Fruit detection and 3D location using instance segmentation neural networks and SfM photogrammetry

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INTRODUCTION

The development of remote fruit detection systems able to identify and 3D locate fruits provides opportunities to improve the efficiency of agriculture management. Most of the current fruit detection systems are based on 2D image analysis. Although the use of 3D sensors is emerging, precise 3D fruit location is still a pending issue. This work presents a new methodology for fruit detection and 3D location, combining the use of instance segmentation neural networks and Structure-from-Motion (SfM) photogrammetry.

DATA ACQUISITION

- 11 Fuji apple trees containing 1455 apples.
- 582 photographs to create a 3D model using SfM (Fig. 1)
- Manual annotation by placing 3D bounding boxes around each apple.
- Dataset publicly available at www.grap.udl.cat/en/publications/datasets.html (Fuji-SfM dataset).

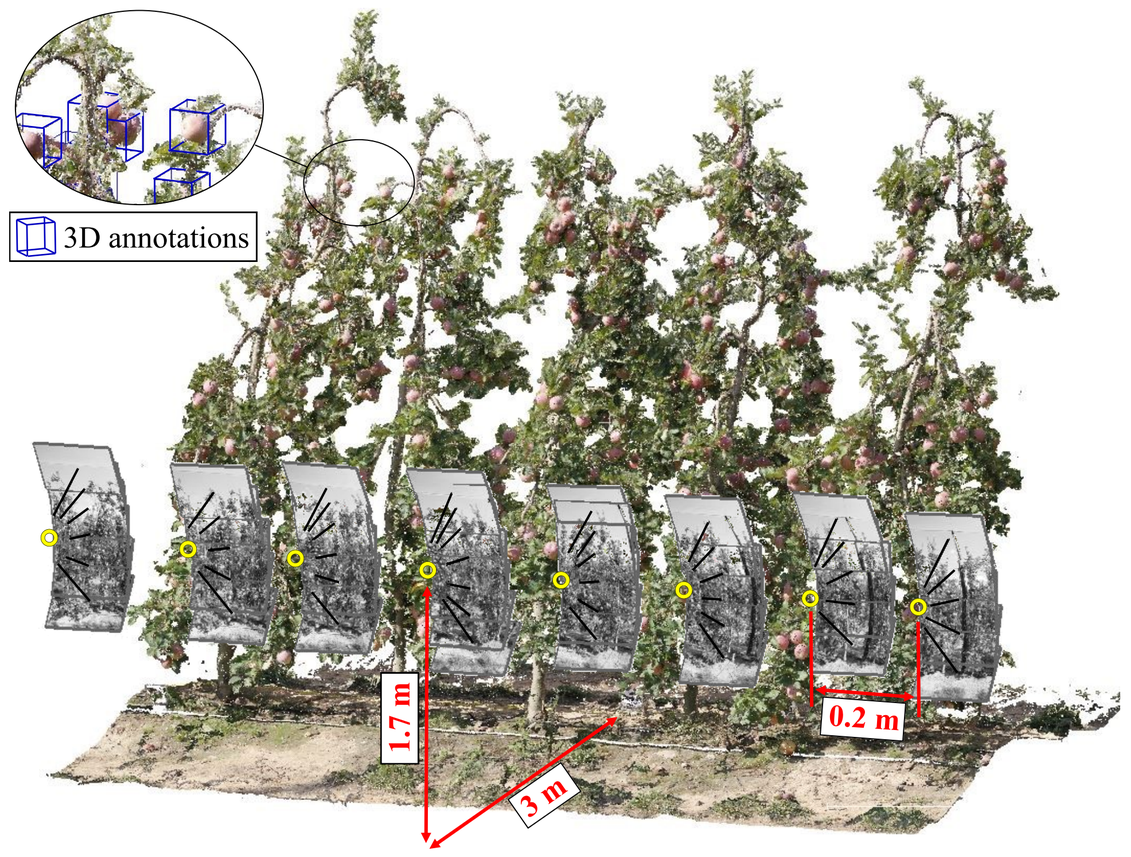

Fig.1. Data acquisition layout.

METHODOLOGY PIPELINE

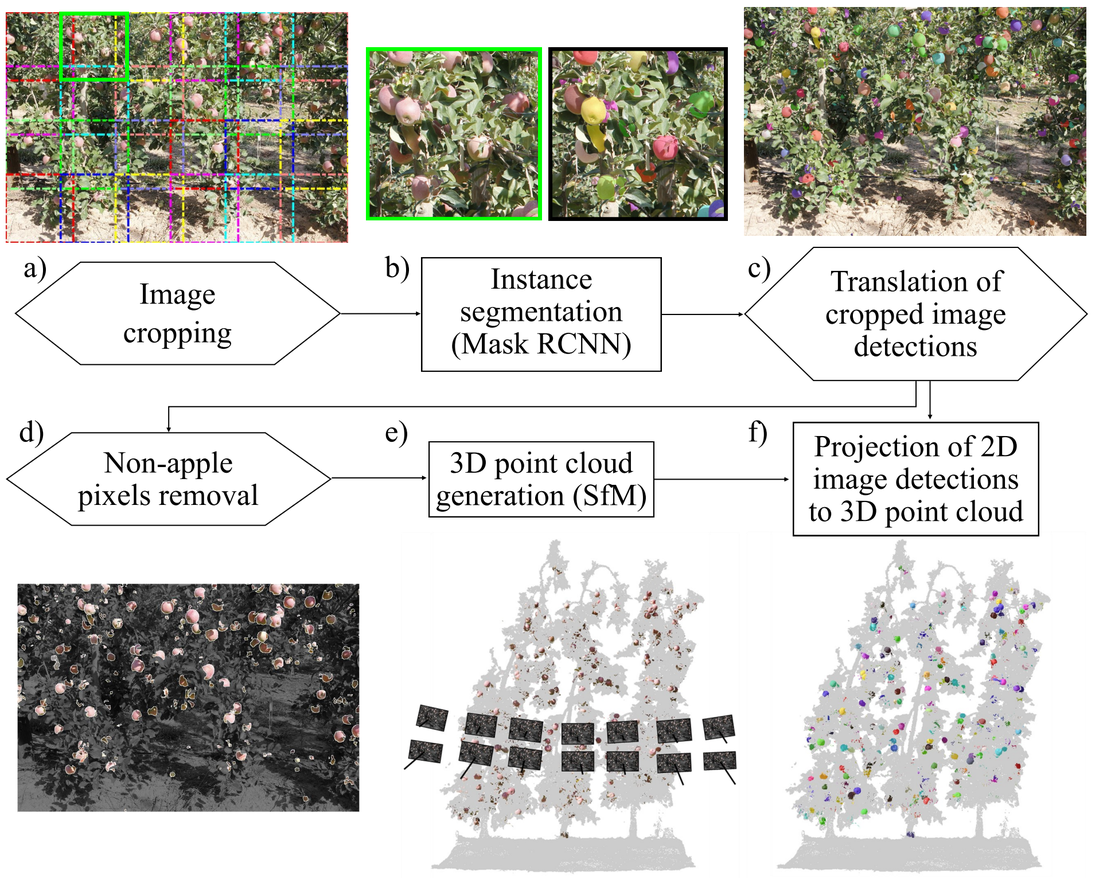

Fig.2. Fruit detection and location methodology.

Fig.3. Fruit detection results

RESULTS

By projecting 2D segmentation masks onto the 3D point cloud, results showed an increase of 2.8% in recall (from 0.878 to 0.906), 9.5% in precision (from 0.762 to 0.857) and 6.5% in F1-score (from 0.816 to 0.881) (**Table 1**).

Table.1. Fruit detection results in 2D images and in the 3D SfM point clouds.

	R	P	F1-score
2D data	0.878	0.762	0.816
3D data	0.906	0.857	0.881

For a qualitative evaluation, the reader is referred to the following link for an interactive 3D visualization of test fruit detection results: http://www.grap.udl.cat/documents/photogrammetry_fruit_detection.html

CONCLUSIONS

- Due to the multi-view approach on which SfM is based, results showed a small number of fruit occlusions and also a small number of false positives.
- The main disadvantage of this methodology is that, due to the computationally-intensive operations of SfM, it cannot process the data in real-time.

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