

Coarse-to-Fine Imitation Learning: Robot Manipulation from a Single Demonstration

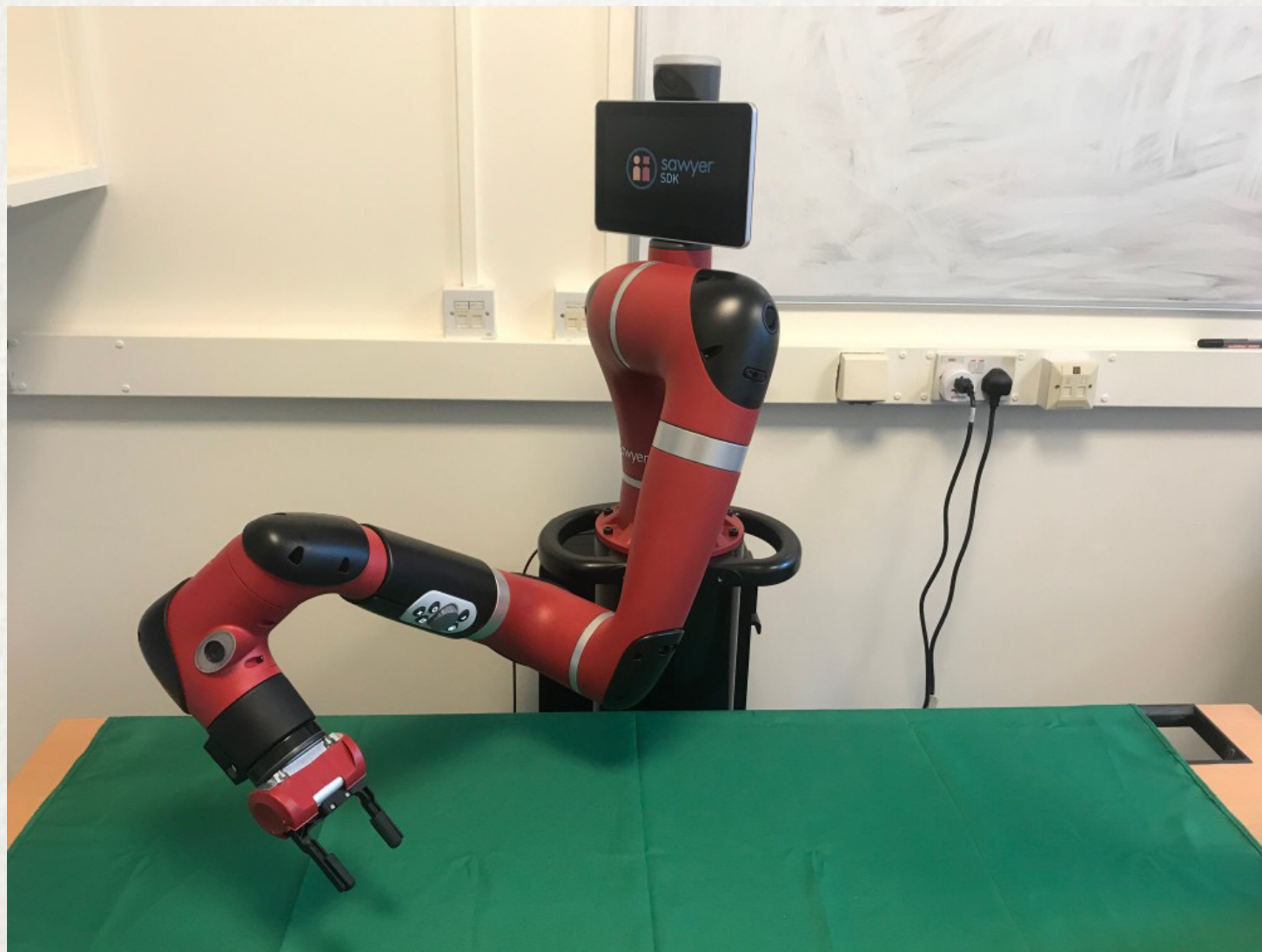
Edward Johns

The Robot Learning Lab

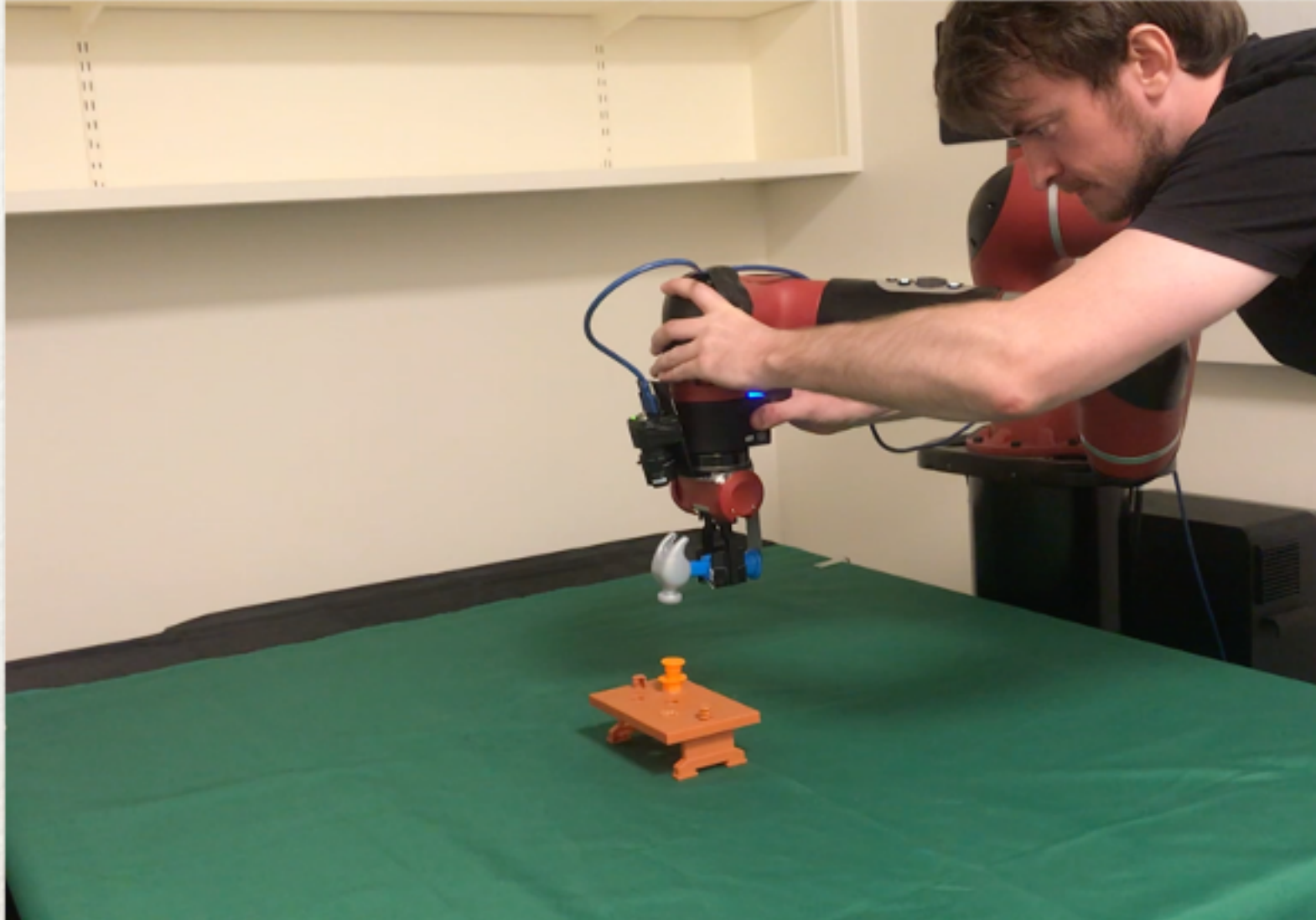
at

**Imperial College
London**

Robot Manipulation

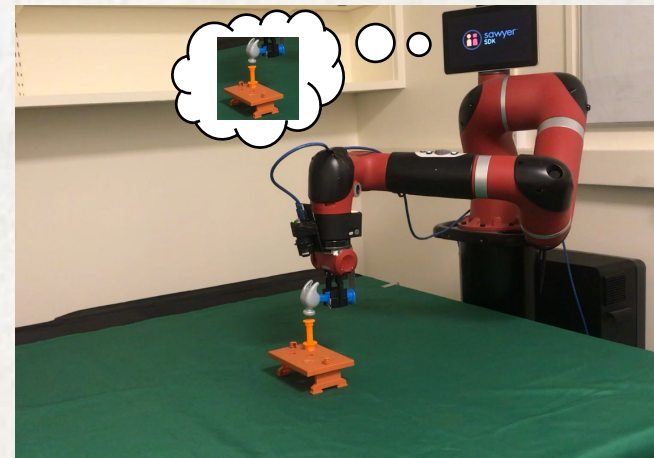
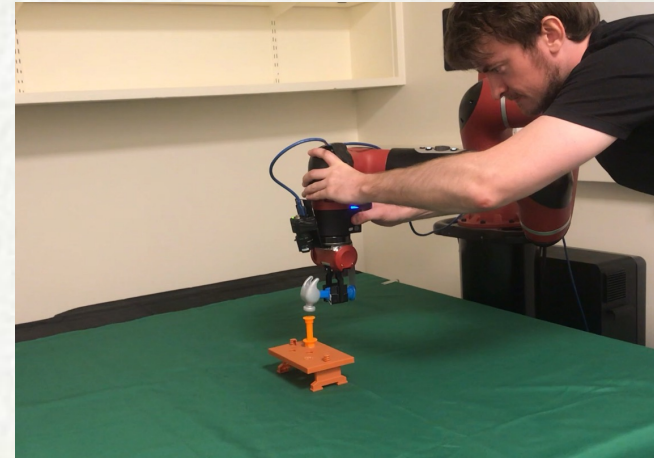


Imitation Learning



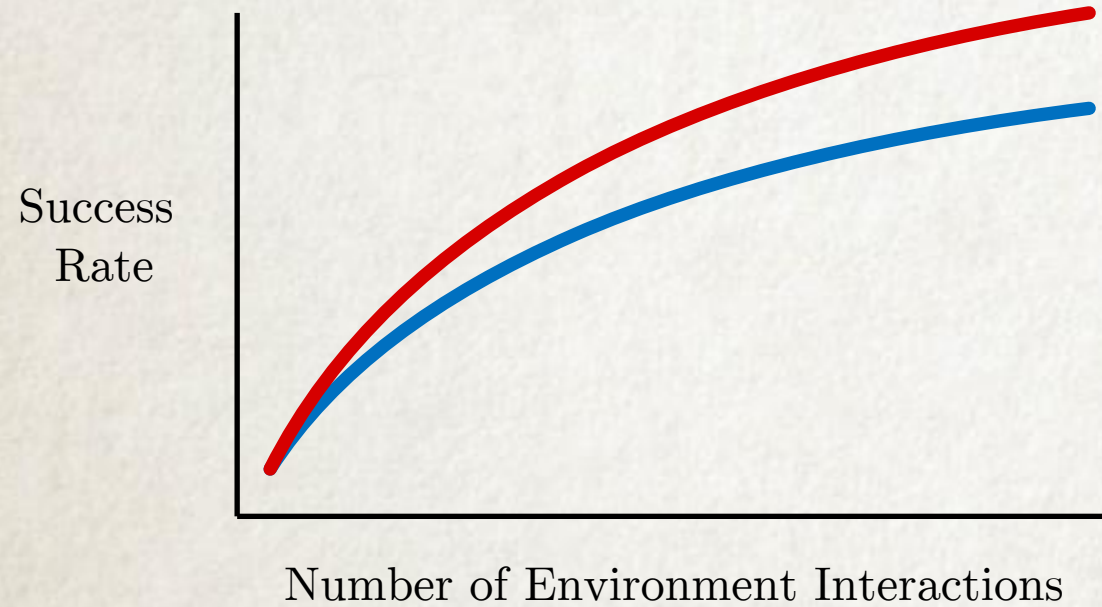
Universal Imitation Learning

1. Minimise the amount of physical interaction required of the human
2. Minimise the amount of prior task knowledge required by the algorithm

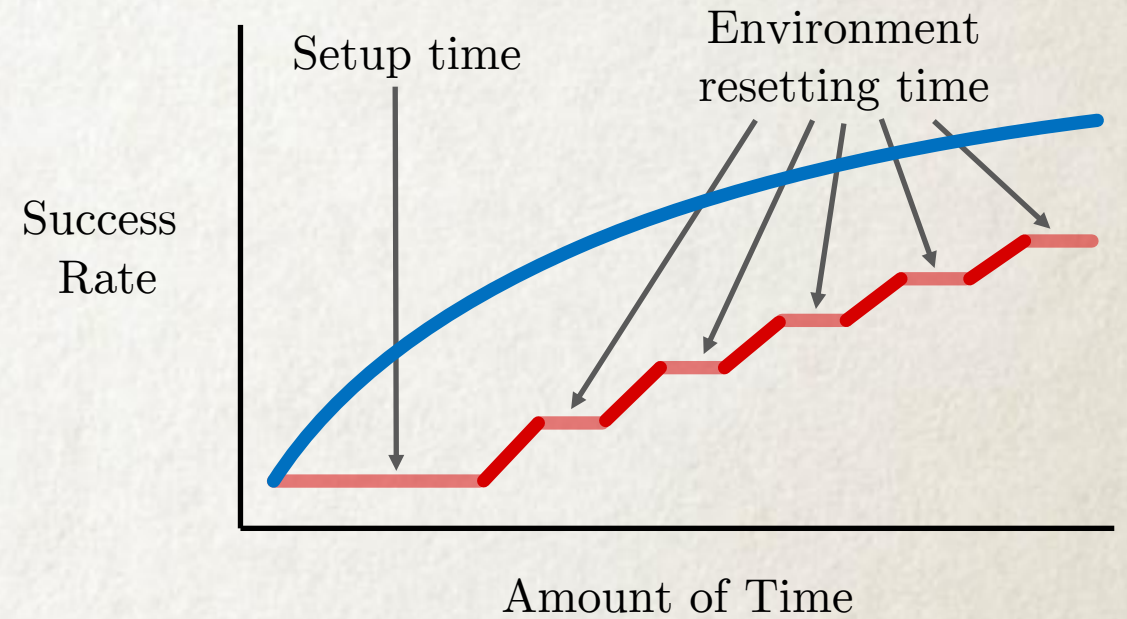


Minimise Human Time

How we currently evaluate imitation learning



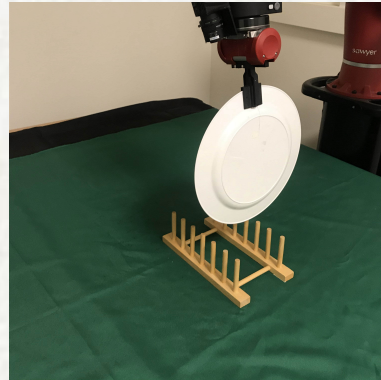
How we should evaluate imitation learning



Minimise Prior Task Knowledge



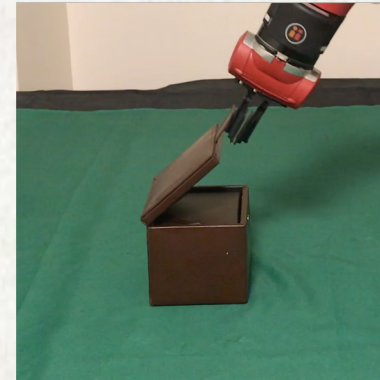
Bottle



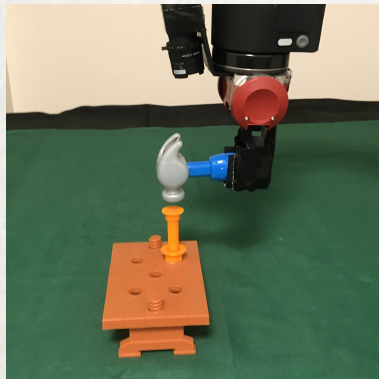
Plate



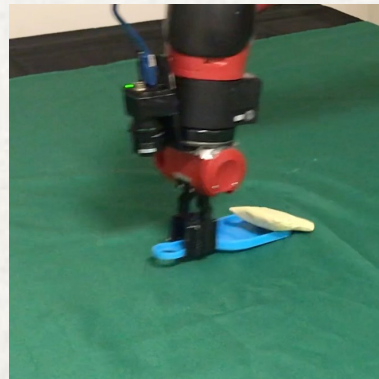
Screwdriver



Lid



Hammer



Scoop



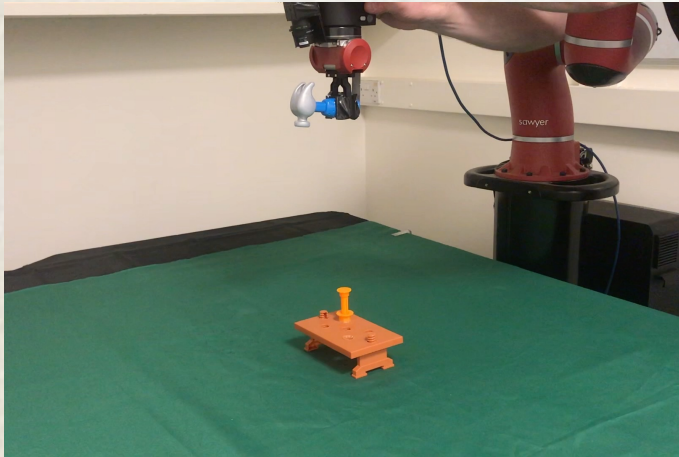
Knife



Plug

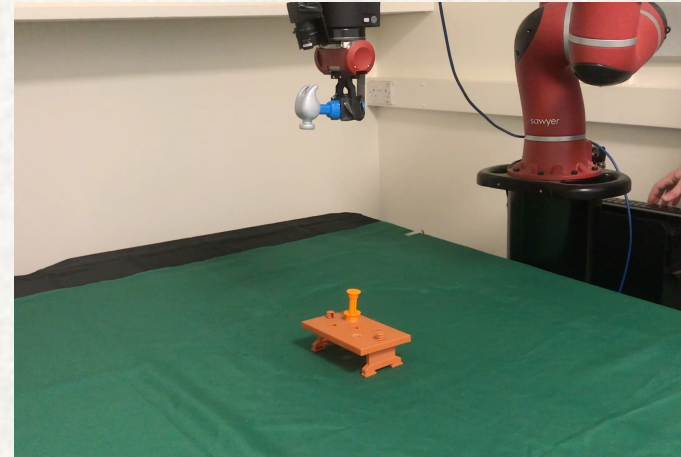
Existing Approaches

Behavioural Cloning



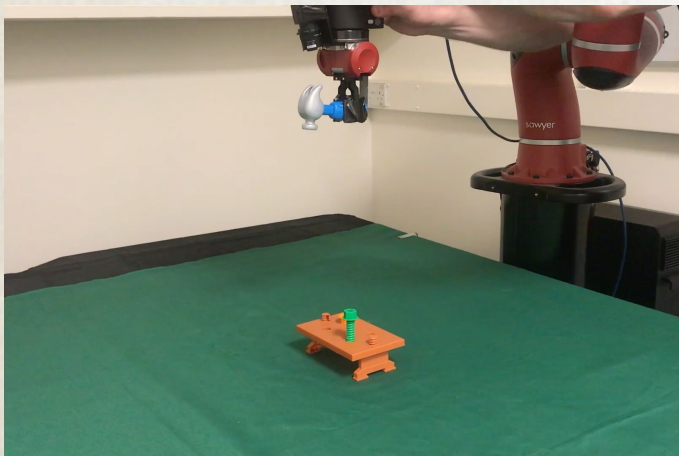
Low physical interaction? ✗
Low prior task knowledge? ✓

Reinforcement Learning



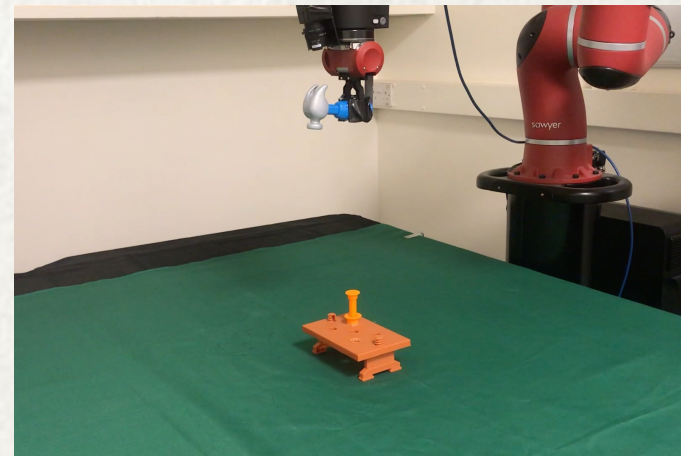
Low physical interaction? ✗
Low prior task knowledge? ✓

Transfer Learning



Low physical interaction? ✓
Low prior task knowledge? ✗

Engineered States



Low physical interaction? ✓
Low prior task knowledge? ✗

Coarse-to-Fine Imitation Learning

Low physical interaction?



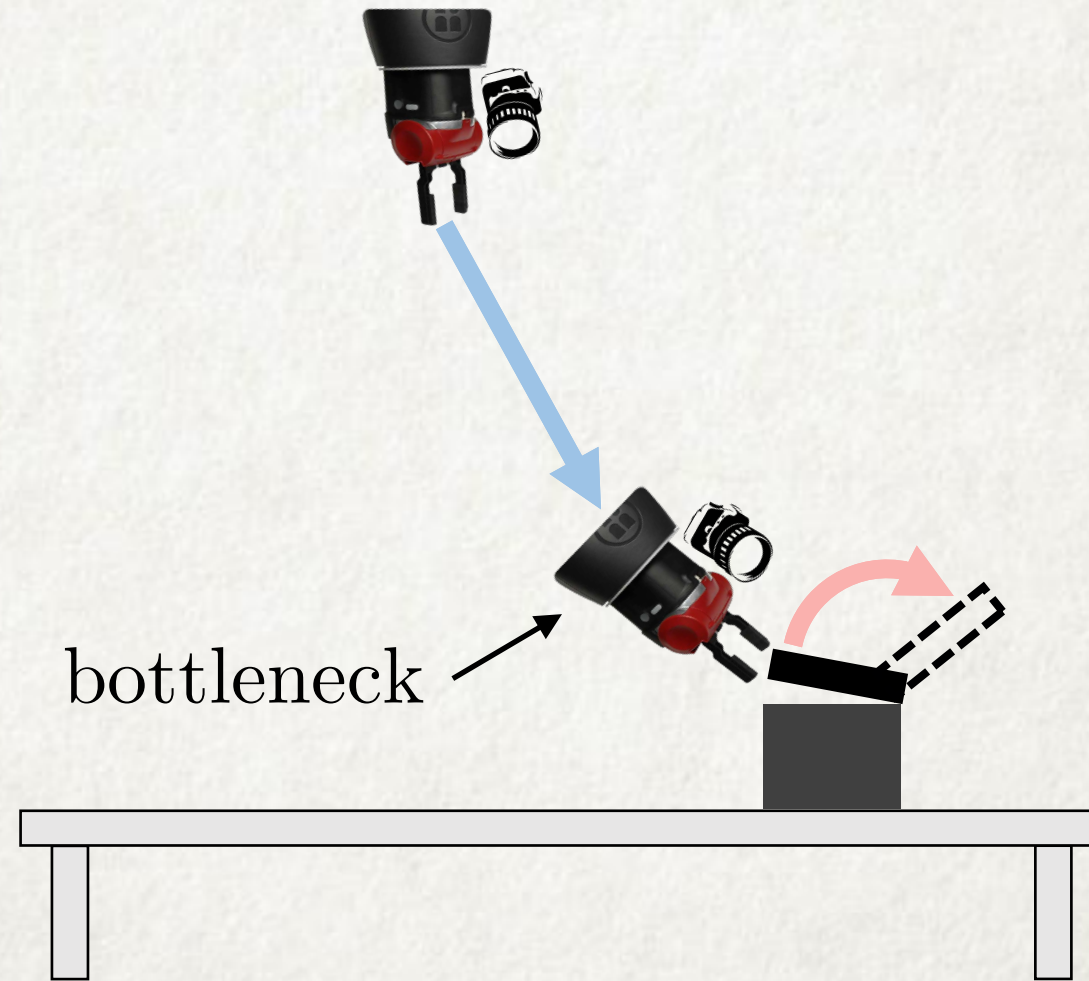
Only one demonstration,
no environment resetting

Low prior task knowledge?



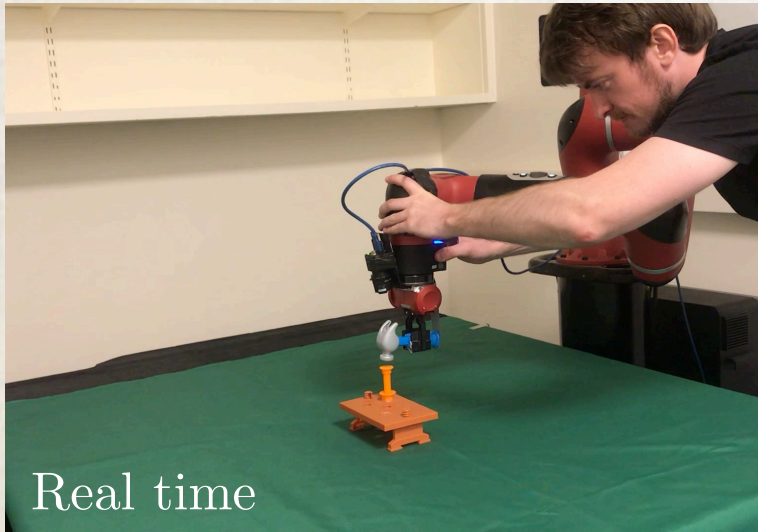
Works on entirely novel objects

Coarse-to-Fine Imitation Learning



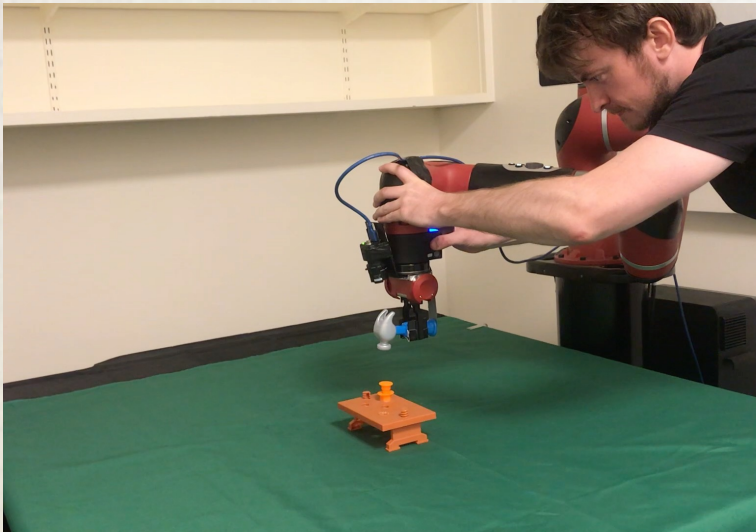
Coarse-to-Fine Imitation Learning: Training

① Record human demonstration

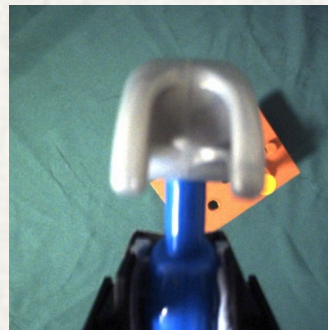
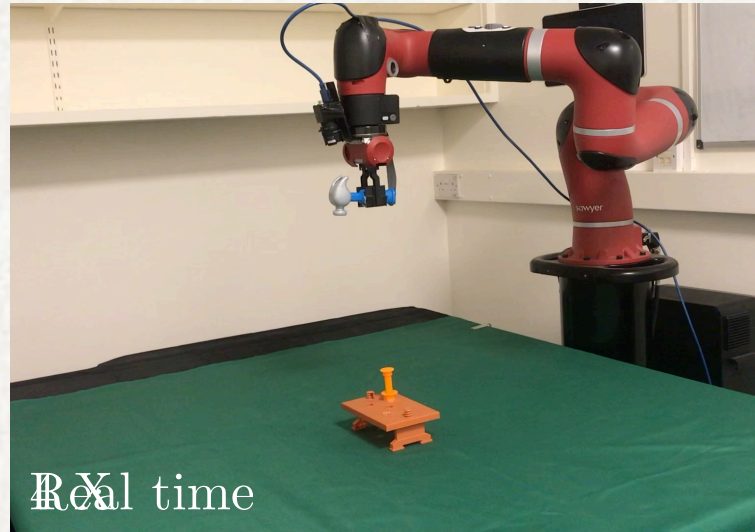


Coarse-to-Fine Imitation Learning: Training

① Record human demonstration

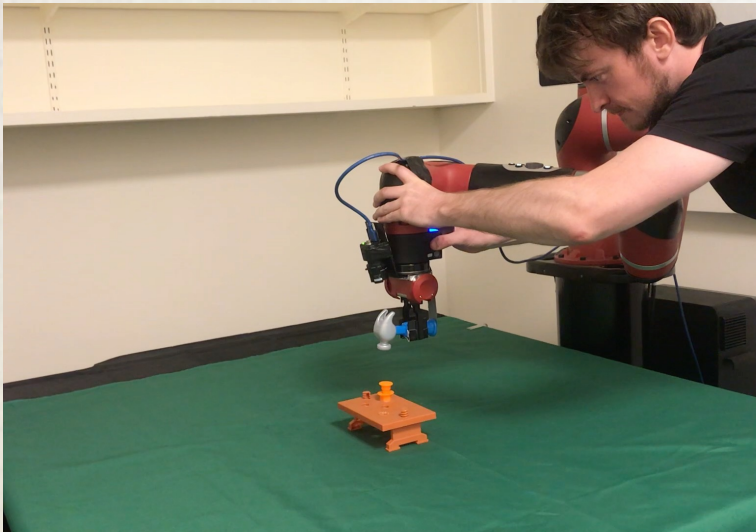


② Collect self-supervised dataset from ...
... above object

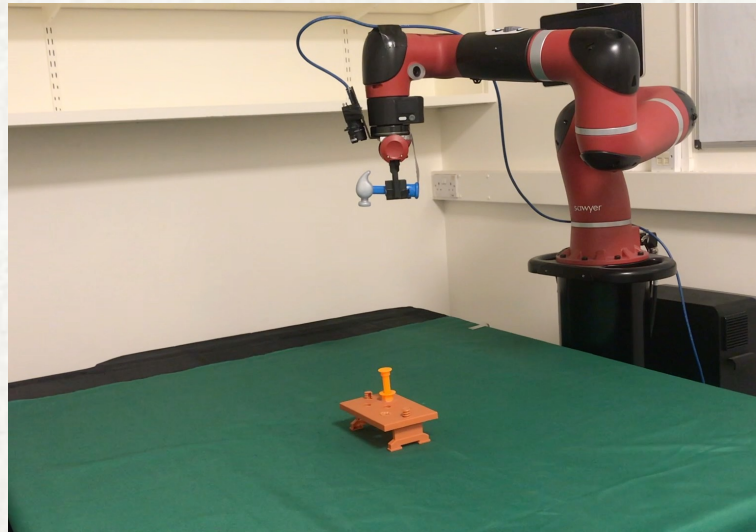


Coarse-to-Fine Imitation Learning: Training

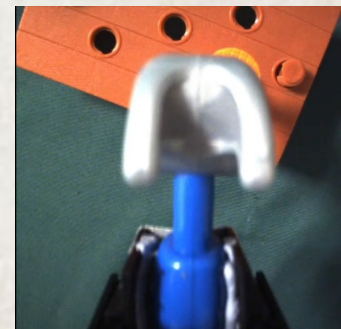
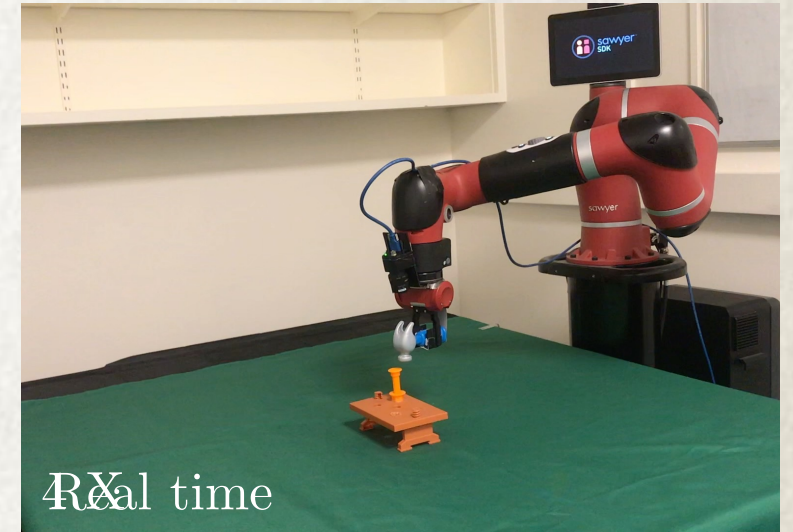
① Record human demonstration



② ... above object



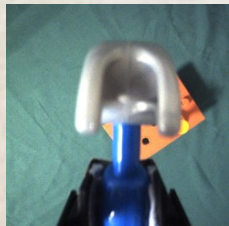
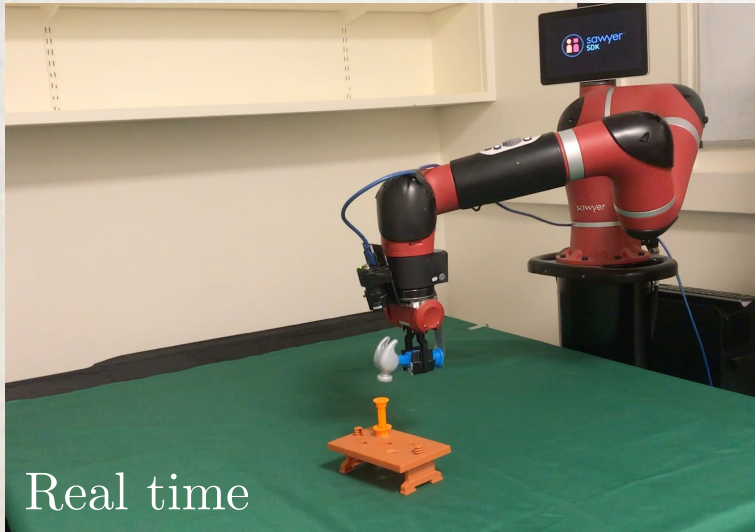
③ ... nearby object



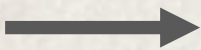
Coarse-to-Fine Imitation Learning: Testing

①

Move towards
object



Neural
network

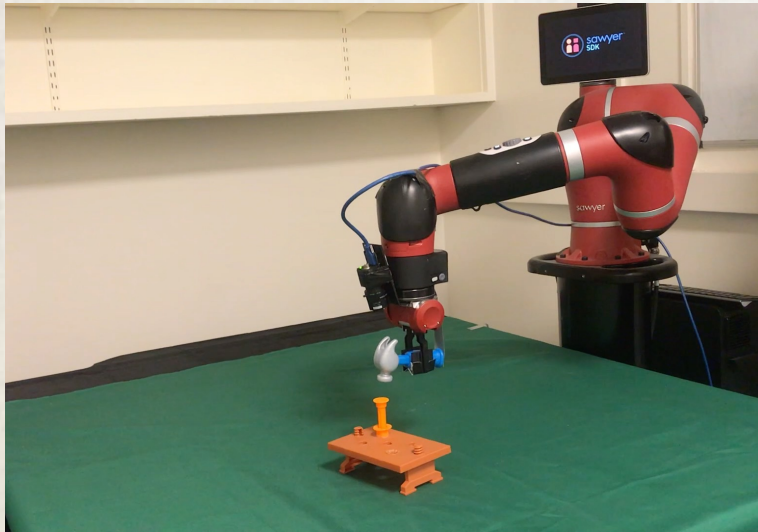


Bottleneck
pose

Coarse-to-Fine Imitation Learning: Testing

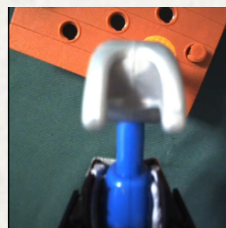
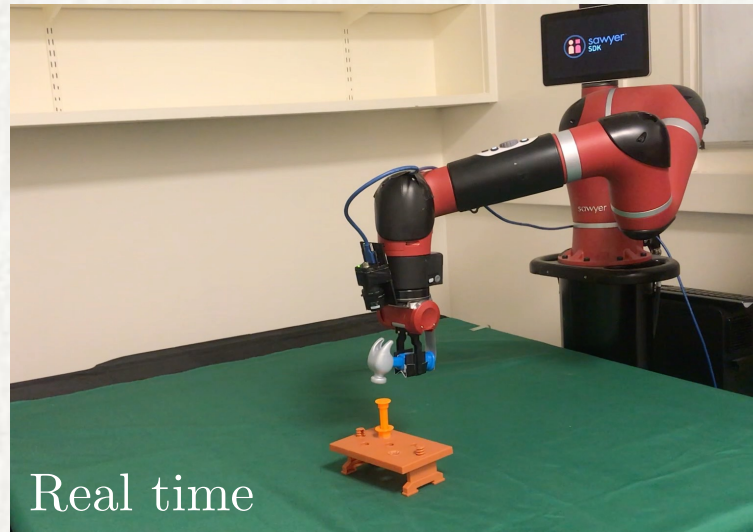
①

Move towards
object



②

Make pose
correction



Neural
network

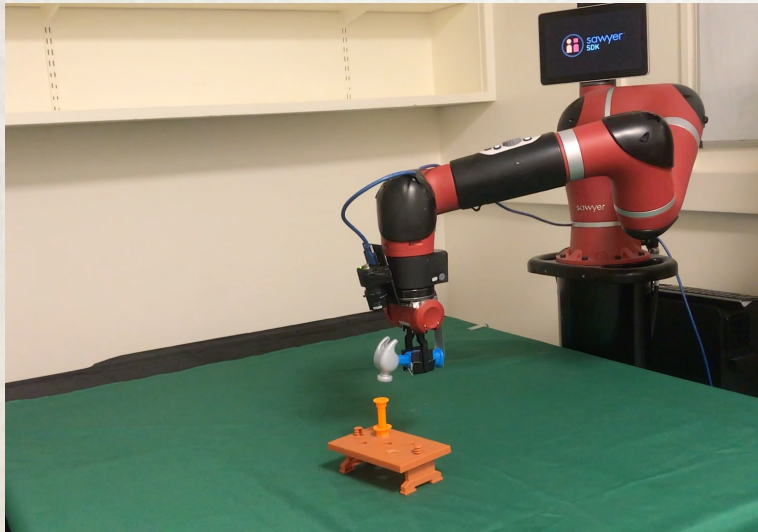


Bottleneck
pose

Coarse-to-Fine Imitation Learning: Testing

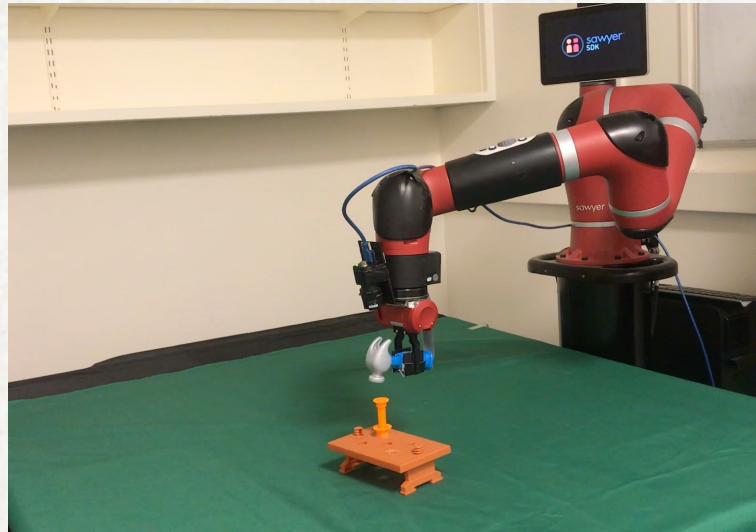
①

Move towards
object



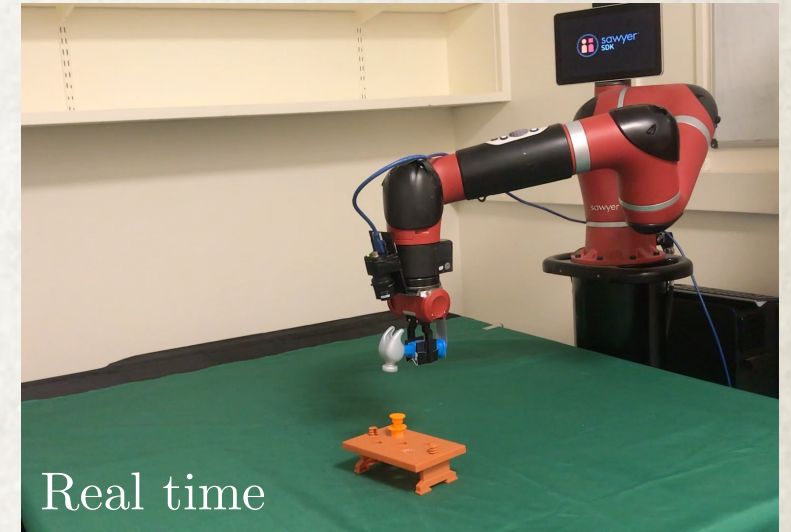
②

Make pose
correction



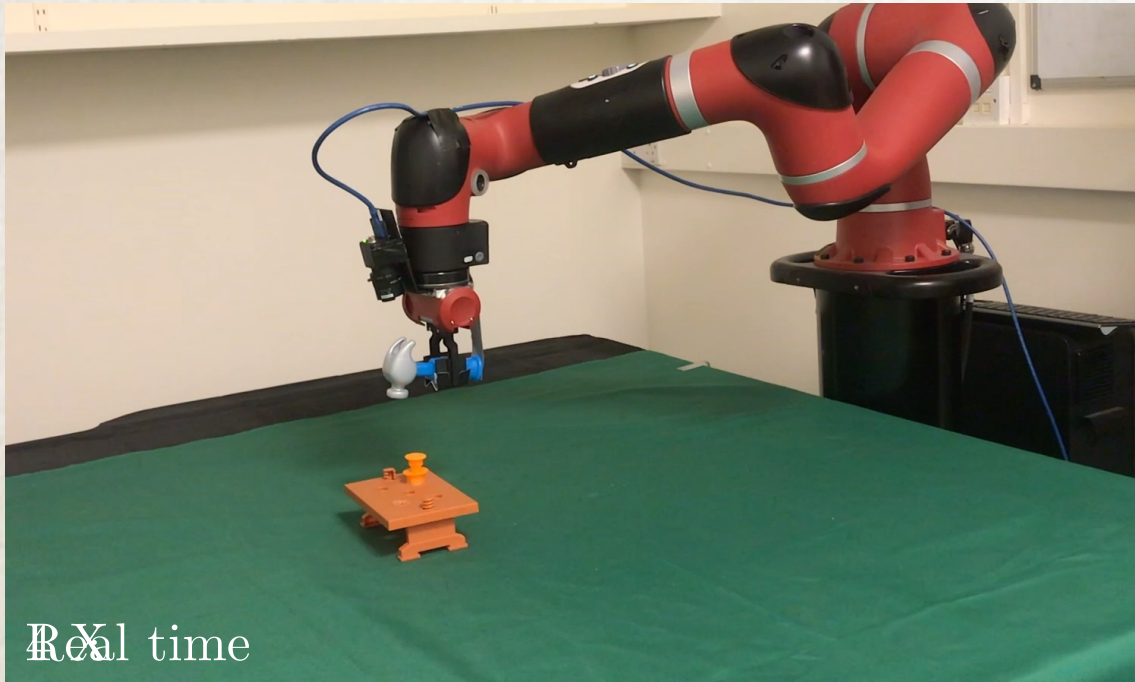
③

Repeat human
demonstration

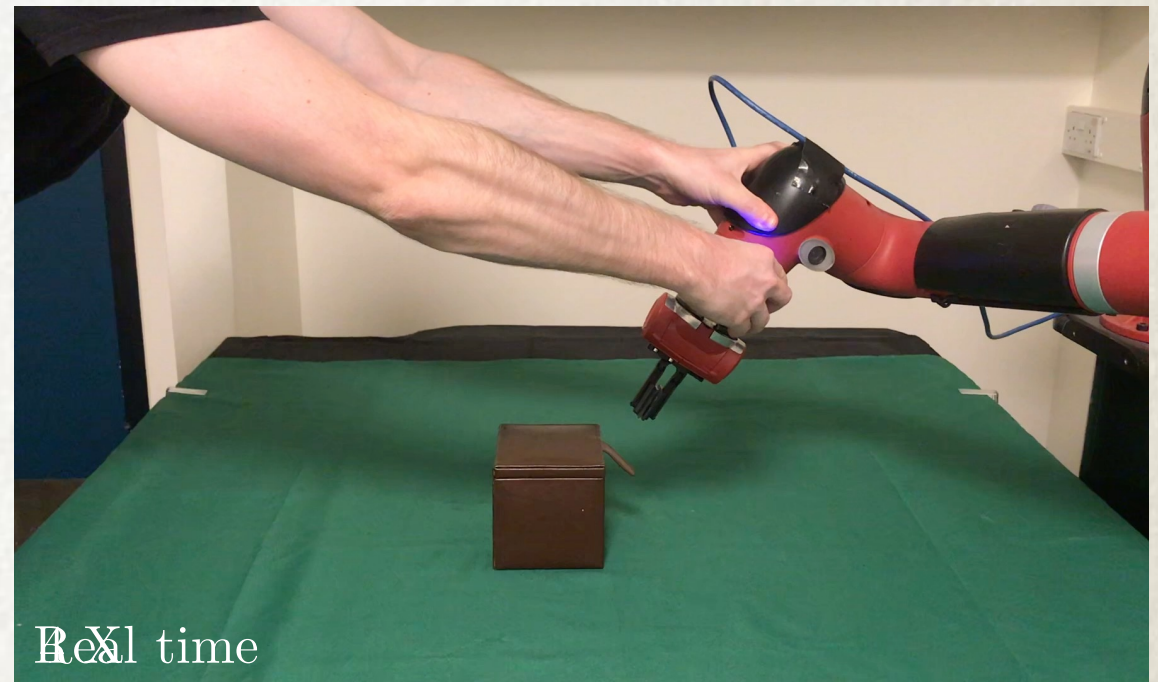


Coarse-to-Fine Imitation Learning: Results

Hammer (Demo)

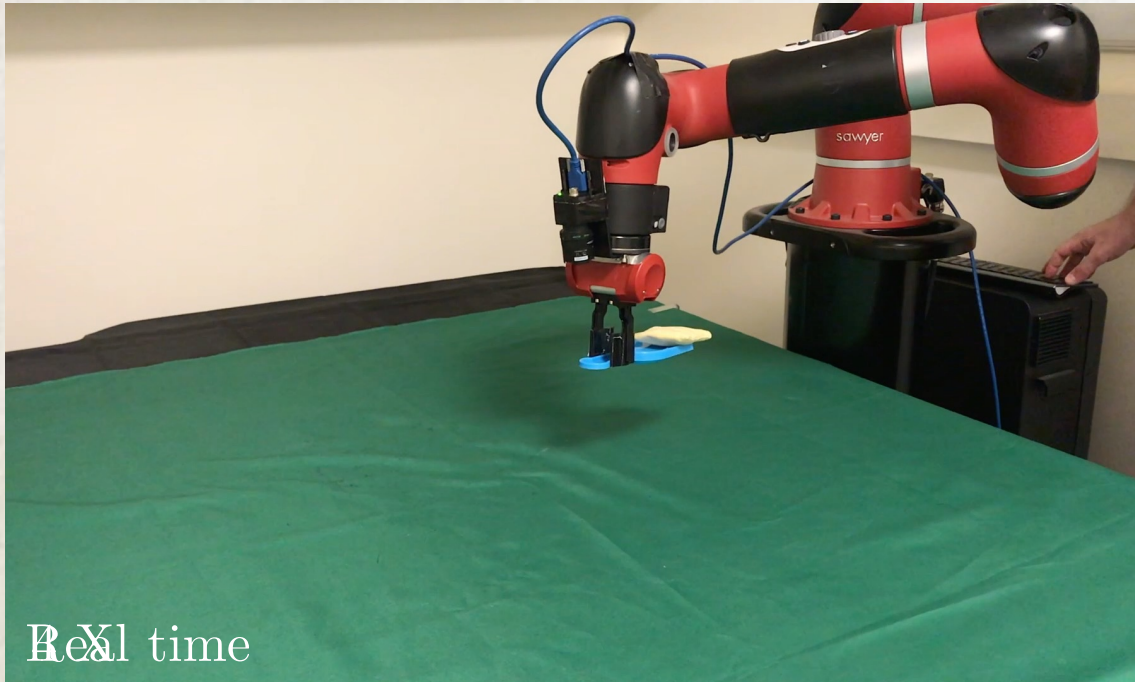


Lid (Demo)

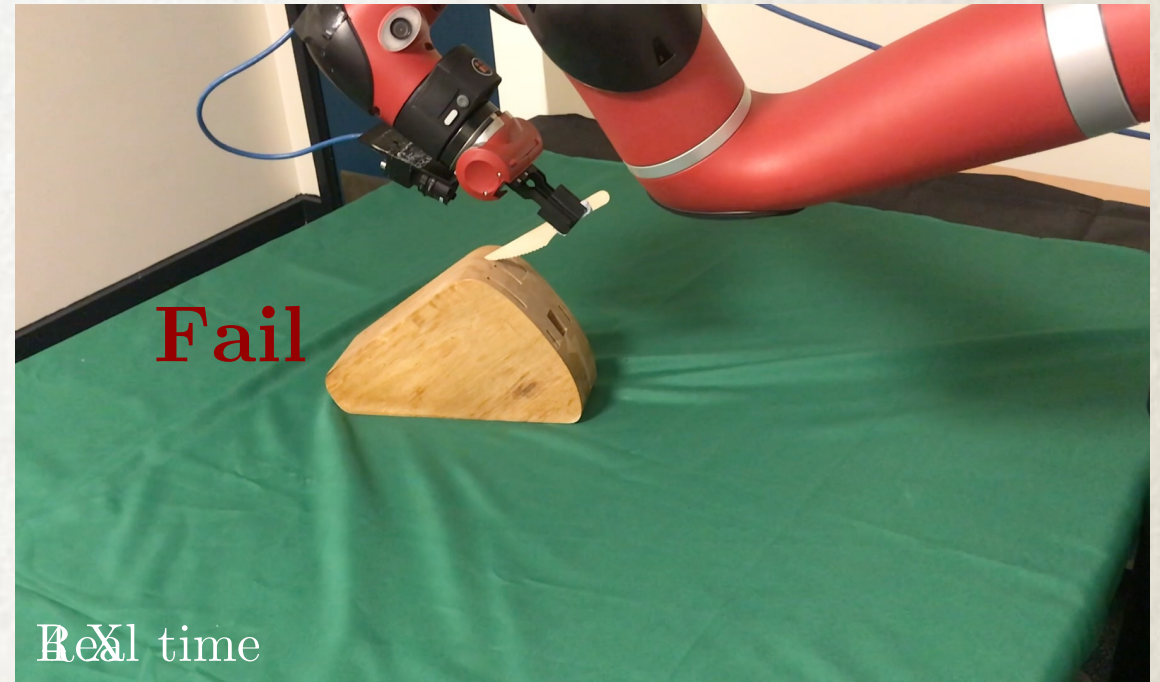


Coarse-to-Fine Imitation Learning: Results

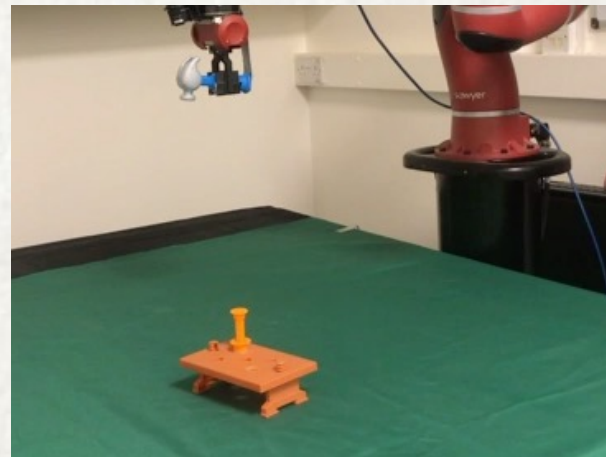
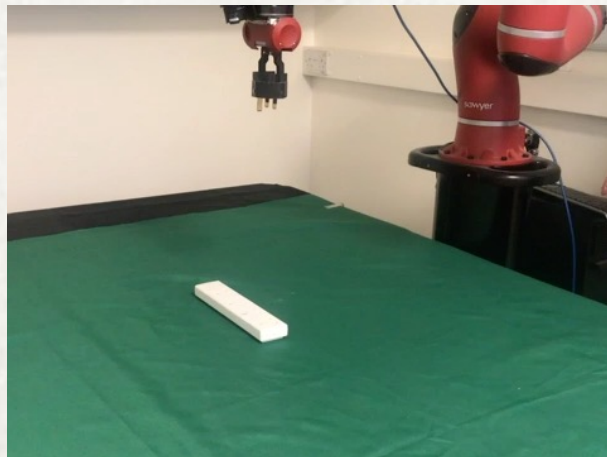
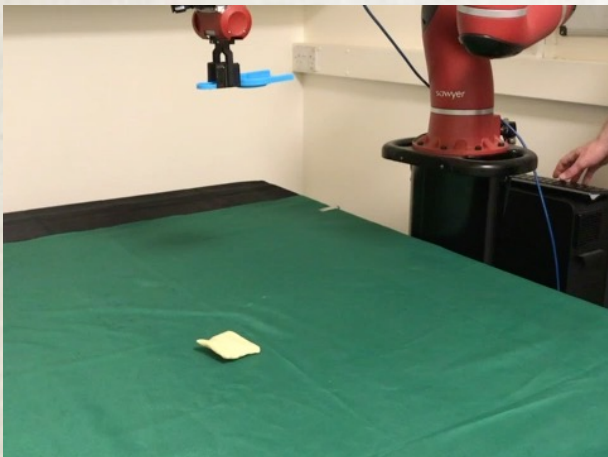
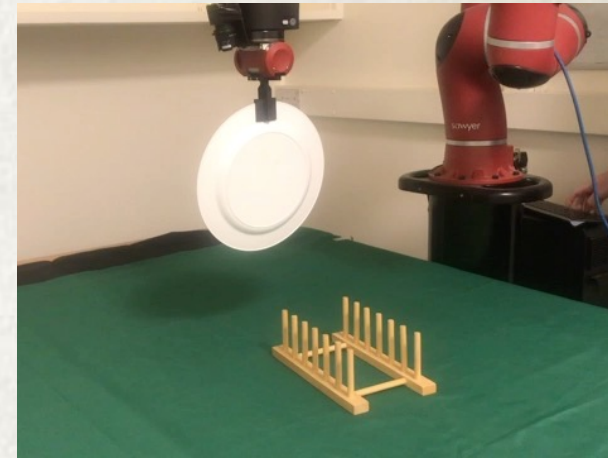
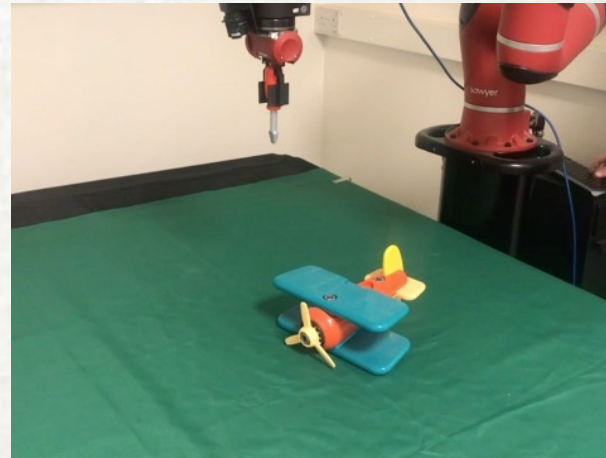
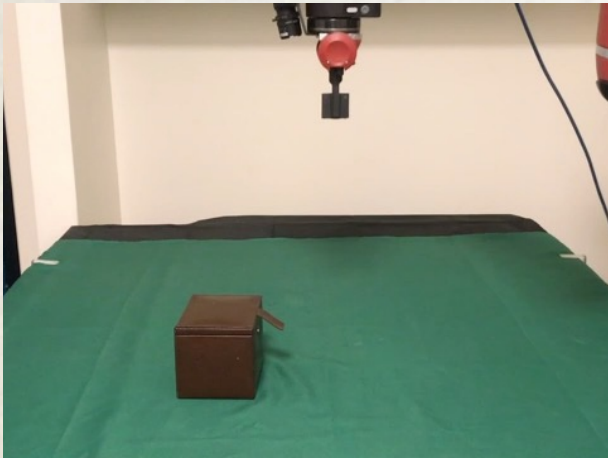
Scoop (Demo)



Knife (Demo)



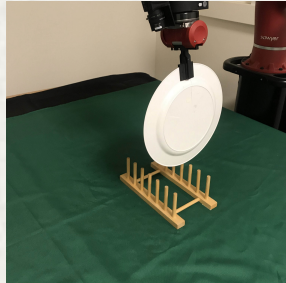
Coarse-to-Fine Imitation Learning: Results



Coarse-to-Fine Imitation Learning: Results



Bottle



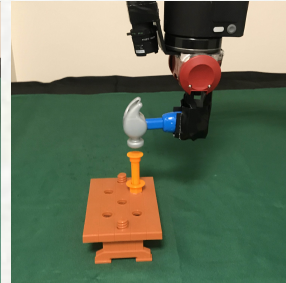
Plate



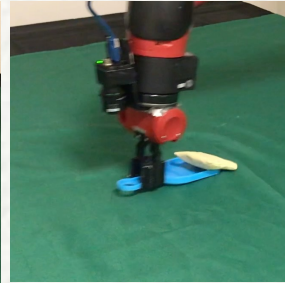
Screwdriver



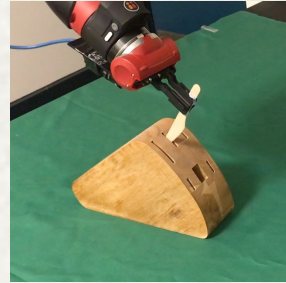
Lid



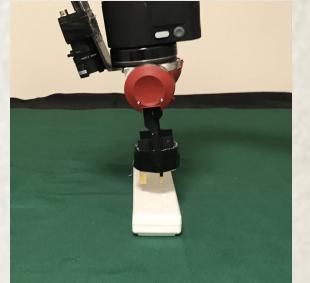
Hammer



Scoop



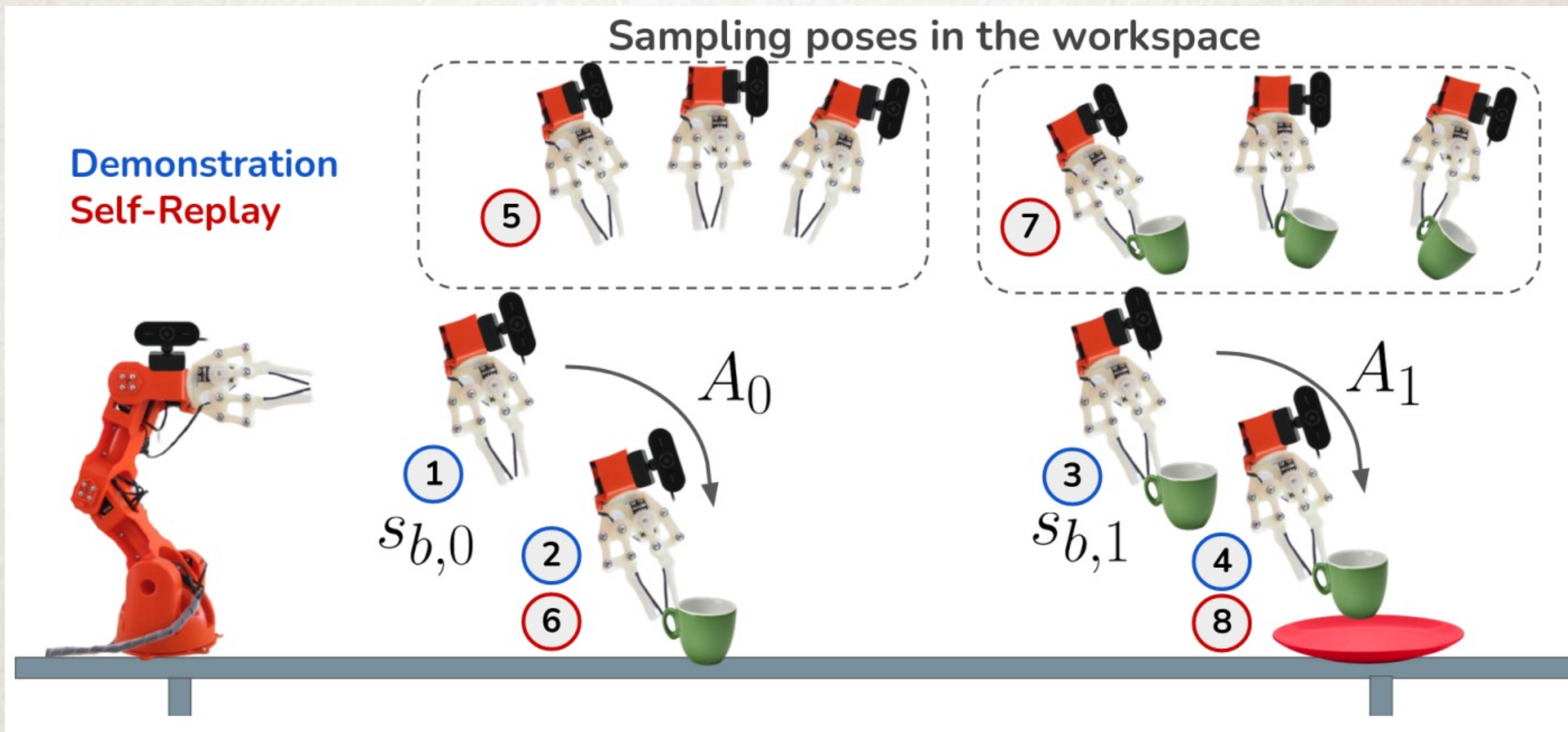
Knife



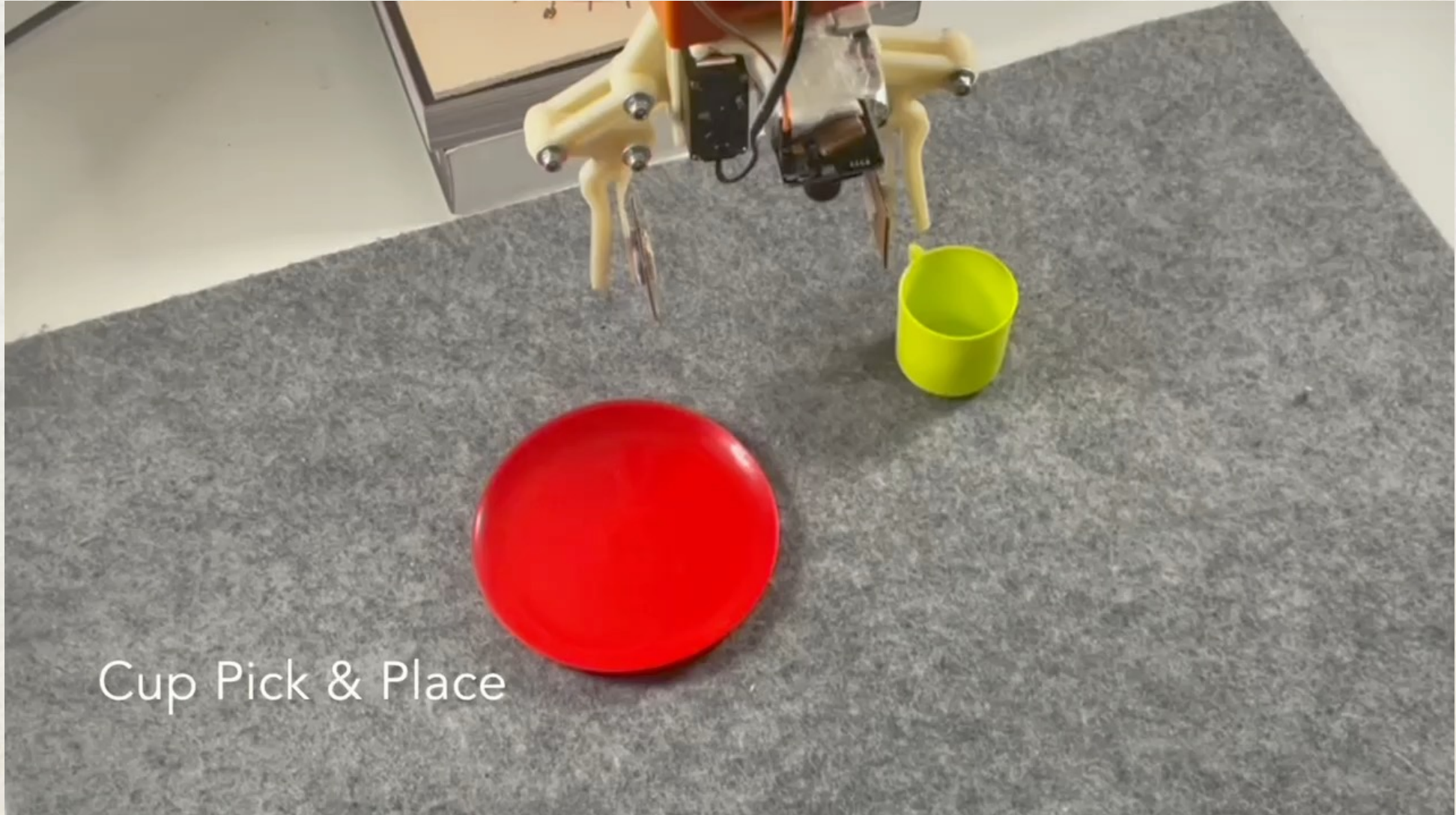
Plug

Method	Bottle	Plate	Screwdriver	Lid	Hammer	Scoop	Knife	Plug	Average
Visual Servoing	65	25	20	65	35	55	15	5	35.6
Visual Servoing + Correction	100	95	70	100	40	95	10	10	65.0
Filtering	85	25	10	85	50	90	0	10	44.4
Filtering + Correction	100	80	60	100	65	100	10	45	70.0

Coarse-to-Fine Imitation Learning: Multi-Stage Tasks

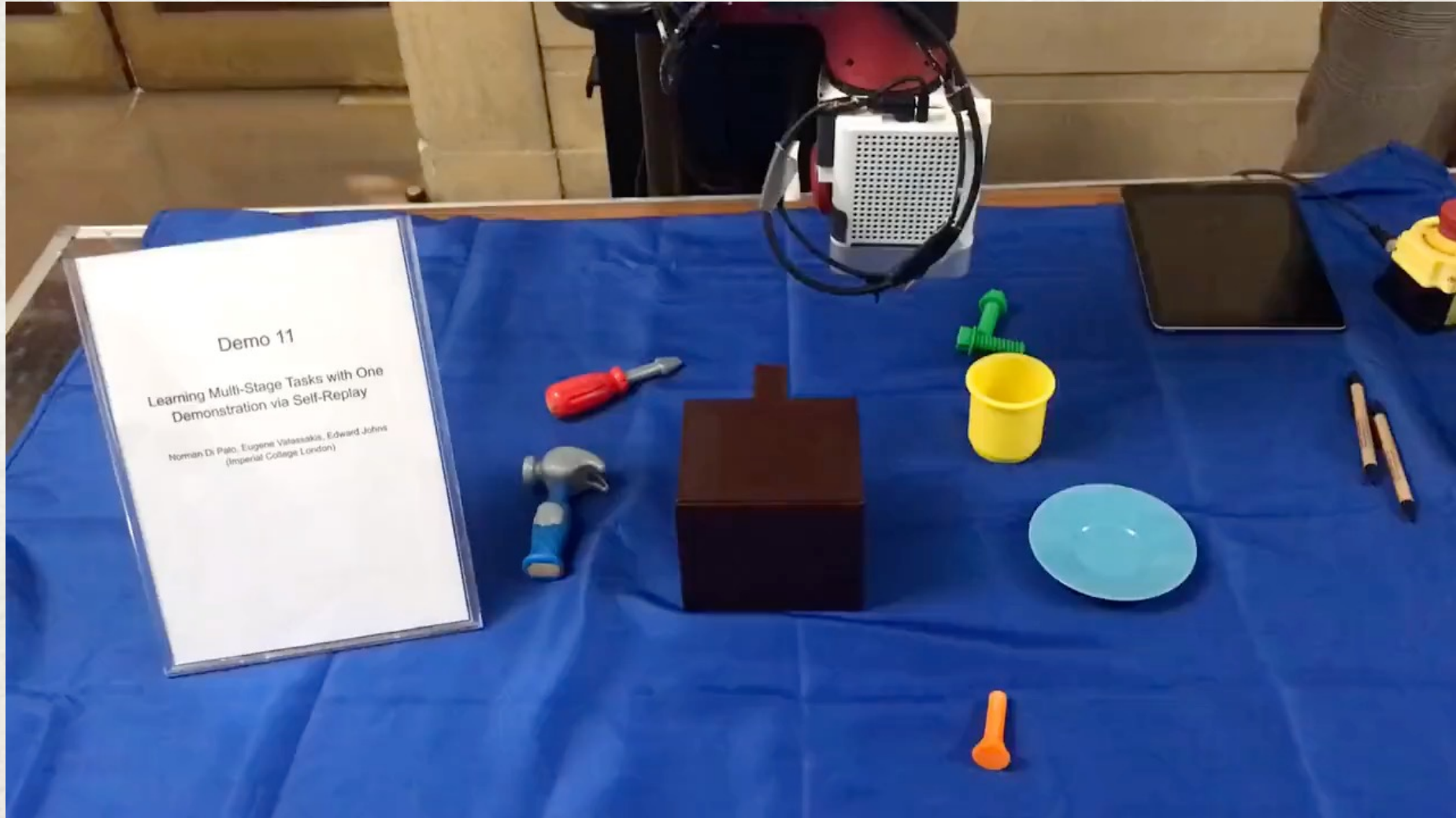


Coarse-to-Fine Imitation Learning: Multi-Stage Tasks



Cup Pick & Place

Live Demo at CoRL 2021



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at

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