

3 DIMENSIONAL MEASUREMENT OF CULTURAL HERITAGE AT TYRE, LEBANON

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ABSTRACT:

This paper describes a suitable 3 dimensional measurement method and simplified data handling for relatively large scale of cultural heritage (Tyre, Lebanon) using the measurement instruments of the laser. Typically the raw data from the laser is outputted on relative coordinates, and it is difficult to determine where the behind object area cannot measure from single scanning station (referred as occlusion area). Therefore, methods of data acquisition and managing from various scanning stations and efficient method of determining the occlusion area are discussed. Scanning from various stations create large data files, and they make processing and analysis go slow in the field; thus efficient way to manage large measurement data set is also studied. At last, simplified way of visualizing target objects in 3 dimensions to depict its shape is studied as well.

1. INTRODUCTION

This paper describes 3 dimensional measurement of cultural heritage done from September 24, 2002 through September 23, 2003 at the city of Tyre in southern Lebanon. The map of Tyre is shown in Figure 1. This investigation was done as a part of the project that focuses on establishment of GIS technique based for cultural heritage research, their geographical distribution research in the area, and experiment in 3 dimensional visualization of the cultural heritage at Tyre, Lebanon. An excavational investigation team and a terrestrial survey team were formed for this project. In Ramali Area, an excavational investigation team from Nara University researched the area. In both Albass and Ramali Area, the cultural heritage was surveyed using ground based 3 dimensional laser scanner (referred as laser scanner) by the terrestrial survey team. In this report, investigation outline and survey method from actual case in the Albass Area will be summarized. And issue and results of 3 dimensional data acquisition in cultural heritage are also summarized.

2. INVESTIGATION OUTLINE

2.1 Background of Investigation

In the year of 2000, the group from University of Tokyo surveyed the area using same laser scanner. Since the target area was set in broad area, it was not able to survey all area precisely. In this year, the target area was set smaller the distance among scanning stations for the survey mission.

2.2 Field Condition

There is a *hippodrome* in the center of target area where iron horse racing took a place. There is a *necropolis* in north of *hippodrome* where refers as the city of death. In east and west, there is stone-paved area with *city gate* stacks in the middle. There are stone coffins that are exposed on the ground, and many of those stone coffins have damaged holes. They seem that had been robbed and vandalized. Laser scanning was done mainly around *hippodrome* where there is an obelisk pointing to sky and cathedral remain at south of the obelisk. There are

spectators' stands partially remain with an entrance gates located both in north and south of the *hippodrome* track. The Aerial photograph of the area can be seen from Figure 2.

3. SURVEY METHOD

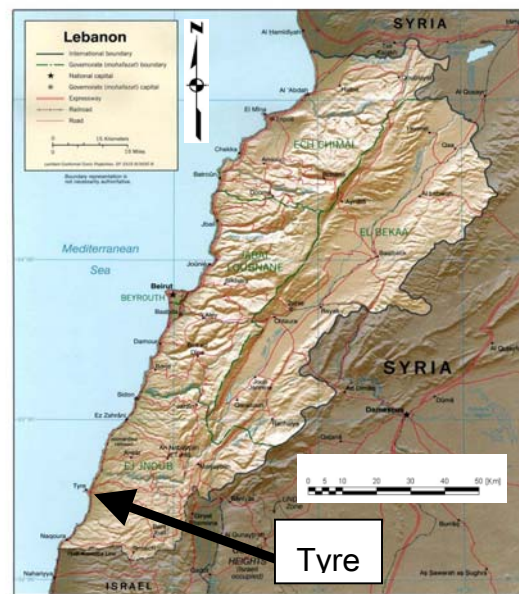


Figure 1: Map of Tyre

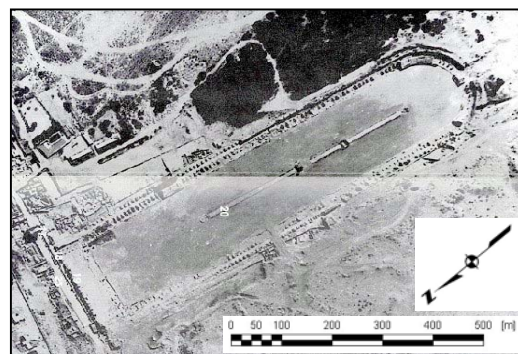


Figure 2: Aerial Photograph of Hippodrome

The size of *hippodrome* area is 600m (N-S) and 150m (E-W). Since the scale of target object required scanning long depth range, the RIEGL LMS-Z210 was selected for its long scanning range capacity (Maximum: 350m). In general, a measurement data of cultural heritage has complex shape and a occlusion area. And it usually requires measuring from various scanning stations in order to cover the whole object with minimum occlusion area. Figure 3 shows a single scanning result from three stations using software used at the field. Upper window in Figure 3 shows range image and lower window shows digital camera image. All these samples were

occlusion area there is. Therefore the laser scanning was done from 18 different stations to eliminate the chance of having a occlusion area. Also 56 control points were selected for the data registration. Target reflector was attached onto all 56 control points, and their relative coordinates were measured by the total station. Location of scanning station was determined to include at least 4 to 6 of those control points in single scanning data. The locations of scanning stations were indicated in Figure 4, and these stations were used in the actual project.

scanned from single station, and it is difficult to assess how

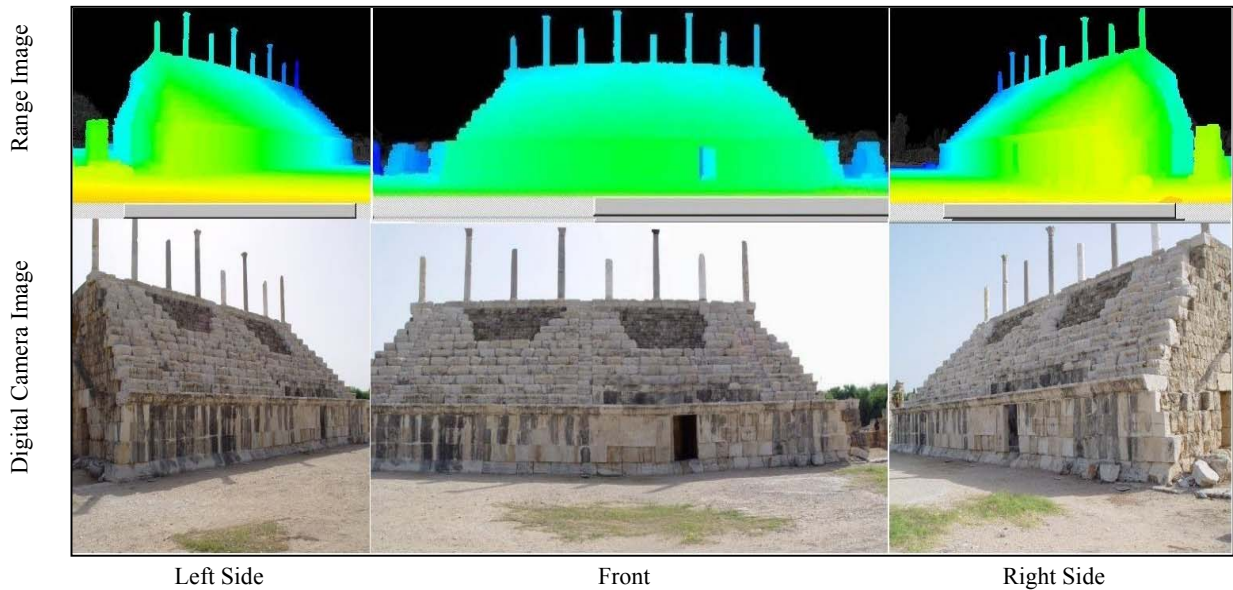


Figure 3: Obtained Image on Site (North-East Side of the Auditorium of Hippodrome)

much of the target object is actually scanned and how much of

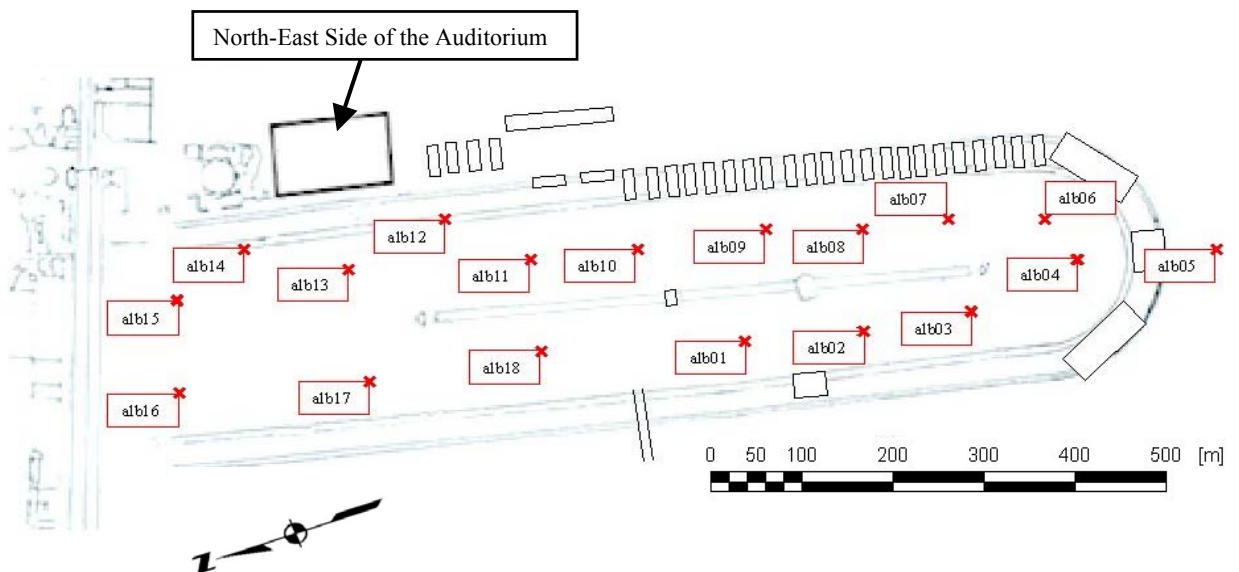


Figure 4: Location of Scanning Stations of Hippodrome

4. RESULTS OF INVESTIGATION

4.1 Efficient Method to Detect Data Occlusion Area

A simplified plane figure was created to detect occlusion area from obtained measurement data on site. All scanned data was converted into same coordinate system using control points. It was found that reading all data at once makes a data processing time on PC longer at the field. But merging data from 3 different stations makes proper data volume for handling data in PC. Therefore, data from 3 different stations were selected. These data were scanned from distant stations having enough data coverage of the whole target area. These data were used creating a simplified plane figure. Simplified plane figure can be seen in Figure 5. Data is classified by the elevation of the data, and general outline of the target object could easily be visualized. An important part of the target object was selected from simplified plane figure view as priority target. Then data from adjacent 3 stations covering this priority target were processed. It was possible to view the priority target in short period of time and determine the location of data the occlusion area. Combined imagery between those adjacent three stations covering priority target can be seen in Figure 6.

4.2 Examination for Data Reduction Method

In general, an output exchange data format from a laser scanner is ASCII file. However, enormous point clouds amount makes large data file, and it is difficult to handle on PC in the field. Therefore, all data were converted into binary format for smaller file size and faster PC processing than using ASCII file. Usually raw data contains noise data. Diffused reflection of sunlight and mirror reflection inducted by the object surface material are thought to be major reasons of making noise data. For removing these types of noise data, an automated noise removal process was applied first by using statistical method. However data still contains unnecessary data for visualizing and analyzing target objects such as points on the flat area. In order to reduce unnecessary data, target objects were clipped by polygon shape to be protected, and rest of the data was thinned out. Furthermore unnecessary data left from thinning process was removed using polygon clipped by operator. Figure 7 shows the result of data reduction. This method extracted necessary data and made downstream process simple and efficient.

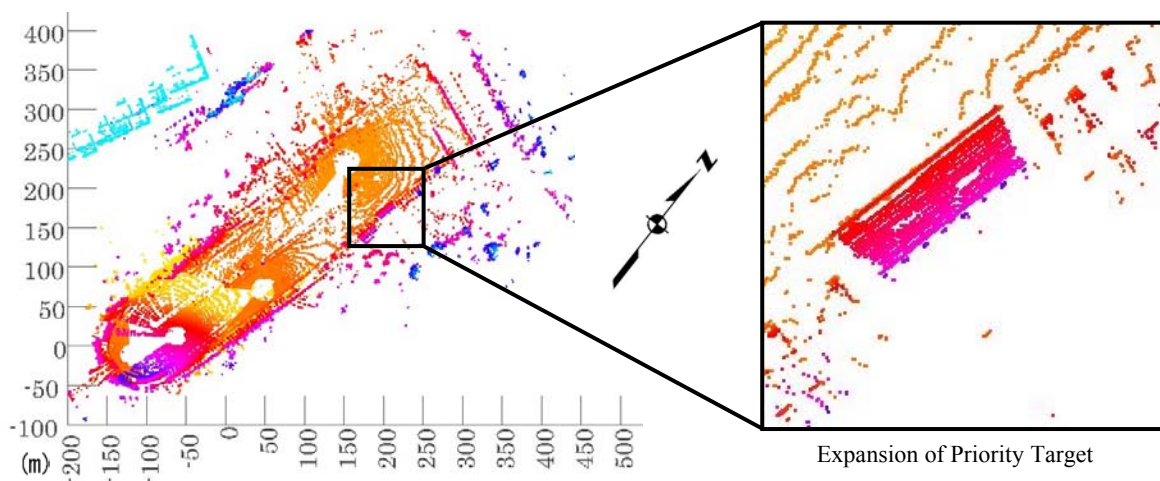


Figure 5: Simplified Plane Figure from 3 distant stations

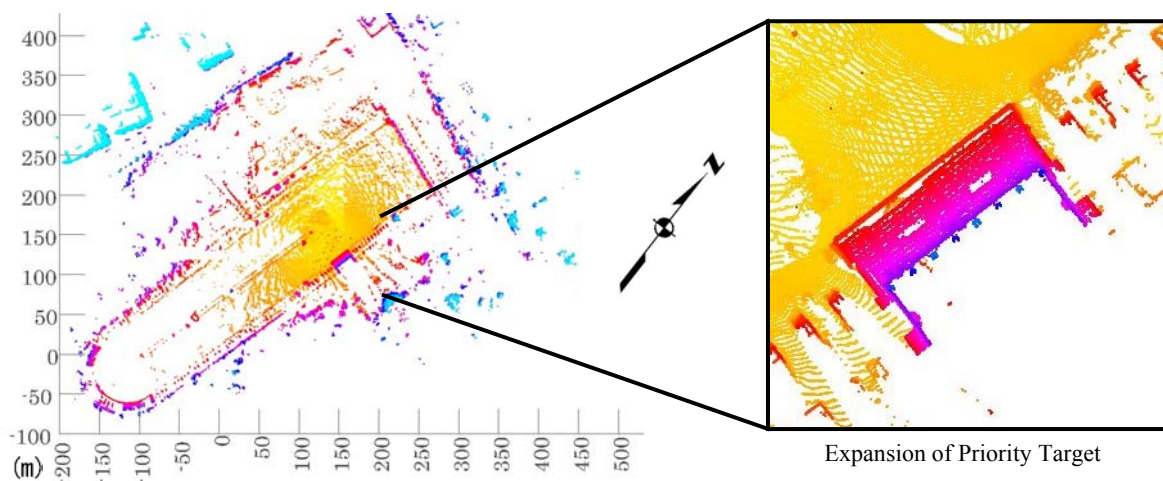


Figure 6: Merged Data Set of Priority Target from 3 Adjacent Stations

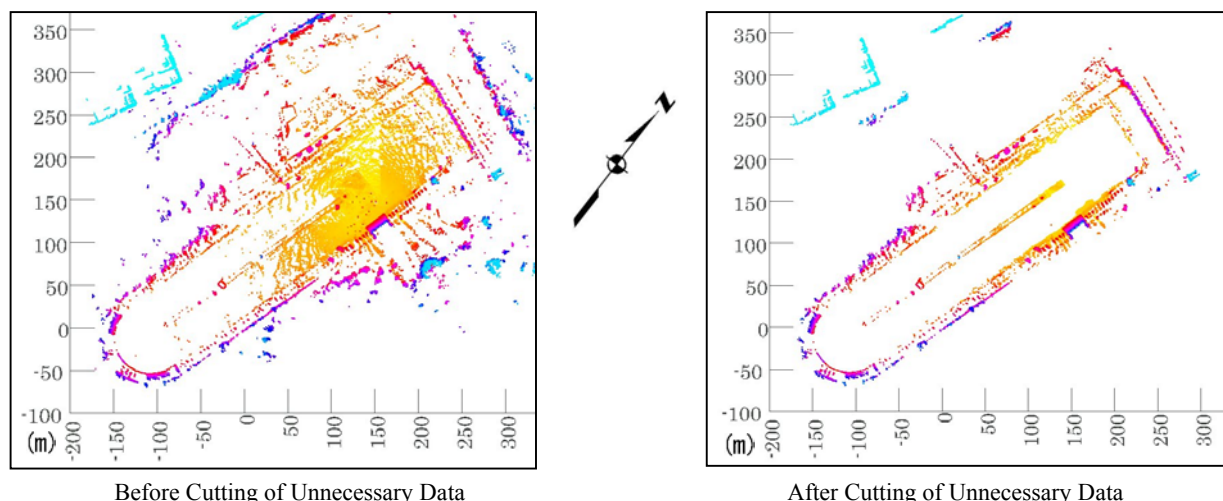


Figure 7: Results of Data Reduction

4.3 3 Dimensional Visualization Method

Since target objects have complex curved or unevenness surface, making a precise 3 dimensional computer graphics of target objects such as buildings or gates at the field could be a time consuming work. In this study, TIN model was selected as a simplified method to visualize objects' solid shape. Figure 8 shows the digital camera image of the target object, but this image dose not depicts enough solid shape configurations. Therefore, software that is capable to rendering the TIN model in 3 dimensions was used. This rendered TIN model can be seen in Figure 9. Where it is circled in Figure 8 and 9 show the area of stairs that have slight depression than surrounded stairs. It was difficult to detect from only digital camera image;



Figure 8: Image of Digital Camera

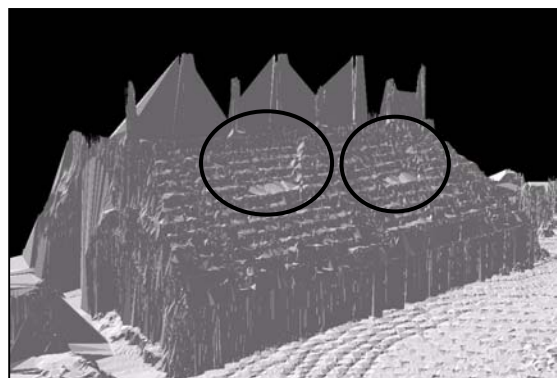


Figure 9: 3 Dimensional Visualization of TIN Model

however, rendered TIN model with shading effect could depict such slight depression on the target surface and helped to determine and see the general solid shape of the target object.

5. CONCLUSION

In this report, investigation outline and survey method in Tyre, Lebanon were mentioned. As a result, data the occlusion area could be determined using both simplified plane figure and priority target methods. This helped to decide where an additional scanning was necessary to cover the target object. Noise removal, data thinning and data reduction methods resulted a smaller data size with the objects' shape is kept as it is. Also making data file into binary format saved a PC processing time and disk space. Generating TIN model and its rendered and shaded visualization in 3 dimensions helped to determine the target objects' shape at the field efficiently. As future tasks, data needs to be applied for making GIS data such as contour map, profiles, plane figure map and elevation data. In order to function these data sets in GIS environment, the data should be affiliated with proper datum and converted into absolute coordinates system. Furthermore, the data sets should be considered as digital archive and stored in 3 dimensional orders for future application.

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