adaptivesportsusa 2019 NATIONAL CONFERENCE
NOVEMBER 10-12 PHOENIX

CSUDH | ORTHOTICS & PROSTHETICS

Applied Technology

Mark Muller, CPO, MS, FAAOP

Rapid Prototyping
&
Additive Manufacturing for Adaptive Sports

We need to create or augment a device for our athletes.

How do we do it?

- Readily available solutions:
  - Duct Tape, Straps, Carboard, Glue, etc..
- Take measurements and build
  - Buy Parts, Weld, Fabricate

- Take and impression and build
  - Plastic vacuum form, Lamination, silicone molds

- Trial and error, learning from our mistakes

CSUDH | ORTHOTICS & PROSTHETICS

In O&P we do subtractive manufacturing

In O&P we do subtractive manufacturing

Subtractive or Additive Manufacturing

What if we could add materials to make a final device and quickly change the design to fit our needs?

Additive Manufacturing

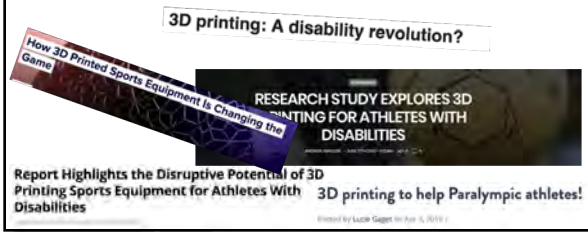
- What do you need
  - Good CAD model or good a Scan to start with
  - Appropriate CAM machine to create it

CSUDH | ORTHOTICS & PROSTHETICS

Additive Manufacturing for Adaptive Sports

- Rapid Prototypes
- Quick changes – Variations easily made
- Vary materials
- Fast turn around

Articles from 2015-19



CAD CAM

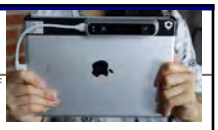
Computer-Aided Design (CAD)
- Designs the product (Drafting)

Or
- Scan the shape – Mesh

Computer-Aided Manufacturing (CAM)
- Uses CAD geometries to program the cutting tools
- Uses CNC machines
  (Computer Numerically Control)
- Slicer Programs for 3D Printing machines

CSUDH | ORTHOTICS & PROSTHETICS

Scanners

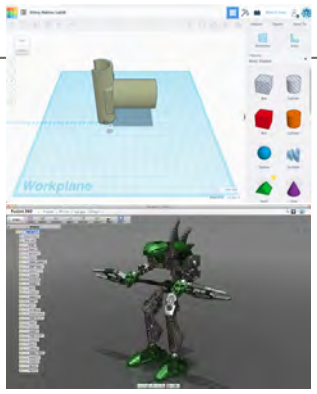


$400-$500
- Makerbot and Cyclops platform
- Structure Sensor
- 3D Systems Sense

$3000-$9000
- EinScan Pro 2
- Peel 1 - 2

$11,000-$60,000
- Artec Eva – Spider
- Drake
- GoScan Spark
- TScan

CAD Software



- AutoDesk
  - Tinker CAD
  - MessMixer
  - Fusion 360
- 3D systems
  Geomagic

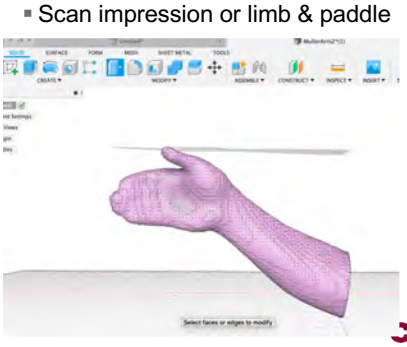
- *3D Builder*
- *SketchUp*
- *Blender*
- *Rhino*

**Free*

CSUDH | ORTHOTICS & PROSTHETICS

Table Tennis example

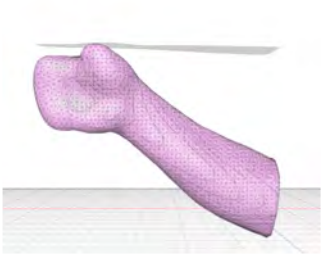
- Scan impression or limb & paddle



CSUDH | ORTHOTICS & PROSTHETICS

Table Tennis example

- Clean up and merge augmentation



CSUDH | ORTHOTICS & PROSTHETICS

Table Tennis example

- Clean up and merge augmentation

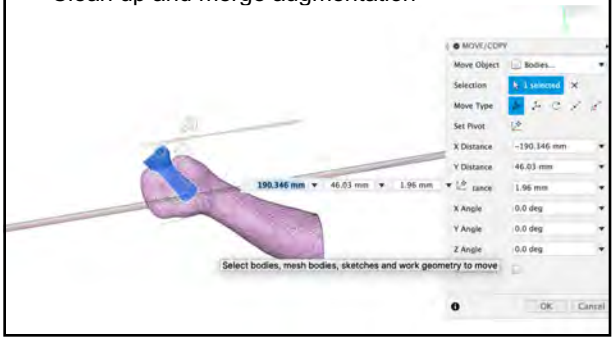
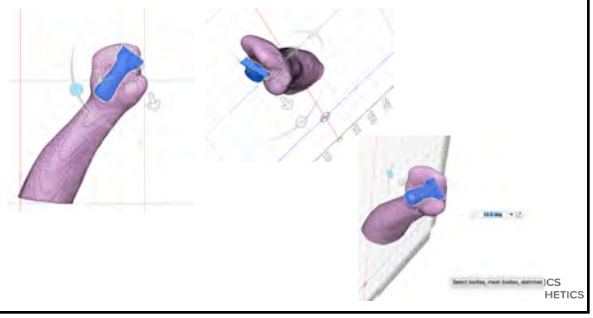


Table Tennis example

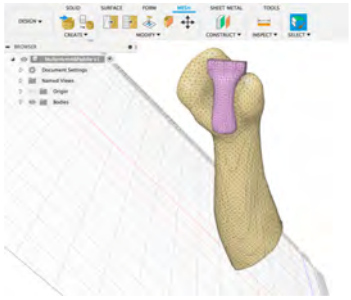
- Clean up and merge augmentation



CS
HETICS

Table Tennis example

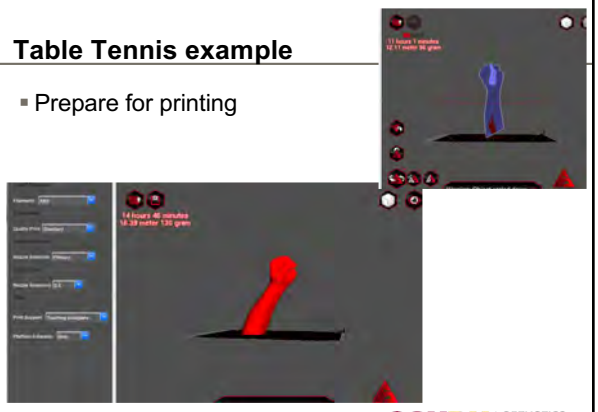
- Prepare for printing



CSUDH | ORTHOTICS & PROSTHETICS

Table Tennis example

- Prepare for printing



CSUDH | ORTHOTICS & PROSTHETICS

Types of files that you can use

- Most Common
  - .stl & . obj. others .ply, .amf, .aop, asc, ptx
  -
- Graphic
  - .vrml, btx
- Slicer files to tell the printer or CNC machine what to do
  - .gcode

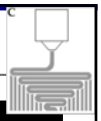
CSUDH | ORTHOTICS & PROSTHETICS

Types of Additive Manufacturing

Type	Technologies	Materials
Extrusion	Fused deposition modeling (FDM)	Thermoplastics (e.g. PLA, ABS), HDPE, eutectic metals, edible materials
Wire	Electron Beam Freeform Fabrication (EBF^3)	Almost any metal alloy
Granular	Direct metal laser sintering (DMLS)	Almost any metal alloy
	Electron beam melting (EBM)	Titanium alloys
	Selective laser melting (SLM)	Titanium alloys, Cobalt Chrome alloys, Stainless Steels, Aluminium
	Selective heat sintering (SHS)[citation needed]	Thermoplastic powder
	Selective laser sintering (SLS)	Thermoplastics, metal powders, ceramic powders
Powder bed and inkjet head 3D printing	Plaster-based 3D printing (PP)	Plaster
Laminated	Laminated object manufacturing (LOM)	Paper, metal foil, plastic film
Light polymerised	Stereolithography (SLA)	photopolymer
	Digital Light Processing (DLP)	photopolymer

CSUDH | ORTHOTICS & PROSTHETICS

Fused Deposition Modeling FDM



CSUDH | ORTHOTICS & PROSTHETICS

Filaments

- Ultimate 3D Printing Materials Guide
  - https://www.simplify3d.com/support/materials-guide/

CSUDH | ORTHOTICS & PROSTHETICS

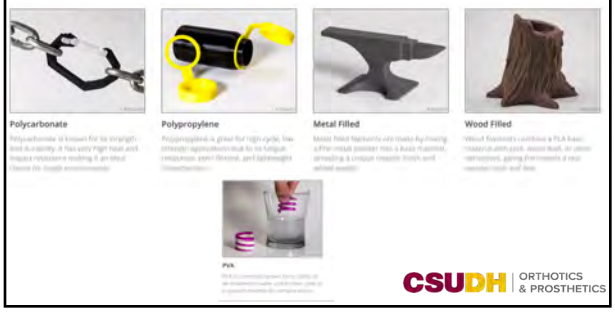
Filaments

- Ultimate 3D Printing Materials Guide
  - https://www.simplify3d.com/support/materials-guide/

CSUDH | ORTHOTICS & PROSTHETICS

Filaments

- Ultimate 3D Printing Materials Guide
  - https://www.simplify3d.com/support/materials-guide/



CSUDH | ORTHOTICS & PROSTHETICS

Directed energy deposition

Wire – Electron beam Freeform Fabrication

CSUDH | ORTHOTICS & PROSTHETICS

Powder Bed Fusion – Selective Laser Melting

Ti Granular Layering – Electron Beam Melting

O&P & Sports Applications?

CSUDH | ORTHOTICS & PROSTHETICS

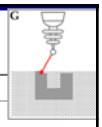
Powder Bed Fusion - SLS

How Selective Laser Sintering works

- Nylon

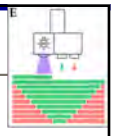
CSUDH | ORTHOTICS & PROSTHETICS

Powder Bed Fusion - SLS
HP MultiJet – Fusion Nylon 11 & TPU



CSUDH | ORTHOTICS & PROSTHETICS

Material Jetting
StrataSys PolyJet printers – Multi-plastics – like InkJet printers (FDM + SLS)

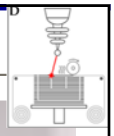


CSUDH | ORTHOTICS & PROSTHETICS

Material Jetting
StrataSys PolyJet printers - 2

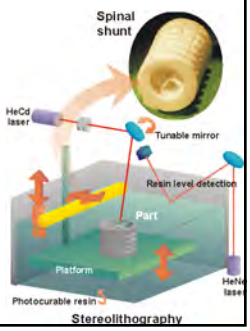
CSUDH | ORTHOTICS & PROSTHETICS

Sheet Lamination
Color prints-Paper, Gypsum – Color Jet
Powder + Binder + Ink (SLS + PolyJet)

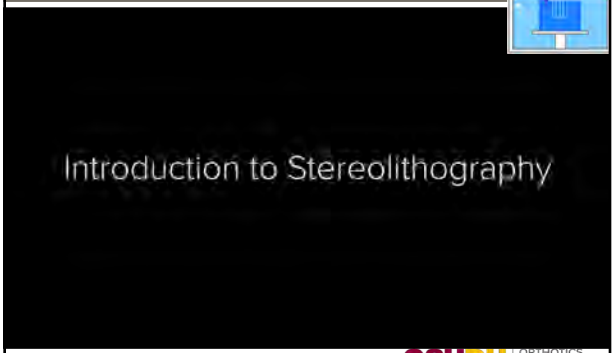


CSUDH | ORTHOTICS & PROSTHETICS

Liquid to Solid - Light Polymerization
SLA - Stereolithography



Stereolithography

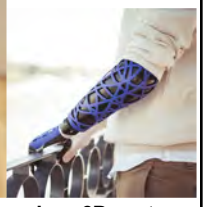


CSUDH | ORTHOTICS & PROSTHETICS

Automation
Additive Manufacturing - 3D Printing

- DYI and Commercial Prosthetics





E-nable

Besopke – 3D systems

https://3dprint.com/132530/lund-prosthetics-scan/

CSUDH | ORTHOTICS & PROSTHETICS

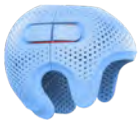
Prosthetic design


https://weburbanist.com/2015/01/08/exo-prosthetics-light-cheap-custom-3d-printed-body-parts/

CSUDH | ORTHOTICS & PROSTHETICS

Lower Limb / Cranial Ox – different ideas




Inventmedical.com

3Ders.org

CSUDH | ORTHOTICS & PROSTHETICS

Cast- Braces


https://weburbanist.com/2013/07/18/handicapable-3d-printed-flexible-casts-artificial-limbs/

CSUDH | ORTHOTICS & PROSTHETICS

Exoskeletal


https://tractus3d.com/3d-printed-prosthetics-reduce-labor-time-immensely/

CSUDH | ORTHOTICS & PROSTHETICS


https://metrouk2.files.wordpress.com/2016/06/ad_210817664.jpg?quality=80&strip=all&strip=all

CSUDH | ORTHOTICS & PROSTHETICS

http://www.abc.net.au/news/2016-01-28/romina-tests-her-3d-printed-legs/7121152

Reconstruction

Ti Printed Implants
- Hip, Knee, Ankle, Shoulder
- Skull, Bone

3D Systems

CSUDH | ORTHOTICS & PROSTHETICS

Reconstruction – ColorJet (Powder) or PolyJet (Plastic)

- MaxioFacial

Photograph: Fripp Design

Printing mixture of silicone and pigments

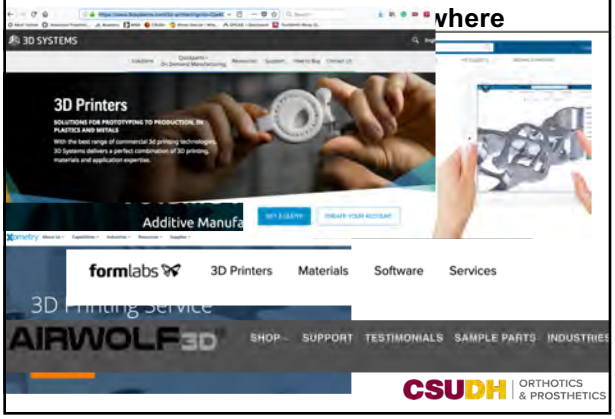
CSUDH | ORTHOTICS & PROSTHETICS

Getting Started
Local Maker Clubs

- Create MakerSpace
- Makers of Phoenix
- Heat Sink Labs

CSUDH | ORTHOTICS & PROSTHETICS

…vhere



CSUDH | ORTHOTICS & PROSTHETICS

CSUDH – O&P Program wants to help

Mark Muller
Jennifer Lucarevic
10461 Calle Lee
Suite 185
Los Alamitos, CA 90720

Work
563 735-3300
Cell
949 241-7999

mmuller@csudh.edu
Jlucarevic@csudh.edu

CSUDH | ORTHOTICS & PROSTHETICS