Using learning from demonstration (LfD) for robotic apple harvesting

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Learning from Demonstration (LfD)

Human Demonstration



LfD

for Any Actions
(action diversity)









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Pictures taken from https://umi-gripper.github.io/

Benefits of LfD

- Main principle:

End-users can teach robots new tasks without programming.

- In agriculture?
- Farmers teach robots new tasks
- Robots can learn multiple tasks

Multi-purpose & easy to use robots

LfD towards apple harvesting

- Complex actions
- Complex environment







Pictures taken from https://umi-gripper.github.io/, https://www.appleselect.nl/nl/over-bonita/, and own work

LfD to perform complete apple harvesting task

Task

- How to deal with variation?
- How to learn the complete task?

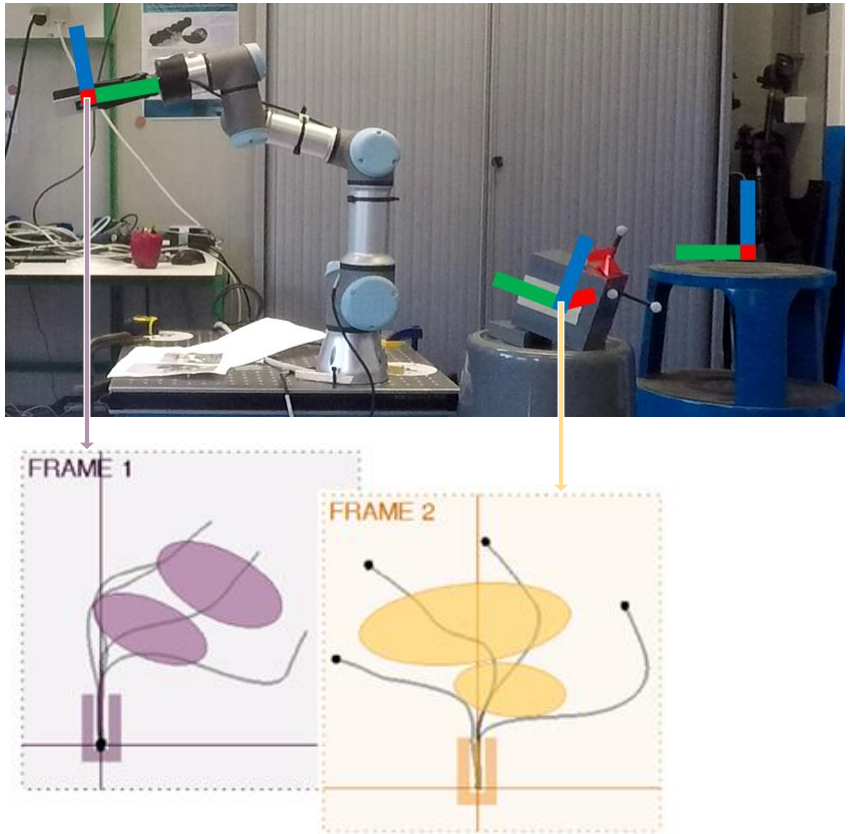
Method

- How many demonstrations?
- What parameters?

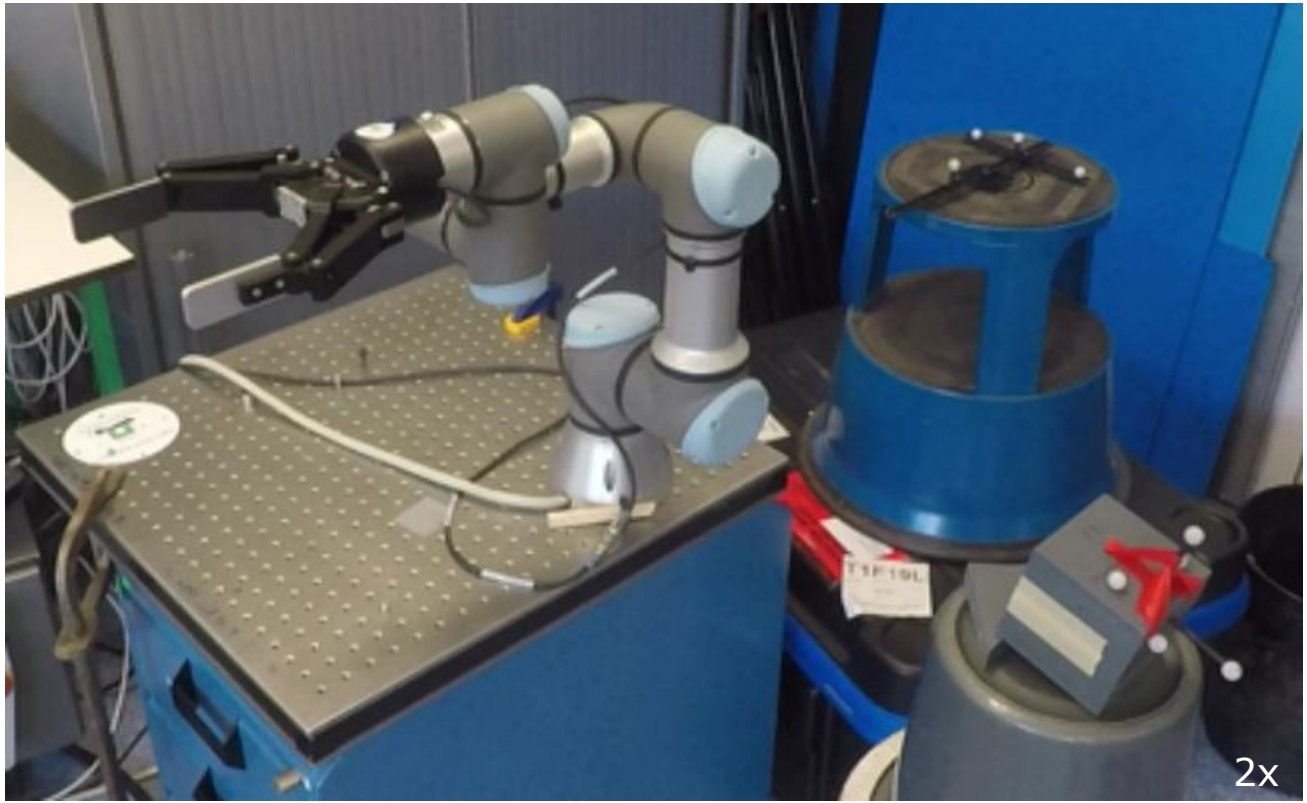


Deal with variation & learn complete task

- Task Parameterization
- Phases in apple harvesting task



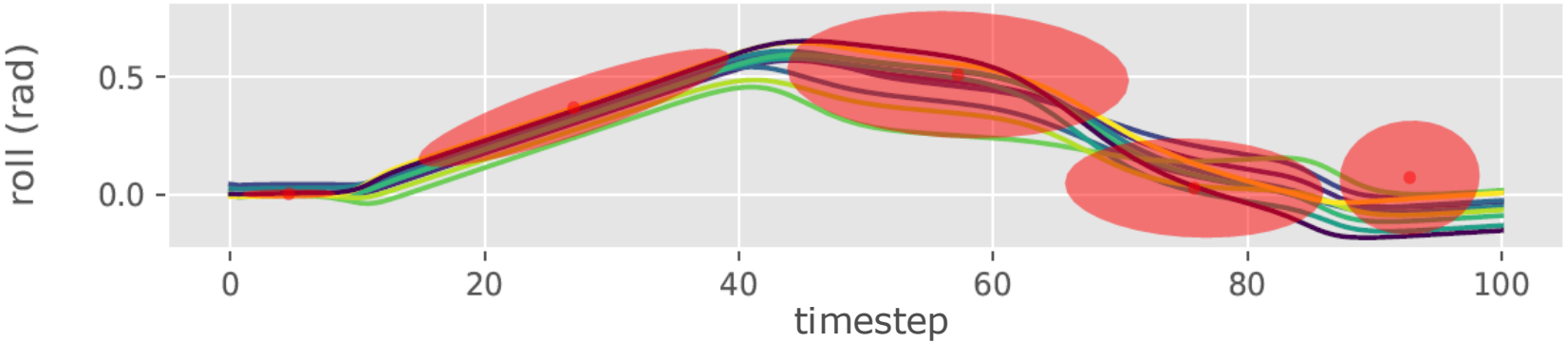
Results



Results

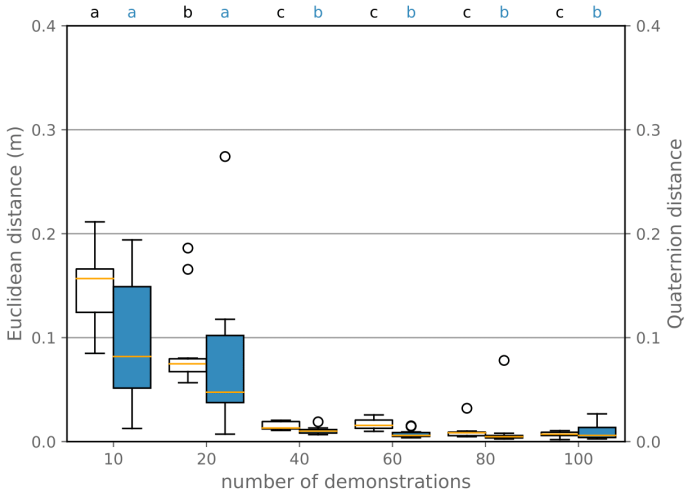


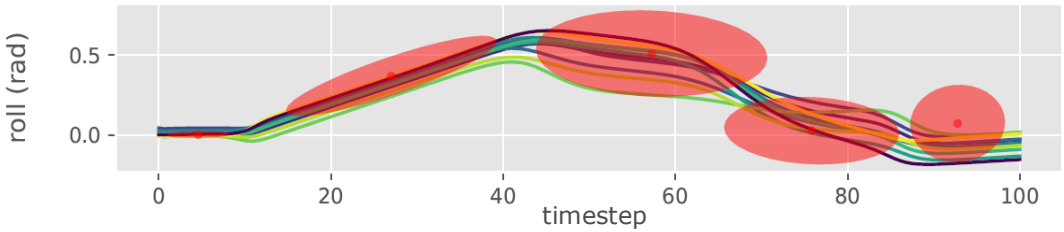


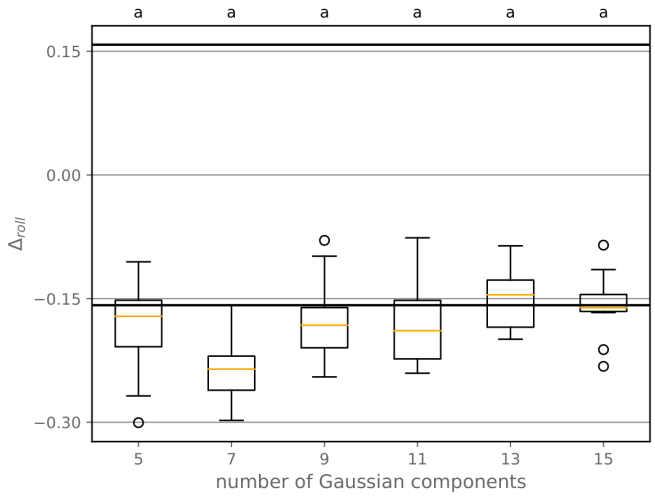



Results

- How many demonstrations?
  - 40 demonstrations
- What parameters?
  - Gaussian components minimal influence





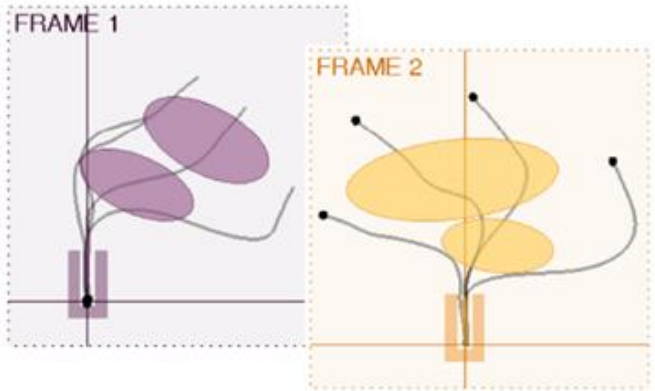


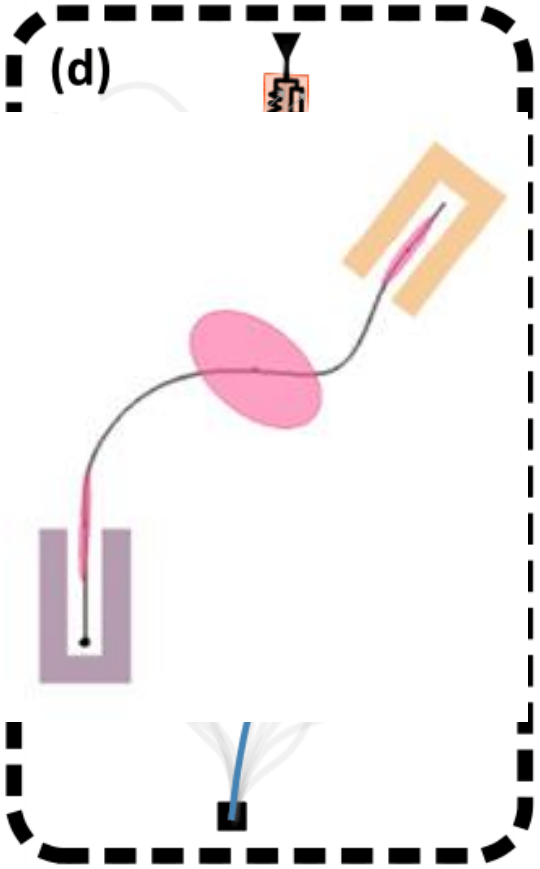
Discussion

- Assumed static environment
- Orchard is not static!
    - Apple movement during approach

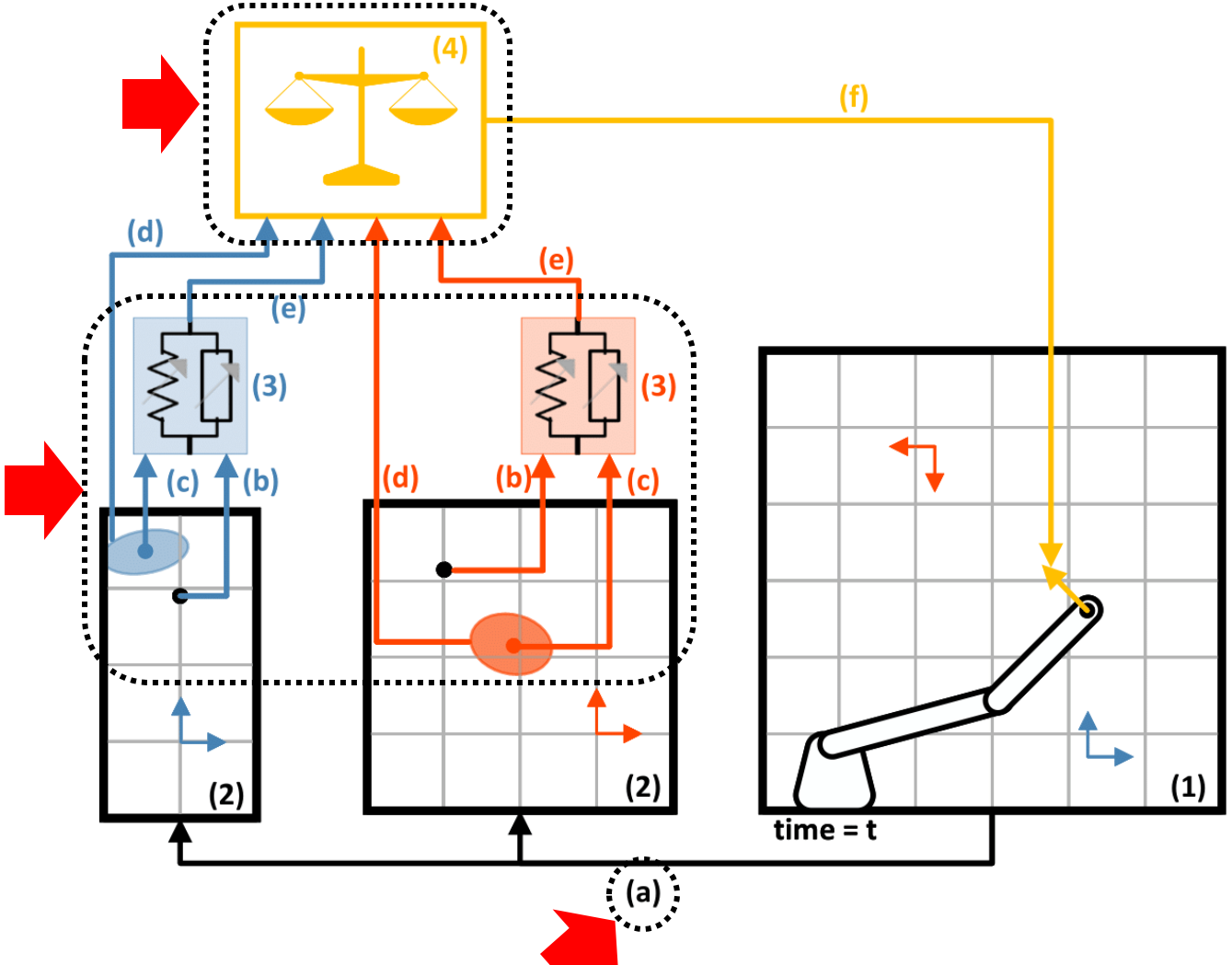


Adjusting methods



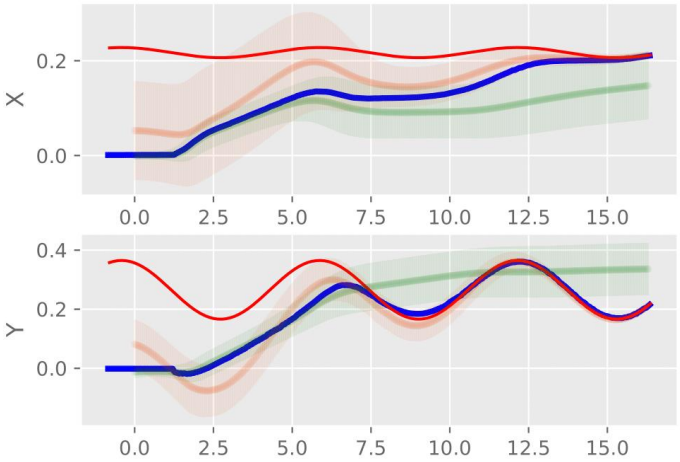


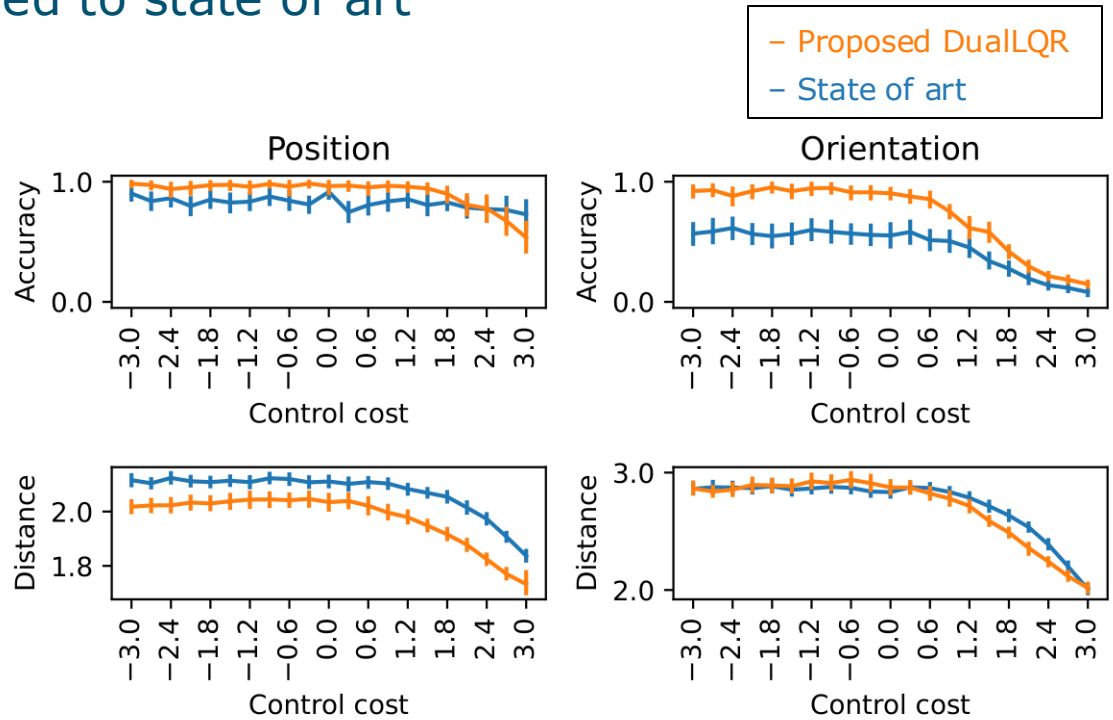
DualLQR



Simulation testing

- Close tracking when near to target
- Reduced distance compared to state of art



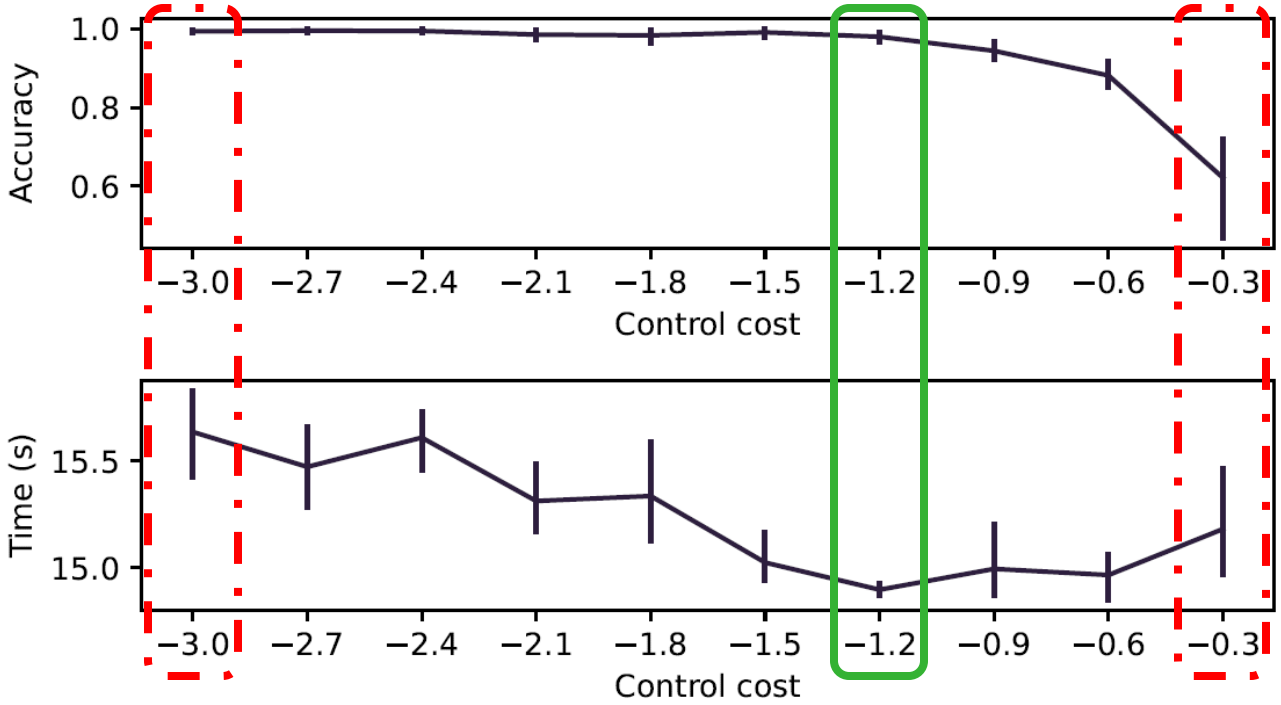


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Apple grasping experiment

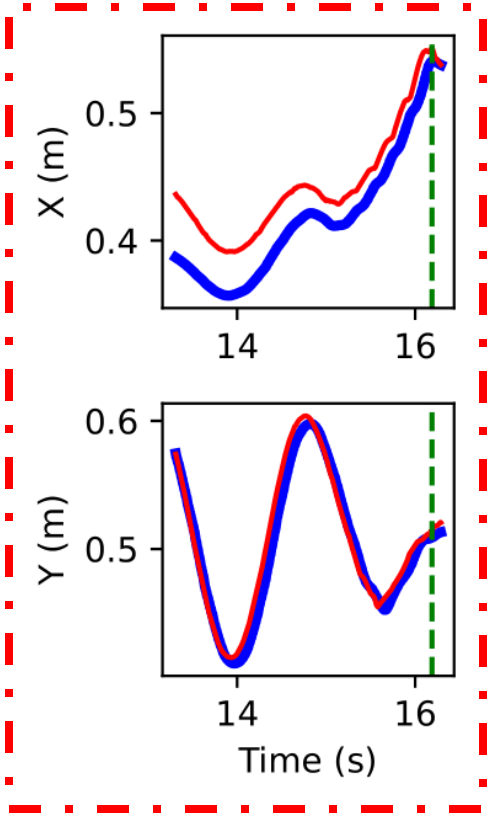


Apple grasping experiment



Undesired behaviour

Control cost at -3.0

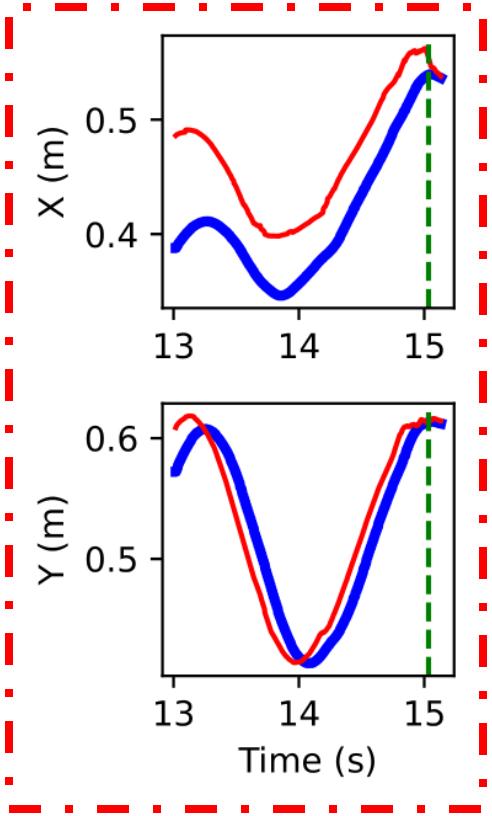




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Undesired behaviour

Control cost at -0.3

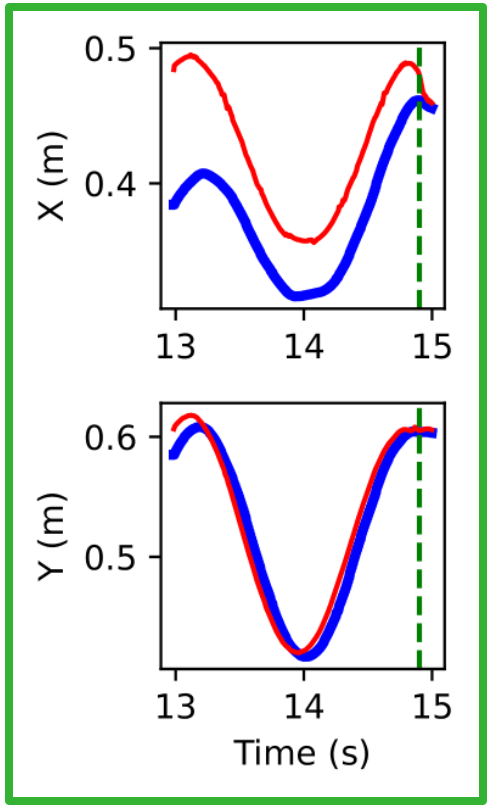




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Desired behaviour

Control cost at -1.2





Discussion

- Perfect pose estimation of apple
    - Test set-up with vision based pose estimation
- Challenge of feedback loop in orchard
    - Vision blocked by suction cup

Take home message

LfD can be used to grasp **moving apples** and perform the **detachment motion**



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