Co-exploring brain and body, in the field

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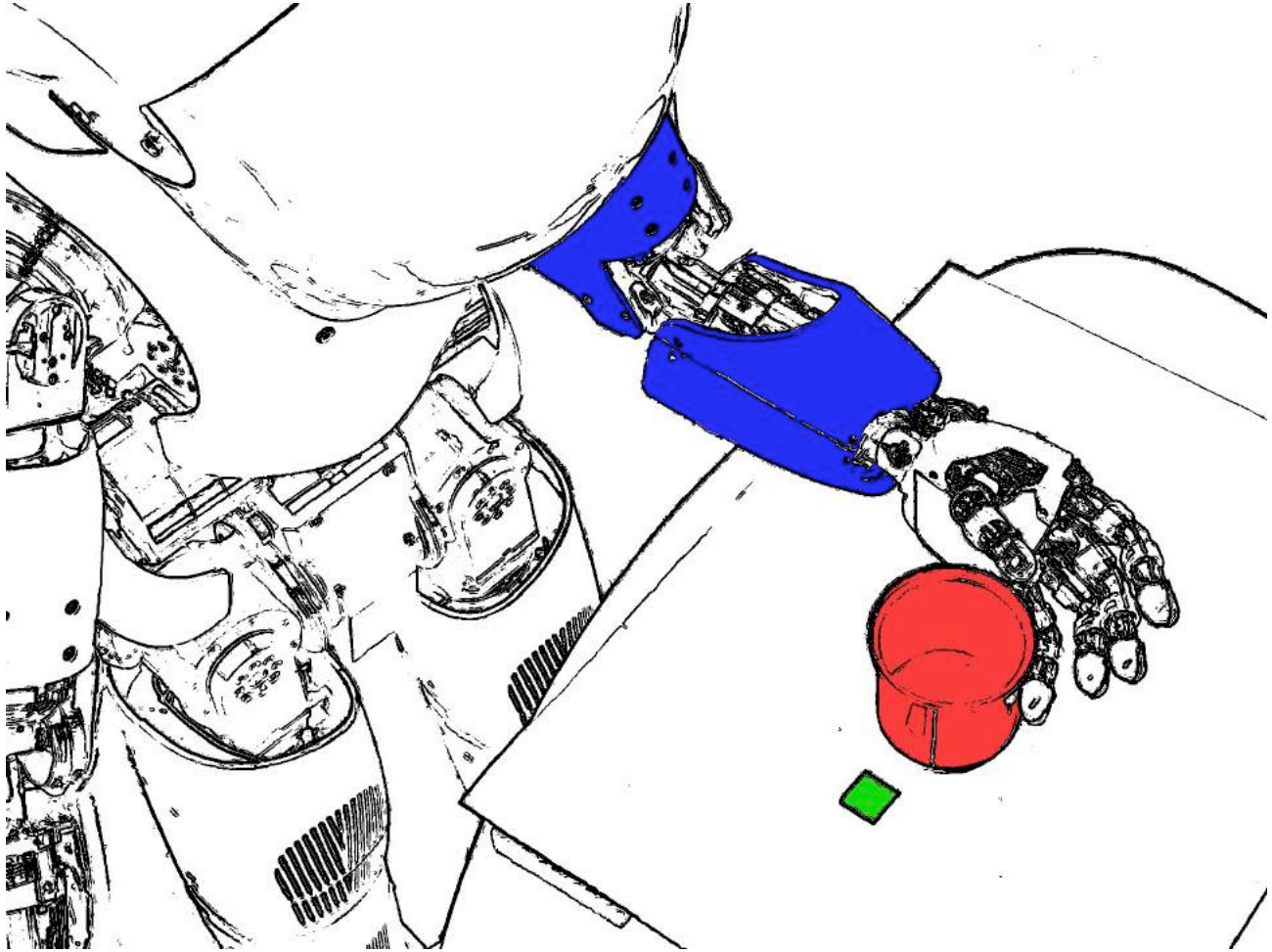
Lecturer in Robotics

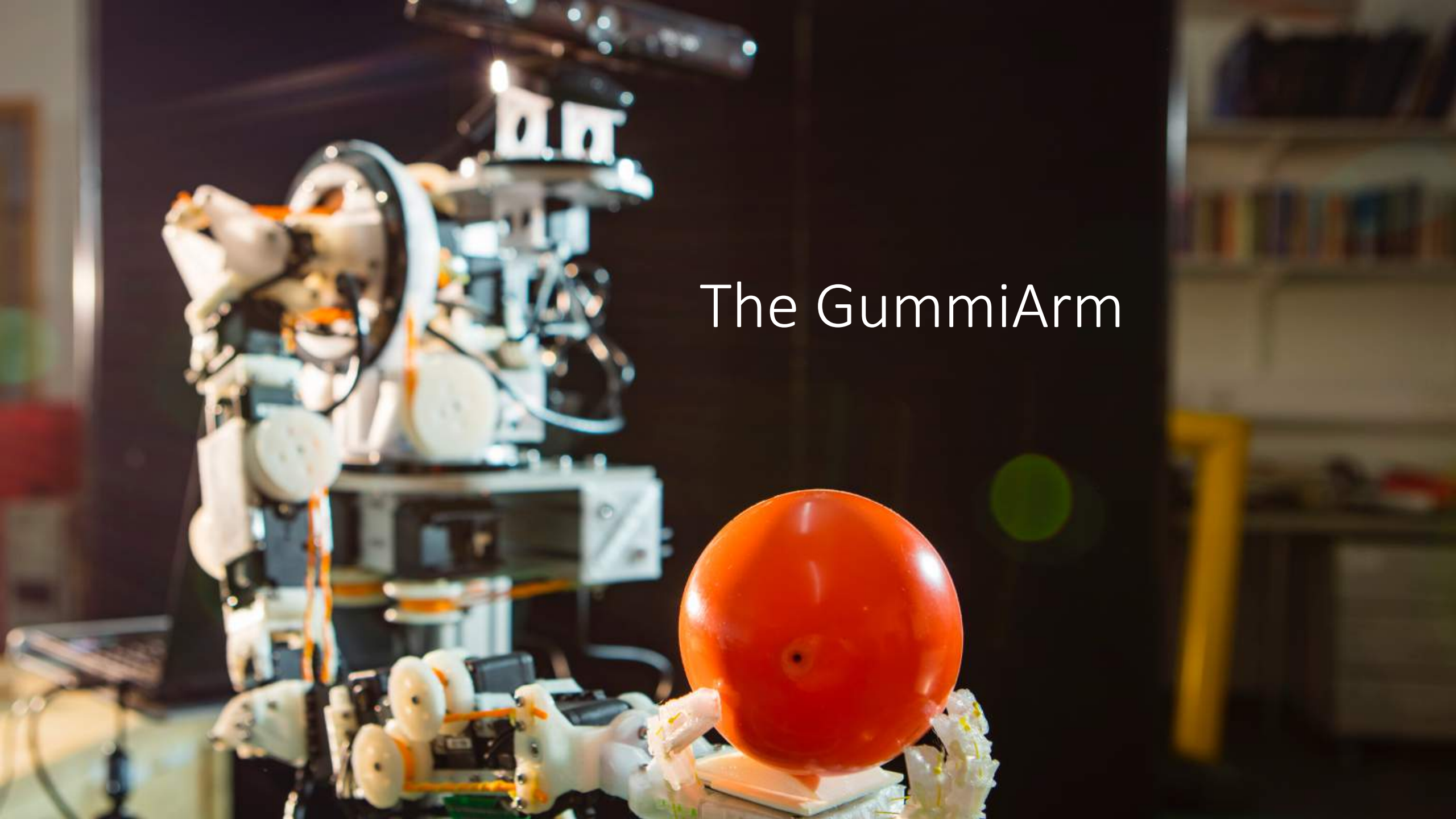
Centre for Robotics and Neural Systems (CRNS)
Plymouth University

ROBOTICS WITH PLYMOUTH UNIVERSITY

A developing mind requires a robust body…

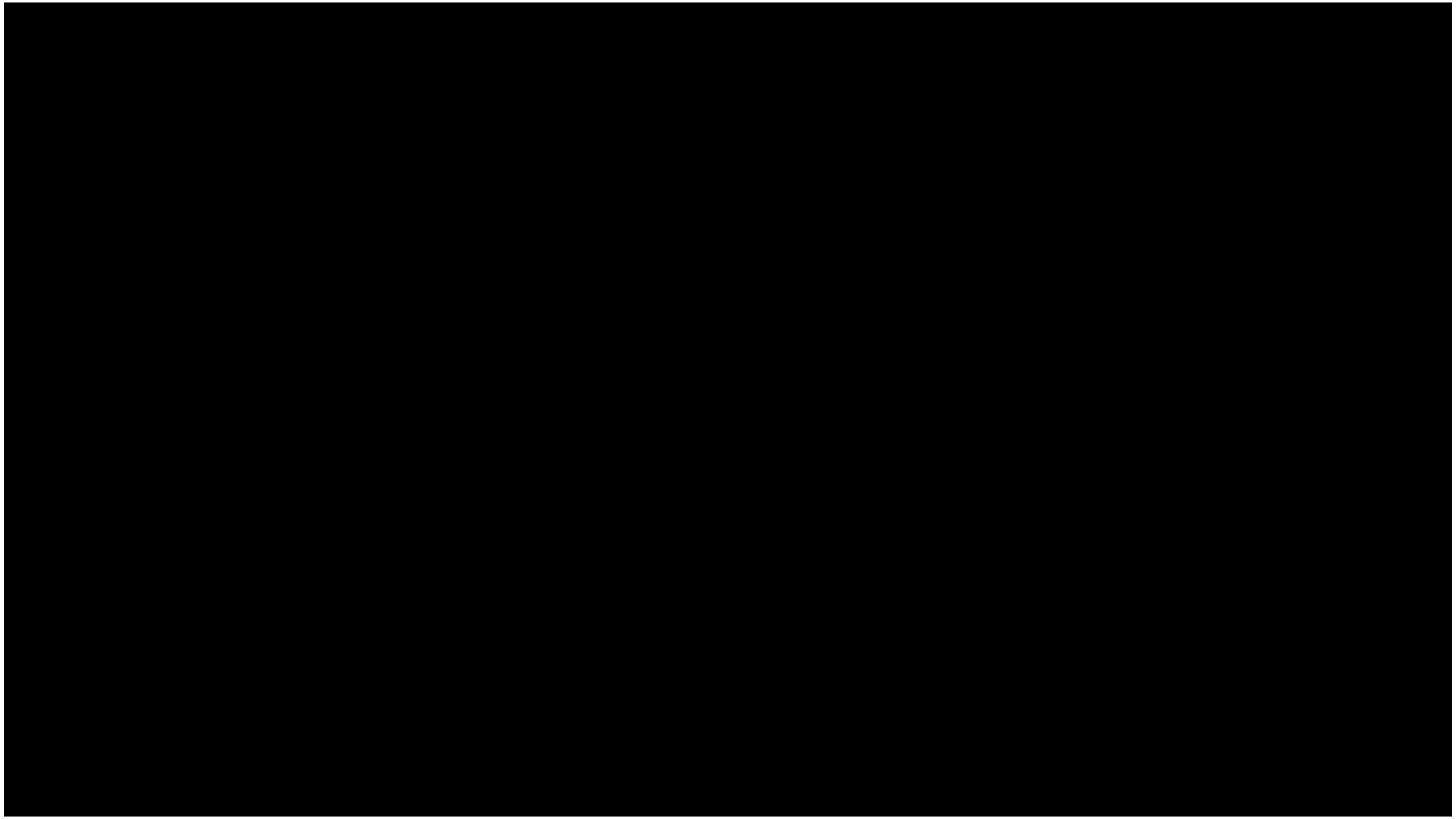


*Part of the **DeCoRo** Marie Curie Intra-European Fellowship at Plymouth (Stoelen & Cangelosi)*

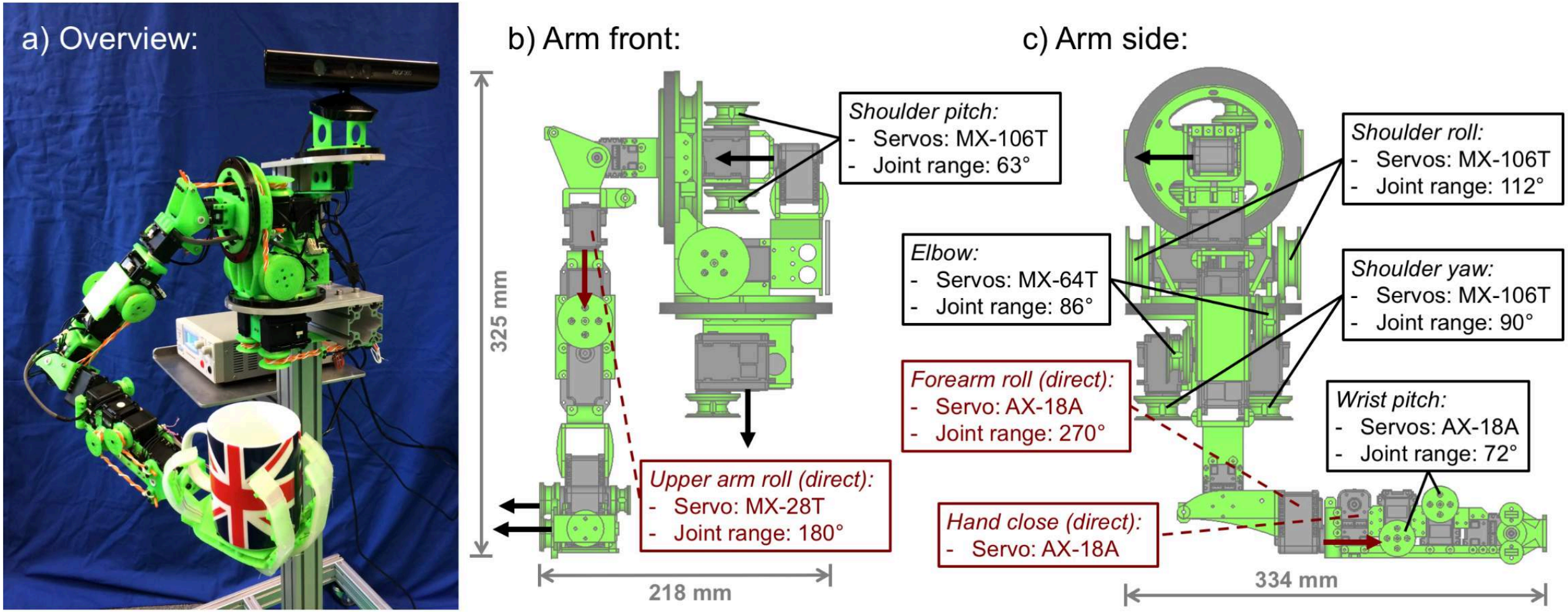


The GummiArm

The GummiArm (a while back…)

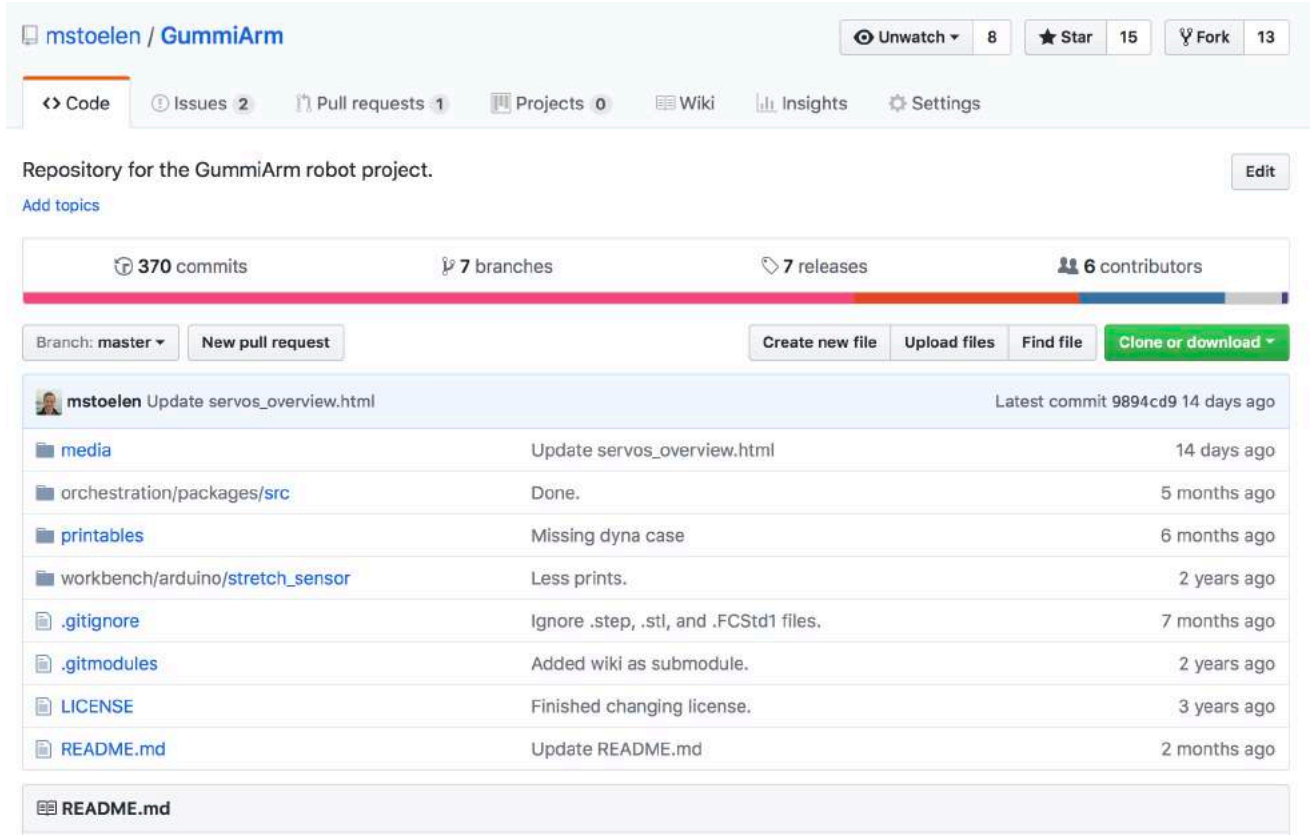


https://youtu.be/_syFAQBrgio


a) Overview:
b) Arm front:
c) Arm side:
325 mm
218 mm
334 mm
Shoulder pitch:
- Servos: MX-106T
- Joint range: 63°
Upper arm roll (direct):
- Servo: MX-28T
- Joint range: 180°
Elbow:
- Servos: MX-64T
- Joint range: 86°
Forearm roll (direct):
- Servo: AX-18A
- Joint range: 270°
Hand close (direct):
- Servo: AX-18A
Shoulder roll:
- Servos: MX-106T
- Joint range: 112°
Shoulder yaw:
- Servos: MX-106T
- Joint range: 90°
Wrist pitch:
- Servos: AX-18A
- Joint range: 72°

Open source AND easily replicable

Open source AND easily replicable



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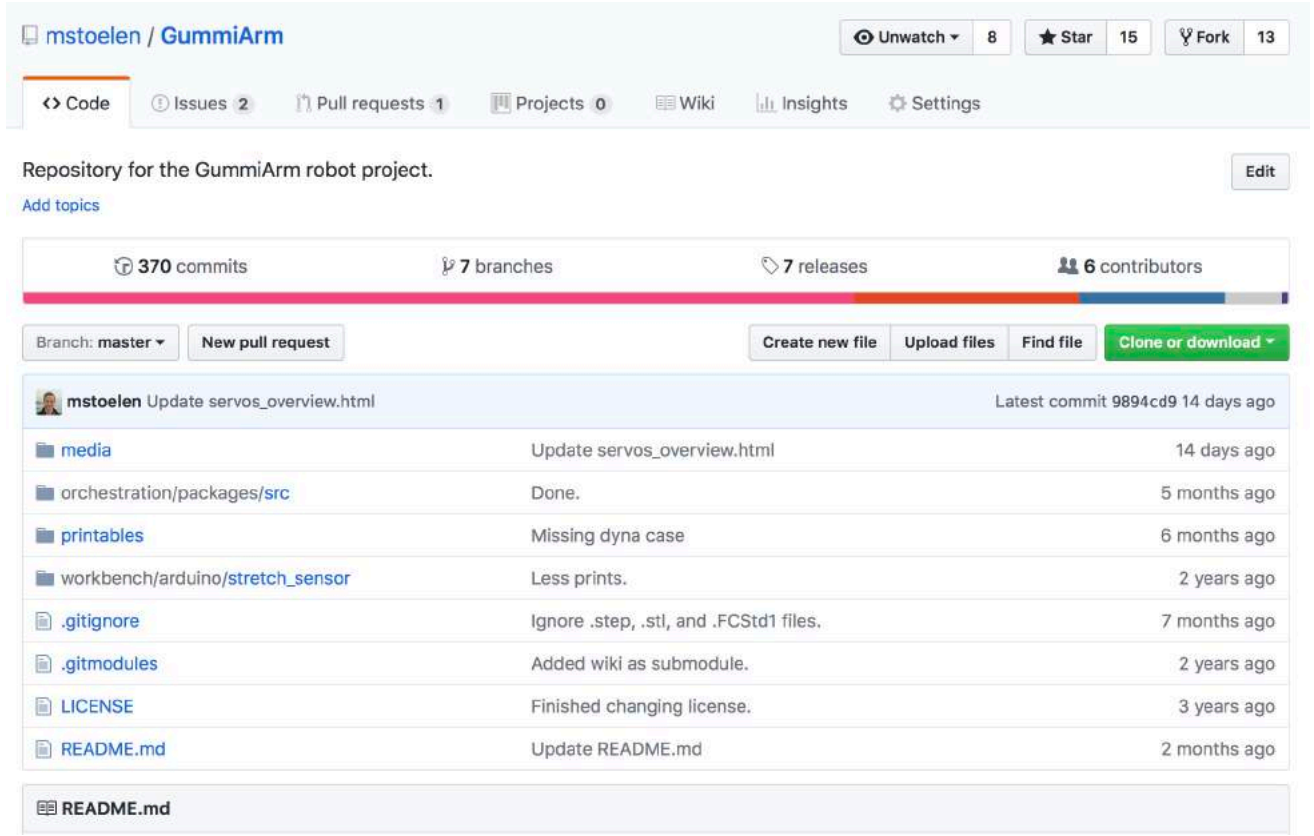


https://mstoelen.github.io/GummiArm/

Open source AND easily replicable

mstoelen / GummiArm

Unwatch 8 | Star 15 | Fork 13

Code | Issues 2 | Pull requests 1 | Projects 0 | Wiki | Insights | Settings

Repository for the GummiArm robot project. Edit

Add topics

370 commits | 7 branches | 7 releases | 6 contributors

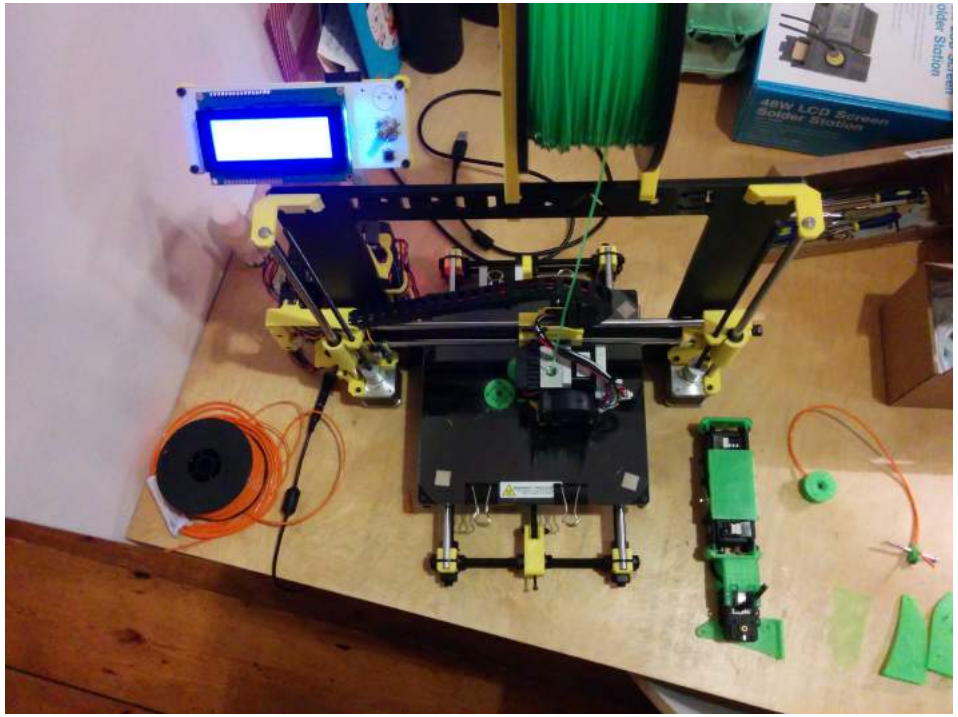
Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

mstoelen Update servos_overview.html — Latest commit 9894cd9 14 days ago

media	Update servos_overview.html	14 days ago
orchestration/packages/src	Done.	5 months ago
printables	Missing dyna case	6 months ago
workbench/arduino/stretch_sensor	Less prints.	2 years ago
.gitignore	Ignore .step, .stl, and .FCStd1 files.	7 months ago
.gitmodules	Added wiki as submodule.	2 years ago
LICENSE	Finished changing license.	3 years ago
README.md	Update README.md	2 months ago

README.md

+



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README.md

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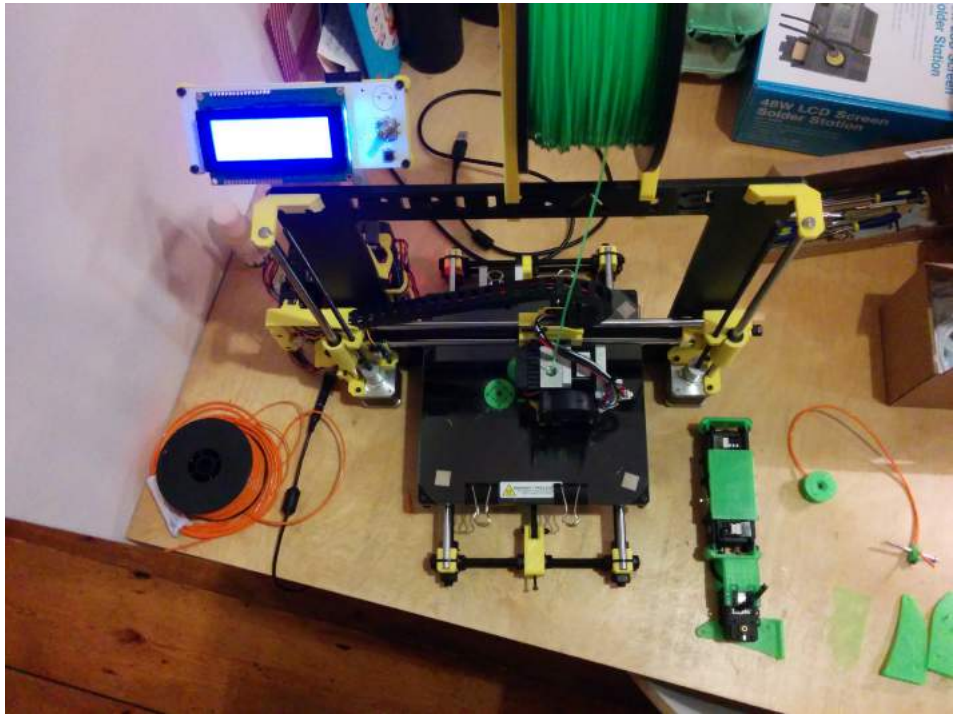


Towards replicable robot experiments?

(Bonsignorio, Hallam, del Pobil, 2007)

https://mstoelen.github.io/GummiArm/

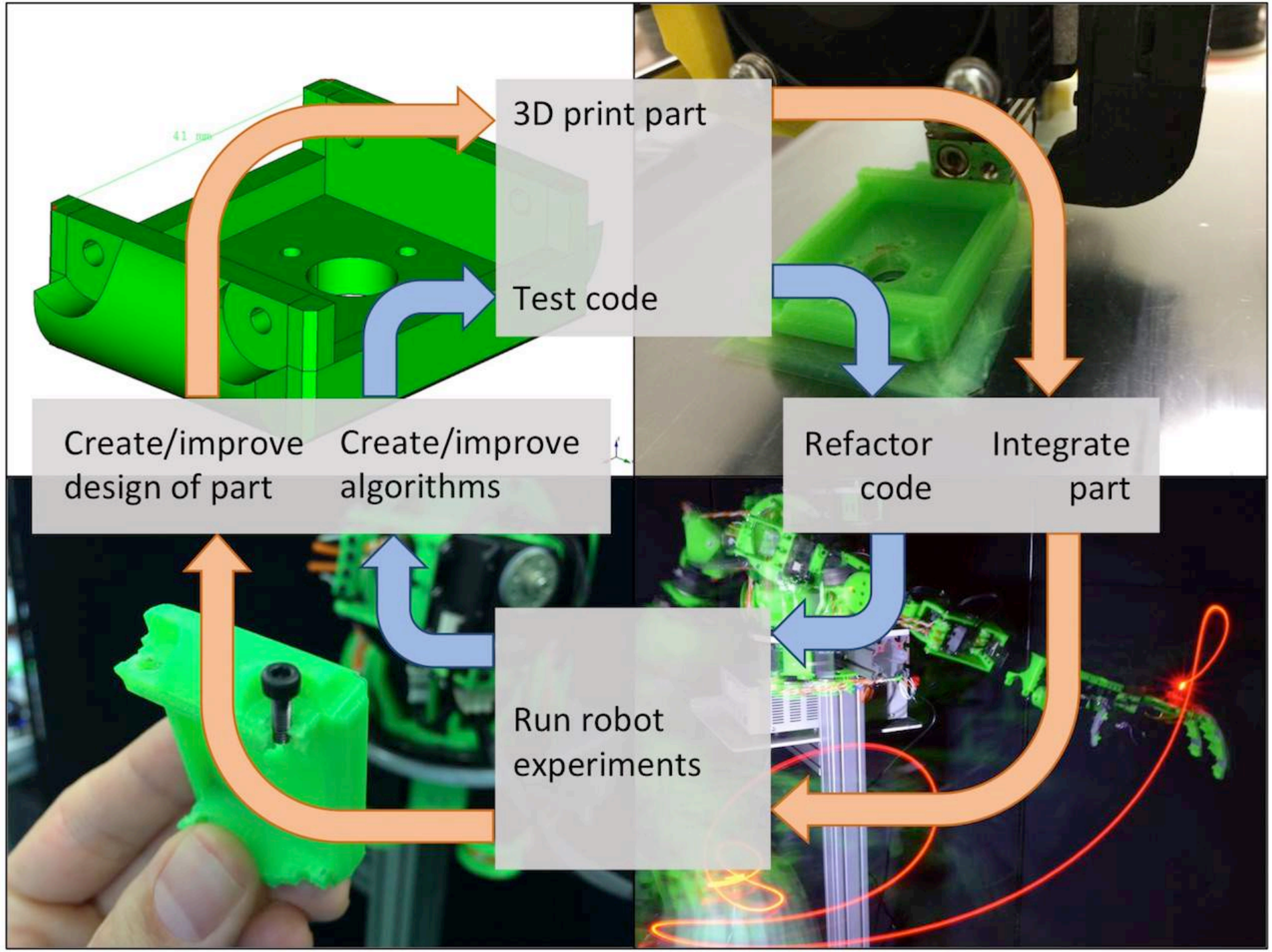
Detailed IKEA-style build instructions

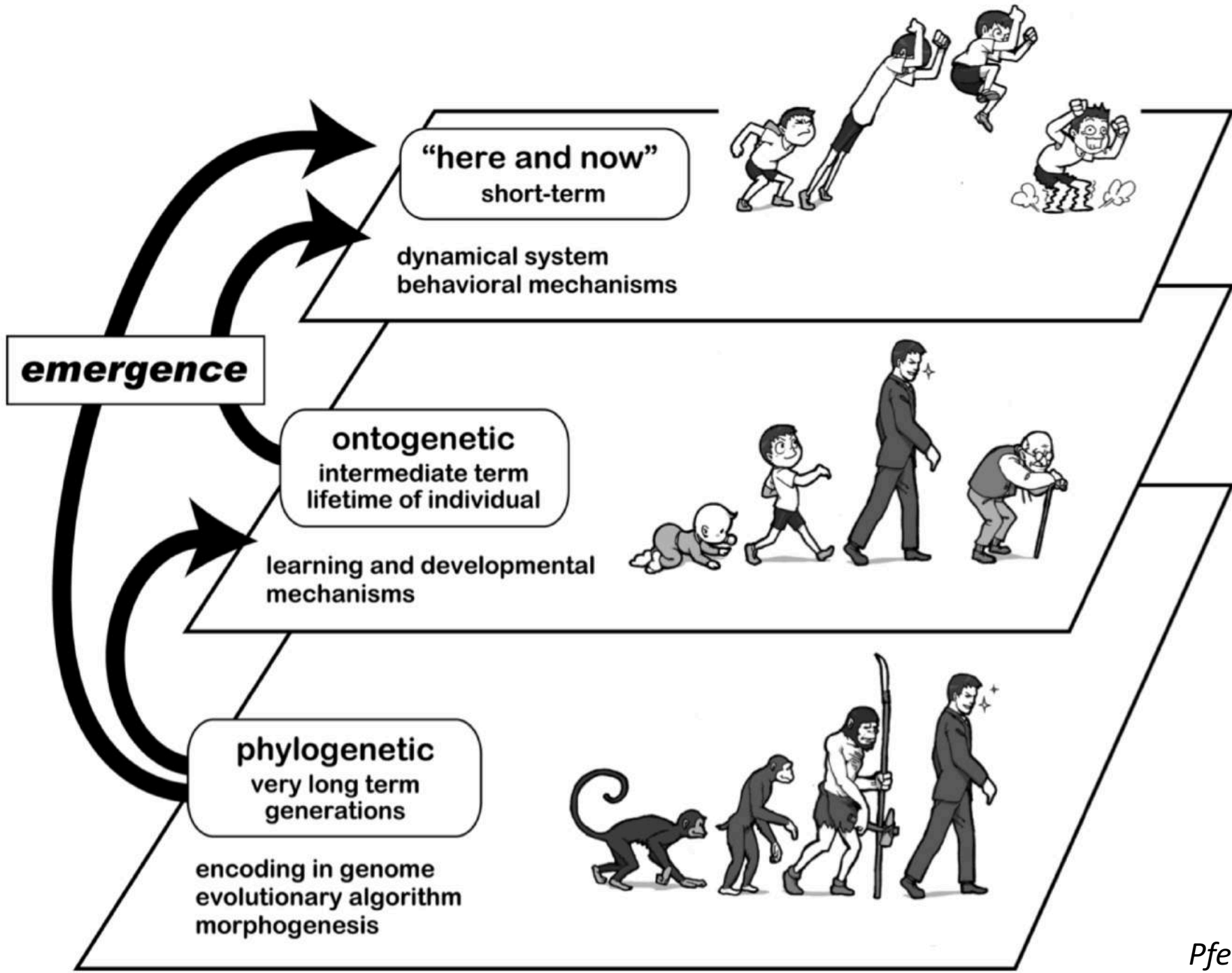
Lower arm

Required :

1. 82x M2x8mm screws
2. 74x M2 washers
3. 80x M2 nuts
4. 6x M2.5x12mm screws
5. 6x M2.5 nuts
6. 4x M2.5 washers
7. 1x M3x10mm with bearing bushing

1. Screw the two elbow parts on servo 21 with M2x8mm. (Figure 1)
2. Screw now the same servo to the lower plate but upside down and put a M2.5 nut in this plate. (Figure 2 and 2.5)
3. Fix all the AX-18 and the AX-12 at the end of the forearm with the reinforcement plastic parts with M2x8mm. (Figure 3 and 3.5)
4. Fix the wrist thank to the M3x10mm and M2x8mm screws. (Figure 4 and 4.5) 5. Fix the prepared wheels on the two middle servos and fix the muscles underneath the wrist's muscle fixer (M2.5x12mm). (Figure 5 and 5.5)


3D print part
Test code
Refactor code
Integrate part
Run robot experiments
Create/improve algorithms
Create/improve design of part



Pfeifer & Bongard, 2006

Agent design principles	
Three constituents	Ecological niche (environment), tasks, and agent must always be taken into account
Complete agent	Complete agent must be taken into account in design, not only isolated components
Parallel, loosely coupled processes	Parallel, asynchronous, partly autonomous processes, largely coupled through interaction with environment
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Cheap design	Exploitation of niche and interaction; parsimony
Redundancy	Partial overlap of functionality based on different physical processes
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Value	Driving forces; developmental mechanisms; self-organization

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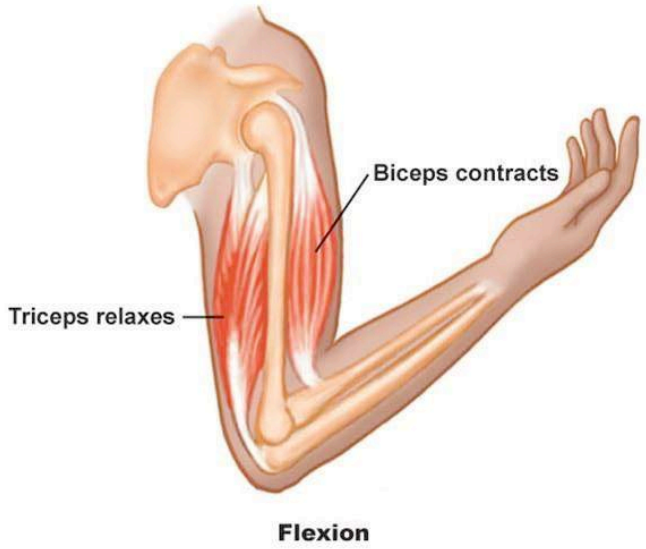
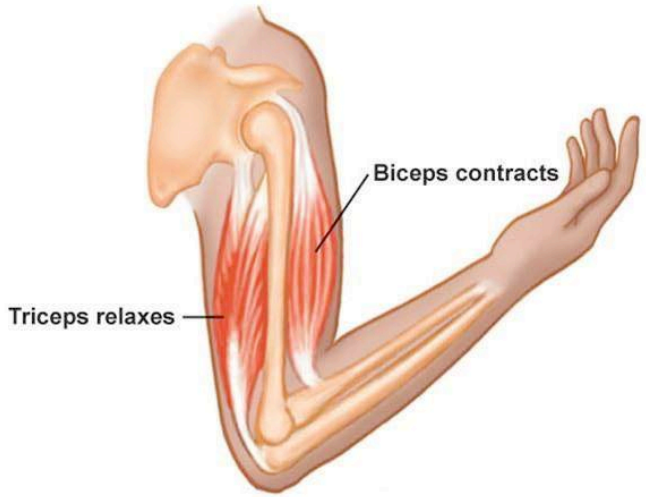
Pfeifer & Bongard, 2006

Rubbery agonist-antagonist joints



** Recreus filaments: http://recreus.com/en/*

Rubbery agonist-antagonist joints



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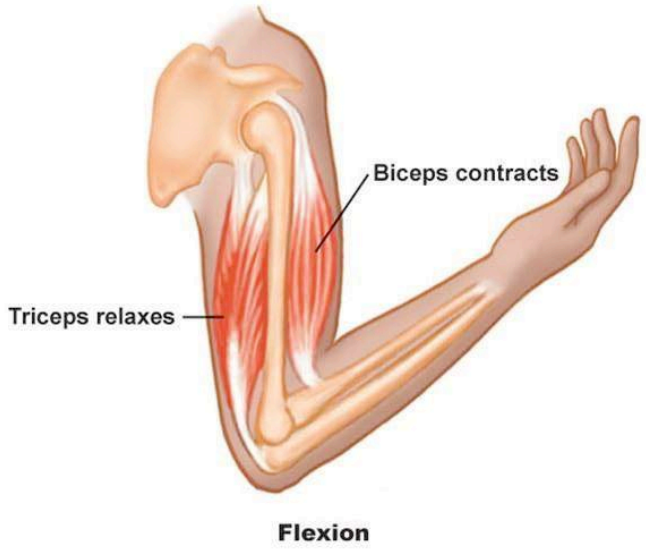
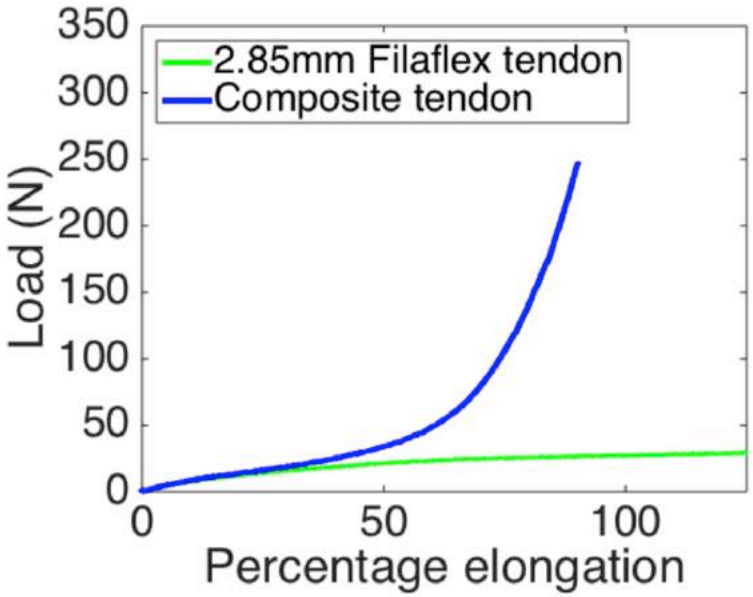
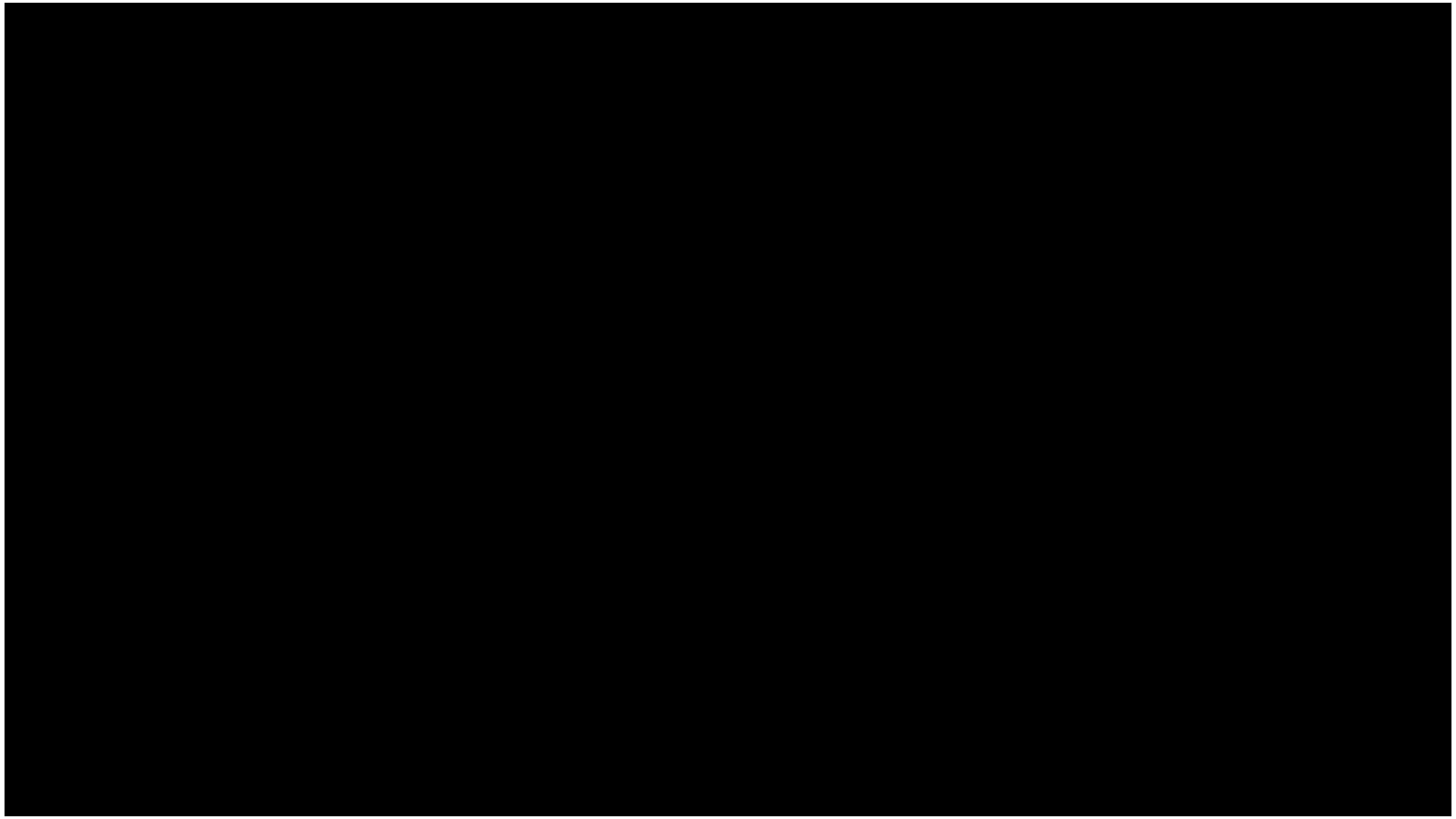




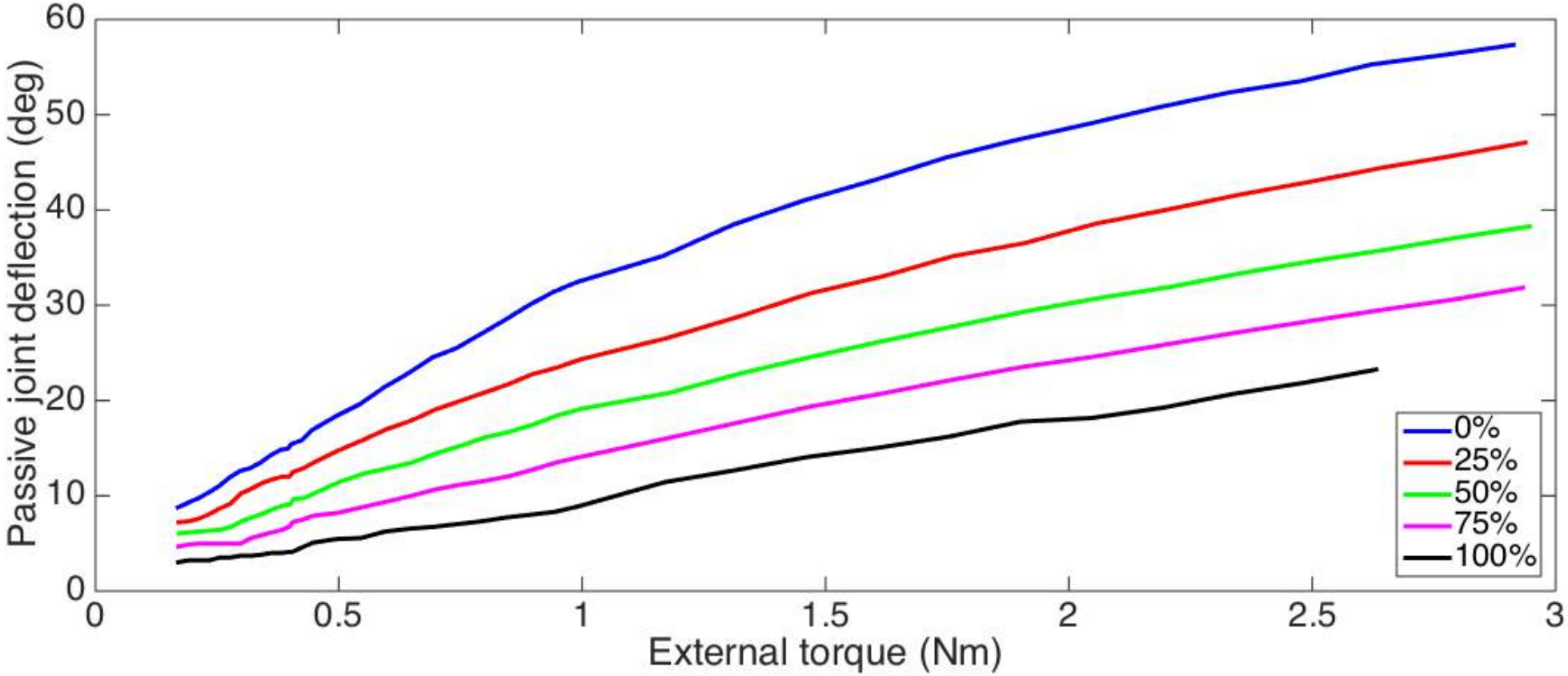
** Recreus filaments: http://recreus.com/en/*

3D printed, but not necessarily fragile



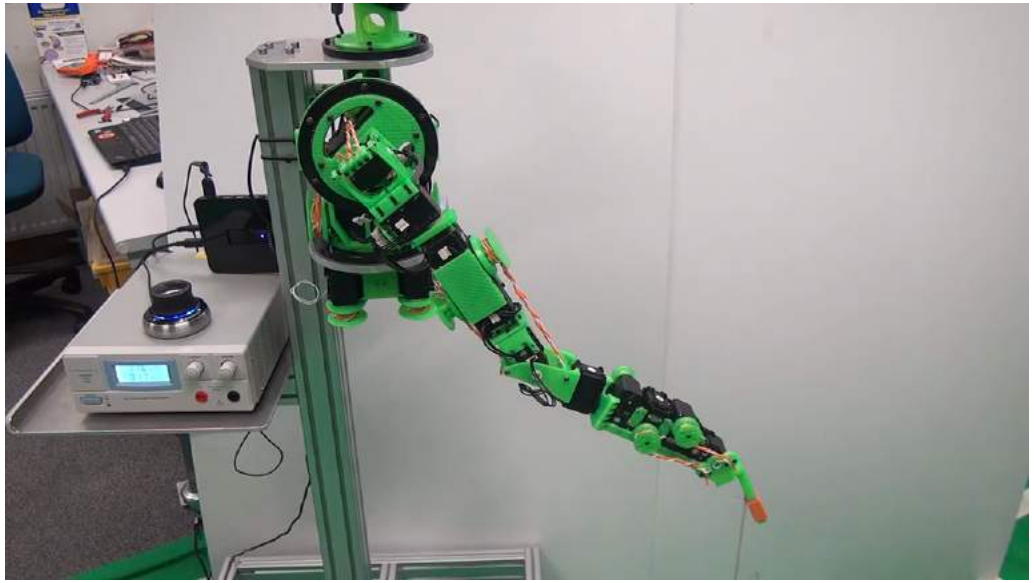
https://youtu.be/945XSTuKtAI

Stiffness varied through co-contraction

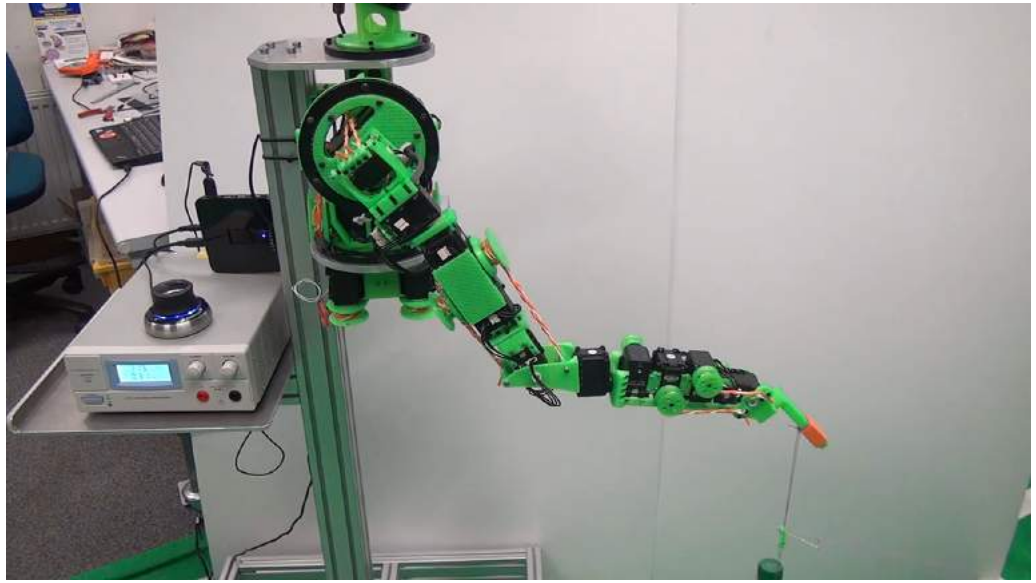


But also intrinsic damping…

20% co-contraction:



100% co-contraction:

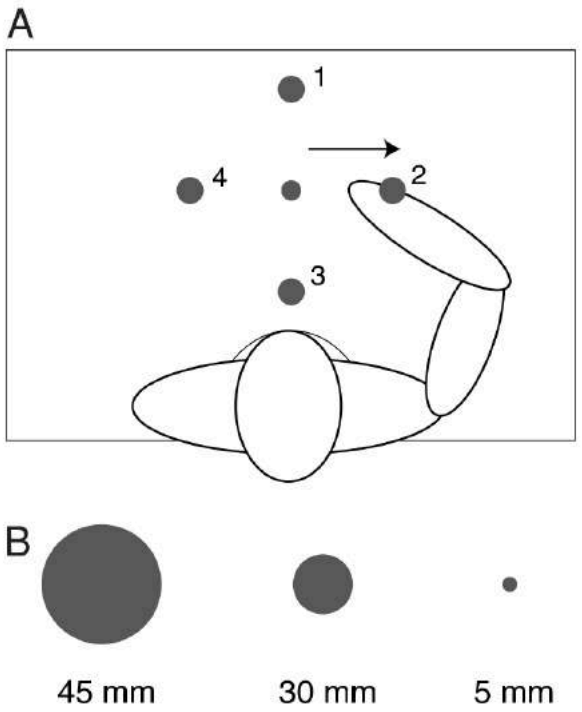


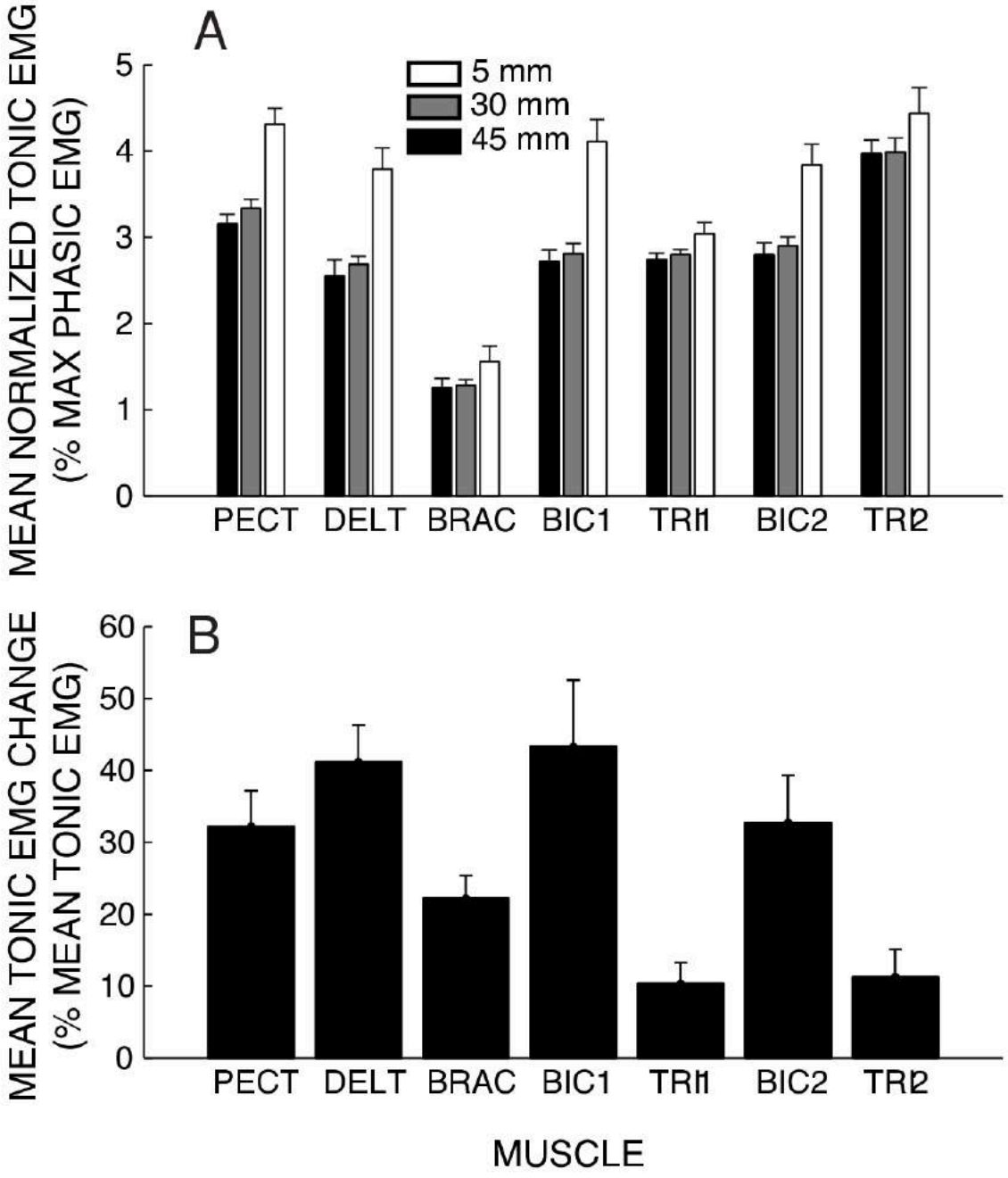
Stoelen et al., under review, IEEE Robotics & Automation Magazine, 2017

Varying stiffness simplifies physical interaction

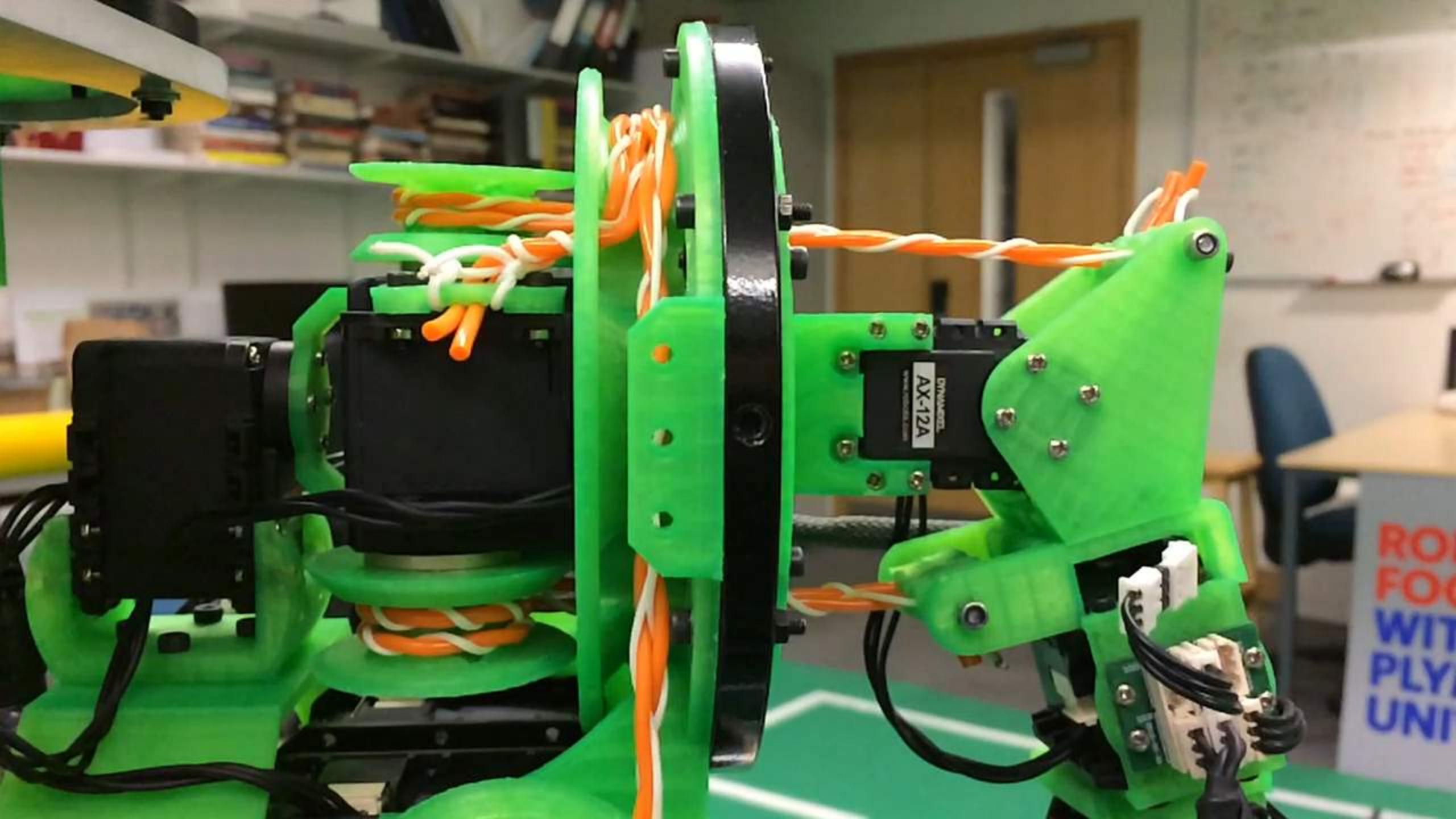
https://youtu.be/QEHxqkwRZZE

Co-contraction used to stabilize human movement





Gribble et al., Journal of Neurophysiology, 2003


AX-12A

Good response even when starting “loose”

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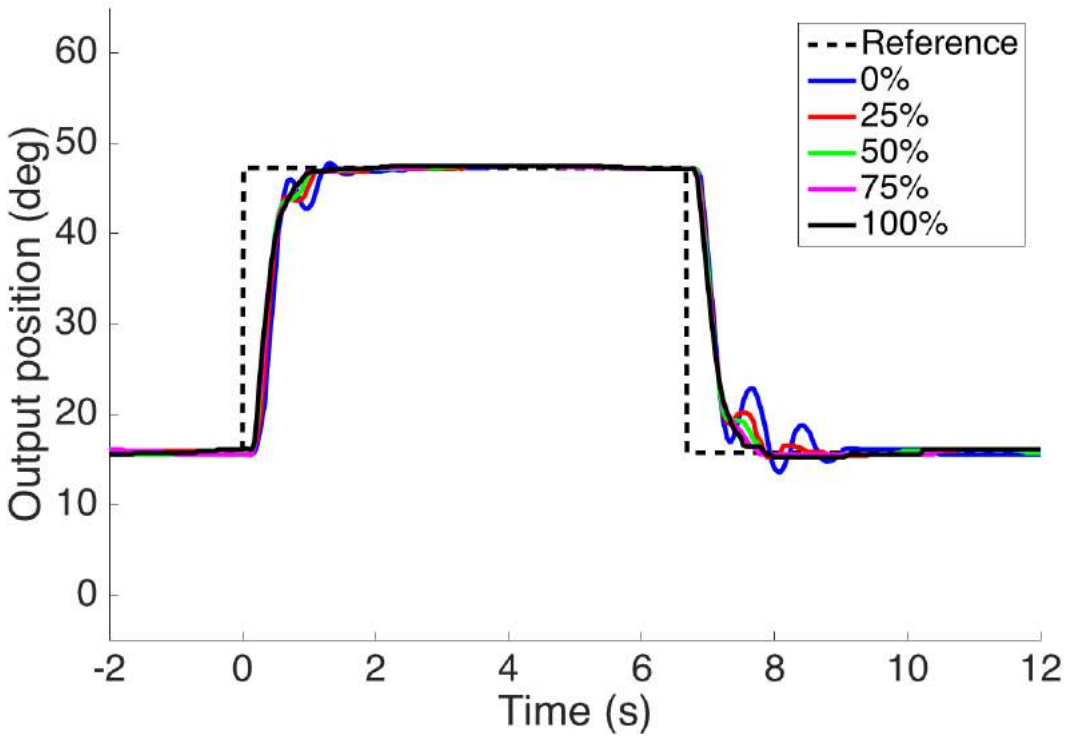
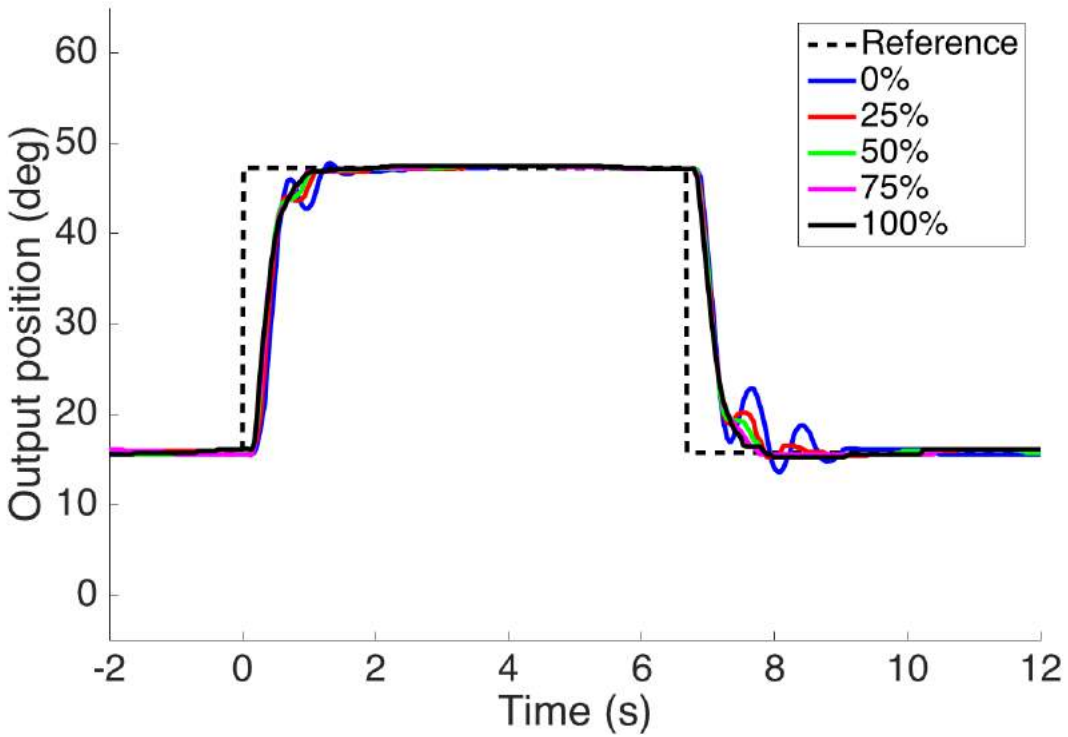


Feedback control only

Good response even when starting “loose”



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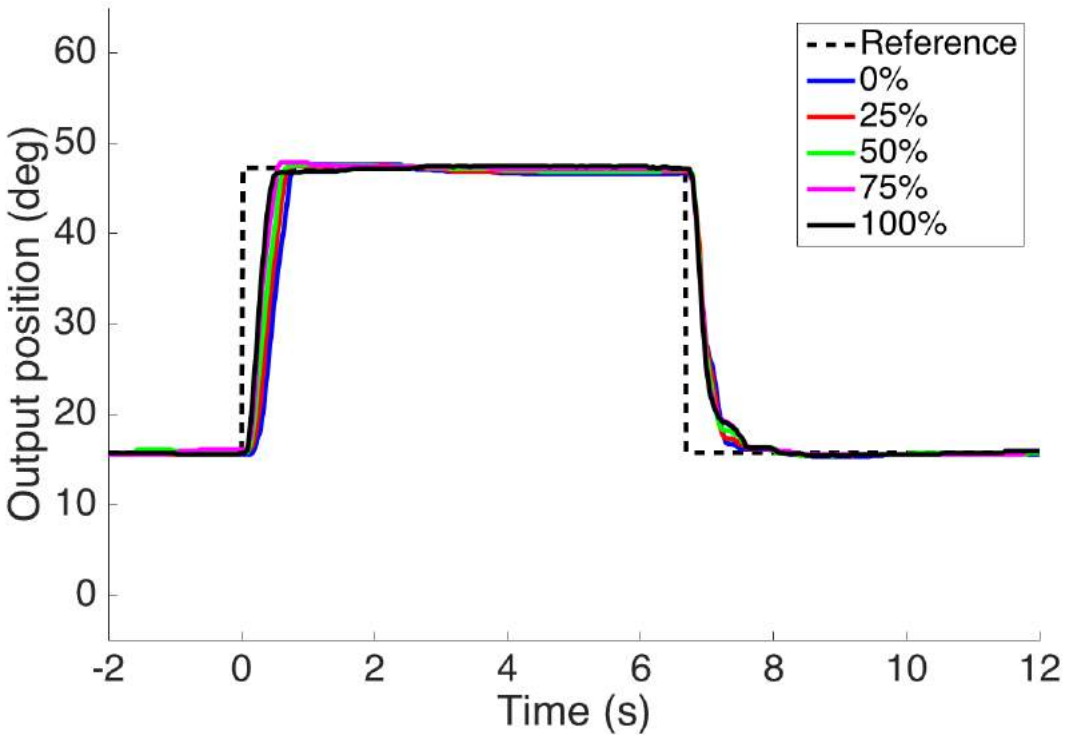


Ballistic/feedback control

Summer 2017:

The GummiAnkle

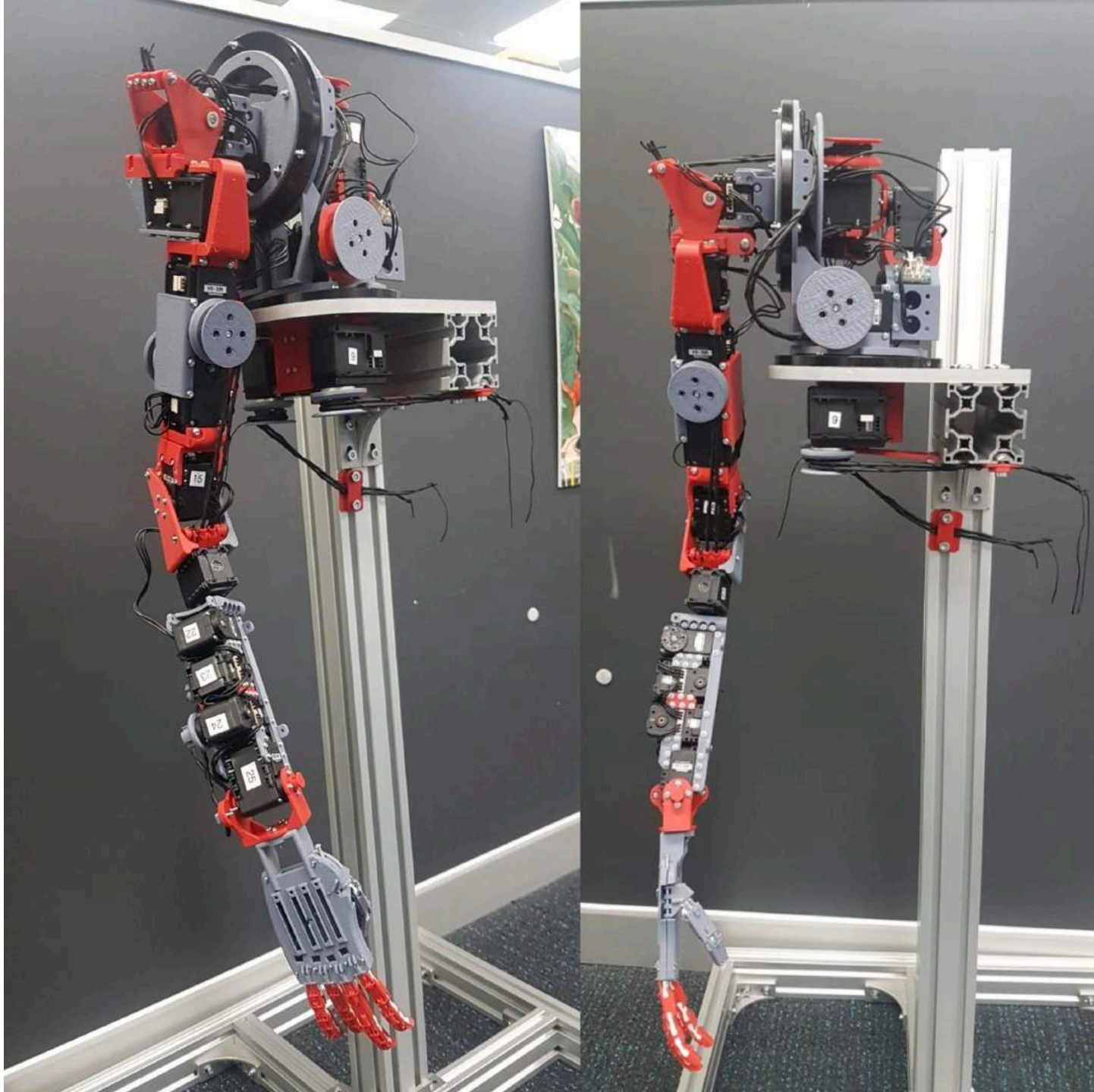
Colombian School of Engineering

https://youtu.be/UCxaTdZbExs

November 2017:

1st Australian clone

Australian Centre for Robotic Vision (QUT)



Most crops sold fresh still harvested by hand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CLAAS

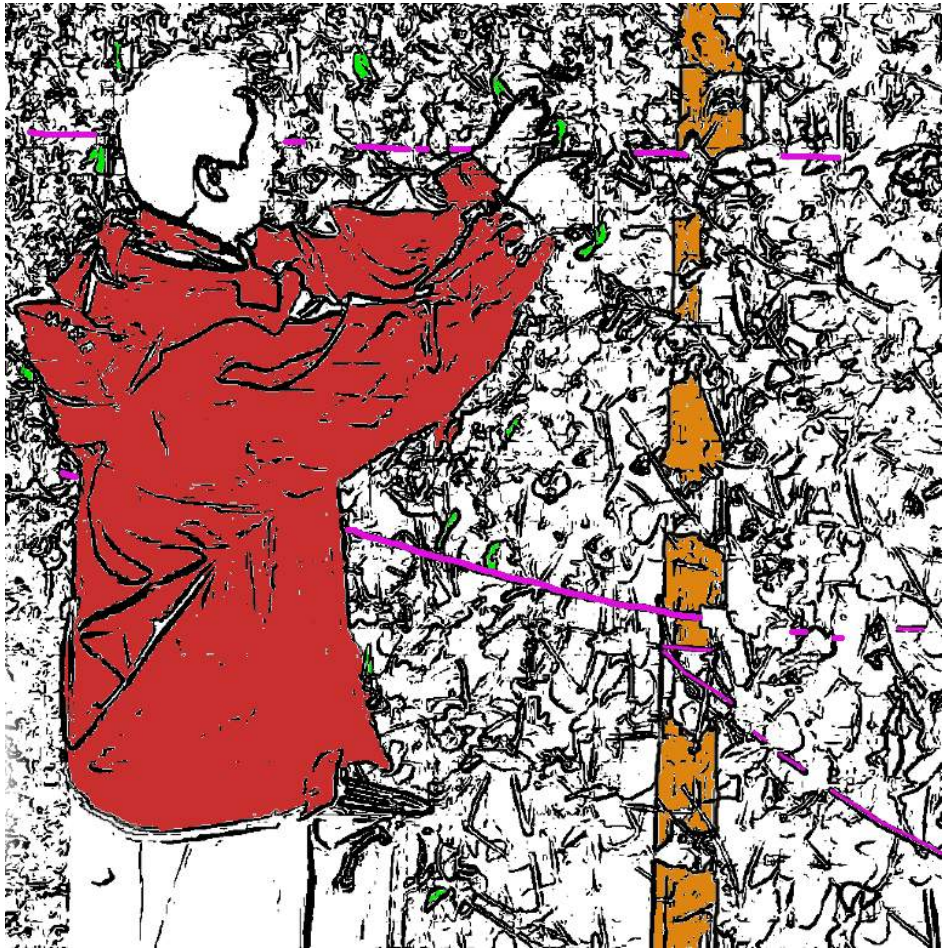
We need soft + precise robots in the field!

Sensory data will be noisy…

https://en.wikipedia.org/wiki/Thunderstorm

And ambiguous…

Errors will be made, compliance needed

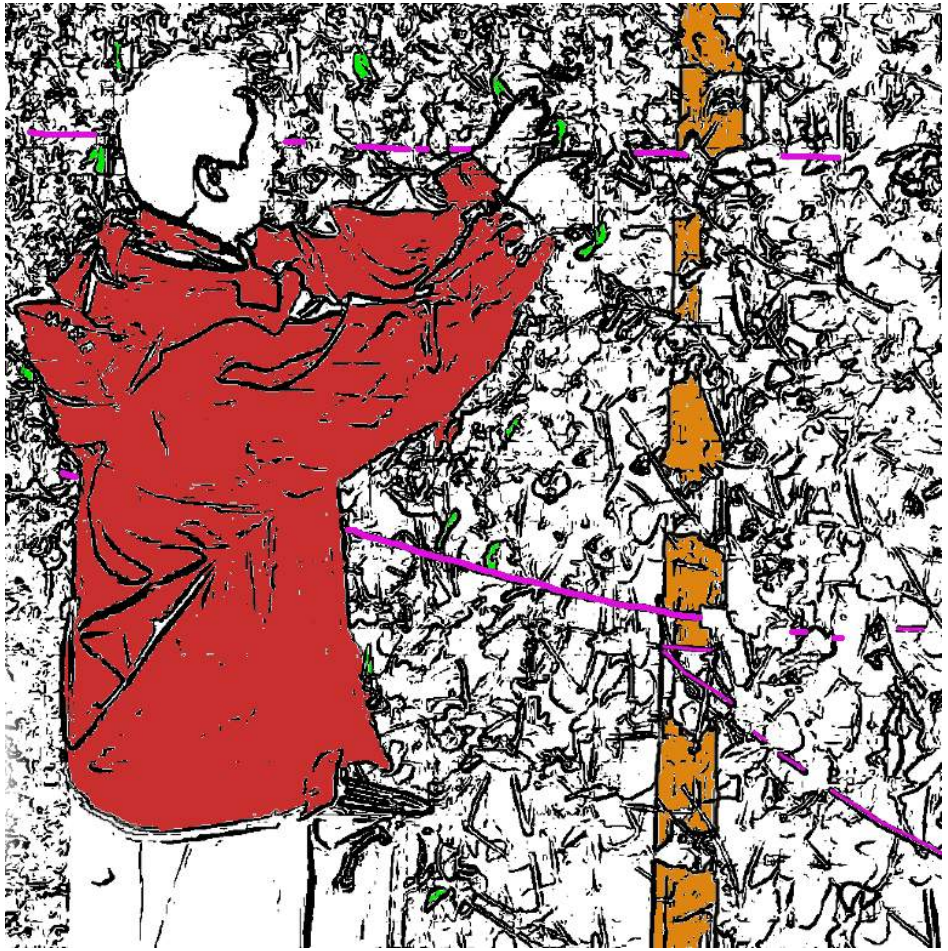


** Zinn et al., The international journal of robotics research, 2004*

Errors will be made, compliance needed

Collisions with obstacles

- Hard to prevent 100%
- E.g. wooden poles



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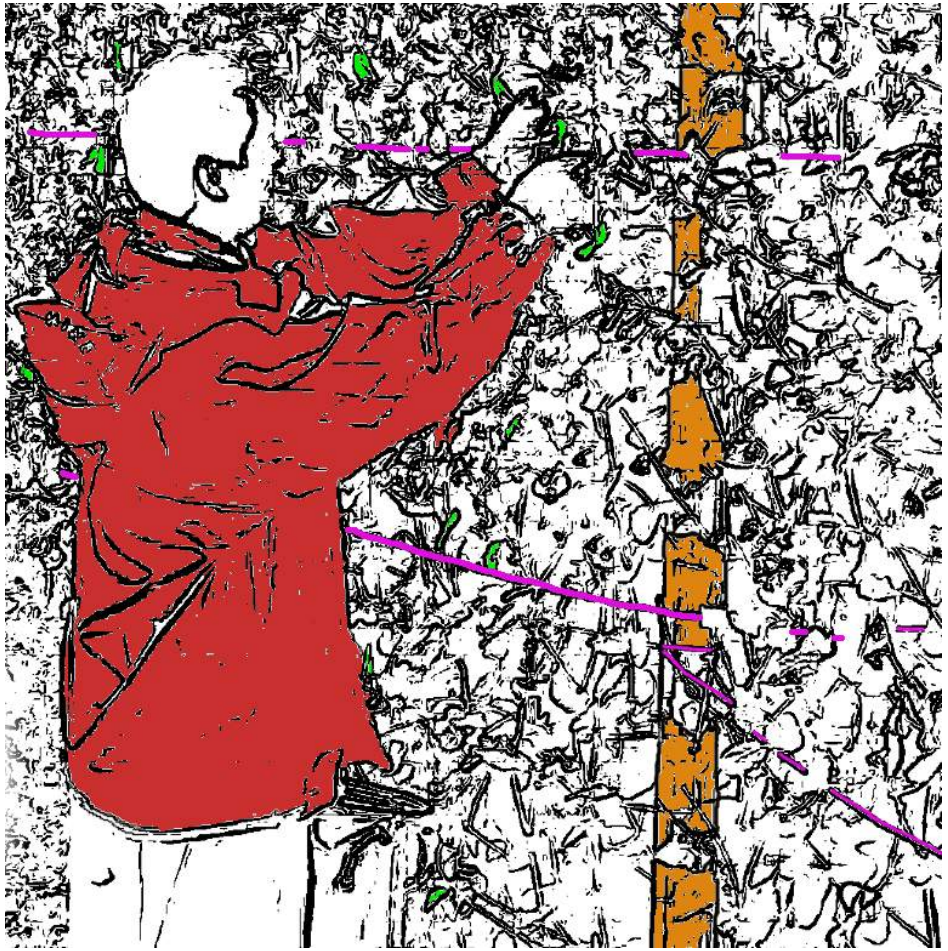
Working alongside humans

- Head Injury Criterion*
- Cutting mechanisms a risk



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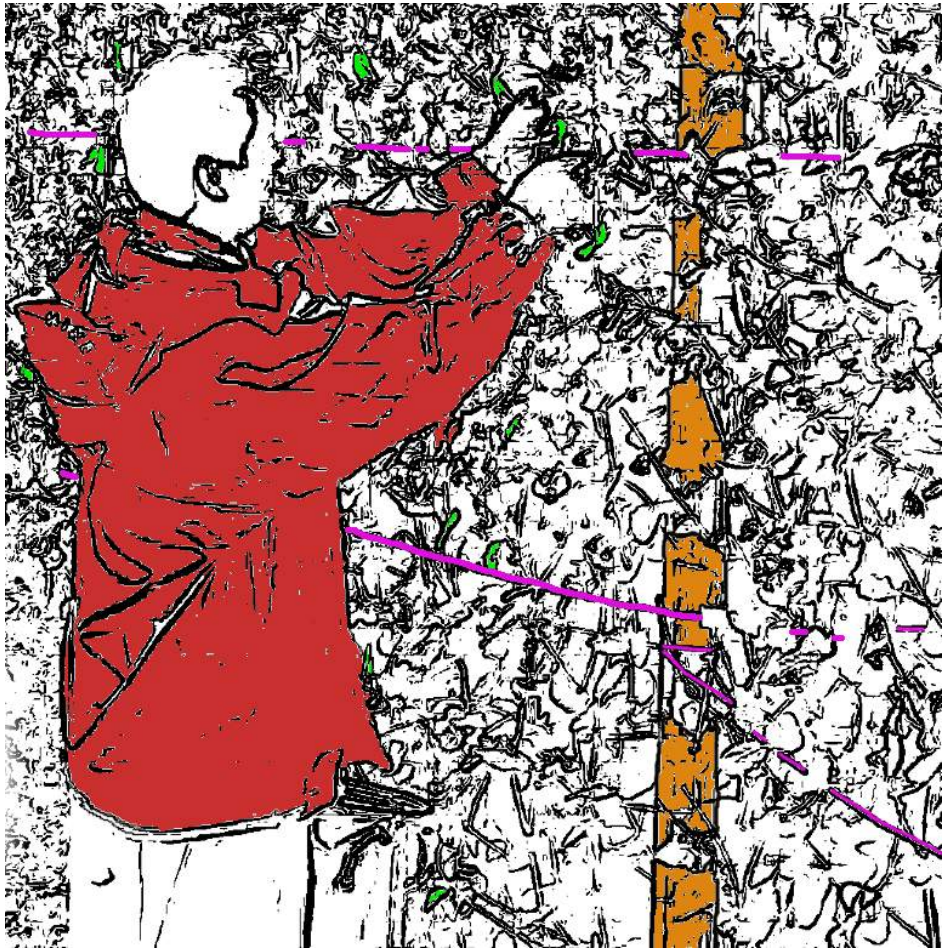
Entanglement risks
- Cords
- Branches/stems



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SUNQIAO
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ROBOTICS WITH PLYMOUTH UNIVERSITY

SHANGHAI JIAO TONG UNIVERSITY
1896

China Robot Harvest project

Agri-Tech in China Newton Network+ (ATCNN), UK

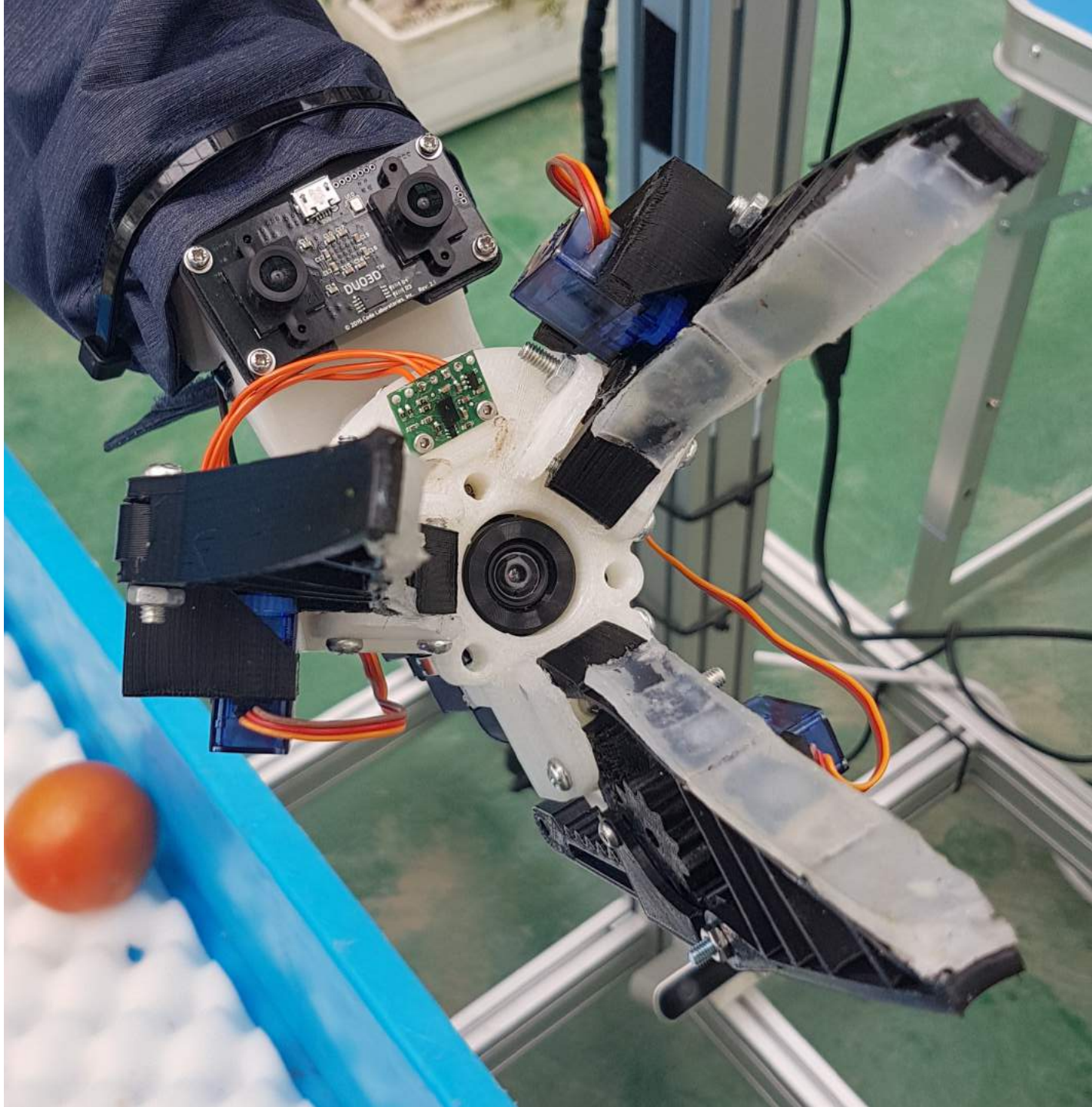
With thanks:

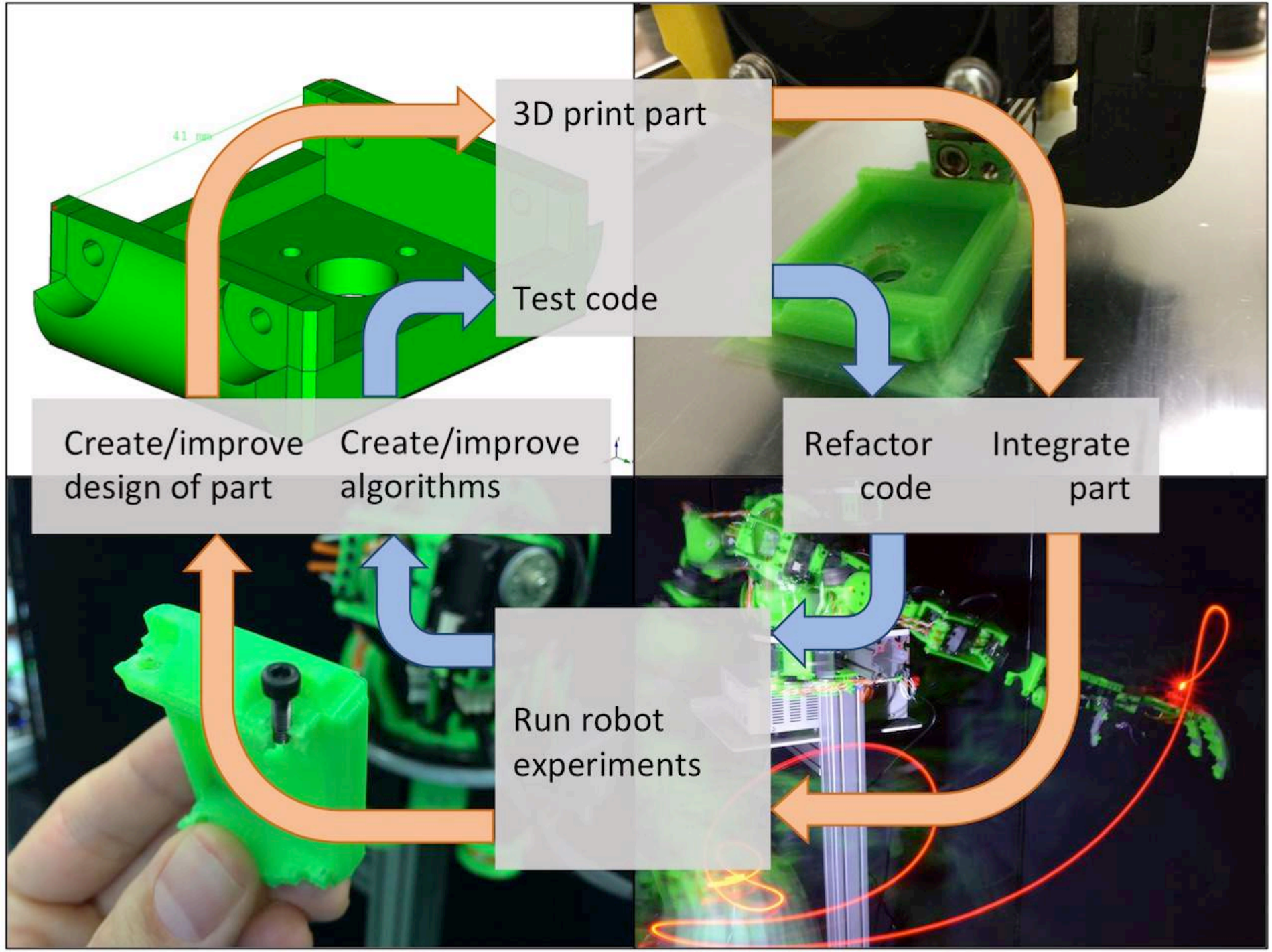
ROTHAMSTED RESEARCH

Newton Fund

DE TAO GROUP 德稻


Fieldwork Robotics


DUO3D


3D print part
Test code
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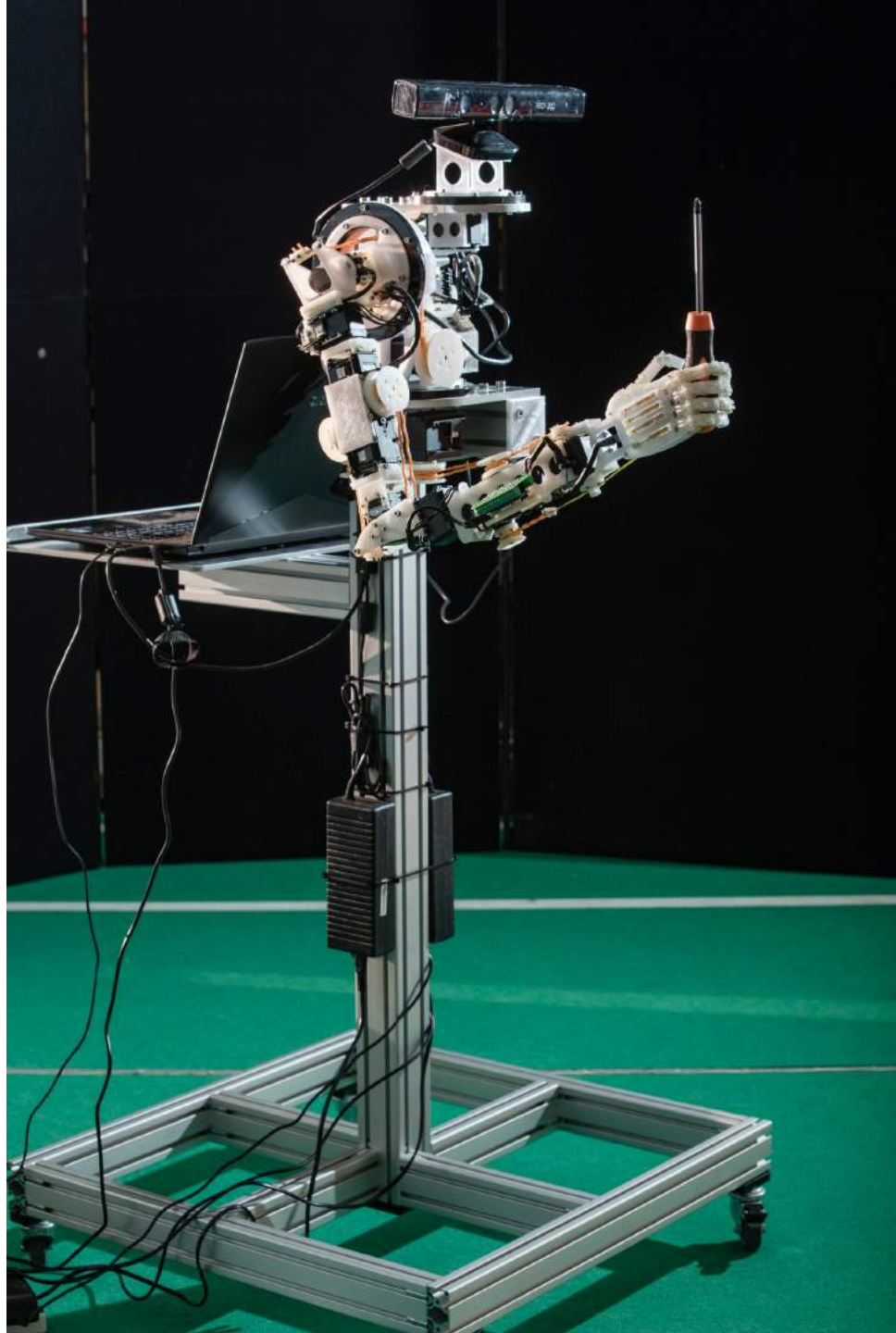
Fieldwork Robotics Ltd

WITH PLYMOUTH UNIVERSITY

Questions?



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