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MOBILE - BASED CLOSE - RANGE PHOTOGRAMMETRY FOR 3D MODELING

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Abstract. *Three-dimensional (3D) reconstruction techniques have revolutionized many different fields, from architecture or archaeology to environmental studies, engineering, or others. Among the techniques that have materialized with the closest relation to current needs is close-range photogrammetry, offering the potential to reconstruct the geometric shape or texture of small to medium-sized objects with the help of overlapped photos or structure from motion algorithms. This paper describes the creation and analysis of a three-dimensional (3D) model created with the aid of close-range photogrammetry techniques utilizing an open-source mobile application. The main focus is to evaluate the feasibility, accuracy, and productivity of mobile-supported photogrammetry techniques, which can be an efficient and affordable substitute for the currently existing 3D reconstruction techniques. A detailed image capturing procedure was also carried out with the help of the standard smartphone camera, taking overlapped photos from different angles to cover the area sufficiently with the help of parallax. The generated data was then processed with the help of an open-source mobile application for photogrammetry, allowing the process of feature points identification, image matching, dense cloud creation, and surface recreation. The reconstructed 3D model was then compared on the basis of geometric precision, resolution, and texture. The result shows that close-range photogrammetry, conducted with the help of open-source mobile software, is able to provide acceptable levels of accuracy for non-meter purposes, especially for the application areas of cultural heritage, environmental scanning, and educational visualizations. The current study also brings attention to the promising mobile technology of photogrammetry, with the possible future application of democratizing 3D technology availability.*

Keywords*: 3D modelling, Close Range Photogrammetry, open source mobile app, image – based modelling*

INTRODUCTION

The technology of three-dimensional reconstruction, or 3DR, has currently become an essential tool for the most diverse areas, ranging from architecture, archaeology, to the environmental sciences, engineering, and many others [2]. The classic 3D reconstruction methods, starting with the technology of laser scanning, are extremely accurate, but the process is often plagued with the difficulty of accessing the technology due to its cost [1].

However, recent advances in mobile technology and computer vision have enabled the development of solutions in the area of photogrammetry that can harness the capabilities of smartphones, along with open-source software, for the creation of highly accurate 3D models [4].

Notably, close-range photogrammetry also has the efficiency required in the creation of geometric models with textures for small to medium-sized objects [3]. Taking into consideration the benefits provided by the overlapped photographical image, one is able to create three-dimensional models without the need for equipment, thanks to the structure from motion techniques available. This study aims to evaluate the process of applying the entire process of photogrammetry on mobile technology with the help of an open-source application for the creation of 3D data collection, processing, and visualization [7].

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MATERIALS AND METHODS

The methodological framework of this study was designed to evaluate the performance of an open-source mobile photogrammetry workflow for 3D model generation [6].

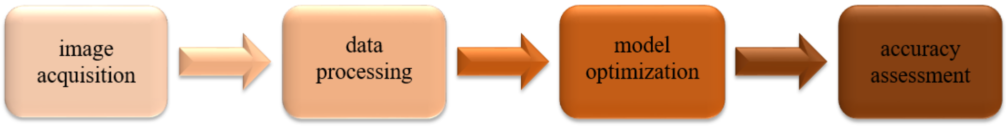

Figure 1. The main stages of the framework

The image dataset was collected using a smartphone equipped with a high-resolution rear camera. The target object was a surveying theodolite THEO010 - a medium-sized object - selected for its complex geometry and varied surface textures, allowing for comprehensive evaluation of the photogrammetric process.

Figure 2. The image dataset acquisition

Photographs were captured in a circular path around the object at incremental angular intervals to ensure complete coverage [4]. Approximately 183 overlapping images were taken under uniform lighting conditions to minimize shadows and reflections. The camera was maintained at a constant distance from the object to achieve consistent image quality. To enhance the accuracy of the reconstruction, the object was placed on a stable surface with a calibrated background scale.

The acquired images were processed entirely on the mobile device using Polycam 3D scanner & editor, an open-source application. The software employed a Structure - from - Motion (SfM) pipeline integrated with Multi-View Stereo (MVS) algorithms. The processing steps included:

- feature detection and matching, using extraction techniques to identify common features across multiple images;
- camera pose estimation, performed through bundle adjustment to optimize internal and external camera parameters;
- sparse and dense point cloud generation, producing a high-density spatial dataset representing the object's surface geometry;

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- mesh reconstruction and texturing, resulting in a textured 3D model with realistic visual representation.

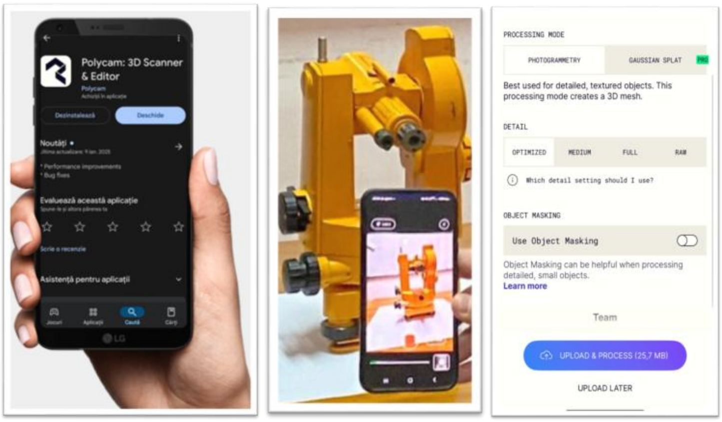

Figure 3. Polycam 3D scanner & editor interface [8]

Processing parameters were standardized, in order to ensure consistency, and the generated model was exported in different formats, if a further analysis is desired.

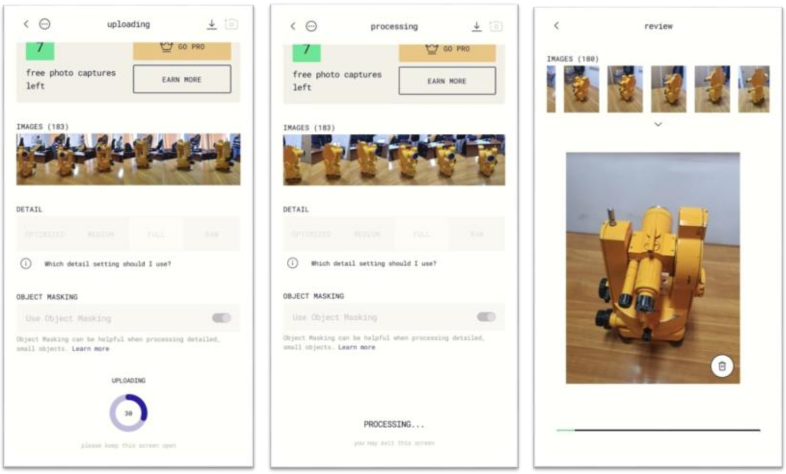

Figure 4. Images uploading, processing and reviewing

Furthermore, post - processing operations were performed to refine the generated model. These included noise reduction, mesh decimation, and surface smoothing to eliminate irregularities caused by photographic inconsistencies or algorithmic errors. All optimization procedures were conducted within open-source application software to preserve workflow accessibility and reproducibility.

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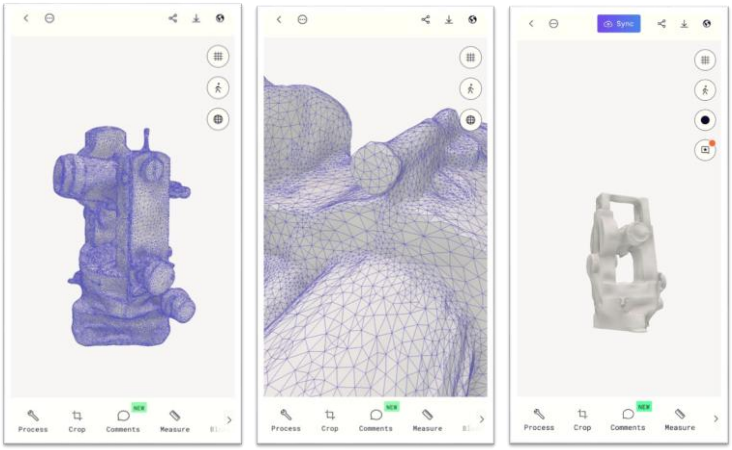

Figure 5. 3D model of the studied object (TIN – model and solid mesh)

In addition, the visual fidelity of the model was assessed qualitatively through focusing on the preservation of fine details and texture consistency. [2]

RESULTS AND DISCUSSIONS

The open-source mobile photogrammetry workflow successfully generated a 3D model of the selected object. The reconstruction process, performed entirely on a smartphone device, averaged 30 minutes. The generated model exhibited a high degree of geometric completeness, with minimal areas of occlusion primarily located on the object's lower surface, where image overlap was limited.

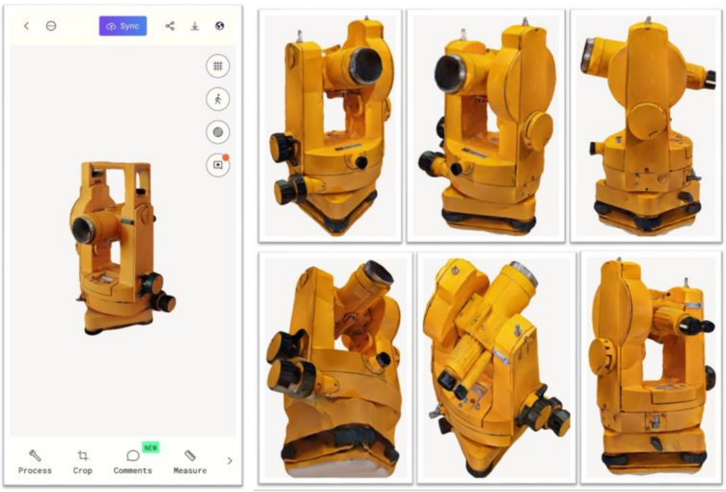

Figure 6. Final 3D model of the studied object

The reconstructed model closely approximated the real - world dimensions of the studied object. These results confirm that the open - source mobile workflow achieves precision levels sufficient for non - metric applications [1; 5], such as documentation, visualization, and preliminary design analysis.

Minor deviations were attributed to uneven illumination during image acquisition and limited feature contrast on certain textured areas. Nevertheless, the overall geometric consistency indicates that mobile photogrammetry can yield results comparable to desktop - based software when acquisition protocols are carefully followed.

Figure 7. Differences caused by reflectance variations in the final 3D model

The texture quality of the reconstructed 3D model was assessed on the basis of its colors, clarity, and texture continuity. The generated textures are highly homogenous, capturing the desired visual properties of the object effectively. Some minute variations are perceived in the areas with sharp edges or highly glossy material, due to the variations in reflectance values acquired during the scanning process. However, the generated object was sufficiently real with appropriate visual properties for virtual presentation purposes.

The mobile-produced model was able to provide high geometric precision, with fewer total workflow hours and lower equipment cost compared with the other models. The results demonstrate the increasing potential of mobile-open-source photogrammetry to act as an alternative solution even in resource-limited field work.

In practical terms, the effectiveness of the system indicates strong potential within the areas of cultural heritage documentation, environmental surveillance, as well as the gathering oflow-costspatial data, due to itsabilityto conduct full photogrammetric processing onsite, without requiring special hardware or the need for post-processing on a workstation, making the technology of 3D modeling democratized.

The study has found that the capabilities of close-range photogrammetry, utilizing open-source mobile apps, are well balanced from the viewpoints of both efficiency and accuracy. Although the process is currently not applicable for metrologic precision tasks, the process has many advantages with regards to mobility, cost, and effectiveness.

Future advances in the hardware of smartphones, especially with respect to the image sensors, processing capabilities, or the use of AI-based image processing, are also anticipated to contribute to the improved efficiency of mobile photogrammetry tasks, accuracy, or both. The inclusion of cloud processing may also alleviate any existing limitations in processing the computations on the mobile device, facilitating real-time, high-quality reconstructions.

CONCLUSIONS

This study was able to show the viability of obtaining correct and finely detailed three-dimensional (3D) representations with high precision close-range photogrammetry on the mobile device solely with the help of the open-source mobile application [2]. The result supports the fact that, in spite of the natural hardware limitations of the smartphone, the current mobile photogrammetry process is able to provide sufficient geometric and textural details for non-metric tasks [4].

The outcomes also indicated that the efficiency and mobility of mobile photogrammetry contribute to the minimization of specialized equipment needs, hence improving accessibility for researchers, instructors, or practitioners working in resource-limited settings.

In sum, the project illustrates the increasing democratization of the state-of-the-art technology of 3D reconstruction, which is now made possible by the open source movement and the advances in mobile technology. The integration of data acquire, processing, and visualization on one device is indeed one of the steps toward making the process light and ready for the field.

Although the results are promising, some drawbacks have also been revealed. The geometric precision of mobile photogrammetry is still dependent on the quality of the image sensors, lens distortions, and lighting conditions in capturing the images. The processing of big data utilizing the mobile device is also hampered by the computational capabilities of the smartphones, sometimes requiring the reduction of the image resolutions or the complexity of the reconstruction models.

The future work may be directed towards extending the comparison study of the different open-source mobile apps to develop common thresholds for precision or usability. The integration of sophisticated image preprocessing steps, including automatic exposure compensation, reflectance adjustment, or the application of artificial intelligence, may also help to improve the consistency of the models.

Moreover, the application of the same method on a bigger scale, perhaps on the facade of buildings or in the context of archaeological excavations, could help clarify the scalability of mobile photogrammetry.

Innovations in mobile technology, in combination with the open development of algorithms, will help fill the current gap between mobile technology and professional photogrammetric solutions, leading to the advancement of accessibility and accuracy of 3D spatial data collection in the future.

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