EVALUATION OF AN APPROACH TO DETERMINE THE DIAMETER AT BREAST HEIGHT OF FOREST TREES USING THE GOSCOUT3D HANDHELD SCANNER IN COMPARISON TO AN IPHONE

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Abstract In the last decades the relevance of forest monitoring has become increasingly relevant. Therefore, the diameter at breast height is one of the most relevant parameters of forest trees. A diameter tape measure is currently used to determine this parameter. In this study we want to digitise this and evaluate accuracy and applicability by using a photogrammetric approach. The goSCOUT3D is used as a representative for high-resolution 3D scanners with a photogrammetric approach. An everyday consumer product with a suitable camera is used for comparison. Specifically, the main camera of the iPhone 14 Pro Max was selected because it corresponds to the state of the art. In total 30 spruce trees were measured and five recordings with both sensors were made for every tree. As a reference for the extracted parameter, we used a tape measure. For each recording 100 images were taken by walking around the trees (360 degree) at about one metre. After measuring the trees, a 3D point cloud was generated for every recording using photogrammetric evaluation software. A Python program was implemented using the convex hull algorithms. These algorithms make it possible to determine the diameter at breast height robust and efficient. Additionally, the program automatically determines the necessary height of 130 cm in the generated point cloud. In this way, the diameter at breast height was extracted for each recording. The final results for both sensors were then evaluated and compared with the reference value of the tape measure. Compared to the iPhone 14 Pro Max, the goSCOUT3D delivers quantitatively better results for the diameter at breast height.

Keywords: photogrammetry, forest monitoring, digital forest monitoring, sustainable forestry, diameter at breast height, wood volume, high resolution 3D-Scanner, iPhone

1. INTRODUCTION

Due to climate change, the monitoring of forests is receiving increasing attention. Detailed knowledge of the timber volume is of enormous importance for sustainable forest management. The diameter at breast height is one of the most important parameters in this case. [1] This is because wood is an effective carbon store and is of great importance for the economy and ecology. [2] Until now, a tape measure has been used to determine this parameter, but the increasing relevance of a digital measurement method makes new approaches necessary. The idea is to create a possibility without human labour for the future. In this study, we want to investigate the accuracy and applicability with a photogrammetric approach in determining the diameter at breast height of trees. In Figure 1, the hand-held scanner goSCOUT3D from the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) is shown. It is used as a representative of modern high-resolution 3D scanners for measuring large objects. The standard image field is approximately one square metre. It's 20-megapixel colour camera achieves a measuring point resolution in the object space of approximately 0.2 mm. [3] A consumer product serves as a comparison. The iPhone 14 Pro Max was selected because it has a camera that represents the current state of the art.

Figure 1. Fraunhofer IOF goSCOUT3D [4]

2. METHODS AND PROCEDURES

A calibration target was initially attached to the trees for representative measurements. Theoretically, it is also possible to make a recording with a calibration target and record several trees at the same time to extract the individual tree trunks for analysis. In German forests, spruce is the most common tree species with a share of 25 %, which is why it was used for the measurements in this work. [5] For a qualitative and quantitative statement, a total of 30 trees were measured five times each with both sensors. When taking the pictures, the sensors were moved around the trees (> 360°) at about one metre, as this is the ideal distance between the sensor and the measurement object. Care was taken to ensure that the start and end images overlapped as much as possible during the measurements. Approximately 100 images were taken for each measurement. Figure 2 shows an example image of the tree section that was recorded during each measurement to create a 3D model.

The images from the goSCOUT3D are stored in a standard image data format and were transferred to a 3D point cloud using photogrammetric analysis software. By the iPhone approach, the 3d Scanner App™ was used in mode 'Photos' which also uses only the camera because this method

without a LiDAR sensor achieved the best results with this method in the study [6]. The images were converted into a 3D point cloud using a Macbook and the desktop application of the aforementioned app.

Figure 2. Example image of the tree section that was taken during each measurement

The 3D point clouds were then analysed using a Python program. A height of 130 cm was initially determined on the tree trunk, as this corresponds to the ideal height for the diameter at breast height. The measurement height was adjusted according to the rules of the German National Forest Inventory if, for example, tubers or branches made a change necessary. [7] The diameter at breast height was then extracted from the individual point clouds using the Convex Hull algorithm (see Figure 3). Because this method is robust, efficient and can identify any 2D shape in point clouds with a lower number of 3D points and that are not ideally round like forest trees. [8]
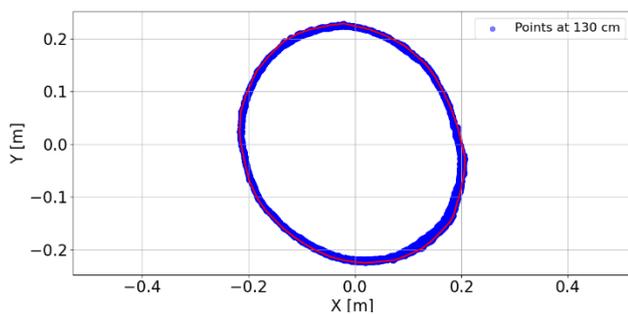

Figure 3. Image from the 3D points of a tree trunk (blue) and it's resulting circumference (red) as an example at a height of 130 cm, taken with the goSCOUT3D to determine the diameter at breast height using the Convex Hull algorithm

3. RESULTS AND DISCUSSION

The quantitative results show that it is possible to determine very precise values for the diameter at breast height with the goSCOUT3D. The average deviation of the goSCOUT3D across all measurements compared to the tape measure was approximately 1 %, which is equivalent to the tolerance by measuring with a tape measure. The iPhone 14 Pro Max showed deviations of approximately 3 %. The number of 3D points measured by both sensors also differs greatly. While the goSCOUT3D recorded approximately 100,000 points at a height of 130 cm ± 2 cm, the iPhone only has 1250 points for the entire 360°. The number of points certainly depends on the diameter of the tree trunk at breast height. The larger the diameter, the more points are contained

in the point cloud. The structure of the bark plays a crucial role here, as this is a photogrammetric approach.

The lighting conditions in the forest have a very large influence on the measurements in a photogrammetric approach. For this reason, care was taken to avoid these dynamic environmental conditions as much as possible to ensure the comparability of the measurements and both sensors.

4. CONCLUSIONS

We have proven that it is possible to determine the diameter at breast height of forest trees using a photo-grammetric approach. In general, we achieved very good results for both sensors during the measurements. The goSCOUT3D is superior to the iPhone in terms of the accuracy of the results obtained. Plausible results can also be achieved with the iPhone, but with a significantly higher deviation.

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