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Salahaddin University-Erbil

College of Engineering

Geomatics (Surveying) Engineering Department



زانكۆی سه‌لاحه‌دین - شه‌ولێر
Salahaddin University-Erbil

Generate 3D City Model Based on Stereo Aerial Images

Research Project

Submitted to the department of (Surveying Engineering Department) in partial fulfillment of the requirements for the degree of B.A or BSc. Of science in (surveying engineering)

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Dedicate to:

In the name of GOD, the most beneficent, the most merciful, we would like to thank our parents who have learned us the way of life. We are also deeply grateful to our supervisor Asst. Prof. Dr Haval A. Sadiq, whose insightful comments and invaluable guidance illuminated our path in the execution of this endeavor. Additionally, we extend our thanks to all professors and individuals who offered their assistance and expertise during the course of this project.

Abstract

This study is focused on the creation of a 3D city model using stereo aerial imagery is a sophisticated process that combines the precision of Differential GPS with the analytical power of photogrammetry software. The initial phase involves the meticulous collection of stereo aerial images, which must be captured with high overlap to ensure that all features of the terrain are accurately represented. Once these images are secured, they are processed through SUMMIT Evolution .

The process is iterative and may require several rounds of adjustments to refine the model to the desired level of detail and accuracy. The final product is a comprehensive 3D representation of the area of interest, which can be utilized by engineers, architects, urban planners, and GIS professionals for a variety of analytical and visualization tasks. The advancements in GIS and photogrammetry not only enhance the efficiency and accuracy of model creation but also open new avenues for innovation in digital mapping and spatial analysis. The study being conducted by the college of engineering is a testament to the interdisciplinary nature of modern engineering challenges and the innovative solutions that can be developed through the integration of various technological fields.

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Chapter One: Introduction

1.1 The aim of the project

The aim of this study is to generate accurate 3D models of Erbil environment, using Summit Evolution photogrammetric software and with ArcGIS Pro.

1.2 Objectives and Description

- 1- collecting GCPs for processing stereo Aerial image
- 2- digitizing the objects from stereo images
- 3- Generate 3D model using ARC GIS pro.

1.3 History of Generating 3D City Models

The history of 3D city modeling traces back to the mid-20th century when early attempts were made to represent urban environments in three dimensions. However, the widespread adoption of 3D modeling techniques gained momentum with the advent of digital technologies and advancements in computing power.

In the 1970s and 1980s, early computer graphics research laid the foundation for 3D modeling techniques, albeit with limited capabilities compared to modern standards. As computing technology progressed, so did the sophistication of 3D modeling software and methodologies.

The emergence of Geographic Information Systems (GIS), remote sensing technologies, and LiDAR in the late 20th and early 21st centuries revolutionized the field of 3D city modeling. These technologies enabled the acquisition of

high-resolution spatial data, facilitating the creation of detailed and accurate 3D models.

Utilizing aerial stereo images for 3D city model generation is a burgeoning field with immense potential for urban planning, disaster management, and environmental studies by employing advanced photogrammetric techniques and computer vision algorithms, researchers have been able to accurately reconstruct urban landscapes in three dimensions. This has paved the way for detailed analysis of building structures, road networks, and green spaces, providing valuable insights for city development and enhancement. Moreover, the use of aerial imagery allows for the creation of realistic visualizations that can aid in decision-making processes and stakeholder engagement. As the demand for precise and efficient urban modeling continues to grow, the integration of aerial stereo images into 3D city model generation offers a promising solution for meeting the challenges of modern urban planning and development.

The field of 3D city modeling has seen rapid advancements in recent years, driven by the increasing availability of high-resolution aerial and satellite imagery, as well as more powerful computing hardware and software. This technique involves the creation of detailed, three-dimensional digital representations of urban environments, capturing the intricate details of buildings, infrastructure, and landscape features.

Through the use of advanced photogrammetry and computer vision algorithms, 3D city models can be generated from stereo aerial images, providing a comprehensive and accurate depiction of the physical world. These models have a wide range of applications, from urban planning and infrastructure management to real estate development, tourism, and disaster response.

Today, with the proliferation of drones, high-resolution satellite imagery, and advanced software tools, generating 3D city models has become more accessible and cost-effective. These models continue to evolve, driven by innovations in data acquisition techniques, computational methods, and applications across various industries.

1.4 Overview of photogrammetry (DeWitt, B.A. and Wolf, P.R., 2000)

Photogrammetry is a technique used to extract accurate three-dimensional information from two-dimensional images or photographs. By analyzing the geometry and spatial relationships of objects within multiple images, photogrammetry can generate precise measurements, models, and maps of realworld objects or environments. It finds applications in various fields such as surveying, cartography, architecture, archaeology, engineering, and virtual reality. The process typically involves image acquisition, camera calibration, image orientation, point cloud generation, and finally, the creation of 3D models or maps. Advances in technology, including digital cameras and sophisticated software, have greatly enhanced the accuracy and efficiency of photogrammetric methods in recent years, making it an indispensable tool in many industries.

1.5 Aerial photogrammetry

Aerial photogrammetry involves taking a series of photos of an area from the sky via an aircraft or drone, with a camera pointing straight down. To accomplish this, you position the camera to take multiple photos along the flight path, each overlapping, and then process using a stereo plotter. A stereo plotter lets you see two photos simultaneously in stereo view, which you can use to make a digital model.

1.6 Aerial Stereo Images and Their Role in 3D City Model Generation

Aerial stereo images play a vital role in the generation of high-quality 3D city models by capturing images from different angles and perspectives, these stereo images provide valuable information for creating accurate and detailed representations of urban environments. The process involves using algorithms to match corresponding points in overlapping images, enabling the reconstruction of the 3D geometry of buildings and structures. This method is particularly useful in urban planning, disaster management, and environmental monitoring. Furthermore, aerial stereo images offer a cost-effective and efficient way to update city models regularly, ensuring that the information remains current and reliable. Overall, the use of aerial stereo images in 3D city model generation demonstrates the importance of advanced technology in improving spatial analysis and decisionmaking processes in various fields.

1.7 Photogrammetry process

1.7.1 Interior Orientation: This step involves calibrating the camera used to capture the images. Calibration ensures that the camera's intrinsic parameters, such as focal length, lens distortion, and principal point offset, are accurately known, lens distortion correction is essential to ensure that straight lines in the real world remain straight in the image. Distortion can occur due to imperfections in the camera lens, by accurately calibrating the camera, Summit Evolution Photogrammetry's software can compensate for these distortions, resulting in more accurate and realistic 3D models.

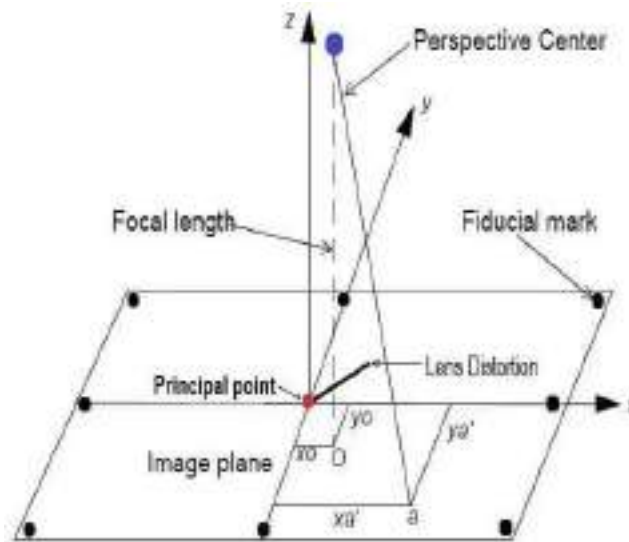


Figure 1.7.1- Interior Orientation Parameters

Image plane: refers to the imaginary flat surface where the focused image produced by a camera lens is formed. It's essentially the surface of the image sensor or film where the light rays converge to create the photograph. The image plane is crucial in photography and imaging systems because it determines the spatial arrangement and characteristics of the captured scene. In photogrammetry, understanding the relationship between the image plane and the physical world is essential for accurate measurements and analysis of the captured imagery.

Focal length: refers to the distance between the lenses optical center and the image plane. It affects the scale and accuracy of the photogrammetric measurements. A longer focal length results in a narrower field of view but potentially higher spatial resolution, while a shorter focal length widens the field of view but may sacrifice detail.

Perspective center: is the point in space where all rays of light entering the camera lens converge after passing through the lens. It is essentially the optical center of the camera. This concept is important in photogrammetry because it helps determine the geometry of the captured scene and is used in triangulation methods to calculate the position of objects in the image relative to the camera.

Principal point: also known as the image center or optical center, is the point on the image sensor where light rays passing through the lens converge and intersect. It's typically located at the center of the image sensor. The principal point is important in photogrammetry for correcting distortions and determining the relationship between the physical world and the image captured by the camera.

Lens distortion: refers to the deviation of light rays as they pass through a camera lens, resulting in image imperfections. Lens distortion can affect the accuracy of measurements and the overall quality of images, but it can often be corrected using software or optical methods.

Fiducial mark: also known as a fiducial or fiducial point, is a distinctive feature or reference point intentionally placed within an image or on an object. These marks serve as reference points for various purposes, such as calibration, alignment, or measurement in imaging systems like cameras or scanners. Fiducial marks are often designed to have known properties, such as precise dimensions or easily identifiable patterns, which allow them to be accurately located and utilized in tasks like geometric correction, scale determination, or object tracking.

1.7.2 Tie point: A tie point is a point whose ground coordinates are not known, but is visually recognizable in the overlap area between two or more images. The corresponding image positions of tie points appearing on the overlap areas of multiple images is identified and measured. Ground coordinates for tie points are computed during block triangulation. Tie points can be measured both manually and automatically. They should be visually defined in all images. Ideally, they should show good contrast in two directions, like the corner of a building or a road intersection. Tie points should also be distributed over the area of the block.

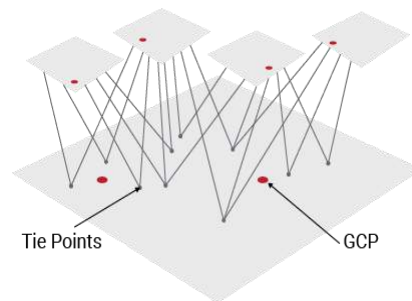


Figure 1.7.2-overlapping between two or more images (tie point)

1.7.3 Relative Orientation: Relative orientation establishes the spatial relationship between multiple images taken from different viewpoints, this step involves matching common features or tie points between overlapping images and using these correspondences to compute the position and orientation of each image relative to others, through bundle adjustment techniques, the software optimizes the camera positions and orientations to minimize errors and ensure consistency between overlapping images, relative orientation is crucial for stitching together the individual images into a cohesive 3D model with accurate geometry and texture.

1.7.4 Absolute Orientation: Absolute orientation involves georeferencing the 3D model to real-world coordinates, this step aligns the model with a global coordinate system such as latitude, longitude, and elevation, enabling integration with other geospatial data and accurate geographic referencing, ground control points (GCPs) or GPS data are typically used to georeference the model. These reference points provide known coordinates that help establish the transformation between the model's coordinate system and the Earth's coordinate system, georeferencing allows for spatial analysis, measurements, and visualization of the 3D model in the context of its realworld surroundings.

1.7.5 Exterior Orientation: Exterior orientation determines the position and orientation of the camera at the time each image was captured, this information is typically obtained through metadata recorded by the camera or by using additional surveying techniques such as GPS or inertial measurement units (IMUs), accurate exterior orientation parameters are essential for correctly placing features in the 3D model relative to the Earth's surface, by incorporating precise information about the camera's position and orientation, the software can ensure the geographic accuracy of the reconstructed 3D scene.

1.7.6 Bundle Adjustment: The bundle adjustment is a non-linear minimization procedure that adjusts points and cameras by minimizing the projection error of points. It is performed at the end of each merge and a final bundle adjustment with all points and cameras is always performed at the end of the structure from motion procedure.

1.7.7 **Strips:** Successive overlapping images form a strip of imagery we usually call (strip) or (flight line), therefore photogrammetric strip (Figure) is formed from multiple overlapping images along a flight line, while photogrammetric block (Figure 4.9) consists of multiple overlapping strips (or flight lines).

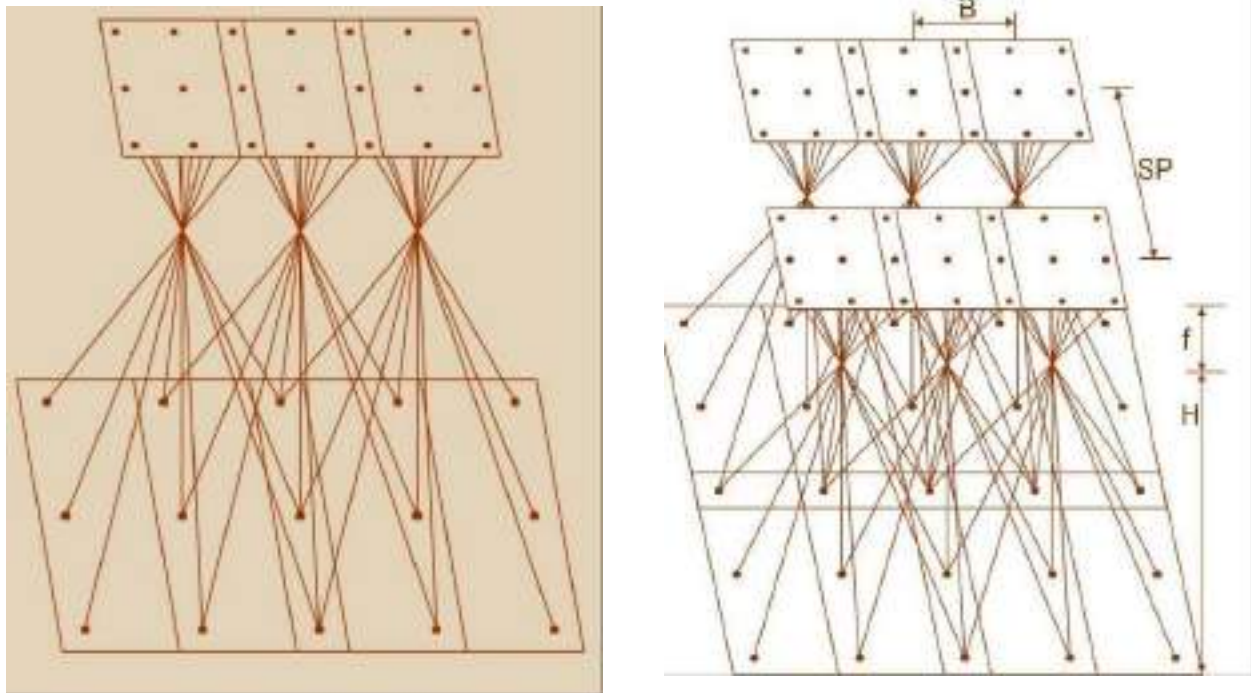


Figure 1.7.7-strips

These steps collectively form the photogrammetric workflow employed by Summit Evolution Photogrammetry's software to generate detailed and georeferenced 3D models from aerial and satellite imagery. Each step plays a crucial role in ensuring the accuracy and reliability of the final output, which can be used for a wide range of applications in fields such as urban planning, environmental monitoring, agriculture, and infrastructure development.

1.8 Benefits of photogrammetry to generate 3D City Model

Photogrammetry offers several key benefits for creating 3D city models:

- 1.8.1 **Accuracy:** Photogrammetry techniques can produce highly accurate 3D models by leveraging multiple overlapping images taken from different angles. This approach allows for precise reconstruction of terrain, buildings, and other features, resulting in realistic and detailed city models.
- 1.8.2 **Cost-Effectiveness:** Compared to traditional surveying methods, photogrammetry is often more cost-effective, as it utilizes aerial or satellite imagery to capture data over large areas in a relatively short amount of time. This can significantly reduce the expenses associated with field surveys and data collection.
- 1.8.3 **Efficiency:** Photogrammetry enables rapid data acquisition and processing, making it an efficient method for creating 3D city models. Automated software solutions, such as Summit Evolution Photogrammetry, streamline the workflow, allowing for quick generation of models with minimal manual intervention.
- 1.8.4 **Comprehensiveness:** Photogrammetry can capture a wide range of features and details within a cityscape, including buildings, roads, vegetation, and terrain variations. This comprehensive data allows for the creation of holistic and detailed 3D representations of urban environments.
- 1.8.5 **Visualization and Analysis:** 3D city models derived from photogrammetry facilitate visualization and analysis for various purposes, such as urban planning, architectural design, infrastructure development, and disaster management. Stakeholders can explore the city model from different perspectives, assess spatial relationships, and make informed decisions based on the insights gained.

1.8.6 Interoperability: Photogrammetry software often supports interoperability with other geospatial tools and formats, allowing for seamless integration with existing workflows and datasets. This interoperability enhances collaboration and data sharing among different stakeholders involved in city planning and development projects.

Overall, photogrammetry offers a powerful and efficient means of creating accurate, detailed, and comprehensive 3D city models, enabling stakeholders to better understand and visualize urban environments for various applications and decisionmaking processes.

1.9 Introduction of ArcGIS pro

ArcGIS Pro is an advanced Geographic Information System (GIS) software developed by esri, designed to facilitate the creation, management, analysis, and visualization of spatial data. It represents a significant leap forward in GIS technology, offering a modern and intuitive platform for professionals and organizations to harness the power of spatial information.

ArcGIS Pro serves as the flagship desktop GIS application within the ArcGIS platform, which encompasses a comprehensive suite of tools and services for working with geographic data. It builds upon the legacy of Esri's earlier desktop GIS software, ArcMap, by incorporating cutting-edge features, enhanced performance, and a more user-friendly interface.

Its prowess lies in its advanced mapping capabilities, supporting both 2D and 3D visualization. This means users can create intricate, visually stunning maps enriched with interactive layers and symbology. This feature opens doors for a myriad of

applications across various sectors, from urban planning to environmental management and emergency response.

ArcGIS Pro's advanced mapping capabilities extend beyond mere visualization, offering users the ability to conduct sophisticated spatial analyses with precision and efficiency. Through its comprehensive suite of tools, users can explore spatial relationships, perform statistical analyses, and derive actionable insights from complex datasets.

Moreover, ArcGIS Pro serves as a collaborative platform, enabling seamless sharing and integration of spatial data across teams and organizations. Whether it's collaborating on a multi-disciplinary project or sharing insights with stakeholders, ArcGIS Pro facilitates communication and collaboration, driving informed decisionmaking and fostering innovation.

Furthermore, ArcGIS Pro is not just limited to desktop environments. Its seamless integration with ArcGIS Online and ArcGIS Enterprise enables users to access and work with spatial data anytime, anywhere, and on any device. This flexibility empowers field workers, remote teams, and decision-makers to leverage spatial information to its fullest potential, even in dynamic and resource-constrained environments.

In summary, ArcGIS Pro represents a paradigm shift in GIS technology, offering a holistic solution for creating, managing, analyzing, and visualizing spatial data. Its advanced capabilities, user-friendly interface, and seamless integration make it a powerful tool for professionals and organizations across diverse sectors, driving innovation, and enabling informed decision-making in an increasingly spatiallyaware world.

1.10 Comprehensive Overview of ArcGIS pro

- 1. Modern Interface:** ArcGIS Pro introduces a sleek and intuitive user interface, featuring a ribbon-based layout similar to popular productivity software such as Microsoft Office. This modern design streamlines access to tools and functions, making it easier for users to navigate and perform GIS tasks efficiently.
- 2. Advanced Mapping Capabilities:** One of the standout features of ArcGIS Pro is its robust mapping capabilities. Users can create dynamic and visually compelling maps in both 2D and 3D, incorporating various layers, symbology, and interactive elements. The software supports a wide range of data formats, including vector, raster, and LiDAR, allowing users to visualize and analyze spatial data with unparalleled flexibility.
- 3. Geoprocessing Tools:** ArcGIS Pro offers a comprehensive suite of geoprocessing tools for performing spatial analysis, data manipulation, and automation of workflows. These tools enable users to conduct complex analyses, such as spatial statistics, network analysis, and suitability modeling, to derive valuable insights from spatial data.
- 4. Integration and Interoperability:** ArcGIS Pro seamlessly integrates with other components of the ArcGIS platform, including ArcGIS Online and ArcGIS Enterprise. This integration facilitates data sharing, collaboration, and access to additional resources such as basemaps, imagery, and demographic data. Furthermore, ArcGIS Pro supports interoperability with various data formats and systems, ensuring compatibility with diverse datasets and environments.
- 5. Customization and Extensibility:** Users can customize and extend the functionality of ArcGIS Pro to suit their specific needs and workflows. The software provides robust scripting capabilities through Python, allowing users

to automate tasks, develop custom tools, and integrate third-party libraries. Additionally, the ArcGIS Pro SDK enables developers to build add-ins and extensions that extend the software's capabilities even further.

- 6. Collaboration and Sharing:** ArcGIS Pro facilitates collaboration and knowledge sharing among users through integration with ArcGIS Online and ArcGIS Enterprise. Users can easily share maps, data, and analysis results with colleagues, stakeholders, or the public, fostering collaboration and enabling informed decision-making.
- 7. Performance and Productivity:** ArcGIS Pro leverages modern hardware capabilities to deliver superior performance and responsiveness compared to traditional GIS software. Its multi-threaded architecture and optimized workflows ensure smooth data processing and analysis, thereby enhancing productivity and efficiency in GIS tasks.

1.11 Benefits of ArcGIS Pro

- ✓ **Improved Performance:** ArcGIS Pro leverages modern hardware capabilities, resulting in superior performance and responsiveness compared to traditional GIS software. This translates to quicker data processing and analysis.
- ✓ **Enhanced Visualization:** Its 2D and 3D mapping capabilities enable users to create immersive visualizations, providing deeper insights into spatial data and fostering better understanding and decision-making.
- ✓ **Streamlined Workflows:** The intuitive interface and workflow-oriented design of ArcGIS Pro streamline GIS tasks, reducing the learning curve and boosting productivity.

- ✓ **Interoperability:** ArcGIS Pro's compatibility with various data formats and systems facilitates seamless integration and data exchange, allowing users to work with diverse datasets and environments effortlessly.

Chapter Two: Methodology

2.1 study area

The project is applied to College of Engineering in Erbil City using five stereo aerial images. The image as shown in Fig1.1 is located in Erbil, Kurdistan region. Lower left coordinate ($36^{\circ}08'16",44^{\circ}01'28"$) and upper right coordinate ($36^{\circ}09'04",44^{\circ}01'53"$). The area covers the College of Engineering campus at Salahaddin University and surrounding areas which are around 4500 buildings.



Figure 2.1 Kurdistan region, Erbil, Salahaddin University-College of Engineering.

2.2 Ground control points

Ground control points (GCPs) serve as reference points with known geographic locations on the Earth's surface. They are crucial in photogrammetry for accurate georeferencing and orientation of aerial or satellite imagery. By precisely locating these points on the ground, photogrammetry software can correct distortions, improve accuracy, and ensure the alignment of the imagery with real-world coordinates. This is essential for various applications like mapping, surveying, and remote sensing, where precision and reliability are paramount.

Ground Control Points, or GCPs, are large marked targets on the ground, spaced strategically throughout your area of interest. If you use ground control points with your aerial map, you first need to determine the RTK GPS coordinates at the center of each ground target. The ground control points and their coordinates are then used to help aerial mapping software accurately position your map to the real world around it. It can reference their locations when it matches all the other map points.

First we start by measuring some control points inside the college of Engineering by differential GPS (GS16) instrument using real-time-kinematic (RTK) method, PS receivers receive signals from multiple satellites orbiting the Earth. By triangulating signals from at least four satellites, the receiver can calculate its three-dimensional position (latitude, longitude, and altitude) with a high degree of accuracy.

You'll require at least three CPs and need to spread these as widely and evenly throughout your site as you can, if there are objects on your site that you are specifically interested in, like a stockpile or structure foundation, make sure to place markers near those points of interest. If there are large terrain elevation areas, try to place markers near the highest and lowest areas of the site.

RTK GPS operates by employing a base station and a rover station. The base station is positioned at a known location with a clear view of the sky and serves as a

reference point. The rover station is deployed at the location where control points need to be measured.

The base station continuously receives signals from GPS satellites and calculates its precise position. Subsequently, it transmits correction data to the rover station via a radio link or alternative communication protocol in real time. The rover station, upon receiving these corrections, applies them to refine its own position, thereby attaining centimetre-level accuracy in spatial determination.

Once the rover station has been set up and is receiving corrected signals from the base station, surveyors can proceed to measure the ground control points. Each control point is accurately located using the RTK GPS method, ensuring that its precise coordinates are recorded.

After all control points have been measured and their coordinates determined, they are then used as reference points during the aerial mapping process. When the drone captures images of the area, these ground control points serve as anchor points that help align the aerial imagery with real-world coordinates.

During post-processing of the drone imagery, software tools utilize the known coordinates of the ground control points to accurately georeference the aerial map. This ensures that the resulting map aligns correctly with existing GIS data and accurately represents the features and terrain of the college of engineering campus.

By employing ground control points and RTK GPS technology, surveyors can achieve high levels of accuracy and precision in their aerial mapping projects, enabling detailed analysis and decision-making based on reliable spatial data.

1. Steps for Measuring Ground Control Points Using GPS RTK method

1. Base Station Setup:

Place the base station on a known point (we have a known control point in college RP1) with accurate coordinates. Establish a stable and clear communication link between the base station and the rover.



Figure 2.2.1-base station setup



Figure 2.2.2-base and rover

- 2. RTK Corrections:** The base station continuously calculates corrections to improve the accuracy of the rover's GPS signals. Ensure the RTK corrections are being transmitted to the rover in real-time.
- 3. Rover Setup:** Place the rover on the point where you want to determine coordinates. Connect the rover to the RTK corrections provided by the base station.
- 4. Data Collection:** Allow the rover to collect data over a sufficient period to ensure accuracy.
- 5. Coordinate Determination:** After data collection, the RTK method calculates precise coordinates for the rover's location relative to the base station.

6. Post-Processing (Optional): Some systems allow post-processing for further refinement of coordinates. the accuracy of the control point depends on factors like satellite visibility, atmospheric conditions, and the quality of the RTK system. Always refer to the specific RTK equipment's user manual for detailed instructions, (we don't process our coordinates because the accuracy is acceptable around a few centimeters).

By following these steps, control points can be accurately measured using the GPS RTK method, providing essential reference data for various surveying, mapping, and geospatial applications.

No of GCPs	Easting	Northing	Height
1	412412.668m	3999936.991m	428.946m
2	412327.329m	3999952.173m	428.239m
3	412398.352m	3999973.969m	428.414m
4	412371.817m	4000063.493m	427.925m
5	412400.393m	4000135.186m	427.585m
6	412401.077m	4000176.202m	427.768m
7	412022.241m	4000291.763m	424.793m
8	412025.682m	4000330.214m	424.737m
9	412331.362m	4000609.888m	429.219m
10	412295.255m	4000466.908m	427.057m

Table 1: List of Ground Control Points

2.3 Positions of GCPs.



Figure 2.3.1: Location of GCP1-Corner of Parcel



Figure 2.3.2: Location of GCP2-Corner of Concrete



Cp3:
E: 412398.352m
N: 3999973.969m
H: 428.414m
Datum: WGS84
Projection: UTM-38N

Figure 2.3.3: Location of GCP3-Corner of Garden



Cp4:
E: 412371.817m
N: 4000063.493m
H: 427.925m
Datum: WGS84
Projection: UTM-38N

Figure 2.3.4: Location of GCP4-Corner of walkway



Cp5:
E: 412400.393m
N: 4000135.186m
H: 427.585m
Datum: WGS84
Projection: UTM-38N

Figure 2.3.5: Location of GCP5-Corner of walkway



Cp6:
E: 412401.077m
N: 4000176.202m
H: 427.768m
Datum: WGS84
Projection: UTM-38N

Figure 2.3.6: Location of GCP6-Corner of walkway



Cp7&8:
E: 412022.241&412025.682m
N: 4000291.763&4000330.214m
H: 424.793&424.737m
Datum:WGS84
Projection:UTM-38N

Figure 2.3.7: Location of GCP7&8-Center of Manhol



Cp9:
E: 412331.362m
N: 4000609.888m
H: 429.219m
Datum:WGS84
Projection:UTM-38N

Figure 2.3.8 : Location of GCP9-Corner of Garden



Figure 2.3.9: Location of GCP10-Corner of Garden

Chapter Three: Generating 3D city model with (Summit Evolution & ArcGIS Pro)softwares

3.1 Interior orientation, Relative Orientation, Absolute Orientation and Exterior Orientation steps.

3.1.1 Creating models from aerial images

For creating a model from aerial images the following steps will be followed:

1. Double click on the icon or go to start the program. This window will appear:



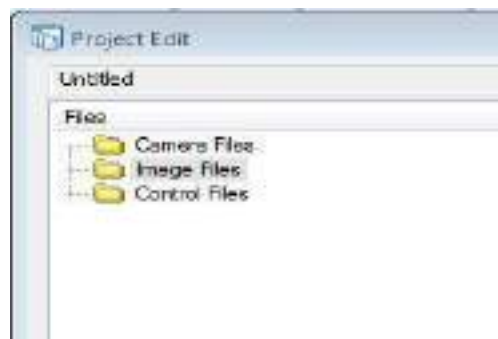
2. Start new project
 - a) Click on New or (File >>New) or click on (New) button in the file Toolbar.



b) A new window will appear as shown below. Click on the icon according to the available data. In our case, we are dealing with Aerial imagery. Therefore, we will select the aerial as shown below, then click on OK.



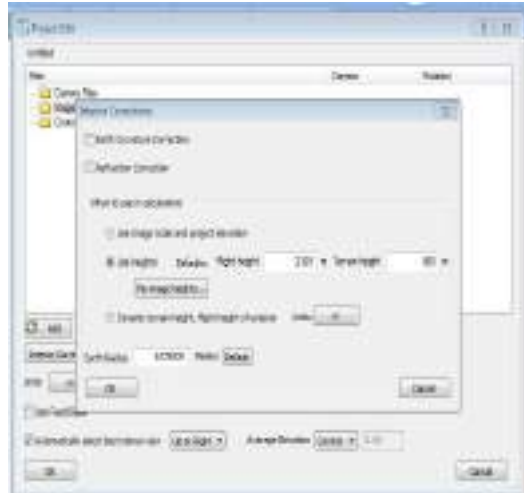
c) A new window will appear as shown to the right. select the (Image Files), and then click on Add (to load the images).



d) Select the images and then click on open to load the photos. And return to the window in section (c).



- e) Click on in the interior corrections, (if needed) tick on Earth curvature correction tick on Refraction correction, for flight height enter 2195m for terrain elevation, enter 400m (approximately).



3.1.2 Interior Orientation (IO)

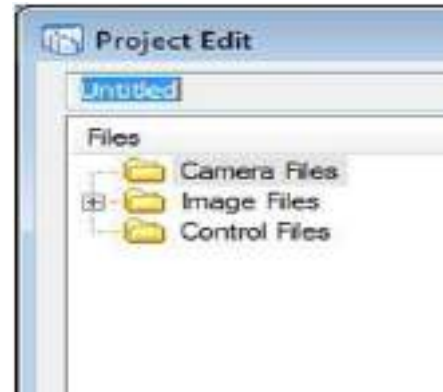
1. Create the camera file, click on camera editor.



2. Select the Digital Camera, based on the camera calibration report, use the parameters save the parameters using save.



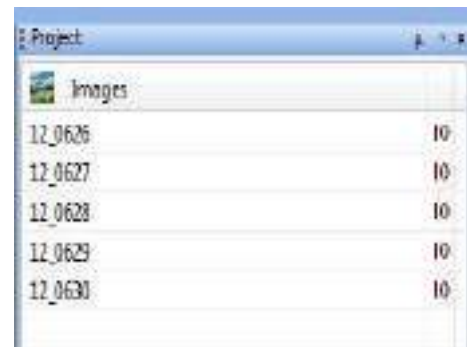
3. Go to Edit the project and open the project window.



4. Select the camera file, click add, then select the created camera file, then click open and then ok.



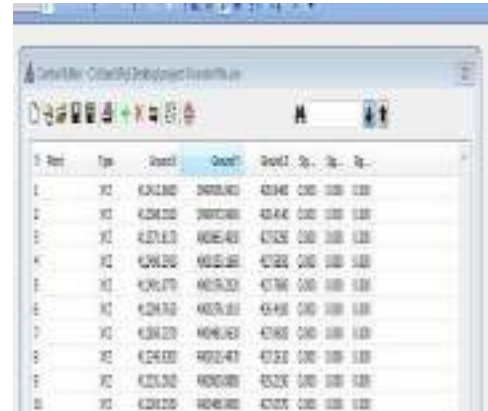
5. You can notice in the view panel the IO has appeared.



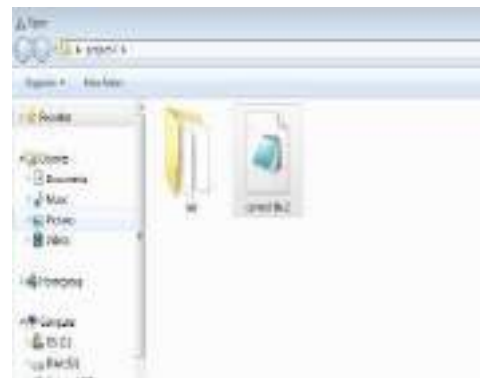
3.1.3 Ground control points file

Create a Ground control points file Model for the images, Achieve Relative and Absolute Orientation, View the images in the stereo model.

1. Create a ground control points file A survey should be done on the ground, so the control points should be gathered. The points from the RTK-GPS survey, click on file menu then click on Edit and select (control file).



2. Automatic relative Orientation and Absolute Orientation, start a New project and add the camera file.



3. Create A model for the images, create a model using the added two images by right click on Model in the Project Panel and then clicking on Add Models.



4. New window will appear, specify the name of the Model and then select an image in the upper field for the (left image) and an image at the bottom area for the (right image).



3.1.4 Absolute Orientation and Stereo Viewing

Tie point

1. Add tie points to link each point to the other by clicking on Orientation and Tie point.



2. A new window will appear, which is called (Tie Points).



3. In the tie points window, Select Side by Side (to preview the images beside each other). Then click on (Align) to align the photos to each other. Select the One Point option.



4. In the Tie Point Window, click on (quick Point) to automatically create automatic and accurate tie points in the overlapped area. In the (Quick Points) window, click on the Von Grubbers 8 option, a new 8 points will appear in the overlapped area, then press OK.



5. In the Tie Points window, a list of the points identified in the left image will only appear. These numbers should be identified in the other image (Right image) also this achieved by:

- i. First, lock the left image by pressing the lock button in the Tie points window and activate the (Auto Next) button.

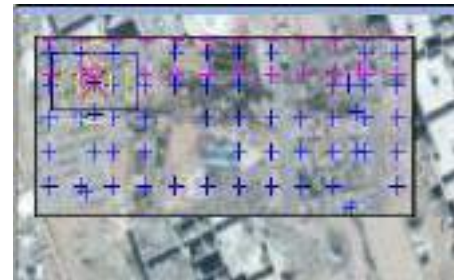
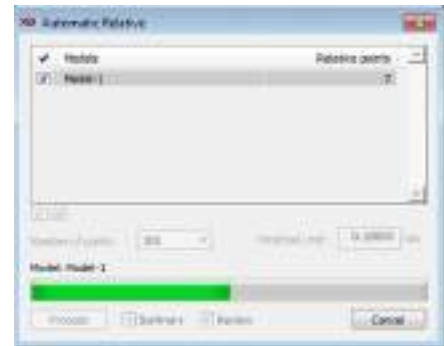


- ii. Then press button (No 4) continuously The (Left) label in the (Tie Points) window will be changed to (both) which means both images. Continue till all the points are finished. When finished the value of the residual will appear.



3.1.5 Relative Orientation

1. Start the relative orientation, From the orientation menu, click (Automatic Relative Orientation) Select the created Model and then press Process.
2. This process will lead to generating more tie points in the Model, and finally, a report will be displayed then press (apply), In the Relative orientation window, a preview will be displayed in each panel during clicking on the points.



3.1.6 Absolute Orientation(AO)

To start absolute orientation in the Orientation menu, click on Absolute orientation the file will be loaded automatically at this stage, the GCP should be assigned to the Model to give the absolute position to the points.

3.1.7 Bundle Adjustment and Exterior Orientation (EO)

Bundle Adjustment and Exterior Orientation (EO) used to perform a Direct relationship between image and ground coordinate.

The images will be marked as EO (which means exterior orientation is determined for each image).



3.1.8 Strip

To create a strip in Summit Evolution software, you typically follow these steps:

1. Right click on strips and make a strip for images by click on add strip.

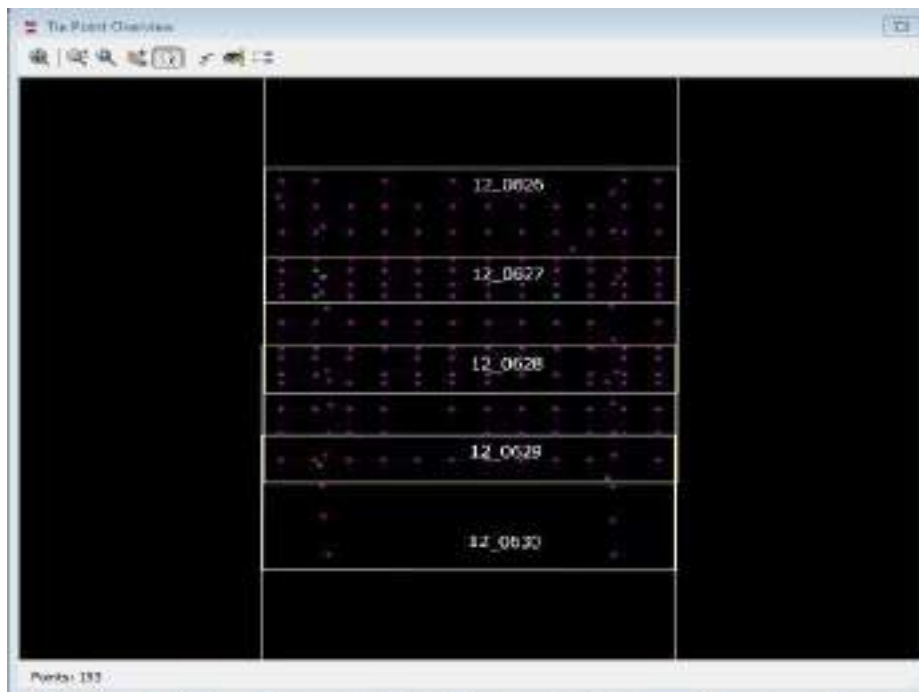
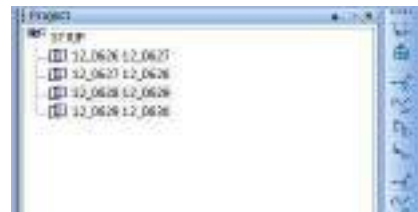


Figure 3.1.: Strips

Once we finish the steps of IO, RO, AO and EO we proceed to digitizing. In this stage, we begin by creating layers for different objects. Each object should be represented by a distinct layer. For instance, green areas might be delineated using light green for trees dark green, for roads grey, for water areas blue, and so on.







Layer	Object
	Building
	Green area
	Road
	Tree
	Parcel
	garage

Table 2: Object layers

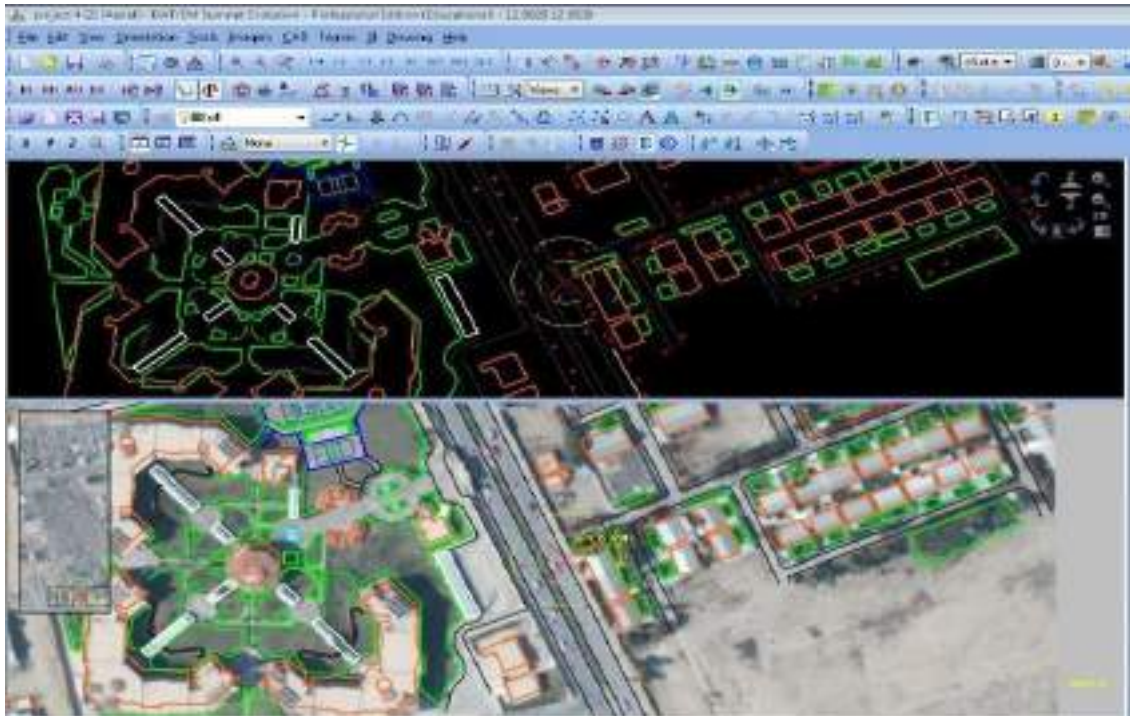


Figure 3.1.2: Digitizing

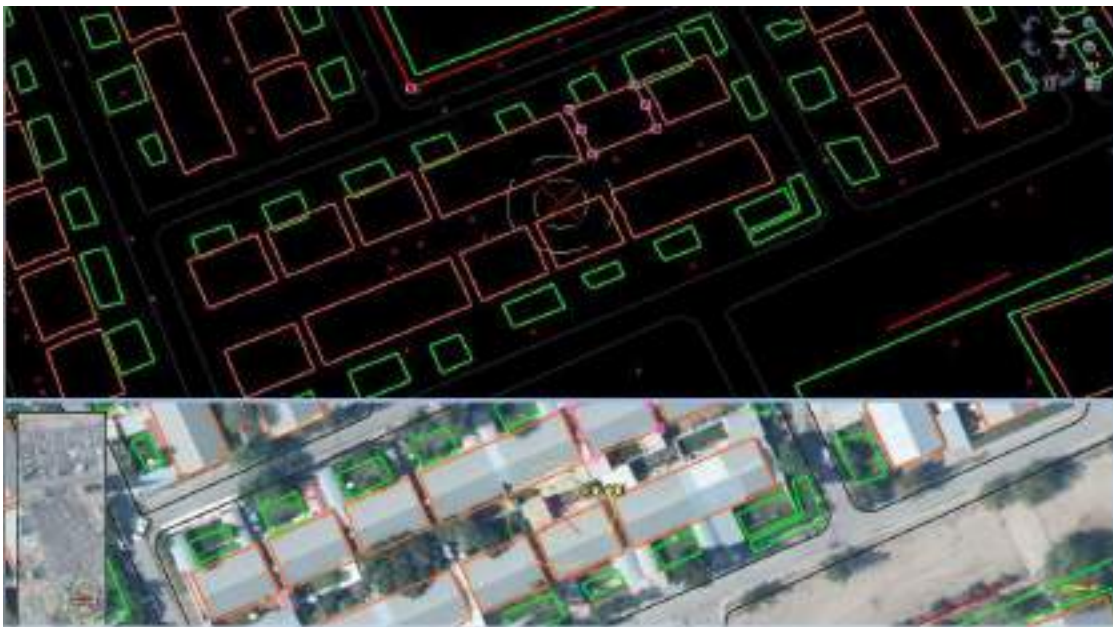
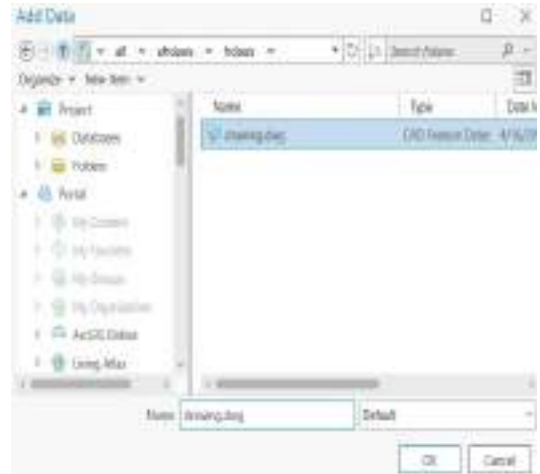


Figure 3.1.3: Digitizing

3.2 Generating 3D City Model using ArcGIS Pro software For generating 3D city Model Follow these steps:

1. Make sure a map or scene is your active view.
2. On the Map tab, in the Layer group, click Add Data and click Data.

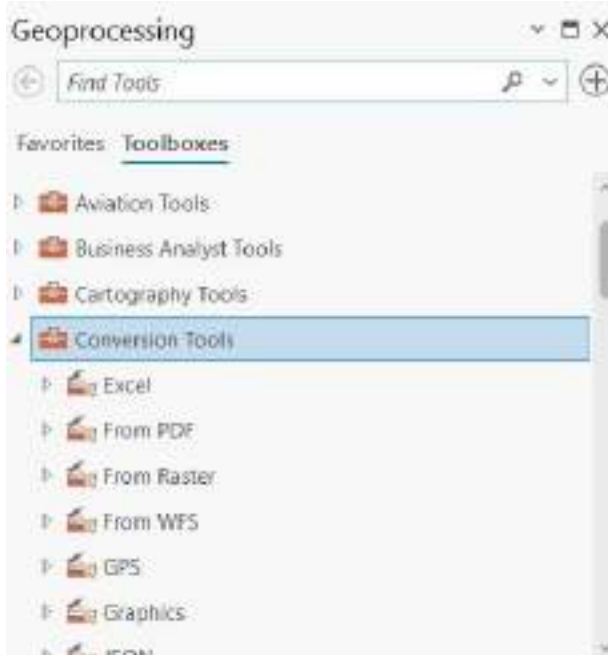


(DeWitt, B.A. and Wolf, P.R., 2000)

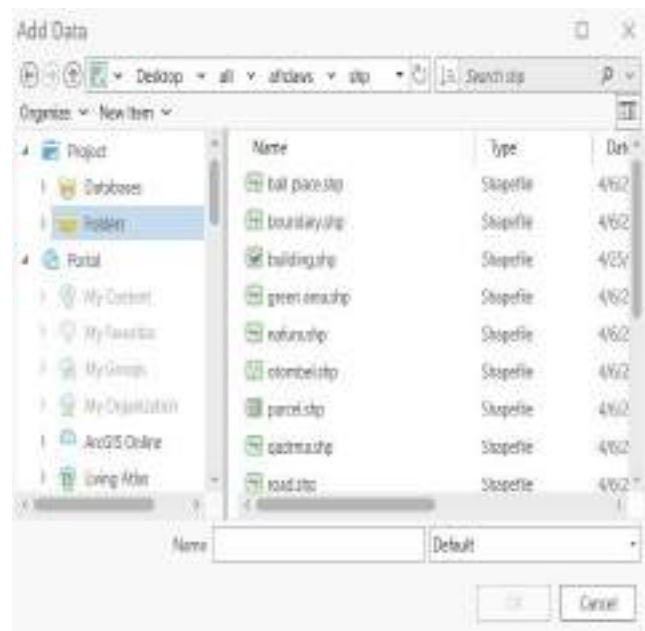
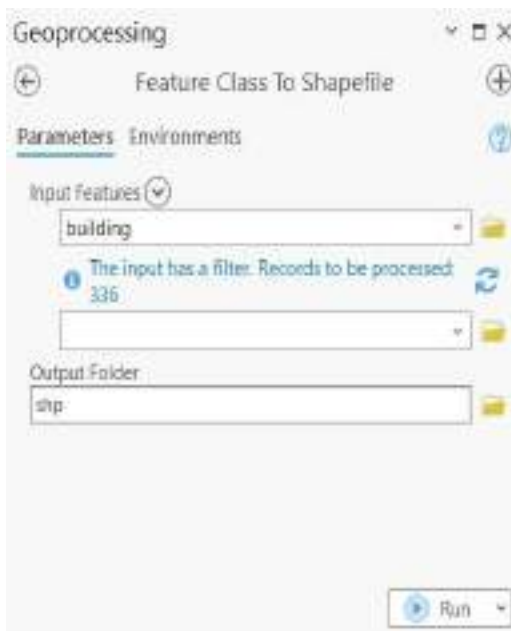
3. After add the data we need to change the coordinates system to WGS 1984 UTM 38N to show the data in the current position.



4. After the go to  analysis and click on tools double click in the conversion tools.



5. Click on to shape file, used for the data to change for the shape file. using the same process to all layer to change the shape files.



6. Then, remove the layer and add the shape file after that changed to the geodatabase, because in ArcGIS pro work with the geodatabase, then remove all the shape files and add the geodatabase that we make.



7. To show the height of features in the reality we have, we need click in the layer and click on properties, in the elevation change the height of features.



3.3 3D Layers




Layer	Object
	Tree
	Fountain
	Car

Table 3: 3D layers in ArcGIS Pro.

Chapter Four: Discussion and Results

4.1 Discussion

Creating 3D models of buildings using ArcGIS Pro offers a dynamic perspective of urban landscapes. By digitizing structures and employing GIS technology, we digitized intricate details of the College of Engineering and its surrounding areas. These images not only highlight the structural elements but also serve as valuable tools for urban planning, environmental analysis, and infrastructure management. Discussing the spatial layout, connectivity, and potential impact on the surrounding community could provide insights into the role of engineering in shaping the built environment. Additionally, highlighting any unique design elements or historical significance of the buildings could add depth to the discussion. Overall, these images represent a fusion of technology, creativity, and practical application in the realm of geospatial analysis and urban development.

4.2 Results



Figure 4.2.1-College of Engineering



Figure 4.2.2-Zanko neighborhood



Figure 4.2.3- Zanko Neighborhood



Figure 4.2.4-College of Engineering & Zanko street

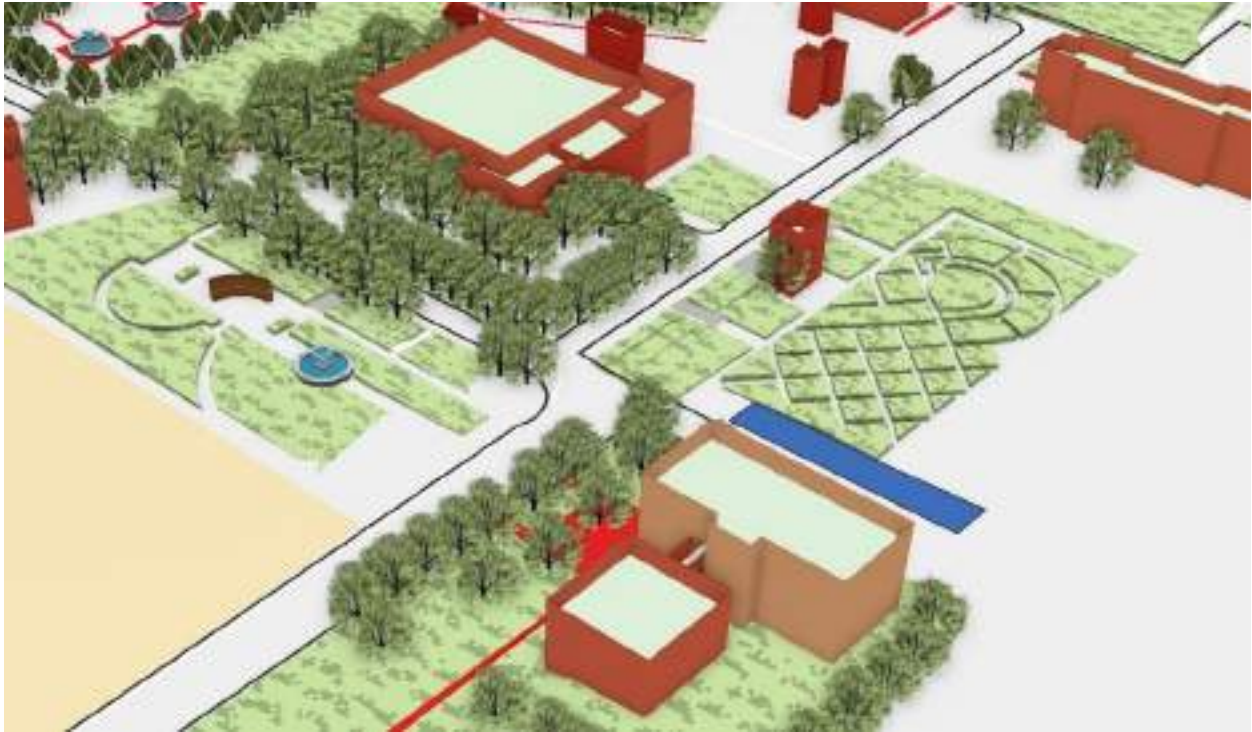


Figure 4.2.5-College of Engineering-Geomatics Dep.



Figure 4.2.6- Adala neighborhood.

Chapter Five: Conclusion

In conclusion, the development of a 3D city model based on stereo aerial images represents a significant advancement in urban planning, infrastructure management, and environmental analysis. Through the integration of cutting-edge technologies such as photogrammetry and remote sensing, this project has demonstrated the potential to create highly accurate and detailed representations of urban environments.

By leveraging stereo aerial images captured from different perspectives, we have been able to reconstruct three-dimensional models of buildings, roads, and other urban features with remarkable precision. These models not only provide visually compelling representations of cities but also serve as valuable tools for various applications, including urban development, disaster response planning, and transportation engineering.

Moreover, the utilization of stereo aerial imagery offers distinct advantages over traditional methods such as LiDAR scanning or manual surveys. It allows for cost-effective and efficient data acquisition over large areas while maintaining high levels of accuracy and detail. Additionally, the scalability of this approach makes it suitable for projects ranging from local neighborhood planning to regional infrastructure assessment.

In summary, the creation of a 3D city model from stereo aerial images opens up new possibilities for understanding and managing urban environments. As technology continues to evolve, further improvements in data acquisition, processing algorithms, and visualization techniques promise to enhance the capabilities of such models, driving innovation in urban planning and decision-making processes.

References

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- 4-Gutiérrez-Peña, J., Herrera, R.F., Atencio, E. and Muñoz-La Rivera, F., 2024. Analysis of visual impact by new building height through UAVs and photogrammetry. Journal of Civil Engineering and Management, 30(3), pp.248-263.