Proposed Design for 3D Map Generation Using UAV

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Abstract *- Unmanned Aerial Vehicle (UAV) that is equipped with different components and different sensors for collecting various physical and geometric information has many applications in diverse sectors. Drones are used in various fields like in military, construction, earthquake analysis, traffic monitoring, forestry, agriculture and what not. Still there is an emerging area of constructing 3D mapping. The images collected from UAVS just gives the top view of the area, but the detailed information is not extracted from imagery.*

The information such as physical information like distance between two buildings, terrain level, boundary level is not known from the 2D images. Therefore, there comes the need of 3D mapping. The process of converting images or video frames into 3D model is a challenging task. The current paper will focus on constructing the 3D mapping using images collected by UAV. Mapping with the help of drone can be done by using a technique called Photogrammetry. For developing 3D models/maps first the task to be done is taking measurements from photographs. Photogrammetry and various techniques can be used for developing maps. For geo-referenced data processing and image processing software such as PhotoScan can be used. Pix4D mobile application as well as desktop application can be used for 3D mapping based on collected images. The main contribution of this paper is to perform 3D mapping using images.

Key Words**: UAV, 3D Map, Pix4D, photogrammetry, Pix4DMapper, videogrammetry.**

1. INTRODUCTION

Unmanned aerial vehicle (UAV) platforms are nowadays a valuable source of data for inspection, surveillance, mapping and 3D modelling issues.3D point cloud data obtained from sensing technologies such as 3D laser scanning and photogrammetry are able to capture the 3D surface geometries of target objects in an accurate and efficient manner[1]. A point cloud consists of a set of 3D points with X, Y, Z coordinates, and sometimes R, G, B colour values and even other attributes. Compared to traditional measurement methods such as manual measurement or other electronic device-based measurement, 3D point cloud data from sensing technologies have a much higher measurement rate and better measurement accuracy. Due to the substantial advantages, various industries have been leveraging point cloud data to improve productivity such as the processing and manufacturing, agriculture, defence surveillance, geography and construction industry. View and process point files with a billion points or more. A dramatic increase in LiDAR ay speed is beneficial for previewing the data before creating a gridded surface model and includes several options for filtering the data during import and for rendering the point cloud to reflect return type or intensity. Metadata access provides a detailed statistical breakdown of the point cloud and customizable point size improves on-screen display [Fig.1]

Fig 1:.Visualization of Point Images

2. LITERATURE SURVEY

Global Mapper works as easily with 3D data as it does 2D data[1]. It supports many types of 3D data including elevation or terrain models as well as 3D mesh formats such as 3D PDF, Collada, Wavefront, 3DS Max and more. These model formats can be transformed in to a 3D point cloud[1], which can subsequently be edited and filtered using the extensive LiDAR processing tools[fig 2]. The software includes a powerful 3D Viewer which can be docked and linked to the 2D map so panning, zooming, and adding vector features will automatically replicate in both windows. This powerful functionality also includes the ability to select and measure features in the 3D viewer[1]. These tools are initiated by selecting the Digitizer tool or Measure tool on the 3D viewer toolbar. Any selections are shared by both the 2D and 3D viewer, and the right-click menu allows you to perform many Digitizer operations on the selection. Global Mapper's 3D functionality includes support for setting up and recording HD 3D fly-through videos of your 3D projects[1]. Additional fly-through features include a setting for UAV or Aerial tracking playback to display a video file synced to any line feature with per-vertex times. Support has been added for features such as draping vector data, GPS tracking and Skyboxes for rendering a sky simulation in 3D. Support has also been added for 3D textures and meshes in GMP files. When recording a fly-through video file, the video file will automatically be associated with the fly-through feature so you can easily play it back from the Feature Info or Digitizer Tool.

The Raster Calculator[1] found under the Analysis menu can be used for performing mathematical operations on multi-band imagery to extract different types of information. Users can use predefined formulas, like NDVI and NDWI, or create their own free-hand formulas using common mathematical operations, like addition, subtraction, multiplication, division, and powers, as well as simple operators like absolute value, minimum value, and maximum value of 2 values.

SLAM is another technique that can be used for structuring the unknown environment. It is highly used in robotics to estimate the location of the robot itself as well as mapping the unknown environment. There are many SLAM techniques available that can be used according to our needs. vSLAM is one of the techniques that can be used for mapping the environment where the visual inputs are taken. In this the disadvantage is that the camera acquires less visual input. In this the continuous positioning of camera is done so that the environment can be reconstructed. The vSLAM algorithm consists of 5 modules [2]. They are as follows: initialization, tracking, mapping, relocalization, global map optimization. As in paper[2], localization and mapping cannot be performed simultaneously, therefore tracking is performed for every frame using one thread and by another thread mapping is done at certain intervals.

vSlam, odometry and online structure from motion can be used to determine the robots position as well as 3D structure of the environment [2].

3. Proposed System

3.1 Pix4Dmapper

The images obtained is analyzed and the control points within each image is obtained. As there are many images of a single object taken from different perspectives, the similar images are then overlapped. But by performing these steps, noisy data and redundancy is introduced in our images. The images then go under filtering process, which make the images more precise and accurate. Then the point cloud of the system or object is generated by analyzing the control points. The point cloud is the basic building block for 3D map generation. Pix4DMapper is used to perform the above process.

Pix4Dmapper[3] is a first-class piece of photography software for professional drone mapping, helping you to produce 3D maps and models, purely from images.

Capture : Capture a range of pictures, such as RGB, thermal or multispectral images.

Digitise: Pix4Dmapper turns your images into digital spatial models and maps. You can then process your projects using the cloud or the desktop photogrammetry platform.

Control: Assess and improve the quality of your project, with information about the generated results, calibration details and more.

Measure and Inspect: Measure distances, areas and volumes and learn more about profile data, as well as perform virtual inspections.

Collaborate and Share: Securely share project data and insights with your team, clients and suppliers.

4. SYSTEM ARCHITECTURE

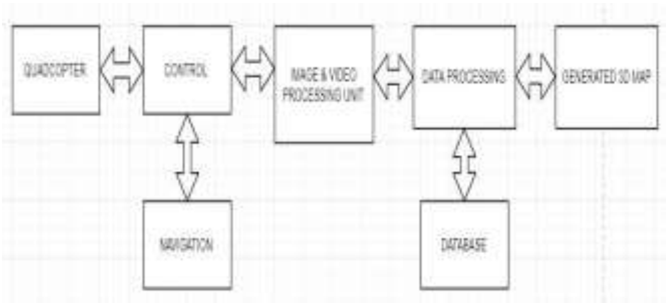

Fig. 2 : System Architecture

The quadcopter will be first set for flight which will be controlled from the base station. Battery backups, hovering period, navigating and ground control points, obstacle detection and such various parameters are controlled by the control and navigate modules from the base station. Ground Control Points (GCPs) will be given and using VSLAM Algorithm can determine the orientation of the sensor with respect to the surrounding. [4] The UAV that we are using will be first collecting images. The UAV will navigate and collect various photographs which will be stitched to get an original photo. Along with photos few number of video frames will also be collected by the UAV and will be processed in the Image and Video Processing Unit. The collected images will be processed by applying image processing techniques for conversion of 2D to 3D images as our output. After processing images again few techniques will be applied which are discussed in literature survey to generate 3D maps. [5] The resultant 3D images can be well understood by the users via User Interface Module; since they are taken from different perspectives and are more enhanced in terms of quality and precision.

5. vSLAM ALGORITHM

1. Feature Extraction.

2. Feature detector, after the feature is detected it is given to feature tracker and loop closer.

3. Feature tracker

4. Triangulation

5. $SSD=\sum_{i=-n}^{n}\sum_{j=-n}^{n}((I_1(u_1+i,v_1+j)-I_2(u_2+i,v_2+j))^2$

6. Landmark observations are given to SLAM

7. Predicted landmark is given to gaze control which is again given to camera position to extract new features.

8. Updated landmark is given to loop closer which is given back to SLAM

9. Finally the map is generated.

6. Tools

1. **Tower App :** It is used for communication between drone and android mobile. It is available for both desktop as well as mobile. It makes communication very smooth and efficient. Way-points can be given easily through the application. The drone then analyzes these way-points and hence follows the path.

2. **Python and Matlab:** Data processing can be done and point cloud can be generated using python and matlab.

3. **Database :**

   6.1 MySQL : The data of the area covered such as way_points, the path followed by the drone, the coordinates of the system, all these parameters can be stored and maintained using the MySQL database.

   6.2 HBase : The images which are captured from drone are stored in Hbase database. As Hbase supports parallel processing, the image processing algorithms can be applied to the data easily.

7. TECHNIQUES

7.1 Videogrammetry

Videogrammetry is like photogrammetry but takes video streams as the input data instead of a collection of images. According to Brilakis et al. Videogrammetry enables progressive reconstruction of point cloud data because video frames are sequential and information from each video frame builds upon the previous frame. The progressive reconstruction is able to gradually improve.

7.2 Photogrammetry

Photogrammetry is the process in which the images are given as input to it then it measures the images and the output produced can be maps or 3D maps.

According to the American Society for Photogrammetry[1] and Remote Sensing (ASPRS), photogrammetry is defined as the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena. Various photogrammetric algorithms and technologies have been developed for the reconstruction of 3D point[2] cloud data based on a collection of overlapping images of the target object.

These images are simply taken using a camera from different locations, thereby capturing different parts of the target object. Algorithms will then estimate the relative locations of these images and eventually convert these images into a 3D point cloud. Some popular photogrammetric algorithms include a structure from motion (SfM) a multi-view stereo (MVS), and a thorough review of the image-based reconstruction algorithms and technologies can be found.

7.3 Image Acquisition:

A location is pre-determined in which the autonomous UAV takes flight. Around 500-600 photos needs to be captured by the UAV. Ground Control Points (GCPs) [2]play a vital role in the image acquisition, these are the points that are visible and marked on the surface of the location.

7.4. Image Processing

Once the UAV has acquired the images, it is to be processed. One of the reliable software for processing purpose is Agisoft Metashape. This software is used in obtaining orthophotos for that particular location for better visualization of the location.

7.5 3D Map Generation

To generate 3D map, we use Pix4DMapper software. This software delivers highly accurate and unambiguous 3D models.

8. CONCLUSION

In this study, we conclude that the images collected from drone can be successfully used to perform 3D mapping. When drone flies over a region, camera points vertically downwards and multiple overlapping images are taken so that we don't miss anything. After performing stitching and adjusting images, image processing must be done to extract useful information by using Photo Scan technique. The 3D point cloud therefore can be used for producing 3D mapping which can be efficiently used in diverse fields for many purposes.

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