DOCUMENTATION OF HOROZLUHAN CARAVANSARY ON HISTORICAL SILK ROAD BELONG TO SELJUK PERIOD, IN TURKEY

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Abstract:

Laser scanning systems have been widely adopted for the acquisition of dense and accurate point data over aerial and close range measurements. Laser scanner point clouds can be satisfies the need of several applications. Terrestrial laser scanning is especially become standard method for close range 3D measurement and modelling. It is extensively used to cultural heritage documentation. In this study, historical Horozluhan Caravansary which was built on historical silk road was scanned by terrestrial laser scanner and its 3D model was prepared

1. INTRODUCTION

Cultural heritages of society in all over the word are common values for humans and be transferred future generations. Today, many international organizations such as ISPRS (International society for photogrammetry and remote sensing), CIPA (International Committee for Architectural Photogrammetry) and ICOMOS (International Council on Monuments and Sites) have been founded to documentation and preservation of them. The documentation of cultural heritage is the record their geometrical and related data. The object dimensions and colors are recorded by different techniques on digital platforms. The letter, if the object shape is get worse, these data can be used for restoration and 3D reconstruction. The photogrammetry is conventional method which has been used to close range measurement and 3D modelling for a long time. However, today laser scanning method is used extensively in cultural heritage documentation, environmental monitoring, reverse engineering, architectural planning and virtual simulation. Laser scanners are used alone or together with photogrammetry in applications. It is fast and accuracy method to measurement 3D spatial data.

3D virtual model is enables us to manipulate and interact with real dimensions and colors of the real world objects. Laser scanners are measure 3D coordinates and intensity data of scan points. The color data (RGB) can also be recorded for scan points via the camera image. Digital object model can be visualized in GIS environment or it can be used to object documentation, restoration and reconstruction. Laser scanner data can be integrated with the other spatial data. In order to integration, registration is performed with common control points [1].

Today, there are various laser scanner instruments with different configurations. The laser scanners use time-of-flight (Riegle, Leica, Trimble, Optech, Callidus, I-SiTE) and phase-shift (Zoller+Fröhlich, Faro, 3rdTech) range measurement principles. The measurement range changes from 3 meters to 3 kilometers. ToF laser scanners tend to measure longer range than phase-shift laser scanners. Accuracy of laser scanner is between 5mm and 2cm in 100 meters [2]. Moreover, there are triangulation laser scanners for measurement of small ranges, about 10 meters.

The laser scanners measure horizontal (α) and vertical (θ) angels and range (ρ) from instrument to scan point (Figure 1). The laser scanner measurements are converted into local Cartesian coordinates by Equation (1). All geometrical information belonging to the object can be extracted from the point cloud i.e. area, dimension, volume, cross-section and 3D surface model. Moreover 3D model of the object can be visualized in different forms [3].

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$$[x\ y\ z\ ]^T = \rho.[\cos\theta\cos\alpha\ \ \cos\theta\sin\alpha\ \ \sin\theta]^T \quad (1)$$

In this study, documentation of Horozluhan Caravansary was performed by ILRIS (Intelligent Laser Ranging and Imaging System) 3D laser scanner [4]. The object 3D point cloud model was created and image texture data was mapped on it.

2. THE STUDY OBJECT: HOROZLUHAN CARAVANSARY

The Horozluhan Caravansary was built in Seljuk period on historical silk roads. It is located 15 km away from centre of the Konya city (Figure 1). It was built from masonry stone (Figure 2). Its facade door at the east side includes fine masonry stone. Its dimensions are 29.88 meters and 28.18 meters. It has big courtyard and surrounded by industrial plants. The built served both visiting and restaurant for tourist groups today.

Figure 1: Location of the Horozluhan Caravansary.

Figure 2: The Horozluhan Caravansary

3. THE MEASUREMENT

The Horozluhan Caravansary was scanned by ILRIS 3D terrestrial laser scanner (Figure 3) from eight stations (Figure 4). The scans were performed with 3 cm point spaces from about 25 meters away. The scans were performed as partially overlapping with the previous scan. The measurements were completed in three hours. The object image data was recorded by mobile phone camera 2560x1920 pixels.

Figure 3: Ilris 3D laser scanner

4. THREE-DIMENSIONAL MODELLING

4.1 Point cloud registration

The point clouds were registered by Polyworks IMAling module using iterative closest point (ICP) method [5,6]. The first point cloud was selected reference and the others registered relation to its coordinate system respectively. The first point cloud, which was selected as a reference, was imported into IMAlign module and lucked. Then the second point cloud was imported into IMAling module. At first, initial registration of the second point cloud was performed approximately. The reference and second point clouds can be visualized on two windows for initial registration.

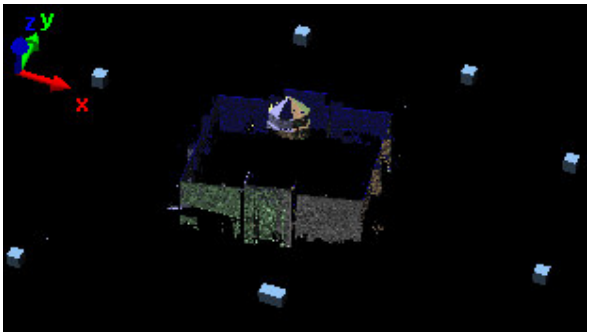

Figure 4: Laser scanning stations

While the first (reference) point cloud is shown on left, the second point cloud is shown on the right window. These two point clouds can be manipulated with interactively and independently. Initial registration was performed by min three common detail points selected from these point clouds. Then the registration was performed by ICP. These two scans were grouped and lacked. This procedure was executed until the complete registration of all point clouds belong to the object (Figure 4 and 5). 3D point cloud model can be visualized on different point density and forms such as flat or wireframe.

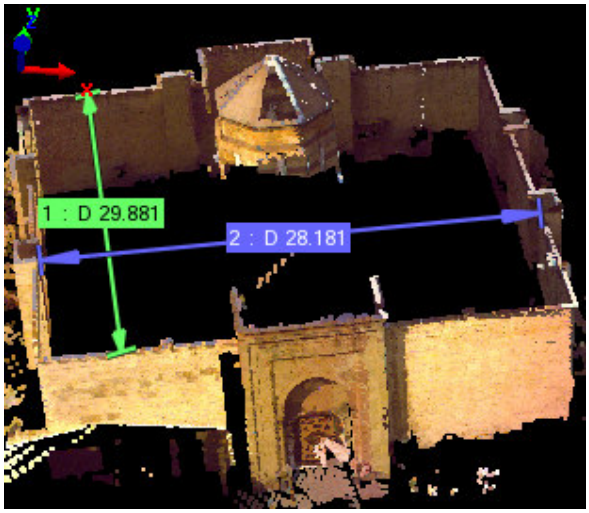

Figure 5: 3D point cloud model of the Horozluhan Caravansary

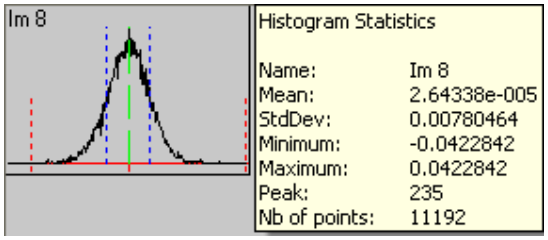

Figure 6: The registration result for the last (8th) point cloud. The first point cloud was selected reference and the others were registered relation to its coordinate system respectively.

4.2 Texture mapping

Triangulated mesh model was created by Polyworks IMMerge module (Figure 7). Polygonal model was constituted by triangles (Figure 8). If it requires, triangles of the polygonal model are decreased by IMCompres module on Polyworks/Workspace Manager window. The mesh model can be edited on IMEdit module. The mesh model was exported to Autocad DXF format. Then the image and mesh model were imported on PI-3000 software [7]. Since the camera that was taken images was not calibrated, the image registration with respect to coordinate system of mesh model was executed by DLT (Direct Liner Transformation) using about ten control points on PI-3000 software. Then image texture data was mapped on the mesh model (Figure 9, Figure10).

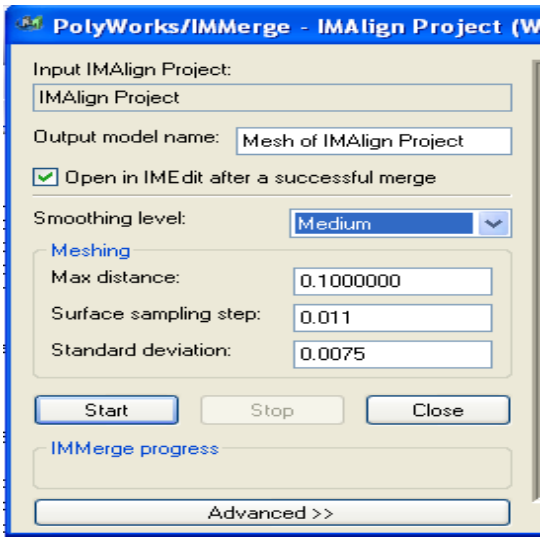

Figure 7: Polyworks IMMerge settings to creating triangulated mesh model.

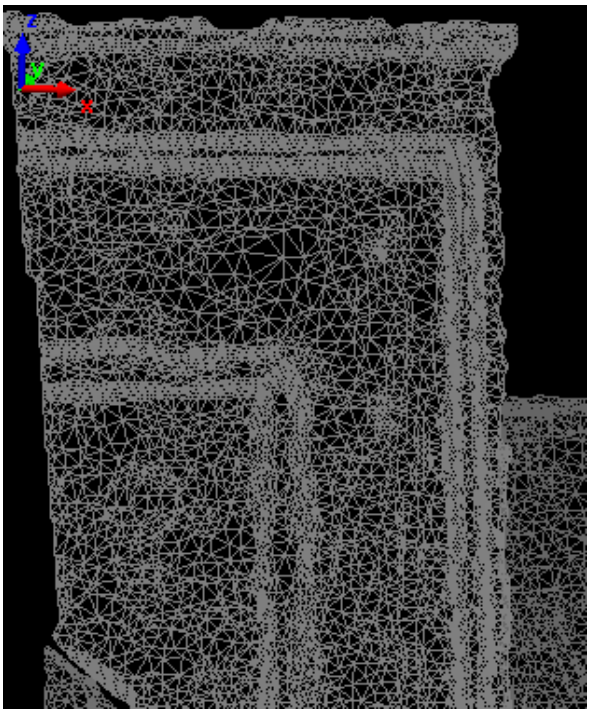

Figure 8: Mesh model.

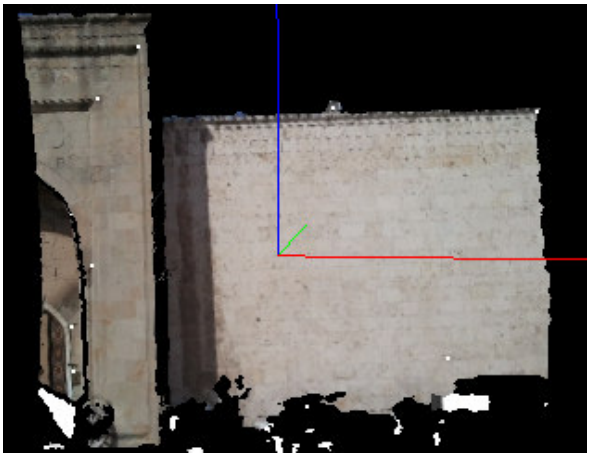

Figure 9: Image texture data was mapped with triangulated point cloud model (mesh model).

Figure 10: 3D textured model of the facade door.

5. CONCLUSION

3D modeling is important research topic for many study fields. Photogrammetry has been used to documentation of cultural heritage for a long time. Today non-contact laser scanning methods introduced with technological development are used for this aim. These methods are also used together in many applications. Laser scanning method is very fast and accurate methods. High density point cloud represents object details. Nevertheless, image texture data should be mapped on point cloud so as to visualization the object with real colors. The images which will be used to texture mapping can be taken by any digital camera. The registration of the images can be performed with control points. In this study, the images were registered by DLT method with manually selected laser points. For more accuracy results, it is recommended that the calibration and distortion parameters of the camera should be known.

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