KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATICS ENGINEERING

A REPORT ON

PREPARATION OF TOPOGRAPHICAL MAP USING UNMANNED AIR VEHICLE(UAV)

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ABSTRACT

The preparation of topographical maps using unmanned aerial vehicles (UAVs) marks a significant advancement in the fields of surveying and cartography. This method offers a highly accurate, cost-effective, and efficient alternative to traditional surveying techniques. UAVs equipped with GPS modules and high-resolution cameras capture detailed aerial images, which are then processed to create comprehensive topographical maps. This report explores the tools, techniques, and applications of UAV-based topographical mapping, highlighting its use in sectors such as construction, agriculture, urban planning, disaster relief, and environmental monitoring. The advantages of UAV-based topographical mapping are substantial, surpassing drawbacks such as weather dependency, regulatory challenges, data processing demands, and limited battery life. Additional disadvantages include the requirement for high accuracy, efficiency, and the ability to survey hard-to-reach areas. Continuous innovations in this field are revolutionizing terrain analysis and geospatial data collection, paving the way for further advancements.

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KEYWORDS

UAV

Orthomosaic

Planimetric map

Pix4D Mapper

ArcMap

GIS

Aerial imagery.

1. INTRODUCTION

1.1 Background

For the purpose of accurately and thoroughly representing the Earth's surface, topographical mapping is a crucial practice in the field of geographic information science. It is crucial to many fields, such as geography, environmental management, urban planning, and civil engineering. Fundamentally, a topographical map depicts the three-dimensional terrain on a two-dimensional surface, paying close attention to the relative positions and elevations of both natural and man-made features. Contour lines, which join points of equal elevation to show the shape and gradient of the terrain, are the basic building blocks of these maps. With the help of this method, users can see an area's topography and recognize features like hills, valleys, ridges, and depressions.

Making a topographical map requires a laborious process of gathering and analyzing data. Digital Elevation Models (DEMs) are high-resolution datasets obtained from satellite imagery, LIDAR, or photogrammetry, and are frequently used in modern techniques. These datasets offer a thorough depiction of the surface of the Earth, which serves as the foundation for creating contour lines. These contour lines are produced by spatial analysis tools in Geographic Information System (GIS) software such as ArcMap, which interpolate elevation points across the terrain. After being created, these contours are divided into major, minor, and intermediate lines to improve legibility and make visible differences between important elevation shifts apparent.

In addition to contours, topographical maps combine a number of features to provide an all-encompassing view of the terrain. Dark, solid colors are commonly used to depict permanent structures like buildings, signifying their durability and stability. Temporary structures can be highlighted by using dashed lines or lighter colors to emphasize their fleeting nature. In order to indicate their removal, demolished buildings are frequently shown in red or with crosshatching. In order to make it simple for users to recognize and understand the contents of the map, natural features such as rivers, lakes, and forests are represented by the appropriate colors (green for vegetation, blue for water bodies).

Topographical maps are useful for much more than just visualization. These maps are essential to urban planning because they aid in the process of choosing sites, zoning, and developing infrastructure by enabling planners to evaluate which locations are best suited for building and development. Topographical maps are a useful tool for environmental scientists and conservationists to plan conservation efforts, monitor changes in land use, and study ecosystems. These maps are essential for geomatics engineers to have when designing and building infrastructure projects because they give vital information about the topography that influences the layout of buildings, bridges, and roads. Moreover, topographical maps are invaluable in disaster management and mitigation. By understanding the topography of an area, authorities can predict flood zones, landslide-prone areas, and other natural hazards, enabling them to take preventive measures and plan emergency responses effectively.

1.1.1 Unmanned aerial vehicles (UAVs)

Unmanned aerial vehicles (UAVs) have, however, completely changed the topographical mapping process, offering a more effective, precise, and economical method. Unmanned Aerial Vehicles (UAVs) or drones are aircraft that are flown without a human pilot present. They can be controlled remotely or autonomously through onboard computers. Their ability to access difficult or hazardous areas, coupled with their flexibility and speed, makes UAVs an invaluable tool in various industries, including surveying, construction, agriculture, and environmental management. With their sophisticated GPS systems and high-resolution cameras, unmanned aerial vehicles (UAVs) can obtain detailed aerial imagery over vast regions much faster than with conventional techniques. Digital Elevation Models (DEMs), 3D models, and high-precision topographical maps of the surveyed terrain can be produced by processing these images with specialist software.

Figure 1 : Unmanned aerial vehicles (UAVs)

Using drones for making maps is a modern way to collect detailed information about landscapes. This report covers the basics of how drones are chosen and equipped with sensors to capture high-quality data. It explains the importance of careful planning for drone flights and how data is processed using special software to create accurate maps and elevation models. By using drones in this way, we can create maps that help with planning cities, managing the environment, farming efficiently, and responding to disasters.

1.1.2 Orthophoto

An orthophoto is an aerial photo that has had the distortions brought about by camera angle and relief in the terrain geometrically corrected. An orthophoto has a consistent scale across the image, which makes it appropriate for precise measurements, in contrast to conventional aerial photos, which could appear distorted because of perspective. In order to ensure that the final image accurately depicts the Earth's surface, this correction process entails digitally aligning the aerial image with a coordinate system or map projection. Because orthophotos accurately and consistently depict ground features, they are widely used in mapping, urban planning, environmental monitoring, and infrastructure development.

1.1.3 Ortho mosaic

An Ortho mosaic is a photogrammetrically orthorectified image product mosaicked from an image collection, where the geometric distortion has been corrected and the imagery has been color balanced to produce a seamless mosaic dataset.

1.2 Problem Statement

Conventional topographical mapping techniques, which involve the-ground surveys, are frequently expensive, time-consuming, and may not be as accurate, particularly in remote or dangerous areas. For applications in urban planning, agriculture, disaster management, and environmental monitoring in particular, a more effective, accurate, and economical method of mapping terrain features and elevation changes is required. Because they can collect high-resolution aerial imagery and interface with Geographic Information Systems (GIS) to enable comprehensive mapping and analysis, Unmanned Air Vehicles (UAVs) offer a promising solution. However, in order to fully utilize UAV technology for efficient topographical mapping, issues like regulatory compliance, complex data processing, and operational constraints in bad weather must be resolved.

1.3 Objectives

1.3.1 Primary Objectives

- To prepare topographical map using UAV.

1.3.2 Secondary Objectives

The secondary objectives are:

- To Integrate UAV-captured data with GIS for detailed map creation and analysis.
- To produce orthophoto and Digital Terrain Model (DTM).
- To visualize spatial data and develop practical GIS skills.

2. LITERATURE REVIEW

Unmanned Air Vehicles (UAVs) have emerged as transformative tools in remote sensing and mapping, offering significant advantages over traditional methods. Colomina and Molina (2014) underscore the capability of UAVs to capture high-resolution imagery and their integration with Geographic Information Systems (GIS) for precise mapping and terrain analysis. This technological synergy enables UAVs to produce detailed topographical maps and Digital Elevation Models (DEMs), crucial for applications in urban planning, agriculture, and disaster management (Colomina & Molina, 2014).

Nex and Remondino (2014) delve into the advancements in UAV-based photogrammetry and 3D mapping, emphasizing the accuracy and efficiency achieved through improved sensor technology and data processing algorithms. Their research highlights UAVs' role in generating precise spatial data that supports decision-making processes in various fields (Nex & Remondino, 2014).

Studies by Manfreda et al. (2018) and Wang et al. (2020) explore the diverse applications of UAVs in environmental monitoring and urban planning. They discuss how UAVs facilitate real-time monitoring of environmental changes, contribute to natural resource management, and enhance the resilience of urban infrastructure through detailed spatial data acquisition (Manfreda et al., 2018; Wang et al., 2020).

However, the adoption of UAVs in mapping is not without challenges. Siebert and Teizer (2014) identify regulatory compliance, weather dependency, and data processing complexity as significant hurdles. Addressing these challenges is crucial for maximizing the potential of UAVs in achieving cost-effective and accurate topographical mapping solutions (Siebert & Teizer, 2014).

Looking ahead, Turner et al. (2015) and Whitehead and Hugenholtz (2014) discuss future directions in UAV technology, envisioning advancements in sensor integration, real-time data processing capabilities, and autonomous operations. These innovations promise to further enhance the efficiency and accuracy of UAV-based mapping, paving the way for expanded applications in diverse industries (Turner et al., 2015; Whitehead & Hugenholtz, 2014).

3. Methodology

3.1 Study area

Figure 2 : Study Area

3.2 Materials Used

3.2.1 Data used

We used the aerial photographs given by the sujan sir. The data contains a total of 105 images

3.2.2 Software used

For image preparation and Generation of Orthophoto, a sophisticated application Pix4D was used. finally, ArcMap10.8 was used to digitize and create the final map layout.:

3.3 Work Flow

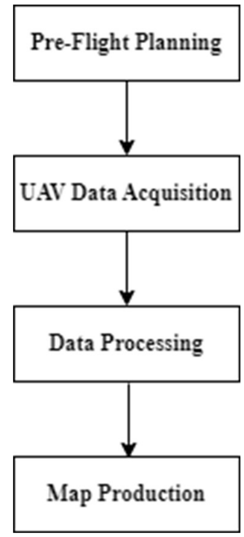


Figure 3 : Workflow

a) Pre-Flight Planning

Select and define the geographical area to be mapped, considering project objectives and spatial boundaries. Utilize UAV flight planning software (e.g., Pix4Dcapture, DJI Ground Station Pro) to design optimal flight paths. Specify parameters such as altitude, overlap (front and side), and flight speed to ensure comprehensive coverage and data quality. Strategically deploy GCPs across the survey area using GPS devices to facilitate accurate georeferencing of UAV-captured imagery.

b) UAV Data Acquisition

Conduct pre-flight checks to ensure UAV and payload (camera, sensors) functionality and calibration. Execute planned flight missions to systematically capture high-resolution imagery of the survey area. Monitor flight parameters and ensure stable flight conditions to minimize data acquisition errors. UAV captures imagery at predetermined intervals, ensuring sufficient overlap for photogrammetric processing.

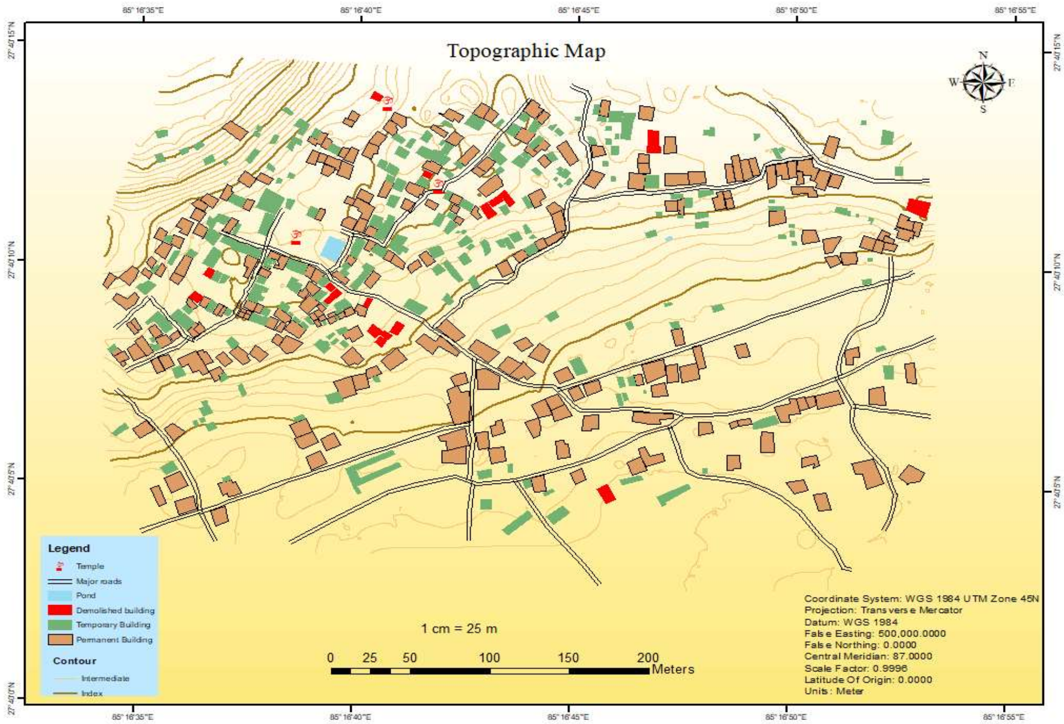
c) Data Processing

Transfer captured images from the UAV to a computer or storage device for further processing. Use photogrammetry software (e.g., Pix4Dmapper, Agisoft Metashape) to stitch individual images into seamless orthomosaics, correcting for distortions and optimizing image alignment. Incorporate GCPs into the image processing workflow to accurately georeference the orthomosaic and ensure spatial accuracy. Derive a high-resolution DEM from the orthomosaic to represent terrain elevation and topographical features.

d) Map Production

Integrate the georeferenced orthomosaic and DEM with GIS software ArcGIS to produce detailed topographical maps. The road, temples, wells, buildings were digitize using the arcmap. Include additional layers such as contours, land use classifications, and infrastructure features as required. Analyze the generated maps and derived data for specific applications such as urban planning, agriculture, environmental monitoring, and infrastructure development.

4. RESULTS



The application of Unmanned Air Vehicles (UAVs) for the preparation of topographical maps

Figure 4 : Final Topographic Map

has yielded significant results in terms of data accuracy, efficiency, and versatility. By leveraging UAV technology equipped with advanced sensors and cameras, high-resolution imagery and precise elevation data were captured over diverse landscapes. The generated orthophotos and Digital Elevation Models (DEMs) exhibited minimal distortion, providing a uniform scale and accurate representation of terrain features.

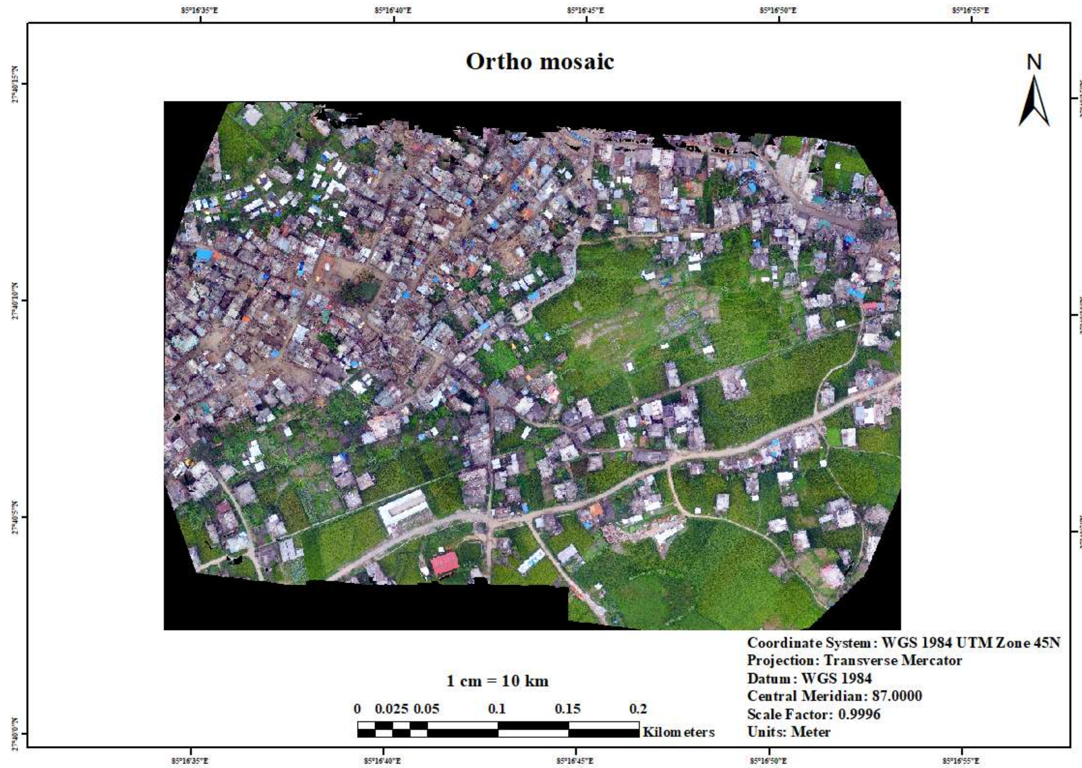


Figure 6 : Ortho-mosaic

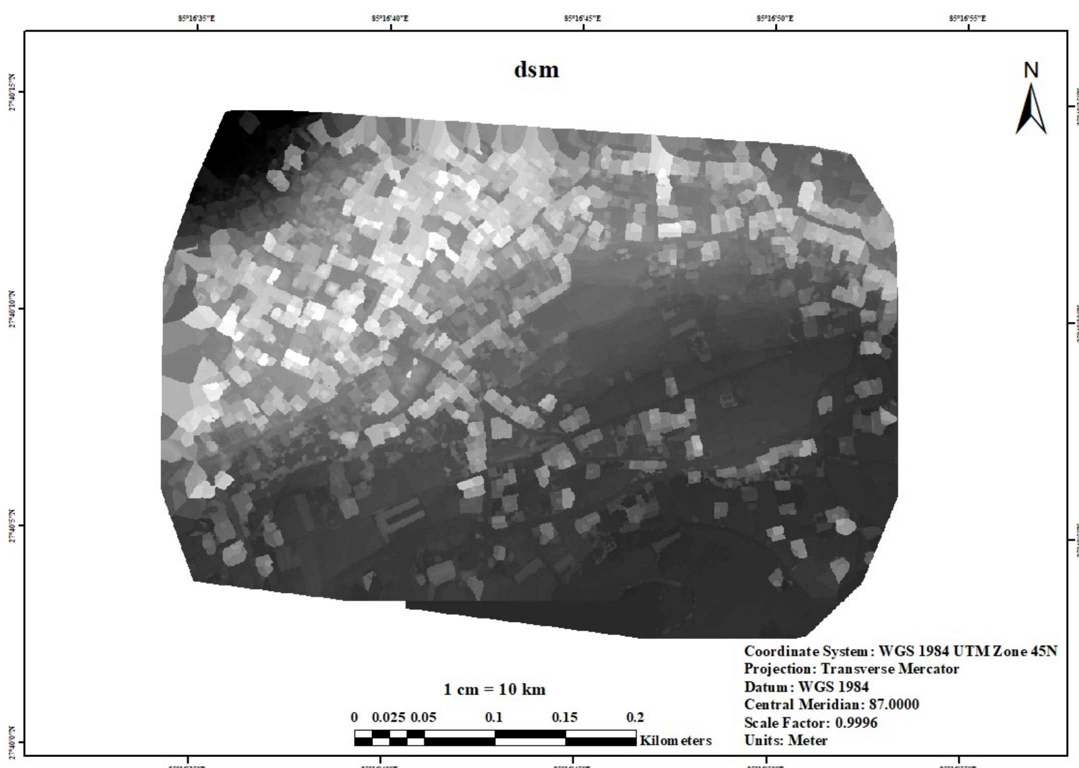


Figure 5 : dsm

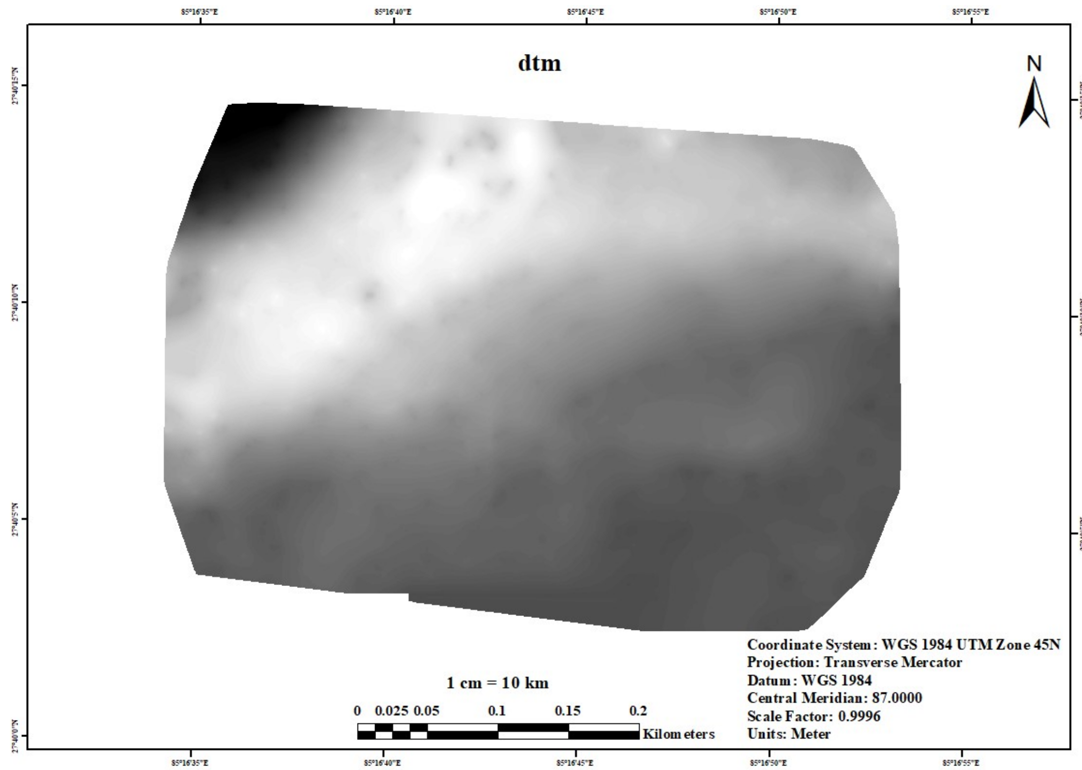

dtm
N
1 cm = 10 km
0 0.025 0.05 0.1 0.15 0.2
Kilometers
Coordinate System: WGS 1984 UTM Zone 45N
Projection: Transverse Mercator
Datum: WGS 1984
Central Meridian: 87.0000
Scale Factor: 0.9996
Units: Meter

Figure 7 : dtm

5. CONCLUSION AND DISCUSSION

Drones can capture detailed pictures from above and use them to create precise maps of terrain and elevation. This method is faster and cheaper than traditional ways of mapping with manned aircraft or ground surveys. It's also versatile, being useful for urban planning, agriculture, monitoring the environment, managing disasters, and constructing buildings. One of the main benefits is how detailed and accurate the maps can be. Drones capture high-resolution images that show even small details of the land's surface. This helps in making decisions about where to build, how to manage crops, and understanding changes in the environment.

However, there are challenges. Drones must follow strict rules for flying, and bad weather can disrupt their flights. Processing all the data they collect also takes time and specialized software. Looking forward, improvements in drone technology will continue to make mapping faster and more precise. Integrating drones with artificial intelligence could automate more of the mapping process, making it even easier to use

Using drones to make maps is a game-changer for how we understand and plan our environment. By solving challenges and building on these advancements, we can use drone technology to create better maps and make smarter decisions for the future.

6. REFERENCES

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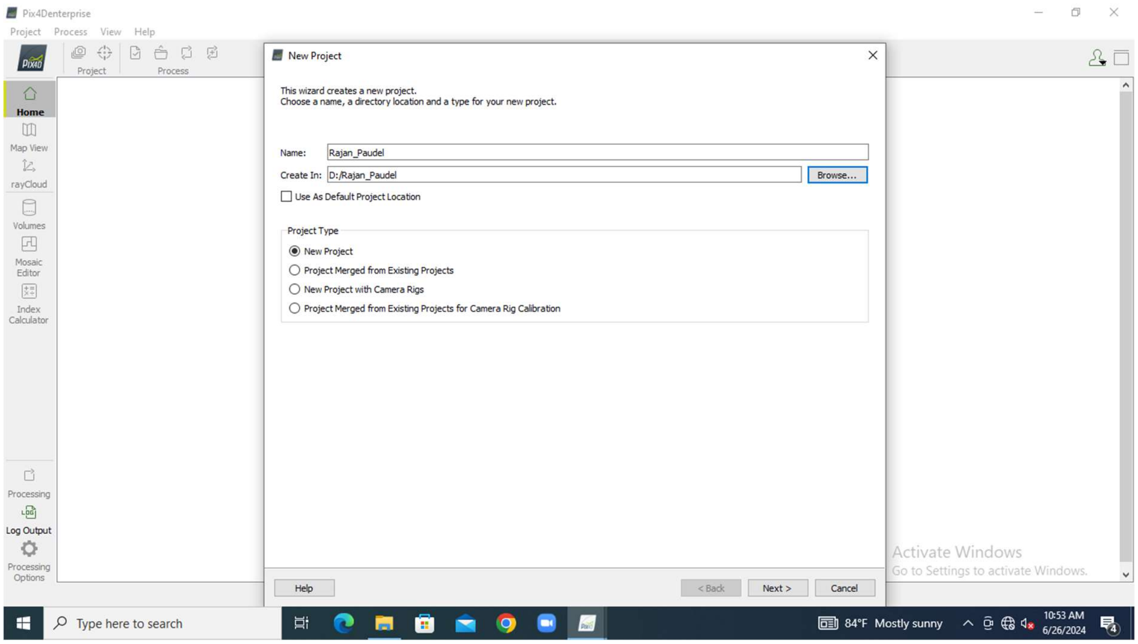
Whitehead, K., & Hugenholtz, C. H. (2014). Remote sensing of the environment with small unmanned aircraft systems (UASs), part 1: A review of progress and challenges. *Journal of Unmanned Vehicle Systems, 2*(3), 69-85. https://doi.org/10.1139/juvs-2014-0006

7. ANNEX


Pix4Denterprise
Project Process View Help
New Project
This wizard creates a new project.
Choose a name, a directory location and a type for your new project.
Name: Rajan_Paudel
Create In: D:/Rajan_Paudel
Browse...
Use As Default Project Location
Project Type
New Project
Project Merged from Existing Projects
New Project with Camera Rigs
Project Merged from Existing Projects for Camera Rig Calibration
Help
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Home
Map View
rayCloud
Volumes
Mosaic Editor
Index Calculator
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Log Output
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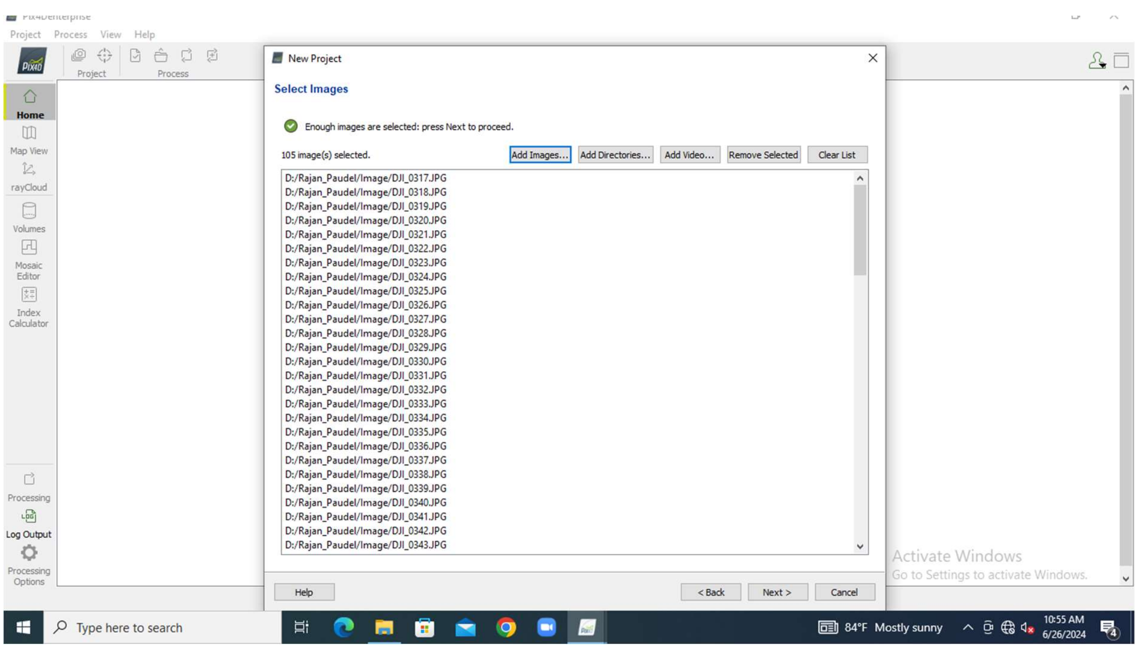
84°F Mostly sunny
10:53 AM
6/26/2024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Select Images
Enough images are selected: press Next to proceed.
105 image(s) selected.
Add Images...
Add Directories...
Add Video...
Remove Selected
Clear List
D:/Rajan_Paudel/Image/DJI_0317.JPG
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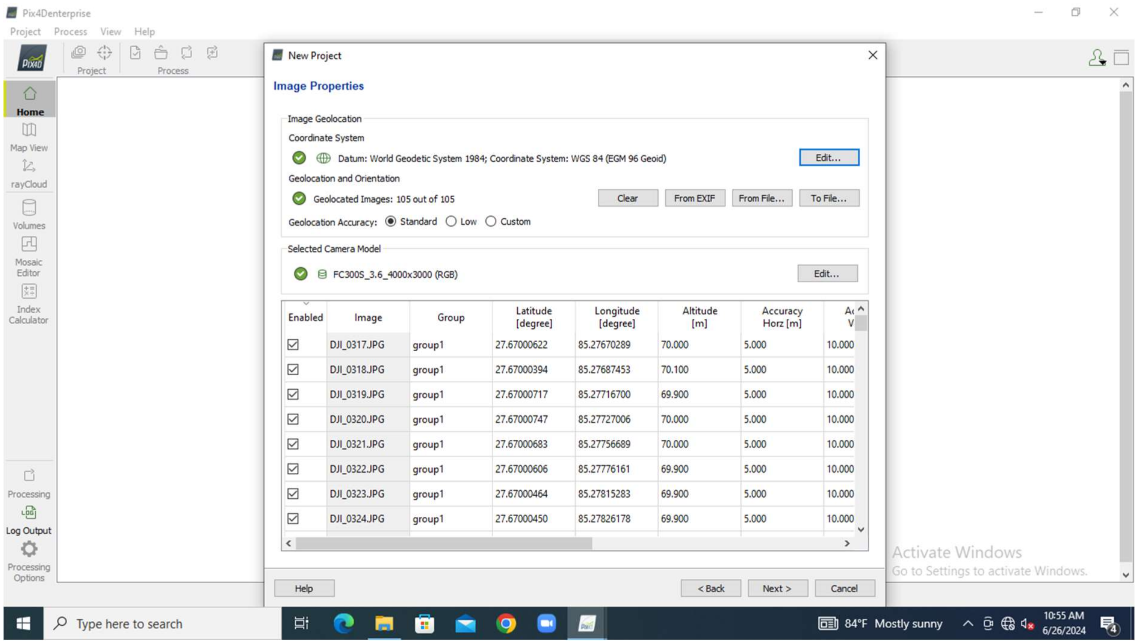
Type here to search
84°F Mostly sunny
10:55 AM
6/26/2024



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☑	DJI_0318.JPG	group1	27.67000394	85.27687453	70.100	5.000	10.000
☑	DJI_0319.JPG	group1	27.67000717	85.27716700	69.900	5.000	10.000
☑	DJI_0320.JPG	group1	27.67000747	85.27727006	70.000	5.000	10.000
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☑	DJI_0323.JPG	group1	27.67000464	85.27815283	69.900	5.000	10.000
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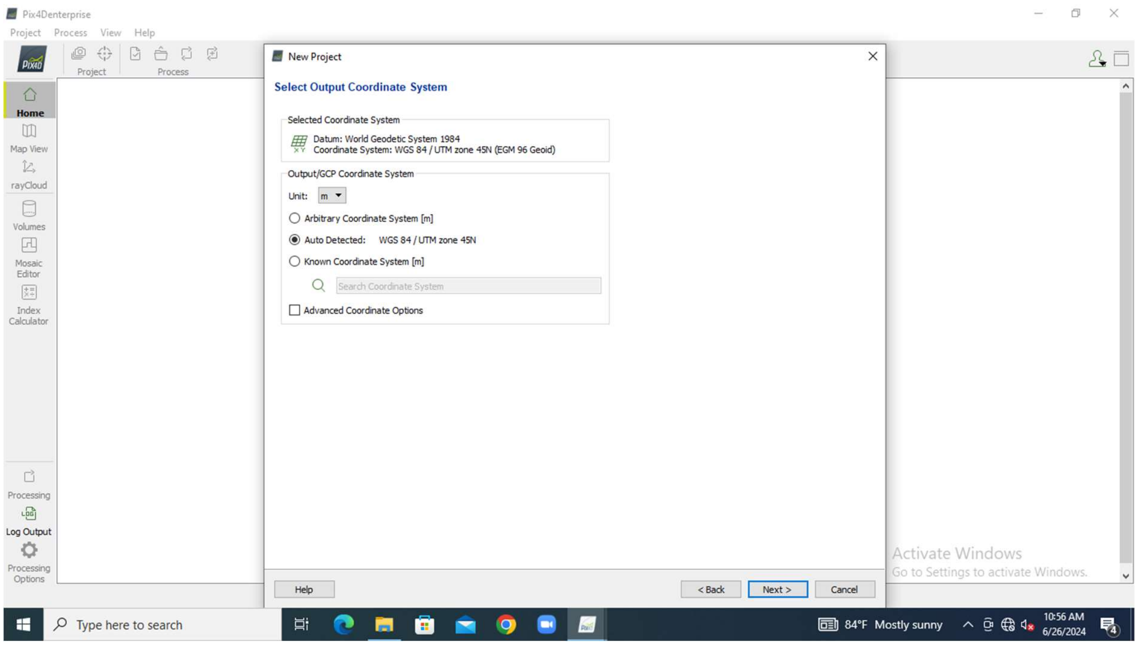

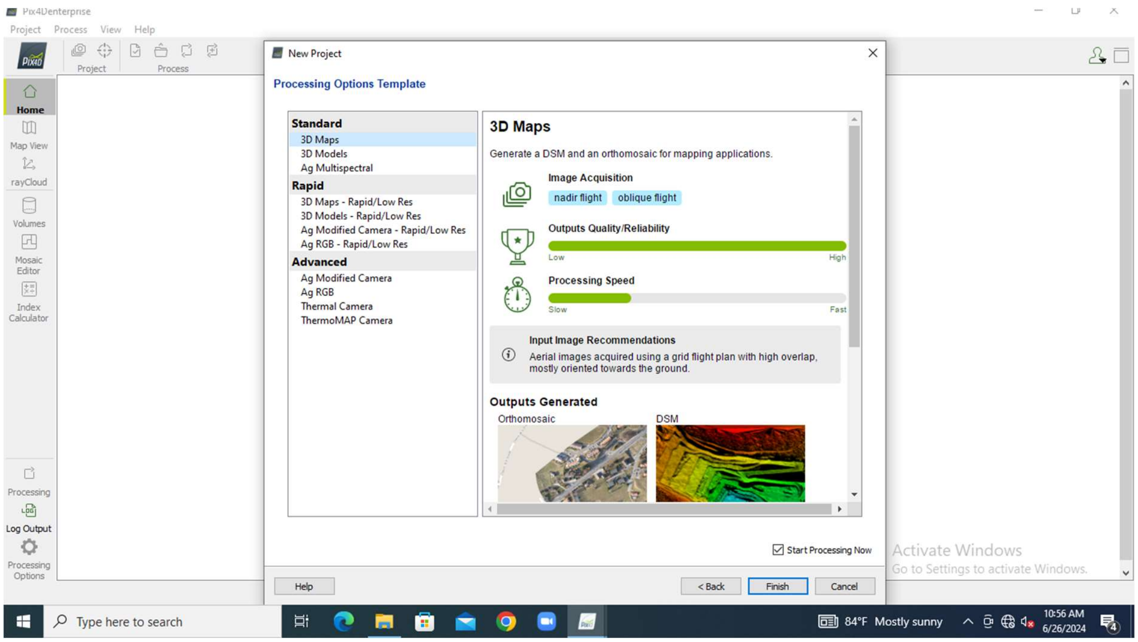

New Project
Processing Options Template
Standard
3D Maps
3D Models
Ag Multispectral
Rapid
3D Maps - Rapid/Low Res
3D Models - Rapid/Low Res
Ag Modified Camera - Rapid/Low Res
Ag RGB - Rapid/Low Res
Advanced
Ag Modified Camera
Ag RGB
Thermal Camera
ThermoMAP Camera
3D Maps
Generate a DSM and an orthomosaic for mapping applications.
Image Acquisition
nadir flight
oblique flight
Outputs Quality/Reliability
Processing Speed
Input Image Recommendations
Aerial images acquired using a grid flight plan with high overlap, mostly oriented towards the ground.
Outputs Generated
Orthomosaic
DSM
Start Processing Now
Help
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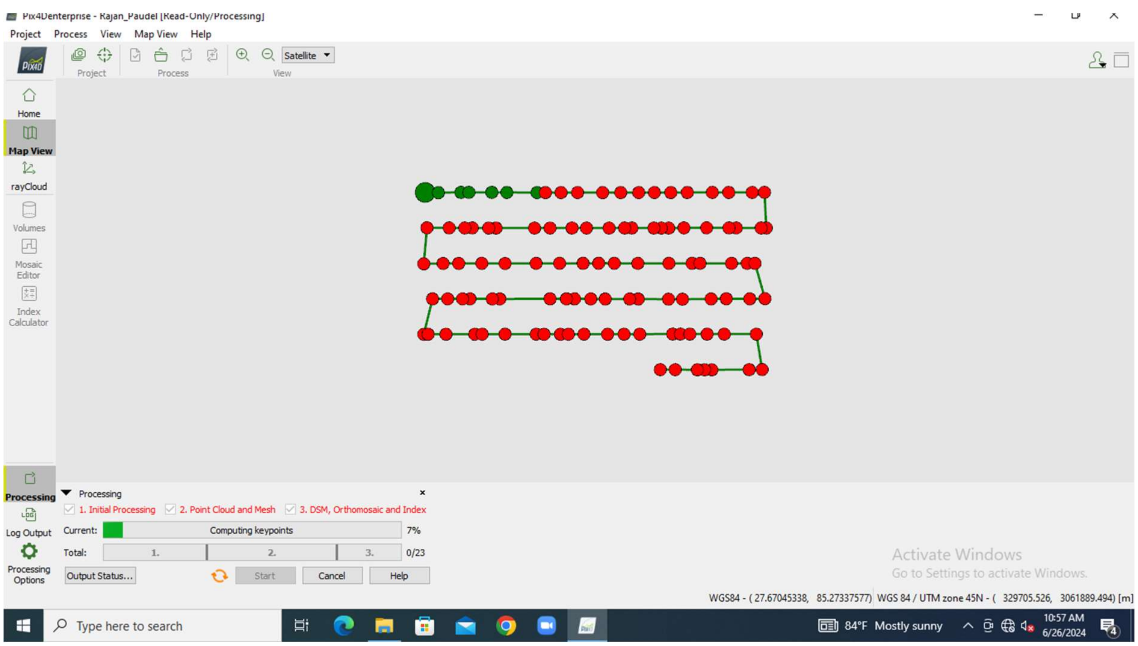
Finish
Cancel



Pix4Denterprise - Rajan_Paudel [Read-Only/Processing]
Project
Process
View
Map View
Help
Processing
1. Initial Processing
2. Point Cloud and Mesh
3. DSM, Orthomosaic and Index
Current:
Computing keypoints
7%
Total:
0/23
Output Status...
Start
Cancel
Help
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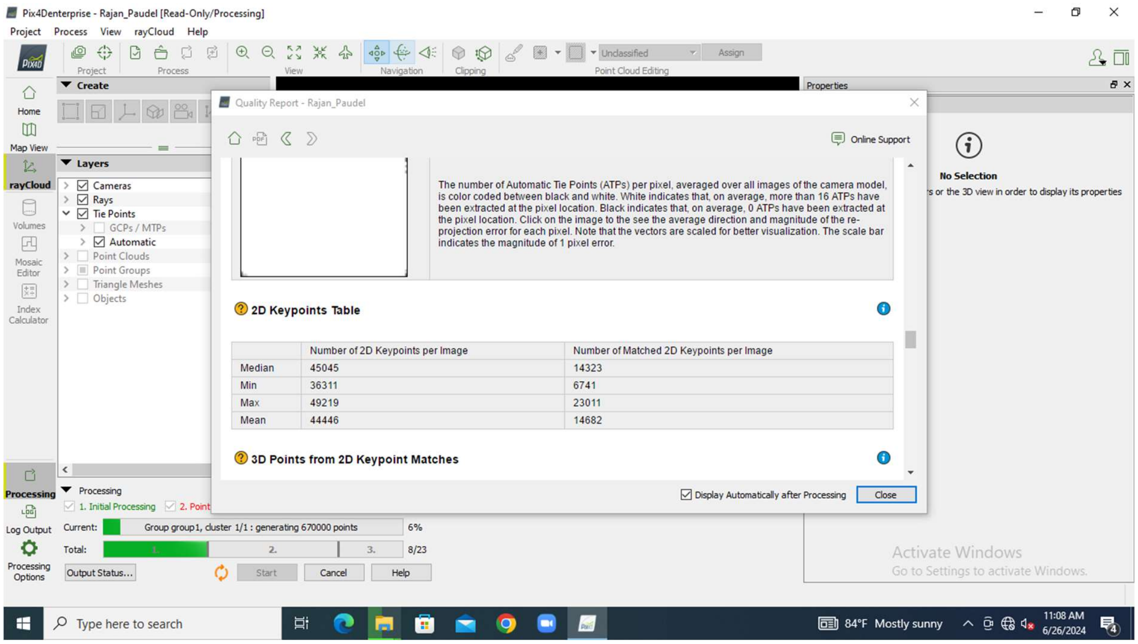
Pix4Denterprise - Rajan_Paudel [Read-Only/Processing]
Project Process View rayCloud Help
Quality Report - Rajan_Paudel
Online Support
The number of Automatic Tie Points (ATPs) per pixel, averaged over all images of the camera model, is color coded between black and white. White indicates that, on average, more than 16 ATPs have been extracted at the pixel location. Black indicates that, on average, 0 ATPs have been extracted at the pixel location. Click on the image to the see the average direction and magnitude of the re-projection error for each pixel. Note that the vectors are scaled for better visualization. The scale bar indicates the magnitude of 1 pixel error.
2D Keypoints Table
Number of 2D Keypoints per Image
Number of Matched 2D Keypoints per Image
Median 45045 14323
Min 36311 6741
Max 49219 23011
Mean 44446 14682
3D Points from 2D Keypoint Matches
Display Automatically after Processing
Close
Layers
Cameras
Rays
Tie Points
GCPs / MTPs
Automatic
Point Clouds
Point Groups
Triangle Meshes
Objects
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Processing
1. Initial Processing
Current: Group group1, cluster 1/1 : generating 670000 points 6%
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84°F Mostly sunny
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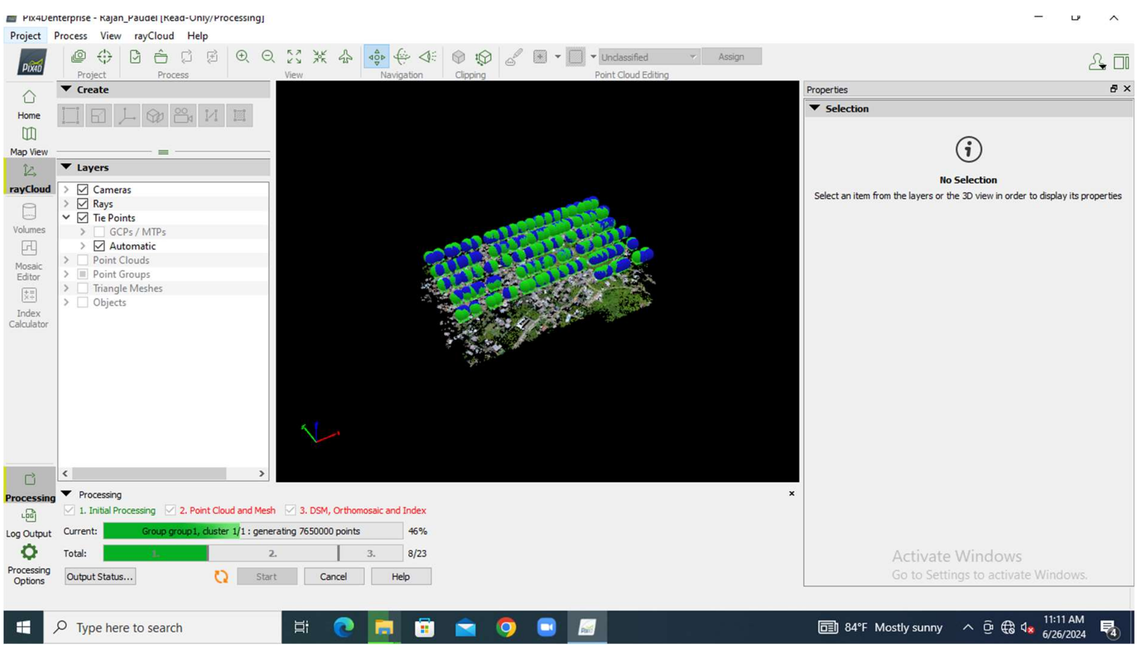
6/26/2024


Pix4Denterprise - Rajan_Paudel [Read-Only/Processing]
Project Process View rayCloud Help
Layers
Cameras
Rays
Tie Points
GCPs / MTPs
Automatic
Point Clouds
Point Groups
Triangle Meshes
Objects
Properties
Selection
No Selection
Select an item from the layers or the 3D view in order to display its properties
Processing
1. Initial Processing
2. Point Cloud and Mesh
3. DSM, Orthomosaic and Index
Current: Group group1, cluster 1/1 : generating 7650000 points 46%
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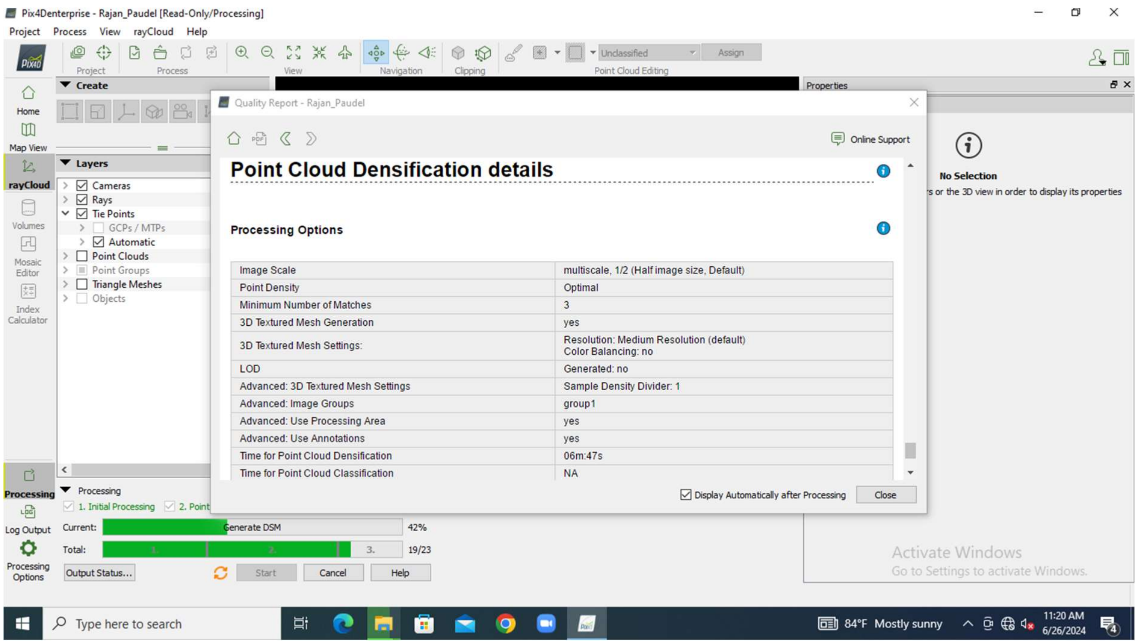
84°F Mostly sunny
11:11 AM
6/26/2024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Project Process View rayCloud Help
Quality Report - Rajan_Paudel
Online Support
Point Cloud Densification details
Processing Options
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3D Textured Mesh Generation yes
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LOD Generated: no
Advanced: 3D Textured Mesh Settings Sample Density Divider: 1
Advanced: Image Groups group1
Advanced: Use Processing Area yes
Advanced: Use Annotations yes
Time for Point Cloud Densification 06m:47s
Time for Point Cloud Classification NA
Display Automatically after Processing
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Current: Generate DSM 42%
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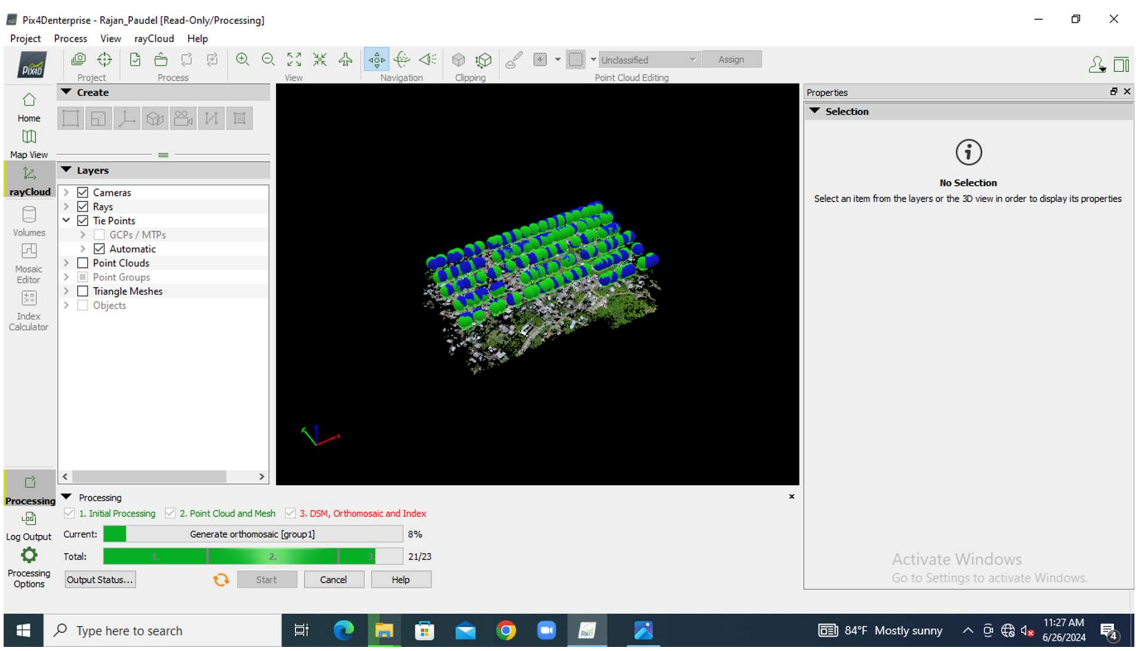
Pix4Denterprise - Rajan_Paudel [Read-Only/Processing]
Project Process View rayCloud Help
Layers
Cameras
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GCPs / MTPs
Automatic
Point Clouds
Point Groups
Triangle Meshes
Objects
Properties
Selection
No Selection
Select an item from the layers or the 3D view in order to display its properties
Processing
1. Initial Processing
2. Point Cloud and Mesh
3. DSM, Orthomosaic and Index
Current: Generate orthomosaic [group1] 8%
Total: 21/23
Output Status... Start Cancel Help
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Go to Settings to activate Windows.
Type here to search
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11:27 AM
6/26/2024