



Evaluation of the Efficiency of SfM-Photogrammetry in Obtaining DEM from Google Earth Images

Received 22 May 2023; Revised 11 July 2023; Accepted 20 July 2023

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Keywords

Digital Elevation Model (DEM), SRTM, Structure from Motion (SfM), Google Earth

Abstract

In this study, we seek to evaluate the efficiency of SfM (Structure from Movement) Photogrammetry in obtaining Digital Elevation Model (DEM) from the free Google Earth browser, by simulating the aerial photography of the terrain displayed by this browser, calculating the resulting block of images, and obtaining DEM, and evaluate its accuracy to know the type of works in which this model can be used. Control data for image orientation are provided using Google Earth and free online services. The results showed that the huge number of dense point clouds generated by applying SfM to Google Earth images has contributed to obtaining a DEM with a vertical accuracy better than the vertical accuracy of the free digital elevation model SRTM1. The achieved vertical accuracy of the DEM produced by SfM was 3.58 m, whereas the vertical accuracy of the free SRTM1 was 4.65 m compared to a DEM derived 1/25000 scale topographic map. This type of DEM can be used in works that do not require high vertical accuracy, such as hydrological works (watersheds) dealing with SRTM models.

1. Introduction

In 2000, NASA launched a Shuttle Radar Topography Mission which accomplished the complete global DEM to date, SRTM1 [1, 2] with a spatial resolution of 30 m. Radar images were acquired by a shuttle equipped with two radar antennas with a baseline of 60 m. This technology is known as Interferometric Synthetic Aperture Radar (IfSAR or InSAR) which produces topographical data (levels) derived from the phasing of the radar visuals [3]. The horizontal reference surface of SRTM1 is WGS84, while the topographic levels are associated with the EGM96 geoid, which roughly corresponds to the mean sea level [4]. This Digital Elevation Model (DEM) is one of the digital elevation models used in the free browser Google Earth, for visualizing terrain. With the advent of aerial Laser scanning (LIDAR), it has become possible to measure a huge number of points which helps to generate highly detailed and accurate digital models of the earth [5]. Besides, other studies proposed an alternative, automated and low-cost solution to produce the digital model

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of the earth by adopting the automated modeling technologies based on photogrammetry, which in return is based on the principle of Structure from Movement (SfM Photogrammetry) by which the density of points generated is not less than the density of laser scanners [6].

SfM (Structure from Motion) is a photogrammetric technique used to create 3D models from 2D images. It involves extracting feature points from multiple images of a scene, and then using those points to estimate the camera positions and orientations for each image. Once the camera positions and orientations are known, the 3D coordinates of the feature points can be estimated, and a 3D model of the scene can be constructed [7]. In the context of DEM generation, SfM involves using overlapping images from different viewpoints to identify and match corresponding features in the images, and then triangulating the positions of these features to generate a dense point cloud. This point cloud can then be used to create a surface model, from which the DEM can be extracted [8].

The utilization of SfM-based DEM generation has numerous advantages over traditional methods such as LiDAR and stereo-photogrammetry [9]. SfM is relatively low-cost and requires minimal equipment, with images often being captured using consumer-grade cameras or even smartphones. Additionally, SfM can produce high-resolution DEMs with accuracies comparable to more expensive and complex methods [10]

The ability to show the terrain in Google Earth makes it possible to simulate aerial photography of any area and extract the digital elevation model by applying the SfM. In this case, the images should be taken at the same altitude (Google Earth enables us to fix the altitude) with 3D control points provided in the study area. These points can be provided by measuring them in Google Earth and then processing the measurements using some services available on the Internet. In this study, a digital elevation model (DEM) was obtained by processing the images resulting from a flight simulation process using SfM, then evaluating its accuracy compared to the global digital model SRTM1 as well as a DEM extracted from the processing of contour lines available in a topographic map of the study area.

2. The Importance of The Study and Its Objectives

The importance of this study lies in the fact that it seeks to evaluate the efficiency of photogrammetry based on the principle of structure from movement (SfM Photogrammetry) in obtaining digital models of elevations from the free browser Google Earth by simulating the process of aerial photography of the terrain shown by the browser, thus calculating the resulting image block, obtaining the DEM and evaluating its accuracy to determine the type of work that this model can be used for. In general, the objectives of the study can be summarized as follows:

1. Introducing an approach that helps those interested in simulating an aerial photography process within the Google Earth browser environment and obtaining the necessary control points for calculating the resulting images using the SfM technology. The output here is a cloud containing a large number of 3D points and a digital elevation model.
2. Evaluating the accuracy of the digital elevation model resulting from the previous images by comparing it with the free digital elevation model SRTM1 using an absolute reference, a digital model obtained by processing the contour lines available in a topographical map of the study area.

3. Methods and Tools

3.1. The Study Area

The study area is the village of Um al-Tuyour and the forest area (Fig. 1), located in the northern countryside of Lattakia Governorate. Umm al-Tuyour is 30 km north of Lattakia, and its coastline is 12 km long, extending from Mount Gozatrangeh in the south to Al-Baseet in the north. It is bordered by the agricultural road Taranga - Al-Issawiya - Al-Bassit to the west and the sea up to the regional borders. The beach area in the south is characterized by a sandy coast where Umm al-Tuyour is located, then a rocky beach with impulsive rocks up to Ras al-Baseet. The site is also characterized by distinguished plants of the deteriorating Mediterranean forest.

The area has been declared a natural reserve to preserve migratory birds and forest areas. This reserve is a coastal forest environment with an area of 10 km² to protect the migratory birds that visit the site and the forest trees prevailing there. Carob, Pistacia lentiscus, and wild olive trees are spread there. Topographically, the study area is located between latitudes 36°46' 41.98" north and 35° 43' 38.99" south and between longitudes 35° 50' 6.63" east and 35° 46' 28.45" west. It is characterized by a rugged topography with large slopes and altitudes ranging from 0 m up to more than 350 m

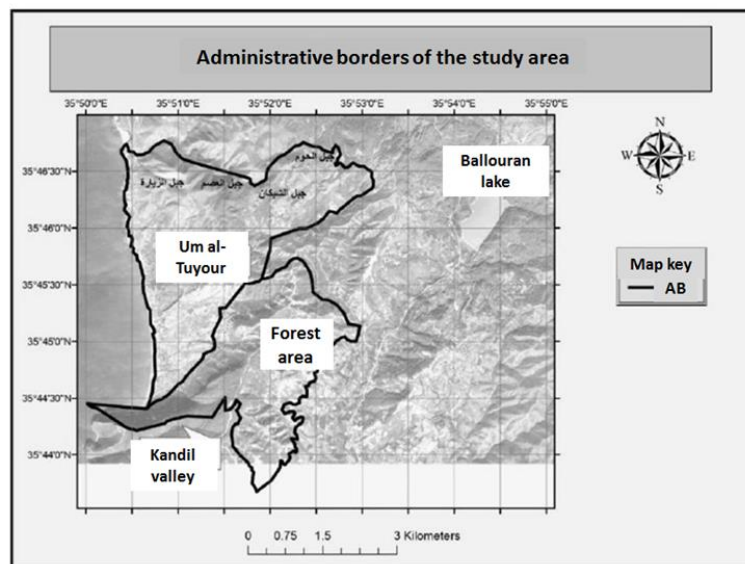


Fig. 1: The administrative borders of the study area

3.2. Google Earth, the Free Browser

Google Earth depends on satellite images and aerial photography; it takes all the images that come from these different technologies and superimposes them, producing the final image that it displays. In addition, it has a 3D Terrain visualization feature, which enables us to simulate an aerial photography process and extract the digital elevation model by applying SfM technology. Hence, the primary idea of the study is based on simulating flying over the area that we want to produce DEM for (Umm al-Tuyour and the forest area) at an appropriate elevation so that the view is as clear as possible. The reason for choosing this region is that there are large changes in elevations, which enables us to give a more realistic assessment of the geometric quality of the resulting DEM.

3.3. The Digital Elevation Model

Indeed, the two most common technologies for producing ground observations needed to generate these digital models are the ground survey and the traditional photographic survey. However, they are costly in terms of effort and time, especially for large areas, mountainous areas, and forest areas, compared to the portable air laser technology and the SfM photographic survey technology [11]. The use of these two technologies has become one of the most important sources for obtaining 3D digital models of the surveyed areas in the form of a Digital Surface Model (DSM) that represents the natural surface of the earth, with all spatial features (e.g., trees, buildings, roads, rivers, etc.). DSMs can be used in the studies of spatial features visible on the Earth's surface as well as in studies related to 3D vision analytics and in the field of communication. There is a big difference between this surface and the Digital Terrain Model (DTM) or the regular Digital Elevation Model (DEM), which expresses these elevations in point form (Raster). This digital model can be defined as a statistical representation of the continuous surface of the natural terrain, with a large number of considered points defined by their triple XYZ coordinates within a coordinate system (Fig. 2).

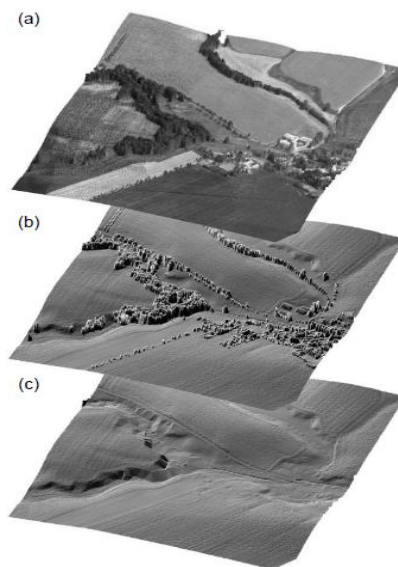


Fig. 2. Obtaining a digital elevation model (DEM) from a digital surface model DSM
(a) Aerial image of the scene, (b) DSM model, (c) DEM mode

Google Earth uses multiple sources of free digital elevation models [12], including:

- 1.NED (USGS): Produced by the United States Geological Survey and covers the United States, Canada, and Mexico with a spatial resolution of 30 m (1 arc-second). This model is also available with a resolution of 60 m for Alaska. Besides, USGS produced a digital elevation model with a spatial resolution of 10 m for some areas of the United States [13].
- 2.SRTM1 (NASA): A digital elevation model with a spatial resolution of 30 m (from the Space Shuttle Radar Topography Mission). Previously, this model covered the United States only, but now it covers the whole world.
- 3.ODP1: A digital elevation model covering European countries only, with a spatial resolution of 30 m [14].
- 4.ASTER: It is a joint production of the US NASA and the Japanese Ministry of Economy. It covers the world with a spatial resolution of 30 m [15].

5.SRTM3 (NASA): A digital elevation model with a spatial resolution of 90 m whole covering the world.

6.The Advanced Land Observing Satellite (ALOS) World 3D: A global digital surface model (DSM) dataset produced by the Japan Aerospace Exploration Agency (JAXA). It is also known as the "ALOS World 3D - 30m" or "AW3D30" dataset.

The vertical accuracy of the Digital Elevation Model (DEM) within Google Earth can vary depending on the source of the data used to create the model. Google Earth primarily uses two sources of data to generate its DEMs: the Shuttle Radar Topography Mission (SRTM) and the Advanced Land Observing Satellite (ALOS) World 3D. The SRTM data has a vertical accuracy of approximately 16 meters, while the ALOS data has a vertical accuracy of approximately 10 meters [16]. SFM-based DEM generation has become increasingly popular in recent years due to its ability to generate high-resolution and accurate DEMs at a relatively low cost and with minimal equipment requirements. Several studies have investigated the use of SFM in different applications, including:

- 1.Environmental monitoring: SFM-based DEMs have been used in studies to monitor changes in land cover, vegetation, and soil erosion. For example, a study by Mancini et al. [17] used SFM to generate high-resolution DEMs for monitoring soil erosion and sedimentation in a Mediterranean river basin.
- 2.Archaeology: SFM has been used to create 3D models of archaeological sites and artifacts, allowing for the identification of features and structures that may not be visible in 2D images. For example, a study by Remondino et al [18] used SFM to create a 3D model of a Roman aqueduct in Italy.
- 3.Urban planning: SFM-based DEMs have been used in urban planning studies to model building heights, calculate urban heat island effects, and analyze urban expansion. For example, a study by Li et al. [19] used SFM to generate high-resolution DEMs for modeling building heights in a Chinese city.
- 4.Glacier monitoring: SFM has been used to monitor changes in glacier volume and surface elevation. For example, a study by Bolch et al. [20] used SFM to generate high-resolution DEMs of the Himalayan glaciers.

4. Results and Discussion

To reach the desired results of this study, we applied the following step:

4.1. Simulating Aerial Photography within Google Earth and Obtaining Control Points

The process of simulating aerial photography and obtaining control points required the following:

1. Showing the terrain on Google Earth.
2. Taking pictures at equal viewing heights (where possible) for all parts of the studied area (to fix the internal geometric specifications for all the images). The viewing height was set at 850 m, through which we obtained sufficient coverage of the image and the clarity of its contents.
3. Ensuring a forward overlap of successive images of not less than 60% and a side overlap between adjacent strips of not less than 25%.
4. The availability of at least two control points in the overlapping area of every two images.

Achieving the above conditions guarantees to obtain a coherent and computable block of images within the coordinates of the element accurately. (Fig. 3) shows the simulated imaging strips with an illustration of the distribution of the control points in a part of the study area. The number of

images covering the study area was 245, saved with the highest resolution available on Google Earth. The number of measured control points was 163.

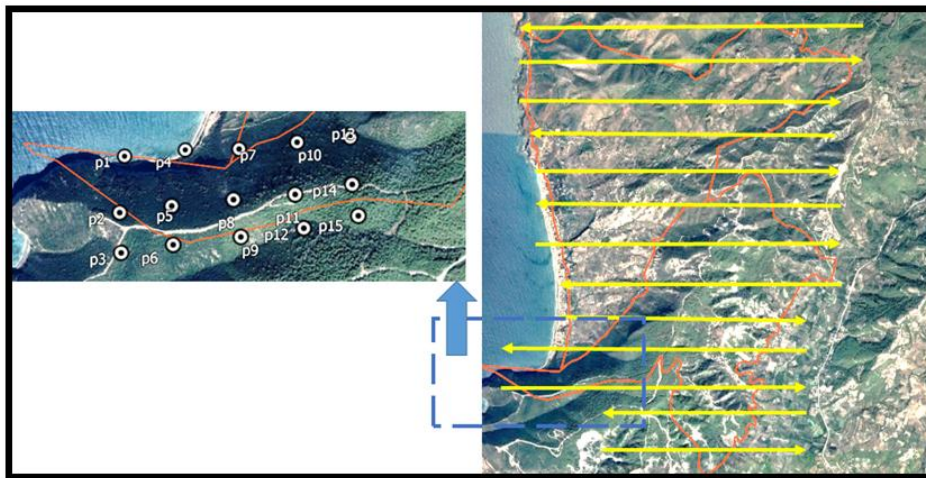


Fig. 3. Simulated imaging lines with an illustration of the distribution of control points in a part of the study area.

Control points were measured using Google Earth (flags added). The accuracy of control points measured with Google Earth both horizontally and vertically can vary depending on several factors, such as the quality of the input images used to identify the control points, the resolution of the input images, and the accuracy of the underlying Digital Elevation Model (DEM) used to georeference the points. In general, the accuracy of control points measured with Google Earth is estimated to be within a few meters horizontally and vertically, depending on the quality of the input data and the level of detail required for the specific application. However, it is important to note that this level of accuracy is generally considered to be lower than that achievable with traditional surveying methods or more sophisticated georeferencing techniques. Such accuracy level is suitable for evaluating the SFM-based generated DEM depends on the specific application and the level of accuracy required. For some applications, such as environmental monitoring or urban planning, the accuracy of control points measured with Google Earth may be sufficient to generate reliable DEMs that meet the required accuracy standards.

As for the 3D coordinates were obtained by drawing a path within Google Earth passing through the vertices of these points, then saving them in kmz format. Then the file was uploaded to the GPS Visualizer (<https://www.gpsvisualizer.com/elevation>) which enabled us to convert the kmz file into a gpx file with elevations added to the points by the best free global digital model available for the study area. The elevations used in GPS Visualizer can come from a variety of sources, depending on the input data that is being used to create the visualization. If the input data contains elevation information, such as GPS tracks recorded with a device that includes an altimeter or elevation data downloaded from a mapping service, then GPS Visualizer will use that elevation information to generate the visualization. If the input data does not contain elevation information, GPS Visualizer may use a digital elevation model (DEM) to estimate elevations for the points in the track. GPS Visualizer can use a variety of DEM sources, including the USGS National Elevation Dataset (NED), the Shuttle Radar Topography Mission (SRTM), and other publicly available DEMs. It is important to note that the accuracy of the elevations in GPS Visualizer will depend on the accuracy of the source data used to generate the visualization. If the input data contains inaccurate or imprecise elevation information, GPS Visualizer will reflect those inaccuracies in the resulting

visualization. Finally, ArcGIS was used to convert the gpx file into a raster shape file that contains the control points with their 3D coordinates (Fig. 4).

c1_1_39_39_GPXtoFeatures												
	FID	Shape *	Id	Name	Descrip	Type	C	S	Dat	Elevation	Latitude	Logitude
▶	0	Point ZM	0	1_1_39_39		TRKPT				86.051	35.8494	35.76756
	1	Point ZM	0	1_1_39_39		TRKPT				172.532	35.855912	35.77065
	2	Point ZM	0	1_1_39_39		TRKPT				168.75	35.858098	35.767752
	3	Point ZM	0	1_1_39_39		TRKPT				129.427	35.860763	35.773043
	4	Point ZM	0	1_1_39_39		TRKPT				147.095	35.863393	35.770081
	5	Point ZM	0	1_1_39_39		TRKPT				173.602	35.861784	35.776484
	6	Point ZM	0	1_1_39_39		TRKPT				79.409	35.856527	35.774171
	7	Point ZM	0	1_1_39_39		TRKPT				210.04	35.851063	35.771417

Fig. 4. A sample control points raster file.

4.2. Processing Using SfM

After obtaining the images and the 3D coordinates of the control points, processing was done using SfM imaging scanning by Agisoft Metashape software. This program is a 3D modeling tool that represents the Image-based 3D modeling method of SfM, and it uses the latest 3D construction technology from multi-view images developed in the field of Computer-Assisted Vision [21]. Moreover, it enables the orientation of the images taken from any location, considering that they fulfill the condition that any point of the element lies on at least two images. The processing steps can be summarized as follows:

1- The relative orientation of the images and calculating the image capture locations (Fig. 5). At this stage, a sparse point cloud is generated, which included approximately 200 thousand points in our study. The availability of this large number of points provides a density of elevation points necessary to generate the digital elevation model equal to 22 points per hectare (the study area is approximately 1324 hectares).

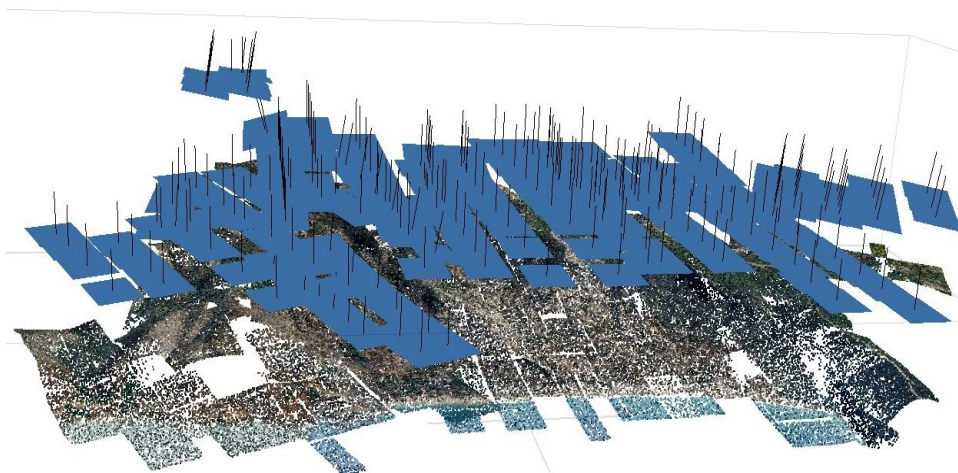


Fig. 5. The oriented images and sparse cloud.

2- Measuring the control points and achieving absolute orientation to link the images to the 3D terrestrial coordinate system (the system used in this study is WGS 84). In Table (1), we show the total mean square error on the coordinates of the control points.

Table 1: Values of the total square error on the coordinates of the control points

σ_X (m)	σ_Y (m)	σ_{XY} (m)	σ_Z (m)	σ_{XYZ} (m)
0.15	0.17	0.22	0.14	0.26

To decide whether mean square error values on the horizontal or the vertical are acceptable, referring to the international standards proposed by Eurosd (European Spatial Data Study) [22] which linked the tolerance limits with the value of a distance Ground Sampling Distance (GSD) (distance covered by a pixel on the ground); in these standards, it was found the following formulas:

$$\sigma_{xy} = 0.75 * GSD \quad , \quad \sigma_z = 0.53 * GSD \quad (1)$$

Before carrying out the evaluation process, an approximate value of the GSD had to be calculated, by measuring the distance between two control points located in the transverse direction of the image (Fig. 6); where it was equal to 1578 m and counting the number of the pixels in this direction; where it was about 4511 pixels, the GSD was equal to 0.35m. By applying relation (1), we get:

$$\sigma_{xy} = 0.75 * 0.35 = 0.26m \quad , \quad \sigma_z = 0.53 * 0.35 = 0.18m$$

By comparing these values with the values in Table (1), it was found that; the accuracy of the performed air triangulation is acceptable.



Fig. 6. Determining the mathematical coefficients needed to calculate the GSD.

3- Building a dense point cloud (Fig. 7) with 1575551539 points.



Fig. 7. Dense point cloud of the study area.

4- Building a mesh model for the study area (Fig. 8) and filling in the gaps by applying the extrapolation algorithms available in the software.

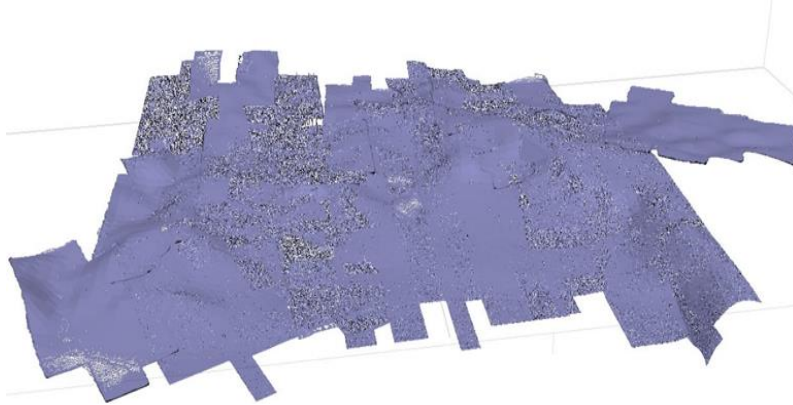


Fig. 8. A mesh model of the study area.

5- Generating the DEM (Fig. 9) based on the mesh model of the study area with a spatial resolution of 1.19 m is an excellent accuracy obtained thanks to the huge number of dense point clouds.

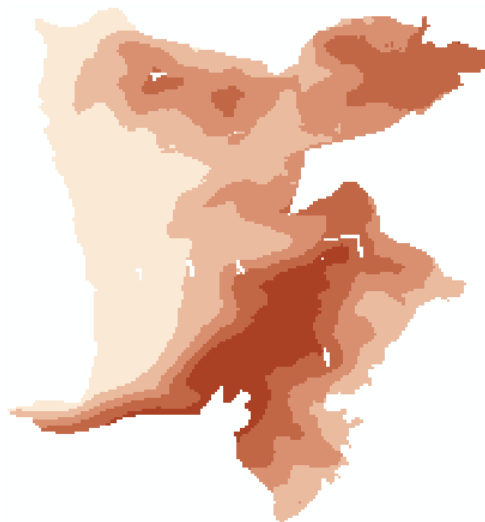


Fig. 9. DEM of the study area, with elevations ranging from 0 to 350 m.

4.3. Generating the Reference Digital Elevation Model from the Contour Lines

A topographic map of scale 1/25000 of the study area with contour lines is available, where the coordinate system attached to this map (the Syrian stereographic system) was first converted to the working coordinate system WGS84 using the conversion parameters available in ArcGIS 10.6. Then the digital model for elevations was built from this map (Fig. 10) taking care to give it a spatial resolution equal to the spatial resolution of the digital elevation model produced by processing SfM (1.19 m) to provide the conditions for a rational comparison.



Fig. 10. The Digital Elevation Model (DEM) for the study area calculated from contour lines with elevations ranging from 0 to 350 m.

4.4 DEM Accuracy Evaluation

To evaluate the accuracy of the digital elevation model resulting from applying SfM to the images extracted from the free browser Google Earth, the following sequences were carried out:

1. Choosing a random group of points distributed in the study area (Fig. 11). The number of these points was 10000 points.
2. Deducing the random point levels from the two digital models generated by SfM and the contour lines.
3. Repeating the second step for the free digital model SRTM1.
4. Calculating the differences between the extrapolated random point levels in the previous step, according to the following:
 - a. The difference between the SfM and the reference models (from the topographic map).
 - b. The difference between SRTM1 and the reference model (from the topographic map).
5. Isolating the irregular points that have big differences in levels.
6. Finally, the best digital elevation model is compared to the most important statistical indicators of both SfM and SRTM1.

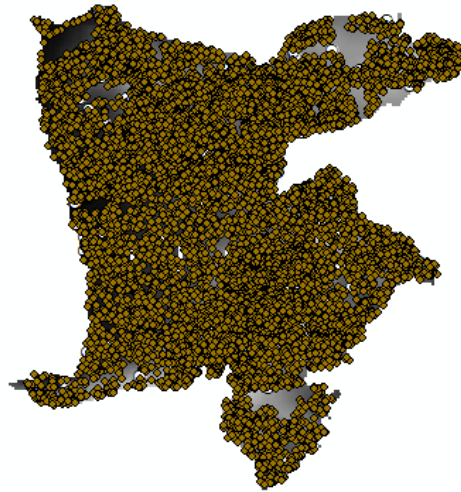


Fig. 11. Distribution of the random points used at the test.

To clarify the fourth point, we give the following example for evaluating the accuracy of the digital elevation model resulting from the SfM method. We used the Normal QQPlot tool available in the Geostatistical Analyst attached to the ArcGIS software to identify the irregular points. The tool assumes that the sample follows a normal distribution and shows graphically the measurements deviate from this distribution [23]. The anomaly scale is how far the measurements are from the best line that goes through them. The following figure shows, we show the results of applying this tool on the differences between the original levels and the extrapolated ones using the SfM method. We notice the presence of a group of irregular measurements which should be excluded before continuing processing. To confirm the anomalies of these measurements, we placed the points on a reference image of the study area and found that they are located in forested areas, not on the ground (Fig. 12).

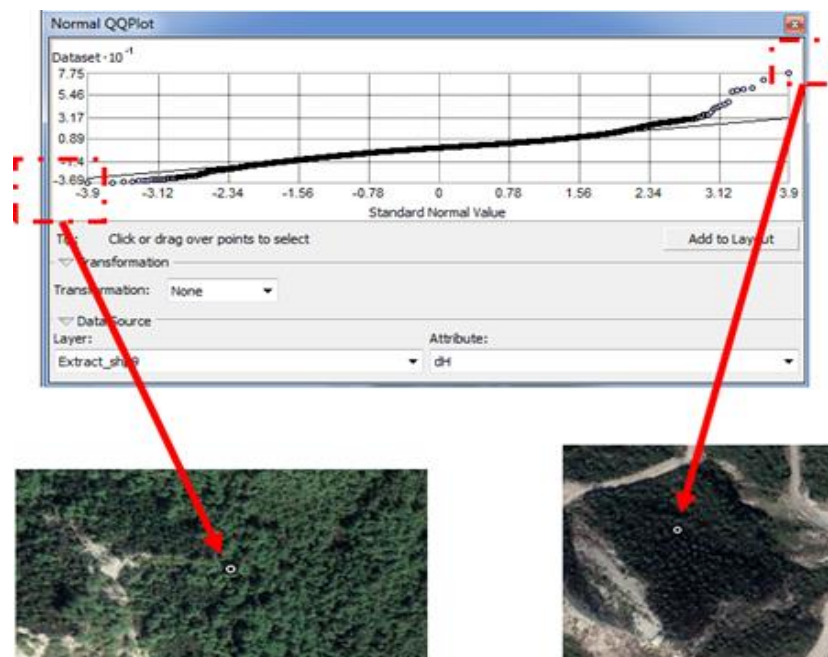


Fig. 12. Showing the location of some anomalies in differences values.

Table 2: Values of the total square error on the coordinates of the control points

Method	Number of differences	Mean (m)	Arithmetic average (m)	Minimum Difference (m)	Maximum Difference (m)	Mean Squared Error (m)
SRTM1	8742	-0.17	-0.24	-10.00	10.01	4.65
SfM	8742	0.09	0.038	-10.00	10.03	3.58

Concerning calculating the statistical indicators required for evaluating the accuracy of both SfM and SRTM models, we used the statistical program NCSS to process as are necessary for assessing the elevation differences between these two models and the reference model resulting from the contour lines. The results are shown in Table (2).

It was also found that the differences in both cases follow a normal distribution with a confidence level of 95% (Fig. 13.a and Fig. 13.b), according to all the dependency tests for the normal distribution implemented by the program, such as the Shapiro-Wilk test and the Kolmogorov-Smirnov test.

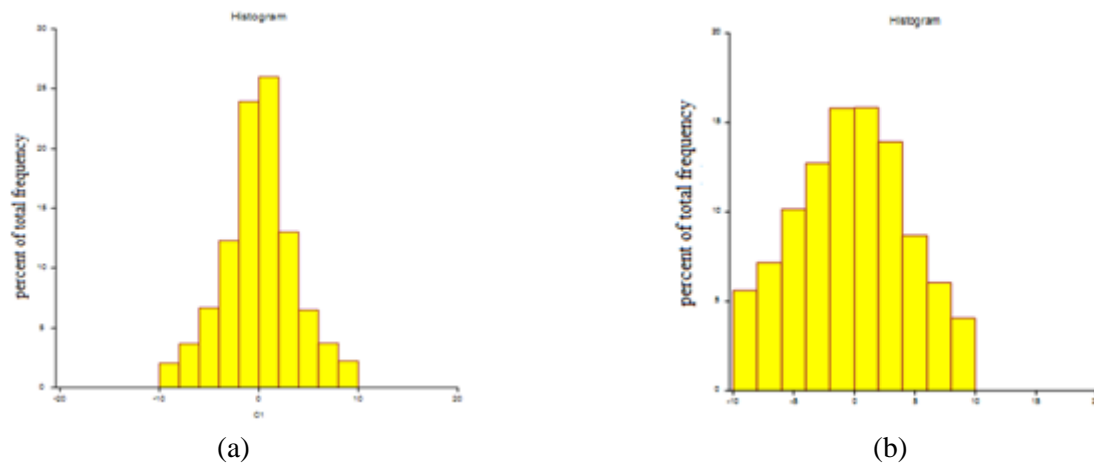


Fig. 13. The elevation differences following the normal distribution at (a) SfM and (b) SRTM1

The achieved vertical accuracy of the DEM produced by SfM was 3.58 m compared to a DEM derived from the topographic map. In contrast, the vertical accuracy of the free SRTM1 was 4.65 m compared to a DEM derived from the topographic map. Such accuracy improvement is good, and it is due to a large number of extrapolated points (point cloud). Accuracy could have been improved if the reference data (the topographic map) and the DEM produced by SfM had been at the same reference level. The converting process from the Syrian stereographic coordinate system to WGS84 affected the horizontal accuracy of the topographic map used to obtain the DEM and consequently affected the extrapolated elevation values. This accuracy could have been improved if we had rectified the map using precise control points in both systems. On the other hand, the method that was suggested in this study has the following advantages:

1. The ability to generate dense point clouds representing the terrain available in the free Google Earth browser can be used independently in many applications, such as regional planning and geological maps for following the extended ores layers.
2. The ability to generate independent mesh models that can be used in determining the borders, such as those of watersheds and waterways.
3. The possibility of generating independent real-time 3D terrain models useful for presentation and planning (Fig. 14).

4. The ability to generate orthophotos that can be used for performing measurements is exactly like the topographic map (Fig. 15).

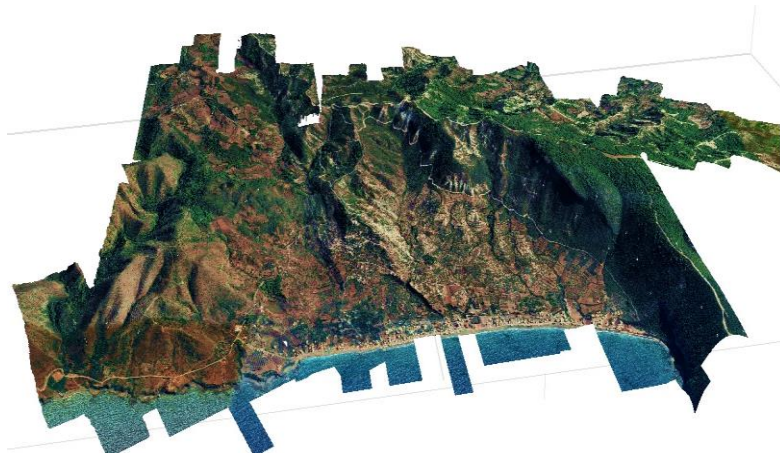


Fig. 14. Real photographic model of the study area



Fig. 15. Orthophoto of the study area.

5. Conclusions and Recommendations

5.1. Conclusions

Based on the theoretical and practical study evaluating the efficiency of SfM Photogrammetry in obtaining DEMs from images of the free browser Google Earth presented in this study, it was found that:

1. The terrain of any area in Google Earth can be represented by simulating the process of aerial photography, obtaining an image that provides the construction of high visual accuracy, and 3D geometry of the photographed area. Furthermore, the necessary adjusting data can be provided for the image orientation using Google Earth and free online services.
2. The accuracy of air triangulation of the images from SfM by Google Earth browser images using control points was 0.26 m, which reflects the accuracy of positioning the images relative to each other within the element coordinate system.
3. The huge number of dense point clouds generated by applying SfM to Google Earth images has contributed to obtaining a DEM with better vertical accuracy than the free digital elevation model SRTM1. The results showed that the achieved vertical accuracy of the DEM produced by

SfM was 3.58 m compared to the DEM derived from the topographic map, where the vertical accuracy of the free SRTM1 was 4.65m compared to the DEM derived from the topographic map.

5.2 Recommendations

At the end of this study, we recommend the following:

1. Replacing the control points measured on Google Earth with accurately measured field control points to increase the accuracy of products, including the DEM.
2. Comparing the orthophoto resulting from SfM with the topographic map of the study area to evaluate its accuracy.
3. Using this kind of DEMs at works that do not require high vertical accuracy, such as hydrological works (watersheds) that deal with SRTM.

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تقييم فعالية المساحة التصويرية SFM في الحصول على النماذج الرقمية للارتفاعات من صور المتصفح المجاني Google Earth

ملخص

سعيًا في هذا البحث إلى تقييم فعالية المسح التصويري القائم على مبدأ البنية من الحركة SfM Photogrammetry في الحصول على نماذج رقمية للارتفاعات (DEM) من المتصفح المجاني Google Earth وذلك عبر محاكاة لعملية التصوير الجوي للتضاريس التي يظهرها هذا المتصفح وحساب بلوك الصور الناتج والحصول منه على النموذج الرقمي للارتفاعات وتقييم دقته لمعرفة نوعية الأعمال التي يمكن لهذا النموذج أن يستخدم فيها. تم تأمين معطيات الضبط اللازمة لتوجيه الصور باستخدام Google Earth وخدمات مجانية متوافرة على شبكة الانترنت.

بينت نتائج البحث أن العدد الهائل من نقاط الغمامات الكثيفة الناتجة عن تطبيق SfM على صور المتصفح Google Earth قد ساهم في الحصول على نموذج الرقمي للارتفاعات ذي دقة شاقولية أفضل من الدقة الشاقولية للنموذج الرقمي للارتفاعات المجاني SRTM1. لقد بينت النتائج أن الدقة الشاقولية للنموذج الرقمي للارتفاعات الناتج عن تقنية الـ SfM قد بلغت 3.58 m مقارنة بالنموذج الرقمي للارتفاعات المستنتج من الخارطة الطبوغرافية وأن هذه الدقة في حالة النموذج الرقمي للارتفاعات المجاني SRTM1 قد بلغت 4.65 m مقارنة بالنموذج الرقمي للارتفاعات المستنتج من الخارطة الطبوغرافية ذات المقياس 1/25000. يمكن استخدام هذا النوع من النماذج الرقمية للارتفاعات في أعمال لا تتطلب دقة شاقولية عالية مثل الأعمال الهيدرولوجية (الأحواض الصبابة) التي تتعامل مع النماذج SRTM.