Acknowledgement

I would like to express my sincere gratitude to Sujan Sapkota Sir for his invaluable guidance and support throughout the course of this mini project. His expertise and encouragement were instrumental in the successful completion of this work. I also extend my thanks to my peers and colleagues who provided assistance and feedback during various stages of the project. Additionally, I appreciate the resources and facilities provided by our institution, which enabled the effective execution of this project.

Abstract

This mini project focuses on the application of Unmanned Aerial Vehicle (UAV) technology and photogrammetry techniques to create a detailed topographic map of the LSU campus mounds. High-resolution aerial images were captured using UAVs and processed in Pix4D to generate a seamless mosaic, Digital Terrain Model (DTM), and Digital Surface Model (DSM). The mosaic image was subsequently imported into ArcGIS for digitization, where various planimetric features were meticulously mapped. ArcCatalog was utilized to create shapefiles for points, lines, and polygons, facilitating a structured and accessible dataset. The final topographic map provides a comprehensive representation of the area, integrating both natural and manmade features.

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Introduction

Background

UAV (Unmanned Aerial Vehicle): UAVs, commonly known as drones, are aircraft without a human pilot on board. They are controlled either autonomously by onboard computers or by remote control from the ground. UAVs are used in various applications, including aerial photography, agriculture, surveillance, and mapping. In photogrammetry, UAVs are equipped with high-resolution cameras to capture detailed aerial images for creating accurate maps and 3D models. (Thapa, 2021)

Figure 1 UAV (quadcopter)

Topographic mapping refers to the process of creating detailed and accurate maps that depict the physical features of a landscape or area. These maps use contour lines to represent changes in elevation and show natural and man-made features such as hills, valleys, rivers, roads, and buildings. They are essential for various applications in civil engineering, urban planning, resource management, and environmental studies. (Duggal, 2013)

Double Grid Photographs: Double grid photography is a method used in aerial surveying where photographs are taken in a systematic overlapping pattern, both longitudinally and transversely. This ensures that each point on the ground is captured from multiple angles, enhancing the accuracy and reliability of the data. The double grid method is particularly useful in generating detailed and precise orthophotos and 3D models.

The advent of Unmanned Aerial Vehicles (UAVs) has revolutionized the field of photogrammetry, offering a versatile and efficient means to capture high-resolution aerial imagery. This mini project aims to leverage UAV technology to create a detailed planimetric map of the LSU campus mounds. Utilizing the double grid photographic technique, we captured a comprehensive set of overlapping images, ensuring meticulous coverage and data accuracy. (Shaaban Ali1, 2022)

These images were processed using Pix4D, a powerful photogrammetry software, to produce a seamless mosaic. The resultant mosaic was then imported into ArcGIS for digitization, where we meticulously mapped various planimetric features. ArcCatalog was employed for effective data management, ensuring a structured and accessible dataset.

Objective

Primary Objectives

The primary objective of this project is to create a detailed topographic map of the LSU campus mounds using UAV imagery.

Secondary Objectives

- Employ Pix4D to process the secondary images and produce a seamless and accurate mosaic.
- Use of ArcGIS and ArcCatalog to digitize and manage spatial data effectively, reinforcing skills in these essential GIS tools.

Literature review

Drones, also known as UAVs, are changing the way we collect aerial data through photogrammetry. These drones are equipped with high-quality cameras and tracking systems, allowing them to take detailed images during flight. With these images, accurate 3D models and maps can be created using photogrammetry (The use of Aerial Photos in Engineering Planning). The use of drones improves the efficiency of tasks such as surveying, infrastructure verification, and environmental monitoring. This is an effective and fast way to collect data, especially in hard-to-reach places. This combination of technologies continues to improve our ability to create accurate maps, making drones an essential tool for data collection and analysis across many industries. (Remondino, 2014)

UAV Photogrammetry is about using flying cameras that can work on their own without a pilot. These cameras, attached to small unmanned planes, take detailed pictures from not too high up, usually around 500 meters. Using these pictures, we can make accurate maps and 3D models. The cool thing about using these flying cameras is that they're easy to move around, affordable, take pictures at just the right time, and work well with regular digital cameras. These qualities make UAVs different and better than the old-fashioned ways of making maps.

Methodology

Study Area

The study area for this project is Louisiana State University in Baton Rouge, Louisiana, located at approximately 30.4140° N latitude and 91.1786° W longitude.

Standard resolution aerial imagery was captured using a UAV, employing a double grid flight planning technique to ensure detailed coverage and accuracy. The images were processed and digitized using photogrammetric and GIS tools, resulting in a precise planimetric map of the LSU campus area. Selected area has historic mounds, dating back to the Marksville and Troyville cultures, were likely used for ceremonial and burial purposes which can be viewed by contour line having equal elevation.

Data Used

UAV images sourced from secondary sources served as the project's major source of data.

Software Used

The software used for the project were:

Pix4D Mapper: A software suite compatible with UAS (Unmanned Aircraft System) imagery that enables us to define areas of interest, select processing options, add ground control points (GCPs), and create and edit point clouds, digital surface models (DSMs), meshes, and Ortho mosaics.

GIS Environment: GIS Environment was used to add the mosaic, create shape files, digitize study area and for mapping as well.

Methodological workflow

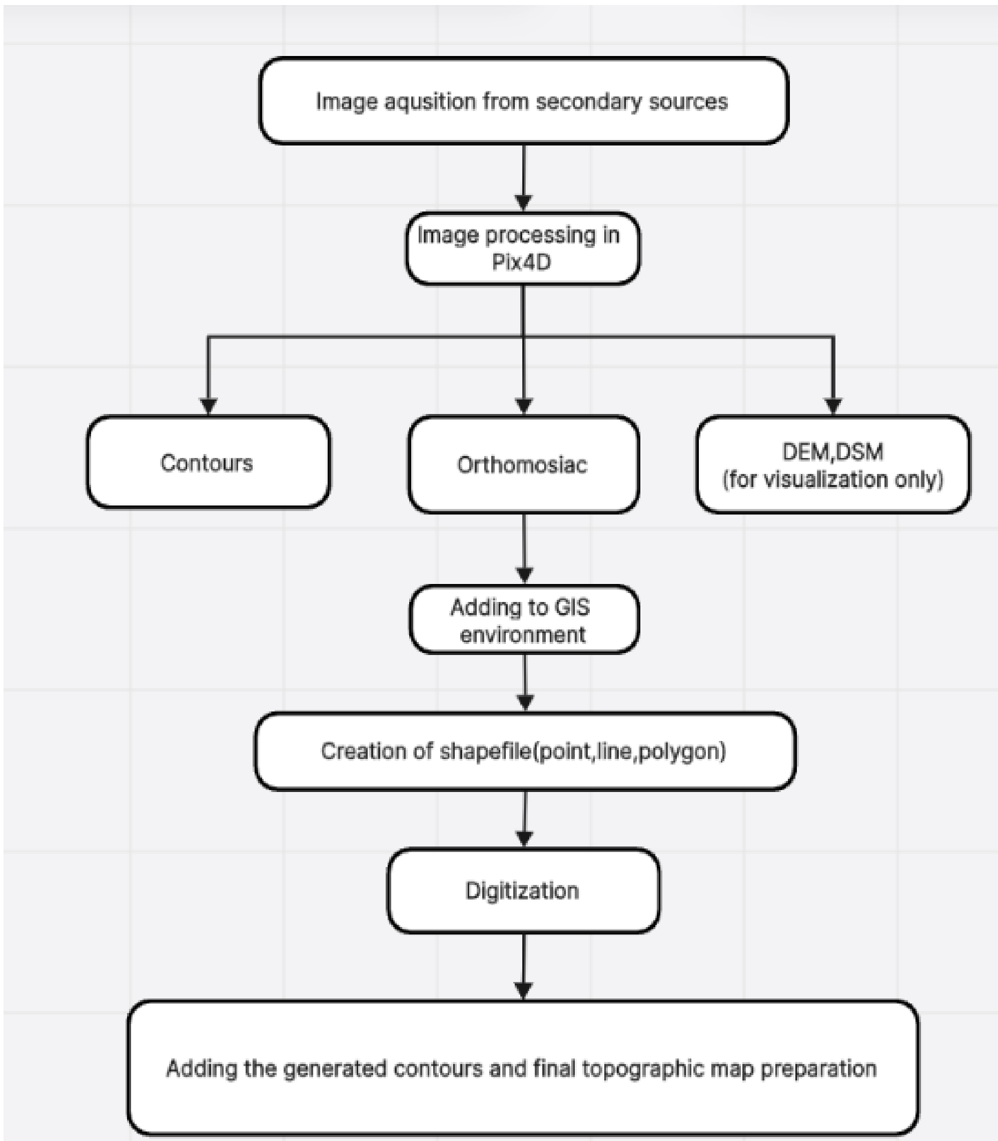

Figure 2 Methodological Flowchart

Description

- **Image Acquisition from Secondary Sources**

A total of 171 photos were collected from secondary sources of LSU Area. These images were used for further processing.

- **Image Processing in Pix4D**

Using ground control points, we matched or georeferenced the UAV image in this step. This technique allowed us to improve the accuracy.

  - DTM generation from UAV

In order to extract DTM from drone photos, the point cloud had to be filtered to eliminate any points that were located above the surface of the planet. The majority of surface packages that are currently available achieve this by using algorithms that classify point clouds. Results are frequently unsatisfactory, leading to inaccurate DTM. Pix4D Mapper was used to process the photographs after the flight. Pix4D software was used to process the UAV-obtained photos.

  - Initial processing:

When started the initial processing, Pix4D mapper first computed key points on the images. It used these key points to find matches between the images. The software runs an Automatic Aerial Triangulation (AAT) and Bundle Block Adjustment (BBA) from these initial matches. After the initial processing, the coordinates of the control points, which were obtained were used for absolute orientation for GCPs referencing. This step was used for transformation of local coordinate system to WGS system. After the re-optimization, coordinates of GCPs were adjusted and the camera optimization changed to certain percentage which lie within the permissible change i.e.<5%

  - Point cloud and Mesh:

This increased the density of 3D points of the 3D model for both the DSM and the Orthomosaic. This tab contained two sections: Point cloud densification: allowed to set parameters for the point cloud densification by defining the scale of images. Image scale, point density and minimum number of matches were manually selected using this tab. Image scale has an impact on the number of 3D points generated. The minimum number of matches per 3D point represents the minimum number of valid reprojections of that 3D point to the images. For our project, the minimum number of matches was 3. Point cloud classification: enabled the generation of point cloud classification. The point cloud classification was used for the DTM generation which significantly improved the DTM.

- **DSM, Orthomosaic and Index**: Allowed to change the processing options and desired outputs for DSM and Orthomosaic generation. It contained 4 sections:
- **Resolutions:** allowed to define the spatial resolution used to generate the DSM and Orthomosaic. By default, 1 GSD was selected.
- **DSM filters:** Allowed to define parameters to filter and smooth the points of the point cloud used to obtain DSM.
- **Noise Filtering:** The generation of the Point Cloud can lead to noisy and erroneous points. The noise filtering corrects the altitude of the points with the median altitude of the neighboring points.

- **Surface Smoothing:** Once the noise filter has been applied, a surface was generated using the points. The surface can contain areas with erroneous small bumps. The surface smoothing corrects those areas by flattening them. Sharp smoothing tried to preserve the orientation of the surface and to keep sharp features such as corners and edges of buildings.
- **Raster DSM:** Allowed to select whether the raster DSM is generated and to select the method with which the DSM was generated. GeoTIFF was activated by default which was used to save DSM as GeoTIFF file. The inverse distance weighting algorithm was used to interpolate between points. This method was recommended for buildings, agriculture fields and flat areas because the results produced are better than triangulation method.
- **Orthomosaic:** allowed to select the output file format for the Orthomosaic as well as different parameters related to the Orthomosaic generation. GeoTIFF was activated by default which saved the Orthomosaic into a GeoTIFF file.

- Contouring

The process of creating contour lines from a digital elevation model (DEM) or digital surface model (DSM) made from aerial or drone footage is known as contouring in Pix4D. Pix4D software reconstructs 3D models of objects and landscape from overlapping aerial pictures using photogrammetry techniques. Following the creation of the 3D model, Pix4D can produce contour lines at predetermined intervals, offering precise elevation data for use in engineering, mapping, and other applications. It's an effective tool for performing terrain analysis and producing precise topographic maps.

- Adding to GIS Environments

The orthomosaic obtained after post-processing was added to the GIS Environment. The mosaic was used as a reference for shapefiles to perform digitization of the allocated area

- Creating Shapefiles

The 'Catalog' was used to create shapefiles such as Road, Agriculture Zone, Primary Buildings and Temporary Buildings. These shape files were added to the GIS Environments with the same spatial reference as the main orthomosaic or both the shape files and the orthomosaic were projected to the same spatial reference.

Road, Foot Trail, Fence, lane: Line Type

Temporary House, Building, park, parking, cycle rack: Polygon Type

Trees: point

- Digitization

Using the editor tool bar, each layer was digitized using Orthomosaic as a reference. Road was created as line in the map & the other features were polygons and point.

- Final Map Preparation

A final layout map was created from the digitized shapefiles with proper map information details. The layout map was exported as an Output.

Result

Figure 3 Showing the images after Mosaicking.

Figure 4 Showing the image after digitizing the features.

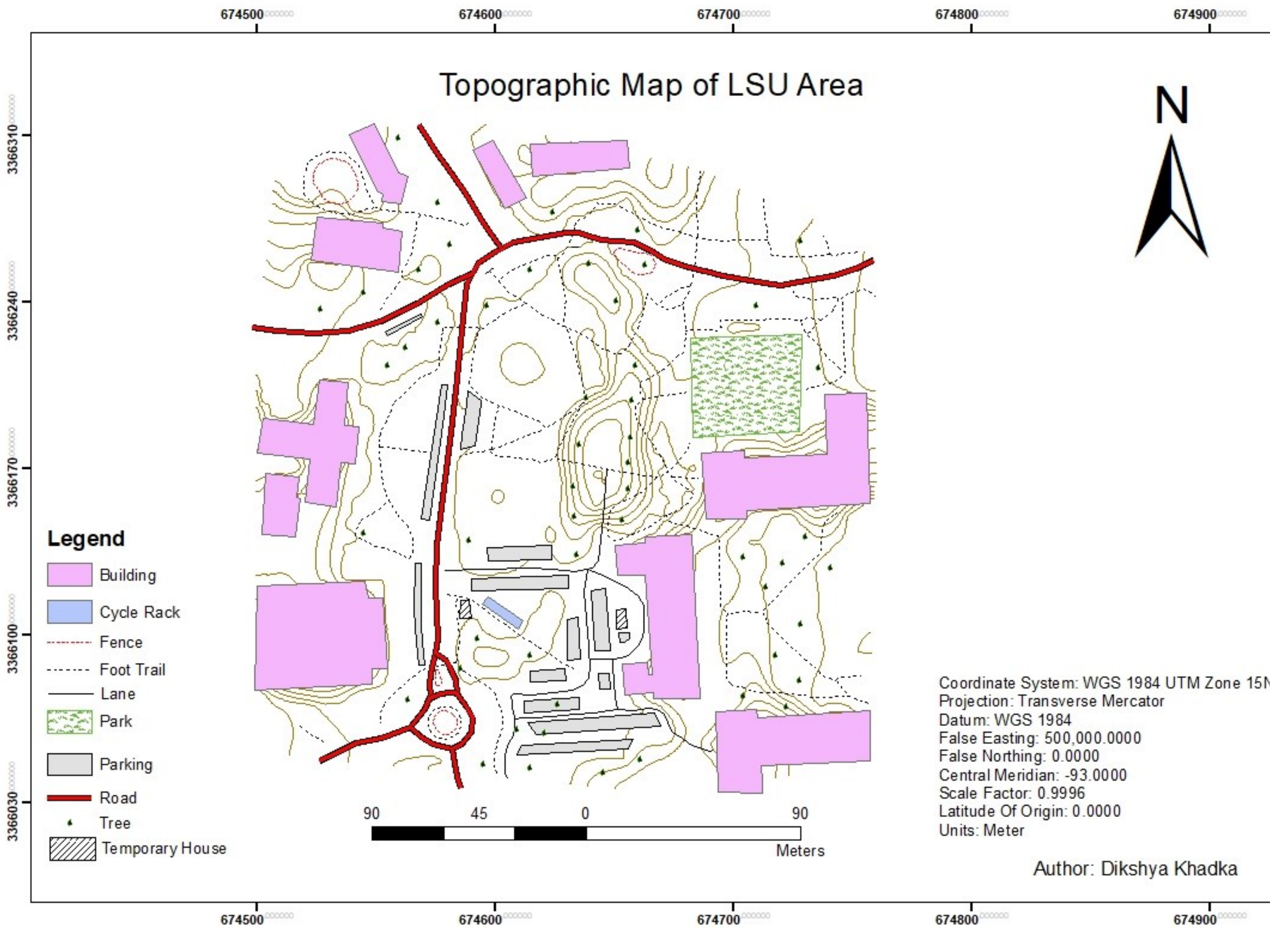

Figure 5 Final Topological Map

Conclusion

In conclusion, contouring in Pix4D represents a crucial capability in transforming aerial imagery into detailed topographic maps through advanced photogrammetry techniques. By generating contour lines from digital elevation models, Pix4D empowers users in various fields, from civil engineering to environmental management, with accurate terrain data essential for precise planning, analysis, and decision-making processes. This capability underscores Pix4D's role as a versatile tool in modern surveying and mapping practices, facilitating enhanced understanding and utilization of geographical landscapes worldwide.

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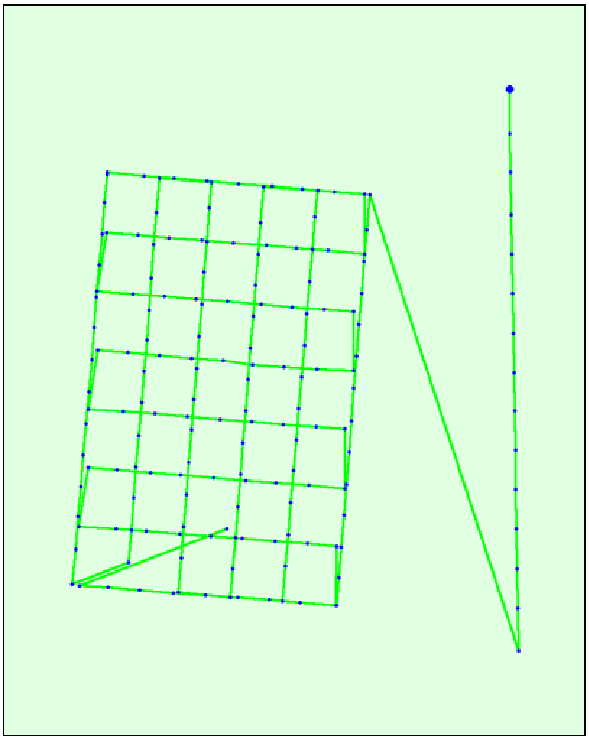
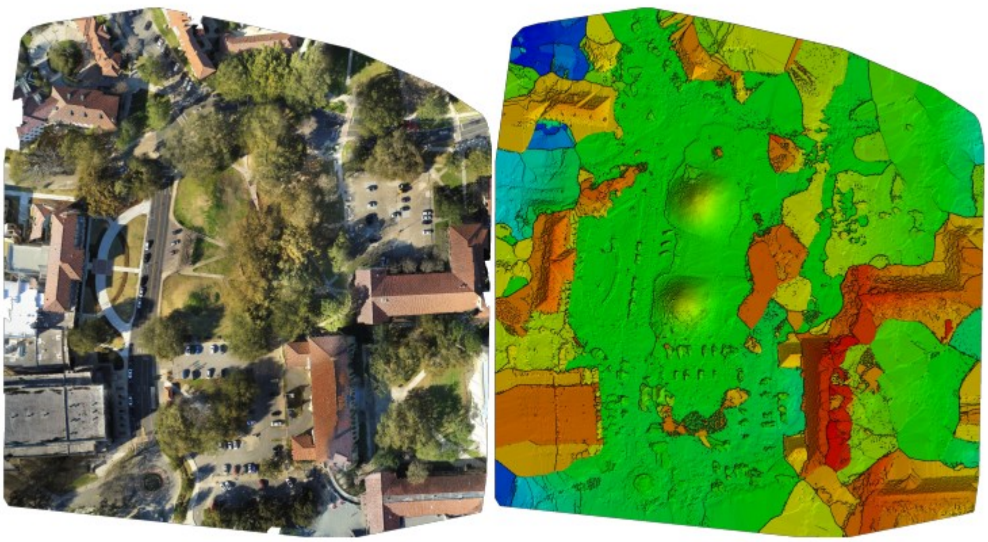
Annex



This is the flight plan done i.e. the image was captured in the following point and it was flighed infollowing direction.



This is the moisac and DSM image of processed UAV images.