



Horticulture 4.0 Conference

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Automation through Grower-reprogrammable Robotics

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EPSRC


Engineering and Physical Sciences
Research Council



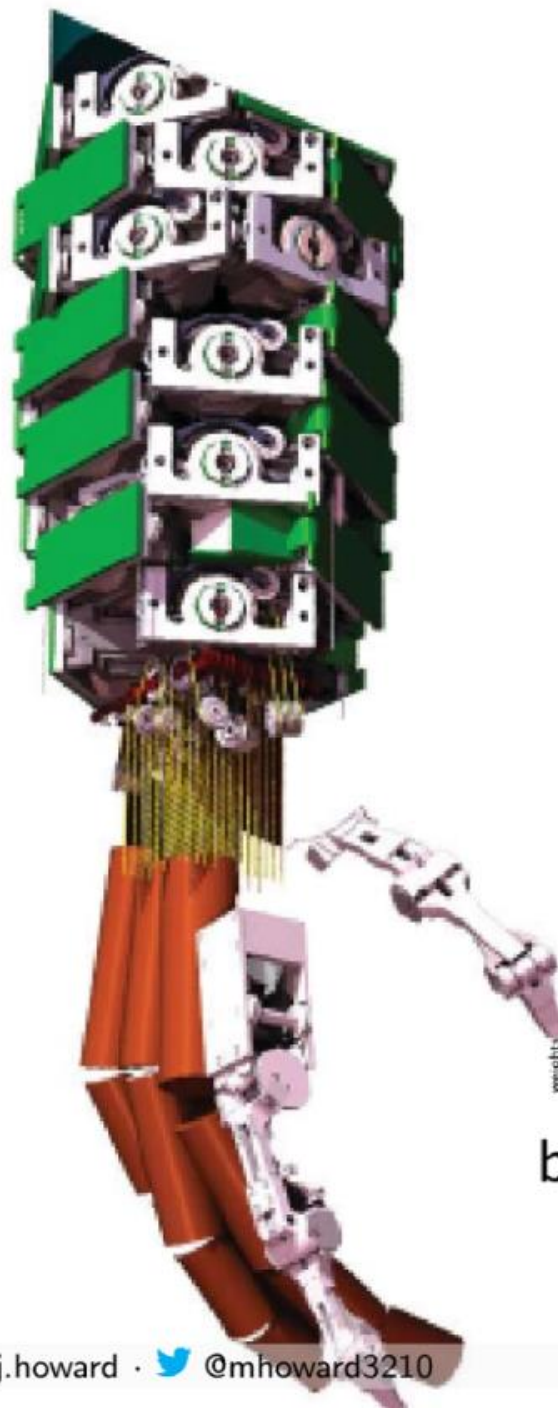
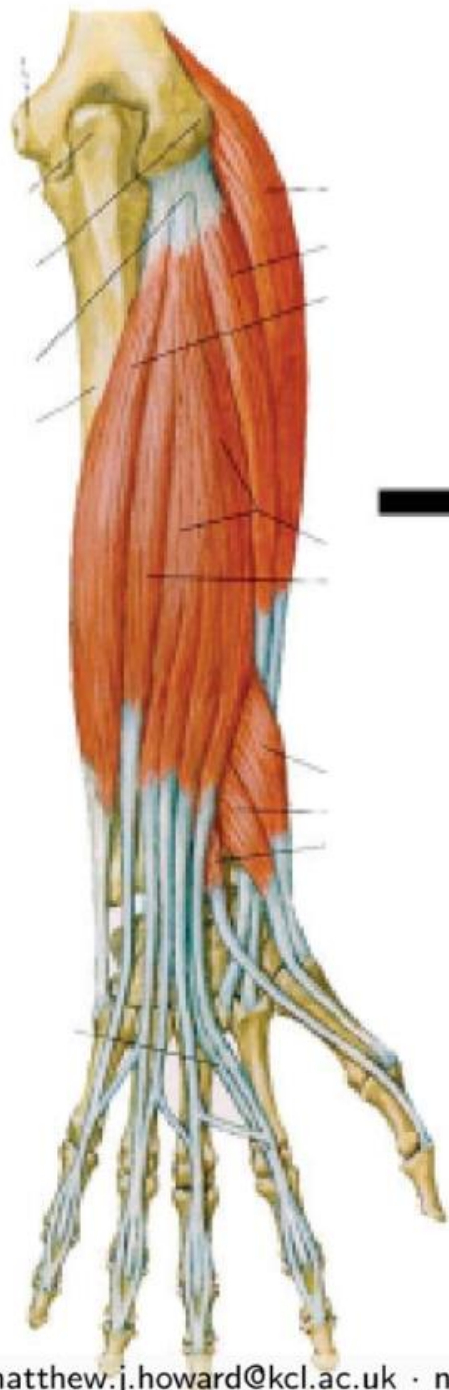


King's: 4th oldest Uni in England, World's first Engineering School.

Informatics: 49 academic staff, ~160 postdocs, RAs & PhDs in C.S., A.I., Telecomms & Robotics.

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Robot Learning Lab

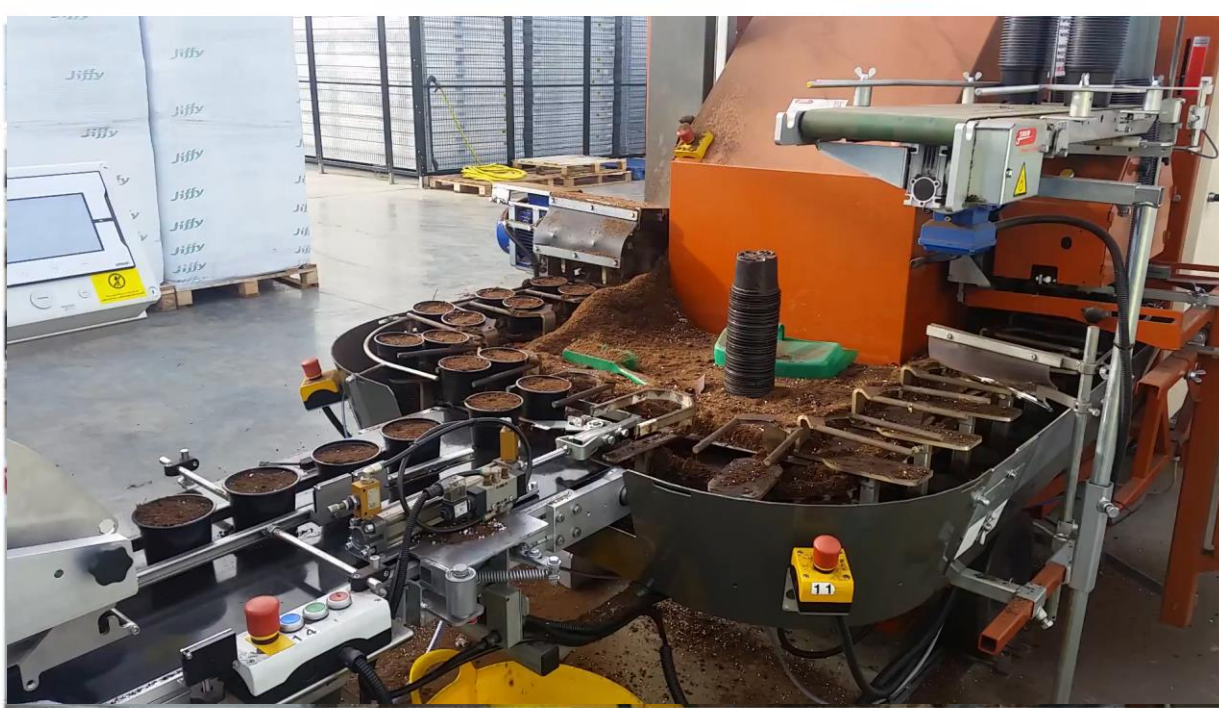
- Human behaviour modelling, extraction, understanding.
- Imitation learning, programming by demonstration.
- Optimal feedback control, reinforcement learning.
- Humanoid robotics, variable impedance actuation.
- Natural interfaces for capturing human behaviour.

feasible non function way able stiffness full find action space position hote tracking
algorithm sample start hand risk generic must VECTOR command provide features dof case strained three local may method demonstration
drawing around since as learning wall clearly provide features dof case strained three local may method demonstration
positions linear set show end cost gplvm two dpl robot different policies
weights

Why am I interested?



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Challenges to Automation

Technical Challenges

- Wide variety of plant species, processed in small batches.
- Delicate items, uncertain shapes and properties.
- Other practicalities (location, footprint).

→ **Hard to find commercial solutions.**

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86% UK horticulture businesses are small/medium.*

- 45% have turnover < £500k.
- 41% are £500k – £5m.

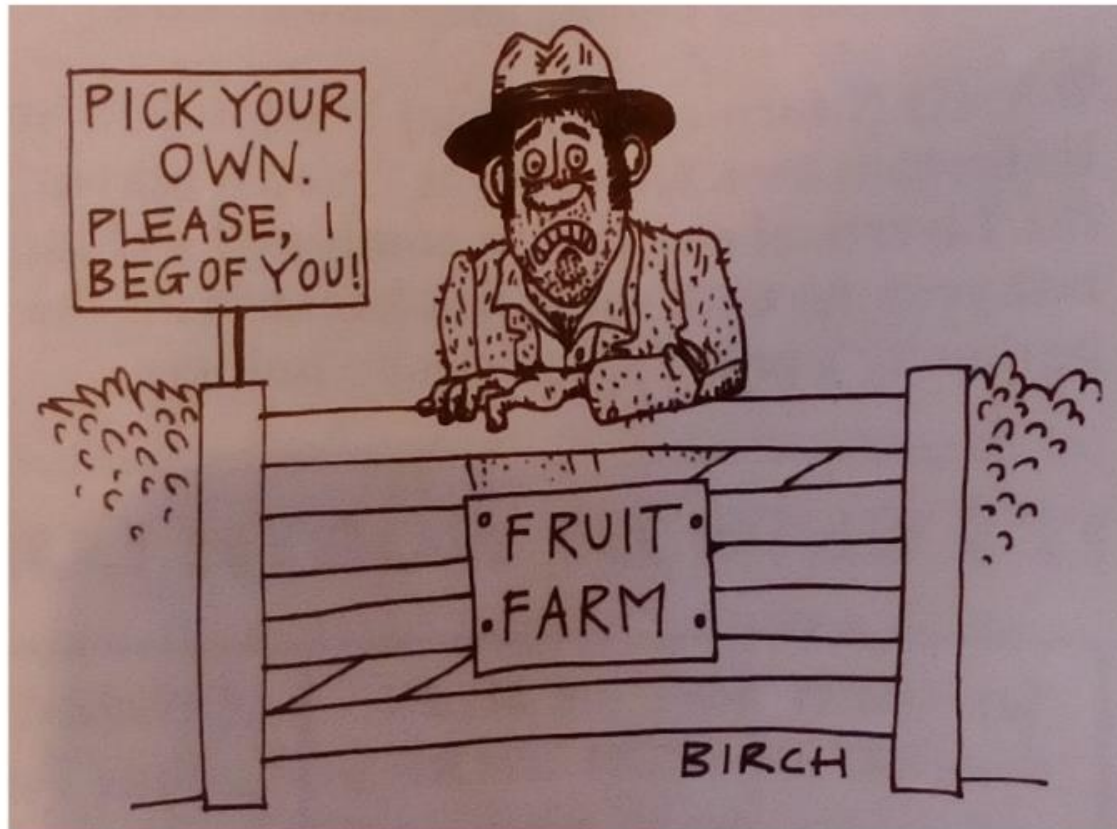


Major risk in large investments in machinery...

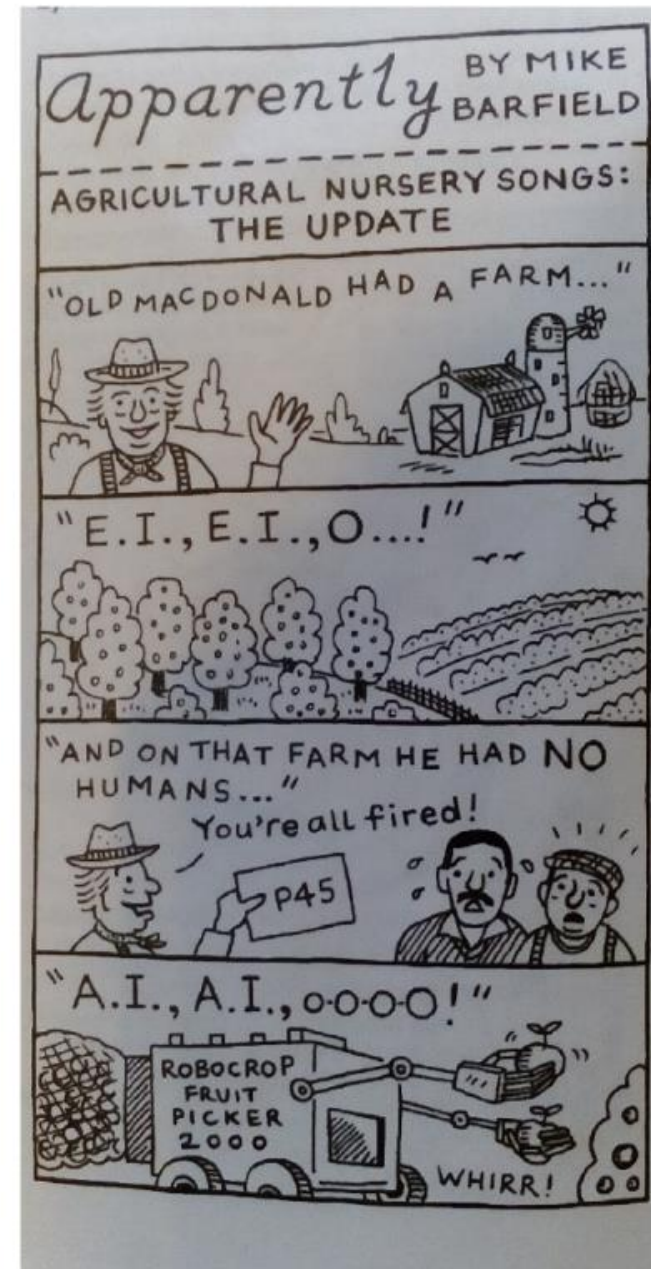
*

Workforce issues...

- National living wage.
- Unappealing to the young...
- Brexit!



Private Eye, #1472, June 2018



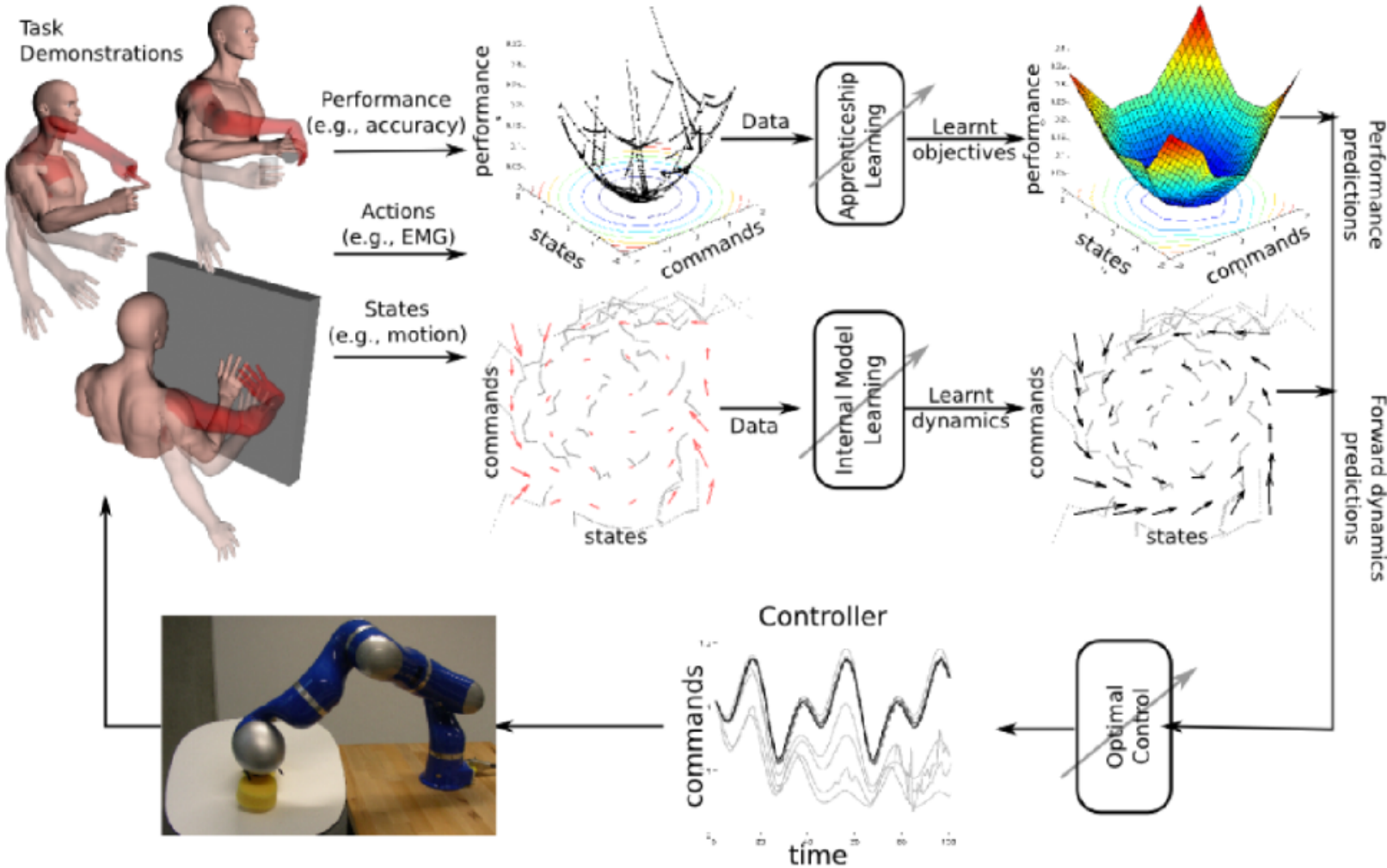
Private Eye, #1470, May 2018

Where are there solutions?





Learning from Demonstrations



Flavours

- Policy learning, trajectory modelling.
- Apprenticeship learning, inverse optimal control.
- Reinforcement learning.

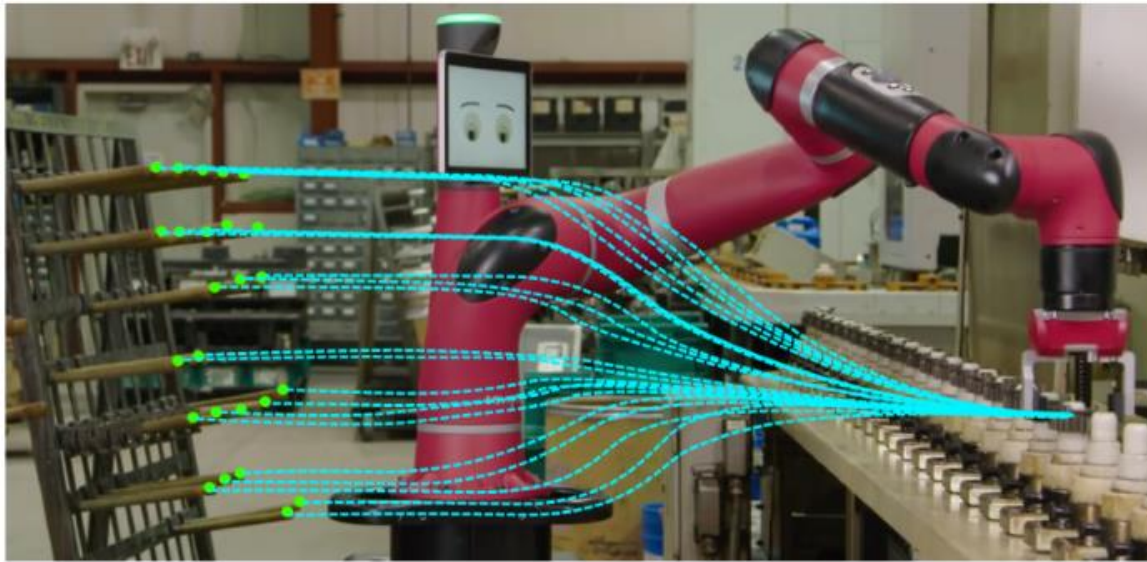
Deep, Bayesian, ... etc.

MH & Y. Nakamura. Locally weighted least squares policy iteration for model-free learning in uncertain environments. *IROS*, November 2013

MH, D. Braun, & S. Vijayakumar. Transferring human impedance behavior to heterogeneous variable impedance actuators. *IEEE T-Ro*, 29(4):847-862, 2013

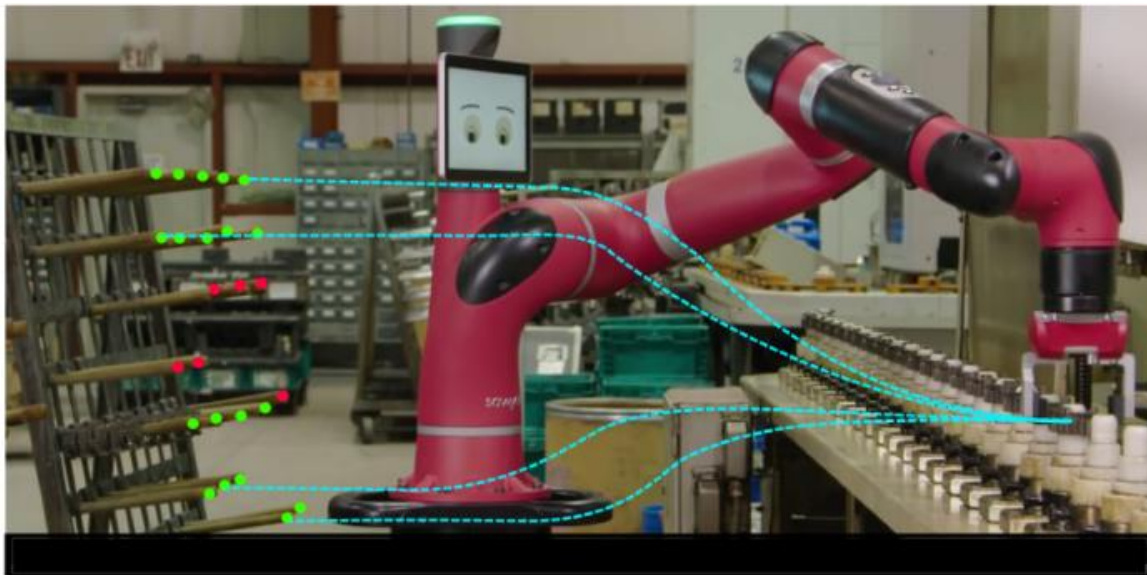
MH, et al. Methods for learning control policies from variable-constraint demonstrations. O. Sigaud & J. Peters, eds., *From Motor to Interaction Learning in Robots*, p. 253-291. Springer, Berlin, Heidelberg, 2009

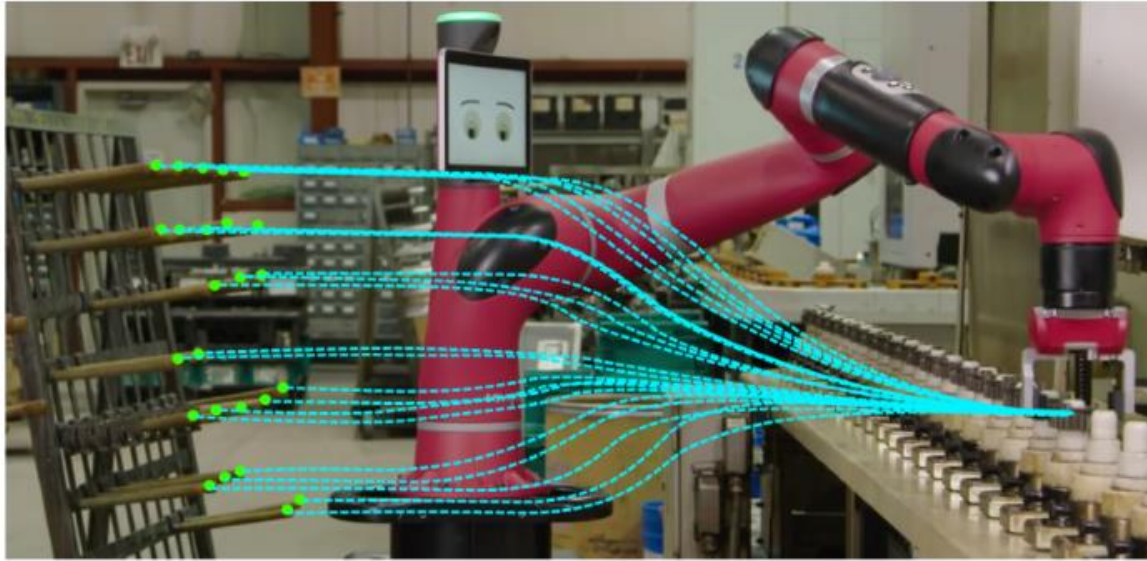




Generalisation

How to teach the robot to cope with unseen situations?

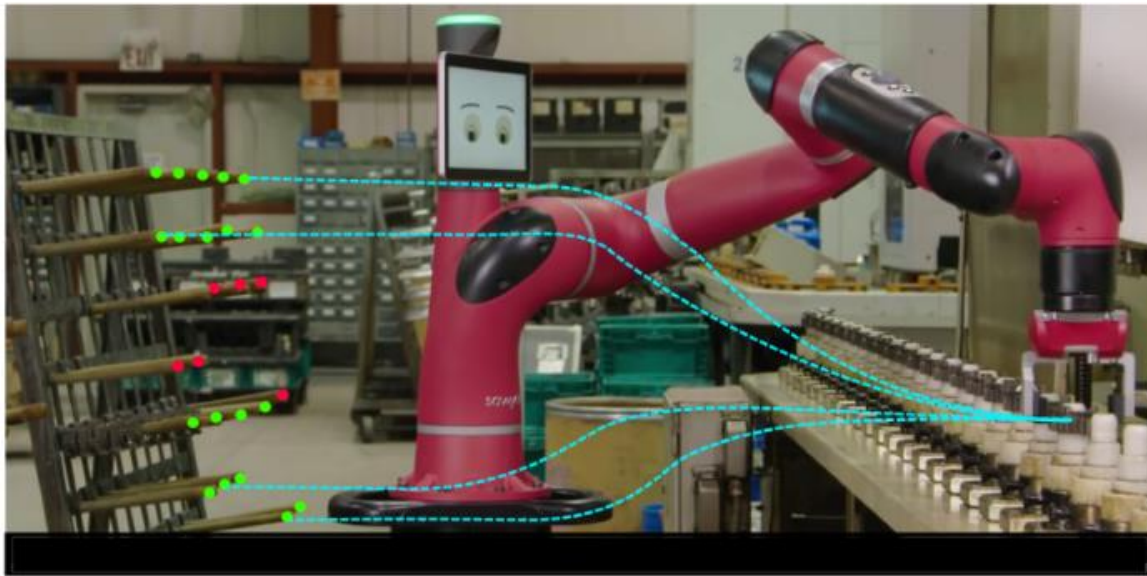


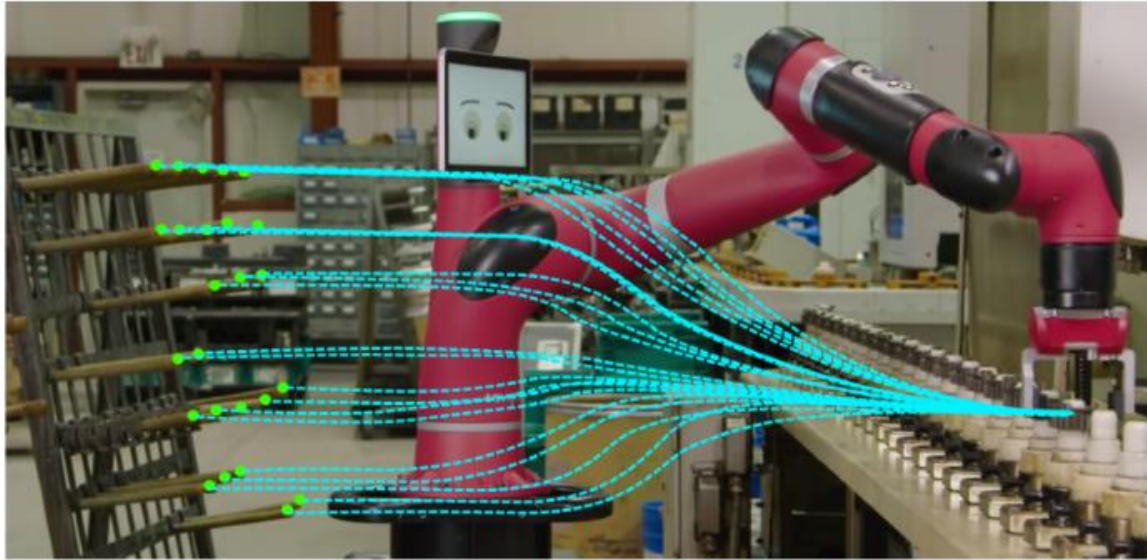


Generalisation

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Human help needed...



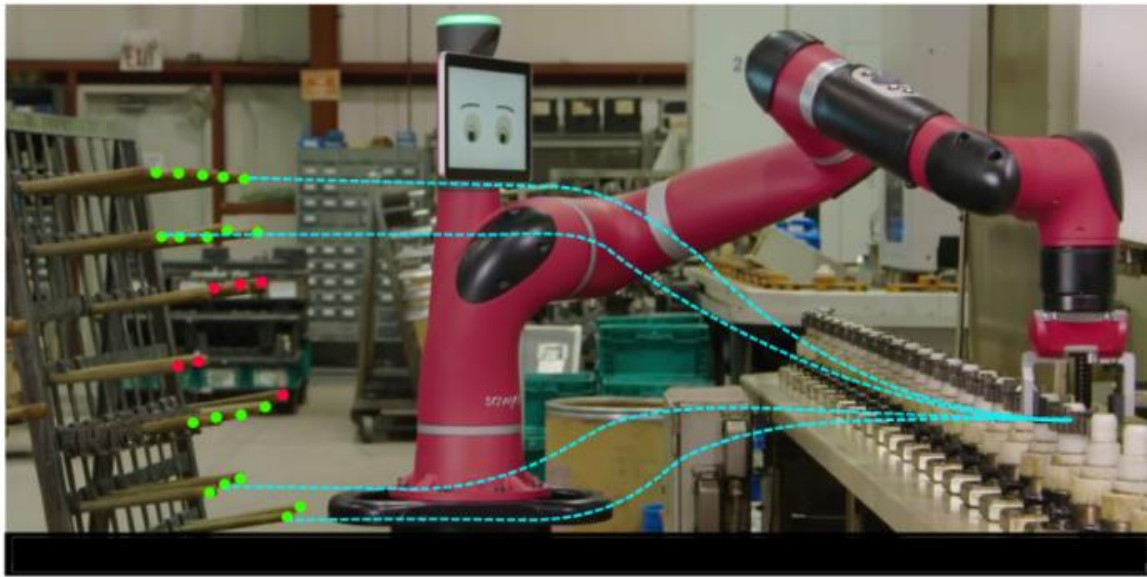


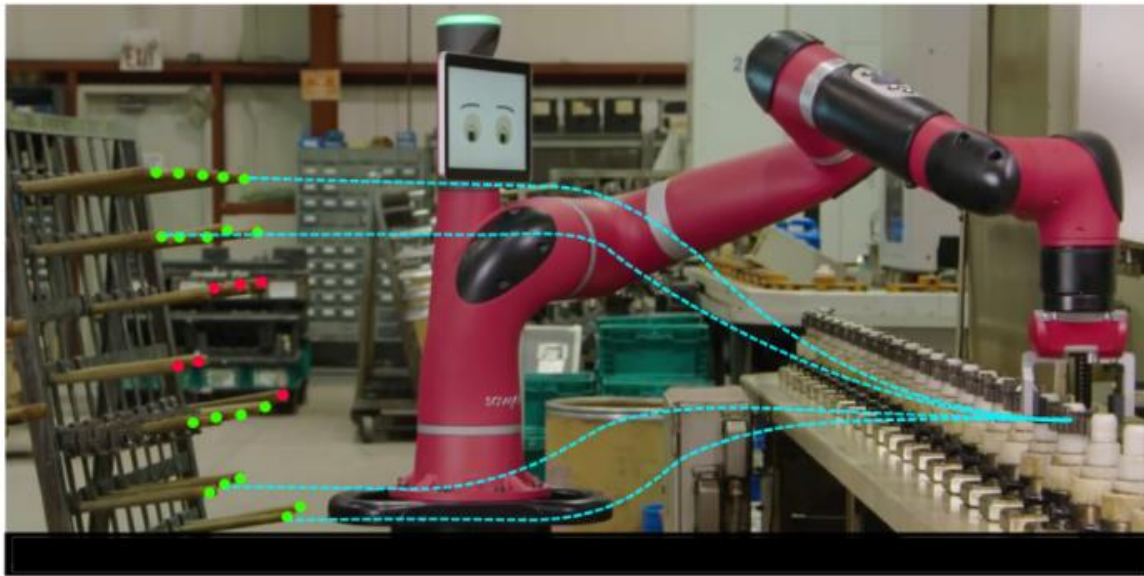
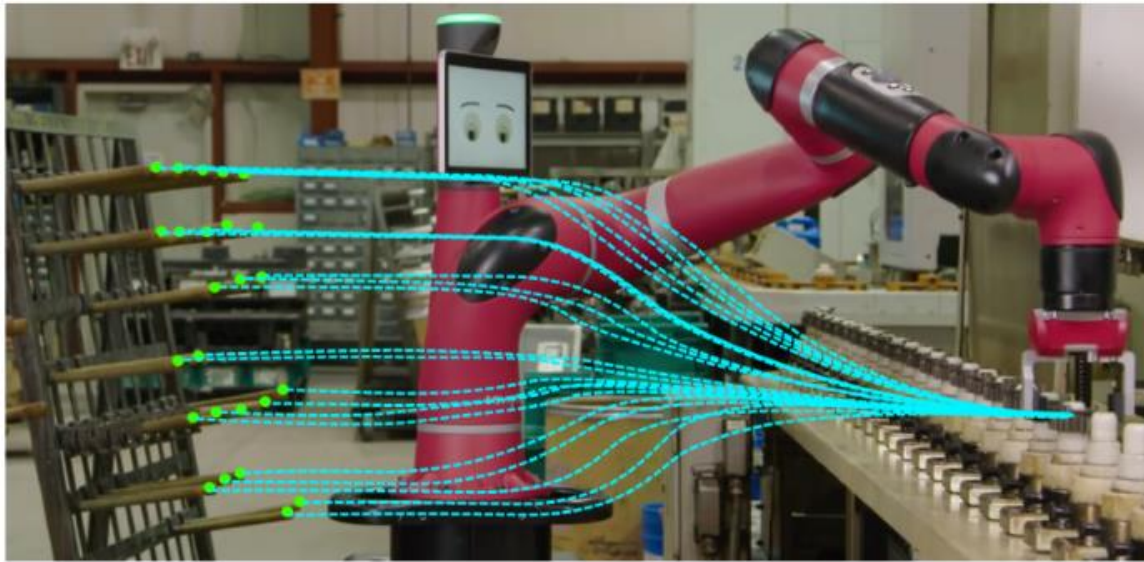
Generalisation

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...but do they understand robot understanding?





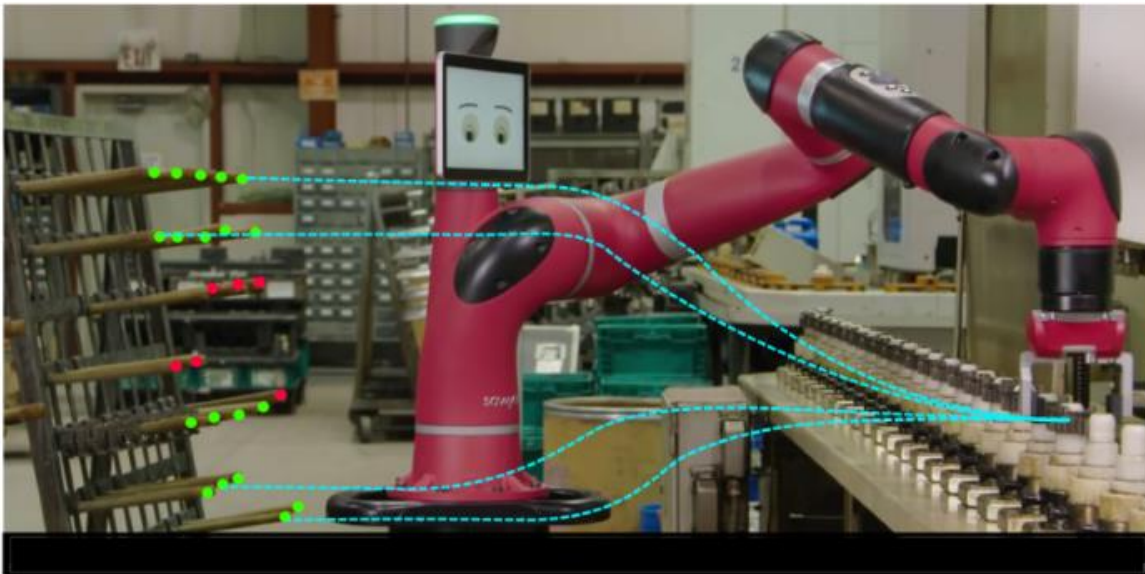
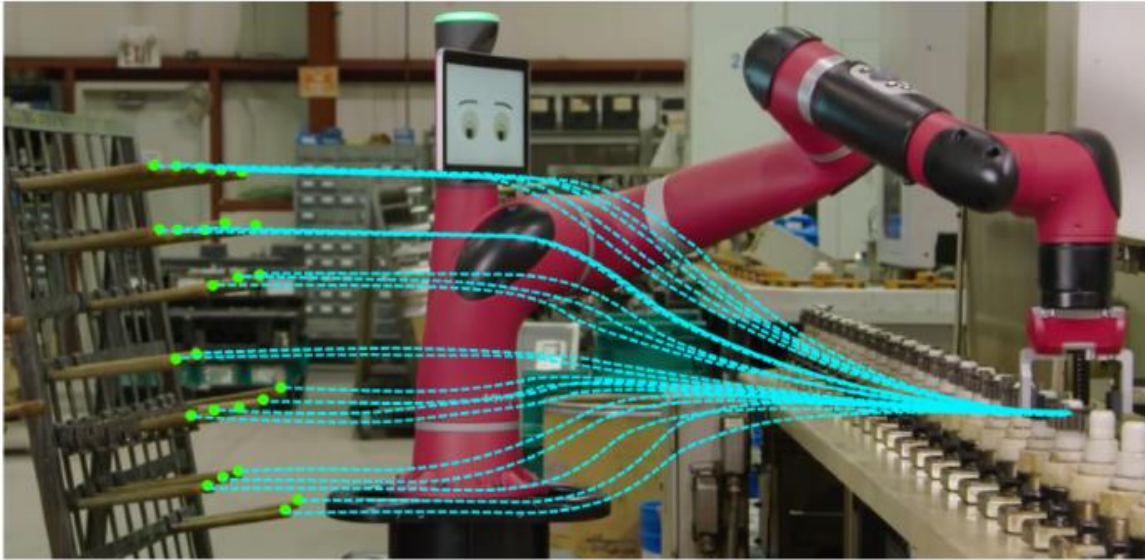
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- **Undemonstrated states**
(lack of data impedes learning).



Generalisation

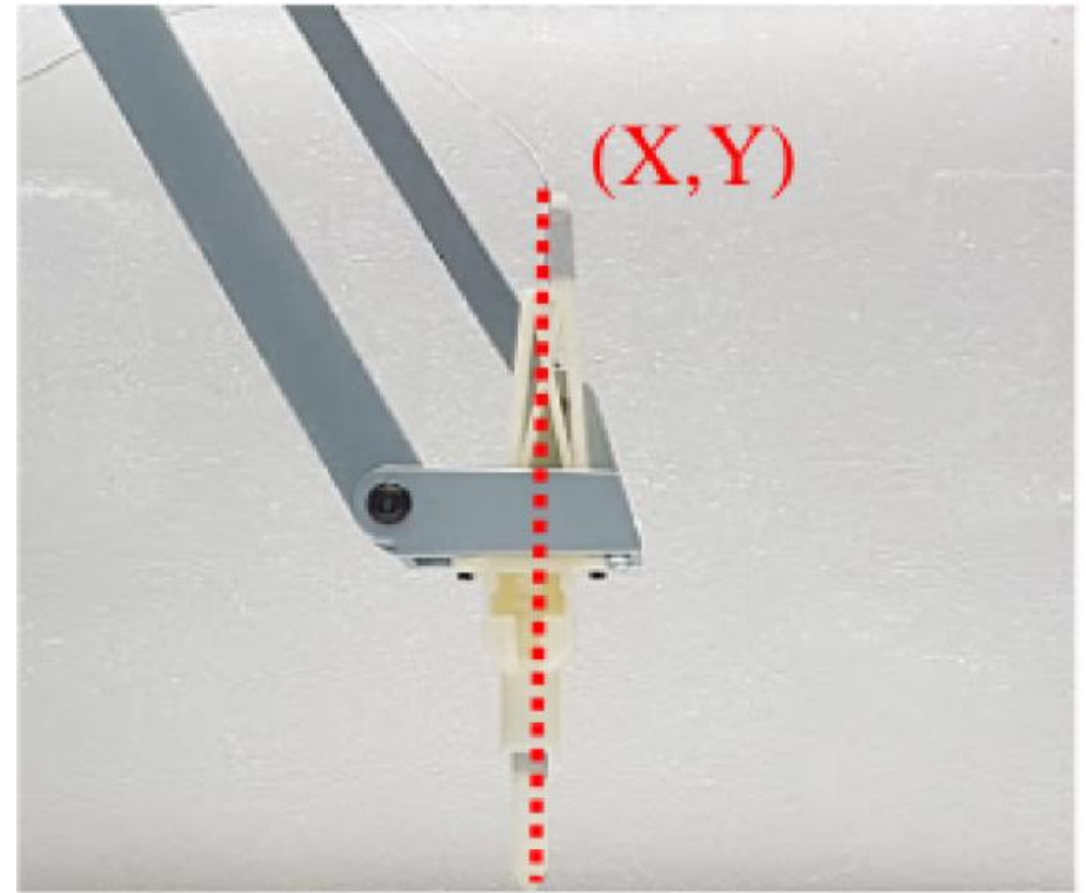
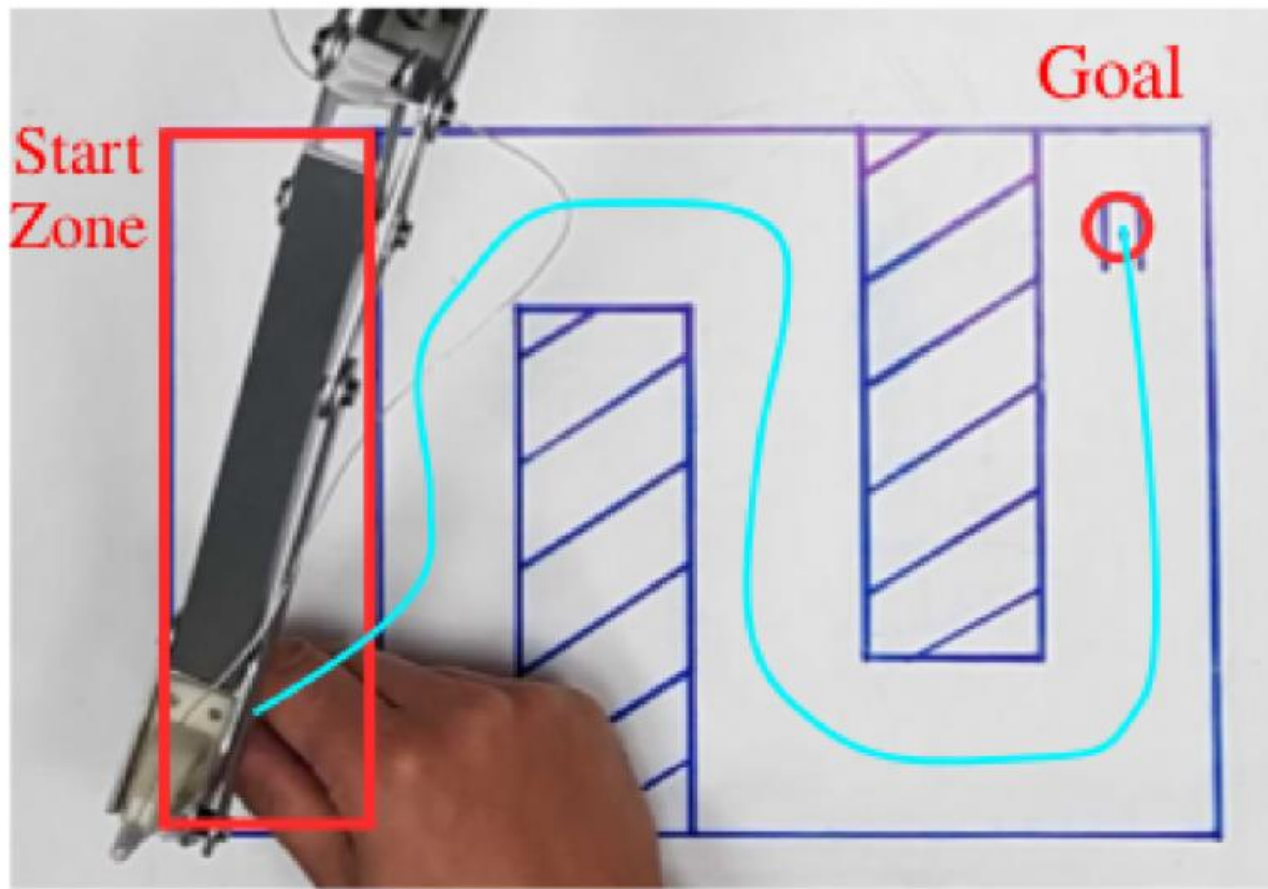
How to teach the robot to cope with unseen situations?

Human help needed...

...but do they understand robot understanding?

- **Undemonstrated states**
(lack of data impedes learning).
- **Ambiguous demonstrations**
(insufficient information to improve model).

Teaching Human Teachers...



Compare:

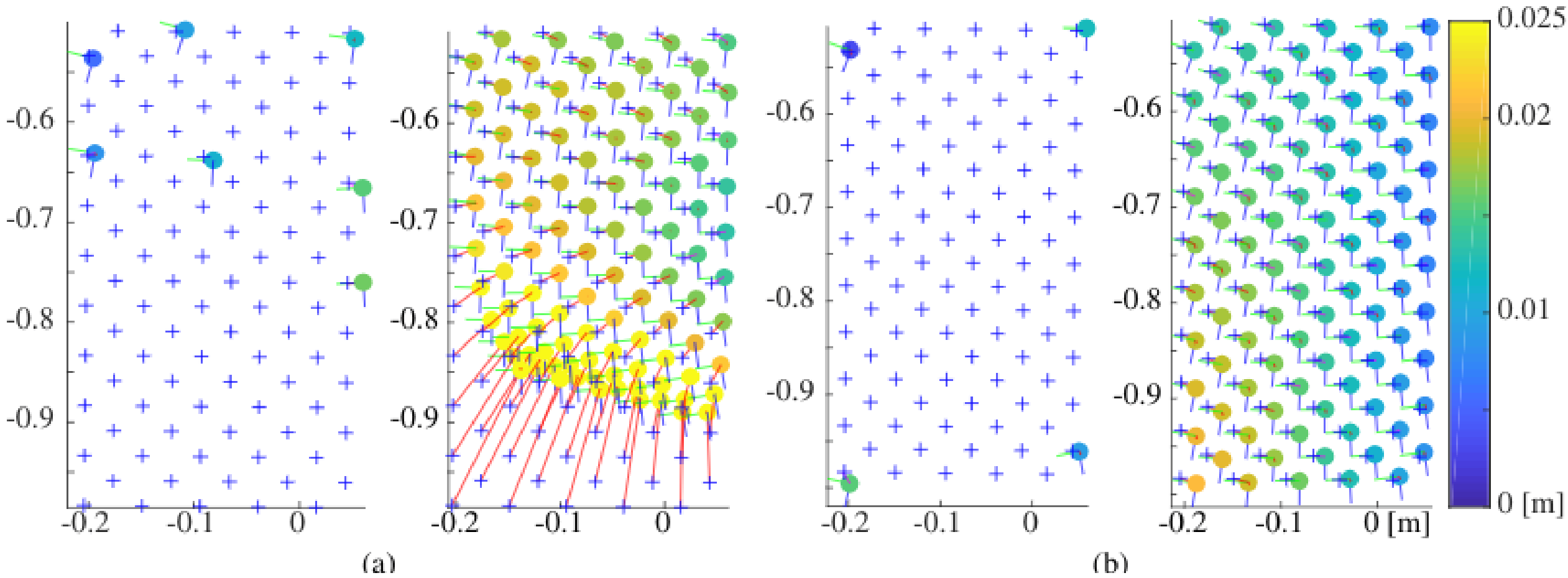
- ① No feedback ('teach as you see fit').
- ② Visual feedback (trajectory success shown).
- ③ Visual feedback with heuristic guidance.
 - Provide a demonstration starting anywhere, continue providing demonstrations within 4cm of the first, until surrounded by successful test points, provide further demonstrations within 4cm of the successful test points, in the area with the greatest number of failed test points.

A. Sena, Y. Zhao, & MH. Teaching human teachers to teach robot learners to learn. *ICRA*, 2018

Trials on Grower Sites

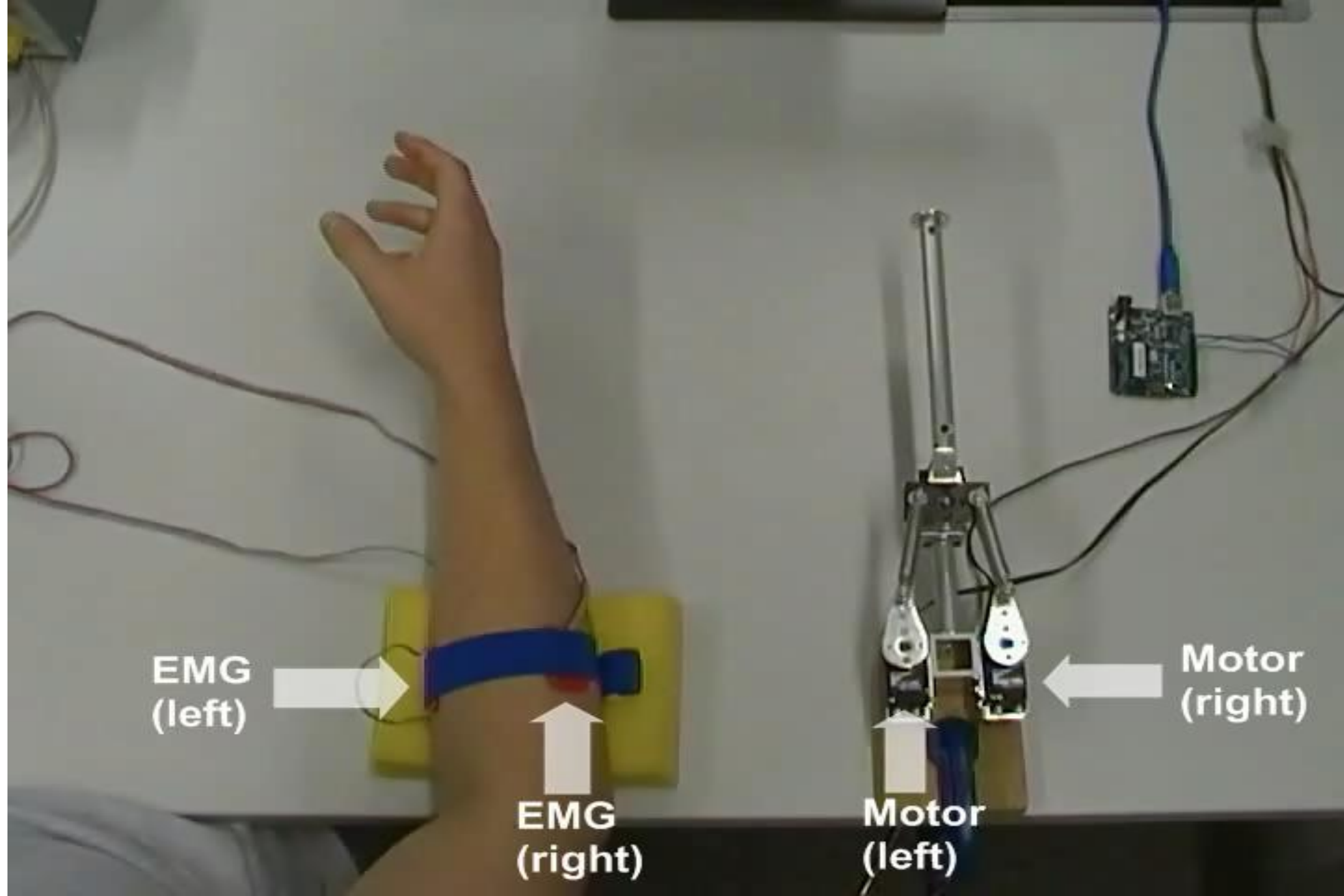
Video Removed





Where next?





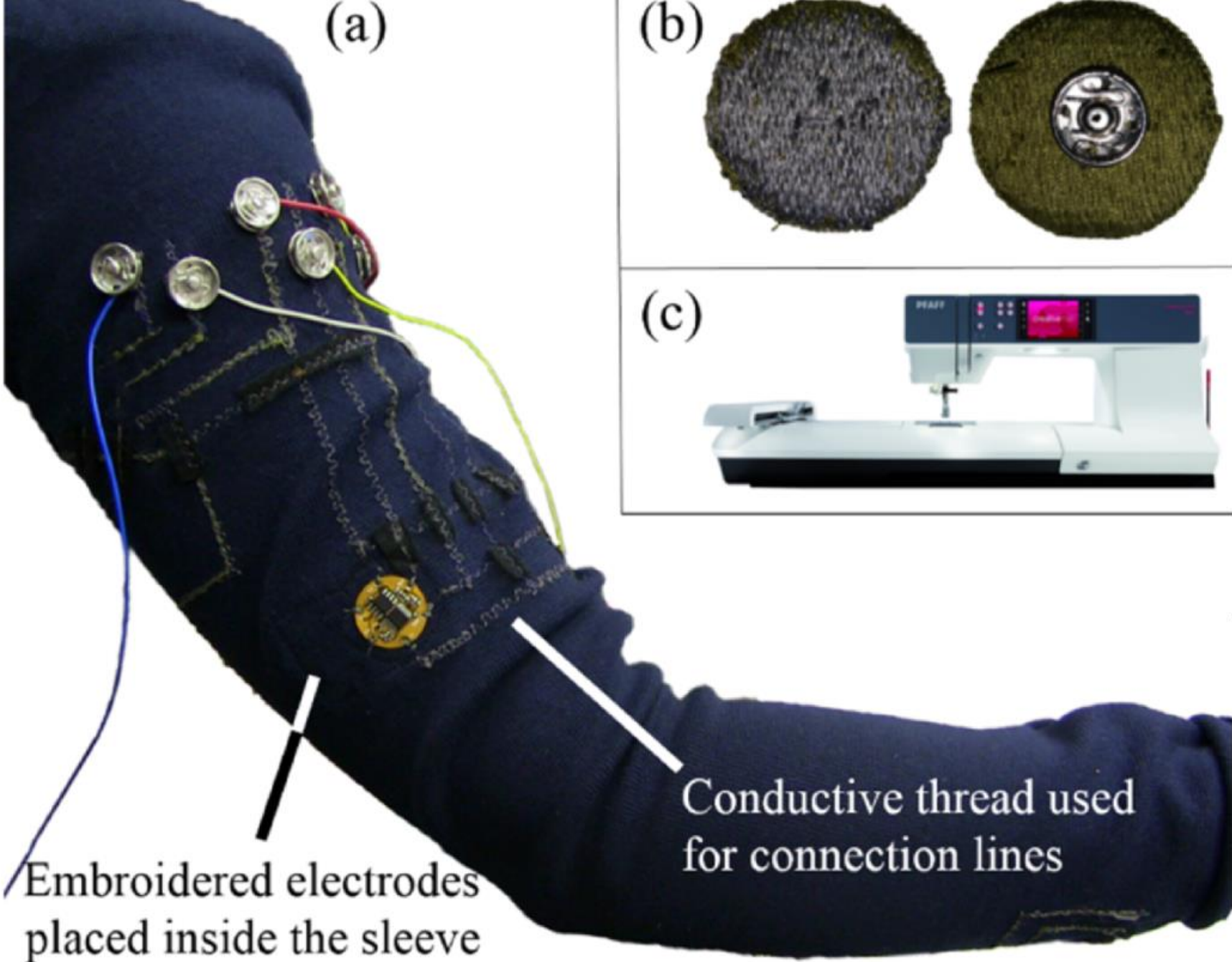
EMG
(left)

EMG
(right)

Motor
(left)

Motor
(right)

Embroidered EMG



(a)

(b)

(c)

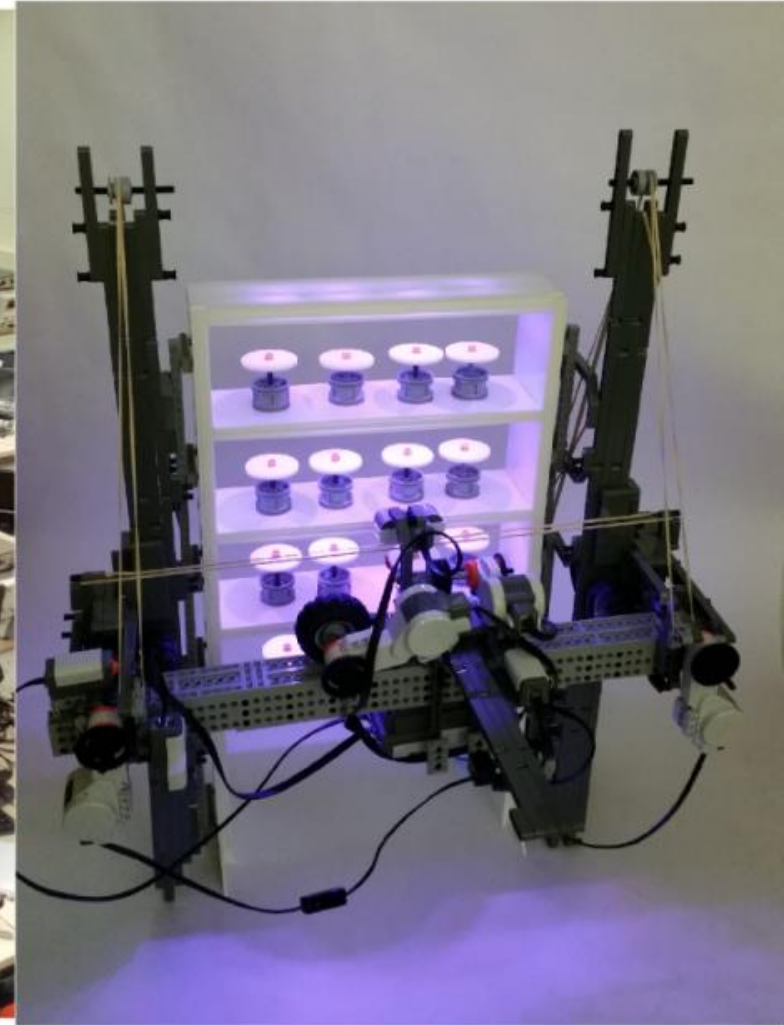
Embroidered electrodes placed inside the sleeve

Conductive thread used for connection lines

A. Shafti, et al. Embroidered electromyography: A systematic design guide. *IEEE TNSRE*, 25(9):1472-1480, 2016

R. B. R. Manero, et al. Wearable embroidered muscle activity sensing device for the human upper leg. *EMBC*, number 38, August 2016

The next generation of growers?



Summary

Summary

There are low hanging fruit in automation in this sector.

Putting power in the hands of growers will be key.

Programming by demonstration needs both advances in algorithms . . .
and consideration of their usability.



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