WEB Open Drone Map (WebODM) a Software Open Source to Photogrammetry Process

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Key words: low cost photogrammetry, Open Source, WebODM

SUMMARY

In the photogrammetric process of the 3D reconstruction of an object or a building, multi-image orientation is one of the most important tasks that often include simultaneous camera calibration. The accuracy of image orientation and camera calibration significantly affects the quality and accuracy of all subsequent photogrammetric processes, such as determining the spatial coordinates of individual points or 3D modeling.
In the context of artificial vision, the full-field analysis procedure is used, which leads to the so-called Structure from Motion (SfM), which includes the simultaneous determination of the camera's internal and external orientation parameters and the 3D model. The procedures were designed and developed by means of a photogrammetric system, but the greatest development and innovation of these procedures originated from the computer vision from the late 90s, together with the SfM method.
The reconstructions on this method have been useful for visualization purposes and not for photogrammetry and mapping. Thanks to advances in computer technology and computer performance, a large number of images can be automatically oriented in a coordinate system arbitrarily defined by different algorithms, often available in open source software (VisualSFM, Bundler, PMVS2, CMVS, etc. .) or in the form of Web services (Microsoft Photosynth, Autodesk 123D Catch, My3DScanner, etc.). However, it is important to obtain an assessment of the accuracy and reliability of these automated procedures.
This paper presents the results obtained from different UAV survey processed with open source software using the Structure from Motion approach WEB OpenDroneMap (WebODM).
For the UAV survey we used the Spark DJI has a CMOS sensor of 1 / 2.3” and 12 Mpixel (dimension of the pixel 1.5 micron), FOV 81.9° and focal of 25 mm.
Photogrammetric surveys have also been processed with the Metashape commercial software by Agisoft. The results were used as a reference to validate the point clouds coming from WebODM. The validation was done using the Cloud Compare open source software.

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1. INTRODUCTION

Development of the technology in the field of digital cameras, computer vision and 3D reconstruction from the images has brought the close range photogrammetry to a high degree of popularity (Jurjević, L. et al., 2017). Furthermore, the implemented automatisms and algorithms in multi-image photogrammetry software both with the low cost of digital cameras have led many architectural operators to approach this methodology.
In particular, thanks to the implementation of the Structure from Motion (SfM) approach also in the software for the close range photogrammetry and drones, low cost software, easy to use and with high performance and accuracy, have been developed. [1]
With these software dense point clouds, high resolution orthophotos and other photogrammetric products can be obtained for accurate and fast documentation of architectural heritage [2, 3]. This contrasted the multi-image photogrammetry, based on SfM, to the Terrestrial Laser Scanner (TLS) methodology, the latter, in fact, since it provides fast and comprehensive survey of objects, stable results and visualization of data in the form of digital 3D models [4,5].
Furthermore, the Multi-Images Photogrammetry has many advantages respect to TLS, higher accuracy for shorter imaging distances (< 5 m), relatively easy data collection, easy use software, high radiometric resolution of final point cloud and relatively low purchase costs of the photogrammetric system. In fact, there are many applications that use multi-image photogrammetry such as the modeling of facades [6], buildings [7, 8], monuments [9, 10], etc. Today even the Multi-Images photogrammetry has shown itself able to obtain quality data with high informative value, reliable information about the position of objects, about their geometrical properties and also about radiometric characteristics of their surfaces. Moreover, the development of a considerable number of open source or free software that allow 3D reconstruction from images from digital cameras even at low cost, has further contributed to the spread of multi-image photogrammetry.
The paper presents a study about a low cost photogrammetric system based on the low cost UAV and Open Source software for multi-image photogrammetry based on the SfM approach. For the UAV survey we used the Spark DJI. It has a CMOS sensor of 1 / 2.3" and 12 Mpixel (dimension of the pixel 1.5 micron), FOV 81.9° and focal of 25 mm. For images processing we used the open source software WebOpenDroneMap (WebODM).
The aim of this study was to test the ability of WebODM to generate accurate orthophoto, point clouds, and digital surface models from digital images from a low cost UAV. To verify it, a UAV flight was carried out on a coastal tower located in Puglia. The Guaceto tower was built in 1531 to defend the Salento coast. It is a tower with a pyramidal truncated plan of 16 m x 16 m (Figure 1).

For the validation of the results, the images have also been processed with the Metashape commercial software by Agisoft. All point clouds were compared with each other using Open Source Cloud Compare software.

Figura 1: Guaceto tower

2. MATERIALS AND METHODS

1.1 Web Open drone Map

WebOpenDroneMap (WebODM) is an open-source toolchain written in the Python programming language. It can be used to perform photogrammetric workflows and was originally designed for processing UAS imagery [11, 12]. WebODM produces a variety of photogrammetric products, from sparse and dense point clouds, to mesh reconstructions and orthophoto. The software relies on several open source libraries, including OpenSfM (an SFM library on top of OpenCV), OpenMVS, and CMVS/PMVS2 (or simply CMVS) . The typical workflow for generating photogrammetric products from digital images is described below (see Figure 2) [13].

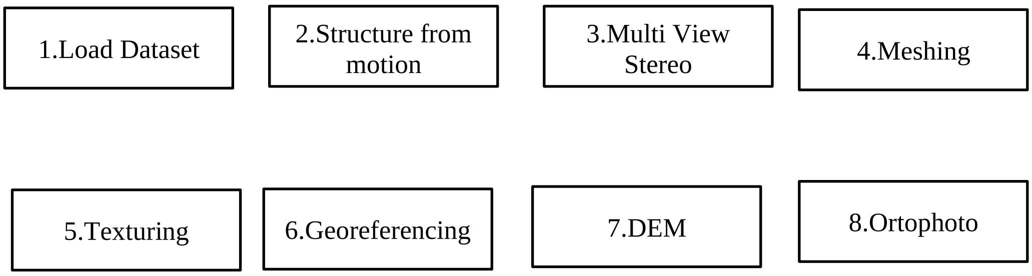


Figura 2: WebODM's processing pipeline

Load Dataset: This step counts the images, extracts dimensions and parses GPS information from all available images. For reducing storage requirements, lowering memory usage and increasing processing speed, at the expense of potentially lower quality results, you can choose to resize your images prior to processing.
Input: images + GCP (optional)
Output: image database

Structure from Motion (SFM): is a photogrammetry technique for estimating 3D objects (structures) from overlapping image sequences (from the motion of a camera taking pictures). WebODM uses a software package called OpenSfM [14] for efficiently solving the SFM problem.
Input: images + GCP (optional)
Output: camera poses + sparse point cloud + transform

Multi View Stereo. While SfM focuses mostly on the estimation of camera poses, Multi-View Stereo (MVS) focuses on the reconstruction of 3D models from multiple overlapping image pairs. MVS programs expect that information about cameras has already been computed and this allows them to focus on one thing: create a highly detailed set of 3D points (a *dense point cloud*). WebODM currently offers two options for MVS:
• Multi-View Environment (MVE), a software suite developed at TU Darmstadt [15].
• OpenSfM has a dense reconstruction feature also.
Input: images + camera poses + (sometimes) sparse point cloud
Output: dense point cloud

Meshing and texturing: Mesh and texturing reconstruction
Input: dense or sparse point cloud
Output: 3D and 2.5D meshes, textured meshes

Georeferencing: is the process of converting (*transforming*) a local coordinate system into a world coordinate system. WebODM can do this only if location information about the world is available, either via GPS coordinates embedded in the input images or a GCP file. When GCPs are available, the GPS information is ignored and GCPs are used for the alignment instead.
Input: transform + point cloud + textured meshes
Output: georeferenced point cloud + textured meshes + crop boundaries

Digital Elevation Model Processing: During this step WebODM takes the georeferenced point cloud and extracts a surface model by using an inverse distance weighting interpolation method. If there are any holes in the model (perhaps an area is missing), they are filled using interpolation. Finally, the model is smoothed using a median filter to remove noise (bad values). With certain settings it can also attempts to classify the point cloud into ground vs. non-ground points and generate a terrain model by first removing all non-ground points. Finally, the results are cropped.
Input: georeferenced point cloud + crop boundaries
Output: digital surface models + digital terrain models + classified georeferenced point cloud

Orthophoto Processing: the orthophoto is generated by taking a picture of the textured 3D mesh from the top. The image is then georeferenced and converted to a GeoTIFF using the information computed in the georeferencing step.

Input: textured mesh + crop boundaries
Output: orthophoto

2.2 Methodology

The coastal tower was surveyed with the low-cost photogrammetric system composed of the DJI Spark drone and the images was processed with the open source software WebODM.
Spark DJI has a CMOS sensor of 1 / 2.3” and 12 Mpixel (dimension of the pixel 1.5 micron), FOV 81.9° and focal of 25 mm. The small UAV (Figure 3) is equipped with propeller guards, compulsory to operate in critical scenarios, having a take-off weight of 340 g.

Figura 3: Spark DJI

A flight was performed consisting of 139 images between nadiral and oblique from two different heights 30 m and 10 m.
The images were then processed with the WebODM software and with Metashape. The georeferencing was leave to 10 GCPs distributed around the building and on the top of the tower. The GCPs were surveyed through a GNSS RTK survey using the network of ITALPOS GNSS permanent stations.

Figura 4: GCPs position and UAV flight paths

In the table 1 there are the processing results for the different software open source.

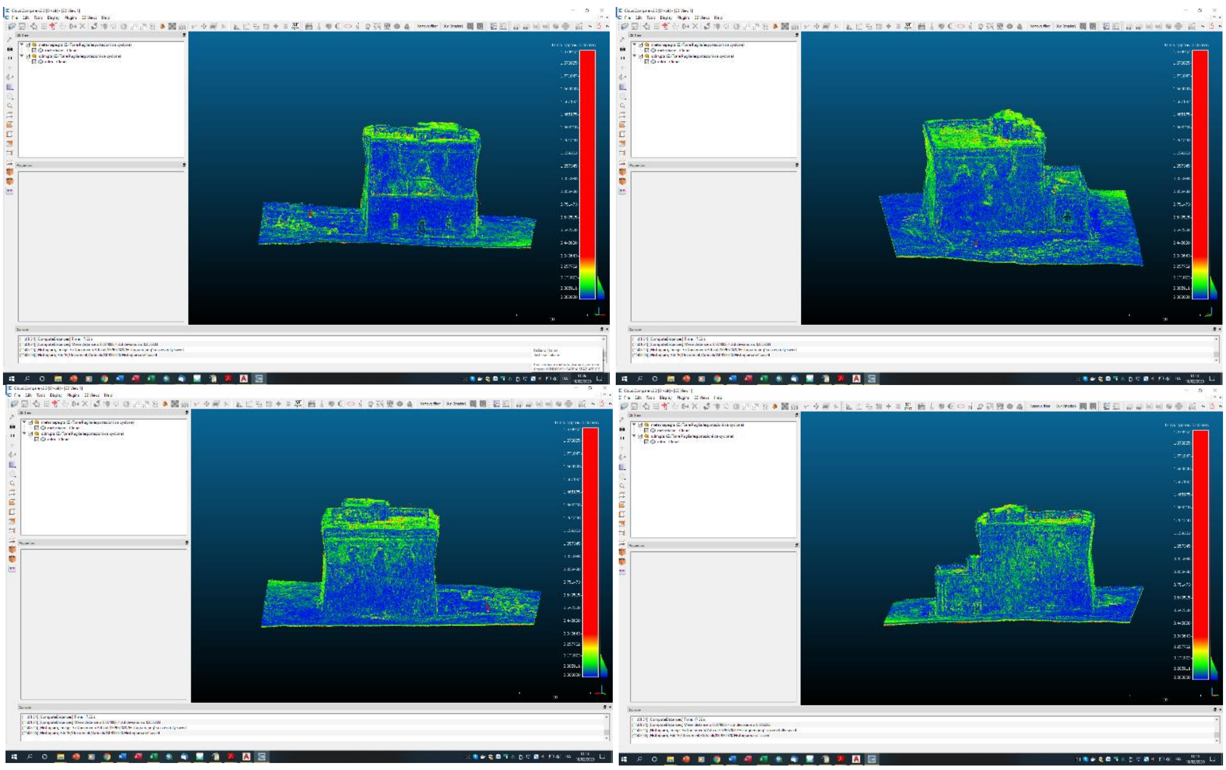
	n. images	n. points of point cloud	Processing Time
WebODM	139	6.218.480	6 h
Metashape	139	3.042.396	4 h

Table 1: processing results

The dense point clouds from WebODM has been compared with point cloud from Metashape. This comparison was done comparing the measurements of distances taken on the point clouds obtained with CloudCompare software (Open Source Software). Specifically, this analysis was done by calculating the minimal distance between every point of the models using the nearest neighbour algorithm. Furthermore, the software allows the calculation of statistical values, such as the minimal distance, maximal distance, average distance, and standard deviation.
Table 2 reports the results of the comparisons between the point clouds obtained with Metashape and the point clouds from WebODM.

Min (m)	0
Max (m)	2.00
Mean (m)	0.045
Dev. Stand (m)	0.20

Table 2: Statistical values of the comparisons between the Metashape data and the WebODM point clouds.



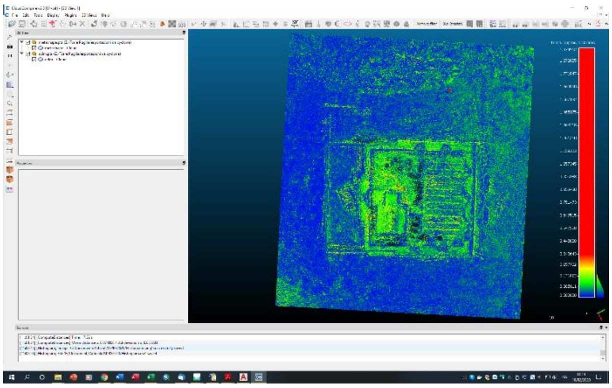


Figure 5: Discrepance map (m) between the Metashape point cloud and WebODM point cloud

Figura 6: OrtophotoWeb ODM

3. Conclusion

The paper describes an experimentation of a low cost photogrammetric system consisting of a Spark DJI UAV and open source WebODM software based on the SfM algorithm.
The flight of 139 images on a historical building was elaborated with WebODM and the results compared with those coming from the Metashape commercial software. The point clouds obtained presented average deviations of 4 cm and presented a good geometric description of the building.
The study and experimentation with low cost tools and software is continuing with further types of survey.

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