Toward Robot Co-Labourers for Intelligent Farming

Zhuoling Huang

Supervisors: **Prof Simon Parsons**

Prof Elizabeth Sklar

Photograph by Dina Litovsky / Redux for The New Yorker

Introduction

1. **Picking point detection method**
- Method
- Potential improvement

2. **Robot behaviour study**
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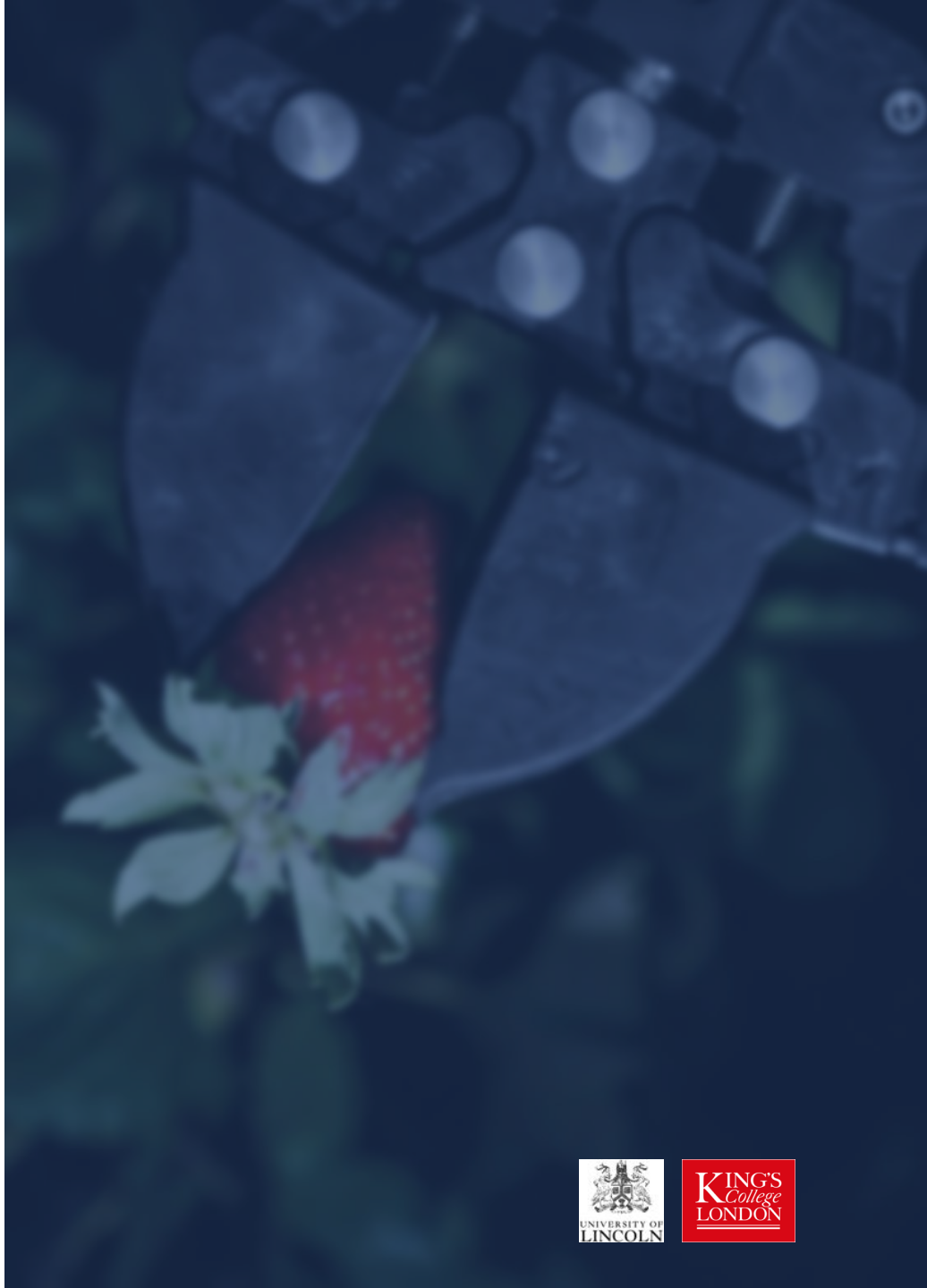
- Experiment design
- Experiment results

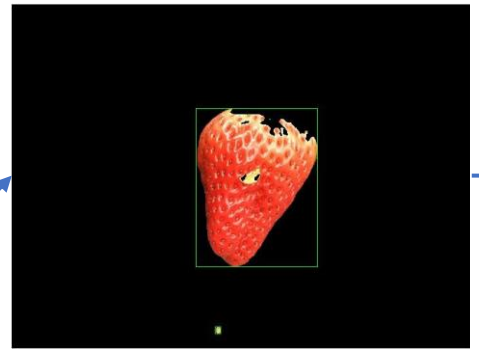
3. **Current work**

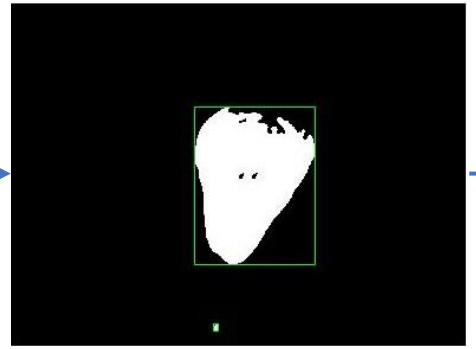


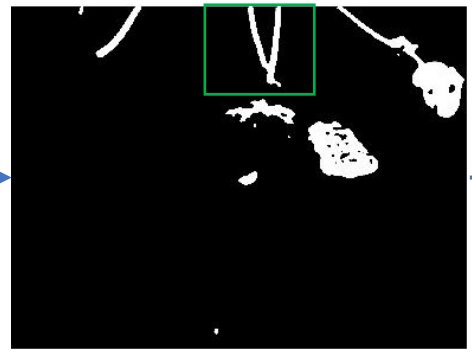
1. Picking point detection method

Method

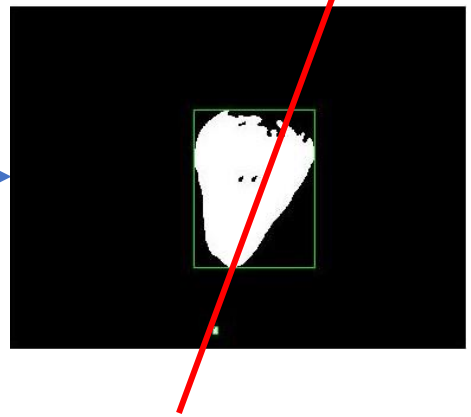
Colour segmentation







Crossing lowest point and centroid

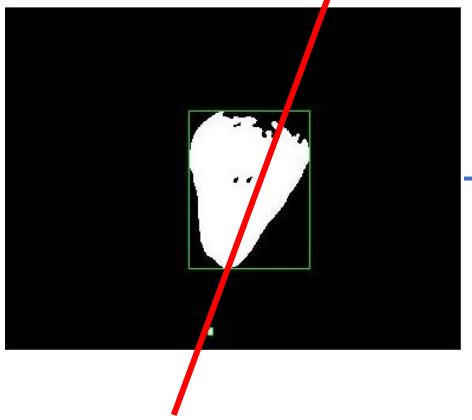


Potential area for picking point

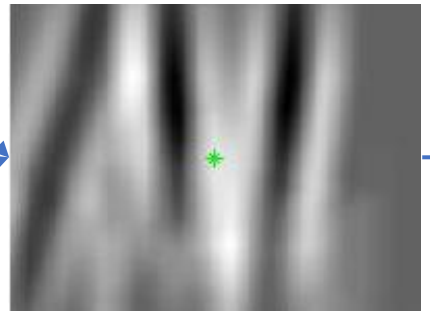
1. Picking point detection method

Method

Crossing lowest point and centroid



Template based on this angle



Template matching

Potential area for picking point

1. Picking point detection method

Potential Improvement

- Combine with machine learning

- 2D → 3D

→

2. **Robot behaviour study**

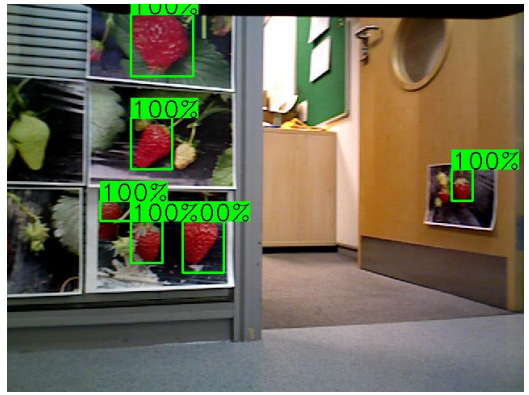
Detection methods comparison

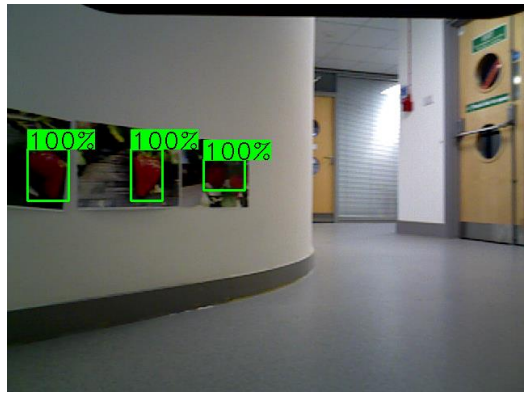
Faster R-CNN (by Adrian)

The Faster R-CNN used in our experiments follows the network structure proposed in [1], while the detection network following the RPN is based on a Fast R-CNN structure [2].

The training dataset we used for Faster R-CNN contains 540 images, containing 3738 ripe strawberries, and 3735 unripe strawberries. There is great variation in size, shape, and color among the ripe strawberries in the training pictures.

In Faster R-CNN, both the RPN and the detection network share convolutional layers, making the model much faster and more efficient than other region-based approaches [1]. However, the shared structure for both the RPN and classification network leads to mismatched goals in feature learning, which typically increases the number of **false positive** predictions produced by Faster R-CNN.





[1] Ren, S., He, K., Girshick, R., Sun, J.: Faster r-cnn: Towards real-time object detection with region proposal networks. In: Advances in neural information processing systems (2015)
[2] Girshick, R.: Fast r-cnn. In: Proc of IEEE intl conf on computer vision (2015)

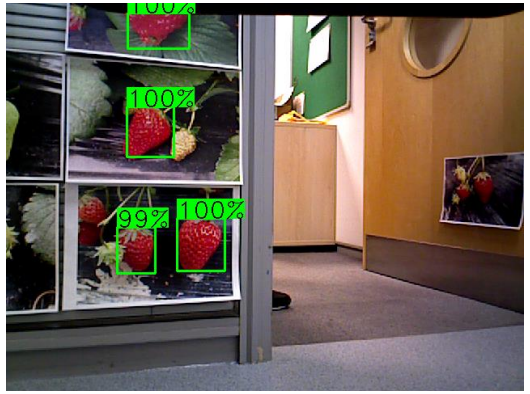
2. **Robot behaviour study**

Detection methods comparison

YOLOv3 (by Richie)

For our set of experiments, we implemented the YOLOv3 object detection network utilising the Darknet-53 feature extractor. The YOLOv3 model also utilised pre-trained weights of Darknet-53 originally trained on the COCO data set [3]

The training dataset we used for YOLOv3 contains 145 images from the same dataset as Faster R-CNN, including 1497 ripe strawberries and 2047 unripe strawberries. During training, images were scaled to a resolution of 608x608 pixels.



[3] Redmon, J., Farhadi, A.: Yolov3: An incremental improvement. arXiv (1804.02767)(2018)

2. **Robot behaviour study**

Detection methods comparison

Provides two different robot behaviours in this experiment:

	Method	Name used to reduce bias against methods	Key feature	Explain	Example
Robot Behaviour 1	Faster R-CNN	Robot F	More false positive (FP)	Higher probability to recognise non-strawberries as strawberries.	
Robot Behaviour 2	YOLOv3	Robot Y	More false negative (FN)	Higher probability to miss strawberries.	

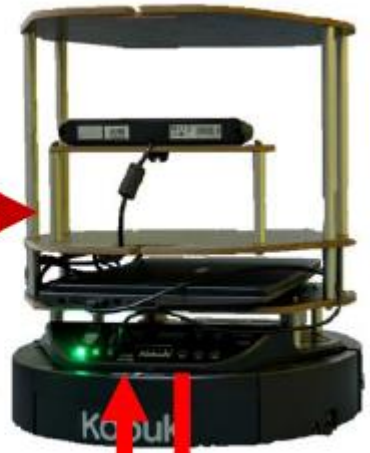
shows strawberry detected by robot

2. **Robot behaviour study**

Experiment Design

Simulated Farm

Image



Turtlebot2

Image

GUI

Feedback for updates

Image with detection information

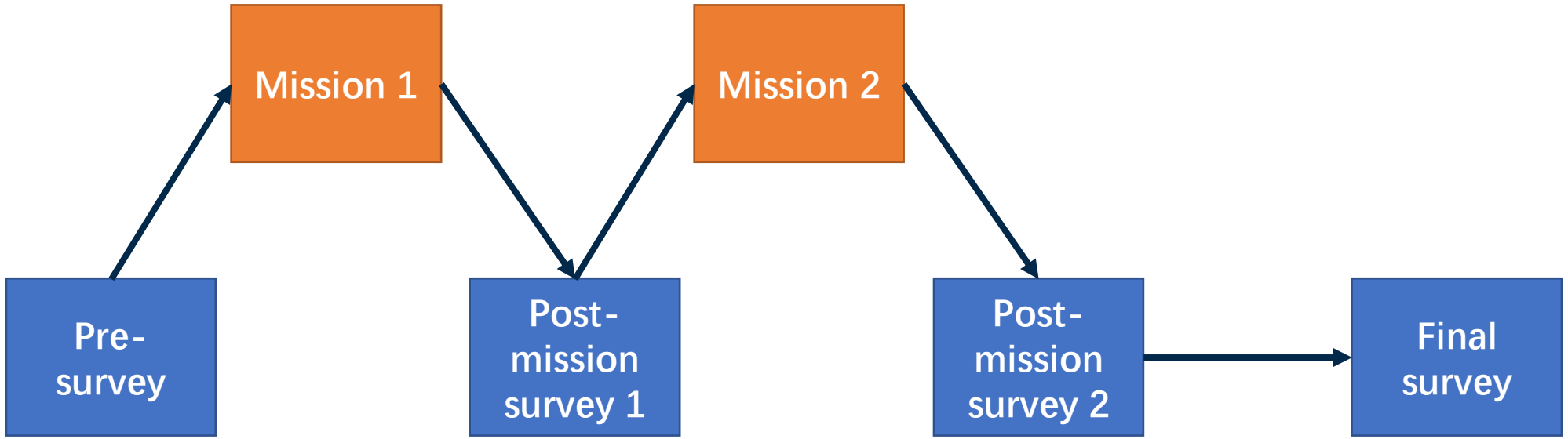
Vision server

2. **Robot behaviour study**

Experiment Design

Missions: user work with two different robot behaviours (YOLOv3 or Faster R-CNN) in a random order

Surveys:



Four features being evaluated:
success, collaboration, trust and speed.

2. **Robot behaviour study**

Experiment Results

30 users took part in the experiment.

- the differences between time metrics and the total numbers of strawberries are minimal
- there are significant differences in the number of TP, FP and FN results
- Robot F providing more false positives and Robot Y providing more false negatives, was noticeable to the users

	Robot F	Robot Y	t (p)	Significant?
interaction time (s)	471.9 (197)	456.2 (208)	0.4 (0.69)	no
Number of TP	52.7 (2.9)	36.5 (1.9)	26.0 (1.1E-21)	yes
Number of FP	6.7 (2.8)	0.7 (0.9)	11.9 (1.1E-12)	yes
Number of FN	29.0 (13.7)	43.0 (15.4)	-6.8 (1.8E-7)	yes
total	No. 81.7 (14.3)	79.5 (15.4)	1.2 (0.25) no	no

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2. **Robot behaviour study**

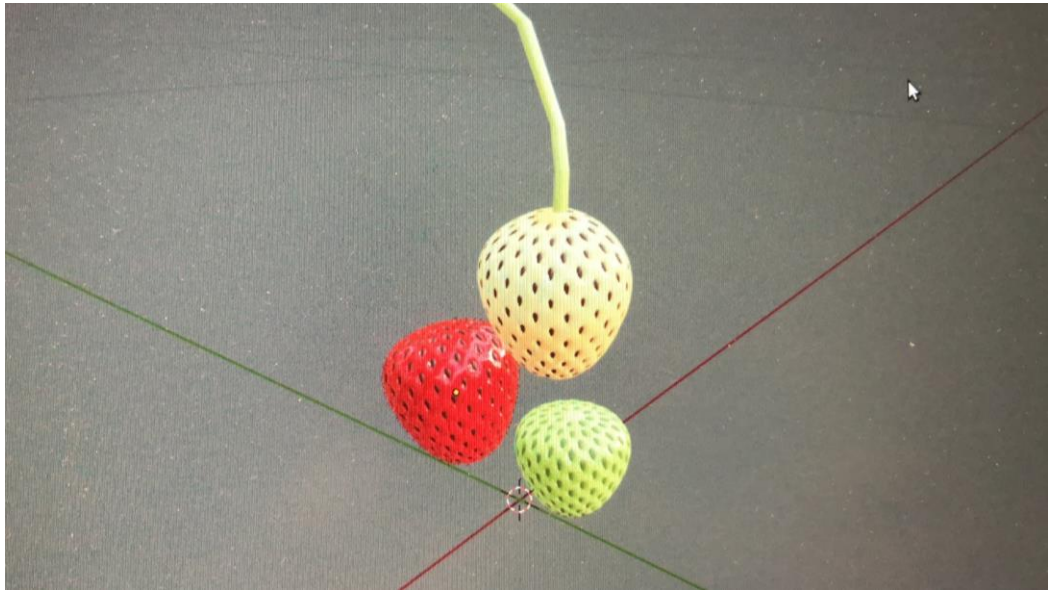
Experiment Results

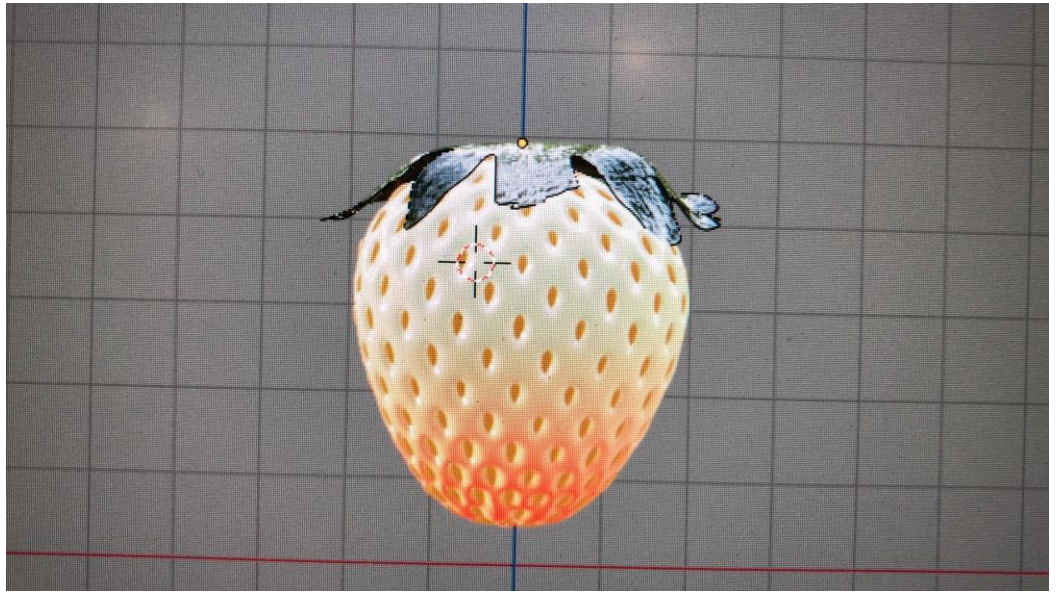
30 users took part in the experiment.

- During the interviews, 29 out of 30 users mentioned specifically that the two robot behaviours are **noticeably different** because one provides more false negatives and the other provides more false positive answers (or equivalent description)|which implies that our setup is obvious enough to compare as we have done here.
- Our results show that **neither** detection method is more accurate than a human working alone but users felt that working with robots would speed up their overall task.
- Users indicated a **higher tolerance** for the robot that made mistakes (false positives) as opposed to the robot that missed samples altogether (false negatives).
- Our next steps involve demonstrating this task in a live strawberry farm and improving detection methods.

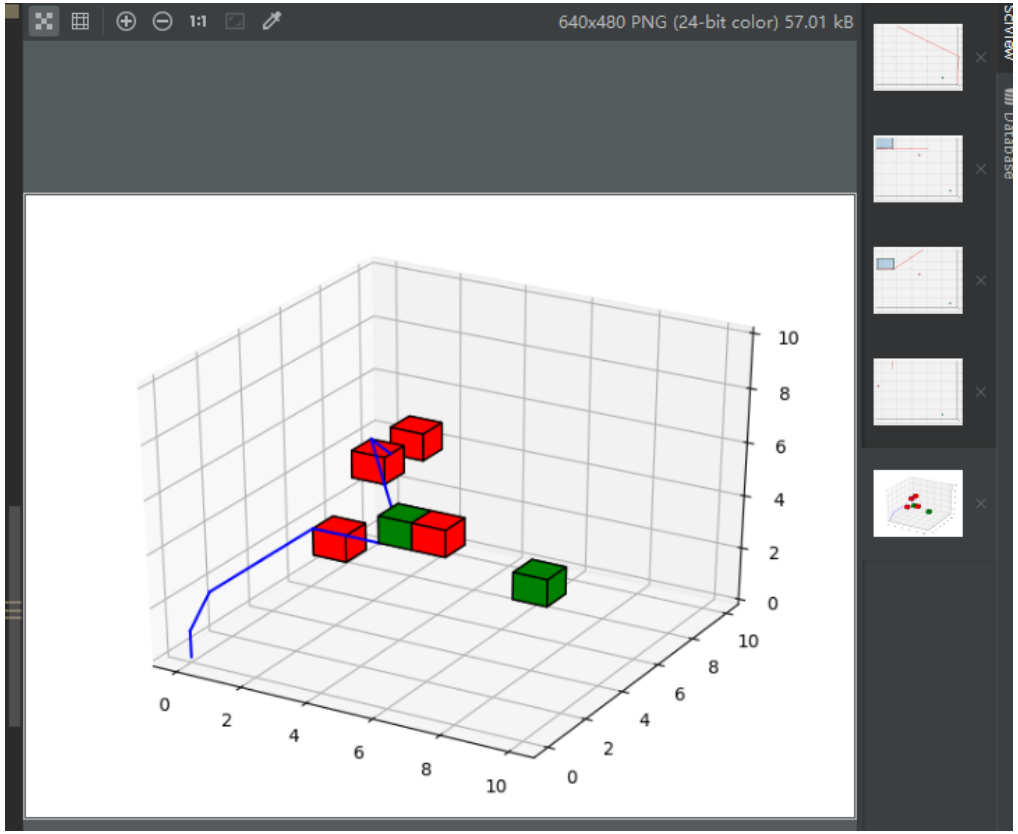
3. Current work

Simulated strawberry farm





Path planning for manipulator



- Green strawberry
- Red strawberry

Cheers!

zhuoling.huang@kcl.ac.uk