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3D modelling of Heritage sites for its conservation and enhancing Ecotourism: An application of Terrestrial LiDAR Technology

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Abstract-Terrestrial Light Detection and Ranging (LiDAR) is a land-based laser scanner which, combined with a highly accurate differential GPS, enables us to produce 3D computer models of the buildings, captured area or any laser scanned structured. Terrestrial laser scanning (TLS) is now frequently used in earth sciences to achieve greater precision and completeness in surveying natural environments. It is known that the preservation of cultural heritage can help to educate younger generation through the history. It also helps in conservation and documentation of the natural beauty of the natural heritage. This paper comprises the application of Terrestrial LiDAR data in conservation of Heritage sites and enhancing Ecotourism. For the present study Laser scanning of Alambagh gate, Lucknow has been done. The point cloud data is captured by Terrestrial LiDAR Scanner with the help of Differential GPS. The TLS scanner used for the purpose is 3D laser scanner P40. Later on the data is processed in Cyclone software. This paper also describe the step by step collection of the point cloud data and its processing in the Cyclone software. As datasets provided by the Terrestrial LiDAR system are denser and bigger it implies that the accuracy achieved by the LiDAR dataset is of the order 0.0001m. Thus, the defects in the structure could be easily identify with the help of TLS. TLS will provide a one-time collection of the data for numerous applications which my help in 3D modelling.

Key words: TLS, LiDAR, DGPS, 3D Modelling

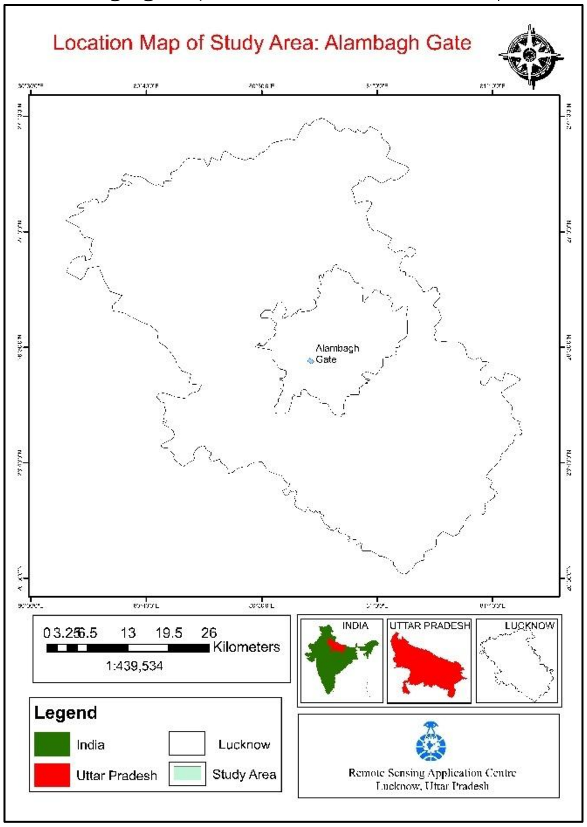
I. INTRODUCTION

Terrestrial laser scanning (TLS) is now frequently usedin earth sciences studies to achieve greater precision andcompleteness in surveying natural environments thanwhat was feasible a few years ago. Having an almostcomplete and precise documentation of natural surfaceshas opened up several new scientific applications.With the idea of getting an almost complete and precise documentation of natural surfaces has opened up several new scientific applications. These include the detailed analysis of geometric properties of natural surfaces over a wide range of scales (from a few cm to km). Yet, there are some difficulties in developing such procedures: (a) the 3D nature of data as oppose to the traditional 2D structures of digital elevation model (DEM); (b) the natural heterogeneity and complexity of natural surfaces; and (c) the large amount of data that is now generated by modern Terrestrial LiDAR system.
As innovation advances, datasets provided by the LiDAR system are denser and bigger which implies that projects with billions of points are likely to become common in the next decade. Programmed handling is automatically critically required, together with quick and exact strategies minimizing user input for rapidly classifying large 3D point clouds. Sometimes it is difficult to attain natural heterogeneity and complexity of natural surfaces, for example, in steep mountain stream, natural surfaces can exhibit complex geometries. Terrestrial lidar data are mostly 3D as opposed to digital elevation models or airborne lidar data which can beconsidered 2.5D. This means that the conventional data processing and analysis methods based on raster formats or 2D vector data processing cannot in general be applied to ground based lidar data. The classification and analysis process of 3D point cloud data is more complex than the processing of 2D raster or vector data.

1.1 Heritage sites
Historic site or Heritage site is an official location where pieces of political, military, cultural, or social history have been preserved due to their cultural heritage value. Heritage sites are usually protected by law, and many have been recognized with the official national historic site status. A heritage site may be any monuments, landscape, site or structure that is of local, regional, or national significance.
There are fewhistorical monuments in Lucknow, Uttar Pradesh, India, which are as follows: Bada Imambara, Chota Imambara Alambagh Gate, Chattar Manzil, Rumi Darwaza, Constantia, etc.
1.2 Concept of Ecotourism
Ecotourism is defined as tourism that sustains or enhances the distinctive geographical character of a place- its environment, heritage, aesthetics, culture, and the well-being of its residents.

II. Study Area

The study are for the research work is alambagh gate (26°48'45.9"N 80°54'15.3"E).



It was said that the history of Alambagh began with the construction of Alambagh palace which was erected by Nawab Wajid Ali Shah during the years 1847-1856, for his wife Alam Aara, who was also known as Khas Mahal. It had a well-kept beautiful garden in its surroundings. Moreover, a huge gateway known as Alambagh gate (Kothi Alamara Gateway), designed by the architect Chhote Khan was constructed in the same area. Now the same gate serves as an entranceway to the Chander Nagar colony. Both the palace and the gate were made up of lakhauri bricks. The two-storeyed palace comprises spacious halls and rooms. The rooftops of the rooms are quite high. The interior walls of the palace were once decorated with floral designs but are now in ramshackle.

In order to carry out our research work we required 46 DGPS points in all and 30 scans of the monuments from all its surroundings.

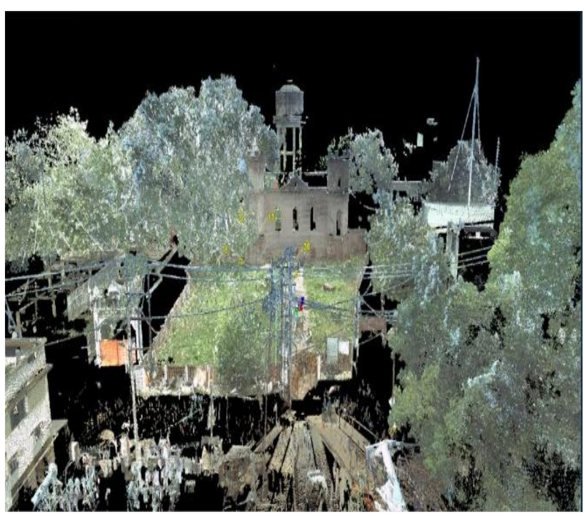


Figure 1 Point Cloud Data of Alambagh Gate with the location of TLS scanner points (before classification).

Figure 2 Point Cloud Data of Alambagh Gate with the location of TLS scanner points (after classification).

III. Aims and objective

1. To capture point cloud data of a heritage sites
2. To remove noise from the data
3. Create 3D model of the structure

IV. METHODOLOGY

Data collection

During data collection, the phase-shift based 3D laser scanner P40 is normally mounted on a tripod and held fixed for the duration of measurements made at a particular position. The result of a single LiDAR scan is a large amount of 3D data, usually of the order of several million point measurements, each with an x, y, z and its intensity value. This dataset is termed as point cloud and is the raw 'product' of scanning. Laser scanning is a relatively simple way of obtaining a high-resolution dataset describing a geological field area, especially in comparison with stereo-photogrammetry, where much planning and processing is required, and the success is more sensitive to image geometry and contrast levels. Despite this, there are a number of important factors that must be considered before a LiDAR survey is carried out, so that the aims of the study are fulfilled, and so that the reason for using this technology is justified.

Terrestrial LiDAR data acquisition is carried out in 2 steps: - Laser scanning and photographing. The geometry and intensity of data is acquired by Terrestrial LiDAR Scanner, while the RGB valued of the scan is captured by a high resolution digital camera.

Figure 3: Leica TLS Scan Station P40

Figure 4: Components of Leica TLS Scan Station P40

Operating Principle

A laser beam deflected by a rotating mirror scans a vertical plane, and the complete rotation of the device allows hemispherical scanning. This results in the digitization and the representation of surrounding objects in a three-dimensional (3D) point cloud.

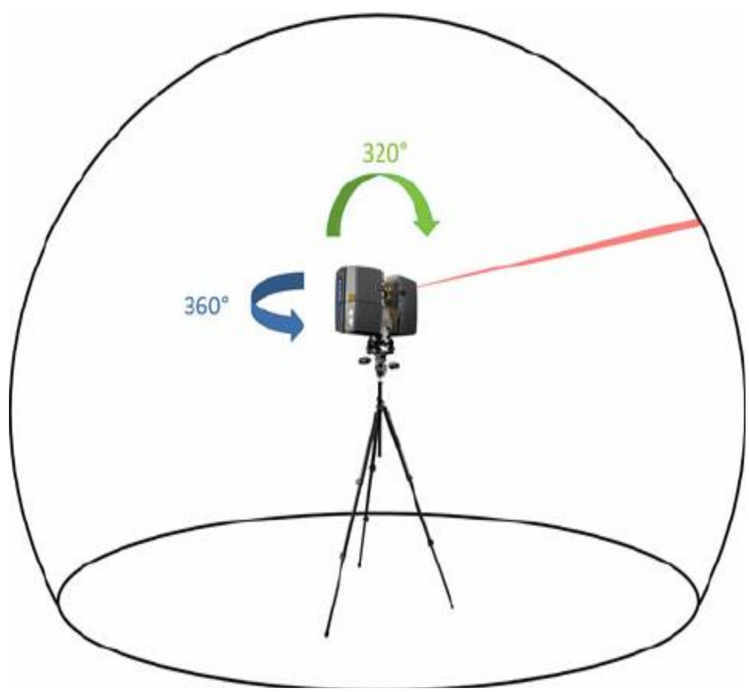
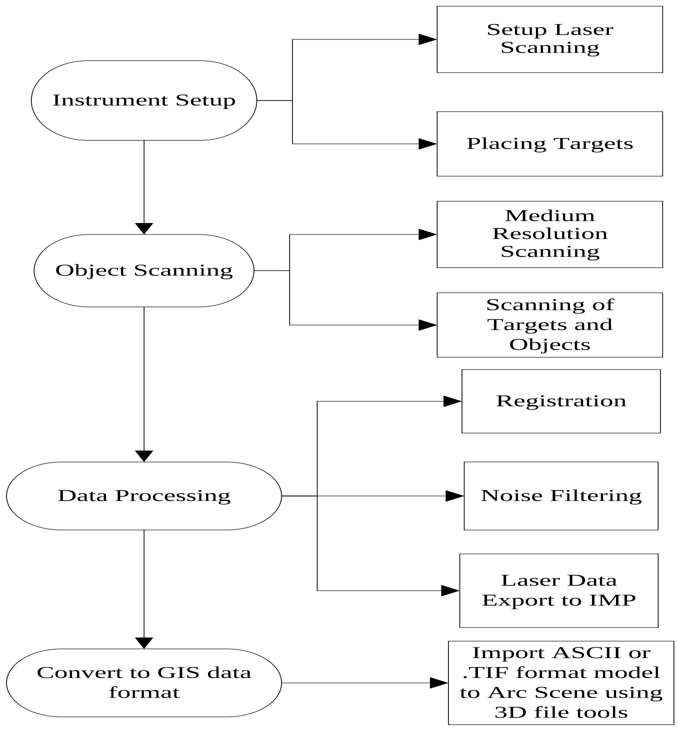


Figure 5: Operating principle of TLS

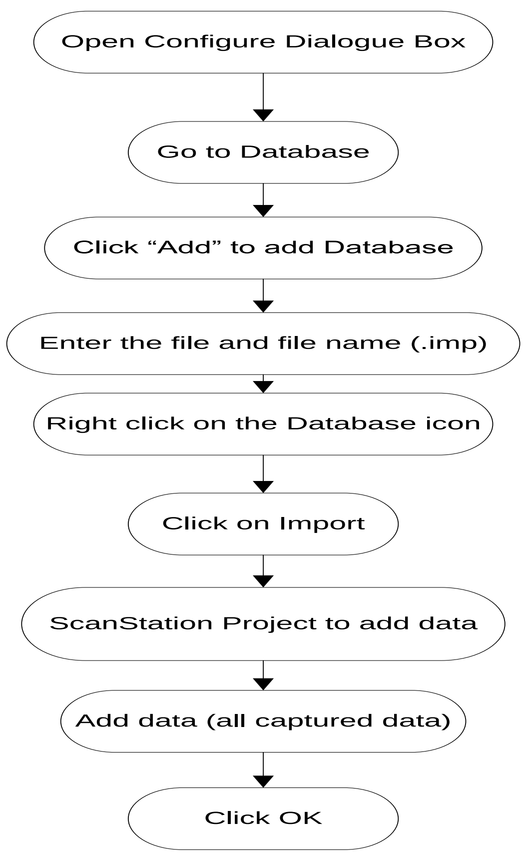
In order to create a 3D model of any site. First, data is captured by Terrestrial LiDAR with the help of DGPS and Target points. Then captured data is processed by Leica Cyclone (Version 9.1).



Block Diagram 1: Workflow of 3D model construction based on point cloud data using Terrestrial LiDAR Scanner

3.1 Creation of Database

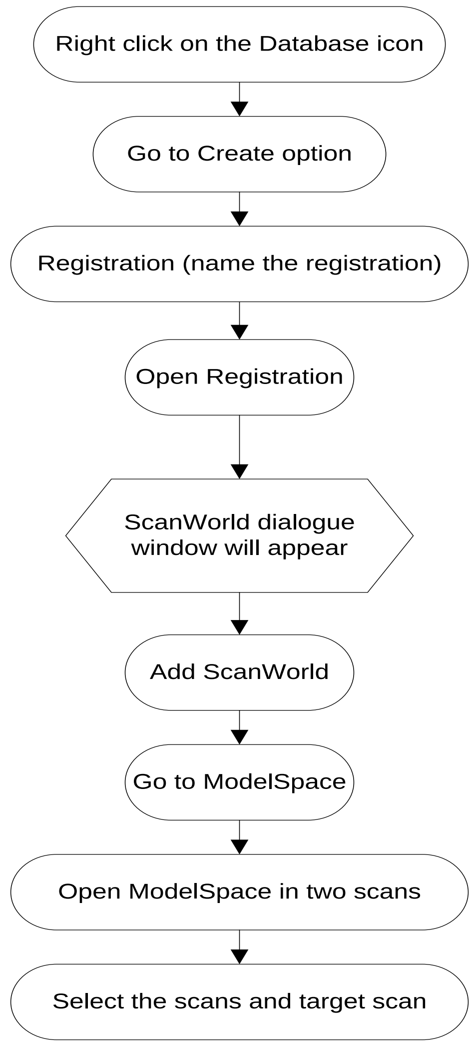
Database is where data is stored and managed. It is like a container for dataset usually with built in infrastructure around it to interact with it.



Block Diagram 2: Steps to add point cloud data in the Cyclone software

3.2 Merging of two ModelSpace

Registration is the process of integrating a project's ScanWorlds into a single coordinate system as a registered ScanWorlds. The integration is derived by a system of constraints, which are pairs of equivalent or overlapping objects that exist in two ScanWorlds. The objects involved in these constraints are maintained in a ControlSpace, where they can be reviewed, organized, and removed. The registration process computes the optimal overall alignment transformations for each component ScanWorld in the Registration such that the constraints are matched as closely as possible.



Block Diagram 3: Steps to register point cloud data in Cyclone

Now, the data from 2 scans are compared and at least 3 common points are observed in the both scans in order to combine the scanned images. This is done with the help of 'Multi-Pick mode' icon in the 'ModelSpace window'. Each ModelSpace is observed carefully to find the 'Target points' used at the time of data acquisition process. This process could be done with 2 images at a time.
After selection of common points, steps are performed in order to register and freeze the constraint.

3.3 Unify point cloud data

In a ModelSpace containing a registered set of scans and a large number of point clouds, performances is improved by the cloud unification process.
Therefore, after registration of Scanned data, the points are to be unified. This process is done so that a point in the point cloud data should have a unique and metadata.
When running a unification process all point clouds will be combined into one single efficient point cloud object. The point-reduction will try to maintain an average spacing of 10mm between points and hence remove points closer together. This can be useful when a lot of overlap areas are present. Though, this is not an exact value- but an average spacing.

3.4 Classification

The general thought behind the classification method is to characterize the best mix of scales at which the dimensionality is estimated, that permits the most extreme distinguishableness of at least two classes. Practically, the user could have an intuitive sense of the range of scales at which the categories will be the most geometrically different, but in many cases, because of natural variability in shape and size of objects, this is not a trivial exercise. In this paper we used classification in two categories – one is the site, which is required to be conserved and other is the noise, which is to be removed. The steps to be followed in Cyclone software are as follows:

3.5 Export the point cloud data

The point cloud data was then could be exported in picture, ASCII, Binary and CAD format. We could take snapshots of ModelSpace Scenes or create Ortho Images of desired areas.

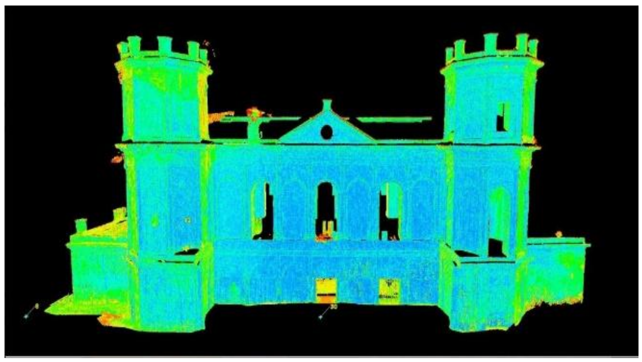
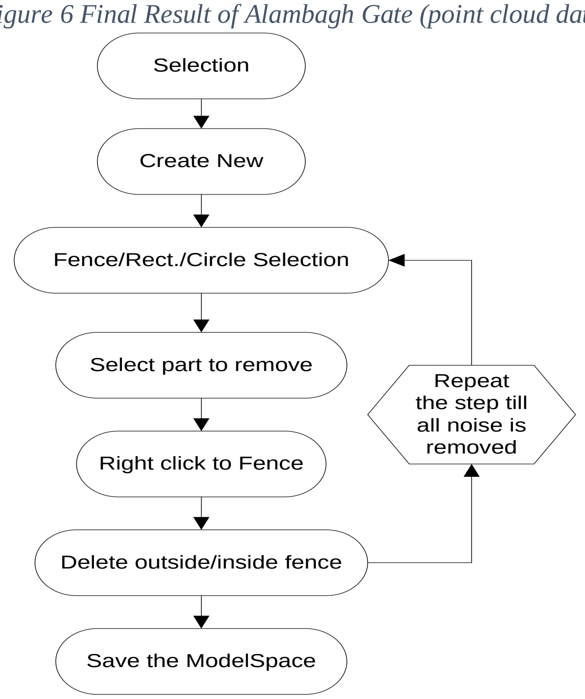


Figure 6 Final Result of Alambagh Gate (point cloud data)



Block Diagram 4: Steps to remove noise from data

V Analysis

Conservation of historical monuments is required to keep the cultural history of the area. By seeing historic monumentstourists and longtime residents are able to witness the aesthetic and cultural history of an area. Just as banks prefer to build stately, old-fashioned facades, even when located in commercial malls, a city needs old buildings to maintain a sense of permanency and heritage.

The preservation of historic monuments is a one-way street. There is no chance to renovate or to save a historic site once it's deteriorate as it is a source of inspiration for future generation. This reality brings to light the importance of locating and saving monumentsof historic significance—because once a piece of history is destroyed, it is lost forever.

Analysis of TLS data is required for documentation of the structure so that later on we could compare and find the deformation and deterioration in the historical monument and the rate of impact of environment on the structure. Accuracy achieved by the TLS LiDAR dataset is of the order 0.1mm.

Figure 7 TLS data showing the deterioration in the both structure.

VI CONCLUSION

This paper has outlined the potential of TLS for analyzing the geometry of structure.TLS has become an established method for obtaining 3Dgeometry in many applications, such as architecture, mining,geology, and the wider earth sciences. In these disciplines,the method has become attractive, due to the rapid dataacquisition, the high point precision and the ease of use,which has resulted in highly adopted technique by domainexperts. Because laser scanning isan active technique, the strength of the returned laser pulse referred to as intensity of a point data which reflects the geometry of falling object in three-dimension which inculcate all dimensions of analysis.

VII ACKNOWLEDGEMENT

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