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MAINTENANCE OF STRUCTURAL AND DESIGNS OF HISTORICAL BUILDINGS USING LIGHT DETECTION AND RANGING (LiDAR)

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ABSTRACT

Maintenance of heritage building structures and design was usually based on existing written documentation which was got after excavating. This paper analyses the use of LiDAR for documentation of the buildings for preservation of historical building structures. LiDAR is preferred over other written documentation techniques due to its speed of documentation of the structure and designs of the building. For performing 3 dimensional scanning of images LiDAR is used over other scanning techniques such as infrared or photogrammetry. The reason for using LiDAR is as it provides the highest quality image when compared to all the other existing 3 dimensional scanning techniques. A beam of light is reflected by the target which was illuminated and a sensor records this light to measure. Based on different wavelengths and return times on the historical buildings, this recorded light generates a 3-dimensional representation about the shape and the surface characteristics. A point cloud which is a group of points is collected by the sensors which consist of data in accurate details.

Keywords*: 3Dimensional Scanning, Airborne, Infrared, GPS, Photogrammetry.*

I. INTRODUCTION

In the earlier days, maintaining of Structural and Designs of Historical Buildings was usually based on excavating or based on written documentations. However the process of written documentations was slow and very little documentation was possible in a short period of time before any significantly useful heritage data was lost. With advancements in technology more data can be gathered rapidly to preserve historical buildings before any destruction can take place. For documentation in a fast way, LiDAR(Light Detection And Ranging) technique is used.

LiDAR is an acronym for Light Detection And Ranging or also means “LIght and RaDAR”. LiDAR illuminates the target by using light in the form of pulsed laser and that measure the distance to that target. LiDAR senses remotely. A beam of light is reflected by the target which was illuminated and a sensor records this light to measure. Based on different wavelengths and return times on the historical buildings, this recorded light generates a 3-dimensional representation about the shape and the surface characteristics. A point cloud which is a group of points is collected by the sensors which consist of data in accurate details. Every light pulse reflected is a point in the point cloud which has 3-dimensional co-ordinates (latitude, longitude, and height).

The laser was invented in the early 1960s and that was the time when LiDAR was originated [6]. In this the distances were calculated by measuring the time taken for a signal to return after hitting the surface. This was measured by using relevant data attainment devices and sensors. The use of LiDAR in maintaining the structure and design of historical buildings has a number of advantages over existing technologies. A few are mentioned below

- LiDAR can be operated in any weather.
- Can operate at night as well. LiDAR’s illumination sensor can collect data either during day or night when compared to traditional photogrammetric techniques
- Data can be collected quickly with very high accuracy.

- Data acquired is of a higher density which improves results.
- Reveals accurate information.
- LiDAR systems allow researchers to examine buildings with correctness, accuracy and flexibility.

The main objectives of LiDAR are

- To gather digital point clouds from captured data of historical buildings which is used for further analyses and 3-dimensional presentation.
- This 3-dimensional point clouds are acquired in a relatively short time with high spatial resolution.

II. RELATED WORK

A number of works have been published in the area of LiDAR for documenting building structures. One such work aims at establishing LiDAR technology as a high accuracy tool [1]. Digital surface model was generated and extracted so that only building points were extracted and all other spatial features were not. Different analyses were done such as slope and aspect analyses to help about making sure only building points were extracted. Analyzing based on the shape gave the height of the building under consideration. This height is almost same as when compared to measurement from ground with just a 1m tolerance. This work which had been done earlier gives accurate points in estimating building points by applying segmentation based on gradient, shape and aspect analyses. The second such work related to LiDAR was extraction of boundaries of buildings outlines from the point cloud which is got after laser beam is targeted and reflected back by means of sensors [2]. For the point cloud a 3 dimension reconstruction is done starting with extraction of line segments. This has a unique way for extraction of the structure of the buildings

III. METHODOLOGY

In this paper LiDAR is used over other scanning techniques. The other scanning techniques are Infrared, Photogrammetry.

Infrared sensing is used to sense the buildings **by either emitting and/or detecting infrared radiation. Infrared** sensing basically measures heat emission of any entity based on which it can extract the structure of the building. Photogrammetry is another such scanning technique which can measure the exact positions of buildings from photographs, provided the scale is identified. In this technique from the photograph, an accurate 3 dimensional image with relative motions is estimated [7]. The 3 dimensional co-ordinates define the locations of object points which can be used to extract the image of the building.

The Comparision of all the 3 techniques is shown in the table below.

Table 1. Comparision of different 3D Scanning techniques

SL. NO.	TECHNIQUES	PROS	CONS
1	Infrared	This technique is the least expensive	The quality of image is not of high quality
2	Photogrammetry	The price is reasonable when compared with the resolution of scans	If a better quality image is required, a better quality camera is required.
3	LiDAR	Comparatively this generates the highest quality image	But this technique is the most expensive and also requires a considerable amount of technical knowledge to operate on.

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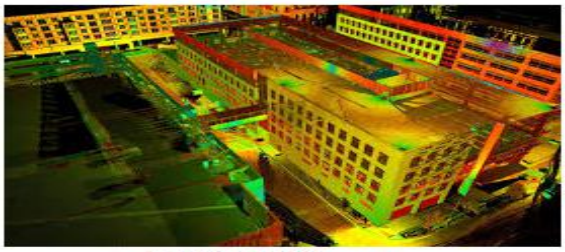
a) Infrared Image

b)Photogrammetry Image



c) LiDAR Image

Figure 1: Comparision of 3D scanning techniques

When compared to other 3 dimensional scanning techniques LiDAR is used as it extracts the highest quality image [3]. For maintaining of the structure of buildings highest quality image helps better in finding out which building needs maintenance and which does not.

LiDAR lights up the target using a laser and calculates the distance to generate the point cloud. A point cloud is collected by the sensors which is usually highly accurate information. There are 3 co-ordinates for each of the point which is latitude, longitude, and height. LiDAR instrument usually consists of an airborne laser, a scanner, and a specialized GPS receiver. The point cloud needs to be subdivided into ground, trees and buildings to prepare a Digital Elevation Model (DSM). This is usually done by using image classification techniques. The different components of LiDAR are

- Airborne laser

An airborne laser is used to capture images. A sensor which is attached to the aerial vehicle during flight captures images by creating a 3 dimensional point cloud after emitting beams of light from the laser. Each and every emitted laser has many returns as it is projected to objects of various heights. From the laser's energy, part of it is reflected immediately after in contact with nearest object and some of it goes through which is reflected after in contact with other objects.

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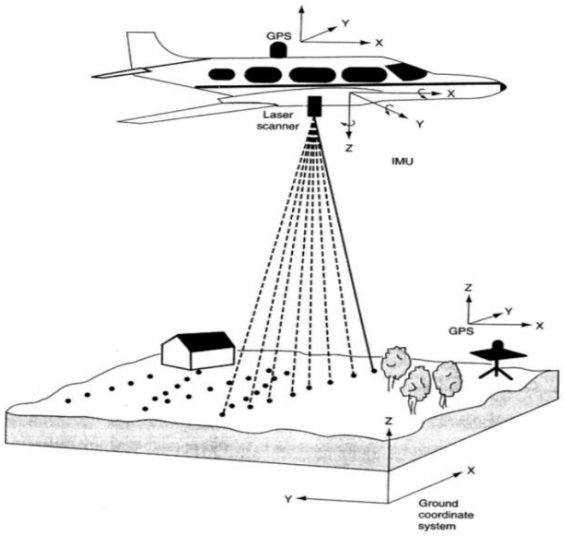

Figure 2: Airborne LiDAR[5]

- Scanner

3 dimensional scanning is done to get the image of the building in the form of point cloud with respect to latitude, longitude, and height. LiDAR scanner helps archeologists with the ability to create high resolution digital elevation models for all the heritage buildings.

- GPS Receiver

Usually, if the unmanned aerial vehicles are used, they commonly rely on GPS for uninterrupted and precise position estimates. However, due to errors in using only GPS measurements, GPS- LiDAR fusion technique has been identified to accurately characterize their inaccuracy. A GPS- LiDAR fusion technique is an unique method for efficiently modeling the inaccuracy based on surface and edge features in point clouds [8].

IV. RESULT & DISCUSSION

LiDAR capturing is increasing in large scale internationally but in India still researchers have not yet started on a large scale for fear of not being successful. The government policy also on aerial data collection has been unclear. But however, today India is showing interest slowly as India has always been interested in the processing of data and so clear that Indian companies have shown interest in the processing of the millions of laser points we call point cloud. A number of them are now capable of classifying LiDAR data, creating terrain models etc. for various domains including cartography, mining, power and telecommunications network industries.

V. CONCLUSION

Airborne lidar, creates a 3 dimensional point cloud of the building under consideration. This laser scanner is attached to an aircraft during flight to find the structure of buildings. This method is the most comprehensive and precise method of creating digital elevation models, replacing other 3 dimensional scanning techniques. This technique filters out reflections from other objects when compared to the object under consideration based on the point cloud generated. Then a digital surface model is created which represents cultural heritage buildings which couldn't be seen because of trees. The main constituents of airborne lidar include digital elevation models (DEM) and digital surface models (DSM).

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