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Review Article

Drone Mapping Versus Terrestrial Laser Scanning for Building Mapping and Assesement

Rick Adhikary[1], **Komal Parikh**[2*]

[1]*B.Tech, Faculty of Technology, CEPT University, Ahmedabad;* [2]*Assistant Professor, Faculty of Technology, Ahmedabad*

ABSTRACT

Drone mapping and terrestrial laser scanning are two advanced techniques that have been used around the world in recent years for documentation and mapping of buildings with historic value, construction project/infrastructure monitoring, mapping of cities, and a lot more survey. A well-defined methodology for data extraction, modelling, and monitoring is yet to evolve. This study compares and demonstrates terrestrial laser scanning and drone survey for building mapping with validation and accuracy checks. A terrestrial scanner was used to perform three scans of a building and drone was used to capture high-performance vertical images and oblique images. A three dimensional (3D) model was generated using advanced software techniques. Building façade elevation and plans were extracted from the 3D model after validation and accuracy check. The drone model produced high-quality visualization while terrestrial scanner output data allowed to extracting minute details after removing noise. Drone mapping and terrestrial laser scanning are two unique stand-alone technologies for serving different purposes individually, but they greatly complement each other when used together. Visualization of digital real-time 3D model helps in scrolling around at different nooks and corners of the building for a survey which is not possible through conventional mapping techniques; this is one of the greatest advantages of these techniques.

Keywords: Data visualization; Drone; Mapping; Monitoring; Terrestrial laser scanning; 3D model

INTRODUCTION

In widely used traditional mapping methods we usually measure the lengths, widths and heights of an object using measuring tools to create a 3D model but it is hard to visualize it with minor dimensional details of real time and details of inaccessible area. To identify the changes with time these advanced methods like terrestrial laser scanning and drone mapping are easy to perform, process and less time consuming in comparison with traditional mapping methods. In Indian context, built infrastructure, industrial plants and construction sites are critical places that require regular monitoring of structural system or material resources also data required for risk analysis. Accuracy of details and measurements for data documentation is an essential aspect of mapping in today's digital world. This data helps to assess and preserve existing conditions and situations if analysed with a respective proper method [1]. Buildings and structures of historical value are very crucial and need to be conserved to maintain the cultural heritage of society.

Terrestrial Lase scanning process

Laser Scanning registers the collected points with each other using a reference station point, which can be actual geodetic co-ordinates (Northing, Easting Elevation) or local coordinates (X, Y, and Z). For the reference station, either total station or GPS receivers can be used. The data collected is in the form of the point cloud which generally refers to a set of tens of thousands or even more in some cases number of points that are captured by the laser scanner [2]. Laser scanners have inbuilt range measurement using deflection of the laser beam, to direct the laser beam as per measurements to be taken.

The laser beam reflects from the point back to the deflector and the distance is measured. The accuracy of measurements greatly depends on the intensity of the reflected laser beam and also depends on the reflectivity of the surface to be measured. The angle of incidence and surface reflectivity are two major factors governing the accuracy. The laser scanners with a higher range

Correspondence to: Komal Parikh, Assistant Professor, Faculty of Technology, Ahmedabad; E-mail: komal.parikh@cept.ac.in

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are the Time of Flight (TOF) based laser scanners which measure distances of points in space using a laser beam that is rapidly thrown on the object and reflects back to the scanner. The time taken for the laser beam is used for calculating distances and angular measurements. Such scanners rotate in both X-Y planes collecting spatial data rapidly by scanning for about a few minutes.

Drone mapping process

The term "drone" refers to as unmanned flying object or UAV (Unmanned Aerial Vehicle) or Remotely Piloted Aircraft (RPA). Remotely Piloted Aircraft (RPA), autonomous aircraft and model aircraft are various sub-sets of unmanned aircraft. Unmanned aircraft system (UAS) is an aircraft and its associated elements, which are operated with no pilot on board. Drones are mounted upon various payloads consisting of various interchangeable sensors like extra cameras, thermal imaging sensors, LIDAR sensors, RGB (Red Green Blue) sensors, and vegetation sensors, etc. They collect land topographic data within a short period by quickly flying over the place and scanning it. For large area mapping, airplanes are used to capture aerial images from high altitude, which can then be interpreted for land contours and 3D visualizing models. Drones are mounted with high definition cameras to obtain clear, high-quality photos that help in the reconstruction of the 3-D model [3]. Widely used small drones for UAS are either multicolor or fixed-wing drones. The multi-rotor drones can carry high definition cameras, sensors, and even Light Detection and Ranging sensors. They are generally used for mapping with high accuracy in small areas such as architectural 3D surface reconstruction. For the 3D reconstruction of a structure or building, close-range photogrammetry is used. This involves capturing images from a comparatively low altitude to obtain detailed imaging of the required area and then converting these images into a 3D model using the software [4]. Close range aerial photogrammetry is usually done using small multi-rotor UAV.

SCOPE AND OBJECTIVE

The scope of work includes conducting a literature study on advanced mapping techniques through case studies, research papers, and current practices and define a data collection methodology for on-field application of both the terrestrial laser scanning and drone mapping process to develop a three dimensional model. Criteria for building selection are only considering feasibility for data collection. The data will be process using Trimble business canter in case of TLS and context capture in case of drone mapping [5]. It also includes analysis of the 3D model for condition assessment of the building and identifying the skeptical detail collected and deriving a conclusion based on the methodology.

FIELD DATA MEASUREMENTS

Field measurements taken with Trimble SX10 and phantom 4 for building. Scanning has been started with permanent reference point available near to library building which is marked with DGPS. Building was scanned from three DGPS locations. Drone mapping multi-rotor drone DJI Phantom 4 RTK was used to capture perpendicular and oblique RTK images of library building.

UAV survey

Close range aerial photogrammetry was done for obtaining perpendicular and oblique from ground images at heights 40m and 25m respectively covering an area of 960 sq. m.

DGPS survey

For drone mapping, Ground Control Points (GCP) is required to register the actual position of the constructed 3D model in the software. GCPs are Geo reference co- ordinates (Northing, Easting, and Elevation), which we marked on the ground. Differential Global Positioning System was used to mark the Ground Control Points accurately.

Drone flight planning

The maximum time that the drone can fly on the battery was 30 minutes. Hence the data collection was done within that time. Images were collected in two parts. First, images were clicked at 90 degrees from the horizontal surface at 40m height from ground when the drone flew in an automated pre-decided path. It took 12 minutes to collect the data in a total of 106 images on the Automatic flight mode with predefined path which cover entire building. Oblique images were taken at 60 degrees from the horizontal surface of the sheet so that the lateral surfaces are more visible. Oblique images were capture by manual flying around the building at a height of 25m from ground [6]. A data of a total of 149 images were collected at the angle of 60 degrees by flying the drone manually in 8minutes. These images were all 80% overlapping with each other and also covered all the GCPs.

TERRESTRIAL LASER SCANNER SURVEY

Terrestrial Laser scanning was performed using Trimble SX10 Laser Scanner which had an in-built total station. SX10 was set up at first scanning position after doing orientation with permanent bench mark.

Setting up reference station

The reference station needs to be set up before scanning to register the scanned points to their original geo reference positions [7]. For this, one Reference station needs to be set up by known DGPS coordinates for accurate measurements.

Terrestrial laser scan planning

For a building mapping and assessment Sx10 were placed at 3 location surrounding building to get the dense information about the façade. The scanner has an auto-locking function in which it locks the target prism in a way that if the prism is moved, the scanner lens will move along with it focusing on the target. This helps in the process of back sighting which can be done faster because of the auto-locking of the target. The stations were back sighted in the following sequence

STN1>STN2>STN3>STN4>STN5 to measure the building information.

Fixing Scan frame and scan resolution

Once the instrument is set back sighted at the aligned at the station, the scan frame and resolution is to be set before scanning. The scan frame is the frame that is to be scanned. It is selected through the controller screen. A scan frame of 360 degrees x 300 degrees was fixed at station 2. It was a dome scan that scanned information in all directions from the scanner [8]. At Station 3, 4, and 5, the frame was set as a polygon accordingly so that only the building is covered in the frame. The angles of these polygons were between 60 to 90 degrees horizontal and 90 degrees vertical.

Field scanning

Once the instrument is fixed and set at the station location, the scan is begun after setting the frame size and resolution of the scan. The scanner scans within the fixed frame starting from left to right. It continuously rotates up and down on its Y-axis scanning from top to bottom and also rotates clockwise on the X-axis. For scanning the full dome, the scanner took approximately 12 minutes. For the rest of the three scans which were done around the building, the scanner took 6 minutes each. The scanner scans the objects first as image data through its camera. This image data is used in photogrammetry and for creating a true color-coded point cloud model. It also 3D scans the building using a laser beam this invisible to the human eye.

DATA PROCESSING

Scan data obtained from terrestrial laser scanner to be imported to Trimble business centre software. Trimble Business Centre software is capable of registering the scan files and integrates them into a single point cloud file. It has the functions to select points from the point cloud file and layer them into different regions as per requirement. Measurements can be derived between two points lying in any plane. It provides a fully detailed panoramic and perspective view of the 3D point cloud model, allowing zooming and visualizing details. Images acquired from the drone to be imported to Bentley Context capture software for further process. Context Capture Master software with Context Capture Engine provides a workflow for processing images of equal focal lengths and sensor sizes, aero triangulates the images using surveys to create a reference 3D model. It processes the reference 3D model further to reconstruct it either as a 3D mesh for visualization or exports it as a point cloud for third party software. It allows taking linear, surface and volumetric measurements on the 3D mesh.

Data extraction through Trimble Business centre (TBC) software

The system will display all the points which have been scanned during the software and even those which are not required in the model. For example, trees, people, context data like surrounding building walls, floor, etc. which is not required or is not a part of the subject, the building. This data is referred to as "noise." Noise has to be removed from the point cloud data to visualize the model clearly. As all the points are in a three-dimensional spatial arrangement, the noise will be visible behind or in front of the required point cloud model. Hence the noise has to be removed from the model. The highlighted area is the building region which is required for us. Hence the points outside the area are considered to be noise. Even some points which are very close to the building but are not a part of the building are captured in the data. Like the leaves of trees touching the roof, the stair system tied to the frame on the west façade, cables attached to the frame of the north façade, people are sitting inside the openings of the building, etc. Are all considered as noise and are selected and added to a layer that can be hidden while visualizing the model.

DATA VALIDATION AND VERIFICATION

3d models are validate with the acquiring positioning on earth surface as in both the technologies DGPS coordinates are used. These models are checked based on their scan stations and image capturing location on Google Earth for Position Accuracy. KML extension file created for scan stations and image capture location. Both the models are geo-referenced almost correctly on the actual position of the building on Google earth. This process gives a basic idea for the positioning of the constructed 3-D model and for accuracy check [9]. For a detailed positioning analysis, both models are compared through a common ground control points using the Root Mean Square (RMS) method. As both the mapping techniques had different ground control points, four common points on the ground are selected at four corners of the building. Coordinates of these same four common points are checked in both the models and compared with respect to Northing Easting and elevation.

RESULTS AND DISCUSSION

Automatic registration of point clouds in SX10 gives smooth workflow when working with more number of scans compare to conventional scanner. Consistently accurate data up to 1mm accuracy achieved using DGPS compatible total station scanner [10]. Software helps in Import, Export of all kinds of scanned point cloud files. Computer aided drafting on point cloud offers almost exact measured drawings

Usage of common control points for both mapping methods may provide exceptionally accurate positioning data.

In terms of effort, time, and accuracy, these technologies are far better than conventional mapping techniques, especially to create measured drawings of a structure/building.

Visualization of digital real-time 3D model helps in scrolling around at different nooks and corners of the building for a survey which is not possible through conventional mapping techniques. This is one of the greatest advantages of these techniques.

For TLS, the scan frame matters most for the accuracy obtained. Perpendicular scans to the surface can provide more point cloud data than inclined scans. Accuracy of TLS can be relied upon as it is precise and consistent.

For UAV, care has to be taken while setting up the flight path as the visibility and clarity of images drive the accuracy of the reconstructed model.

FUTURE SCOPE OF STUDY

As-built documentation and mapping of buildings and structures are taken to a whole new level using these techniques [11]. Minor faults identified and errors noticed in the readings of these techniques are majorly caused due to faulty or out of control data collection. A well-established methodology cannot be designed for a particular building as it may vary from case to case [12]. Future scope of study using these techniques can be done for

Heritage building Mapping

Old Bridge Monitoring

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