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Development of Mapping and Surveying Drone

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***Abstract*— Traditional surveying and mapping methods for obtaining ground data are often inefficient, inaccurate, expensive, and risk damaging or losing equipment. Enter drones, and unmanned aerial vehicles (UAVs), which address these issues by providing innovative mapping capabilities. GIS professionals can use drones to perform topographic surveys with accuracy, matching traditional methods, but with reduced efficiency and cost. The use of drones reduces the workload of on-site experts and improves the efficiency of on-site investigations. The project aims to develop a mapping and surveying drone capable of capturing terrestrial images that can be converted into a 3D representation, collecting important parameters such as distance, area, and volume.**

Essentially, traditional surveying and mapping methods have limitations such as inaccuracy, high cost, and high risk, while drones used for surveying and mapping have multiple advantages including faster surveys and more efficiency, reduced costs, and relief of the experts' workload. The main objective of the project is to design a drone capable of capturing terrain images and converting them into a 3D representation, making surveying more efficient and precise, potentially revolutionizing surveying methods.

Keywords—Drone, Prototype, Mapping, Photogrammetry, 3D Model

I. INTRODUCTION

Land mapping in India has suffered from a variety of issues, with a primary cause being inefficiency, inaccuracy, and high costs. The traditional method of land mapping is a lengthy and tiresome process, requiring extensive human effort to manually measure distances and collect data. As a result, this method is prone to human error and inaccuracies, which often results in disputes over land ownership and boundaries. Furthermore, traditional mapping techniques often rely on outdated equipment and technology, rendering them less reliable and less precise. This obsoleteness can lead to further complications and disputes, as the data gathered, may not be reflective of the current state of the land. The financial burden of traditional mapping techniques is also a significant issue, making them inaccessible to rural communities and small-scale farmers. The inaccessibility to accurate land mapping data poses a considerable obstacle to economic development, leading to social inequality.

In summary, traditional land mapping techniques in India have faced numerous challenges, limiting their effectiveness and accuracy. The solution to these challenges may be in the adoption of modern technologies such as drone mapping, which can provide a more precise, faster, and cost-effective method of mapping land, benefitting individuals and society as a whole. [1,2]

II. BASIC CONCEPTS

A. Drone Mapping

Drones are flying robots, ranging from unmanned aerial vehicles (UAVs) that fly for miles to small drones that fly in confined spaces. They are aerial vehicles without a human operator, which can fly remotely or autonomously, carry lethal or non-lethal payloads, and are considered drones.

Drone mapping is an aerial survey which is conducted by the means of a drone and specialized cameras, which can include RGB (for photogrammetry purposes), multispectral, thermal, or LiDAR sensors. Drone mapping is a process that involves surveying an area of land using an unmanned aerial vehicle (UAV). This method is used by many industries that require surveyors to provide maps of areas of land. The process involves flying the drone over an area of land and taking hundreds of pictures. These images are then stitched together using computer software to create a model of the site. The drone mapping process allows surveyors to collect highly-accurate data quickly and safely. In fact, drone mapping collects data over 90% faster than manual methods. The collected data can be processed through several available drone mapping software to create 3D models, 2D maps, and digital elevation models. These assets are used to extract information that is required by the user such as highly-accurate measurements and volumetric calculations.

Drone mapping has several advantages over traditional mapping methods. It is faster, cheaper, and safer. Drones can scan large swathes of terrain in a fraction of the time it takes to manually measure on the ground, especially in areas with difficult terrain. This reduces operational costs and risks, as investigators do not necessarily need to be onsite or in hazardous areas to obtain data. Combined with traditional surveying methods, drone mapping can also produce extremely detailed and highly accurate point files down to millimeters. In summary, drone mapping is a highly efficient and effective way to survey and map areas of land, providing valuable data for a range of industries. [3]

B. Photogrammetry

Photogrammetry is a method that permits the creation of 3D models from 2D photographs. It is utilized in a broad range of applications, including architecture, archaeology, and geology. The method comprises capturing a series of photographs from different

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viewpoints and then employing specialized software to generate a 3D model from the images.

The process of photogrammetry can be quite intricate, involving multiple diverse steps and calculations. The first step is to capture a series of photographs of the object or scene to be modeled. These photographs must be taken from varying angles and distances to capture all the necessary details. Once the photographs have been captured, they must be processed using specialized software. This software employs algorithms to match up the diverse images and calculate the positions and orientations of the cameras that captured the photos. This information is employed to create a 3D point cloud, which represents the surface of the object or scene. The point cloud can then be employed to create a 3D model using further processing steps. These steps may include smoothing the surface, filling in any gaps or holes in the data, and adding textures or colors to the model. The resulting 3D model can be used for a diverse range of purposes, such as visualization, measurement, and analysis. [4-5]

For example, an architect may use a photogrammetric model to plan a building renovation, while a geologist may utilize a model to examine the topography of a landscape.

Photogrammetry is a powerful tool for creating detailed 3D models from photographs. Nevertheless, it can be a complex and time-consuming process, requiring specialized equipment and software. Additionally, the accuracy of photogrammetric models depends on many factors, including the quality of the photographs, the precision of the camera positions, and the processing algorithms employed. Despite these challenges, photogrammetry is a valuable method that has transformed the way we create and study 3D models.

III. DRONE PHYSICAL PARAMETERS

Drones are all the rage nowadays, being widely used across various industries such as photography, agriculture, and surveillance. Nevertheless, operating a drone without considering its physical parameters like weight, thrust, and power consumption can prove to be very dangerous. These are just a few of the physical parameters that affect a drone's flight characteristics, like speed, agility, and endurance. Grasping these parameters allows drone operators to pinpoint the perfect battery size, propeller type, and motor power required to attain their desired flight objectives.

According to the required needs for the functioning of the drone, the values were calculated to be as follows: -

Sr. No.	Parameter	Value
1	Minimum Thrust per Motor	0.3 kg
2	Average Current Drawn	18 A
3	Average Flight Time	16.7 min

Table 1. Calculated values for the drone

IV. CONVERSION OF 2D PHOTOGRAPHS INTO 3D MODELS

Photogrammetry is the process of creating 3D models from 2D images. It consists of the following steps: -

1) Collect a series of photographs of the object or scene from different angles and positions.
2) Prepare the images by formatting, aligning, cropping or resizing, adjusting brightness and contrast, and removing distortions.
3) Import the images into photogrammetry software and identify common points in the images manually or through automated software.
4) Generate a point cloud, which is a collection of 3D points representing the object or scene.
5) Use the point cloud to create a mesh, a 3D surface approximating the shape of the object or scene.
6) Apply texture mapping to the mesh by projecting the images onto its surface to create a realistic 3D model.

A. *Capturing Images*

The key to successfully creating great 3D models through photogrammetry is to capture high-quality images that provide good coverage of the object or scene from multiple angles, with consistent camera settings and lighting conditions. For this we must note these points before capturing images:

1) Use a high-resolution camera: A high-resolution camera is essential for capturing sharp and detailed images that can be used to create an accurate 3D model.
2) Ensure good lighting: Good lighting is important for capturing clear images with proper contrast and color.
3) Capture the scene from multiple angles: Capturing the scene from multiple angles will help ensure that you have good coverage of the object or scene, and will provide more data points for the photogrammetry software to work with.
4) Use a stable camera platform: Using a stable camera platform, such as a tripod or steady surface, will help ensure that your images are sharp and in focus.
5) Use a consistent camera setup: Consistency is important when taking photographs for photogrammetry. Use the same camera settings, including aperture, shutter speed, and ISO, for all of your images.
6) Overlap each image: Overlapping each image by about 60-80% will help the software to identify common points in the images more accurately and create a more detailed 3D model.
7) Avoid blurry images: Blurry images can cause problems for the photogrammetry software and result in a less accurate 3D model. Make sure your images are sharp and in focus.

Fig.1 Reference Photograph of the area

B. *Generation of Point Cloud Data*

Point cloud data is a 3D representation of an object or scene, consisting of a collection of points that describe its surface. Generating point cloud data in photogrammetry involves identifying common points in multiple images and using these points to triangulate the object or scene's position in space. [6-7]

Point clouds are collections of XYZ coordinates that precisely locate every point within a 3D model. They act as the base for creating more intricate models such as mesh or surface models and have a broad range of applications such as analysis, measurement, and more. Because of the vastness and complexity of point clouds,

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specialized software is necessary to manage and process them. With the help of this software, users can accurately manipulate and utilize the data contained within point clouds. In summary, point clouds provide a detailed representation of 3D models, and by using specialized software, they can be leveraged for a wide range of purposes. The generation of point cloud data in photogrammetry is based on triangulation.

Triangulation is a mathematical process that photogrammetry uses to generate point cloud data. This process determines the 3D position of a point in space by analysing its relationship with other known points. In photogrammetry, triangulation is used to calculate the position of common points in multiple images. By triangulating these common points, photogrammetry can create accurate and detailed 3D models of real-world objects. Therefore, triangulation is a critical component of photogrammetry that enables the creation of precise and reliable 3D models.

The software (In this case software used is 3DF Zephyr) identifies these common points by either manual identification or through automated feature detection algorithms. Once the common points have been identified, the software uses the geometry of the camera lenses and the relative positions of the cameras to triangulate the position of each point in 3D space. By using appearance data from multiple images, the software generates a dense point cloud that accurately represents the surface of the object or scene. [8-10]

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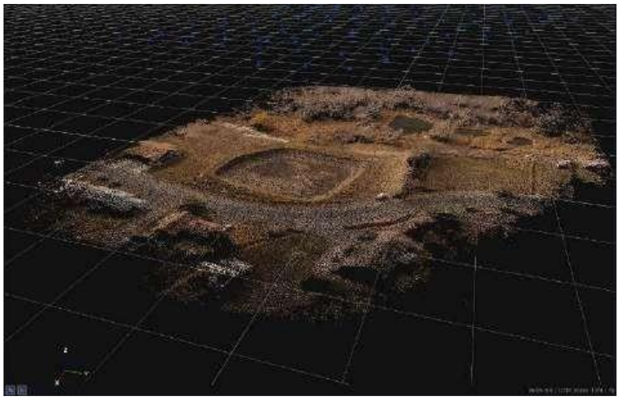

Fig.2 Point cloud data

C. Mesh Creation

In photogrammetry, a mesh refers to a 3D surface model of an object or scene that is created by connecting the points in a point cloud to form a continuous surface.

Mesh creation is an essential aspect of photogrammetry that involves creating a 3D surface model of an object or scene. In the process, a mesh is formed by connecting the points in a point cloud to create a seamless surface. The mesh is made up of a network of triangles that define the surface geometry of the object or scene being scanned. The mesh creation process comprises several steps, including cleaning and processing the point cloud data to eliminate any noise or outliers. The next step involves connecting the points to form a triangular mesh that is then refined and smoothed to create a more accurate representation of the object's surface. While mesh creation can be done manually, specialized software often automates the process. The software provides users with various parameters to adjust the quality and density of the mesh to their desired output. In summary, mesh creation plays a vital role in photogrammetry, converting raw point cloud data into a more usable and visually pleasing 3D model.

Fig.3 Mesh Creation

D. Texture Mapping

Texture mapping is the process of adding color and texture to a 3D mesh created from photogrammetry.

Texture mapping in photogrammetry involves projecting 2D images onto a 3D mesh model to create a texture map. The process starts by aligning the 2D images with the 3D model through camera calibration, which determines the camera parameters like focal length, lens distortion, and relative position. Then, texture projection is applied to project the images onto the 3D model by determining the position and orientation of the cameras at the time of image capture. After texture projection, a seamless texture map is generated by blending the 2D images together and removing any seams or artifacts.

This results in a single texture map that can be applied to the 3D model to create a realistic and visually appealing representation of the object or scene. Texture mapping is a vital step in photogrammetry as it enhances the visual quality and realism of the 3D model. Specialized software is often used to automate the texture mapping process and enable the user to adjust parameters to control the texture map's quality and resolution. [11-13]

Fig.4 Texture Mapping

V. Creation of a Prototype

Prototyping is an essential step in the product development process that enables designers and engineers to test their ideas before committing to costly and time-consuming production processes. By creating a physical model of a proposed product, they can identify areas where the design needs refinement and improvement. Creating a prototype allows designers to observe and interact with the product in a way that is not possible through mere digital simulations or descriptions. This hands-on experience provides valuable insights into the strengths and weaknesses of the design, which can then be used to refine the product further. For

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example, a prototype can reveal issues related to ergonomics, aesthetics, or functionality, which can be addressed in subsequent iterations. Moreover, the prototyping process can also help designers to communicate their ideas more effectively to stakeholders and investors. By providing a tangible representation of the proposed product, it becomes easier to demonstrate its potential value and appeal. [14-15]

A. Materials required

When it comes to the performance and durability of drones, material selection is a critical factor. There are a multitude of reasons why this is the case. Firstly, drones are not bound to a specific environment, which means that they have to be able to handle a broad range of weather conditions and other environmental factors. Secondly, lightweight materials are crucial to maximize flight range and duration, making it necessary for the materials used to have specific characteristics. Lastly, drones are employed for a vast array of purposes, such as agriculture, surveying, and aerial photography, and the quality of the data they gather is reliant on the material properties of their components.

When selecting materials for drones, various factors must be considered. These include weight, strength, stiffness, durability, and corrosion resistance, among others. Carbon fiber, aluminum, titanium, and various types of plastics and composites are some of the commonly used materials in drone construction. [19,20]

Carbon fiber is a top choice for drone frames and components due to its strength, stiffness, and lightweight properties, which make it ideal for flying. Aluminum and titanium are also preferred materials because of their high strength-to-weight ratios and corrosion resistance. Plastics and composites are often utilized due to their ease of manufacturing, affordability, and their ability to be molded into complex shapes, which makes them a great choice for components that require intricate designs.

The materials selected for the creation of the prototype:

1. Drone Frame: - Carbon Fibre
2. Propeller Arm: - Carbon Fibre
3. Propellers: - ABS Plastic

B. Electronic Components

Drones rely heavily on electronic components to function properly. These components are responsible for controlling the flight, capturing data, and communicating with the operator. Without them, drones would be rendered useless. The most crucial electronic components include the flight controller, GPS module, motors, and camera. The flight controller acts as the brain, receiving commands from the operator and transmitting them to the motors. The GPS module provides location data, while the motors control movement. Finally, the camera captures high-quality imagery and video, enabling a broad range of applications, such as aerial photography, surveying, and inspections. [16- 18]

The electronic components used are: -

1. Flight Controller: - Flight Controller is a circuit board with a set of sensors that detect the movement of the drone as well as user commands. Using this data, he can control the speed of the motors to make the craft move as directed. It supports 8 RC channels and 4 serial ports. Therefore, this prototype uses a PIXHAWK PX4 2.4.8 Flight Controller which is a high-performance autopilot on-board module for fixed-wing, multi-rotor, helicopter, or any other robotic platform that can move.
2. Electronic Speed Control (ESC): - The electronic speed controller (ESC) is an important part of the drone flight control system. They regulate the speed of the motors for stable flight, precise motion control and efficient power management. As mentioned earlier, the prototype draws an average of 18 A, so a higher ESC is required and the next available standard was a 30 A ESC.
3. Geo Positioning System (GPS): - Drone GPS modules provide position data for accurate and reliable navigation, precise positioning, and autonomous flight capabilities. Therefore, the prototype uses a new generation of Ublox NEO-M8N GPS, which has low power consumption and high accuracy. The final accuracy reaches 0.6 meters, which is actually close to 0.9 meters, which is larger than the previous generation NEO-7N 1.4 -1.6 American precision.
4. Motors: - Motors provide the necessary lift and propulsion for a drone to fly, enabling it to move and maintain stable flight in the air. The prototype has a 1000kv motor at its disposal.
5. Camera: - For photogrammetric purposes, cameras are an essential element. For the current application, the GoPro camera was chosen because of its light weight of around 150-200 grams, pits ability to record and capture in 4K, and its excellent image stabilization allowing for sharp images even when the prototype moved and wobbled.

Fig.5 Prototype Image

VI. CONCLUSION

The paper provides a compelling argument for using drones instead of traditional methods for land mapping. The traditional method of land mapping is time-consuming, labor-intensive, and inefficient, as it requires extensive human effort to manually measure distances and collect data. In contrast, drones are faster, cheaper, and safer, and can scan large patches of land in a very short amount of time, making them ideal for mapping large areas quickly and efficiently. This is especially useful in areas with difficult terrains, such as mountainous regions, where it can be challenging for humans to measure distances manually.

The paper also discusses how drones can be used for land mapping through the means of photogrammetry which is a technique that uses photographs to create 3D models of an area. The process involves taking a series of overlapping photographs of the area and using specialized software to create a 3D model from these images some of the steps involved in creating the 3D model, being; capturing images, creation of point cloud data, mesh generation, etc.

The paper also describes the creation of a prototype drone for land mapping purposes. The physical parameters and electronic components of the prototype are also discussed, providing a blueprint for the construction of similar drones.

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Overall, the paper highlights the advantages of using drones for land mapping purposes, including increased efficiency, cost-effectiveness, and safety. It also explains the process of using photogrammetry to create 3D models and provides a detailed description of the prototype drone.

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