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Combined Geospatial Approch to Extract Spatial Data from UAV Imageries

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***Abstract* - Evaluation of UAV have opened the whole new world of survey with less cost. Vertical and Oblique aerial imageries took from UAV's are used to generate various geospatial data like high resolution ortho photo, color point clouds, DSM, DTM and 3D models [1]. The main objectives of this paper is to understand the UAV systems, components, image acquisition technique and high precision geo data extraction method from UAV imageries for better spatial decision support system [2].**

Keywords — Ground Control Point Sketch up ; DGPS Survey ; UAV Survey ; Aerial Triangulation ; 3D Point cloud generation ; DTM extraction ; Digital Ortho Photo generation ; Modelling ; Data Validation ; Mapping features in 2D

I. INTRODUCTION

UAV's are commonly known as "*Drone*" and they are initially operated for military applications. But the growth of mini drones opened the civilian market and they are used for verity of applications like monitoring, mapping and inspecting etc. Compare to tradition methods UAV's require only small open place to take off and landing. It will enable the geospatial surveyor to acquire high resolution aerial images with short period of time. UAV aerial survey provides cloud free and multi temporal data with less cost [3]. The study includes the conventional DGPS survey integration to optimize output for real world matching.

II. STUDY AREA

The research study was contacted in Outer Ring Road near poonamallee, Chennai for 3 kilometer length and 50 meter buffer from road center line. The Outer Ring Road is a major transport corridor being developed along the periphery of Chennai Metropolitan Area (CMA) by the Chennai Metropolitan Development Authority (CMDA). It is 62.3 km long connecting NH 45 (GST Road) at Vandalur, NH 4 (GWT Road) at Nazarathpet, NH 205 (CTH Road) at Nemillicherry, Tiruninravur to NH 5 (GNT Road) at Nallur and TPP road at Minjur [4].

Exact location of the study area is in between right from Panimalar College of Engineering and Technology and left from poonamallee – avadi high road (13°02'54.0"N 80°05'02.4"E). Average Mean Sea Level (MSL) height of the study area is 24.5 meter. The study area is chosen because it covers multi-disciplinary spatial features like settlement, pond industries, road, river and bridge etc. The study area map is shown in Fig-1[5].

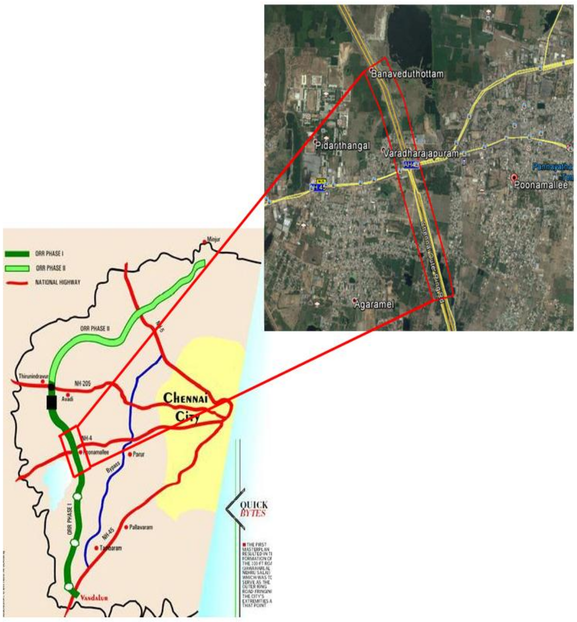

Fig1– Study Area Map

III. GROUND AND AERIAL SURVEY

Ground and Aerial Survey refers DGPS survey and UAV Aerial image acquisition. It includes end to end data acquisition technique and provides Meta for better spatial data calibration.

A. Ground Control Point Sketchup

First stage of the study starts from the establishment of control points on the ground and they are surveyed by DGPS. DGPS survey provides the position accuracy to UAV aerial imagery both vertical, horizontal and confirm the real world matching of object presented on images [6]. Ground control points plays the key role in image matching and aerial triangulation process.

Preliminary control points are identified on ground and they are marked by special reflecting paints. Conformation of visibility of control points from air and the permanent structures are verified before marked by paint. Sample control point markings and DGPS observation on control points are shown in Fig- 2.

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B. DGPS Survey

Spectra Precision SP80 multi frequency receivers are used to survey the control points. Out of the three receivers, one was mounded on base point and the observation done for entire day to that point. Remaining two receivers are surveyed rest of the control points in the same day by 20/20 minutes each.

Fig-2 Sample Control Point Markings

After the completion of DGPS survey, base point are duly connected by nearest GNSS service station (*IISC Bangalore*) and its location is optimized by baseline process method in *Spectra Office Suite 3.2*. All other points are optimized based on optimized base point coordinate values. The RMS value of the optimized points as per the base line process report is 0.038 (HRMS) and 0.079 (VRMS) [7]. The final report is generated in following format, Point ID, X, Y, Z under UTM 44N and WGS84 Datum.

C. UAV Survey

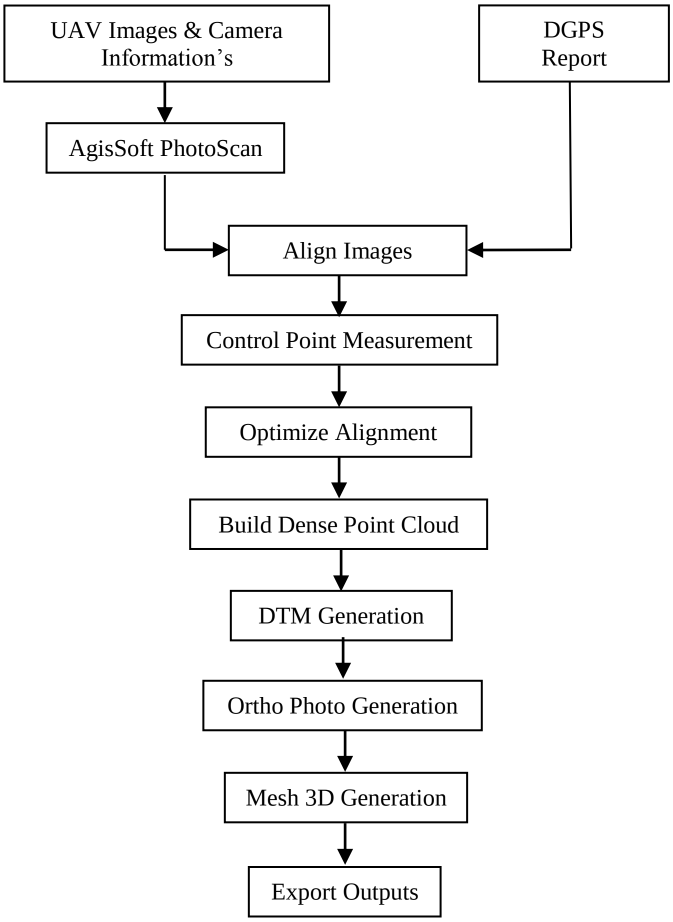
Aerial Image Acquisition is done by *"Phantom 4"*. It is the familiar civilian drone from DJI, China. The drone has equipped with 12 MP Sony - CMOS camera resolution up to 4000 X 3000 pixel, 3 axis gimbal stabilizer and GLONAS GPS satellite support for navigation [8]. The Autopilot mode was adapted for making survey with the help of "*Pix 4D capture - Android App*" which is freely available in play store (Fig-3).

The entire study area has been covered by tree flight plan with 80-meter altitude and 70 * 60 % image overlap. Totally, 1094 images are taken and they are properly geotagged. All the images are downloaded and verified with AOI coverage.

Fig-3 UAV takeoff for Survey

IV. DATA PROCESSING METHODOLOGY

UAV images are processed in many ways like Real Time Image Streaming (RTIS) [9], Cloud based etc. In this research, UAV images are processed under conventional photogrammetry method to extract high accuracy spatial data. The following diagram showing the work flow adopted under this method [10] (Dig-1).



Dig-1 UAV Data Processing Methodology

A. Aerial Triangulation(AT)

Aerial Triangulation (AT) is the process of providing the accurate orientation parameter to aerial images as require for stereo compilation [11]. This process achieved using *AgisSoft PhotoScan* software, is a software product that performs photogrammetric processing of digital images and generates 3D spatial data. It uses SFM (Structure from Motion) algorithm for image matching [12]. Geotag reference matching method along with control points are used to generate stereo image orientations. All the images are adjusted to ground control point coordinate with following accuracy as shown in Table-1.

Markers	Easting(m)	Northing(m)	Altitude(m)	RMS
Base	400272.247	1443596.579	24.071	0.005825
RSP2	400385.281	1443488.827	25.114	0.004829
RSP12	400791.094	1442354.363	25.031	0.004433
RSP13	400672.693	1442498.077	24.324	0.006626
RSP15	400512.499	1443010.293	25.325	0.005941
RSP17A	400125.972	1443747.011	25.484	0.001534
RSP6	400815.908	1442456.01	24.561	0.002366
RSP8	400972.151	1441921.34	24.413	0.000356
RSP9	400852.566	1441938.836	24.364	0.000316

Table-1 AT Matching Report

B. 3D Point Cloud Generation

3D Point Cloud Generation option in *AgisSoft* generated point clouds for stereo overlapped places in high aggressive mode that used SFM algorithm. The density of the point is 200 points per square meter. The final point clouds are exported as LAS 1.2 with RGB color format. The final generated point clouds are shown in Fig-4.

Fig-4 Point Cloud Color

C. DTM Generation

DTM is simply an elevation surface representing the bare earth referenced to a common vertical datum [13]. It can be generated from point cloud. It is commonly used for generating ortho photo and surface analysis. *AgisSoft* has separate module to generate DTM from point clouds.The generated DTM files can be exported as GeoTiff format that is shown Fig-5.

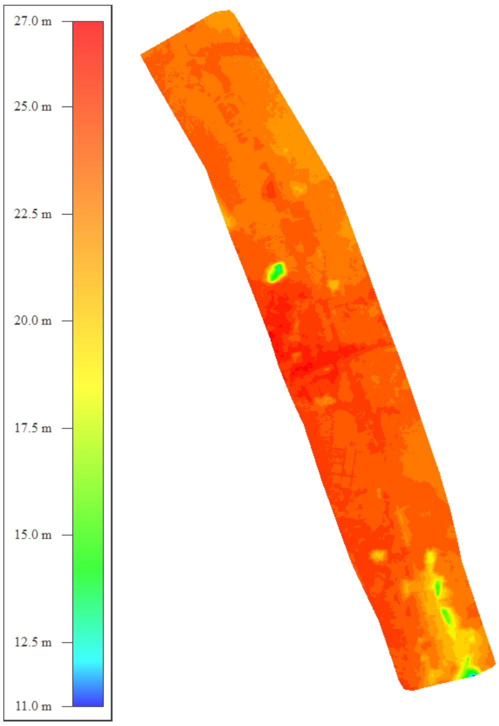


Fig-5 DTM File

D. Ortho Photo Generation

A digital ortho photo image is a raw digital aerial photo image rectified to a suitable DTM of the same area. *AgisSoft* merges the UAV image with the DTM and aligns the image orthogonally [14]. Orthos are generated at 0.02 meter GSD (Ground Sample Distance). The process mosaic (Stitching orthos) and color adjustment has to be done in same *AgisSoft PhotoScan* that confirmed the color unity. Mosaicked orthos are exported as GeoTiff format with respective tile bounds. Sample orthos are shown in Fig-6.

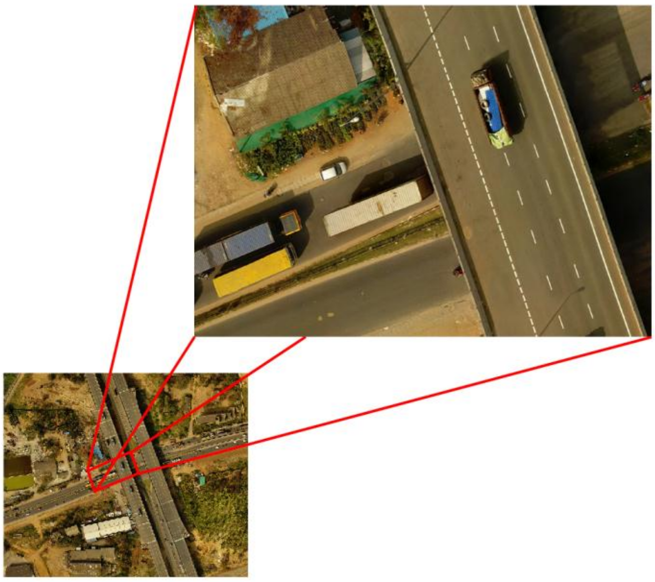


Fig-6 Ortho Photo

E. Modelling

AgisSoft allows to generate 3D mesh models combine with 3D point cloud and aligned UAV images. It provides real color 3D view to the objects.3D mesh models are capable to provide 3D measurement and volumetric measurement of an individual objects presented with in its [15].3D mesh models are exported as OBJ, KMZ format for online publishing. The final generated mesh models are shown in Fig-7.

Fig-7 Mesh Model

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F. Data Validation

Outputs are verified by overlay the control points measured on ground to ortho photo. DTM files are verified by the control point's altitude values. Data validation parameters are cross checked by the AT matching report and found that validation parameter and AT matching report's RMS values are same. The sample overlay of control points on ortho photo shown in Fig-8.

Fig-8 Control Point Overlay on Ortho Photo

G. 2D Mapping

2D mapping has be done with the help of ortho photo. All the planimetric and topographic features are captured with their respective geometry type. Final 2D map is free from topological errors and their geometry types are verified. This 2D map is helpful for planning and extension activities of road. This 2D elements can be converted as 3D by dropping to DTM height. The final 2D vector overlaid with orthos are shown in Fig-9.

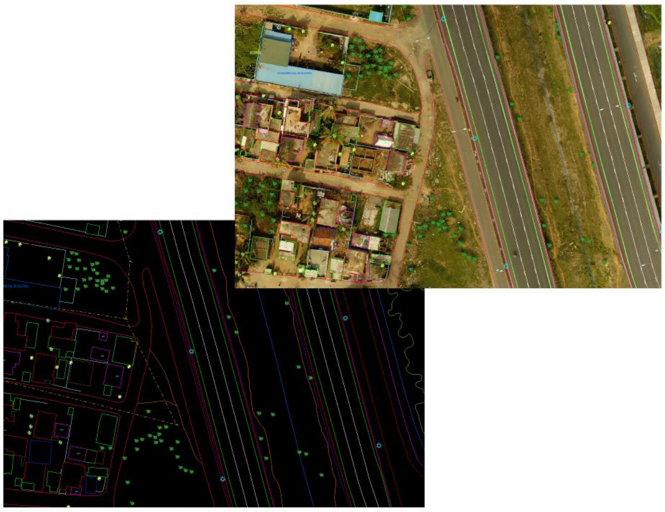

Fig-9 2D Vector Overlay on Ortho Photo

CONCLUSION

Data processing methods used in this research study is provided excellent spatial data outputs and they are representing the real world coordinate. The final outputs derived in this study is extremely high, compare to aerial and satellite technology. All the images are processed under one roof software (AgisSoft PhotoScan) enable the data integrity and accuracy of the outputs. This kind of data processing method confirmed that, only UAV images are enough to construct all type of spatial data with less cost and time.

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