Volume Calculation from UAV based DEM

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Abstract— **UAV Images are valuable resource to extract various geospatial data like High Resolution Ortho Photo, DSM, DTM and 3D Spatial Models. In this study, discuss the methods available to calculate the volume from UAV image based DEM. The hardware used for data acquisition of this study includes mini UAV family drone called *"Phantom 4"* and *"Spectra Precision SP80"* multi-frequency receiver for positional survey. AgisSoft PhotoScan, Global mapper software's are used for data processing cum analysis [1]. The output of the study was the volume of brick stock, damaged brick, waste dump etc. and the volume calculation results. The results of the study is used for better decision making in sales estimation, stock management and waste dump management.**

Keywords—UAV Survey; Aerial Triangulation; Point Cloud Generation; DEM Generation; Volume Calculation

I. INTRODUCTION

Knowing the stockpile volumes on a regular basis is critical to optimize. The accuracy indicate how much raw material was extracted, which allow to effectively plan subsequent activity of any stock yard. UAV image based DSM will provide such details while correlating volume calculation algorithm to it. Accurate volume calculation results will support minerals extraction optimization, financial estimation and stock estimation. UAV image based volume calculation reduces the time and manual stock calculation efforts [2].

II. DATA ACQUSITION

A. UAV Instrument

UAV instrument used for the data acquisition for this study is DJI Phantom 4 (fig.1) familiar civilian drone from China. It is equipped with 12 MP CMOS Sony camera and the image resolution is 4000*3000 pixels. It can fly up to 28 minutes in pre planed flight path with GLONAS GPS satellite support. The operating rages of this drone is 1 kilo meter vertical and 5 kilo meter horizontal direction and the operation temperature is 0º to 40º C [3]. Gimbal, stabilizer attached with this drone is insure undistortion aerial photo.

Figure 1: DJI Phantom 4

B. DGPS

Spectra Precision Multi frequency receivers (no: 3) was used for control point survey in study area. One of the receiver was mounted on base point and the observation done for 8 hours (fig.2). On the same base observation time all other control points are surveyed by remaining two rower. The base point was optimized by IISC (GNSS base station in Bangalore) GNSS data. All the other points are optimized using based point by base line process method. The final DGPS report has the optimized control point details in XYZ format under UTM44 N, WGS84 datum.

Figure 2: Base Point Observation

C. UAV Image Acqusition

UAV images are captured by drone using *PIX4D Capture* Android app. It is freely available on play store. It is useful for determine preflight plan, image overlap, camera angle, height and speed of the drone (fig.3). Pix4D capture allow the user to design the settings in desktop system that can be uploaded to app. In this study single grid flight plan was created and 64 images are captured by 80*70 overlap at 80 meter altitude.
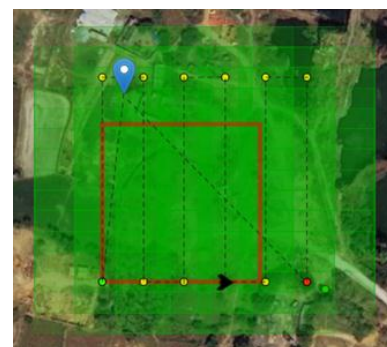

Figure 3: UAV Flight Plan

III. LOCATION OF THE STUDY AREA

Study area is located in Sivanthangal, Kanchipuram district, Tamil Nadu, India in between Northern Latitude 13° 0'28.95"N and Eastern Longitude 80° 5'46.08"E (fig.4).
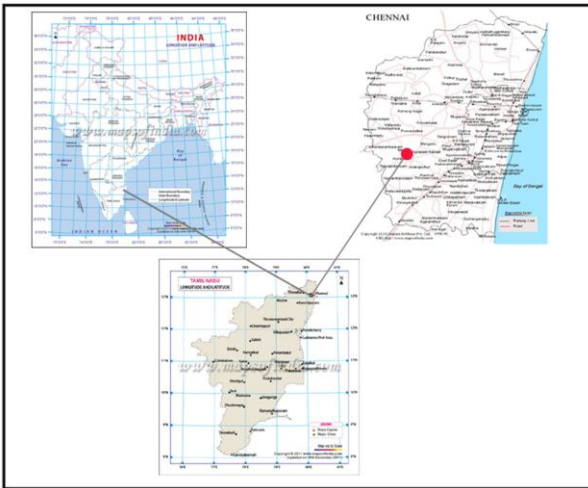

Figure 4: Location map of Sivanthangal Brick Pit

IV. SOFTWARE USED

Software used for the study is AgisSoft PhotoScan and Global Mapper.

A. AgisSoft PhotoScan

AgisSoft PhotoScan is a stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data [4].SFM algorithm is used by the PhotoScan for constructing point clouds from UAV images. AgisSoft require minimum 5 generation processor, 16 GB RAM, 2 GB graphic supported desktop system.

B. Global Mapper

Global Mapper is an affordable and easy-to-use GIS application that offers access to an unparalleled variety of spatial datasets and provides just the right level of functionality to satisfy both experienced GIS professionals and beginning users. Analysis menu allows the user to create elevation dataset and manipulating DEM. Pile Volume option in analysis/measurement menu is used for volume calculation from DEM [5].
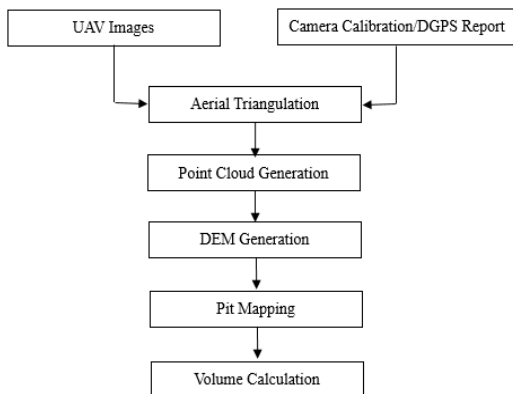
V. DATA PROCESSING METHODOLOGY

A. Aerial Triangulation

Aerial triangulation is the process to determine the real world coordinate and orientation of an aerial image [6]. UAV images have already geotagged. Reference to geotagged details, images are aligned and the orientation parameters were calculated by AgisSoft's reference photo matching algorithm. The final result of the matching report is shown in (fig.5)

Markers	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)
☑ 🚩 point 1	401938.360000	1438271.020000	37.660000	0.005000
☑ 🚩 point 2	401988.330000	1438233.230000	37.930000	0.005000
☑ 🚩 point 3	401931.150000	1438204.000000	38.050000	0.005000
☑ 🚩 point 4	401894.400000	1438308.240000	37.890000	0.005000
☑ 🚩 point 5	402027.420000	1438317.520000	34.640000	0.005000
☑ 🚩 point 6	401964.770000	1438329.980000	38.560000	0.005000

Figure 5: Aerial Triangulation Results

B. Point Cloud Generation

AgisSoft automatically generate color point cloud using SFM (Structure from Motion) algorithm. The generated point cloud has XYZ, color details that can be exported as LAS file (fig.6). Auto classification of point clouds are available in AgisSoft which is automatically classify ground, building, low points and vegetation points. Ground classified point clouds are used for generating DEM.

Figure 6: SFM Generated Point Cloud

C. DEM Generation

Classified point cloud file was imported to Global mapper and elevation grid file were generated using Elevation grid from 3D vector data option. DEM elevation was verified with GCP and found that elevation vary max 0.03 meters only. The final DEM is shown in fig.7

Figure 7: DSM from Point Cloud

D. Volume Calculation

Pit area was identified using ortho photo and the boundary polygons are created. Each polygon are uniquely named. Totally five pit areas are marked. Out of the five polygons, two polygon are represent brick pit and the remaining is sand pit.
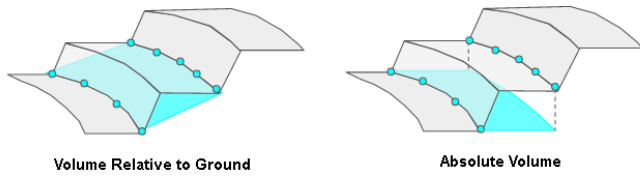

Figure 8: Volume Calculation Method

All the pile areas were selected and the pile line volume are calculated by analysis/measurement menu of global mapper. Total volume refers the absolute volume and net volume refers the volume relative to ground (fig-8). The final outputs are show in Table.1.

Table1: Volume Calculation Result

ID	Name	TOTAL_VOLUME (cubic meters)	NET_VOLUME (cubic meters)	Area (Sq.KM)	PERIMETER (Meter)
1	Brick 1	151.73678	151.71918	0.0000804	35.82
2	Brick 2	147.15063	147.13859	0.000082	35.422
3	Sand 3	4.8911958	4.8868595	0.000016	15.54
4	Sand 4	8.6615348	8.6534423	0.0000174	15.224
5	Sand 5	1.3243306	1.3228244	0.0000065	9.389
Sum		313.7644712	313.7208962	0.0002023	111.395

CONCLUSION

The results of this study demonstrated that UAV images have the potential to provide the estimation of volume with enough accuracy. This study proved that UAV become a cost effective and time consuming technology for volume calculation. The results of the study was verified in the field and found that results are matching with the details derived from field. Data processing methodology used in this study is simple and effective. Result of the study can used for stock measurement and sales estimation. Further, the results are useful for periodic study and change detection analysis in future.

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