COMPARATIVE ANALYSIS OF SfM BASED CRP AND TLS FOR 3D MODELLING OF VARIOUS TYPES OF SURFACES

Conference Paper

COMPARATIVE ANALYSIS OF SFM BASED CRP AND TLS FOR 3D MODELLING OF VARIOUS TYPES OF SURFACES

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ABSTRACT

Close Range Photogrammetry (CRP) and Terrestrial Laser Scanning (TLS) techniques have been widely used in 3D modeling applications. Due to recent developments in computer vision algorithms, CRP is also seen to provide same level of details (point cloud density) as that of TLS. Hence an assessment of these two techniques has to be carried for cost effective applications. This paper deals with the comparative analysis of the point clouds generated by the CRP and TLS to access the accuracies. In this work, point cloud is generated from multiple overlapping sequences of images using Structure from Motion (SFM) photogrammetry and TLS for a building over planar, curved and cylindrical surfaces. GCPs (Ground Control Points) were collected by the total station to geo-reference the point cloud from CRP and TLS. Overlapped photographs were processed in Agisoft Photoscan along GCPs to generate photogrammetric point cloud. TLS point cloud was generated from Riegl VZ 400 with minimum possible horizontal and vertical resolutions and GCPs were used to geo-reference it in Cloud Compare software. Flat and Curved surfaces area of same region are segmented from both the point clouds and compared with reference plane in Cloud Compare software. In case of CRP, more than 90% of the points are at zero distance from the actual surface. This study has shown that 3D model generated using CRP is denser in comparison to that of TLS. The fraction of points closer to the reference plane is relatively greater in case of Terrestrial Laser Scanning and mean error value obtained was much closer to zero. The mean error in case of CRP and TLS is 0.026 m and 0.016 m respectively. From the analysis it is also observed that higher accuracy of the points is achieved in case of TLS when compared with that of CRP. So, CRP could be used as an alternative low cost technique of TLS for 3D modelling.

1. INTRODUCTION

3D modelling from images has experienced a transformation over the last few years. The process of gathering 3D from 2D observations is the result of complex mechanisms that are still quite far from being resolved. For a long time, this task has been considered the essential part of visual processing. Pioneers in the fields of artificial intelligence and computer vision set out to recover a 3D representation of visible 2D objects which could then be used to recognize objects and to extract other useful information. Nowadays 3D scanners are also becoming a standard source for input data in many application areas, but image-based modelling still remains the most complete, economical, portable, flexible and widely used approach [1]. Low-cost data acquisition for large scale 3D models from a sequence of images from a high-resolution camera is highly demanded. Objects can be monitored by several different techniques (Pesci, et al., 2012) such as conventional close range photogrammetry(Gruen et al., 2002), infrared thermography (IRT) (Clark, et al.,2003), image-based (Hutchinson and Chen, 2006), TLS (Pesci et al., 2011; Park, et al., 2007), digital photogrammetry (Bitelli, et al., 2007; Girelli, et al., 2005). 3d point cloud generated from the data acquired by Terrestrial Laser scanner mounted camera provide richer 3D contents than those built from other techniques. The simultaneous applications of different algorithms, the different techniques of image matching by detecting common overlap in the sequence of 2D image data set, feature extracting and mesh optimization are inside an active field of research in computer vision. TLS is a popular and reliable method for heritage documentation (Rüther, et al., 2011). TLS systems are regarded to the standard method for recording cultural heritage (Christofori and Bierwagen, 2013). Interactive modelling at laser scanning systems and automatic generated point cloud by dense image matching is easier than conventional photogrammetric systems.

Structure from Motion

The emergence of Structure from Motion (SfM,) in recent years has revolutionised 3d modelling of various objects and enhancing surveys in physical geography by democratising data collection and processing. Structure from motion is a new computing vision technique that deals with the extraction of 3D structure of an object by analysing motion signals over time [2]. This technique can be applied to a large number of photographs having some common overlap to obtain sparse point cloud for a wide range of objects such as buildings and historical monuments. It is becoming increasingly recognised as a means to capture dense 3D data to represent real-world objects. It is an easy and convenient method to generate millions of 3D point coordinates in the form of point cloud.

2. STUDY SITE

For the present work, Godavari Hostel which has flat, circular surfaces of IIRS (ISRO), Dehradun was chosen as study area for this work. The location of the study site is shown in Figure 1.

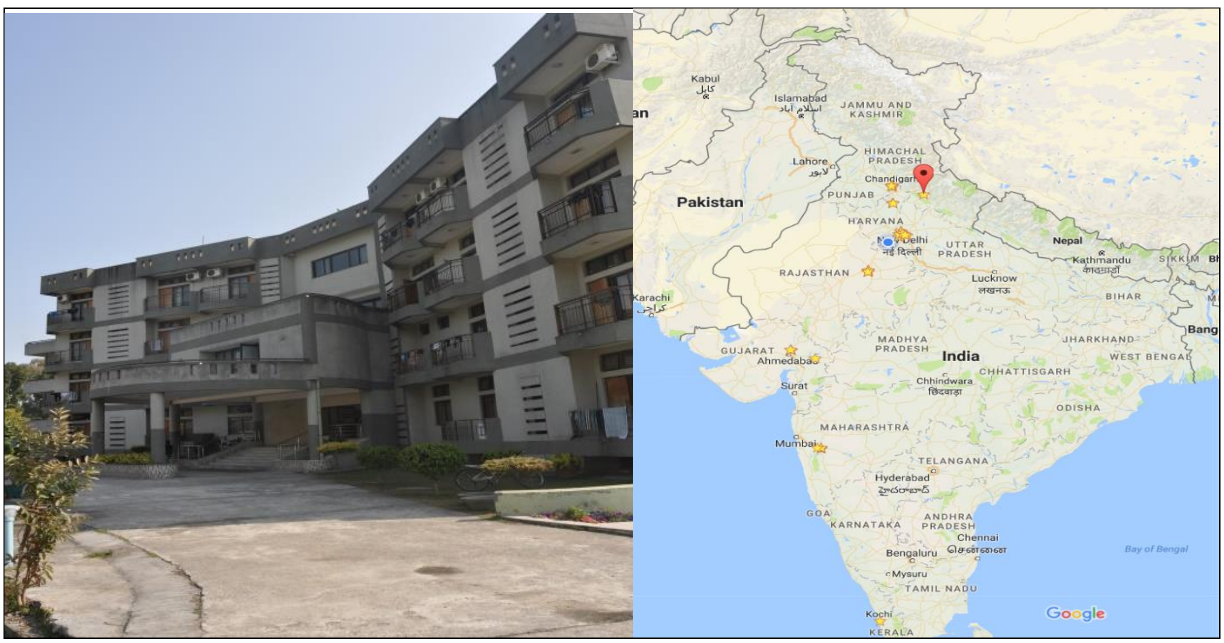


Figure 1: Godavari Hostel, IIRS (ISRO), Dehradun

3. DATA ACQUISITION

3.1 Close Range Photogrammetry

A total of 189 images were acquired all around the hostel building. Some other buildings such as Canteen, Ganga hostel were also acquired near the Godavari hostel building. The images were captured with Nikon D5300 Camera by keeping the focal length constant. During the entire data acquisition process, it was ensured that every two images must have some common overlap. It was tried to capture the images at a fixed distance all around the building. Figure 2 shows the estimated camera positions after dense point cloud generation.

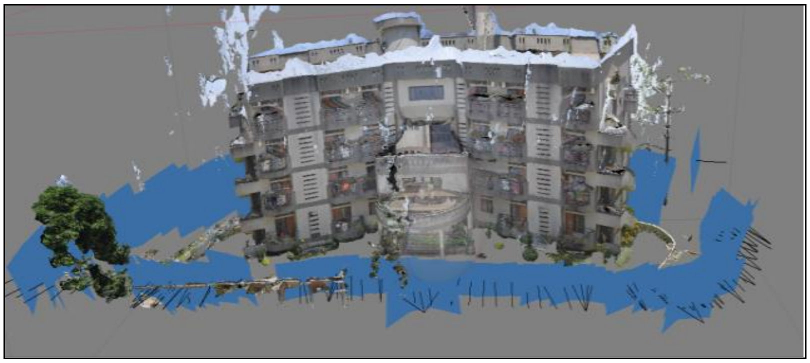


Figure 2: CRP Dense point cloud with camera positions

Images were not acquired for some rear part of the hostel building as some construction was going there at time of data acquisition. To overcome this, images of that part from TLS data were included for extracting information of this part.

3.2 Terrestrial Laser Scanning

For this study, Riegl VZ-400 laser scanner was used for the acquisition of laser data. The distance of the instrument was around 20-25 meters and the scan resolution was set to be 0.02 degrees for the detailed information of the study area.

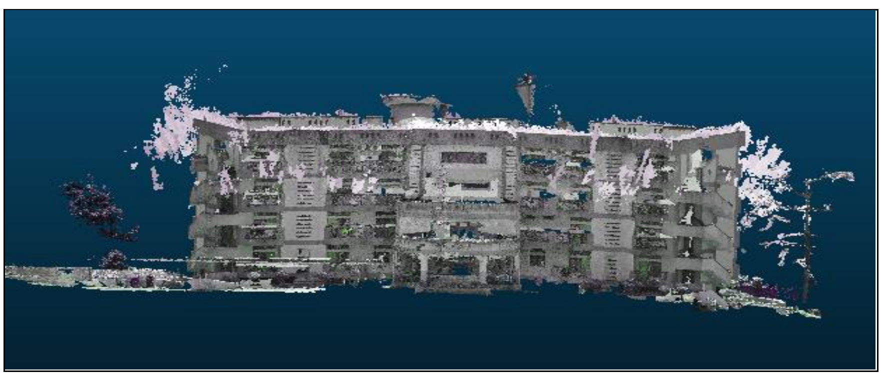


Figure 3: TLS dense point cloud

4. Data processing

The acquired overlapping images were aligned using image conjugate points using SFM and then photogrammetric solutions were applied to generate dense points cloud and geo-referencing was carried out using the GCPs collected on the few selected points on building.

Figure 4: Approach for a) CRP processing b) TLS processing

4.1 Agisoft Photoscan Processing

CRP data processing has a very simple workflow as highlighted earlier. It is a four step process involving addition of photos, matching of points and image pairs, sparse cloud and dense cloud generation. In Photoscan, the accuracy was kept 'high' and pair preselection was kept 'generic'. For generation of dense point cloud, the depth filtering was kept as 'moderate' and quality was kept 'high'. Generated dense point cloud might be altered and classified prior to export as .txt file or proceeding to 3D mesh model generation.

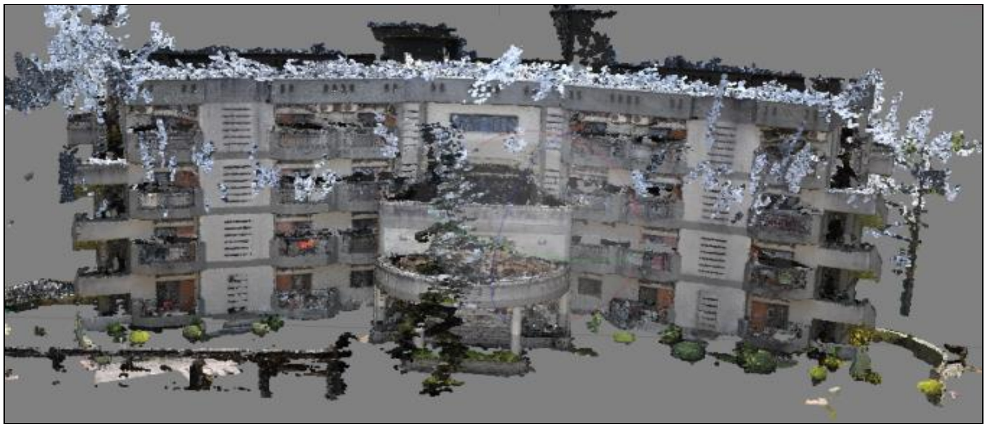


Figure 5: CRP dense point cloud

4.2 Establishment of Ground Control Points (GCPs)

Several Ground control points are taken near the study area using GPS in differential mode. Trimble R7 is used for collecting GCPs. Ground Control points are taken on the road in front of hostel and marked temporarily for the collecting tie points. By orienting the total station instrument Leica Pinpoint R1000 at GCPs established, several tie points were taken on the front part of the hostel building.

4.3 Co-Registration and Geo-Referencing of dense point cloud

The Models generated by both techniques were in arbitrary coordinate system. The point clouds were co-registered with TLS being the benchmark. Point cloud generated through CRP and TLS were geo-referenced by manually aligning with tie points obtained earlier. CRP model was geo-referenced in the Agisoft Photoscan software and TLS point cloud in Cloud Compare.

4.4 Section Segmentation

The segments for the various types of surfaces were extracted for each point cloud. Different types of surfaces like Planar, Curved and quadric are segmented using Segment tool for the better assessment of the accuracy for both the techniques.

4.5 Plane fitting

A suitable plane such as planar, curved, 2.5 quadric was fitted to the segmented parts. The distance of points to the plane were calculated to for the accuracy assessment. At the early stage, it was observed that CRP point cloud was better than TLS point cloud as tie points can could be easily accessed in case of CRP. The sections additionally draws out the details of interest on the surface of the object which can be thought about for the better assessment.

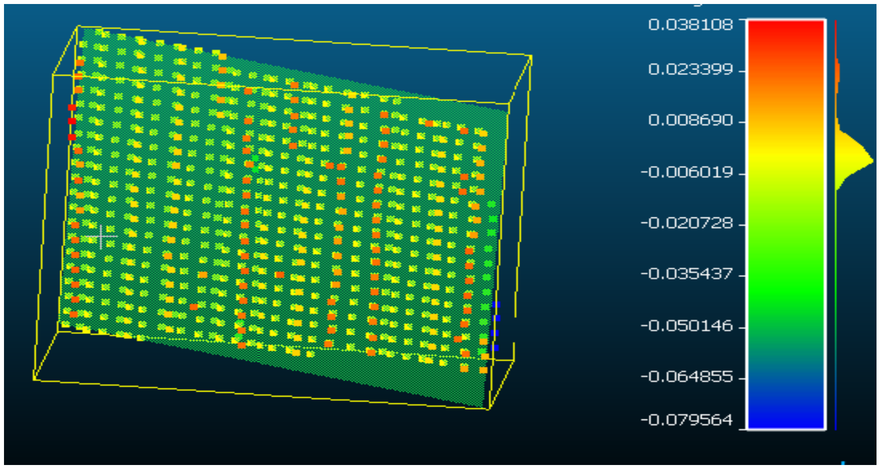


Figure 6: Plane fitted to a segmented CRP model

5. RESULTS

5.1 Plane Fitting

5.1.1 Close Range Photogrammetry

For the section one(Figure 6(a)),the standard deviation in case of Photo Scan point cloud was found to be 0.0128622 .The standard deviation for the section two (figure 6(b)),was found to be 0.0151689 .

(a)

(b)

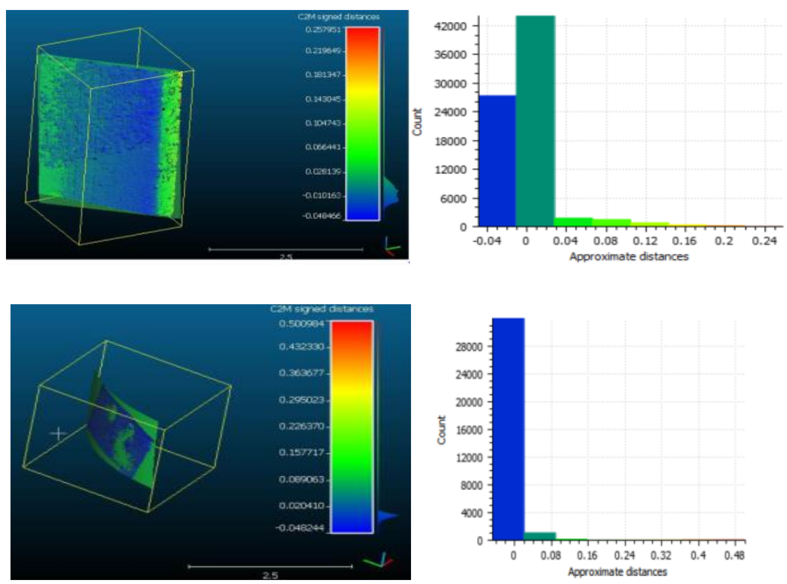
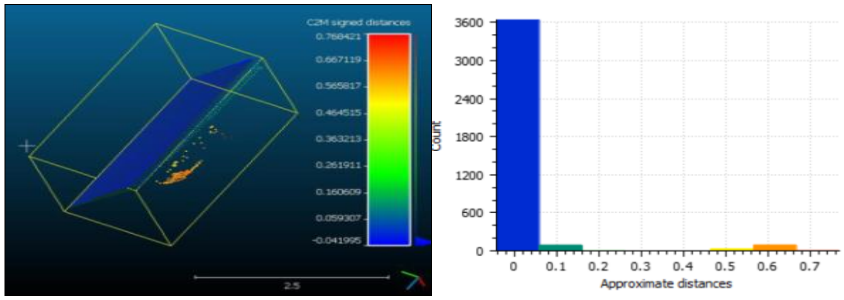


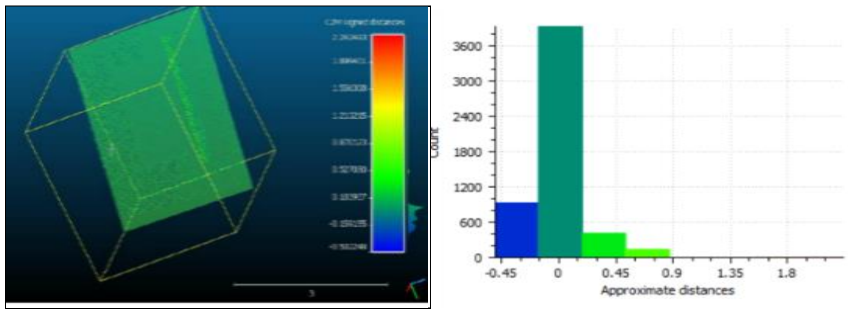
Figure 7: Overlaid CRP generated surfaces of (a) Flat area (b) curved area

5.1.2 Terrestrial Laser Scanning

The standard deviation for the subset one (a), was found to be 0.0117122 and for subset two (b), it was found to be 0.0140772.



(a)



(b)

Figure 8: Overlaid TLS generated surfaces for a) flat area b) curved area

It was obvious from the figures (a) and (b) that TLS point cloud has more prominent ratio of points nearer to the plane when contrasted with the CRP point cloud.

6. CONCLUSIONS

In this work, two Remote Sensing techniques are utilized for 3D demonstrating of the Godavari Hostel Building, IIRS, Dehradun. 3D models created by the two methods are compared by fitting to a reference plane for level surfaces and conical plane for curved surfaces. Close Range Photogrammetry is more convenient strategy than Terrestrial Laser Scanning as far as information obtaining and processing is concerned. The 3D point cloud generated through CRP has high no of points however it has lesser exactness than TLS.The Mean error obtained in case of CRP is 0.02571999 m and in that of TLS is 0.016216420 m .CRP is able to provide the fruitful information about which can be used to generate a photorealistic 3D model for the building. The high density of CRP point cloud data can offer an accurate detailed architectural description for the study sites, which is hence capable of providing a direct solution for digital 3D modeling. The no of points are TLS being a costly system including high instrument cost can be utilized where high accuracy is required .In different Cases where a less precision is acceptable, CRP is a lucrative technique .CRP includes lesser instrument cost, human endeavors and it gives better information at lesser cost. As far as exactness is concerned, TLS tends to be more precise than CRP. The number of points per unit area are comparatively higher for CRP but the error is less in case of TLS model. However, point density needs to be improved in case of TLS for better representations. Further, both TLS and CRP point clouds can be merged for achieving better accuracy.

7. REFERNCES

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