

ot2eye: Detection of labware conditions to monitor and extend affordable liquid-handling robots



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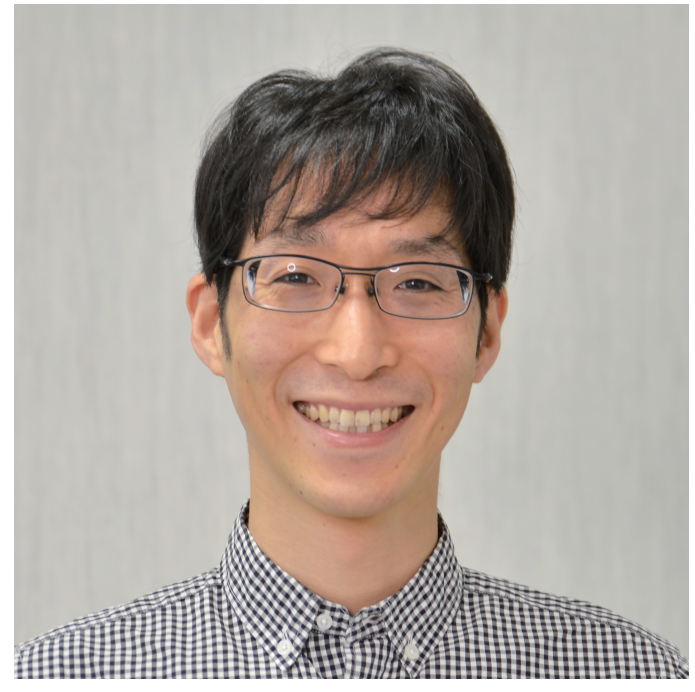
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Summary

- We developed ot2eye, a labware detection system for images and videos of Opentrons OT-2.
 - ot2eye can detect labwares (e.g. micro-well plates and tip racks) in images using the YOLO algorithm.
- Our results exemplifies how automatic detection of labwares helps to acquire labware states and search logs.



Motivation

- **Recording is important for laboratory automation**
 - To monitor the status of labwares, samples, & robots
 - To detect anomaly in the status and processes
- **Long video is hard to watch for humans**
 - Video is hard to “search” automatically
 - What we want to see is usually the small part of long video
 - Continuous monitoring of video is tough for humans

Methods

- Python, YOLO v5 (popular object detection algorithm)
- Fine tuning of YOLO model for *detecting labwares on OT-2*
 - Dataset: OT-2 labware annotation ver 1
 - train: 26, validation: 8, test: 2
 - Labels: 96-well plates, 6-well plates, tip racks, tips
- **Trade-off of computational cost and accuracy**

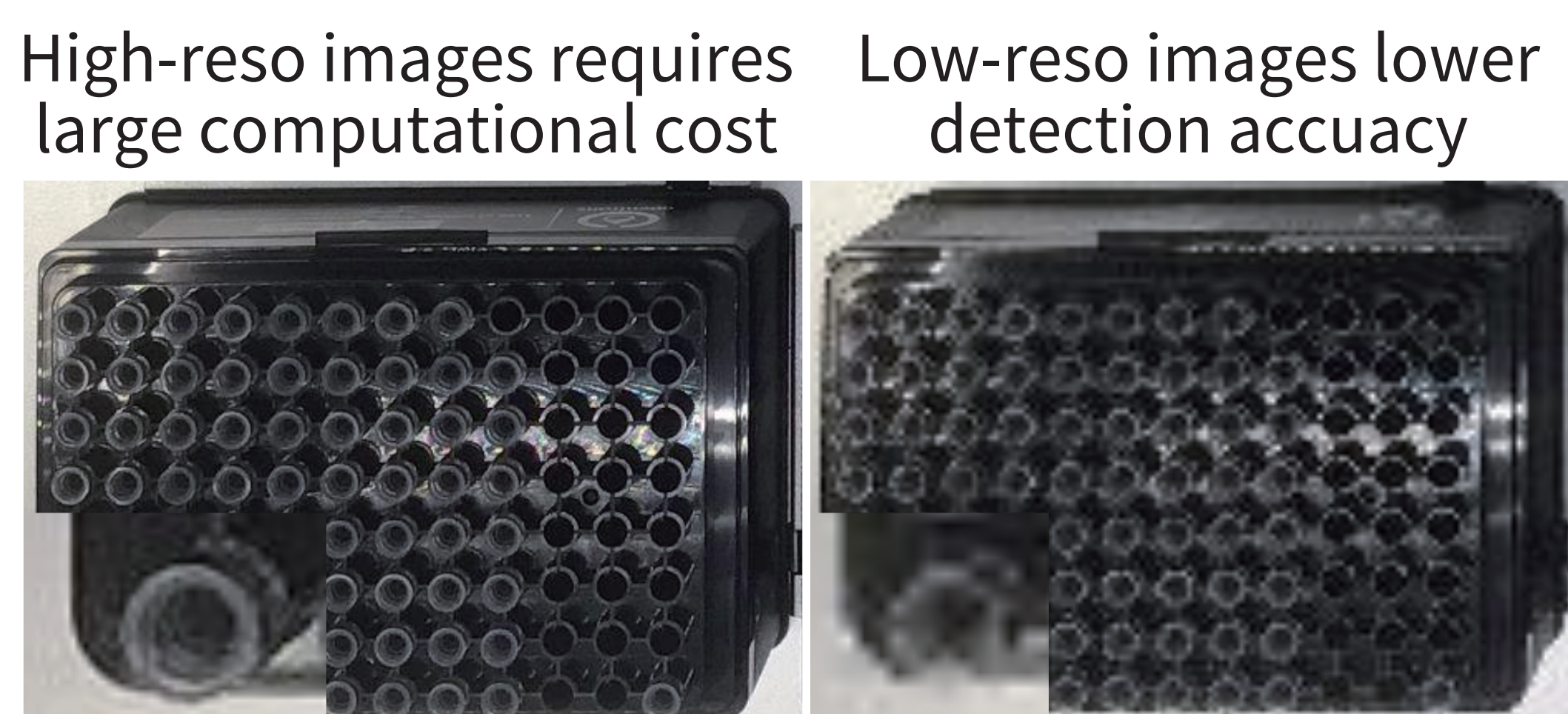


Fig. 1 High- and low-resolution image of a tip rack.

• Our solution

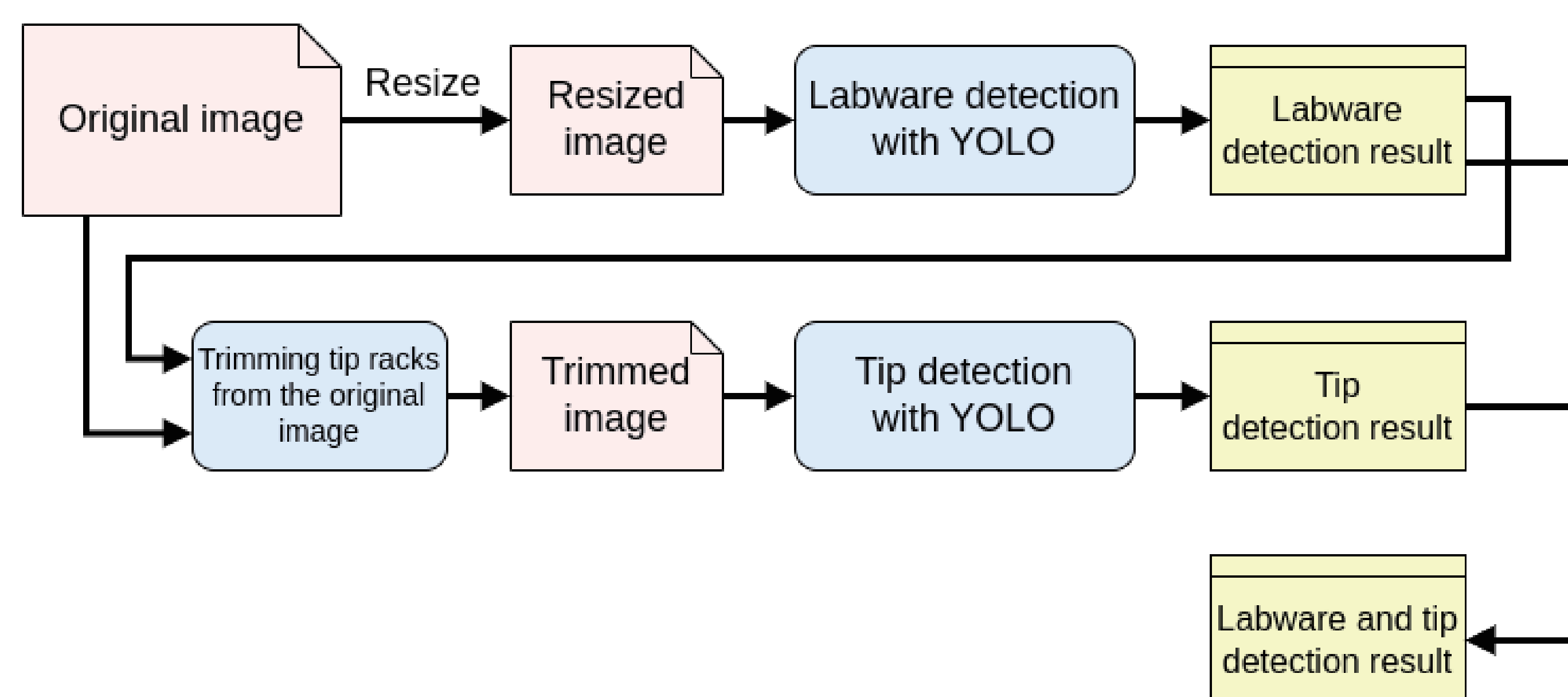


Fig. 2 Flowchat of ot2eye. We separate *labware detection* and *tip detection*. The use of trimmed high-reso image only for tip detection decreased computational cost.

Performance evaluation

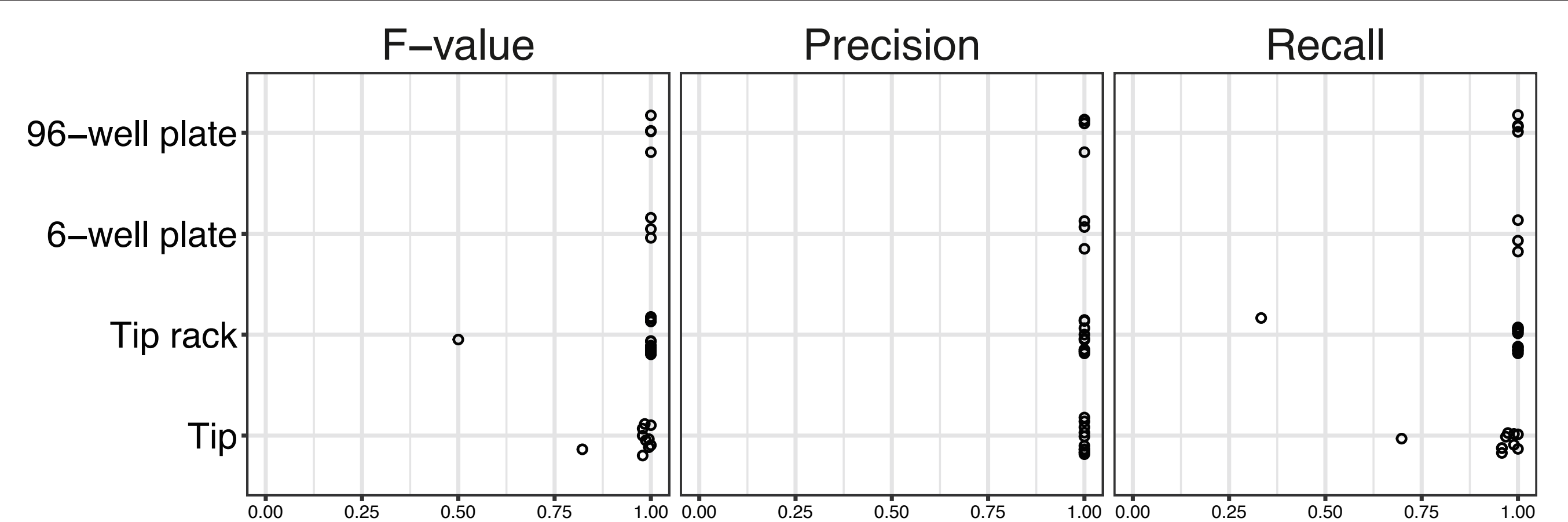


Fig. 3 Performance evaluation using test dataset.

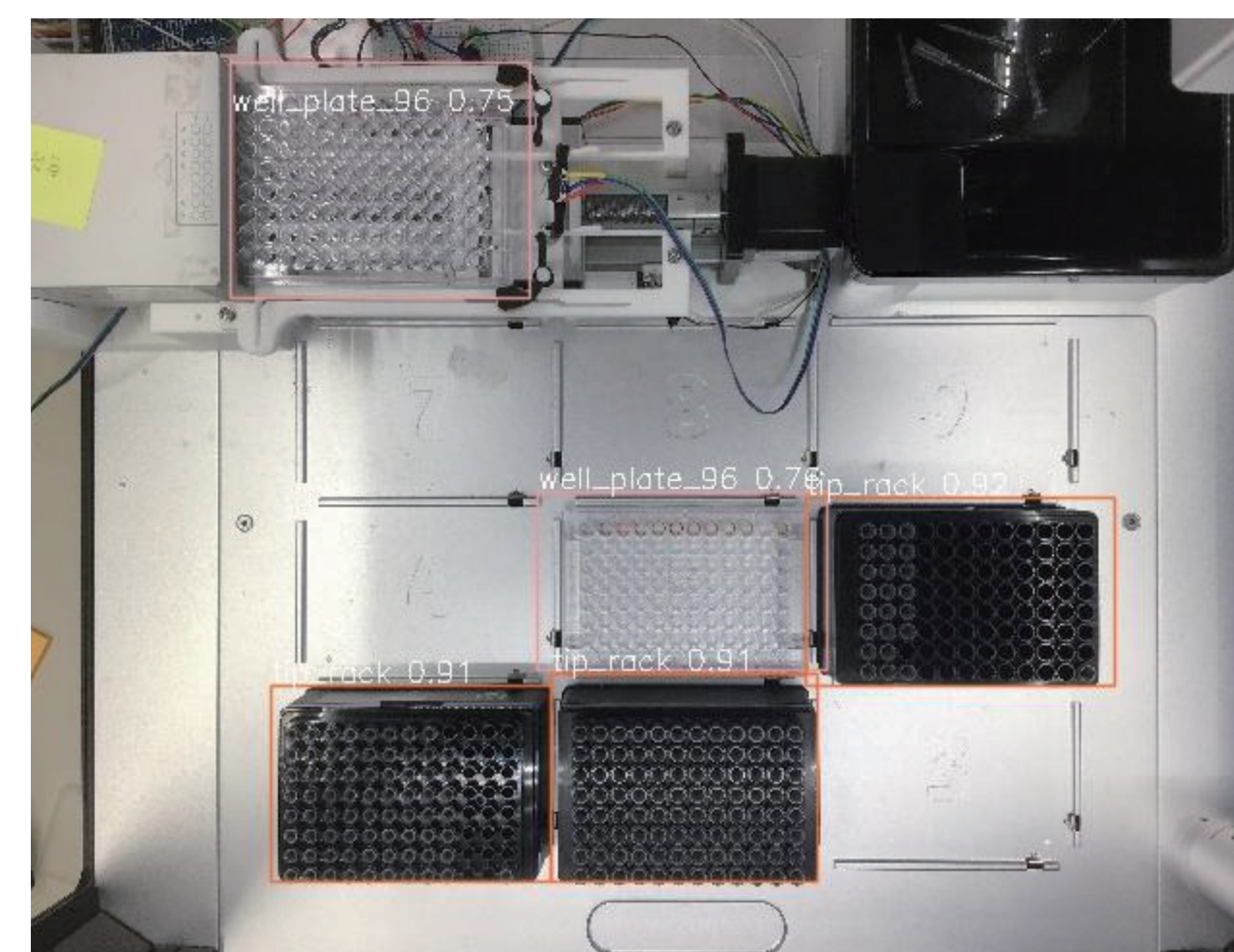


Fig. 4 Example of labware detection

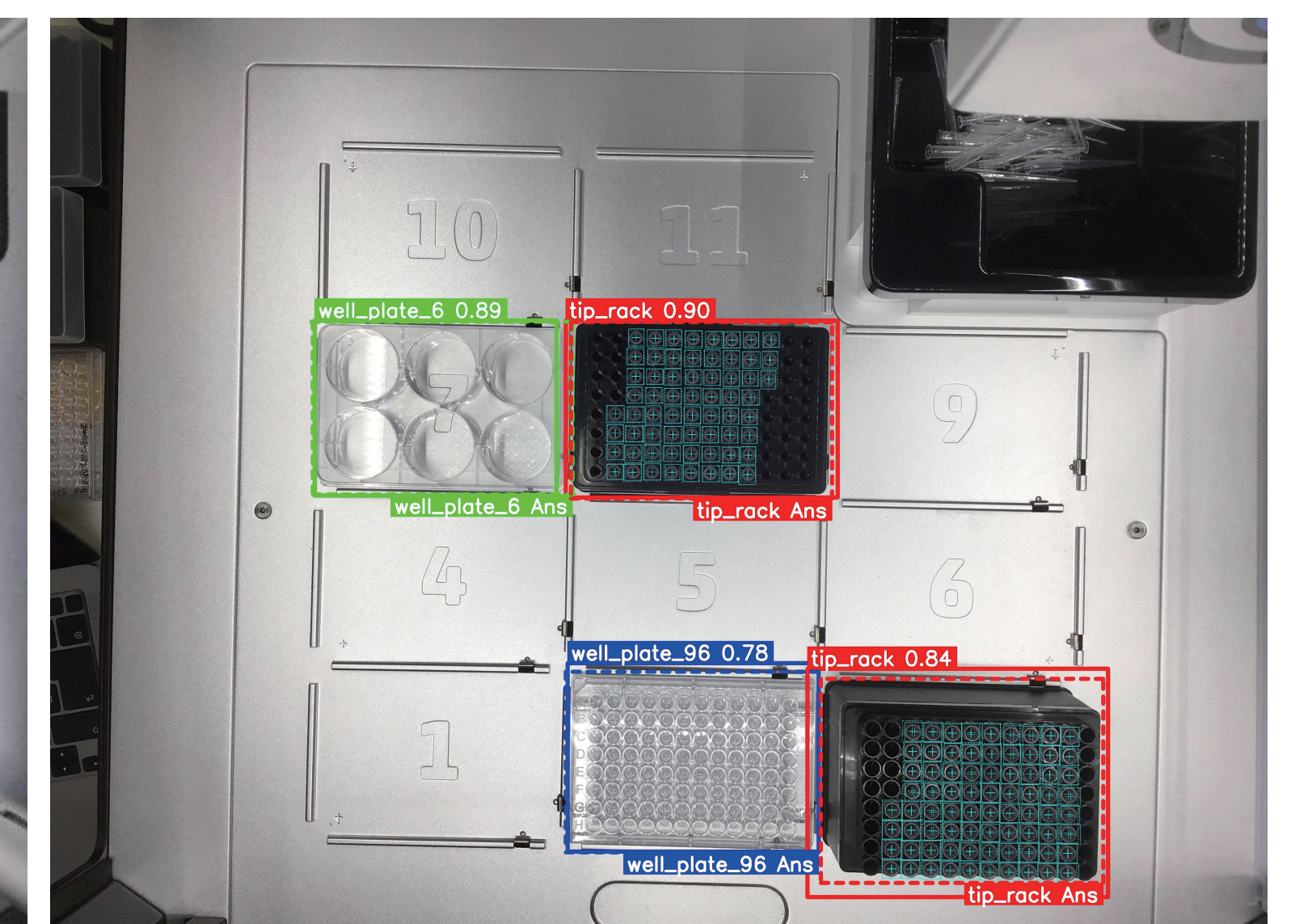
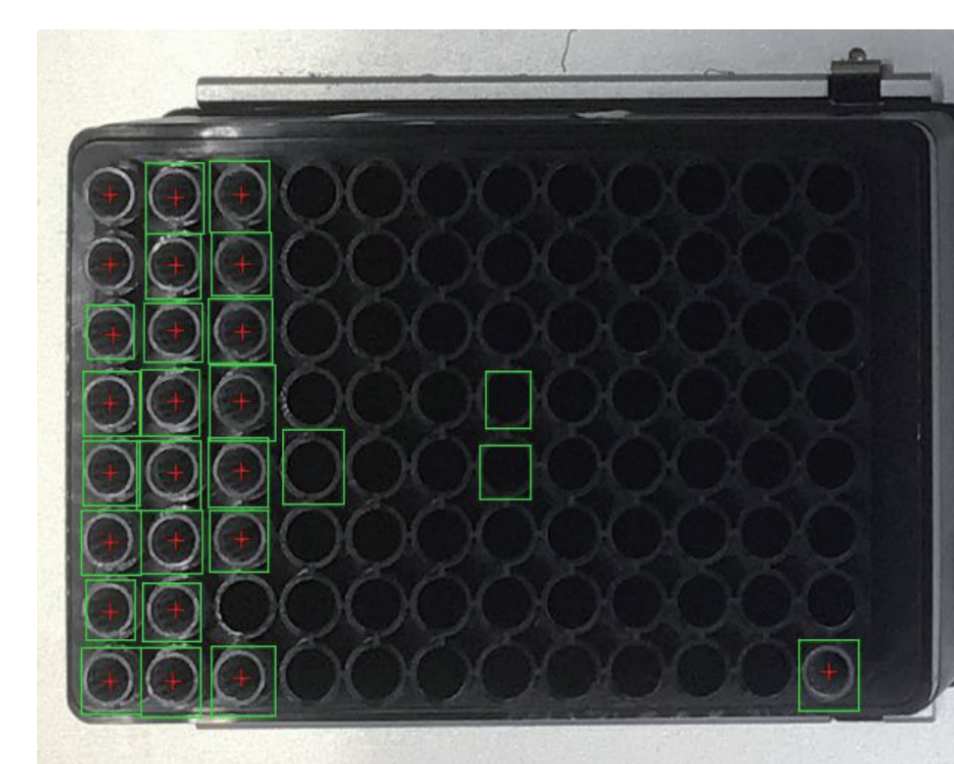


Fig. 5 Both predictions and ground truths (Ans) are shown.



Precision: 0.880
Recall: 0.917
F1-score: 0.898



Precision: 0.889
Recall: 1.000
F1-score: 0.941

Fig. 6 Examples of tip detection and matches to ground truths

Potential applications

• Textize long video

- ot2eye outputs labware detection results both by images and texts (.scv). The latter can be parsed easily.

• Search long video sequences for anomaly

- e.g. When the number/position of tips is unintended

• Check availability of labwares on the start of protocols

- Integration of OT-2 and ot2eye by Python is easily achieved
- e.g. Parsing OT-2 protocol for labware definitions, then checking the existence of labwares on deck using ot2eye

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