Multi-camera system based on low-cost Raspberry Pi computers for measurements of single trees

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The close-range photogrammetry (CRP) is a robust tool for point clouds generation. We can see a huge usage spread of the CRP in all different sectors. In our research, we are focusing on the use of CRP for forestry. Especially, for forest inventory with focus on trunk diameter. The main advantage of CRP is lower hardware costs with a comparison to terrestrial laser scanning for example. But the data acquisition and data pre-processing are challenging. Especially within the forest. The operator during the data acquisition must have deep experience and knowledge about the CRP to provide proper images with sufficient overlap. Furthermore, to set the camera based on the present condition in the field could be sometimes difficult. Another issue is the scaling and orientation of point clouds. At least one artificial object must be placed in the area to provide the scale. Multiple objects should be used to provide the error of scaling. But for forestry practice, it is important to use as few objects as possible to simplify the data acquisition in the forest. Therefore, we have decided to start the developing of the multi-camera system which will provide easy use in the field.

The multi-camera system is based on Raspberry Pi Zero (RPiZ) computers and PiCameras. RPiZ is a 5 dollar computer with 1GHz single core CPU, 512 MB RAM and all necessary ports. It supports SD cards, and the officially supported operating system is Raspbian (based on Debian). PiCamera is a Sony IMX219 which provide 8-megapixel resolution with CMOS image sensor. The multi-camera system was created from four RPiZ computers with four connected cameras to each of the computers. The image capturing was done with one button which is connected to all computers. Additionally led lights were connected to computers to provide the status of computers and cameras. The case for the multi-camera system provides a space for placing the RPiZ computers and electronics. At the front, the cameras were placed in a square shape with 8 cm distance between them.

The first test of the multi-camera system was done within the research plots of University of Évora (Portugal). The perimeter of cork oak trees was measured by tape in three different heights: 0.8 m, 1.3 m and 1.8 m. The imagery by the multi-camera system was done from multiple positions around each tree. The images were processed to point clouds in Agisoft Photoscan Professional 1.2.6 software. Then the estimation of diameters was done in DendroCloud 1.44 software and ArcGIS desktop 10.2 software. To estimate the diameters convex hull algorithm was used.

The root mean square error (RMSE) of diameter estimation was 1.5 cm. We have detected a high correlation between measured and estimated diameters where Pearsons r equals to 0.983 and r squared to 0.966. The capability of the multi-camera system to provide sufficient results was proved.

Further development and testing of the multi-camera system is undergoing. Regarding the number of cameras, refining the case and electronics to different purposes, software development and so on.