Revolutionizing Spatial Data Collection:The Advancements and Applications of 3D Mapping with Drone Technology(Photogrammetry)

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***Abstract*—3D mapping using drone technology is rapidly changing the way spatial data is collected, analyzed, and applied across various industries. The technology has allowed for collecting the good-resolution, precise, and up-to-date spatial data that can be used for mapping, surveying, monitoring, and analyzing environments with greater efficiency and detail. The benefits of using 3D mapping with drone technology are numerous, including increased safety, reduced costs, and improved accuracy and speed of data collection. 3D mapping without drones is limited in coverage area. It relies on the photographer or surveyor to cover the area on foot or from a stationary position, making it difficult to capture large or inaccessible areas. It is generally less accurate than using drones. This is because it relies on manual measurements or estimates of distances and angles, which can result in a less precise representation of the environment or object being mapped. We use photogrammetry technique for spatial data collection, analysis and mapping by utilizing photographs from different angles to create a 3d model using Pix4D software.**

***Keywords*— 3D mapping, Photogrammetry, drone technology, Pix4D software**

I. INTRODUCTION

Mapping 3D environments is a crucial task in various applications, including urban planning, disaster response, environmental monitoring, and agricultural management. The applications of drone technology for spatial data collection and 3D mapping are vast and varied. For example, in construction and engineering, drones can be used to survey and monitor construction sites, detect structural defects, and assess the progress of construction projects. In agriculture, farmers are using drones to map crops, monitor plant health, and optimize irrigation and fertilization strategies. In archaeology, drones can be used to survey and map archaeological sites, providing insights into ancient cultures and civilizations. Traditional approaches for 3D mapping involved the use of ground-based surveys, which were time-consuming and labor-intensive. The advent of unmanned aerial vehicles, known as drones, has revolutionized the process of 3D mapping. Drones can quickly capture high-resolution images of the terrain, allowing for faster and more efficient creation of 3D models.

Our Quadcopter used for 3D mapping

This research paper aims to explore 3D mapping using drones. The paper will begin by providing an overview of the current state of 3D mapping without using drones and the limitations of traditional approaches. The paper will discuss the data acquisition process, including the type of drones and sensors used to capture images of the terrain. The paper will then delve into designing the flightpath where drone will be collecting the images required for 3D model. Quality of the model depends on the quality of the images captured. The paper will present a detailed analysis of photogrammetry technique used for 3D mapping and the process involved.

However, while drone technology has transformed spatial data collection, there are still challenges and limitations that must be addressed. These include issues related to data accuracy and processing time, as well as privacy and security concerns.

Future research and development in drone technology will continue to enhance the capabilities of spatial data collection and 3D mapping, providing new opportunities for professionals in various industries to make informed decisions based on accurate and detailed spatial data.

II. EXISTING SYSTEMS

A. Close range Photogrammetry

Close range photogrammetry is a technique used to capture highly detailed and accurate 3D models of small to medium-sized objects or structures using photographs taken from multiple angles. It is a non-contact, non-destructive method that can be used to document and analyze the shape,

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size, and texture of objects, and has applications in various industries such as architecture, engineering, archaeology, and cultural heritage preservation.

In close range photogrammetry we will first plan to acquire data, in this we physically need to go to the place where we need to build the 3d map of the place and also need to select the camera and lens required. It is also important to consider the lighting conditions, as changes in lighting effect the accuracy of the 3d model. This step is difficult and also effect in error prone result. The next step is to capture the photographs of the object from multiple angles. This can be done using a handheld camera or a stationary camera mounted on a tripod or other support. We need to take photographs with a consistent overlap between images, typically around 60-80%, so that we can get accurate reconstruction of the 3D model. The camera settings should also be consistent between photographs, including focal length, aperture, and shutter speed. Once the photographs have been captured, the next step we need to do is to prepare the data for processing. This includes organizing the photographs into sets, by dividing photographs into sets helps to ensure that there is sufficient overlap between the images in each set, which is necessary for accurate 3D reconstruction. It allows photogrammetry software to easily identify which photographs should be used in the triangulation process, based on their relative positions and orientations, checking for image quality, and removing any images that are unusable. The photographs should also be geotagged and marked with the camera location to ensure accurate reconstruction of the 3D model. In the next step we have to import images into Pix4D mapper a specialized photogrammetry software, which will automatically detect and match common features between the images to establish correspondences. We call this process as image triangulation or bundle adjustment then it will produce sparse point cloud and camera positions in 3D space.

The next step is key step in the close-range photogrammetry process, where a higher resolution and more detailed 3D point cloud is generated from the sparse point cloud obtained during the image processing step. The dense cloud contains huge number of 3D points and is generated by estimating the position of additional points within each camera image and fusing these estimates to produce a higher-resolution 3D point cloud. This step involves finding the correspondence between pixels in different images of the same object. This is done by detecting and matching features in each image, such as corners or edges, and then comparing them across multiple images.

The photogrammetry software then uses this information to estimate the relative positions of the cameras, the photogrammetry software estimates the depth of each pixel in each image, relative to the camera position. This is done by comparing the pixel intensity and texture with neighbouring pixels in the image and in other images of the same set, Using the depth map and camera position information, the photogrammetry software generates a dense point cloud by triangulating the corresponding pixels in each image. The dense mesh cloud having a much larger number of 3D points than the sparse point cloud, providing a higher level of detail and resolution. The dense point cloud may contain some outliers or noise, so it is important to filter and clean up the data to improve its accuracy. This is done using statistical filtering to remove any points that do not fit well with the rest of the data. The dense point cloud generated in the previous step may contain too many points to create a mesh with reasonable complexity and size.

Overall, close range photogrammetry is a valuable tool for generating accurate 3D models, but it is important to be aware of its limitations and potential shortcomings such as:

Limited field of view: Close range photogrammetry requires capturing multiple photographs of the object or scene from different angles and positions in order to generate an accurate 3D model. However, this can be difficult for large or complex objects, as it may be challenging to capture all parts of the object or scene within the view field of the camera. This can result in incomplete or inaccurate 3D models, particularly for objects with complex shapes or structures.

Sensitivity to lighting conditions: Close range photogrammetry is sensitive to changes in lighting conditions, particularly changes in ambient light and shadows.

III. PROPOSED SYSTEM

The proposed system offers a revolutionary approach to the regular methods of data collection, which are often costly, time-consuming, and labor-intensive.

The proposed system consists of several components that work together to produce high-quality 3D maps of the surveyed area

A. Components Analysis

The first component is the drone, which is having a high-resolution camera capable of capturing aerial images with precision and accuracy. The camera is mounted on a gimbal, which stabilizes the camera and ensures that the images captured are sharp and clear. The drone is controlled using a remote controller, and a mobile device or tablet is used to monitor the flight and capture of images.

The second component of the proposed system is the software used to process the captured images. Specialized software such as Pix4D or Agisoft Metashape is used to generate a 3D map or model of the surveyed area. The software uses photogrammetry algorithms to stitch together the images and create a high-resolution 3D model. The software also allows for the creation of orthomosaic maps, which are 2D maps that are generated from the 3D model. Orthomosaic maps are useful for precise measurements and can be used to create accurate maps of the surveyed area.

B. Advantages of proposed system over existing system

The proposed system for revolutionizing spatial data collection using drone technology and photogrammetry offers several advantages over traditional methods of data collection. Here are some advantages of the proposed system over the existing system:

- Faster and more efficient: The proposed system is faster and more efficient compared to traditional methods of data collection. With drone technology, it's possible to cover larger areas in a shorter amount of time, resulting in a faster turnaround for delivering data to clients.

- Higher accuracy: The proposed system provides more accurate data compared to traditional methods. With the use of GCPs and specialized software, the system can produce highly precise 3D models and orthomosaic maps, which can be used for accurate measurements and analysis.

- Cost-effective: The proposed system is more cost-effective compared to traditional methods. Traditional methods such as manned surveys can be expensive, time-consuming, and require more resources. In contrast, the proposed system requires fewer resources, and it can be completed in a shorter amount of time.
- Improved visualization: The proposed system provides a more comprehensive visualization of the surveyed area. The 3D models generated by the system provides you good understanding of the terrain, structures, and other features of the surveyed area, which can be used for various applications.
- Remote data collection: The proposed system allows for remote data collection. With the use of drones, it's possible to survey remote or difficult-to-reach areas, which would be challenging or impossible to survey using traditional methods.

IV. METHODOLOGY

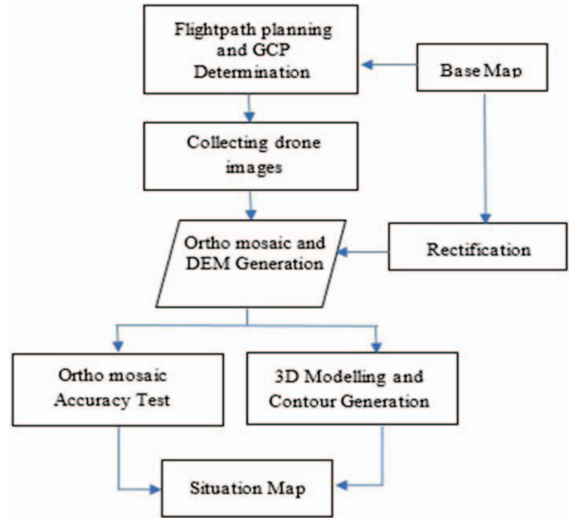
A. *Survey Planning:*

1. The first step in the methodology is to plan the survey. This involves identifying the survey area, determining the survey requirements, and creating a flight plan for the drone. The flight plan is created using specialized software that helps optimize the flight path based on the survey area's size, topography, and features.

Survey area we identified is at NIELIT Aurangabad
Location : 19.8807 latitude , 75.3321 longitude
N 19◦° 52’50.52” and E 75◦ 19°’55.5594
Main gate, compound wall and administrative block is identified as GCP’s (These GCPs are used to enhance the accuracy of the 3D model by providing precise georeferencing points.)
Requirements arranged properly :
High resolution camera
Gimbal Stabilization
Obstacle Avoidance
GPS stabilization

2. Drone Deployment: The drone is deployed to collect images of the survey area. The drone is flown along the predetermined flight path, capturing images using a high-resolution camera. The camera is typically mounted on a gimbal to provide stable and smooth footage, even in windy conditions.

3. Image Processing: The images captured by the drone are processed using specialized photogrammetry software such as Pix4D. This software uses algorithms to stitch together the images and create a high-resolution 3D model of the surveyed area.



The software also generates orthomosaic maps, which are high-resolution aerial images that have been geometrically corrected to provide a true representation of the survey area.

4. Model Validation: The validation along with acuuracy of the 3D model are checked against the GCPs. The GCPs are used to georeference the 3D model, ensuring that it accurately represents the surveyed area. Any discrepancies between the 3D model and the GCPs are corrected, and the model is validated.

$$Accuracy=1-[\Delta/fieldData]\times 100\% Accuracy =1-[\Delta/fieldData]\times 100\%$$

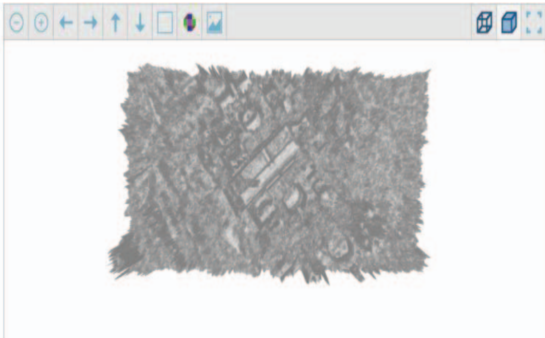
with Δ = Field and data Interpretation.

5. Data Output : Here we generate output data, which includes high-resolution 3D models, orthomosaic maps, and other data that can be used for various applications.

V. RESULT

As the aim of the research is to do mapping and build 3D models by the data collected from the drone.

Images from our drone showing the NIELIT campus i.e OAT(open air theatre) , boys hostel, workshop.



Once if we get the data from different altitudes, the following step is to develop a mesh and then after that we create a 3D model using Pix4D software.

Creating orthorectified images of software-generated mosaics was one of them. Accurate landcover extraction is achieved using orthophotos and digital surface models (DSM) with 0.05 and 0.1 m resolution, respectively, acquired from drone-based data.

Pix4D has been used to make ortho mosaic scenario maps and photos. This procedure aims to increase the area calculations precision.

VI. CONCLUSION

This paper concludes that, especially for coverage of the small area and requiring time-series data, drones offer exciting potential to construct a very high-resolution and accurate maps.

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Today, there has been a major advancement in mapping methods using remote sensing and 3D earth modeling, both in terms of the tools and sensors employed as well as the methods and software. When we merely want to produce a map with a specific area and with a good resolution, utilizing a drone for mapping is really handy.

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