"Enhancing Research Outcomes through Drone-Generated Imagery and Photogrammetry Software Analysis"

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ABSTRACT

Drones have gained popularity in numerous fields, including education, where they are employed as valuable tools for enhancing students' knowledge. In particular, the use of drones in land surveying and mapping has revolutionized the industry, replacing manual and time-consuming methods from the 19th century. Unmanned aerial vehicles (UAVs) enable surveyors to cover vast areas easily, even in challenging terrains, while producing high-resolution maps and collecting extensive data efficiently. With the aid of automated software, quality control can be achieved with minimal training. The benefits of drone surveying encompass terrain modeling, surveying, and 3D mapping for GIS purposes, such as topography and volume measurements. The return on investment (ROI) from utilizing drones in mapping and surveying is substantial.

Furthermore, UAVs find practical application in close-range mapping, particularly in engineering survey works that traditionally incur significant costs, labor, and time. Low-cost UAVs offer reliable information for various applications, including road design, bridges, and land surveys, matching the accuracy of conventional engineering surveys and policies, particularly for small-scale mapping. UAVs present a stable and rapidly advancing technology, positioning them as competitive alternatives to other surveying methods. This study consists of five phases: preliminary study, data collection, data processing, post-processing, and analysis, with a focus on UAVs as a data processing tool.

The project demonstrates the utilization of UAV images and photogrammetry software, which involve capturing overlapping images of the Earth's surface using cameras mounted on drones or airplanes. These images are then processed with photogrammetry software to generate geo-referenced maps, ortho mosaic images, and other valuable outputs. The software is capable of processing both images and lidar points, offering versatility in its applications, including artistic modeling and surveying. The increasing popularity of UAV images and photogrammetry software extends to various fields, such as agriculture, military operations, disaster management, and artistic modeling. As UAVs become more affordable, their accessibility expands to a broader range of users. Aerial mapping with UAVs necessitates mission planning and ground control points, making drones valuable in mapping, search and rescue missions, transportation, and other disaster management applications. Multiple photogrammetry software options are available, each with distinct features and advantages. By leveraging UAV images and photogrammetry software, previously challenging images can be acquired, opening new possibilities for diverse applications.

1. INTRODUCTION

In recent years, the utilization of unmanned aerial vehicles, commonly known as drones, has witnessed a significant upsurge in various fields, including research and surveying. With their ability to capture high-resolution images from different perspectives and altitudes, drones have become invaluable tools for data collection and analysis. Coupled with advanced photogrammetry software, these aerial images can be processed to extract detailed and accurate information, enabling researchers to achieve enhanced outcomes and insights in their studies.

The integration of drone-generated imagery and photogrammetry software holds tremendous potential for numerous research domains. From environmental monitoring and land mapping to archaeology and infrastructure analysis, the application of this combined approach offers a wide range of benefits. This paper aims to explore the advantages and methodologies associated with using drones for image acquisition and employing photogrammetry software for subsequent analysis, while highlighting their contributions in enhancing research outcomes.

One of the primary advantages of employing drones is their ability to access remote or inaccessible areas. Traditional ground-based data collection methods often face limitations in terms of terrain challenges or hazardous environments, making it difficult to obtain comprehensive and accurate data. Drones overcome these obstacles by providing a bird's-eye view of the target area, enabling researchers to capture imagery with unparalleled detail and coverage. By utilizing drones, researchers can extend their data collection capabilities to previously unexplored territories, fostering a deeper understanding of various subjects. Furthermore, the integration of photogrammetry software in the analysis of drone-captured imagery enhances the efficiency and accuracy of data processing. Photogrammetry software utilizes algorithms to reconstruct three-dimensional models from a series of overlapping images, extracting valuable measurements and geometric information. This process enables researchers to generate precise measurements, perform volumetric analysis, detect changes over time, and create detailed orthomosaic maps. The availability of such rich data sets facilitates comprehensive analysis and provides valuable insights into the research subject.

The potential applications of drone-generated imagery and photogrammetry software analysis are extensive. In environmental research, drones can be used to monitor ecosystems, assess vegetation health, track wildlife populations, and detect environmental changes. In the field of archaeology, drones enable the efficient mapping of archaeological sites, identification of buried structures, and preservation of cultural heritage. Infrastructure analysis benefits from drones by facilitating accurate mapping and inspection of buildings, bridges, and other structures, aiding in maintenance and risk assessment. This research paper aims to delve into the methodologies, challenges, and benefits associated with the integration of drones and photogrammetry software in various research fields. It will explore case studies and provide examples of successful applications to showcase the immense potential of this combined approach. By examining the advancements in image acquisition, data processing, and analysis techniques, researchers can leverage this knowledge to enhance their own studies and contribute to the broader scientific community.

Overall, this paper highlights the transformative impact of utilizing drones for image acquisition and employing photogrammetry software for analysis in research endeavours. Through the amalgamation of these technologies, researchers can overcome geographical limitations, collect detailed data, and derive valuable insights, ultimately leading to enhanced research outcomes and a deeper understanding of the subjects under investigation.

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2. MATERIAL AND METHODOLOGY

2.1 Study Area

The study area of surveying and mapping was selected in Ahmednagar district 4 images were selected which were provided by a startup company on certain dates such as 9th January 2023,12th December 2022 and 16th November 2022.

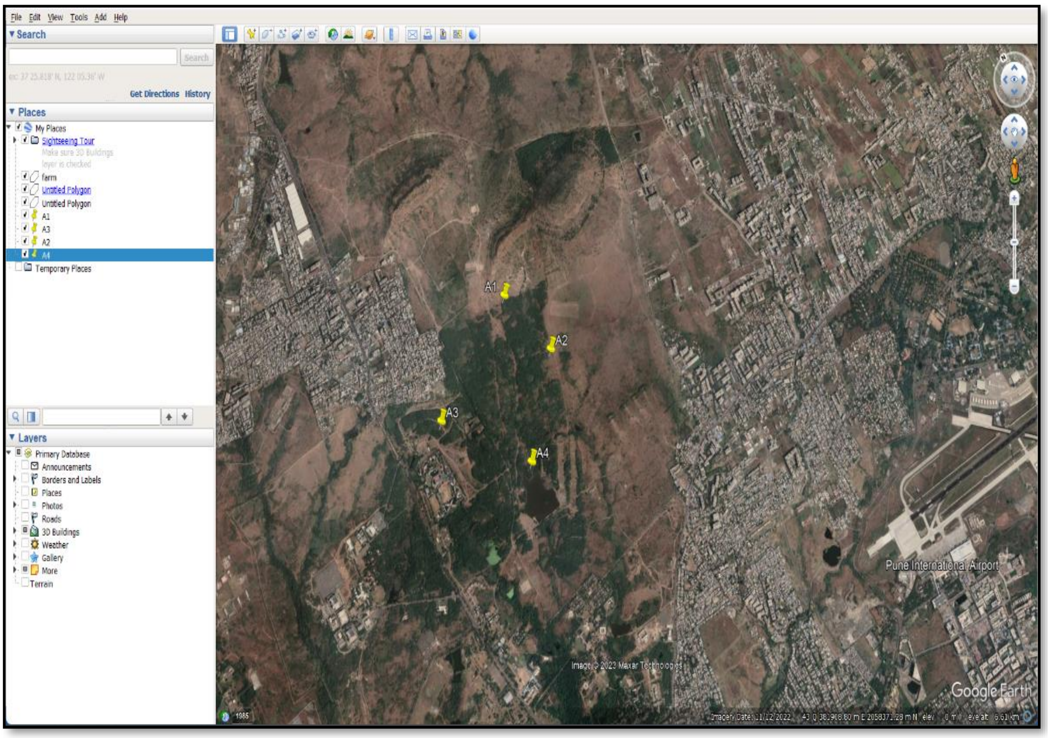


Plate no. 1 Location of Inaccessible Area

Software Hardware Requirements for the use of UAV Images to determine results by using Photogrammetry Software are shown in Table no. 1.

Table no. 1 Requirements of software hardware

Software	Processor	Ram	Storage	Operating System
Pix4Dmapper	64-bit Intel Core i7 or Xenon	16 GB	20 GB Free Space	Windows 7/8 /10. Mac OSX

There are several software applications used in surveying and mapping using UAVs (Unmanned Aerial Vehicles) to process the data and generate 2D maps, 3D models, point clouds, and other products. During land surveying and mapping using UAV following software's generally used which is depicted as below.

Table no. 2 Software Used

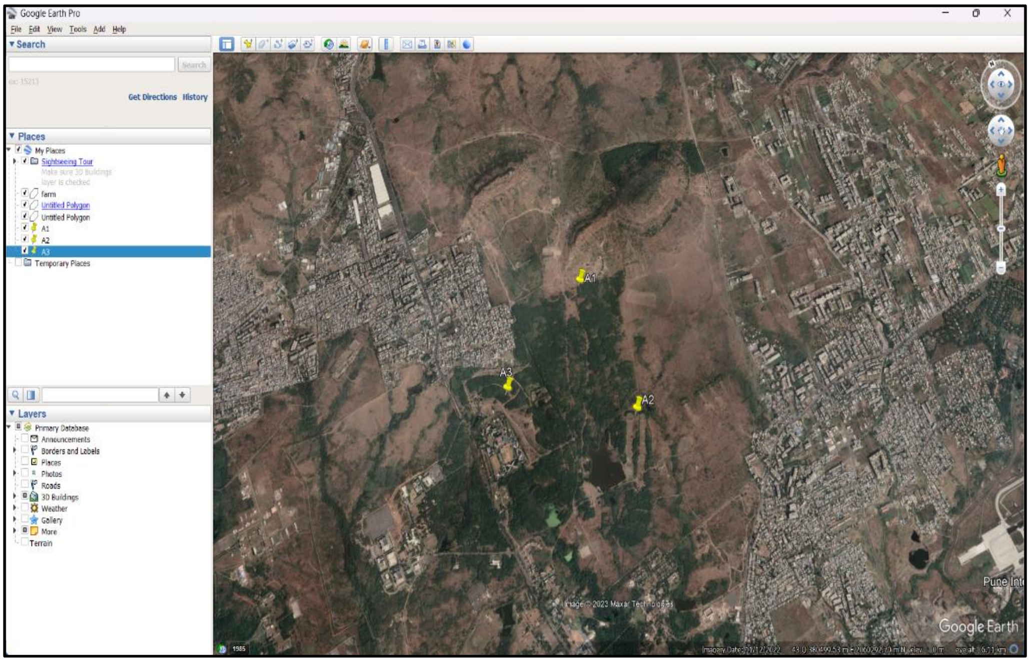
Sr . No	Name of software	Version used	used for
1.	QGIS	2.18	To Create, Edit Visualise, Analyse And publish geospatial information
2.	AUTOCAD	2021	To create boundary drawings, feature drawings, and contours.
3.	Google Earth Pro	Free	Used for visualization, used to see the difference between satellite &drone imagery.
4.	GIMP	2.8.20	Used for adding value, to the ortho mosaic, and images (boundary, logo, title ,scale etc.)
5.	Pix4d (Mapper)	Free (crack Version)	Used for tallying the measurements

2. Methodology

2.1 Tagging GPS Points

Tagging GPS points involves assigning geographic coordinates, typically in latitude and longitude format, to photos or other media. This process, known as geotagging, facilitates accurate mapping and location identification of the media. Geotagging can also include additional data such as altitude and bearing. GPS Essentials, a comprehensive GPS tool for Android, provides features for waypoint management, track navigation, route planning, and the creation of customized dashboards using various widgets. By utilizing GPS Essentials, users can easily tag GPS waypoints and generate KML files for further use. Which is depicted in Plate No. 2.

Plate no. 2 Tagging of GPS Points



2.2 Difference Between Geotagging and GPS Tagging

Geotagging and GPS tagging share the common goal of incorporating geographical information into digital content. Geotagging involves adding metadata, including latitude and longitude coordinates, place names, and other positional data, to photos, videos, or other media. On the other hand, GPS tagging specifically utilizes GPS technology to determine and assign coordinates to media based on the device's GPS location. In essence, GPS tagging is a subset of geotagging that relies on GPS technology for location determination. Images were procured of different latitudes and longitude, were for better understanding, and the result in the analysis names were given names depicted in Table No. 3 which was A1, A2, A3, and A4 respectively.

Table 3 Study Location GPS coordinates

Sr.no.	Name of Image	Latitude (m)	Longitude (m)
1.	A_1	13.4382	77.6283
2.	A_2	13.4376	77.6283
3.	A_3	13.4371	77.6283
4.	A_4	13.4369	77.6283

2.3 Raw Data

Raw Data was procured from one of the leading corporate companies. For the collection of data, they used Phantom 4v2 Pro Drone along with RGB and multispectral cameras for the collection of various types of images. The flight plan was prepared for capturing raw data in the drone deploy application and the operation of image capturing was performed by DJI Go Pro Application. Following are the raw captured images for the study. This data was processed using photogrammetry software to create 3D maps and models. Raw image A_1 is depicted in plate No. 3.

Plate no. 3 Raw Image Captured from a drone at the time of sowing (A_1)

Raw images captured at the time of sowing in surveying refer to minimally processed or unprocessed images taken during the crop planting process. These images hold significant value in agricultural management and decision-making by optimizing planting practices, identifying and addressing issues promptly, and enhancing crop yield and quality. They provide insights into crop growth, including identifying nutrient deficiencies, pest or disease outbreaks, and other factors that can influence crop yield and quality. The analysis of such raw images, like the one represented in Plate A1, enables farmers to assess the crop's progress and make informed decisions for improved agricultural outcomes Plate No. 3.

Plate no. 4 Raw Image Captured from drone after the emergence of the crop (A_2)

Raw Image Captured from drone after the emergence of the crop (A_2) as shown in Plate no. 4.

Plate no. 5 Raw Image when the crop has covered its canopy(A_3)

In general, when a crop covers the canopy of a drone, it can make it difficult to obtain a clear and accurate image of the land below. It may also be necessary to process the images using specialized software to correct for distortions and improve the clarity of the image. It is useful to evaluate the stand count and canopy size of seedlings, and the use of deep learning techniques to classify agricultural crops using raw image channels captured by UAVs. Raw Image Captured from drone when the crop has covered its canopy(A_3) as shown in Plate no.5.

Plate no. 4 Raw Image Captured from drone After the harvesting of the crop(A_4)

The exact result of a raw image captured from a drone after the harvesting of a crop will depend on various factors, including the type and density of the crop, and the time elapsed since harvesting. It is useful to create maps and these maps and visualizations can help to identify patterns and trends in the field and evaluate the effectiveness of the harvest. These images can be used to monitor soil health, estimate crop yield, and identify potential issues with crops. Some drones are equipped with thermal sensors that can capture thermal drone imagery. However, the specific process for capturing raw images after harvesting crops may vary depending on the type of crop and the specific needs of the farmer. Raw Image Captured from drone After the harvesting of the crop(A_4) as shown in Plate no. 4.

2.4 Image Processing Using Pix4D Software

Pix4D software was utilized to process the collected images and several outputs were generated the different processes are depicted as follows,

i. Ortho-mosaic: An ortho-mosaic is a geometrically corrected aerial photograph that ensures a uniform scale. It accurately represents the Earth's surface by correcting for topographic relief, lens distortion, and camera tilt.

ii. Digital Surface Model (DSM) and Digital Terrain Model (DTM): DSM represents the surface with all objects, including buildings, trees, and structures. DTM, on the other hand, represents the background surface without any objects like trees or buildings. These models provide a 3D presentation of the terrain surface.

iii. Contours: Contours are lines that connect points of equal elevation on a map. They are used to quantify elevation and can be customized based on project requirements.

iv. 3D Model: A 3D model is a representation of a three-dimensional surface of an object using specialized software. It can be displayed as 2D images through a process called 3D rendering, capturing the physical body using a collection of points in 3D space.

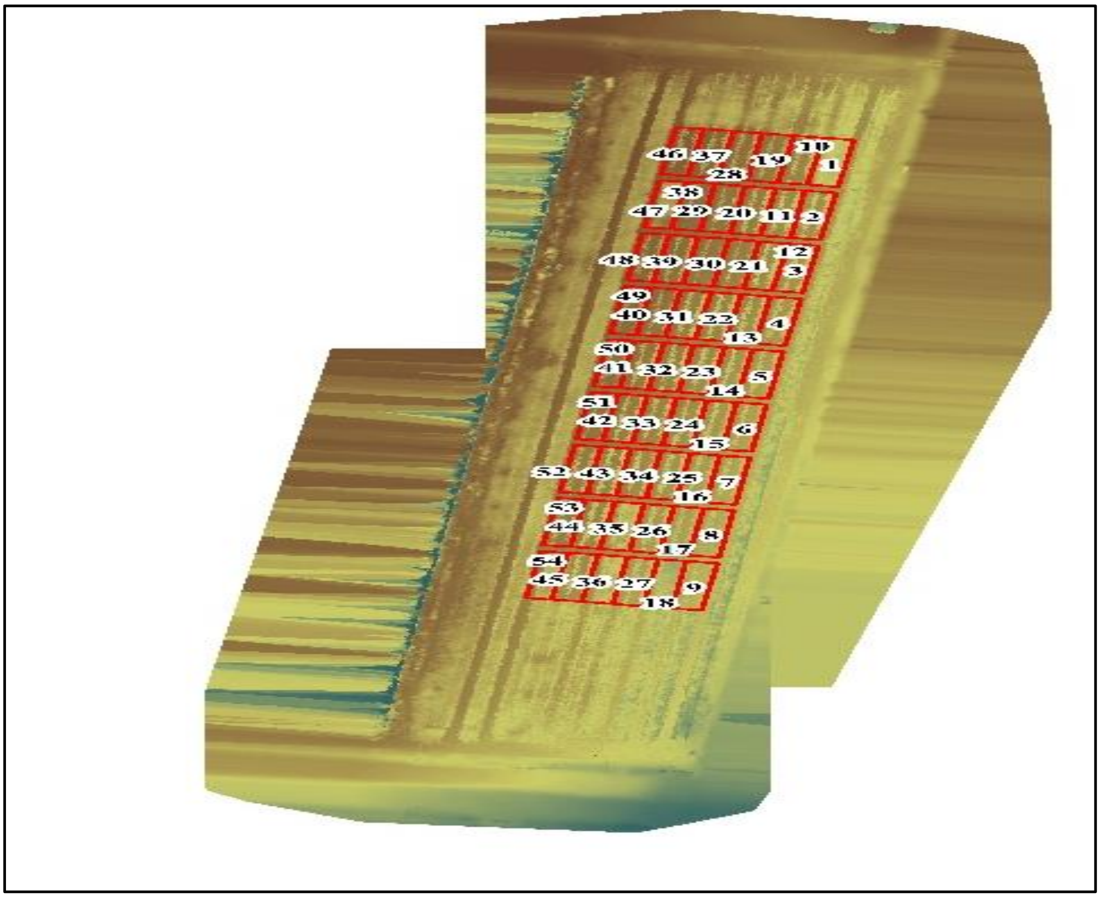


Plate no. 5 Digital surface model of the study area.

Pix4D software allows for the creation of accurate DSMs, which is depicted in Plate No. 5. This includes the height of surface features like buildings, bridges, and trees. These models assist in assessing the accuracy of other digital models, such as DTMs and digital elevation models (DEMs). Additionally, Pix4Dmatic software may be necessary for processing data from large-scale drone mapping projects to create precise DSMs.

Normalized Difference Vegetation Index (NDVI) is commonly employed for vegetation classification and estimation using UAVs. NDVI helps identify areas with vegetation cover and estimate vegetation height and texture. High-resolution images captured by UAVs equipped with NDVI sensors are used to create NDVI maps for various applications, including postfire vegetation analysis and vegetation cover estimation.

2.5 Identify Elevation Values

To identify elevation values in QGIS, a Digital Elevation Model (DEM) of the area of interest is required. DEMs represent the terrain's elevation as a raster dataset, with each cell containing the elevation value. QGIS provides tools for extracting elevation values for specific points or areas by overlaying the DEM with point or polygon layers and utilizing the Extract raster values tool from the Processing Toolbox. The extracted elevation values are typically in the same units as the DEM (e.g., meters). Elevation values was evaluated using QGIS as a DEM is a raster dataset that represents the elevation of the terrain as a grid of cells, where each cell has a value that represents the elevation at that location.

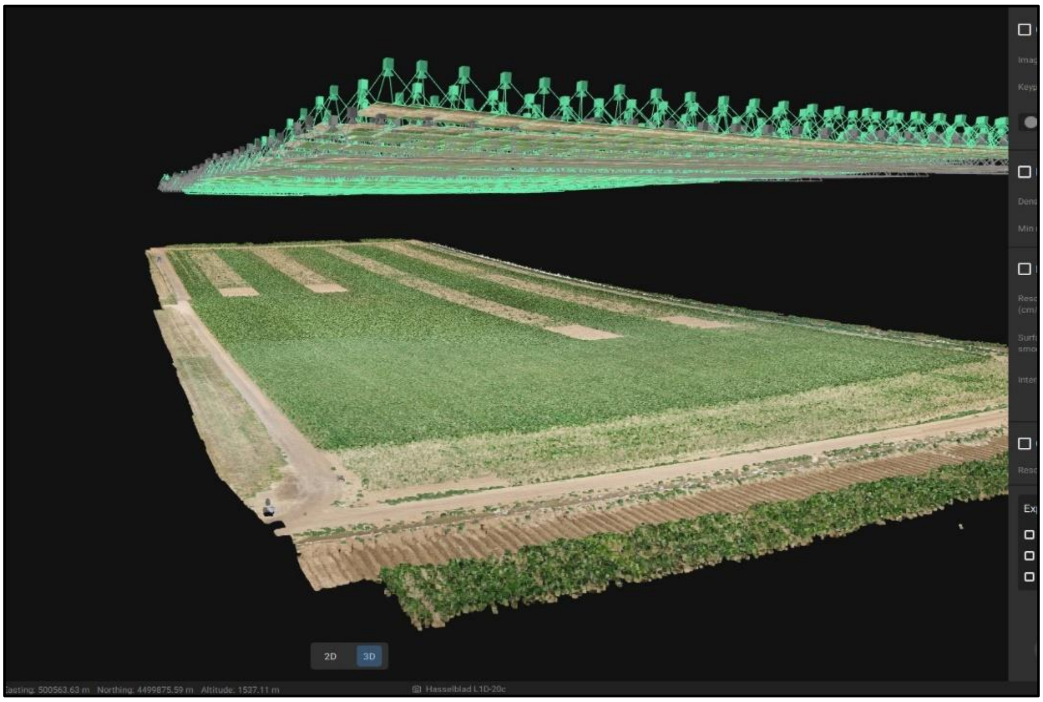


Plate no. 6 Point Cloud of study area

Point clouds are a useful tool in surveying and mapping using UAVs. They are created by collecting data from drone cameras or LiDAR sensors and processing it into a 3D model. Point clouds can be used for land development projects and other applications. To filter the data, various algorithms can be used. LiDAR sensors are commonly used for drone surveying and mapping, and they provide accurate and detailed point cloud data. Generated Point cloud is shown in plate no. 6.

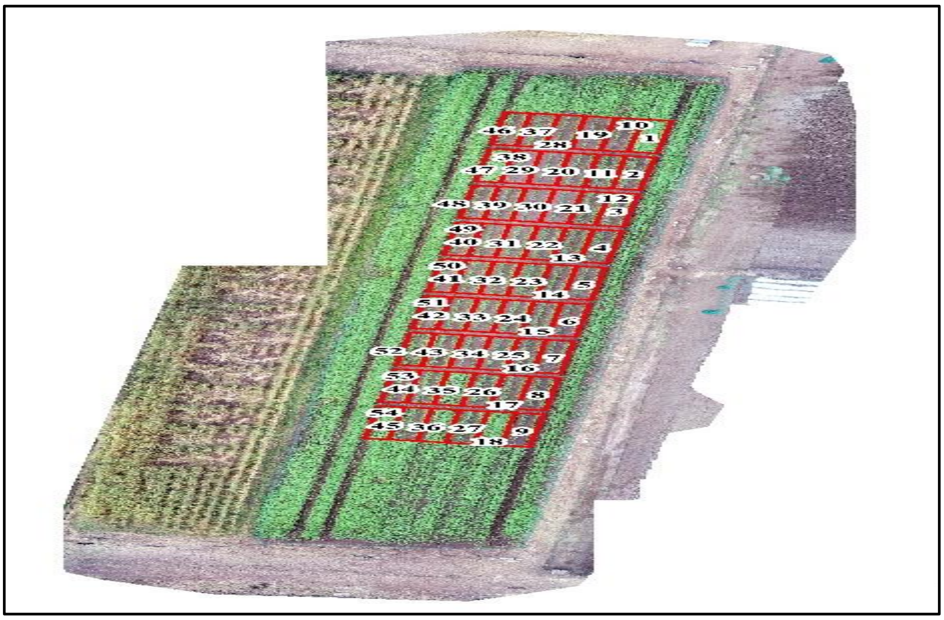


Plate no. 7 Ortho-mosaic of the study area

Orthomosaic mapping is a technique used in surveying and mapping using UAVs (unmanned aerial vehicles) to create detailed, high-resolution images of the terrain below. The process involves taking numerous pictures of the landscape from different angles and then stitching them together to create a visual representation of the area of interest. They are also useful for mapping out busy areas and crime scenes. The stitched orthomosaic of the area is shown in Plate No. 7.

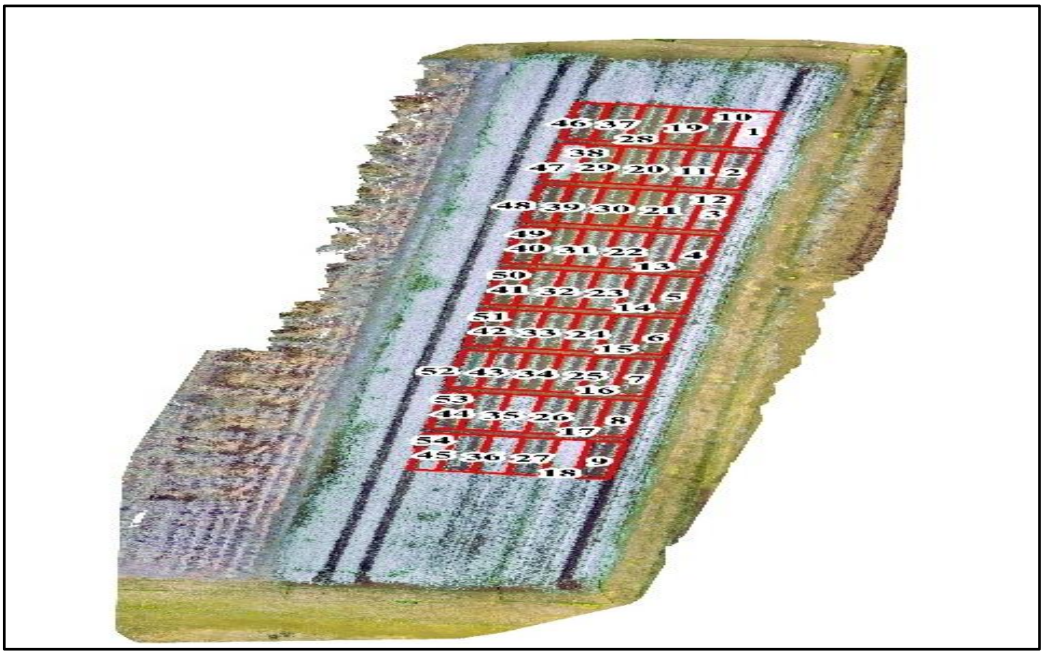


Plate no. 8 Multispectral RGN of study area

Multispectral RGN (Red, Green, Near-Infrared) technique, it involves capturing images using multiple sensors that can detect different wavelengths of light, including visible and near-infrared light. This technique can be used for various applications, such as mapping soil and crops for precision agriculture, evaluating crop performance, and vegetation mapping. The use of multispectral photogrammetry and UAVs can also have applications in industries related to security. Generated multispectral RGN of study area is shown in Plate no. 8.

2.6 Post-processing of images

a) QGIS

To import UAV data into QGIS, there are several methods available. One way is to export an elevation map as a GeoTIFF and import it into QGIS to render the digital surface model. To add annotations in surveying and mapping using UAV in QGIS This plugin provides a dedicated toolbar with buttons to show/hide or remove the text annotations and a tool to convert the canvas map text annotations to labels. Checking noise removal of contour creation is shown in Plate No. 9.

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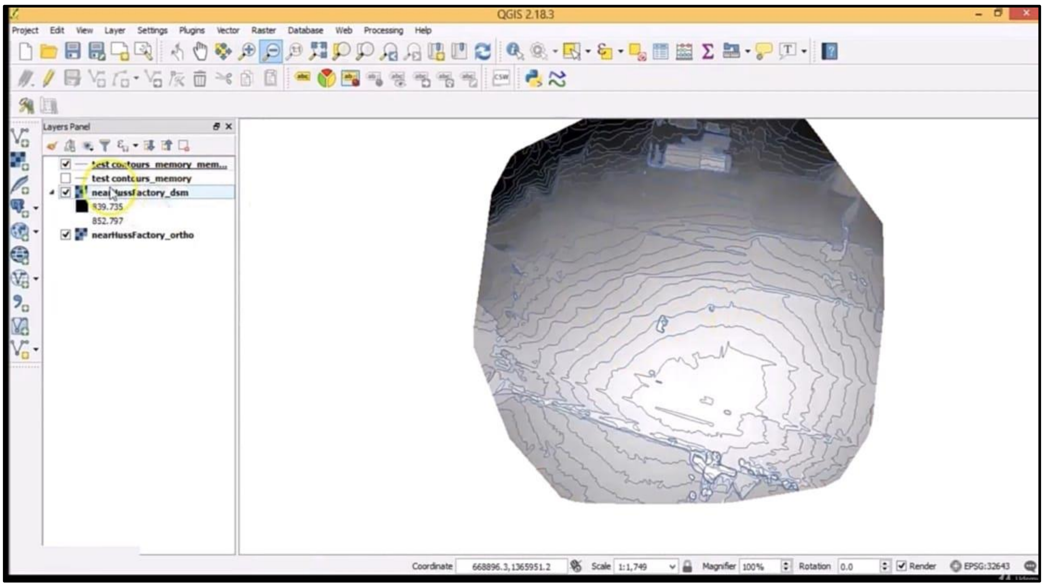

Plate no. 9 Post-processing of contours (noise removal)

b) AutoCAD

Post-processing in AutoCAD during surveying and mapping using UAV involves the use of photogrammetric data collected by drones. There are several ways to import elevation maps into Auto CAD. To generate smooth contours in AutoCAD during surveying and mapping using UAV, there are a few options.

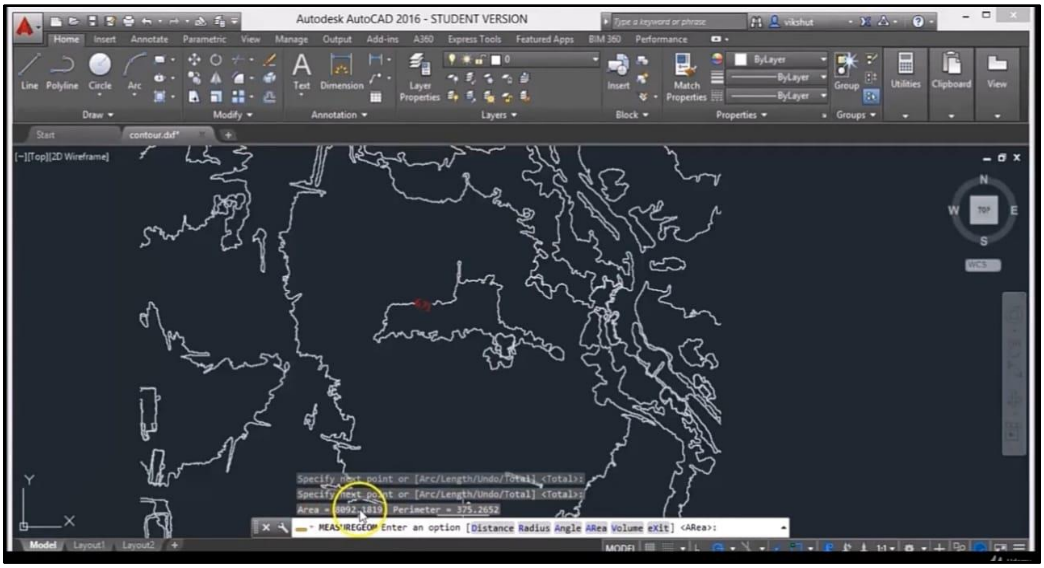

Plate no. 10 Smoothing of Contours

One is to use software such as Survey CAD, which can generate smooth contours within the CAD application. Another option is to generate contours from lower-resolution elevation data, which can help to smooth and generalize the contours. It is also important to ensure that the drone data is not providing too much information, which can result in unreadable top maps. There are several steps involved in the noise removal process, depending on the type of signal and the method used. To measure the area and perimeter of ortho mosaic images in Google Earth, you can use the measuring tools available in the software. First, open Google Earth on your computer. Then, search for the location of the orthomosaic image or select it on the globe. On the left side of the screen, click on the ruler icon to access the measuring tools. From there, you can select the area or perimeter tool and draw a shape around the image to measure its dimensions.

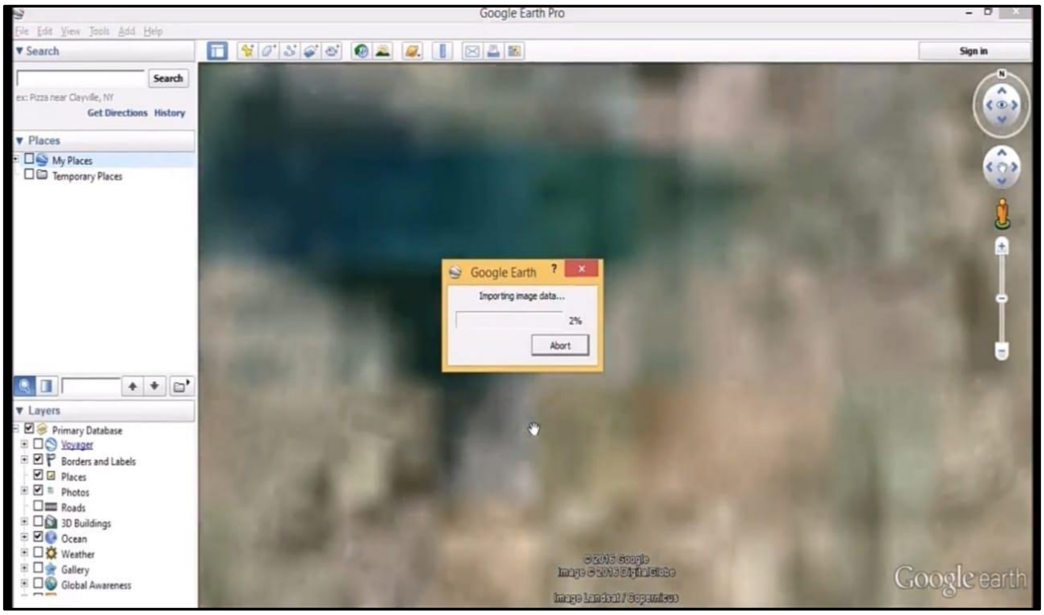

Plate no. 11 Importing Image Data in Google Earth.

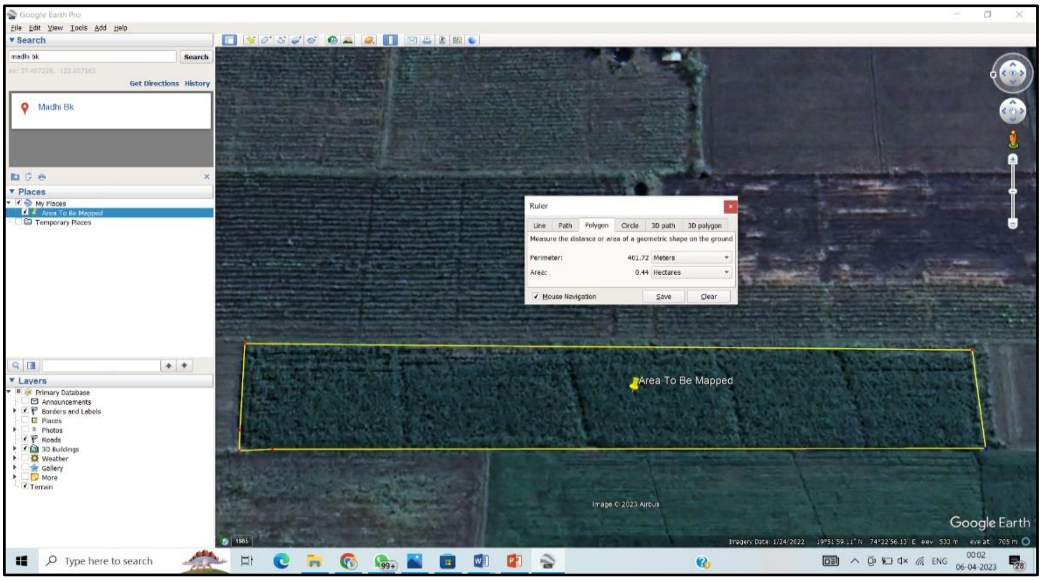

Plate no. 12 Measurement of Area in Google Earth

Google Earth Pro can be used for the post-processing of ortho mosaic images. The following steps can be taken:

i. Georeference the image by placing it on the surface of the earth.
ii. Upload the Geo TIFF image using the Assets tab in the Code Editor.
iii. Use ArcGIS Pro to create an orthomosaic through the automated process of orthorectification.
iv. Make an overlay of the orthomosaic on Google Earth Pro by opening the software, positioning the 3D viewer in the location, and selecting the image.
v. Additional tools like ArcGIS Pro or Google Earth can be used for displaying reference data and obtaining the needed coordinates.

c) GIMP

GIMP is a photo editing software that can be used for qualitative image analysis. However, it may not be the best tool for post-processing UAV images. Instead, specialized drone mapping software like OpenDroneMap can be used to generate maps, point clouds, 3D models, and DEMs from images. Procedures for orthorectified and stitching images together to create composite ortho mosaics can also be found. Additionally, GIS software can be used for georeferencing and creating mosaics. GIMP can be used for false color post-processing of infrared images.

2.7 GPS coordinates

GPS coordinates are a unique identifier of a precise geographic location on the earth, usually expressed in alphanumeric characters. They are points of intersection in a grid system, usually expressed as the combination of latitude and longitude. GPS coordinates are used for pinpointing one's exact location anywhere on the Earth's surface and obtaining the current time at a specific location. GPS is a global navigation satellite system that provides geolocation and time information to a GPS receiver anywhere on or near the Earth. GPS coordinates are most commonly expressed as latitude and longitude, which divide the earth into latitude lines indicating how far north or south from the equator and longitude lines indicating how far east or west from the prime meridian.

2.8 Process of finding GPS coordinates

GPS coordinates are a unique identifier of a precise geographic location on the earth, usually expressed in alphanumeric characters. They are points of intersection in a grid system, usually expressed as the combination of latitude and longitude. GPS coordinates are used for pinpointing one's exact location anywhere on the Earth's surface and obtaining the current time at a specific location4. GPS is a global navigation satellite system that provides geolocation and time information to a GPS receiver anywhere on or near the Earth. GPS coordinates are most commonly expressed as latitude and longitude, which divide the earth into latitude lines indicating how far north or south from the equator and longitude lines indicating how far east or west from the prime meridian.

3. RESULT AND DISCUSSION

The actual accuracy values vary depending on the photogrammetry software used, the quality and resolution of the images, and other factors. The following table shows i.e. table no. 3.4 that how the number of unmanned aerial vehicle images can affect the accuracy of the output generated by photogrammetry software. The Average Orthomosaic Accuracy provides us with an important view of Mapping and Surveying, used to monitor land use and land cover changes, assess vegetation health, detect and measure the extent of natural disasters like wildfires or floods, and aid in the management of natural resources. It is also used to analyze and monitor environmental conditions, such as soil erosion, deforestation, and habitat mapping. Accurate ortho mosaic help scientists and researchers study and understand changes in the environment, support conservation efforts, and assess the impact of human activities.

Table 3.4 Output generated by photogrammetry software's

Sr.no.	Number of unmanned aerial vehicle images	Point cloud accuracy(cm)	Orthomosaic accuracy (cm)
1.	50	20	10
2.	100	15	5
3.	200	10	3
4.	500	5	1

Where the Point cloud accuracy states us to generate high-resolution DEMs and topographic maps, for creating detailed 3D models and visualizations of objects, buildings, and landscapes. By comparing point clouds acquired at different time intervals, changes in the environment can be detected and monitored. This is useful for tracking vegetation growth, monitoring construction progress, identifying structural deformations, and assessing the impact of natural disasters.

Point clouds derived from drone imagery can assist in precision agriculture by providing detailed information about crop health, plant density, and terrain variations. Accurate point clouds aid in optimizing irrigation, fertilization, and crop management strategies, leading to increased yields and reduced environmental impact. Point clouds are valuable for assessing forest inventory, estimating biomass, and planning forest management activities.

Accurate point clouds enable the identification of individual trees, measuring canopy cover, and assessing the health and density of vegetation. The highest longitude and latitude of GPS coordinates indicate the location of the corners or edges of the area being surveyed or mapped. These coordinates simply provide a geographic reference point for the location of the boundaries of surveyed or mapped area. The latitude and longitude of GPS coordinate with elevation as shown in Table 3.5.

Table 3.5 Elevation data of GPS points

Sr.no.	Name of Image	Latitude (m)	Longitude (m)	Elevation (m)
1.	A_1	13.4382	77.6283	1459.631
2.	A_2	13.4376	77.6283	1443.244
3.	A_3	13.4371	77.6283	1418.243
4.	A_4	13.4369	77.6283	1451.323

Additionally, the table provides an overview of the project results, including the average ortho mosaic accuracy and average processing time. The Table Shows That As the number Of UAV Images increases, The accuracy of the orthomosaic also improves, but processing time and cost increase as well. An overview of the project results is shown in Table 3.6.

Table 3.6 Processing time with accuracy of UAV images

Sr. no.	Number of unmanned aerial vehicles images	Average Orthomosaic Accuracy (cm)	Time in hours (hr)
1.	50	10	8
2.	100	5	12
3.	200	3	20
4.	500	1	40

In general, the use of UAV images and photogrammetry software provides a non-invasive and cost-effective method of collecting data for various applications. The conclusions that can be drawn depend on the quality of the images, and the accuracy of the software. The use of UAV images and photogrammetry software can provide various types of conclusions depending on the purpose of the analysis.

The accuracy of ortho mosaics and point clouds derived from drone imagery is crucial for various scientific applications. Orthomosaics provide valuable information for mapping, surveying, environmental analysis, and disaster management. Accurate ortho mosaics aid in monitoring land use, assessing vegetation health, and studying environmental changes. On the other hand, point cloud accuracy is important for generating high-resolution DEMs, 3D modelling, change detection, precision agriculture, and forestry management. Accurate point clouds enable detailed analysis of terrain variations, vegetation growth, and infrastructure monitoring. Increasing the number of UAV images improves the accuracy of ortho mosaics and point clouds, but it also increases processing time and cost. UAV images and photogrammetry software offer a non-invasive and cost-effective method for data collection, with the quality of images and software accuracy affecting the reliability of conclusions drawn from the analysis.

4. SUMMARY AND CONCLUSION

It is summarised that the table presented in the text demonstrates how the number of unmanned aerial vehicle (UAV) images can impact the accuracy of output generated by photogrammetry software. The average ortho mosaic accuracy is essential for mapping, surveying, and monitoring land use, vegetation health, natural disasters, and environmental conditions. Accurate ortho mosaics aid in understanding changes in the environment, supporting conservation efforts, and assessing the impact of human activities. Point cloud accuracy is crucial for generating high-resolution DEMs, and 3D models, and assessing changes in the environment over time. Point clouds derived from drone imagery are useful in precision agriculture, forest management, and infrastructure monitoring.

This study concludes that the use of UAV images and photogrammetry software provides a non-invasive and cost-effective method for data collection in various applications. However, the quality of the images and the accuracy of the software are crucial factors affecting the reliability of conclusions drawn from the analysis. Increasing the number of UAV images improves the accuracy of Orthomosaics and point clouds, but it also increases processing time and cost. Accurate Orthomosaics and point clouds are vital for scientific applications, enabling detailed analysis and monitoring of environmental changes, vegetation health, and infrastructure. Overall, UAV images and photogrammetry software offer valuable tools for data collection, analysis, and decision-making in diverse fields.

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