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Evaluating the ground point classification performance of Agisoft Metashape Software

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Abstract

This paper investigates the complex process of extracting bare land surfaces from point clouds, with a particular focus on filtering out objects such as trees, buildings, and vehicles. It underscores the importance of this task in diverse domains, including cadastral surveying, base mapping, and various geographical sciences, all while excluding specific reference to LiDAR and GIS applications. The research provides an extensive exploration of different algorithms used for point cloud filtering, culminating in a comprehensive evaluation of Agisoft's ground point filtering algorithm in contrast to the well-recognized CSF method. For this comparison, an Unmanned Aerial Vehicle (UAV) flight was performed at Harran University's Osmanbey campus to generate the necessary point cloud. The results of this assessment reveal that a significant portion of the obtained points pertains to ground points, underscoring the efficacy of the filtering process in producing Digital Terrain Models (DTMs). The numerical findings demonstrate that the overall accuracy stands at 0.002, with minimal Type I and Type II errors, reaffirming the robust performance of the filtering algorithms in producing accurate DTMs.

1. Introduction

DTM is a valuable data source for various applications, as noted by Polat and Uysal in (2015). The extraction of bare earth surfaces from point clouds is a multifaceted endeavor. While many studies in surveying, mapping, and topography predominantly focus on natural landscapes, they tend to overlook artificial structures and vegetation. However, in disciplines like cadastral surveying, topographic mapping, and Geographical Information Science (GIS) applications, the imperative to filter out objects such as trees, shrubs, buildings, and vehicles becomes evident.

The creation of a DTM involves the initial step of filtering point clouds to isolate the topography of the bare earth surface. Point cloud filtering entails the removal of points associated with above-ground features like trees, buildings, and bridges, among others. This process is generally challenging, and its success depends on various factors, including topography, the chosen point cloud filtering method, the size and shape of above-ground objects and the expertise of the operator (Yilmaz and Güngör, 2021).

Numerous algorithms have been developed for filtering LiDAR-derived point clouds, with a common goal of distinguishing ground and non-ground points. While these algorithms do not always achieve perfect results, they typically yield accurate filtering outcomes, exceeding 90% accuracy (Zeybek and Şanlıoğlu, 2019). One method involves progressive triangulation to create a sparse TIN iteratively based on the lowest seed points (Axelsson, 2000). The CSF (Cloth Simulation Filter) technique is fundamentally based on the principle of emulating how a fabric-like material behaves when applied to an inverted land surface (Zhang et al., 2016). Mathematical morphology techniques are also employed, utilizing operations like opening, closing, dilatation, and erosion (Liu, 2008; Zhang et al., 2003).

The choice of kernel size is a critical parameter for non-ground point detection. Furthermore, slope-based filtering identifies points with large height differences between neighboring points as non-ground, where high points typically represent non-ground and low points represent the ground (Vosselman, 2000).

The extensive utilization of UAVs has led to a significant increase in the adoption of photogrammetric point clouds as an alternative to LiDAR. To speed up DTM generation from such data, photogrammetric software has begun to incorporate point cloud classification capabilities. Notably, the renowned Agisoft Metashape

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software, among other commercial solutions, now provides the ability to classify point clouds generated from aerial images. This study aims to evaluate and compare the performance of Agisoft's ground point filtering algorithm with the well-established CSF algorithm documented in the literature.

UAV technology has been used frequently in landslide (Kuşak et al. 2021), rockfall (Yakar et al. 2023) and cultural heritage studies (Alptekin and Yakar, 2021; Karataş et al. 2022; Kanun et al. 2022) in the last decade.

2. Method

2.1. Agisoft Metashape Ground Points Classification

In the context of ground point classification, Agisoft Metashape introduces an innovative approach designed to enhance the efficiency of manual labor (Kanun et al. 2021). This method is structured as a two-step process. In the initial phase, the point cloud segmentation into cells of predefined dimensions, facilitating the identification of the lowest point within each cell. The triangulation of these identified lowest points culminates in the primary approximation of the terrain model. In the subsequent phase, new points are allocated to the ground class contingent upon two fundamental criteria. Firstly, they must demonstrate proximity to the terrain model within a stipulated range. Secondly, the angle formed between the terrain model and the connecting line between these new points and an existing ground point must not surpass a predetermined threshold angle. This iterative second step endures until all data points have undergone comprehensive evaluation (URL 1).

2.2. Cloth Simulation Filter (CSF)

The Cloth Simulation Filter (CSF) methodology, as detailed by Zhang et al. (2016), is fundamentally grounded in the concept of simulating the behavior of a fabric-like material placed upon an inverted land surface. Within this simulation, the configuration of the fabric effectively serves as the foundation for constructing the DTM corresponding to the specified geographical area.

The initial step in the CSF method involves the inversion of the point cloud dataset. Subsequently, a pivotal user-defined parameter, referred to as the grid resolution, is introduced to determine the quantity of cloth particles to be released onto the dataset. These points and particles are subsequently projected onto a horizontal plane, where each cloth particle is associated with a corresponding point within this plane. The intersection of each cloth particle with the underlying terrain results in the determination of its height, denoted as the 'intersection height value. If the intersection height value exceeds the current height value, the particle is repositioned to align with the intersection height value and is categorized as immovable, as described by Zhang et al., in (2016).

Throughout the iterative process, the CSF method calculates the distances between the point cloud and the cloth particles, with any point exhibiting a distance greater than a user-defined threshold, commonly known as the 'class threshold parameter,' being classified as a non-ground point, aligning with the findings of Zhang et al. (2016). The movement of the cloth particles is influenced by both internal and external forces, with gravity being a significant external force. This movement continues until the desired height variation, or a predefined maximum number of iterations is achieved. In addition to the parameters delineated above, the CSF methodology integrates two further parameters, namely the time step and rigidness: The former parameter governs the control of particle movements, while the latter parameter is instrumental in specifying the terrain type.

2.3. Accuracy Analysis

In this study, an assessment of the filtering methods was conducted, involving the calculation of error type I, error type II, and overall accuracy to gauge their effectiveness.

$$Type\ I = \frac{\alpha}{\mathrm{Ref}_g} \ ,$$

$$Type\ II = \frac{\beta}{Ref_{ng}}$$

$$Everall\ Accuracy\ = \frac{\alpha+\beta}{\mathrm{Ref}_g\ +Ref_{ng}}$$

In this context, where α represents ground points misclassified as non-ground points, β represents non-ground points misclassified as ground points, and Ref_g and Ref_{ng} indicate the counts of the ground and non-ground reference point sets, the filtering method's performance is assessed by comparing the obtained classification with reference data.

3. Results and Discussion

In the study, a dense point cloud was obtained using aerial photographs. The visualization of the obtained point cloud is given in the Figure 1.

Figure 1. Raw point cloud of the study area.

As can be seen in Figure 1, the ground points, and non-ground objects (such as trees and buildings) points are clearly visible in the dataset. This raw point cloud with points belonging to all objects was filtered with the help of the CSF algorithm. At this stage, grid resolution (grid size) is 0.5 m, iteration 500 and classification threshold is 0.2. Accordingly, the obtained ground points are given in the Figure 2.

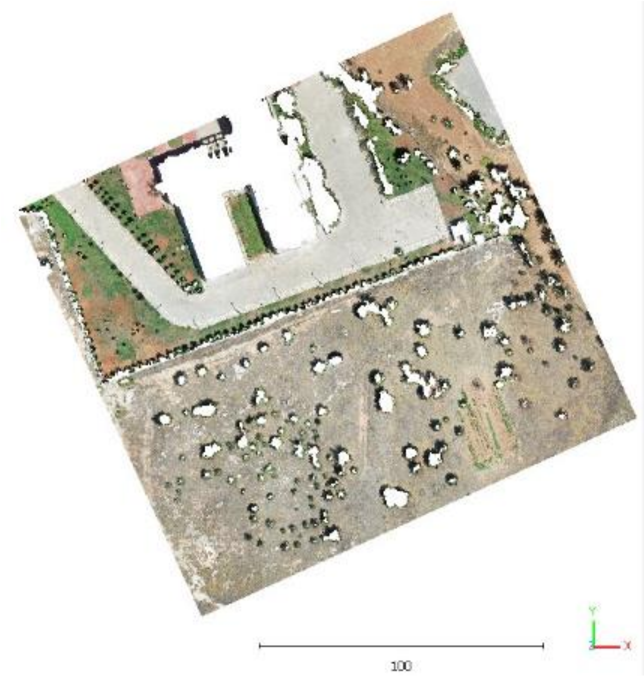

Figure 2. Ground points obtained using the CSF algorithm.

As can be seen from the CSF filtering result image given in Figure 2, the above ground points were removed and only the ground points that will form DTM were obtained. This data will be used as a reference. In the continuation of the study, this raw point cloud with points belonging to all objects was filtered with the approach in Agisoft Metashape itself and only ground points were obtained and presented in Figure 3.

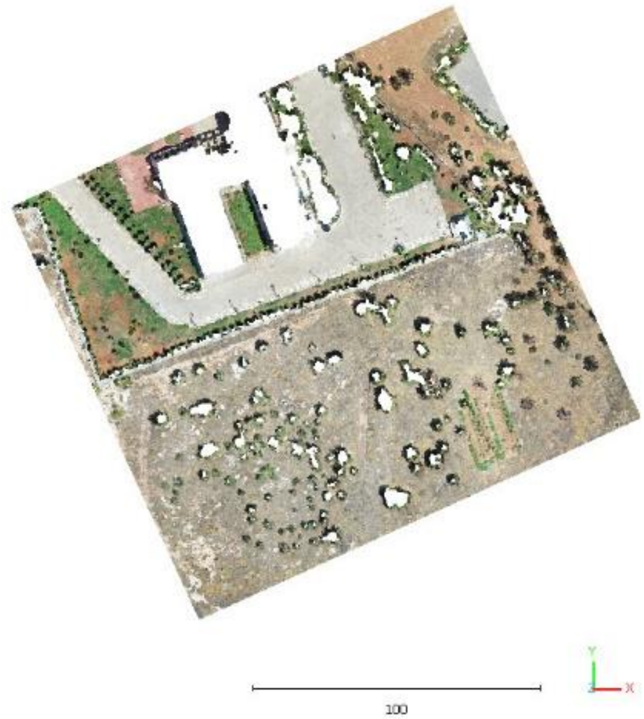

Figure 3. Ground points obtained from Agisoft.

According to Figure 3, mostly ground points were obtained succesfully. Raw data, reference data and Agisoft Metashape filtering results are given in Table 1.

Table 1. Raw data and filtering results.

	Data	Points	Min Z (m)	Max Z (m)
	Raw	23 362 221	498.431	522.891
(CSF)	Ground Reference	16 035 473	498.630	509.739
	Non-Ground Reference	7 326 748	498.431	522.891
Agisoft Metashape	Ground	15 996 027	498.431	520.152
	Non-Ground	7 336 194	498.80	522.871

According to Table 1 α (9 446 points) and β (39 446 points) values were obtained. Then type I and type II errors are calculated as 0.0006 error 0.005 respectively. The overall accuracy is found as 0.002.

4. Conclusion

This investigation has revolved around the evaluation of ground point classification techniques, particularly focusing on the performance of Agisoft Metashape software. The significance of DTMs as a fundamental data source for diverse applications was underscored, emphasizing the critical task of extracting bare earth surfaces from point clouds while excluding specific reference to LiDAR and GIS applications.

The study examined Agisoft Metashape and CSF algorithms, designed for filtering point clouds to distinguish between ground and non-ground points, a task that is essential in diverse fields, including cadastral surveying, topographic mapping, and GIS. The research encompassed the renowned Agisoft Metashape software, which has ventured into point cloud classification, to streamline the DTM generation process. Through a thorough evaluation, the performance of Agisoft Metashape's ground point filtering algorithm was compared with the widely recognized CSF methodology. The results illustrated that the Agisoft Metashape algorithm predominantly produced ground points, successfully eliminating above-ground features. The assessment, involving error type I, error type II, and overall accuracy calculations, further substantiated the robustness of the filtering algorithms.

In conclusion, this study contributes valuable insights into point cloud filtering techniques that are instrumental in producing accurate DTMs. The extensive utilization of photogrammetric point clouds, facilitated by software like Agisoft, signifies a promising avenue for DTM generation in various applications, further advancing the field of terrain modeling and point cloud analysis.

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