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Low-cost terrestrial photogrammetry for orchard sidewards 3D reconstruction

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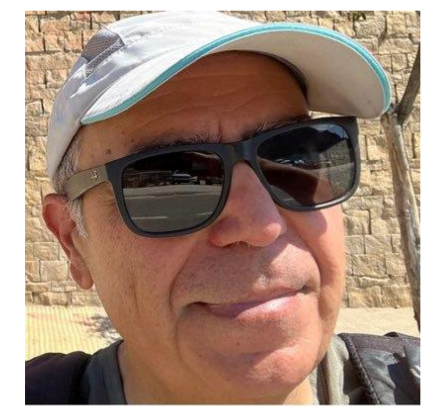

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Objective

Here, a method to obtain 3D point clouds in orchards based on digital terrestrial photogrammetry (DTP) is presented. It consists in using three mobile phone RGB cameras attached to a ground-based vehicle traveling along the orchard alleyways to monitor canopies sidewards. The resulting point cloud will be compared to a LiDAR-based system derived point cloud.

Materials and methods

In order to obtain sufficient image vertical overlap in tall fruit tree orchards (> 3 m tall with 5 m row spacing), a vertical structure was designed to attach 3 mobile phones (Xiaomi Mi Note 10 Lite) at different heights (Figure 1).

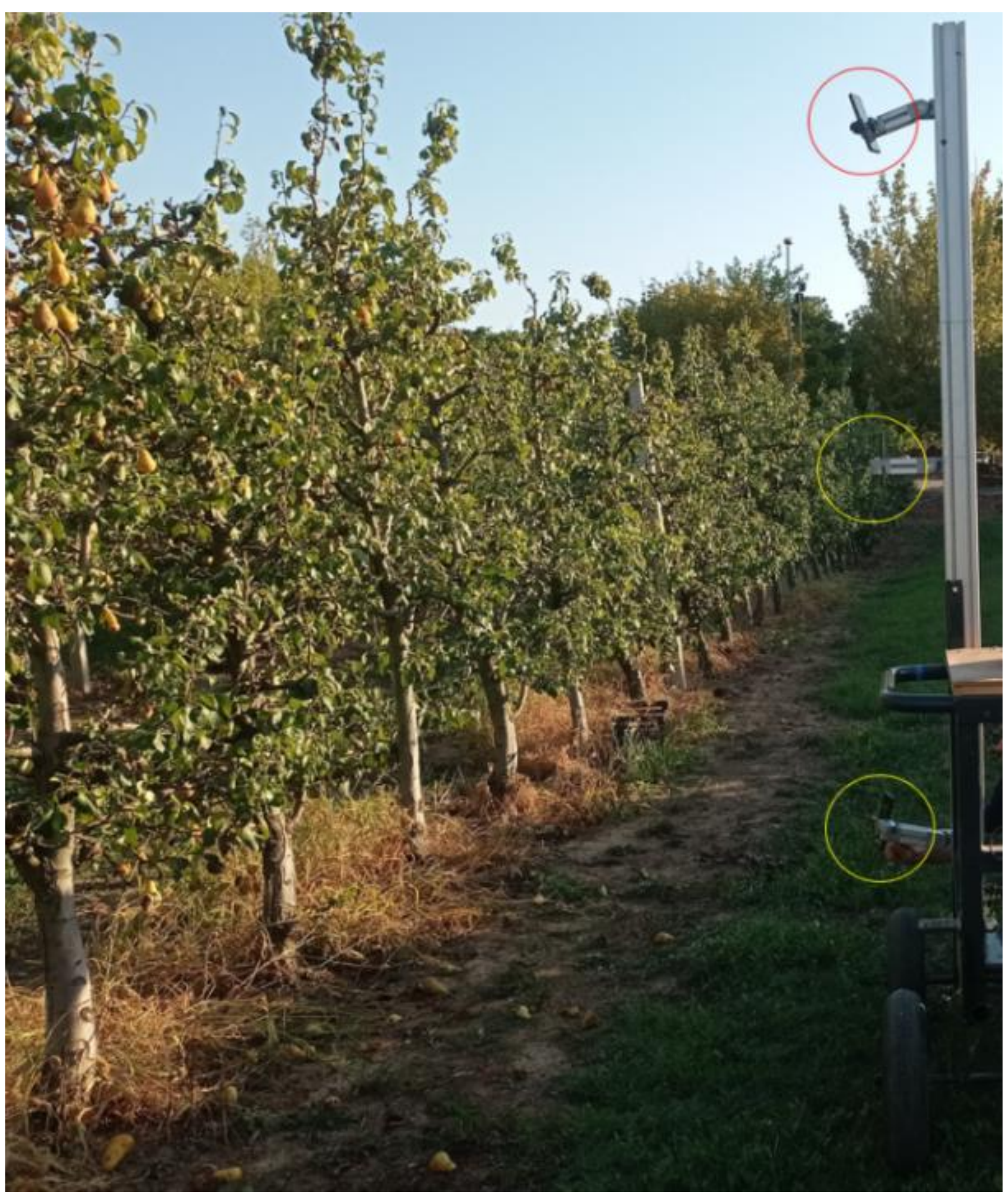

Figure 1. Vertical structure with 3 mobile phones (highlighted with circles) at different heights.

Data acquisition and processing:

- ✓ 64 Mpixel pictures at a 1 Hz frequency of an 8 m long row section (8 trees) using the wide-angle lens option.
- ✓ Creation of the 3D point cloud from the multiple 2D images by using multi-view Structure-from-Motion (SfM) based on bundle adjustment. Software Metashape v1.8.5 (*Agisoft LLC, St. Petersburg, Russia*).
- ✓ The point cloud was scaled and georeferenced in CloudCompare software v2.12.2 (*EDF, Paris, France*).
- ✓ A reference point cloud obtained with the bMS3D 4Cam mobile terrestrial laser scanner, MTLS, (*Viametris, Laval, France*).
- ✓ The two point clouds were compared using the Cloud-to-Cloud tool at CloudCompare.

Results

The resulting point cloud resembled quite well the scene and had 82 100 975 points (Figure 2) while the MTLS-derived point cloud had 316 375 points.

The average difference between both point clouds (only including points of the 8 m long row section and 0.5 m above the ground) **was 0.018 m** and ranged from 0 m to 0.31 m. The 95 % of the points presented differences smaller than 0.04 m. However, the methodology based on DTP missed some vegetation in top parts and close to the cameras.

Figure. 2. Point cloud created with digital terrestrial photogrammetry with about 82 million points.

Discussion and conclusions

The methodology provides with **very realistic and accurate point clouds** with much more point resolution than the reference MTLS-derived point cloud. The system presents **some flaws related to the low image acquisition rate** as a consequence of high image resolution, the **large number of images to process and the overall processing time**. The former could be solved by using faster cameras as the mobile phones required too much time to save 64 Mpixel images, the most suitable for photogrammetry. The last two flaws are an important concern when an entire orchard should be captured. They could be solved with the real-time reconstruction capabilities of some photogrammetry programs.

Digital terrestrial photogrammetry has been proved to be accurate enough to monitor orchard canopies and even to detect apple fruits. However, data acquisition in published works to date was done manually. When solving the mentioned flaws, this methodology could be a good alternative to MTLS and UAV digital aerial photogrammetry as it is cheaper and easier to use.

Acknowledgements

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