

Three Benefits of Simulators for Zero-Shot Transfer

Edward Johns

The Robot Learning Lab
at



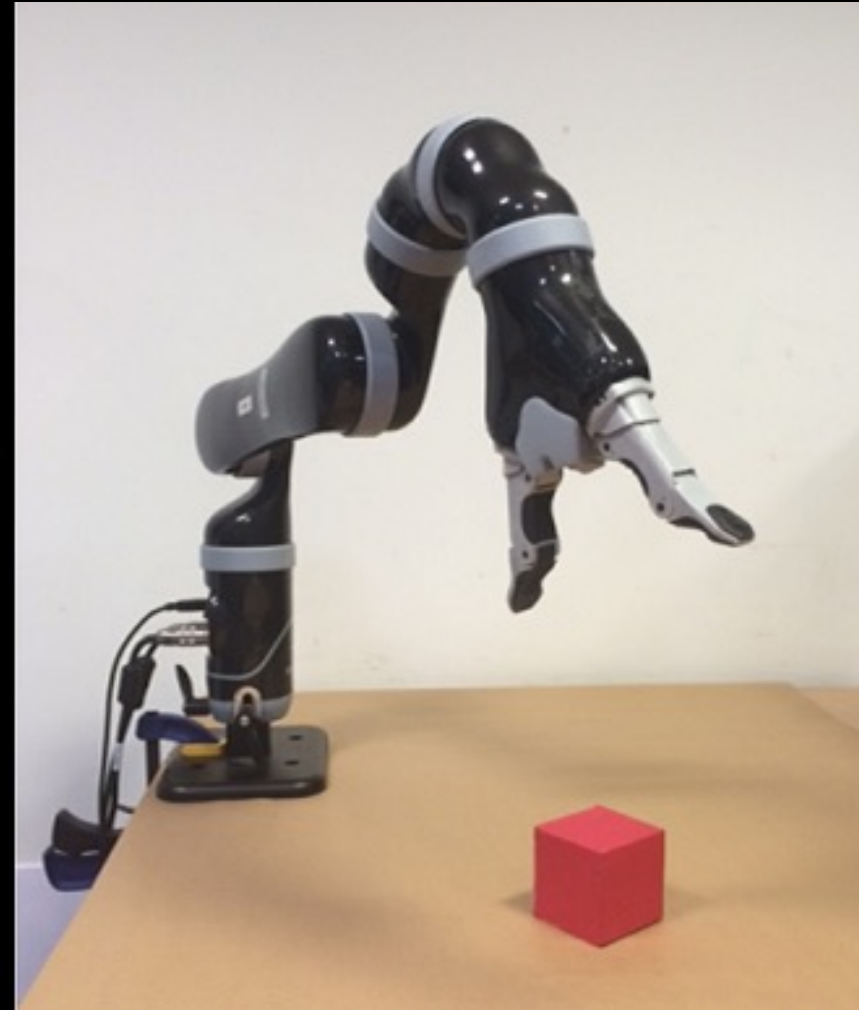
Imperial College
London

23rd June 2019

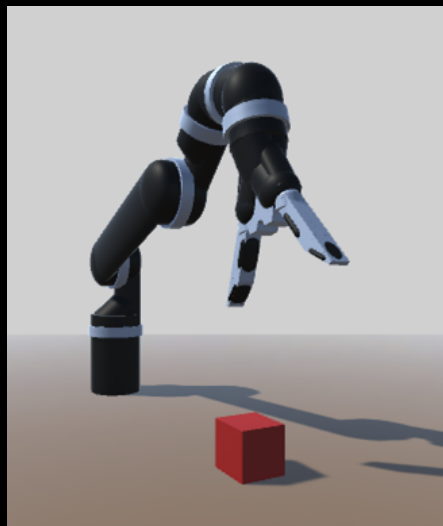
Sim Data



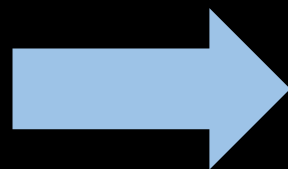
Real Data



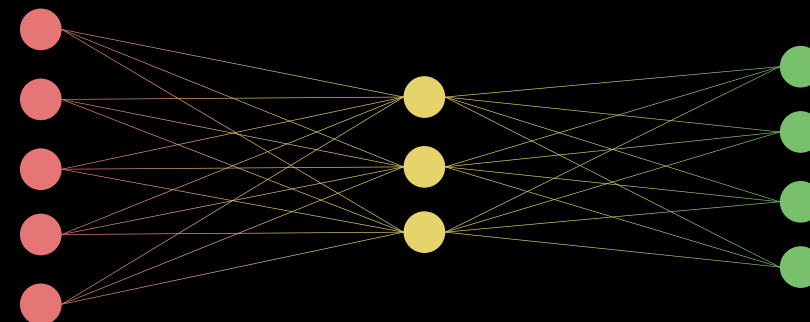
Sim Data



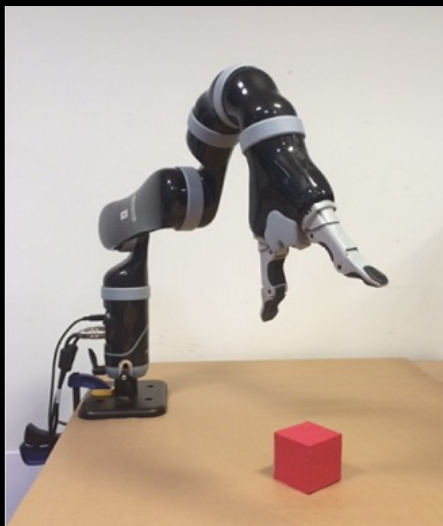
Train



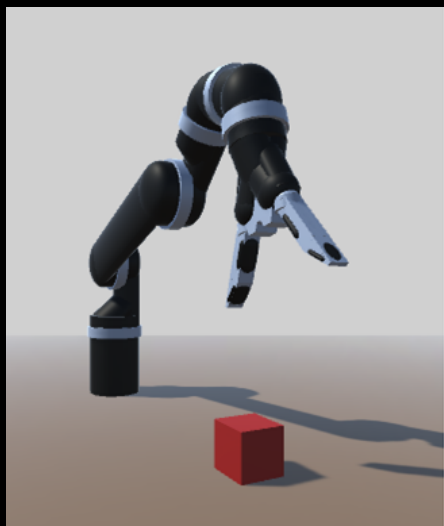
Policy



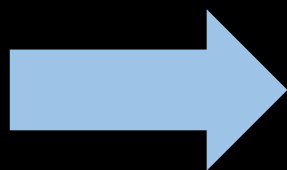
Real Data



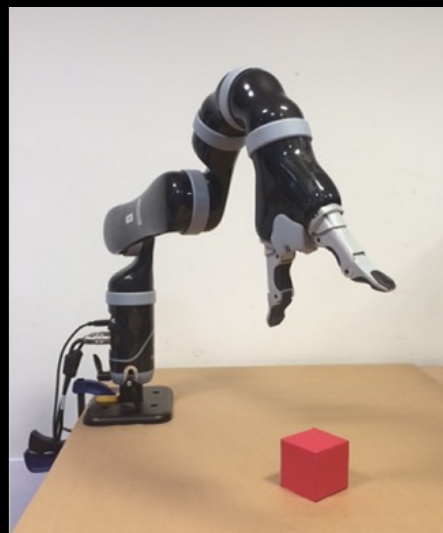
Sim Data



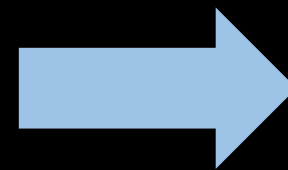
Pre-Train



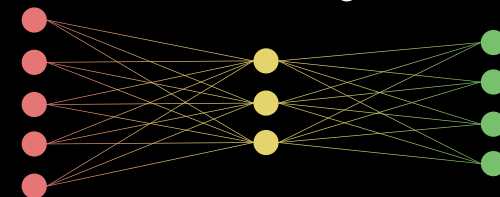
Real Data



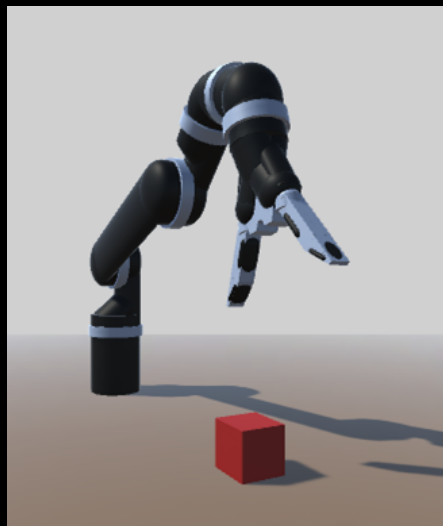
Fine-tune



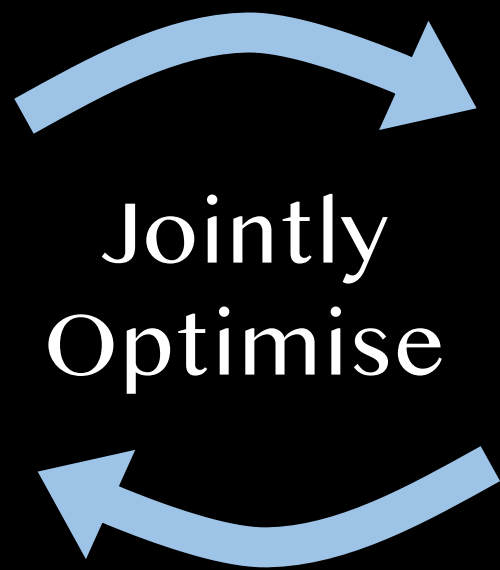
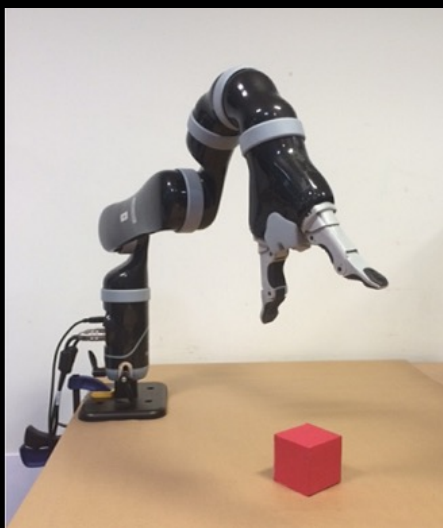
Policy



Sim Data

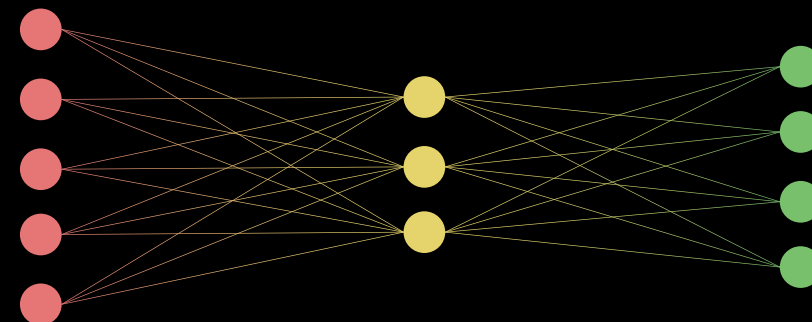


Real Data



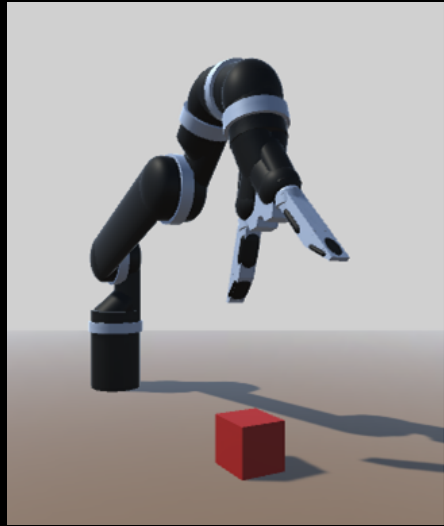
Jointly
Optimise

Policy

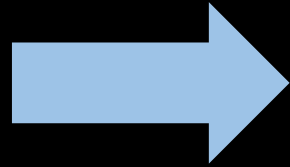


Zero-Shot Transfer

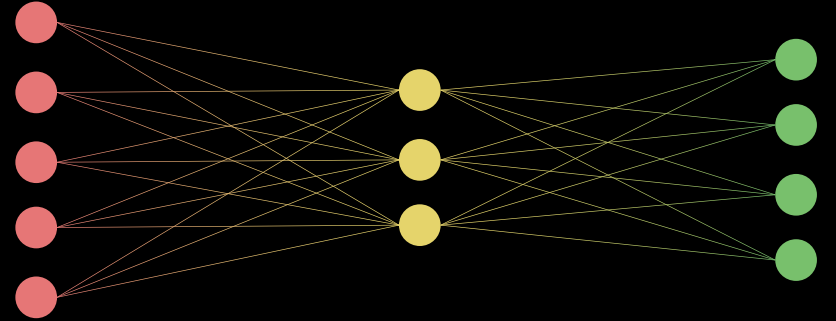
Sim Data



Train



Policy

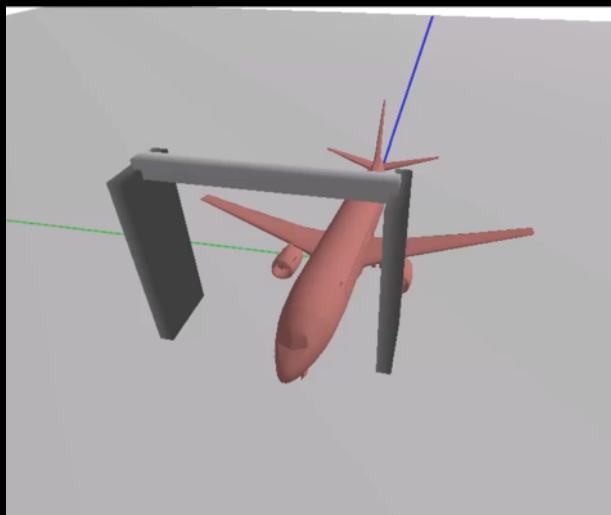


1

2

3

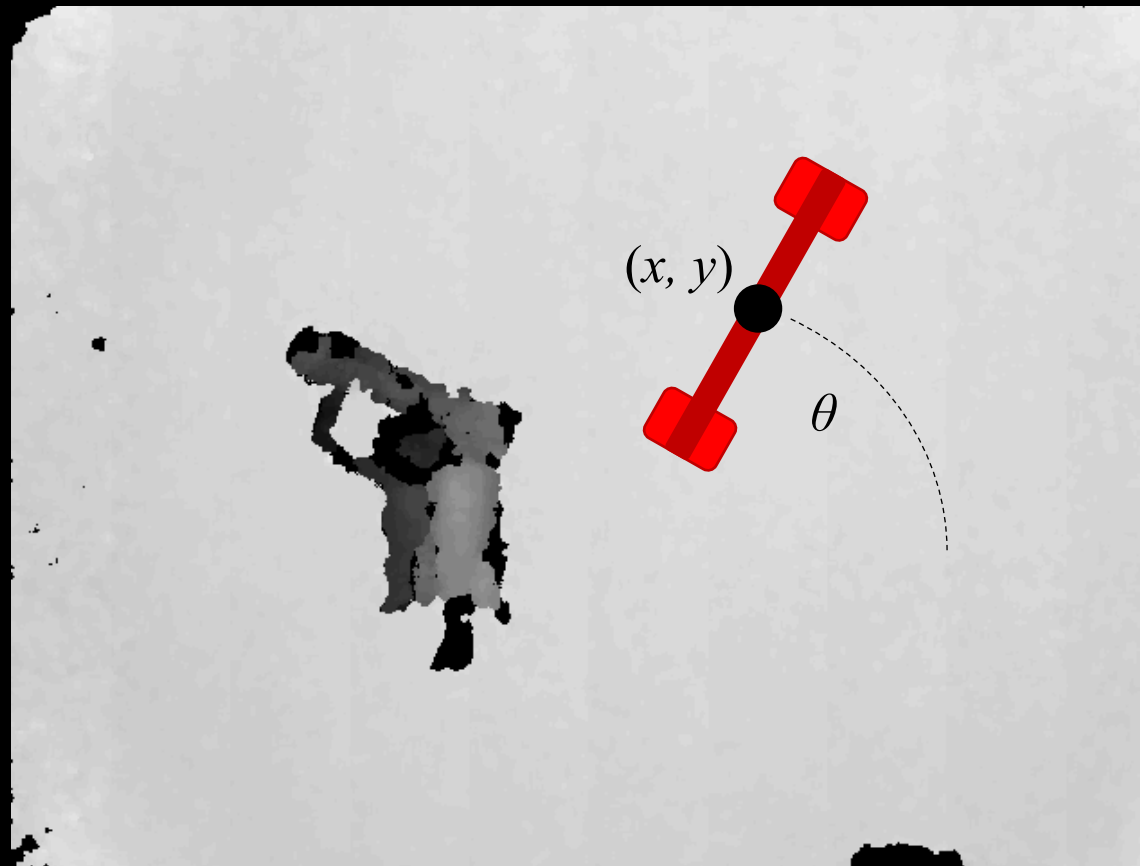
Ease of Large-Scale Data Collection

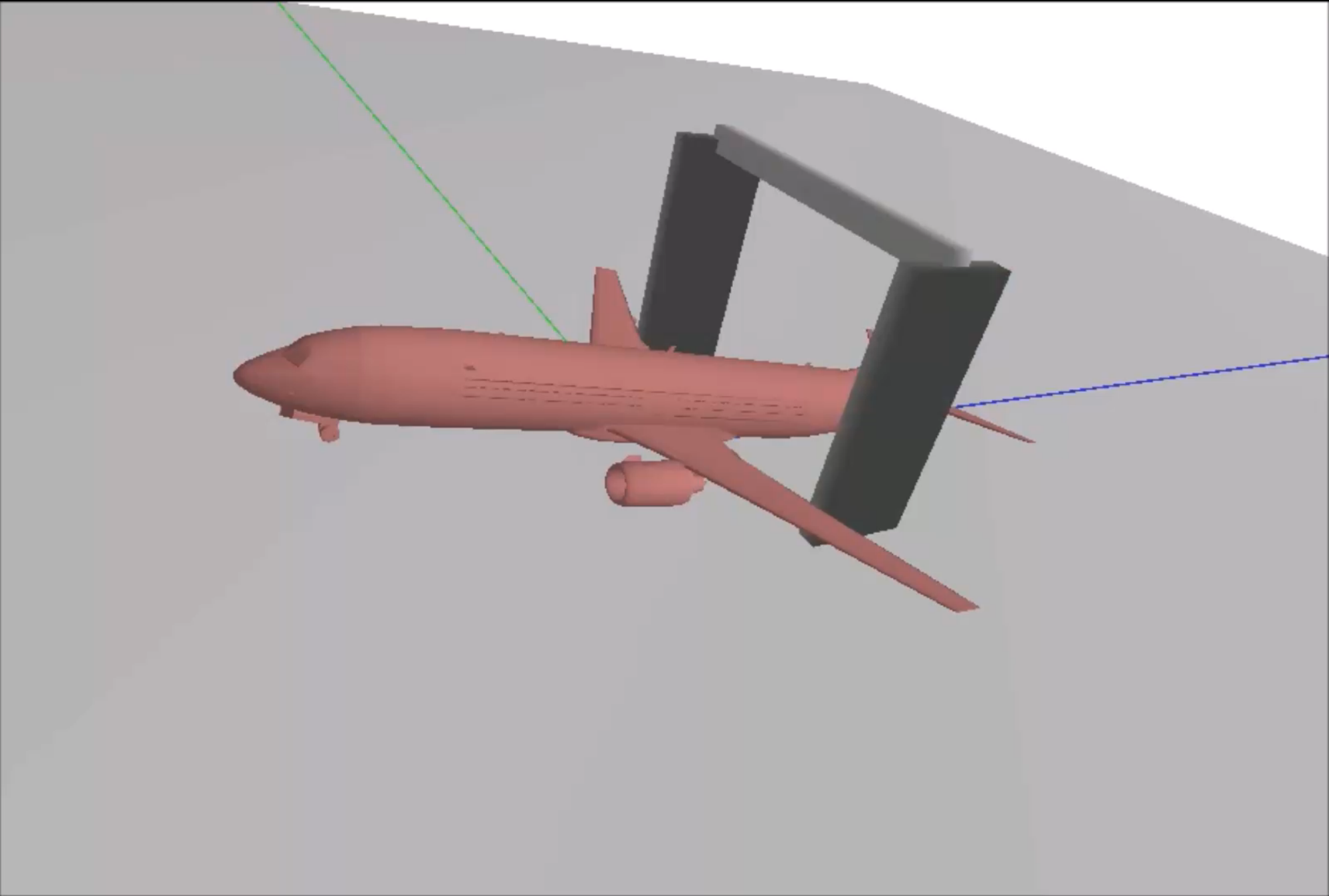


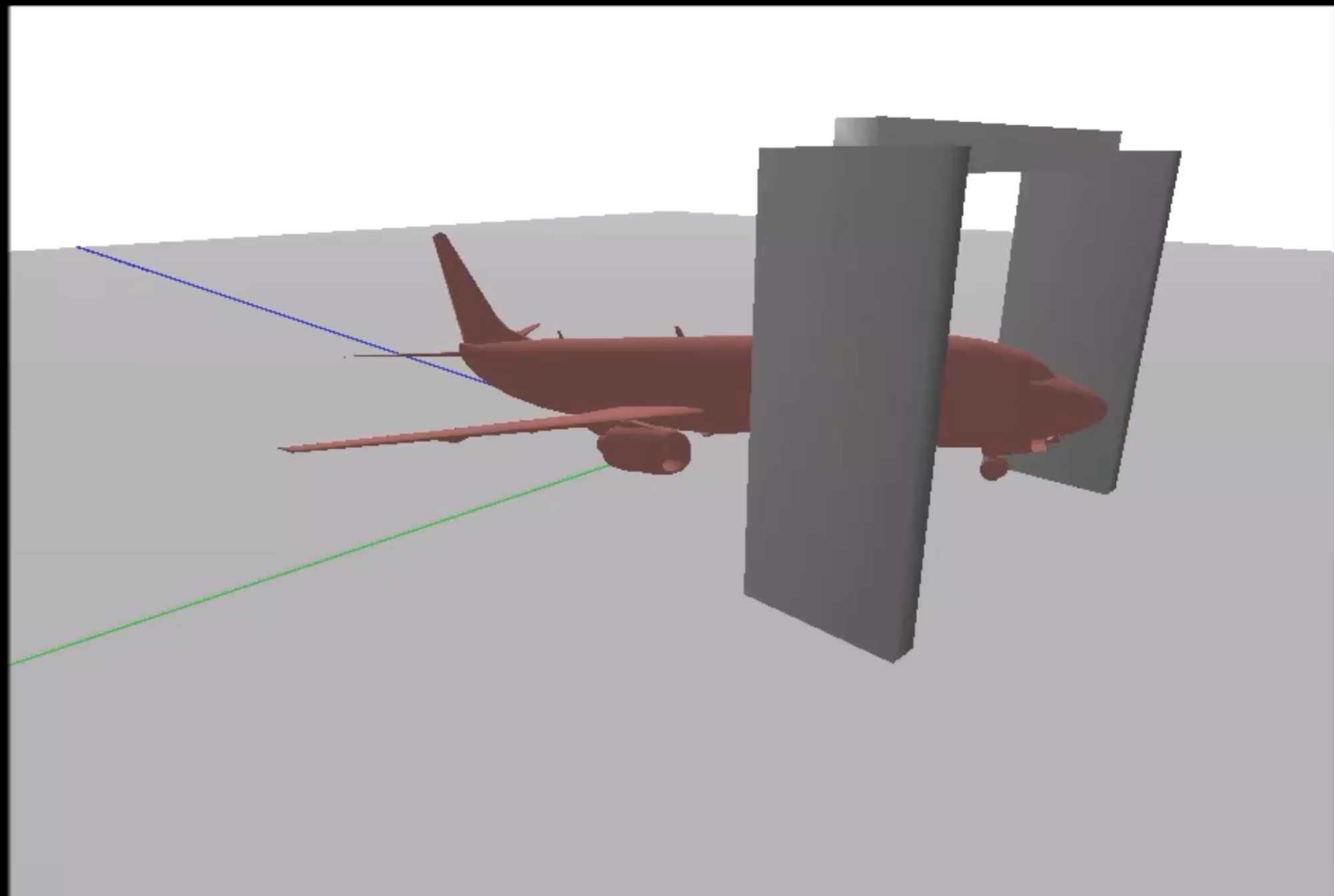
Grasping task

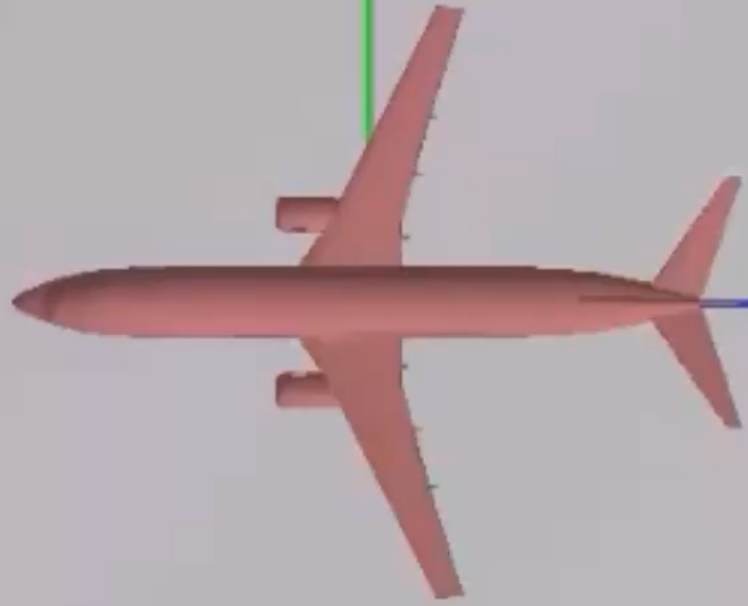


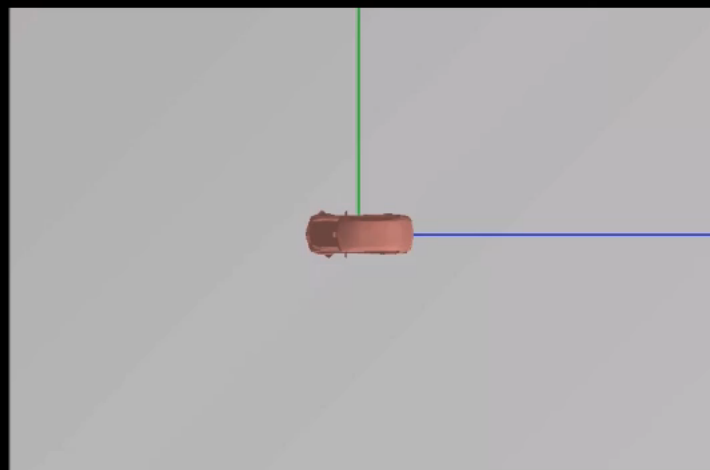
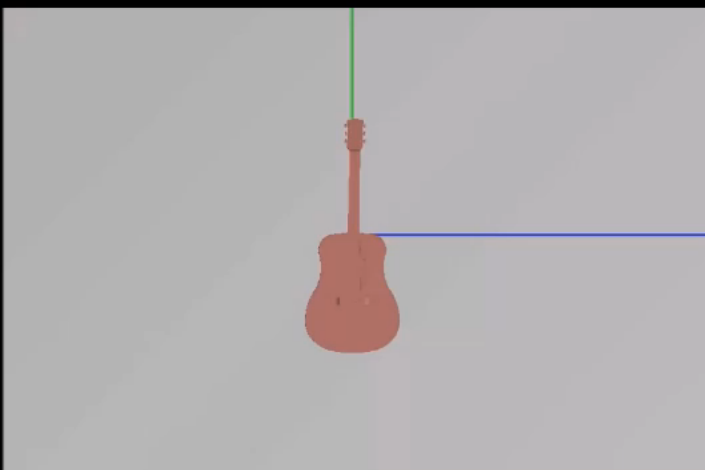
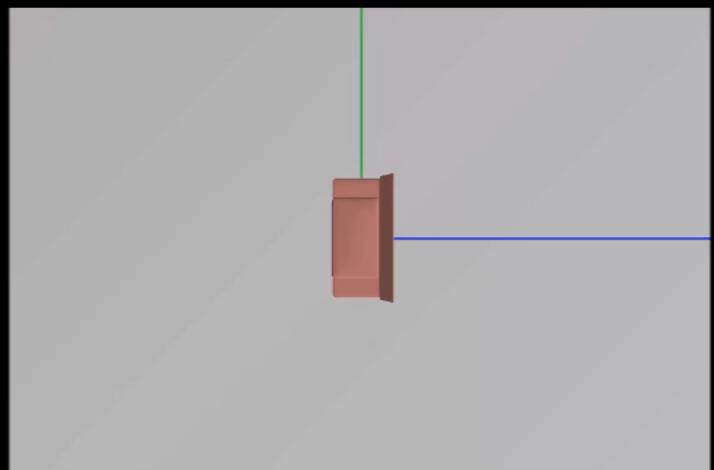
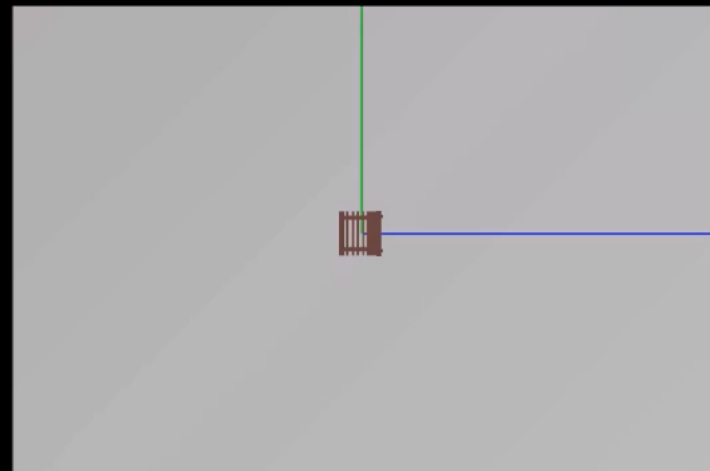
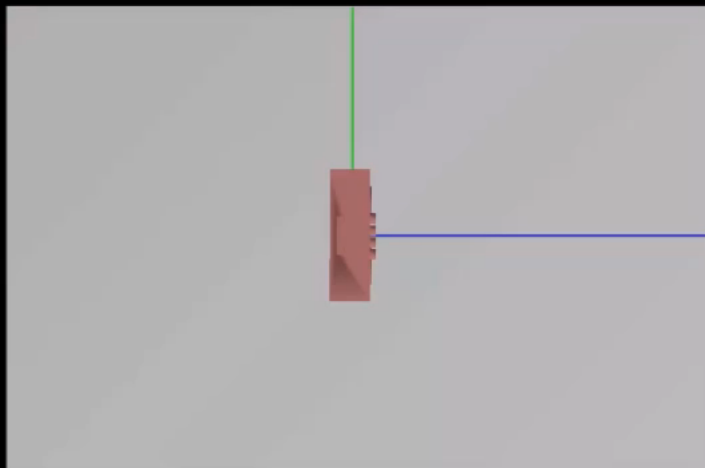
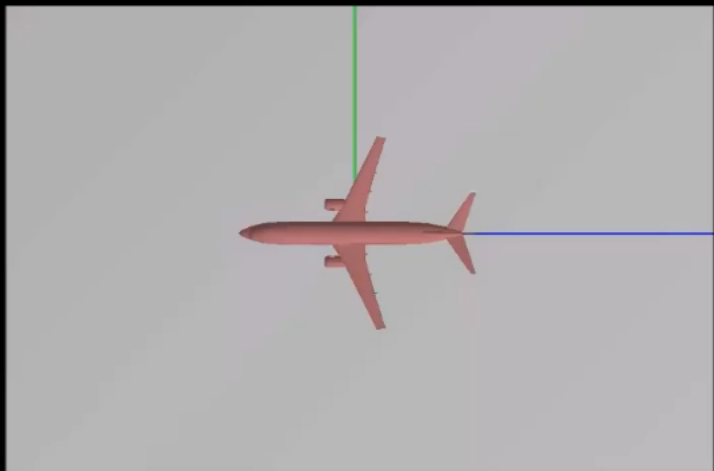
Observed depth image









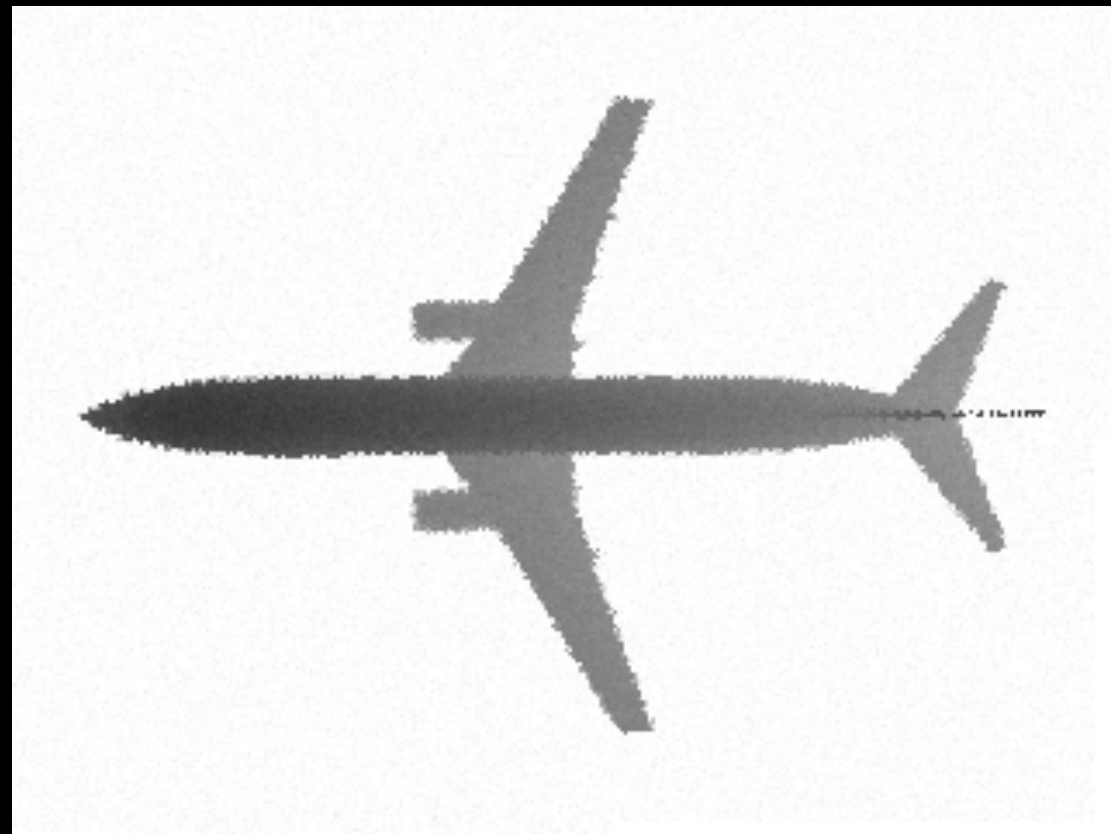


4x

Sim Depth Image



+ Noise

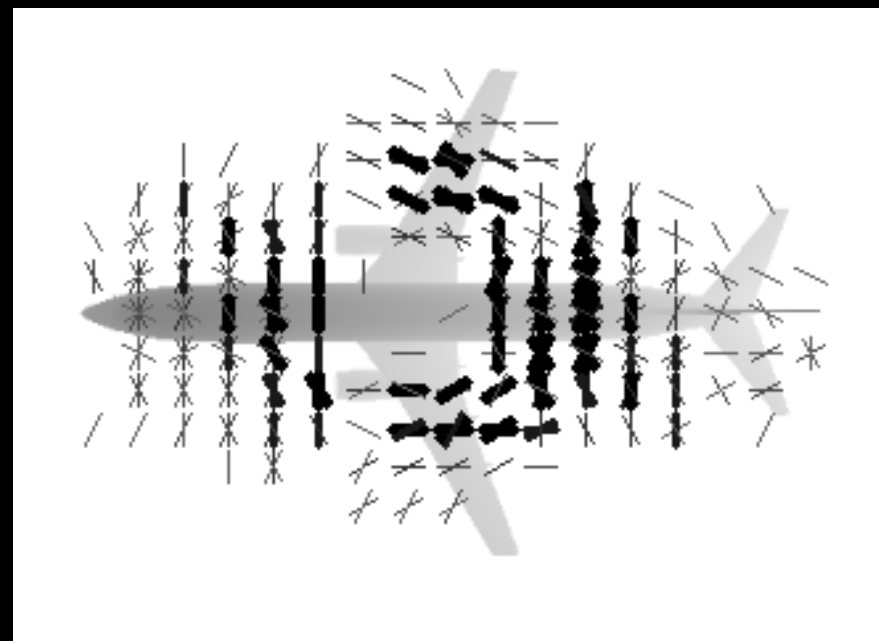


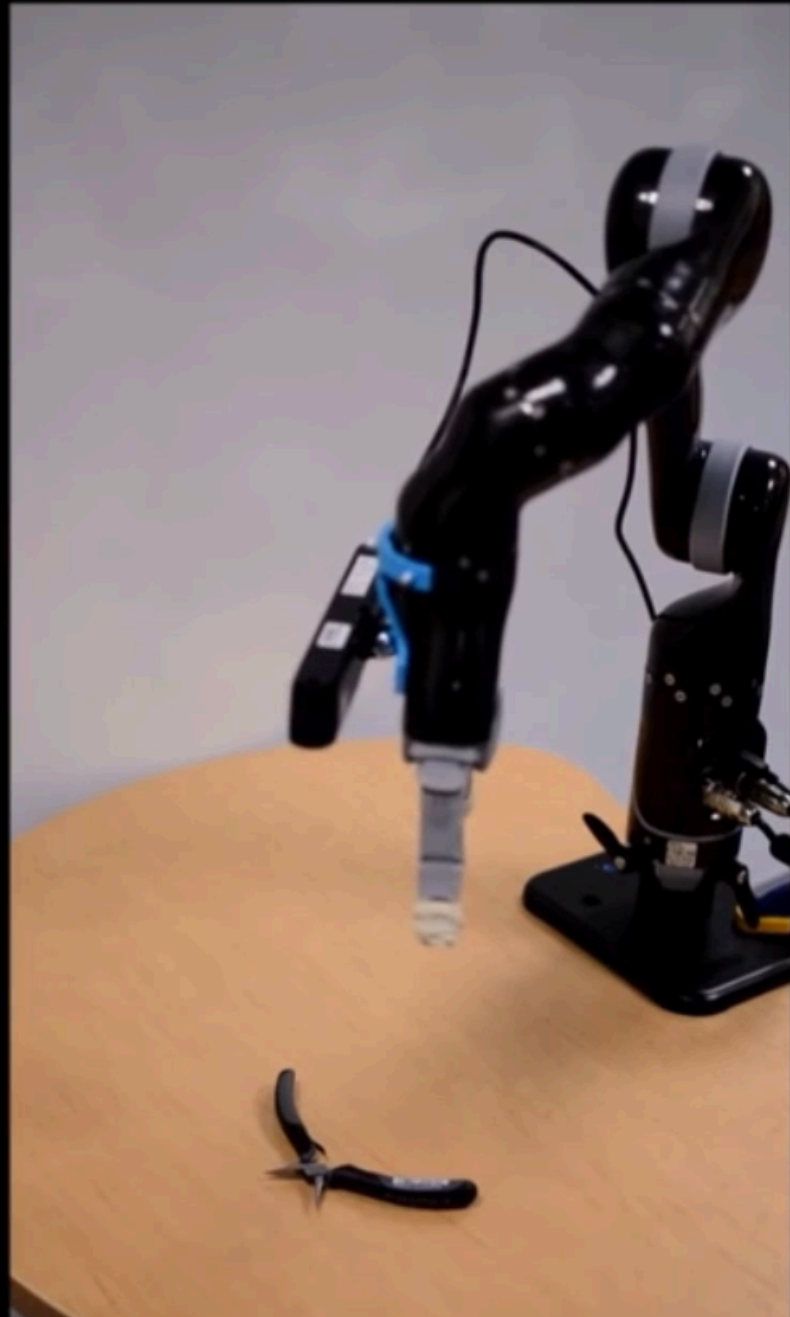
Observed
depth image



CNN

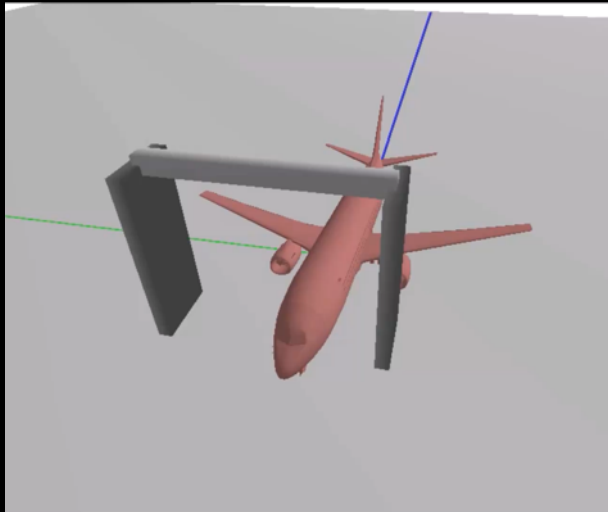
Grasp
function





1

Ease of Large-Scale
Data Collection



2

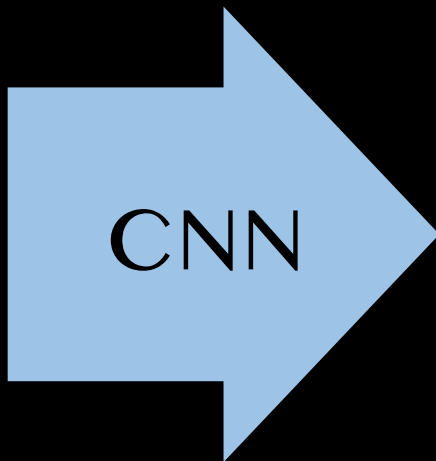
Access to
Full State



3



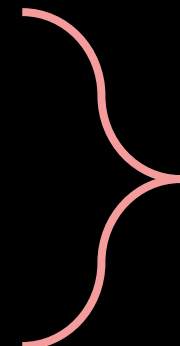




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Joint velocities
(mse loss)

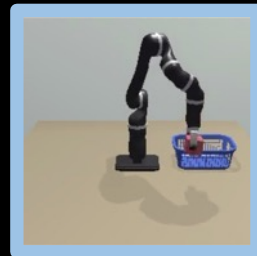
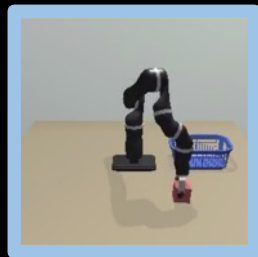
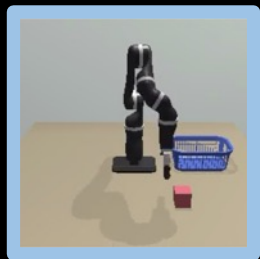
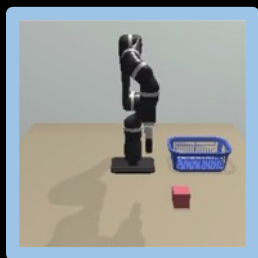


Gripper action
(softmax loss)

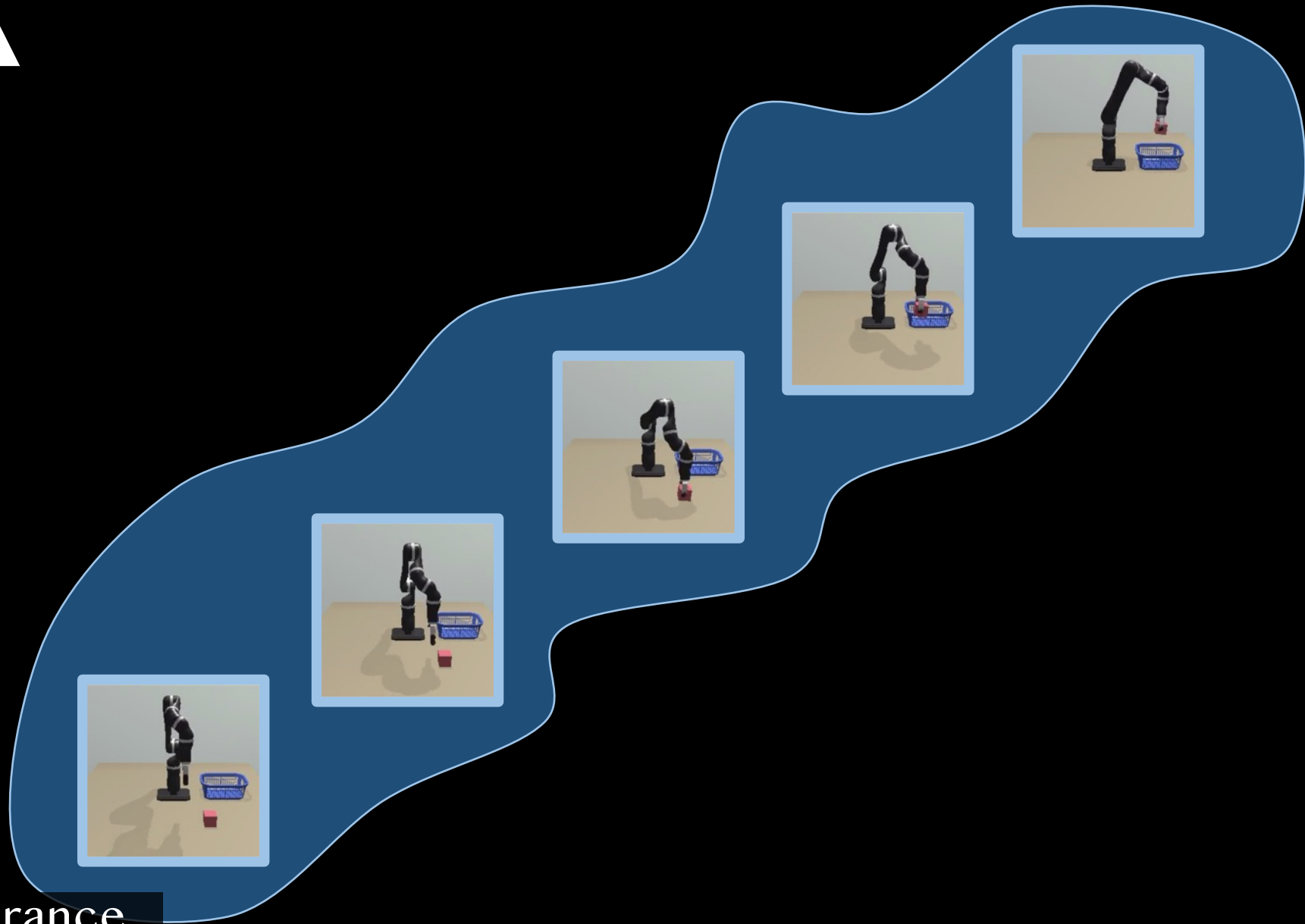


3 X

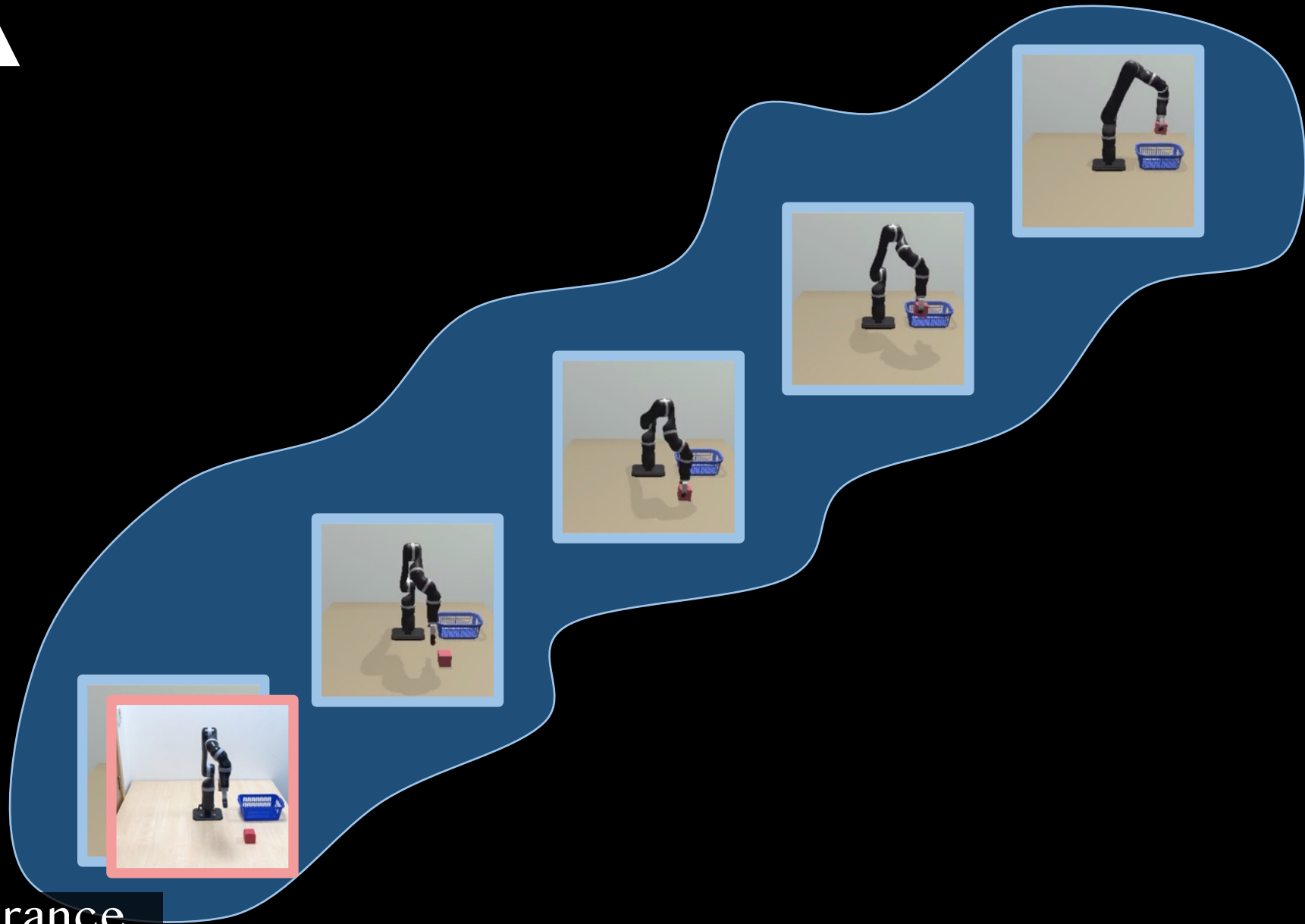
Appearance
space



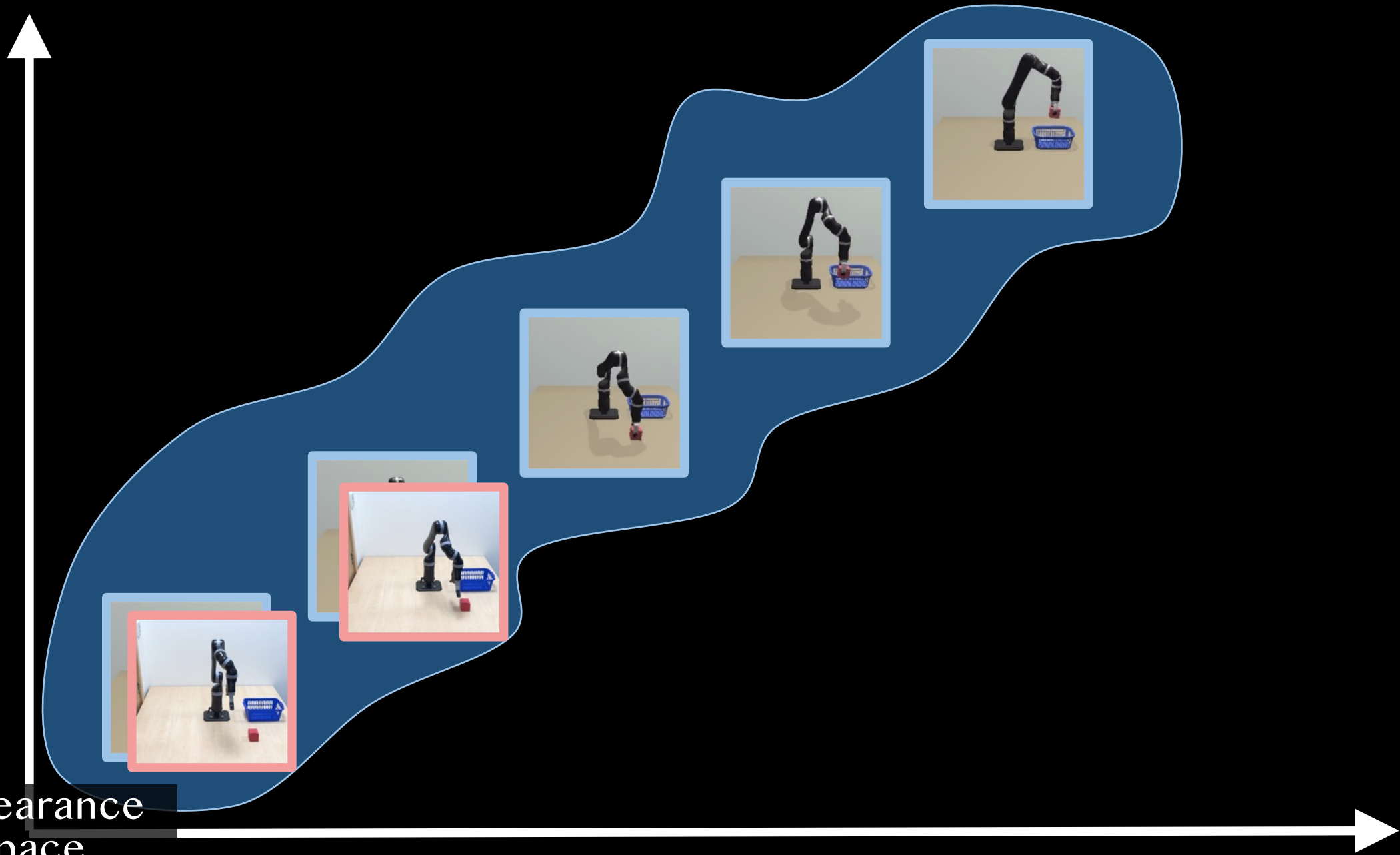
Appearance
space



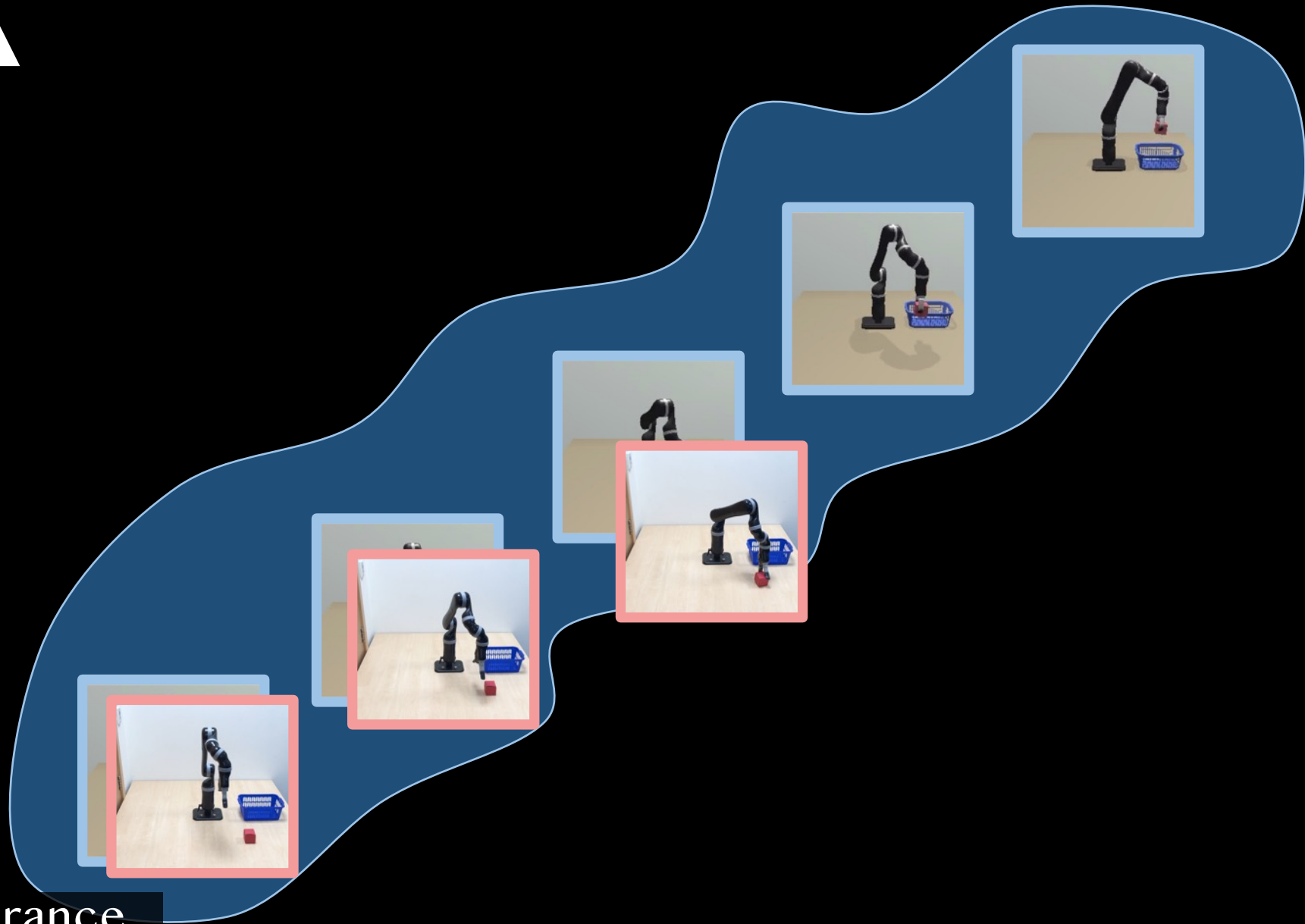
Appearance
space



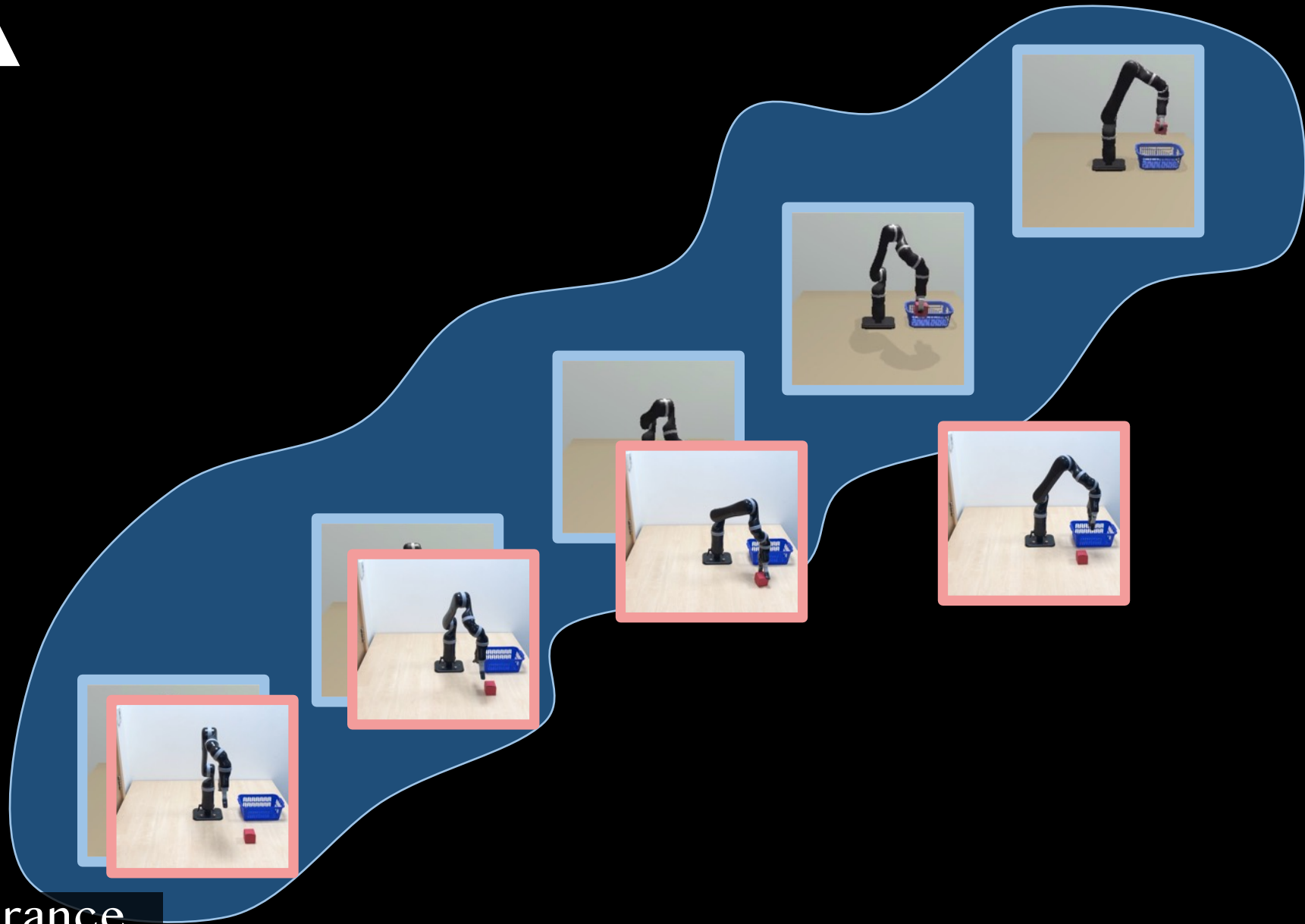
Appearance
space



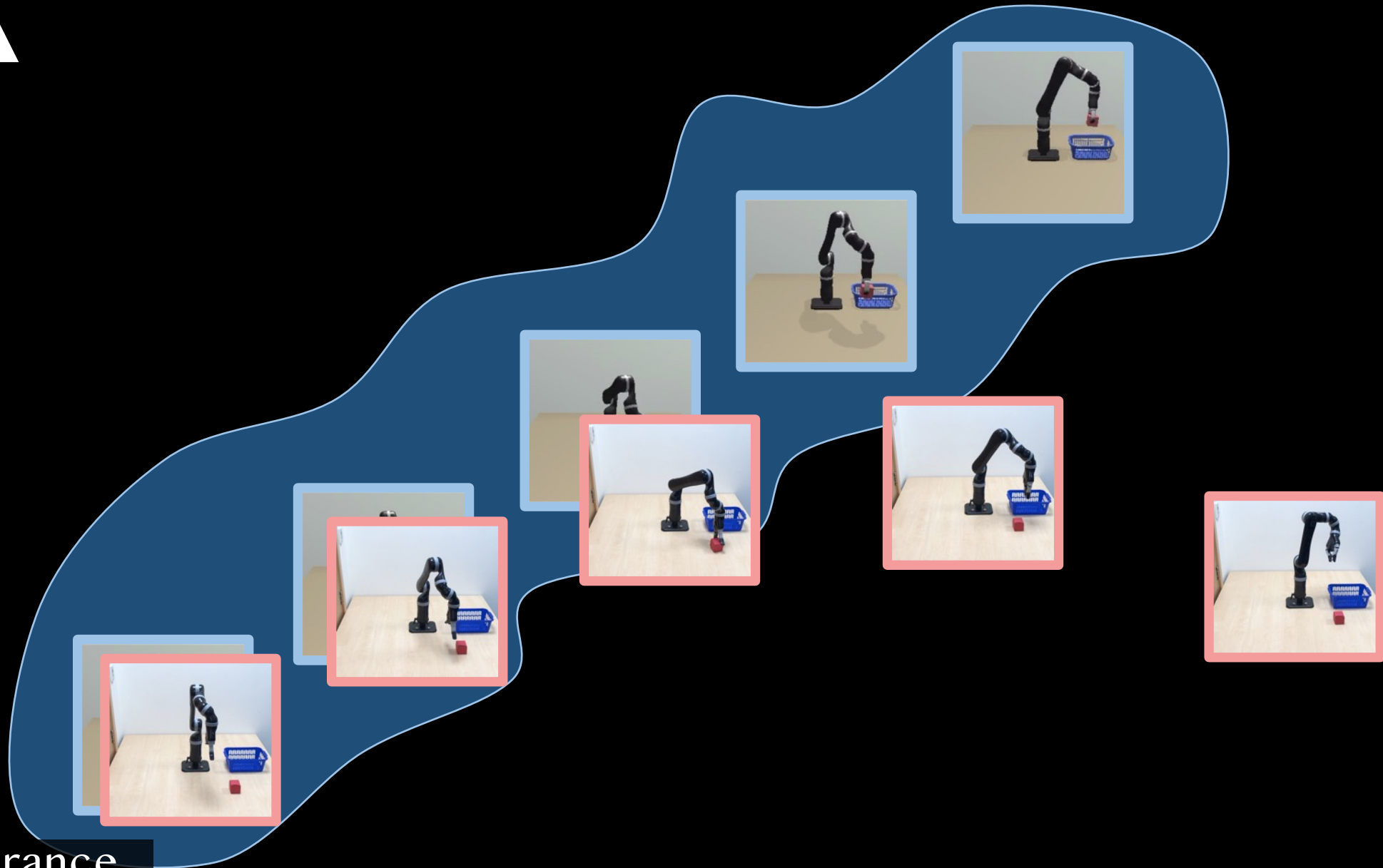
Appearance
space

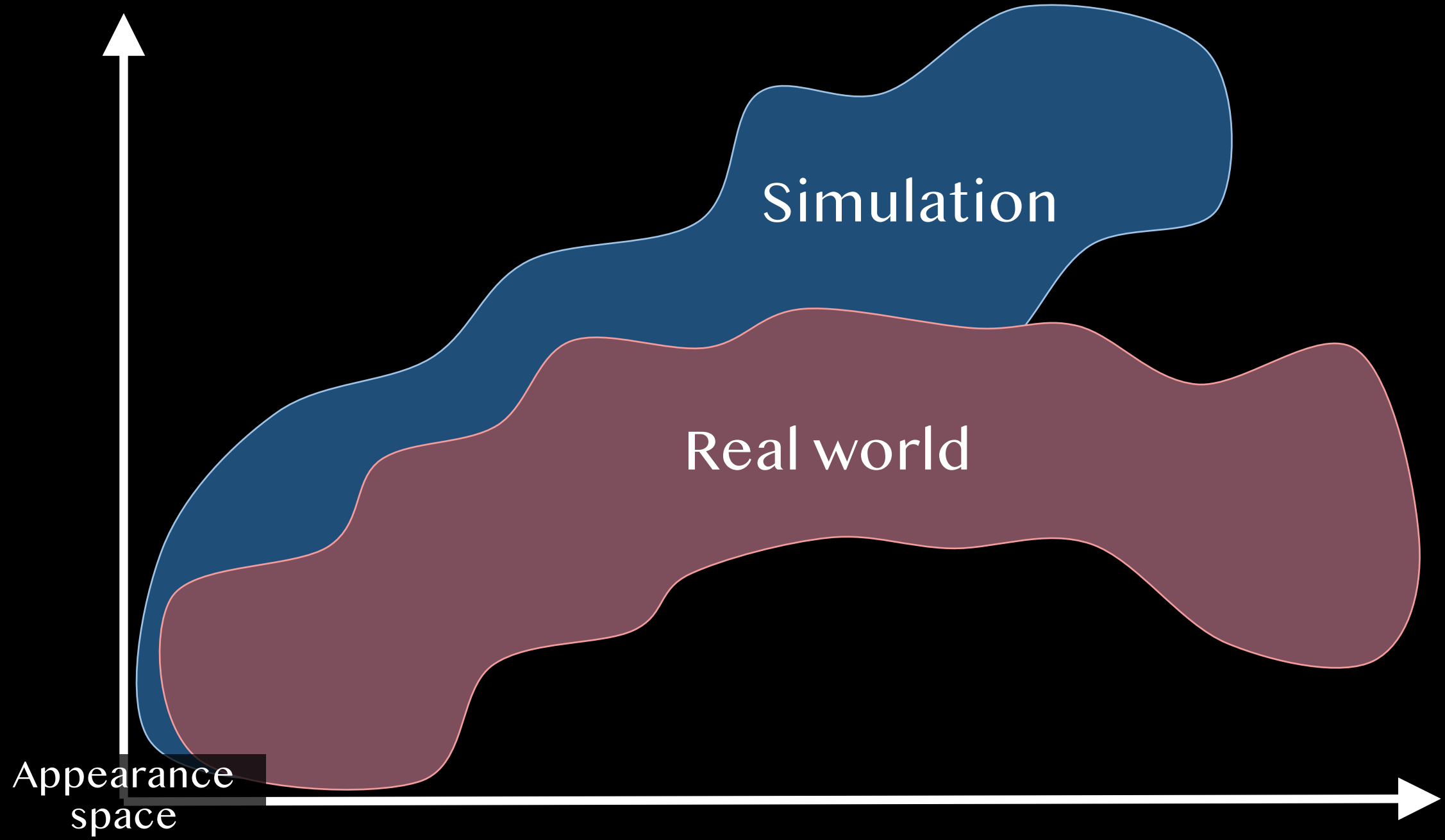


Appearance
space



Appearance
space

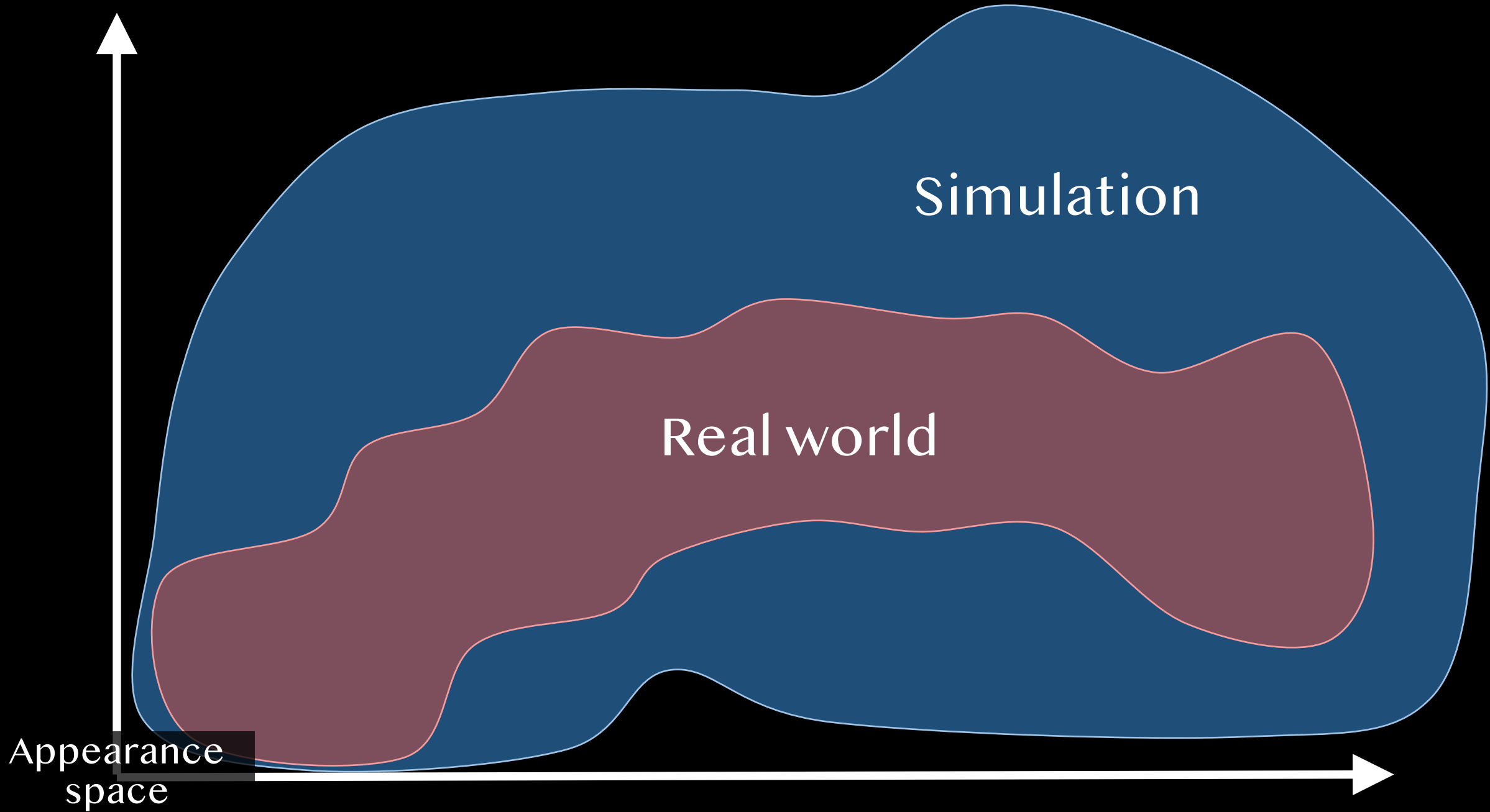


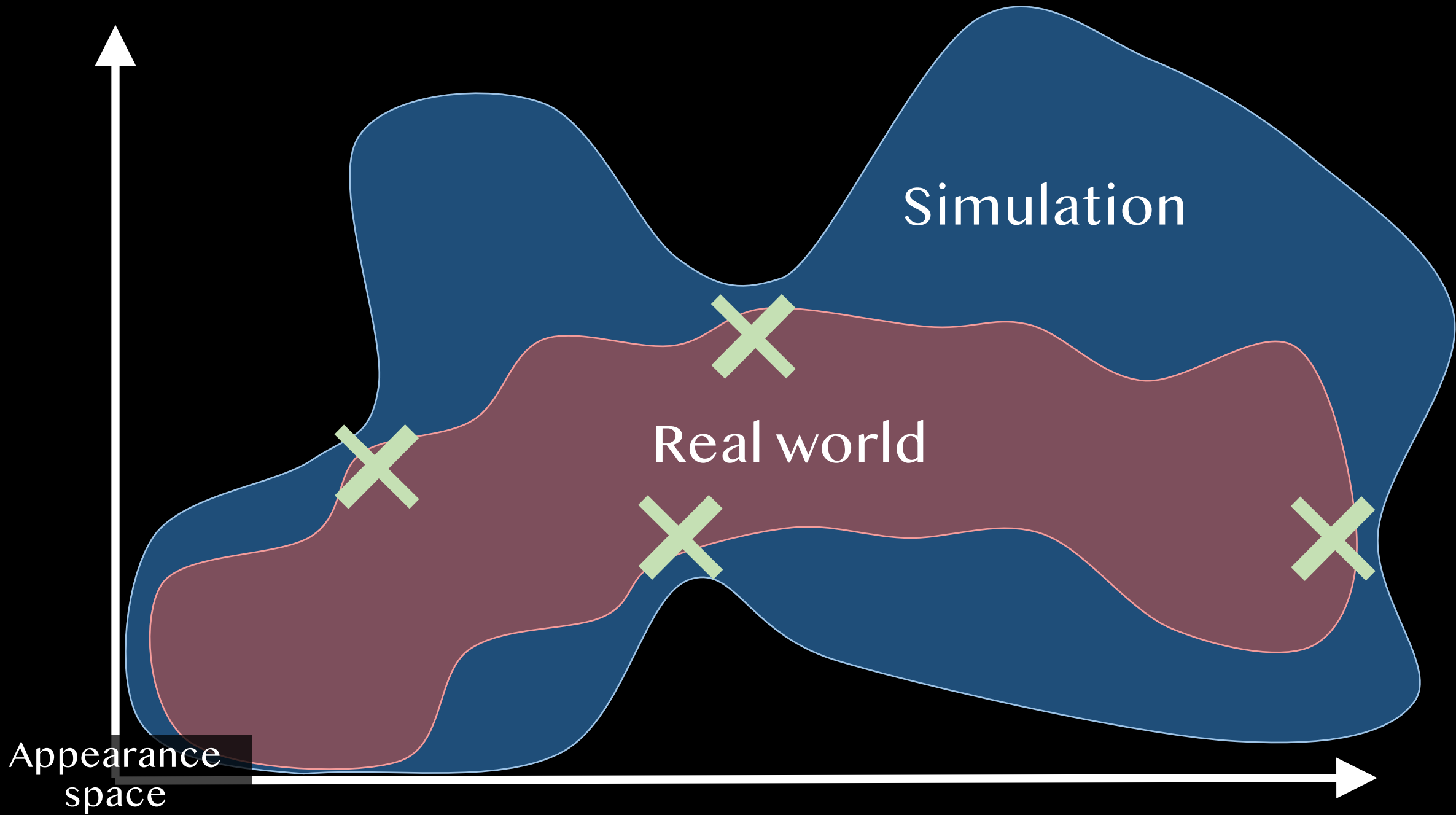


Appearance
space

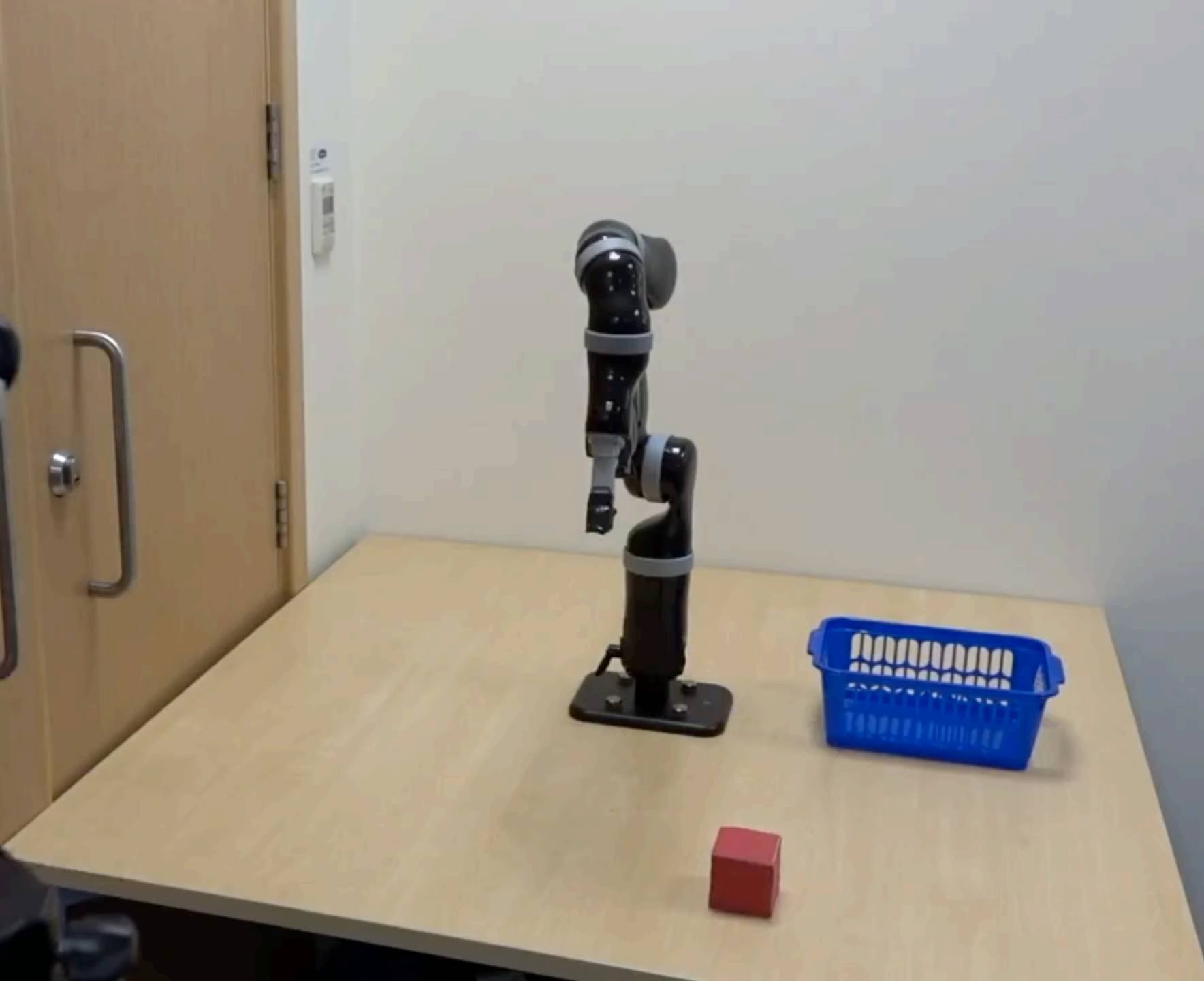
Simulation

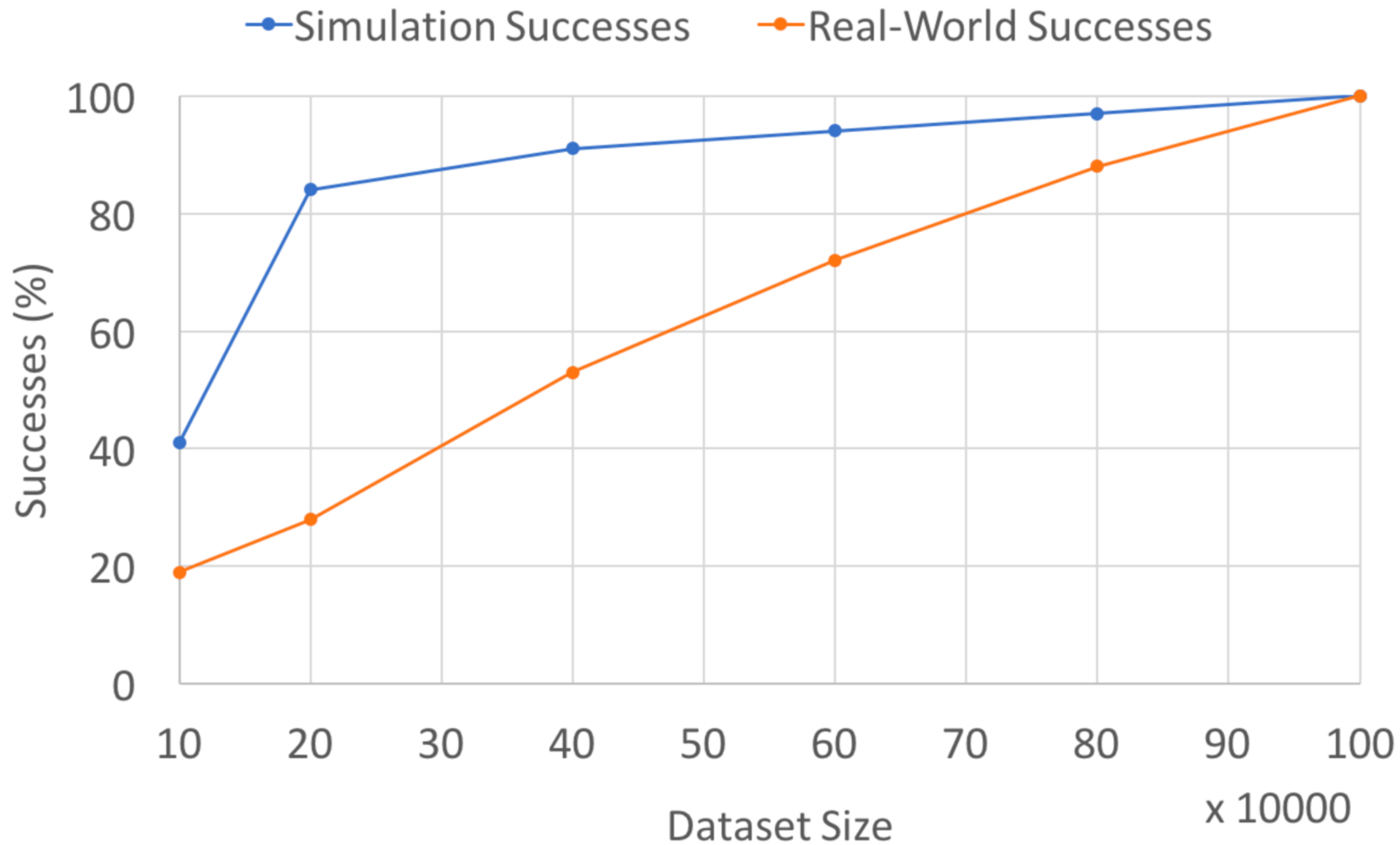
Real world











Real-world success

Everything randomised

100 %

What was not randomised?

Textures

44 %

Light poses

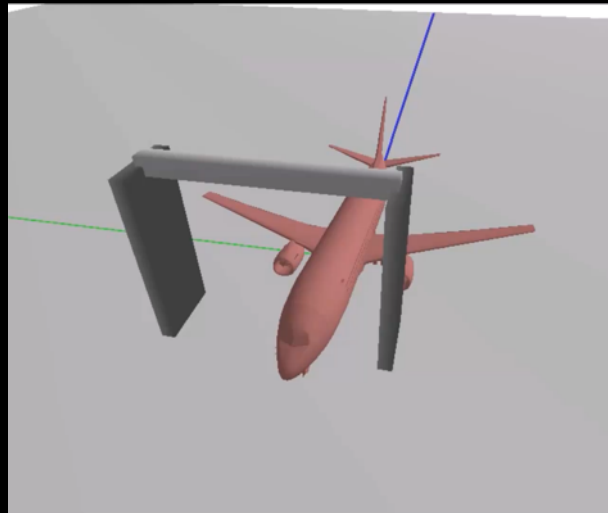
19 %

Camera pose

3 %

1

Ease of Large-Scale
Data Collection



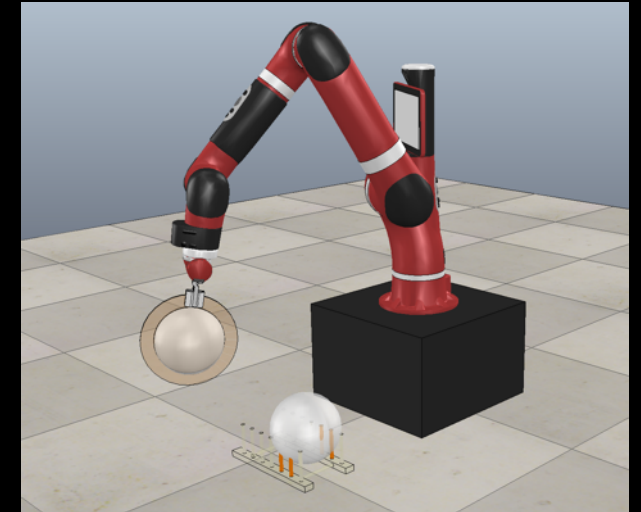
2

Access to
Full State

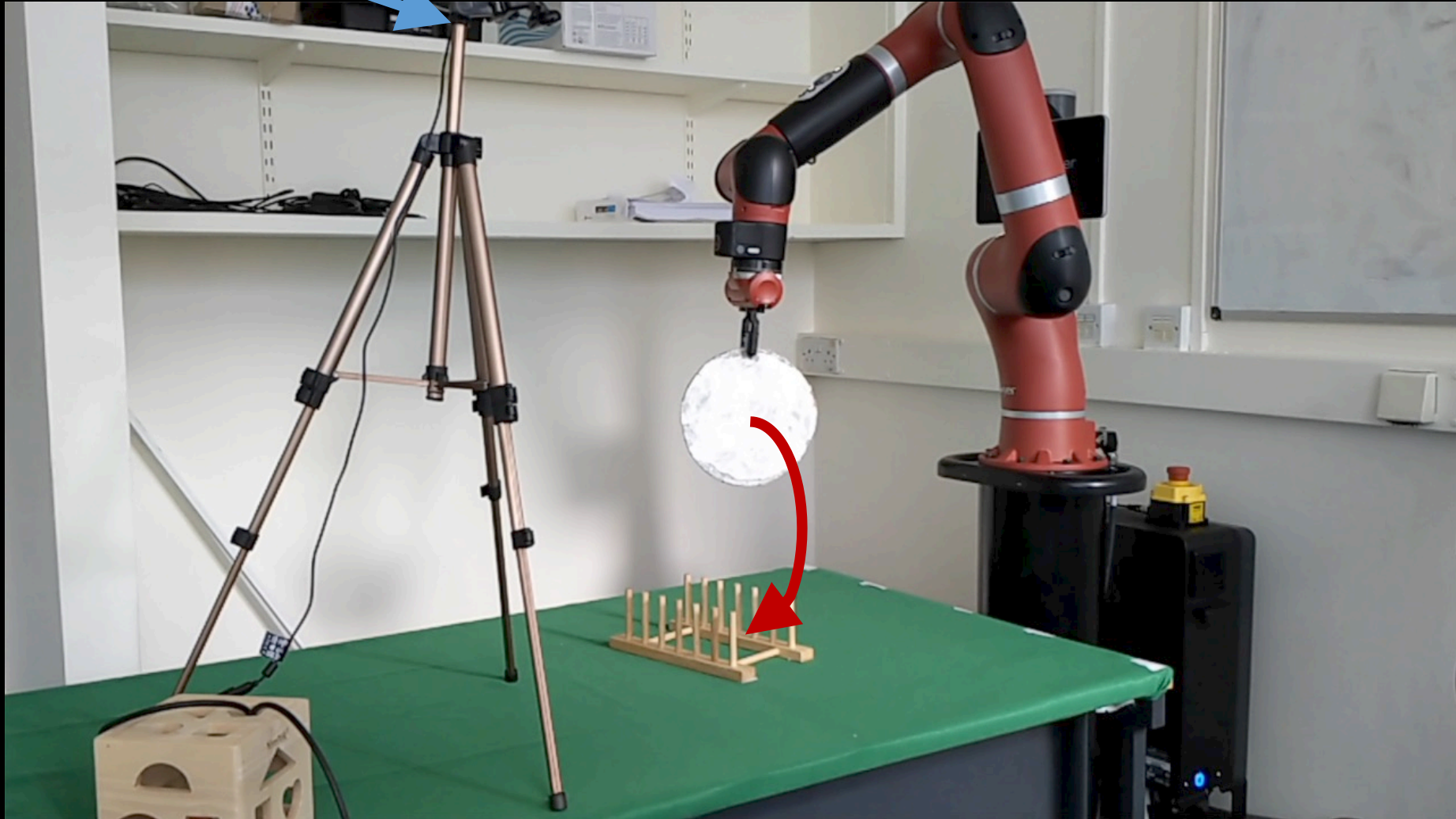


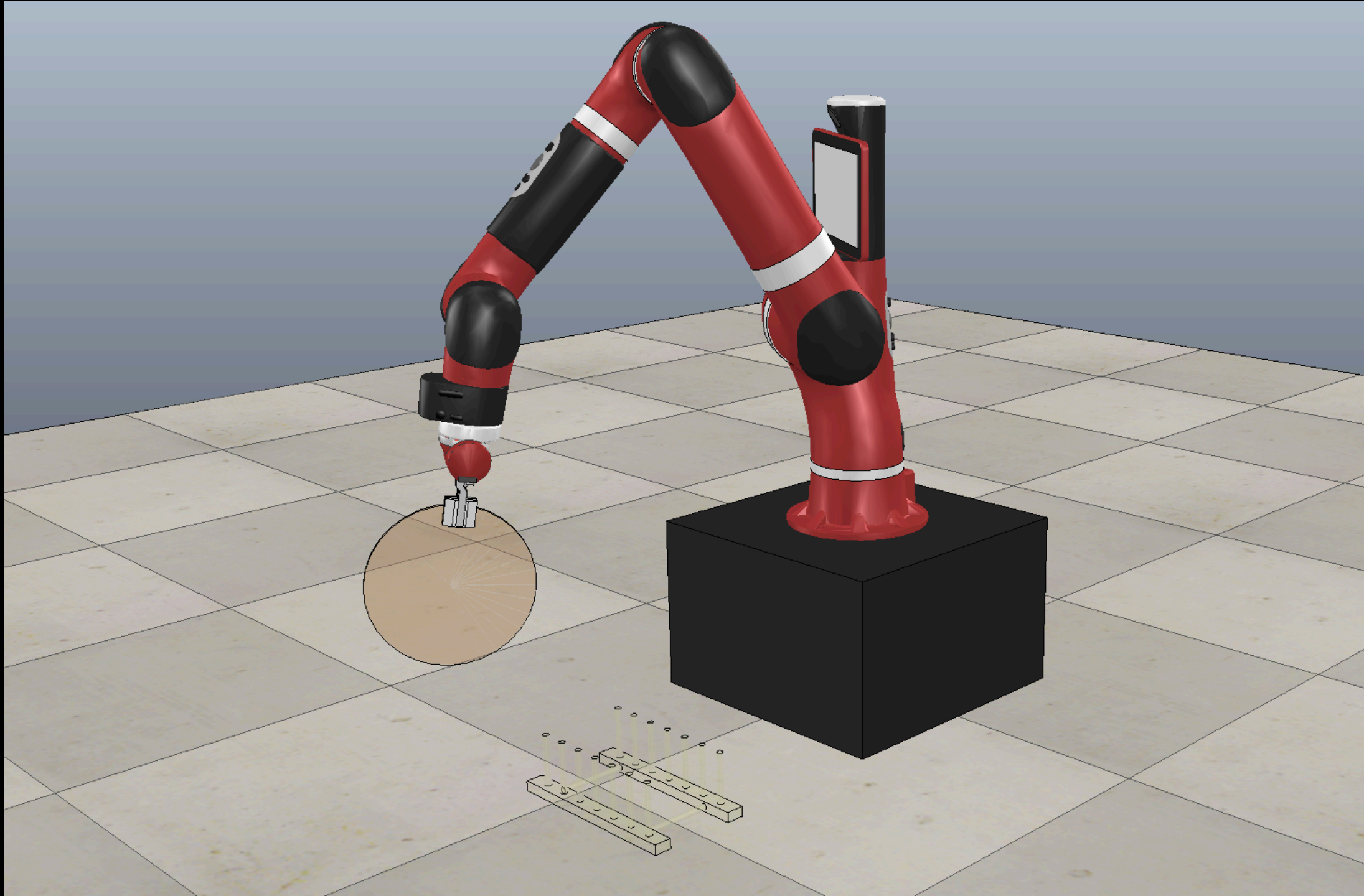
3

Ability to Modify
Environment



camera

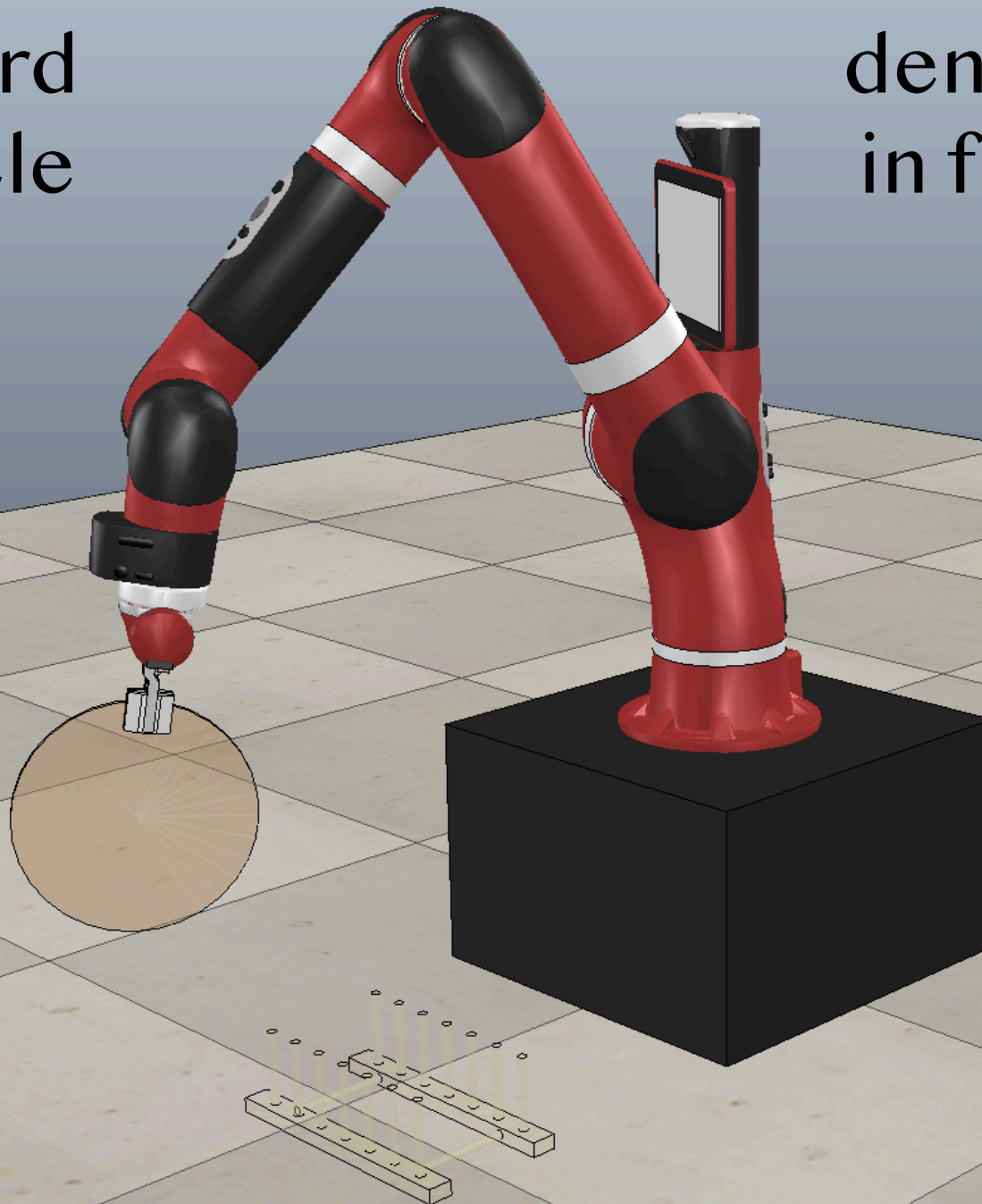




dense reward
with obstacle



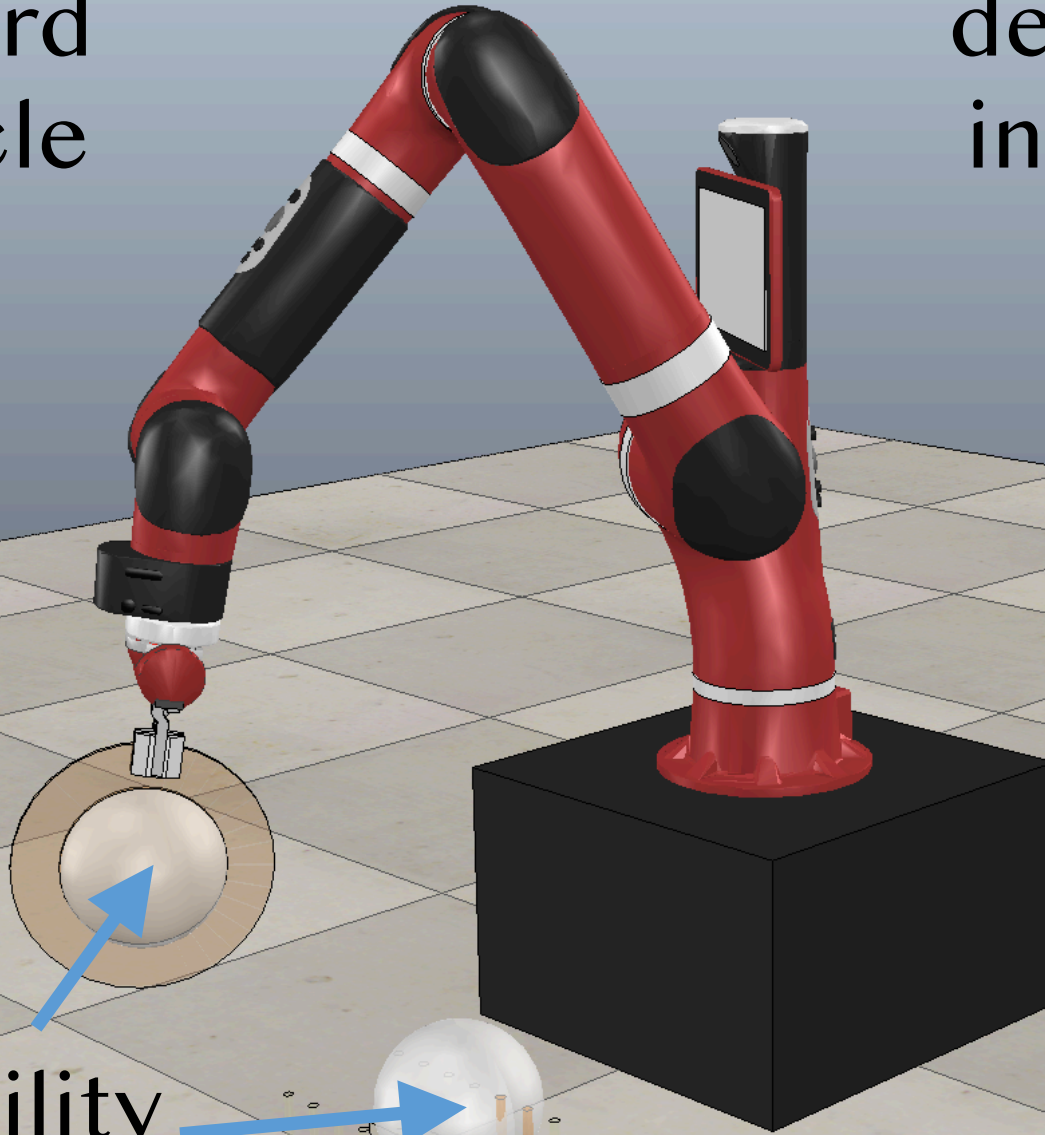
dense reward
in free space



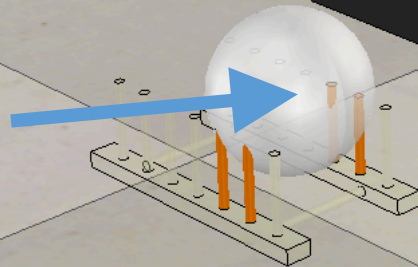
dense reward
with obstacle



dense reward
in free space

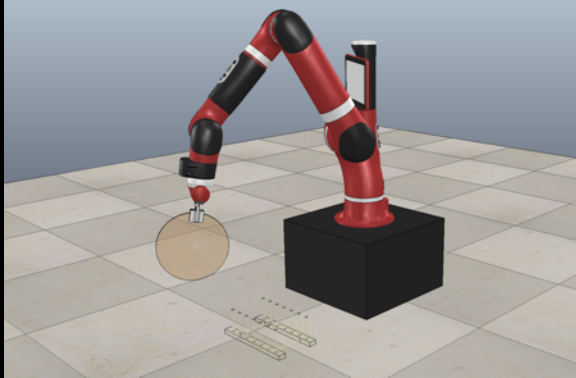


responsibility
mask

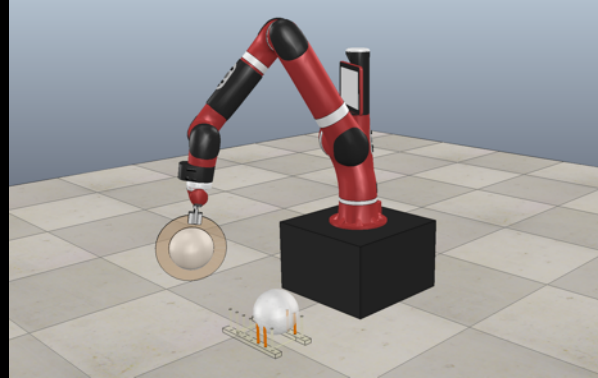


curriculum

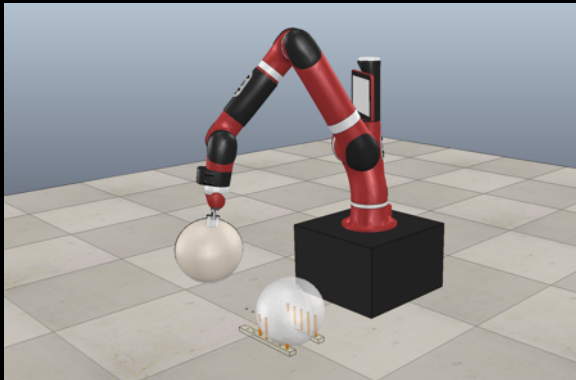
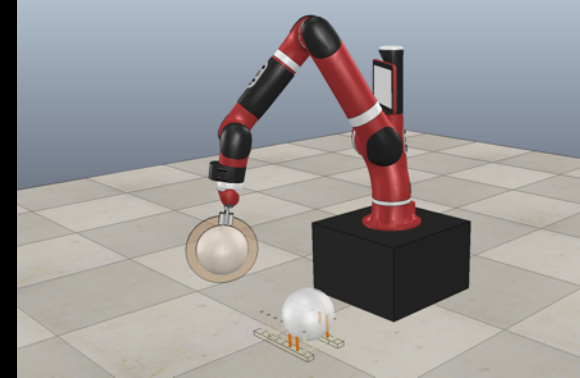
dense reward



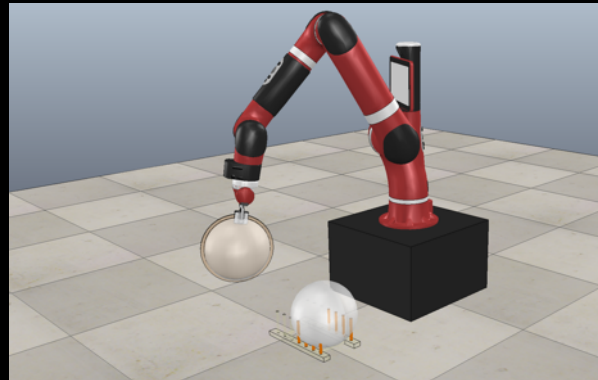
sparse reward



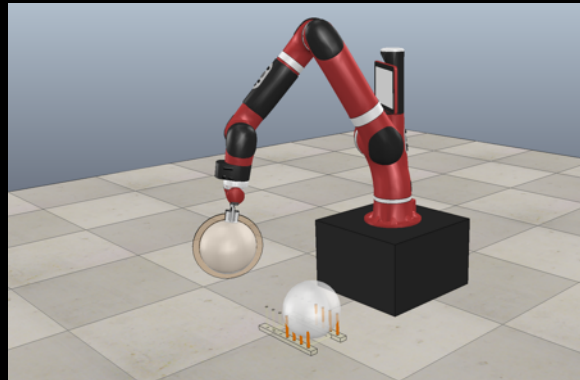
sparse reward



sparse reward



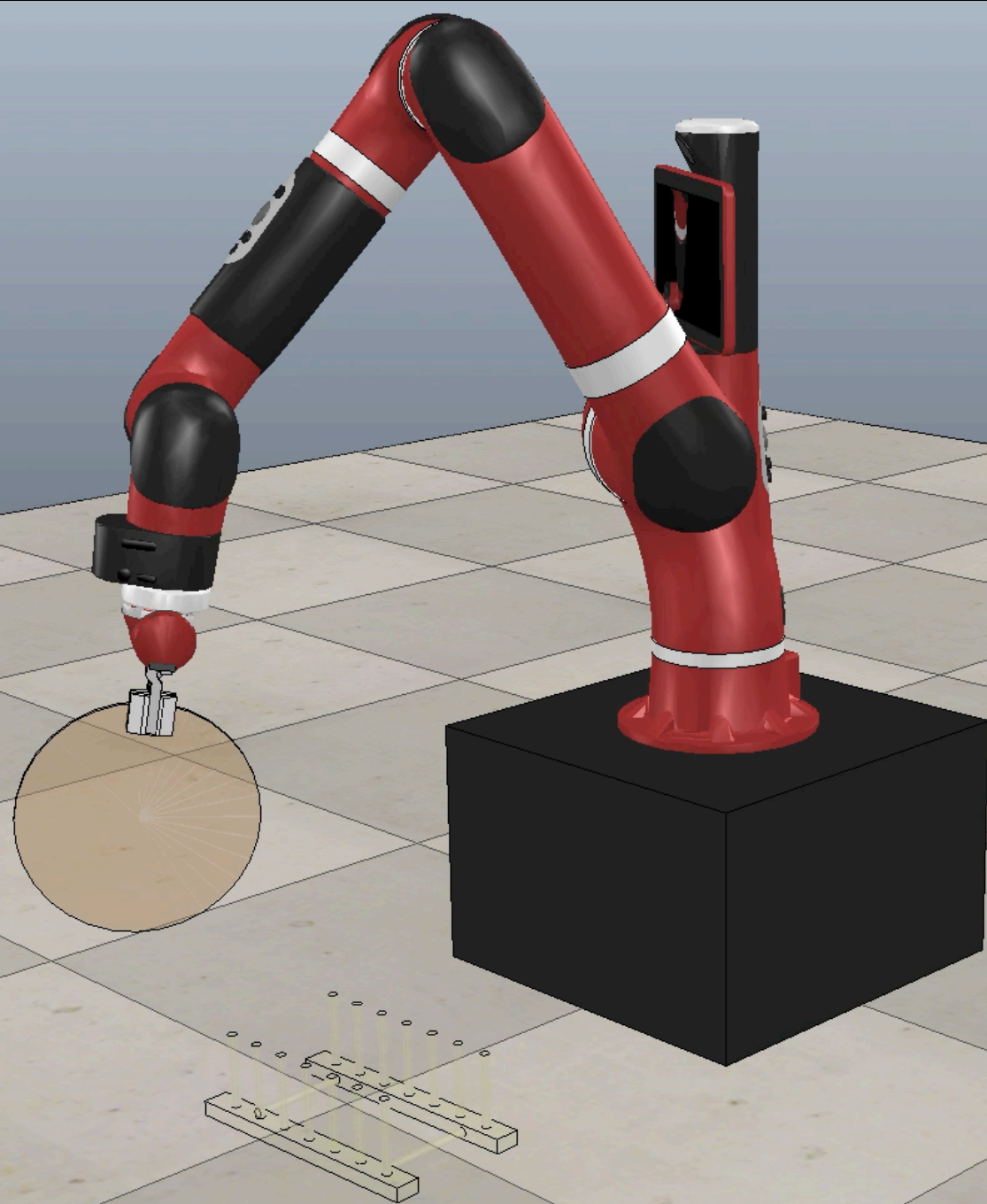
sparse reward



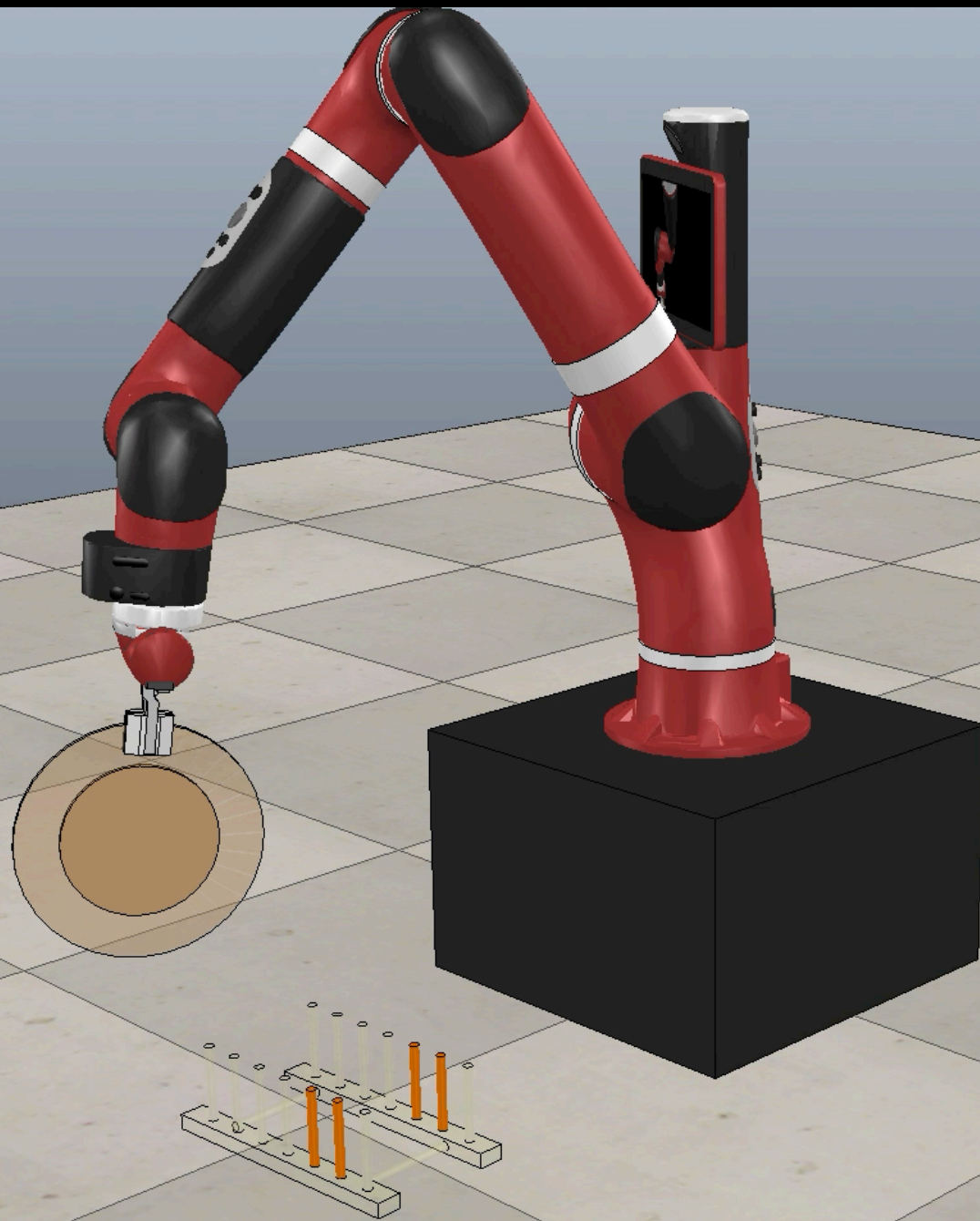
sparse reward



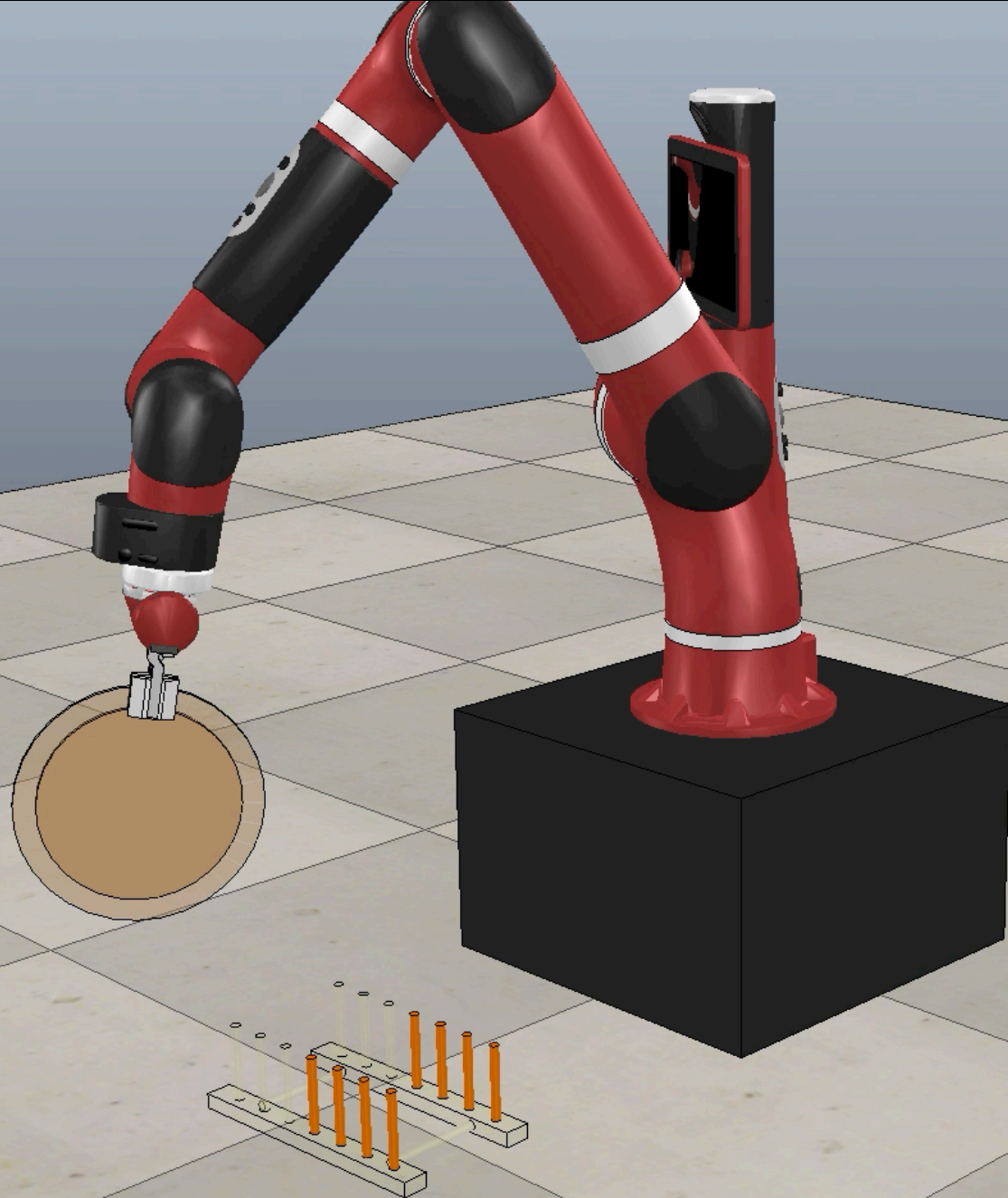
dense
reward



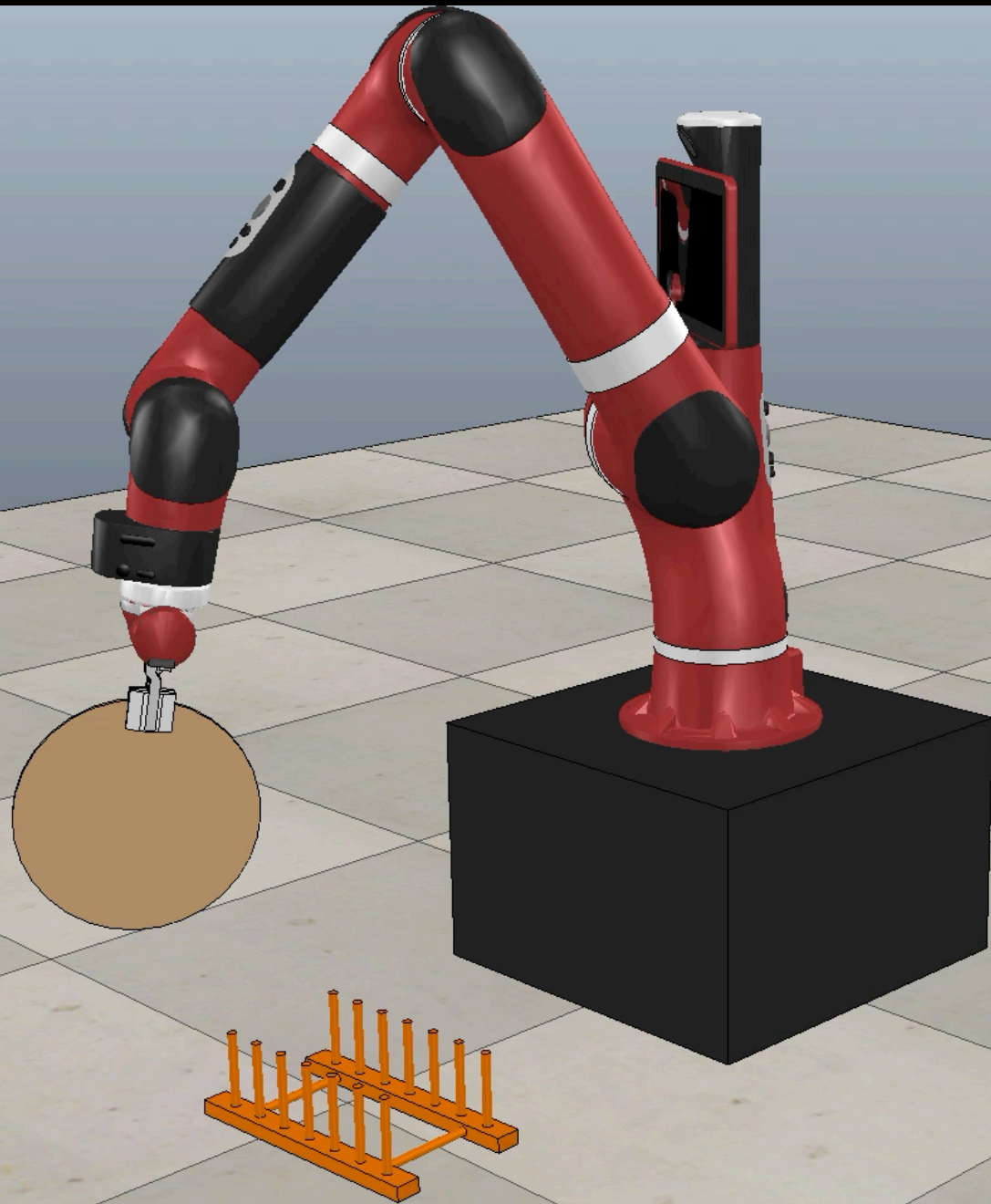
sparse
reward



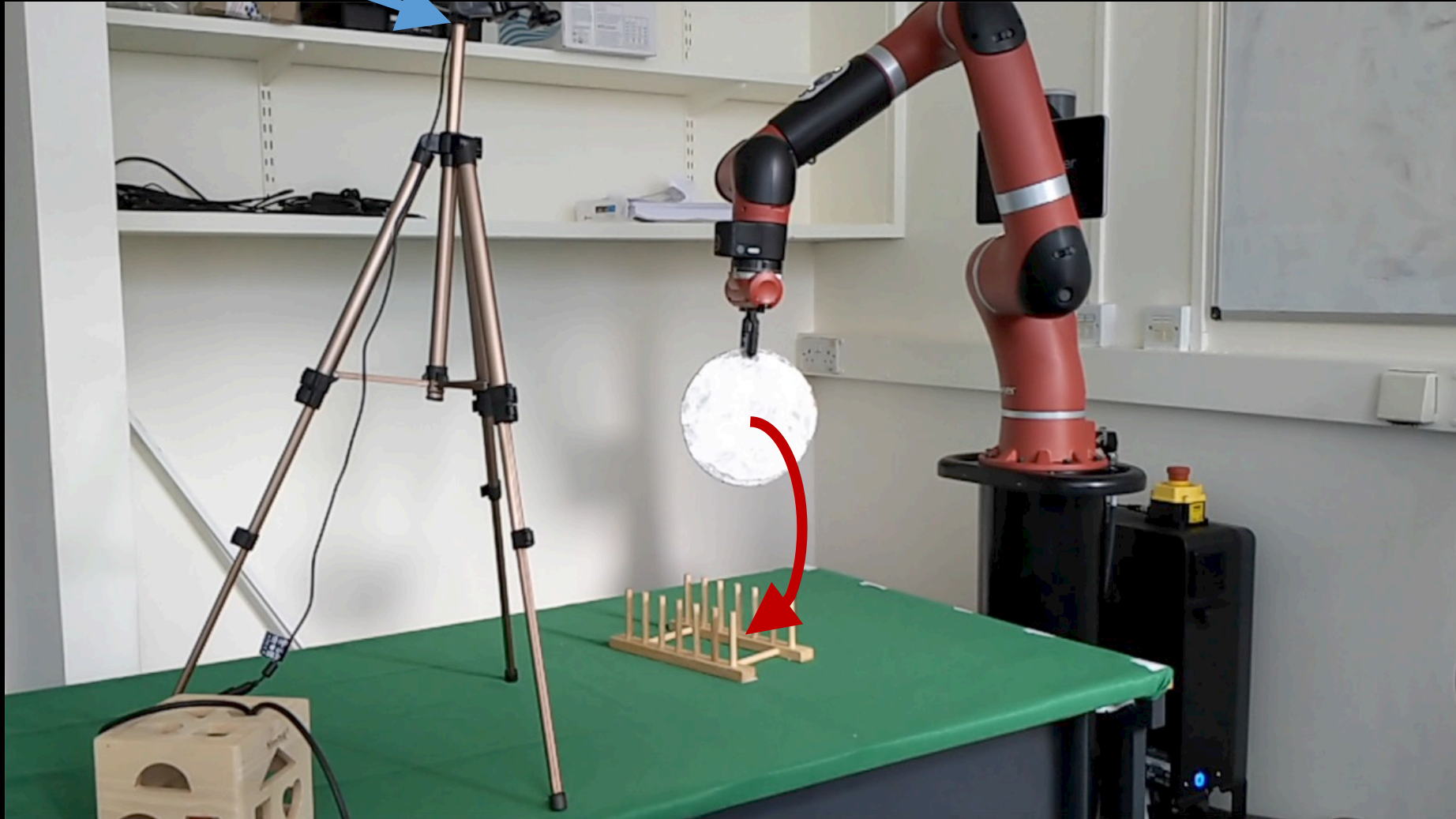
sparse
reward

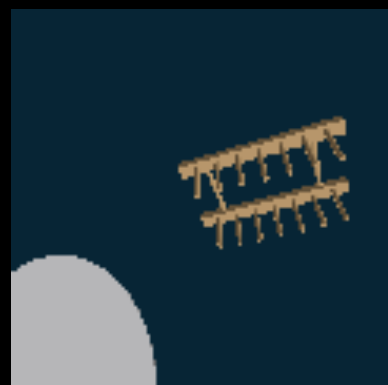


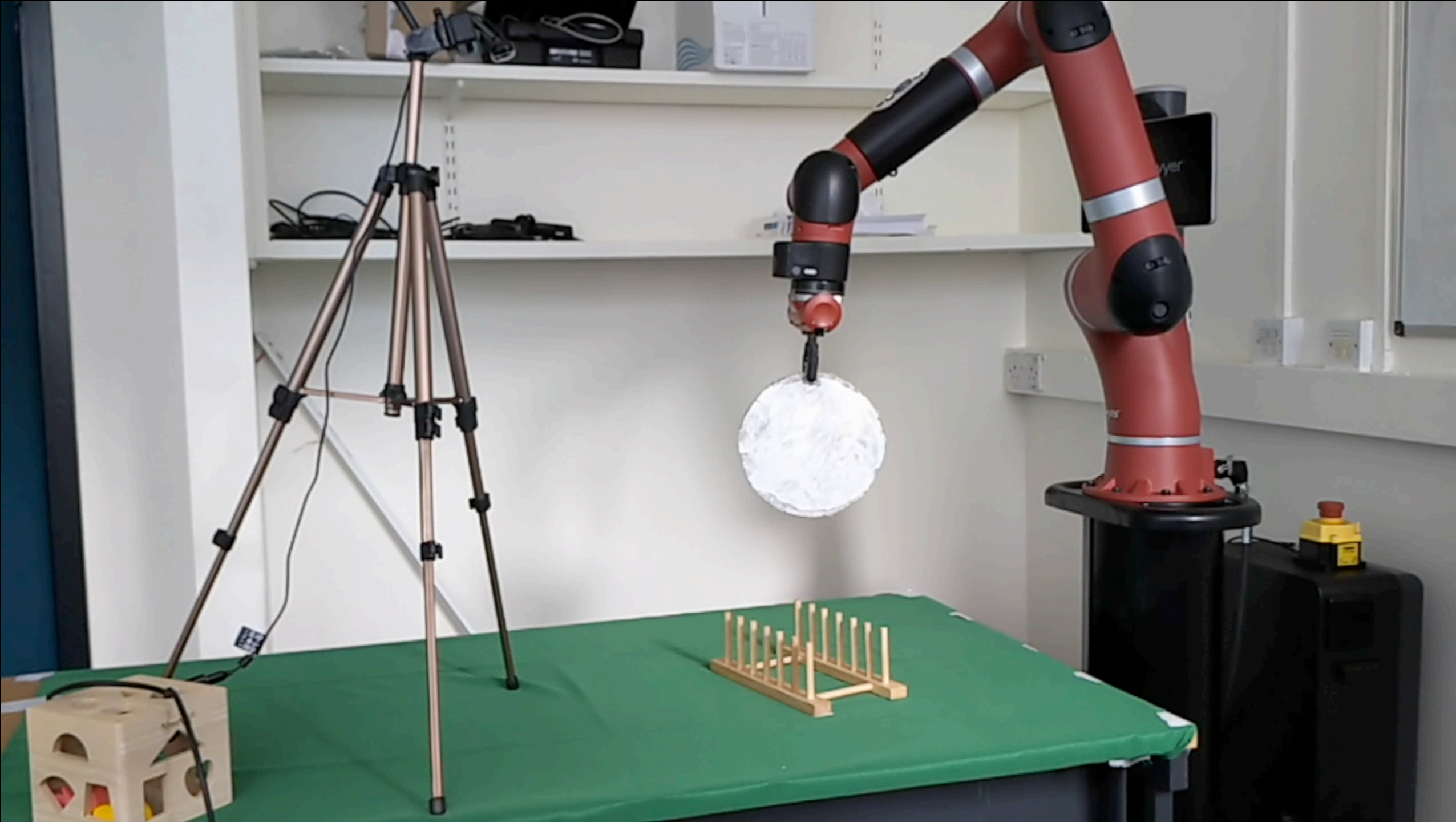
sparse
reward

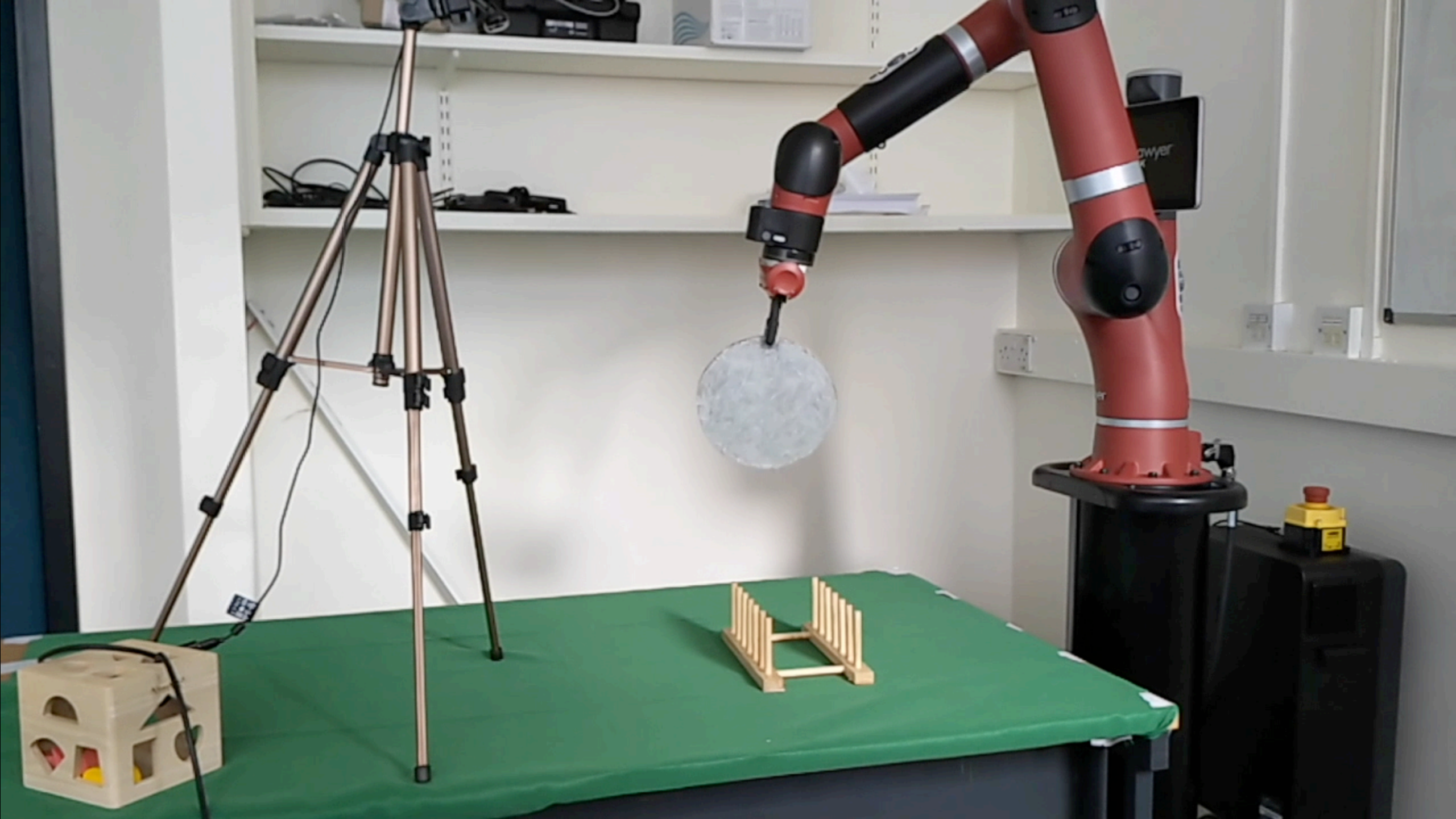


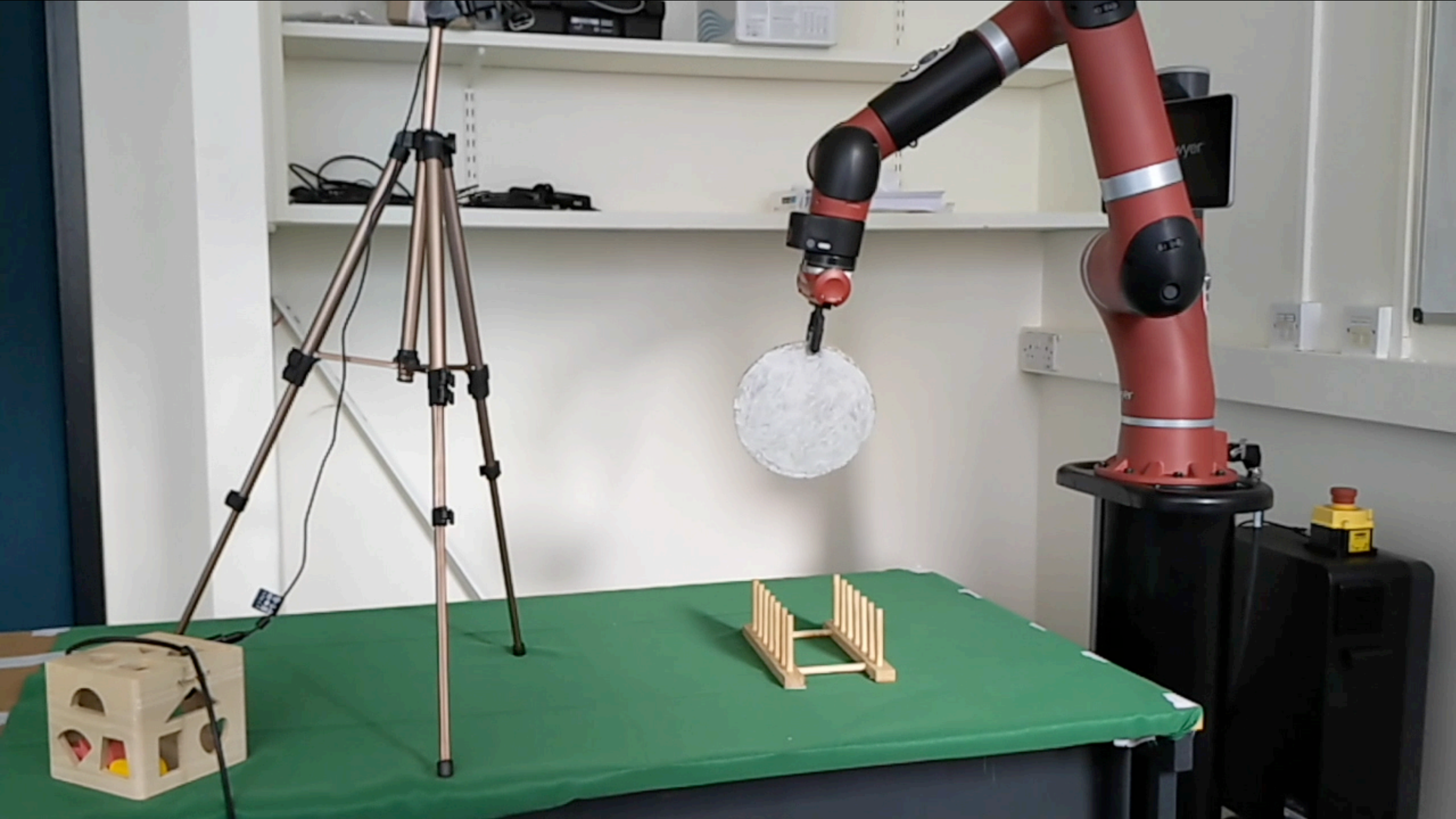
camera





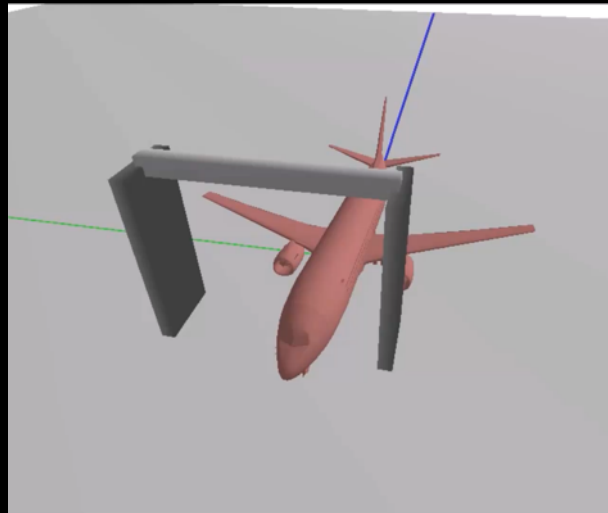






1

Ease of Large-Scale
Data Collection



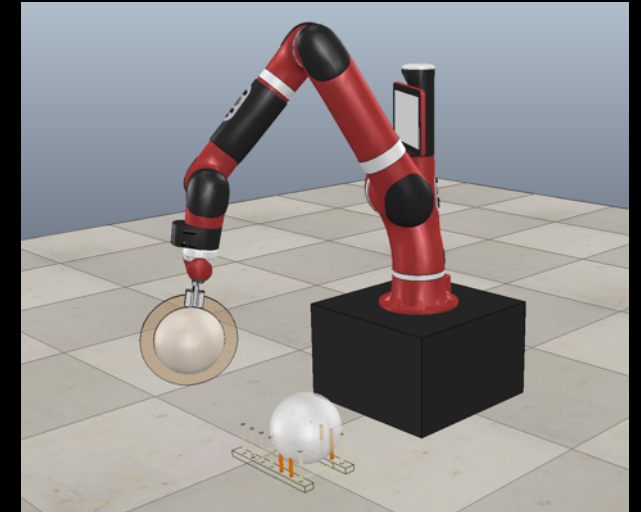
2

Access to
Full State



3

Ability to Modify
Environment



Three Benefits of Simulators for Zero-Shot Transfer

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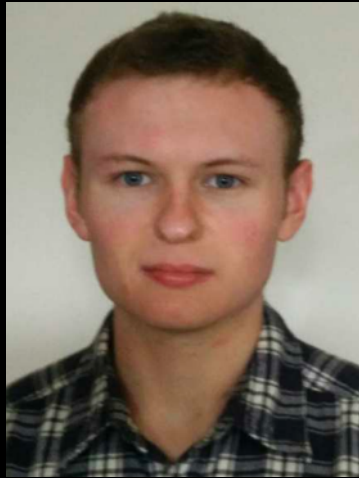
The Robot Learning Lab
at



Imperial College
London

23rd June 2019

Stephen
James



Harry
Uglow



Andrew
Davison



dyson

EPSRC

Engineering and Physical Sciences
Research Council



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Three Benefits of Simulators for Zero-Shot Transfer

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The Robot Learning Lab
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Imperial College
London

23rd June 2019