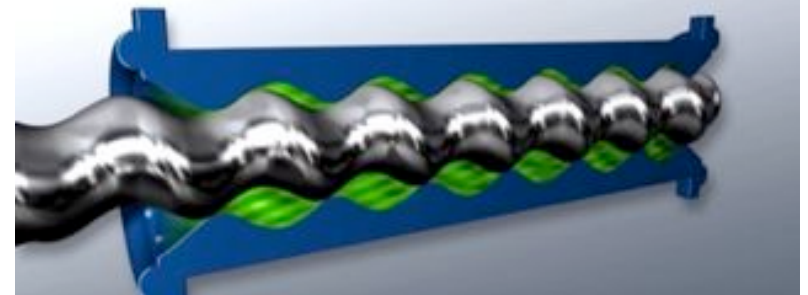
3D-Printing Machine Research: Dispensing High Viscosity Fluids Accurately and Rapidly

Machine R&D for delivery/placement of high viscosity fluid

Based on:
**Open-
source
machine**



- Needs**
1. Size: precision metering of fluid
 2. Location: precision positioning
 3. Liquid → solid transformation
 4. Speed and others

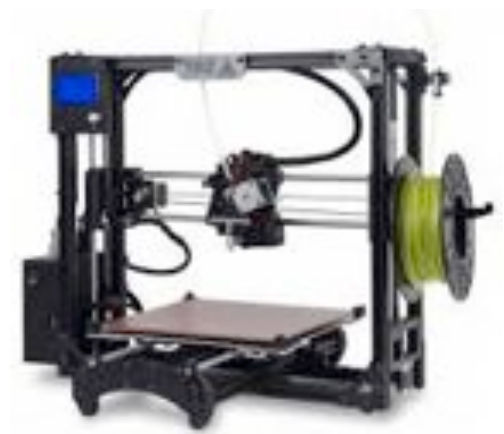


Many Potential “Custom” Products



Education: Hands-On, Video-Enhanced 3D-Printing Course

- Targets:
 - Freshman engineering (ENG 100 in UM)
 - Community College Mfg Technology AM
- An **open-source** FDM machine (all software code and part drawing available) for each student
- Three modules
 1. Machine setup and process parameters
 2. Disassemble and assemble a FDM machine
 3. Learning a simple CAD software (e.g. Google Sketch-Up or Fusion 360) and 3D-print a design



Concluding Remarks

- First AM machine for in UM Orthotics and Prosthetics Center
- Cyber-physical design and AM **System**
- Soft material AM of custom products
- Education: Hands-on, video-enhanced AM course