REPORT DOCUMENTATION PAGE

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02-05-2022	Final Report	1-Jan-2017 - 31-Dec-2017

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Final Report: High Throughput Plasma Manufacturing for Graphene and Related Devices	5a. CONTRACT NUMBER W911NF-17-1-0056
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Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Timothy Fisher
UU	UU	UU	UU		19b. TELEPHONE NUMBER 765-494-5627

RPPR Final Report
as of 03-May-2022

Agency Code:

Proposal Number: 70368SDICR **Agreement Number: W911NF-17-1-0056**

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Report Date: 31-Mar-2018 Date Received: 02-May-2022
Final Report for Period Beginning 01-Jan-2017 and Ending 31-Dec-2017
Title: High Throughput Plasma Manufacturing for Graphene and Related Devices
Begin Performance Period: 01-Jan-2017 **End Performance Period:** 31-Dec-2017
Report Term: 0-Other

Submitted By: Timothy Fisher Email: tsfisher@purdue.edu
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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: 0 **STEM Participants:**

Major Goals: This project aims to use the business model canvas and customer discovery to explore the viability of stretchable transducers for haptic interfaces in augmented and virtual reality.

Accomplishments: We interviewed >100 potential customers and developed our hypothesis that consumers want to experience haptic sensation for greater immersion in AR/VR. The outcome was that VR is quite early and haptics is not needed at the consumer level in the short term. There are opportunities in Enterprise solutions such as automotive design. Ideally, our stretchable transducers would be electrically powered directly and not via a pump. Based on these outcomes, our research has pivoted towards electrical solutions such as DC motor driven tendons, or more energy efficient fluid systems that do not require large pumps.

Training Opportunities: Nothing to Report

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

Partners

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I certify that the information in the report is complete and accurate:
Signature: Robert Shepherd
Signature Date: 5/2/22 2:01PM

CORNELL UNIVERSITY FOUNDED A.D. 1865

ORL™

organic robotics lab™

Stretchable Transducers for Augmented/Virtual Reality

~0.2 MJ/kg - system

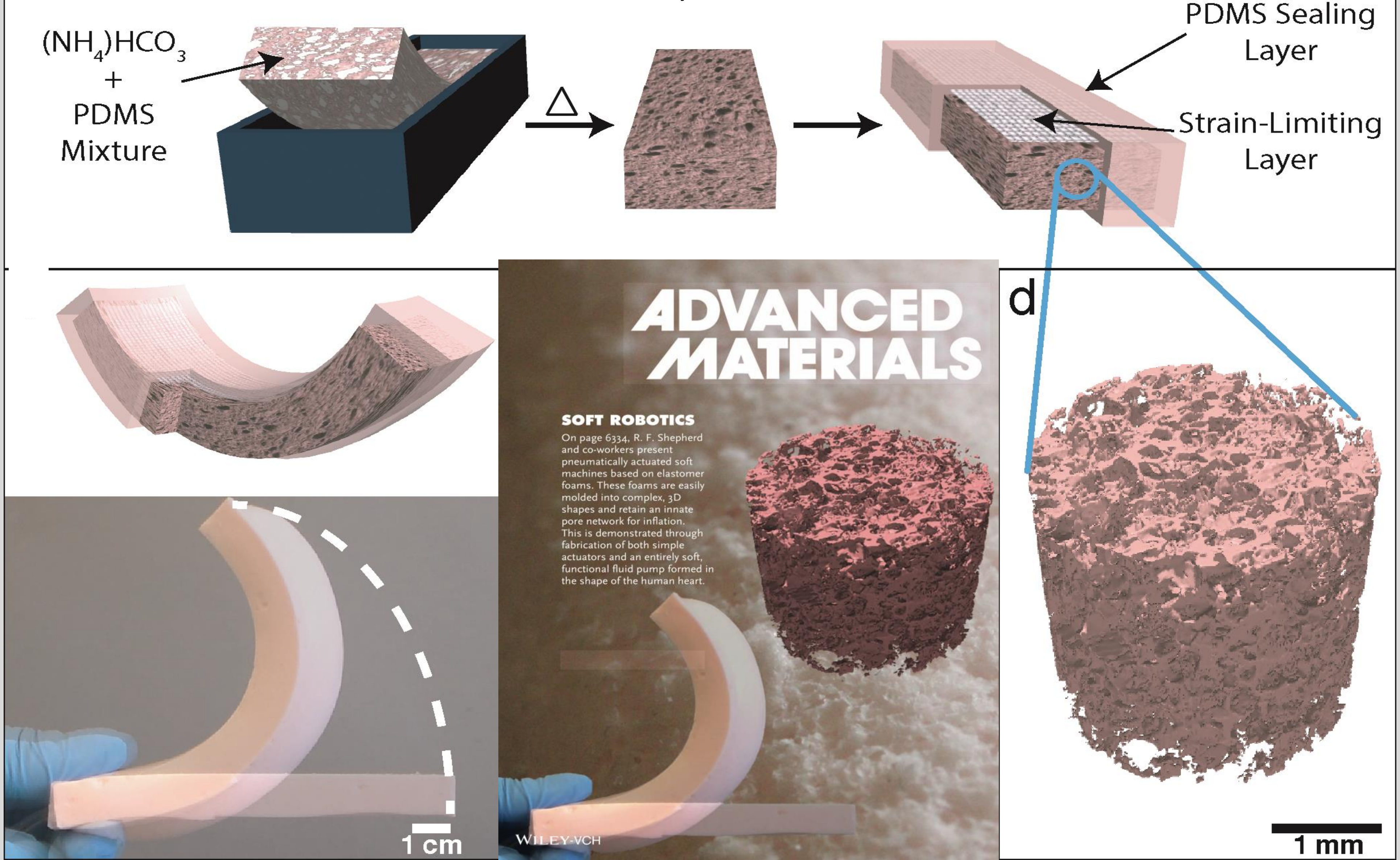
~300 L min^{-1}

~0.15 L/g

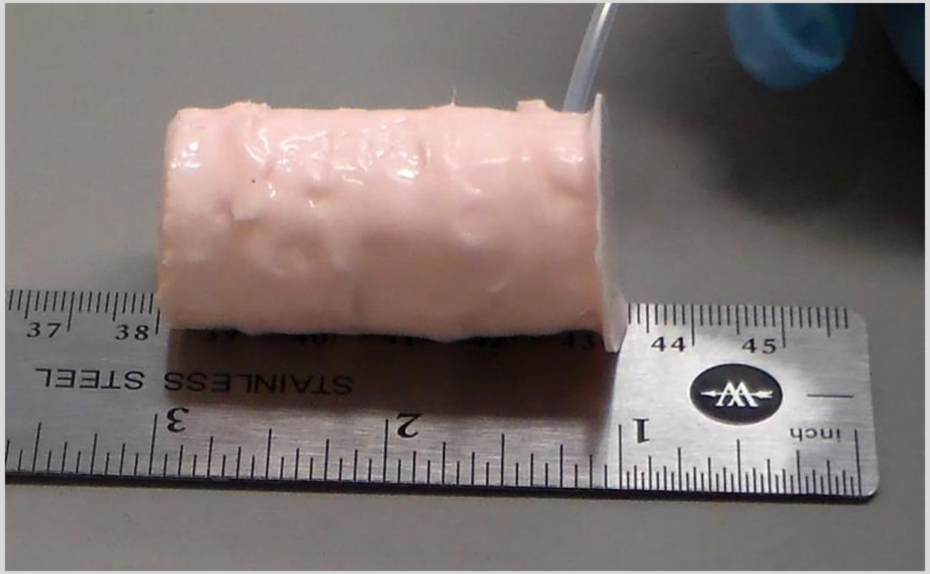
Mosadegh et. al Adv. Fun. Mat. (2014)

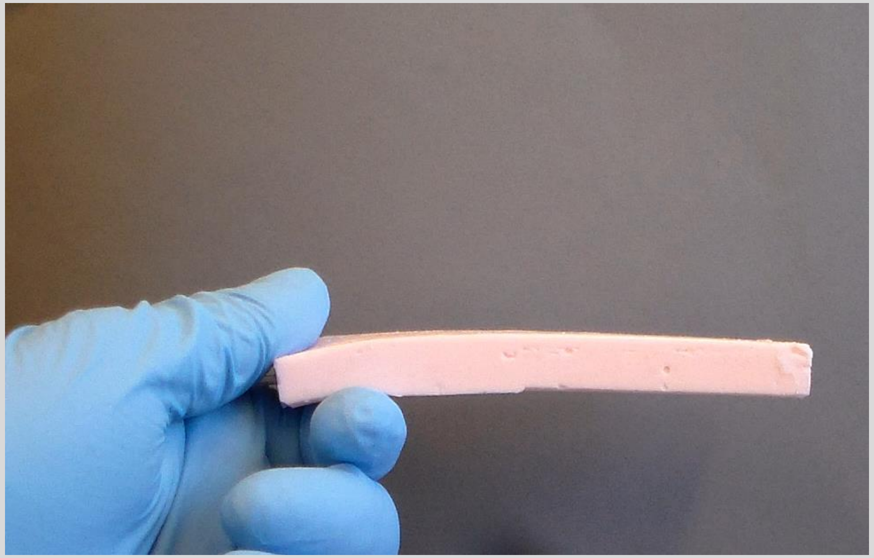
Elastomeric foam actuators for injection molding of complex artificial muscle

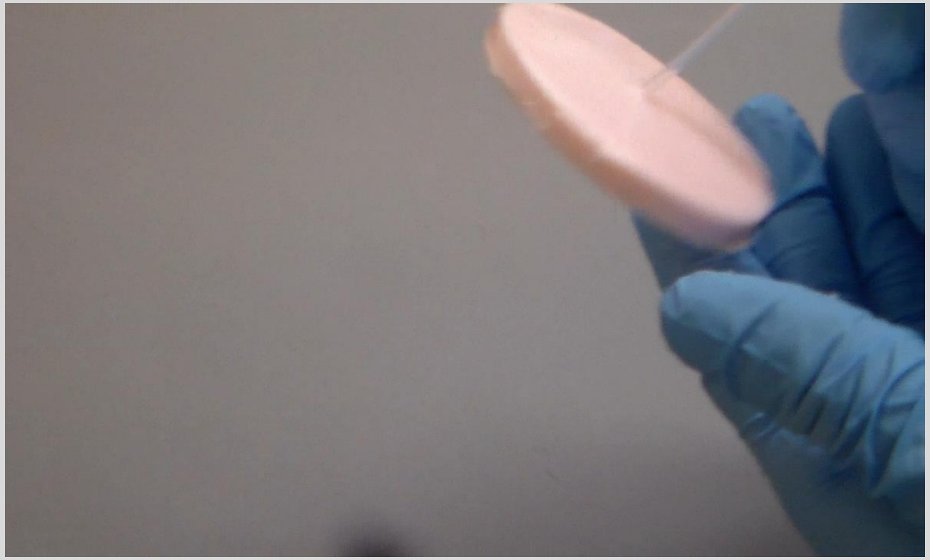
*Mac Murray et al. Adv. Mat. 2015



Simple foam actuators



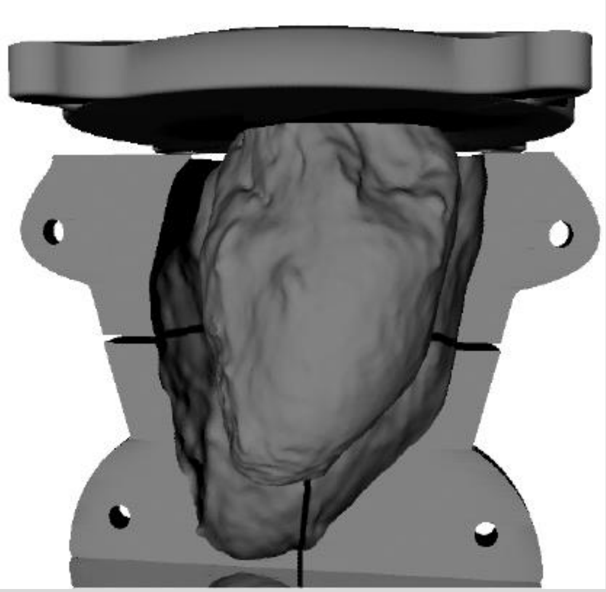


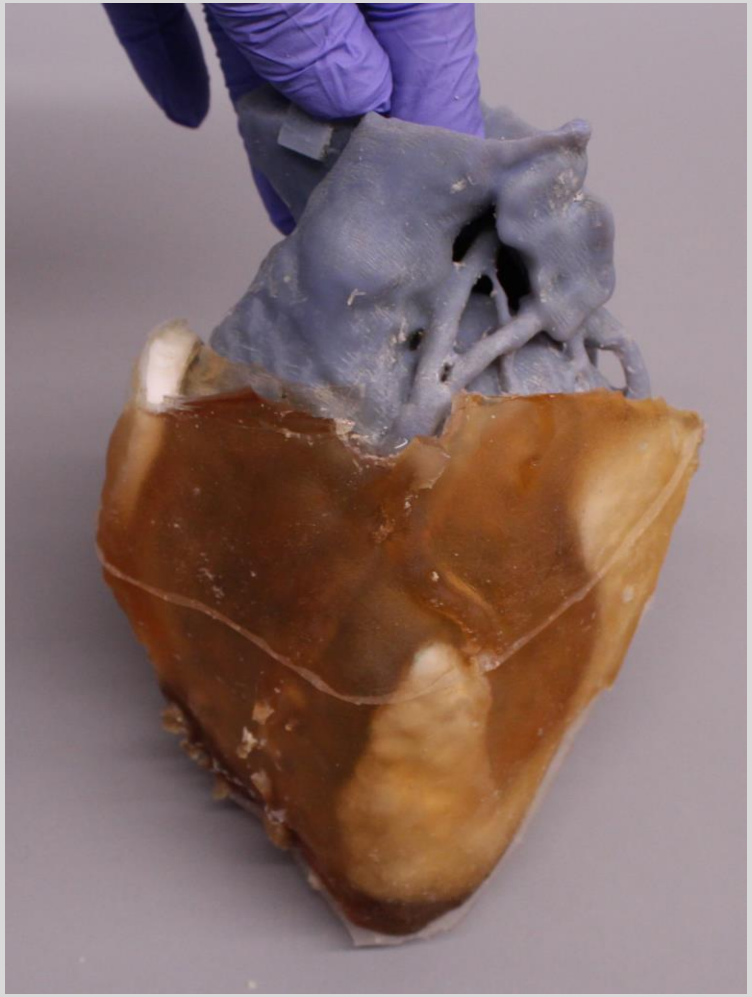


Mac Murray et. al Adv. Mat. (2015)

Complex soft machine from foam actuators

Pig heart

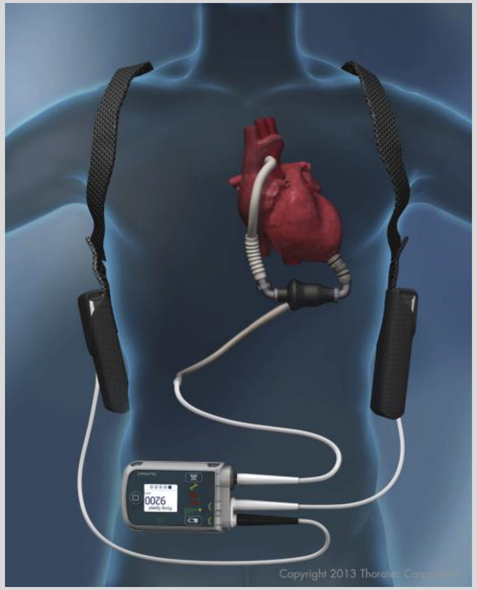




*Mac Murray et al. unpublished
Provisional IP filed

Towards Ventricle Assist Devices

Present State of the Art



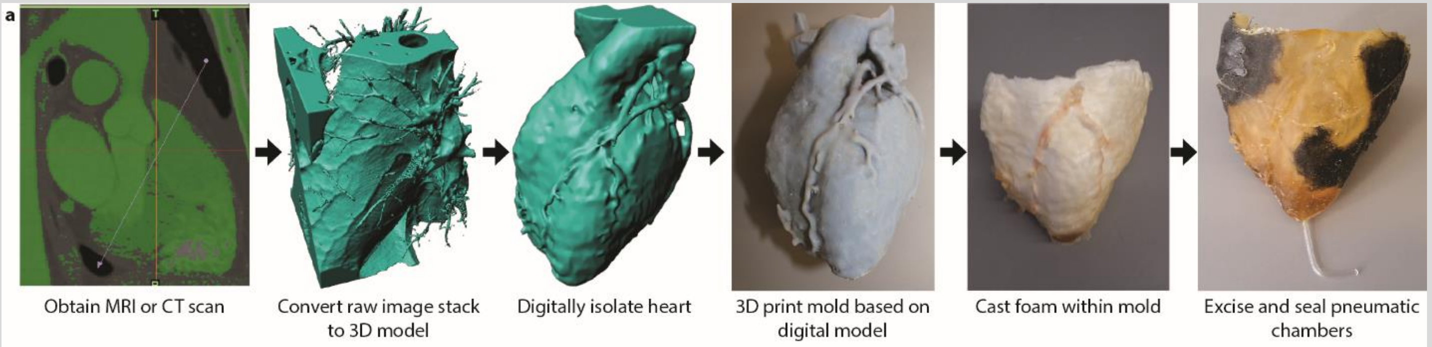
Heartmate II
Thoratec, Inc.

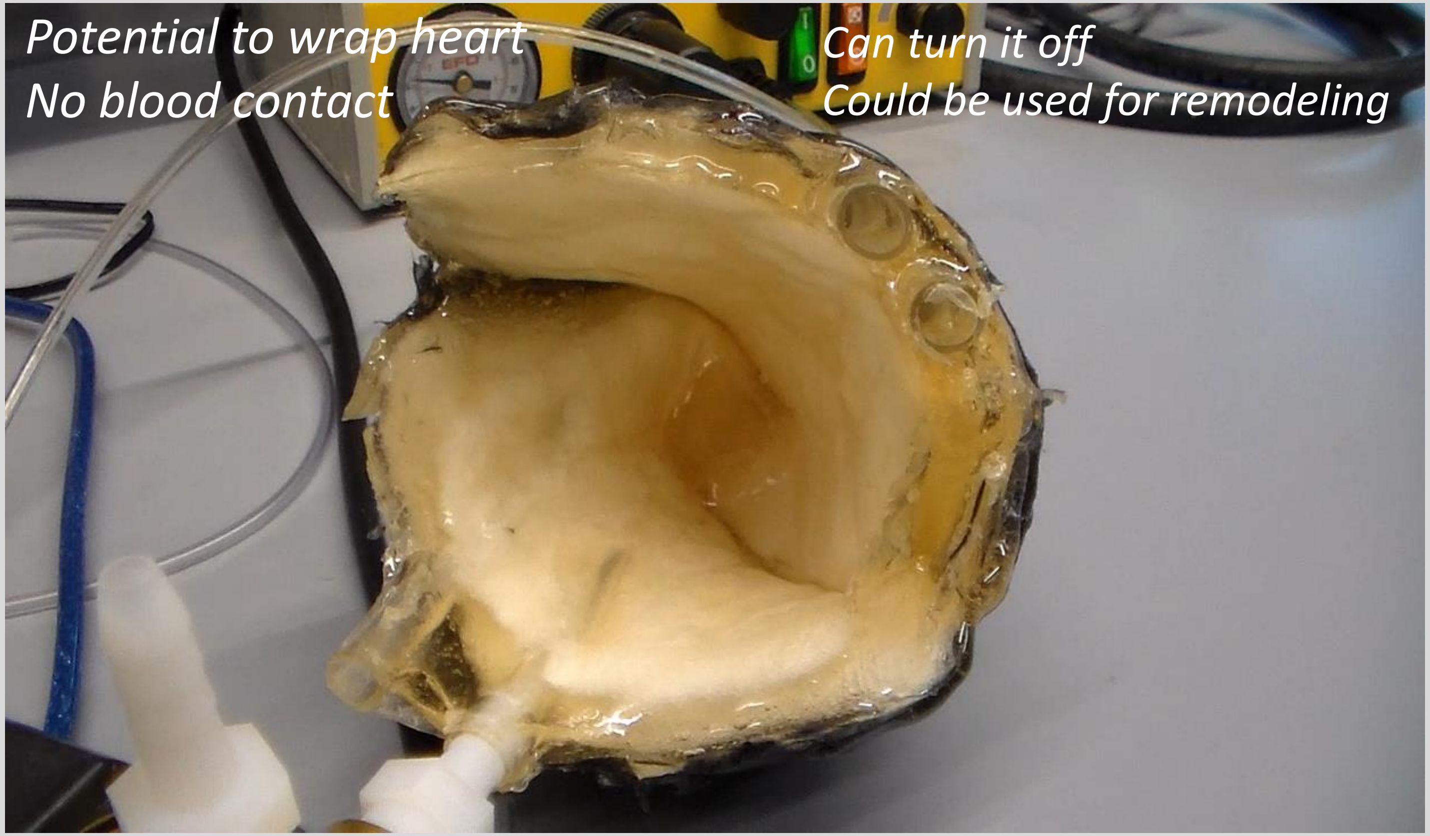
Highly invasive

Clotting issues

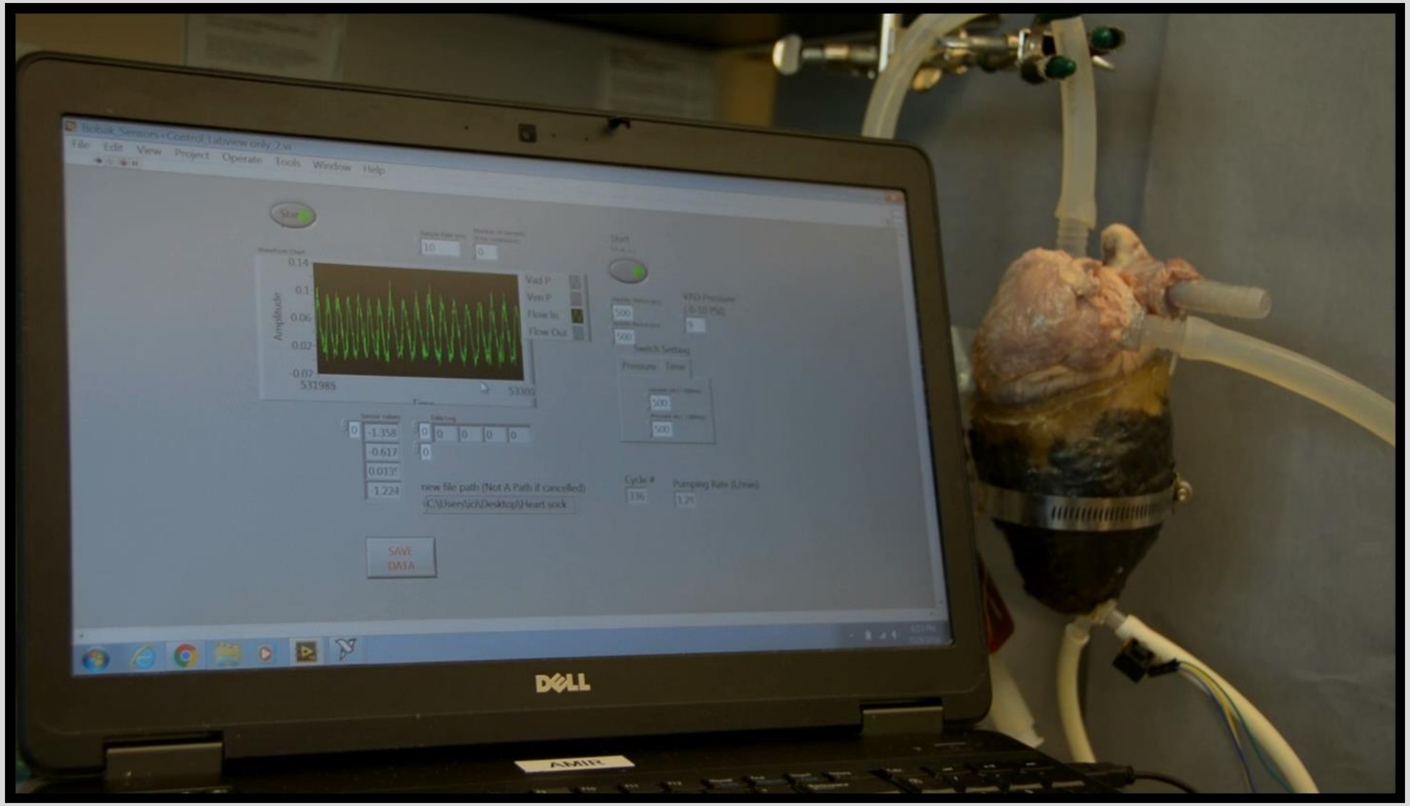
Turning it off is not good

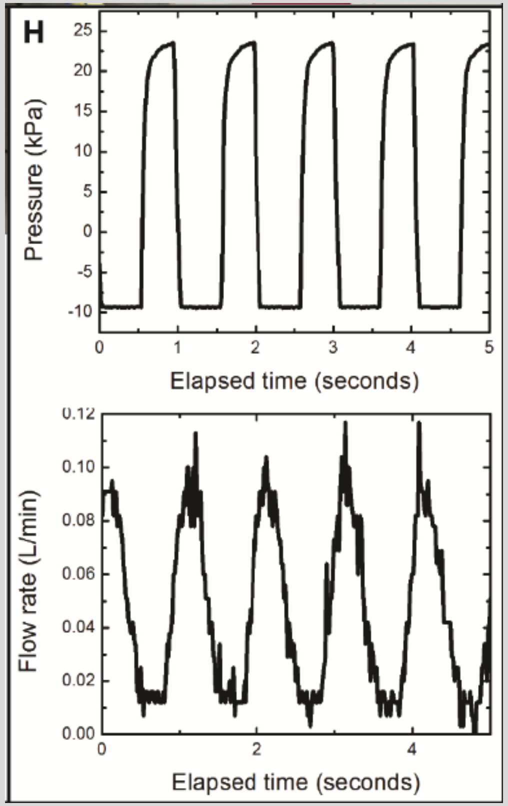
Potential for minimally invasive soft foam assist devices



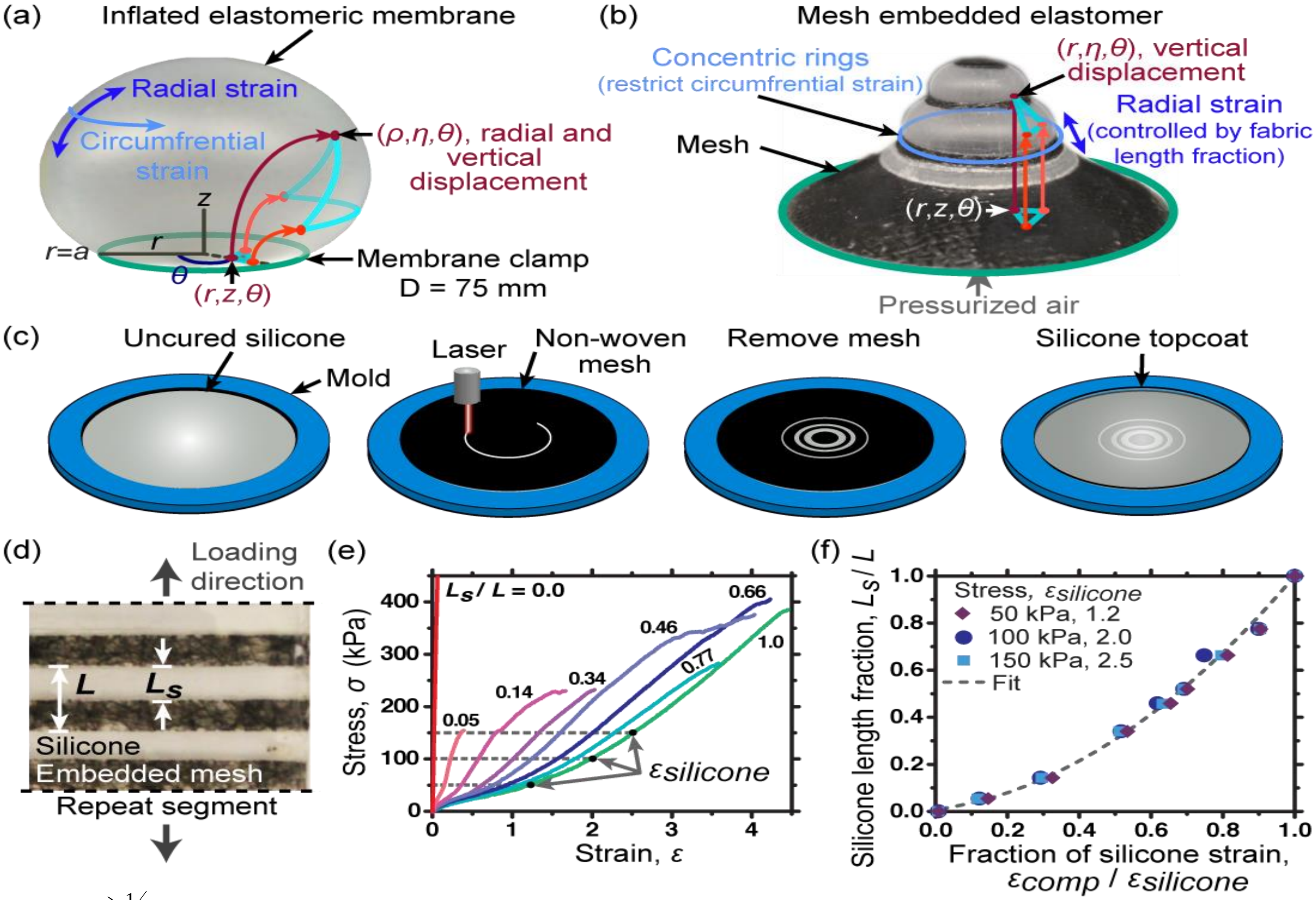


Device Demonstration on Pig Heart at Weill Cornell





Pneumatic Pressure of Foam Chamber and Flow Rate of Pumped Water

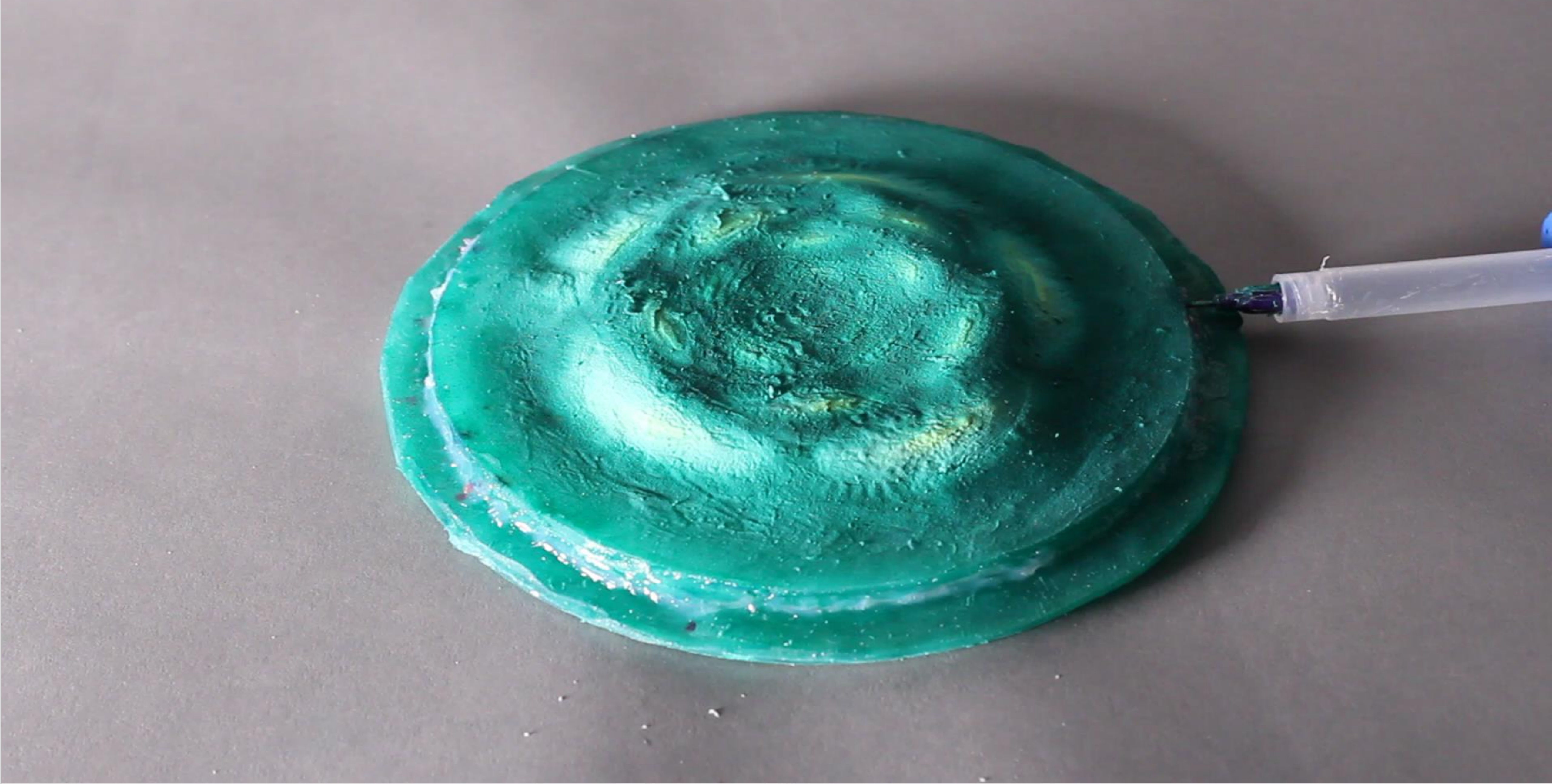


*Pikul J et al., In Preparation

$$e_r = \left(\frac{\frac{dr}{dr}^2 + \frac{dh}{dr}^2}{1 + \frac{dz}{dr}^2} \right)^{1/2} - 1 \qquad e_c = \frac{r}{r} - 1 \qquad e_r = \left(1 + \frac{dh}{dr}^2 \right)^{1/2} - 1$$

W. H. Yang, W. W. Feng, *Journal of Applied Mechanics* 37, 1002 (1970)

Texture Displays for Non-Spherical Fluidic Actuation



Outline:

1. Motivation
2. OmniPulse
3. Variable-stiffness controller
4. Next steps

organic robotics lab

Outline:

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organic robotics lab

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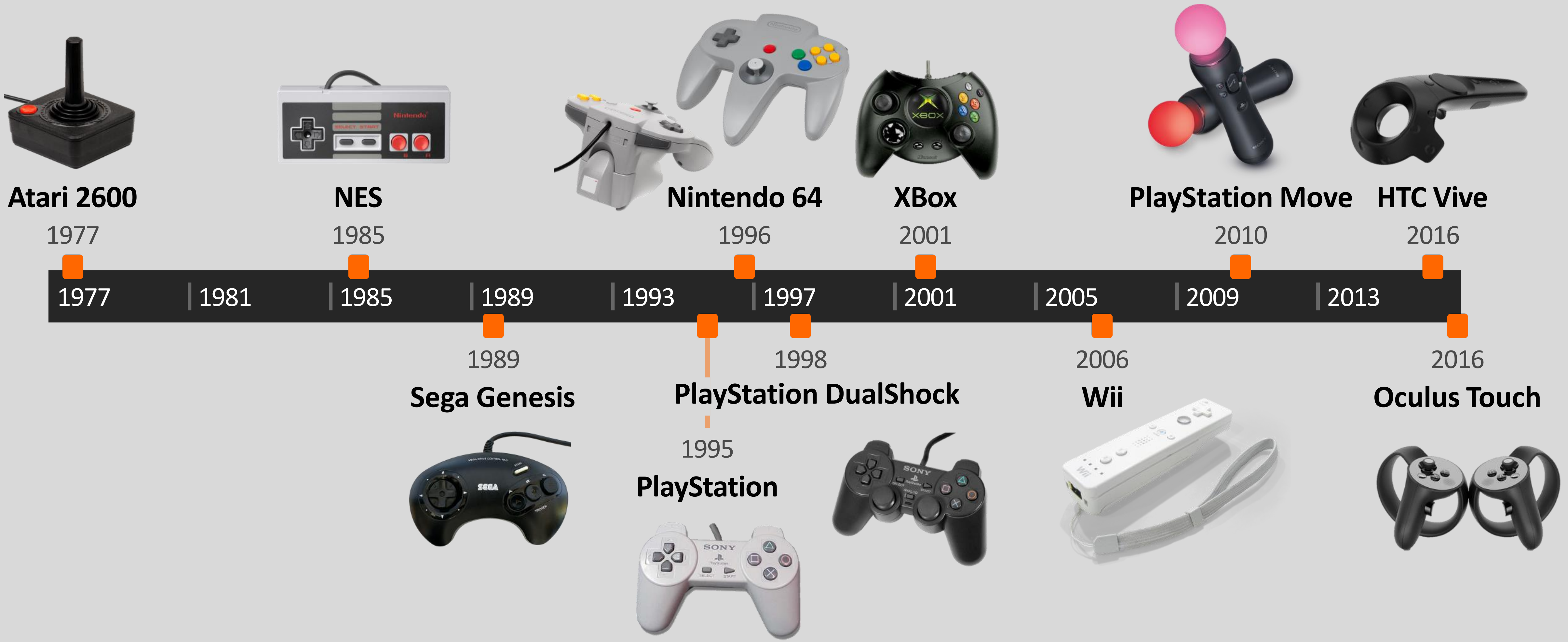
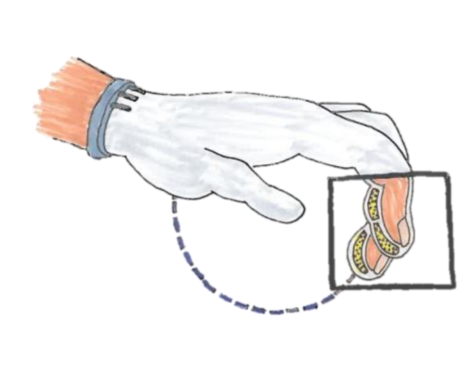
A Brief History of Game Controllers



organic robotics lab ™

Technology Platform

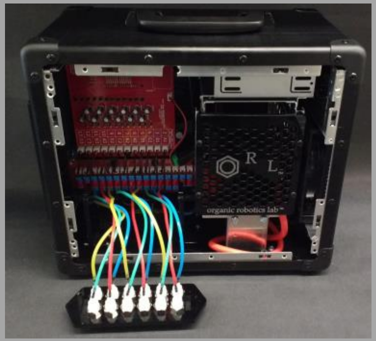


VR FUN HOUSE

NVIDIA

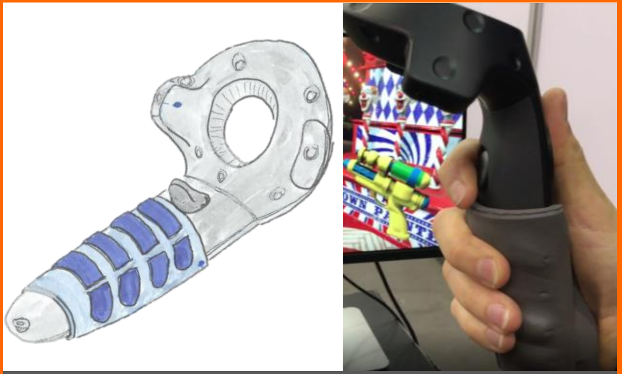
UNREAL ENGINE

Software



Fluidic Controller

Human Interfaces



OmniPulse

Soft Controller

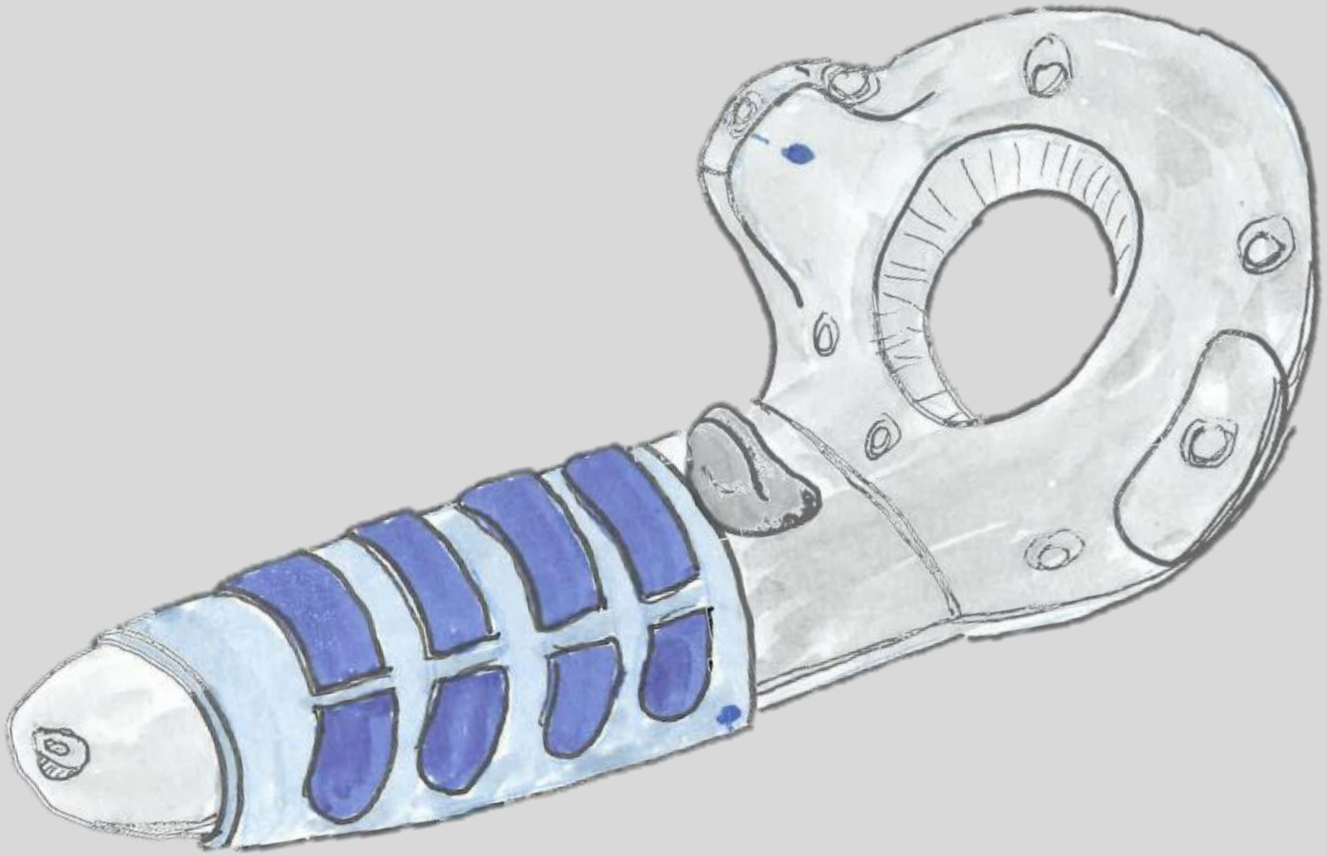
Outline:

1. Motivation
2. OmniPulse
3. Variable-stiffness controller
4. Next steps

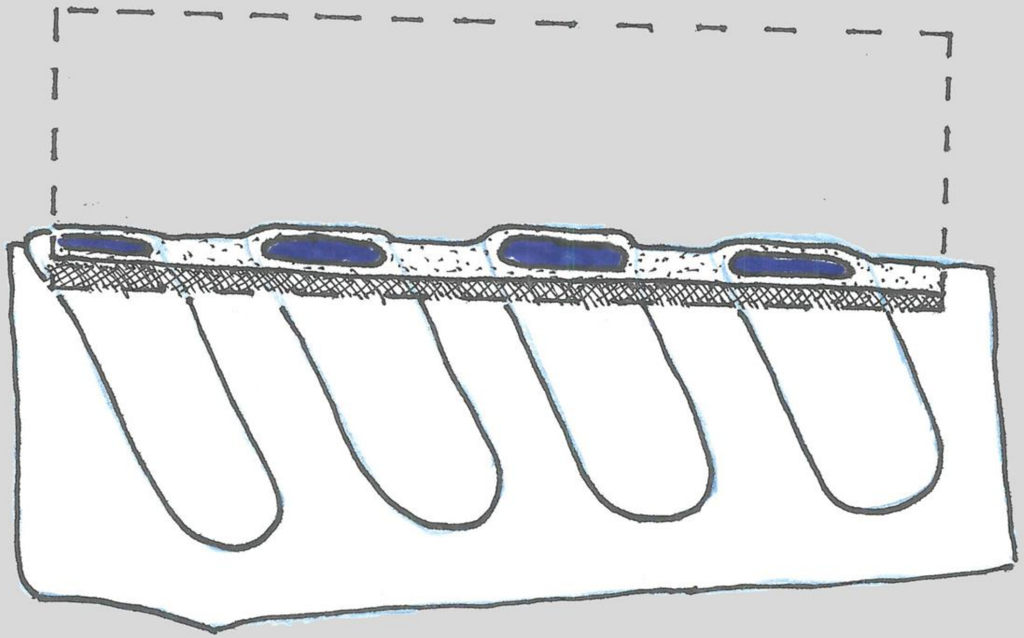
Haptic feedback design challenges:

1. High force actuators
2. Many degrees of freedom
3. Scalable manufacturing

Fluidic Elastomer Actuators (FEAs) for haptic feedback



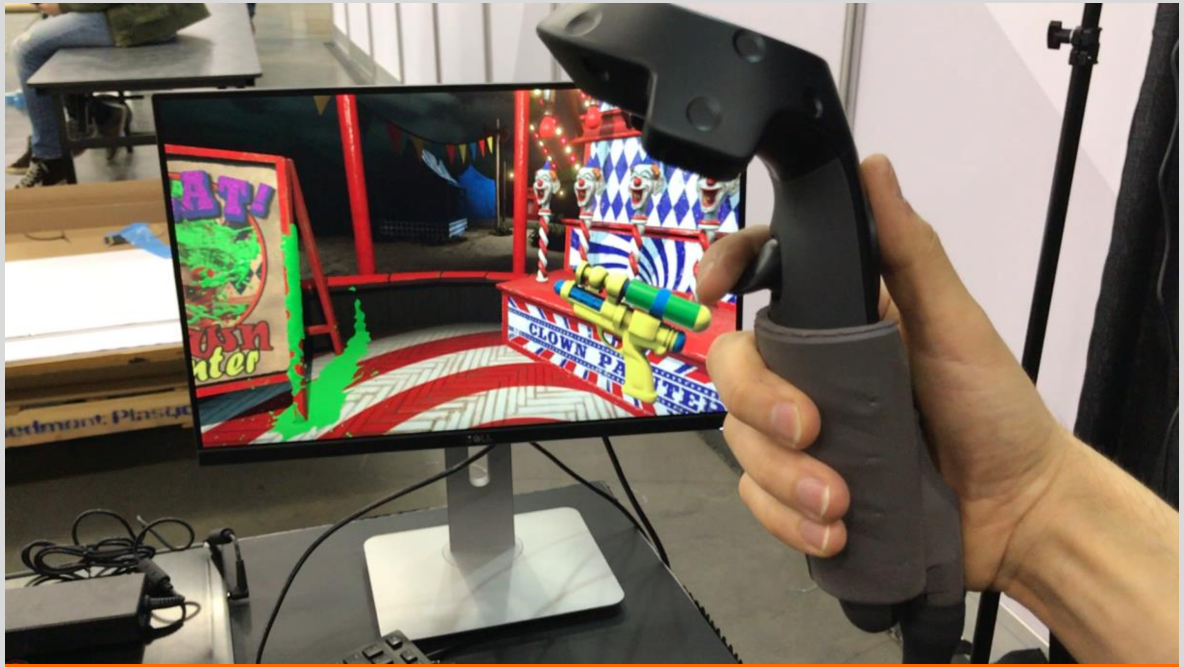
Rubber sleeve with many actuators



Independent control


DIGITAL
CONTROLLER
PV
SV
POWER
HEATER
Heat Miser
3000
MYPIN
TA6

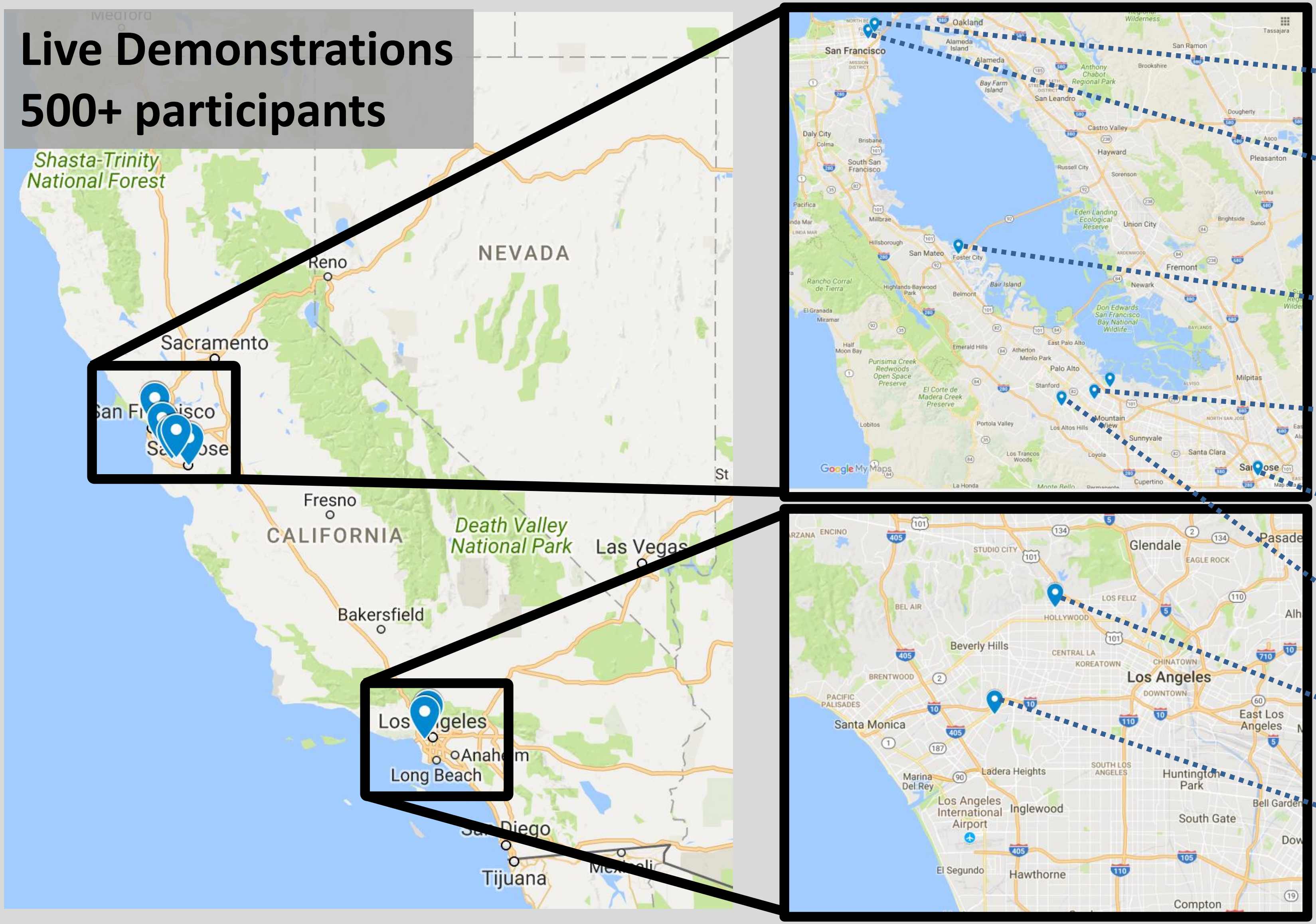
Integration with NVIDIA's VR Funhouse



Goo Gun

Revolver

Live Demonstrations
500+ participants



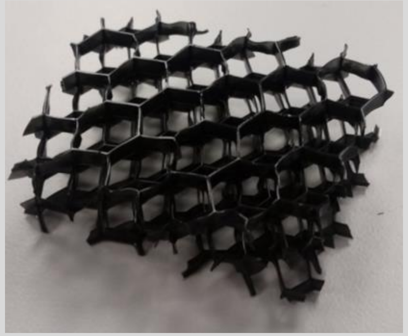
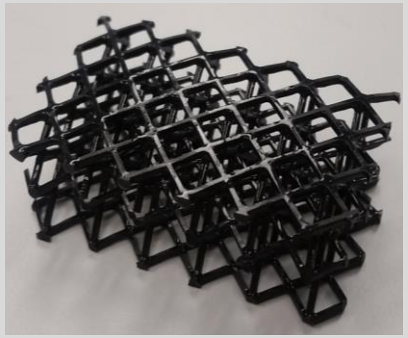
AUTODESK
unity
PlayStation
Google[x]
GPU TECHNOLOGY CONFERENCE
XEROX PARC
30 JULY–3 AUGUST Los Angeles SIGGRAPH2017
MPC


This soft rubber sleeve has
12 in

Outline:

1. Motivation
2. OmniPulse
3. Variable-stiffness controller
4. Next steps

Shape-shifting, variable compliance controllers



Shape-shifting, variable compliance controllers

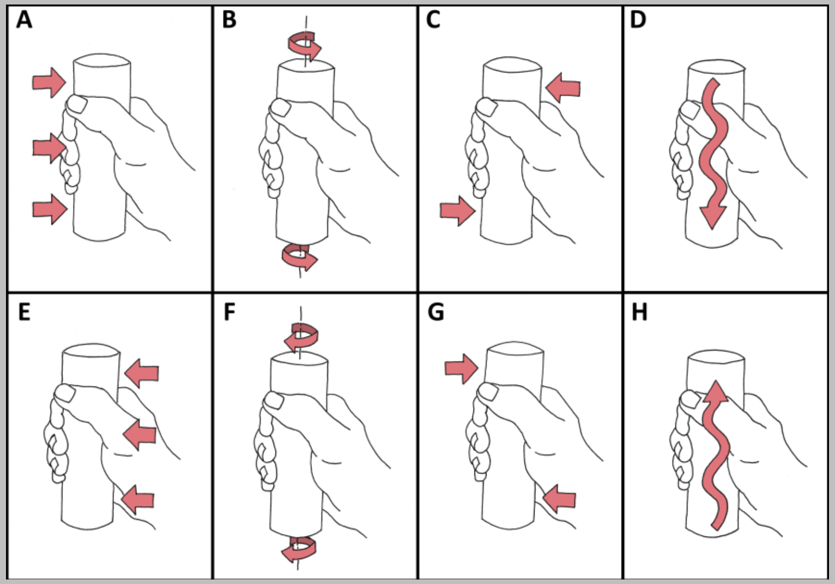
Outline:

1. Motivation
2. OmniPulse
3. Variable-stiffness controller
4. Next steps, learned from I Corps

Next steps

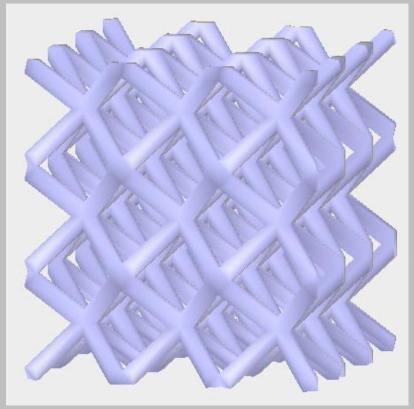
OmniPulse

- Collaborating with Houston Claure and Malte Jung to develop user study:
    - Document the capabilities of FEA-driven haptic feedback
    - Quantify impact on user experience

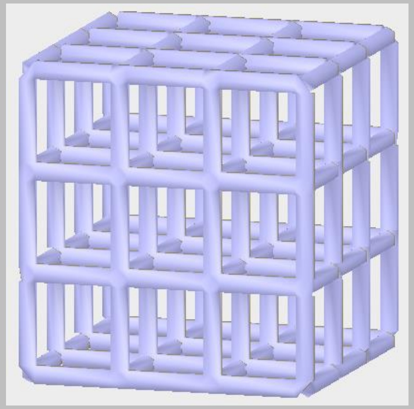


Variable-stiffness controller

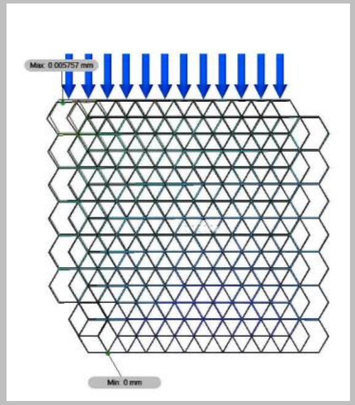
- Increase the stiffness range of the controller by systematically xploring variations to the internal lattice.
    - **Objectives:**
        1. Create a more compliant structure in the unpressurized state
        2. Maintain shape while pressurized to higher pressure.



BCC



Simple Cubic



Next steps

Tendon Driven Actuator

- Electrically powered actuator that does not require air compressors, liquid CO_2 cartridges, or other cumbersome approaches for fluidic actuation organic robotics lab ™

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