3D Modeling of Cultural Heritage Sites

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Softwares used: Agisoft Photoscan, Adobe Photoshop.

Abstract: Cultural heritage documentation is of great significance in terms of historical preservation, tourism, educational and spiritual values. Cultural heritages across the world are at risk from various natural hazards (e.g. earthquakes, flooding, rainfall etc), poor maintenance and preservation, and even human destruction. This paper evaluates the feasibility of low-cost photogrammetric modelling of cultural heritage sites, and explores the practicality of using photogrammetry. The full guidelines for a minimal and effective 3D modeling for heritage documentation and conservation, including visualisation, reconstruction, and analysis, is proposed.

Introduction

Over recent years, it has become increasingly common to use digitization and 3D modelling for preservation and conservation of heritage sites due to advances in lidar (light detection and ranging)-based and image-based modelling and visualization techniques towards virtual reality. 3D construction methods based on laser scanning and automated image-based techniques are both widely applied to heritage documentation. In many cases, it is best to take advantage of both techniques by fusing different data sources. However, given the fact that expensive laser scanning equipment may not be available in developing countries, this paper studies the feasibility of a low-cost, easy to use, and high quality image-based surveying technique *phogrammetry*. Over this document, we will go through the process of developing 3D model of church known as the St Hyacinthi Church Goa, India. We will show how we can preserve the cultural heritages in minimum cost and effective manner. We will also comment on shortcomings and generic problems associated with photogrammetry method.

Description of the heritage site

St. Jacinto Church [1] which graces the St. Jacinto Island, was originally a chapel. Its Transformation since then, from a chapel to a parish has a flow to it. The chapel traces its existence prior to 1731.The chapel was then reconstructed in 1789. To cater to the growing number of its parishioners, it was further expanded. It was granted its status as an independent parish in 1853 on the 16th of April.

Figure 1: St. Jacinto Church

Photogrammetry

Photogrammetry is the technique of taking multiple overlapping photographs and deriving measurements from them to create 3D models of objects or scenes. The basic principle is quite similar to the way many cameras these days allow you to create a panorama by stitching together overlapping photographs into a 2D mosaic. Photogrammetry takes the concept one step further by using the position of the camera as it moves through 3D space to estimate X, Y and Z coordinates for each pixel of the original image. Here we are dividing our process into three parts viz. visualization, reconstruction, analysis.

Visualization

In photogrammetry technique, the biggest impact on the final output file is what happens in the shooting phase therefore getting decent set of photos is significant part of the process. Photos may need to be pre-processed before using them. There is a specific methodolgy to generate a good starter set for the photogrammetry.

Step 1 : Shooting images

We need to shoot nice, clean, sharp, evenly lit images, with every surface of our subject visible from different angles and positions. We used Canon EOS 100D at 250 ISO to shoot pictures for our model. The images you capture should have more than 40 percent overlapping between two consecutive images. The best time for shooting images is morning or on overcast days, we need to avoid the shadows. It is not recommended to use flash or variable zoom for the pictures. We can use circular polarizing lens to avoid reflection from shiny objects.

Figure 2: some images from our set

Step 2 : Pre-processing the images

To get best results from our set of images we need to make some adjustments to the images. We can tweak the contrast, brightness, white balance of the images to make them look even across our set. Secondly we need to mask the unnecessary features out of the images. It will give us better results and save our time by ignoring the calculations in masked areas. We achieved this task with adobe photoshop.

Figure 3: preprocessing of the images in photoshop and masking Agisoft PhotoScan

Reconstruction

We will use Agisoft Photoscan to contruct our photogrammetry model. Other options are autodesk 123D, autodesk remake. This process is hardware intensive, and we need a computer with high processing power and memory. For this project we used 1.7 GHz laptop with 8 GB RAM and 2 GB graphics memory. Processing of images with PhotoScan includes the following main steps:

- loading photos into PhotoScan
- inspecting loaded images
- removing unnecessary images
- aligning photos
- building dense point cloud
- editing dense point cloud
- building mesh (3D polygonal model)
- editing mesh
- generating texture
- exporting results

Aligning photos

Once photos are loaded into PhotoScan, they need to be aligned. At this stage PhotoScan finds the camera position and orientation for each photo and identifies the overlapping parts. Alignment having been completed, computed camera positions and a sparse point cloud will be generated. We can inspect alignment results and remove incorrectly positioned photos, if any. If the generated sparse point cloud vaguely takes shape of the subject, further processing will be easy and smooth, if not we should consider realigning the images.

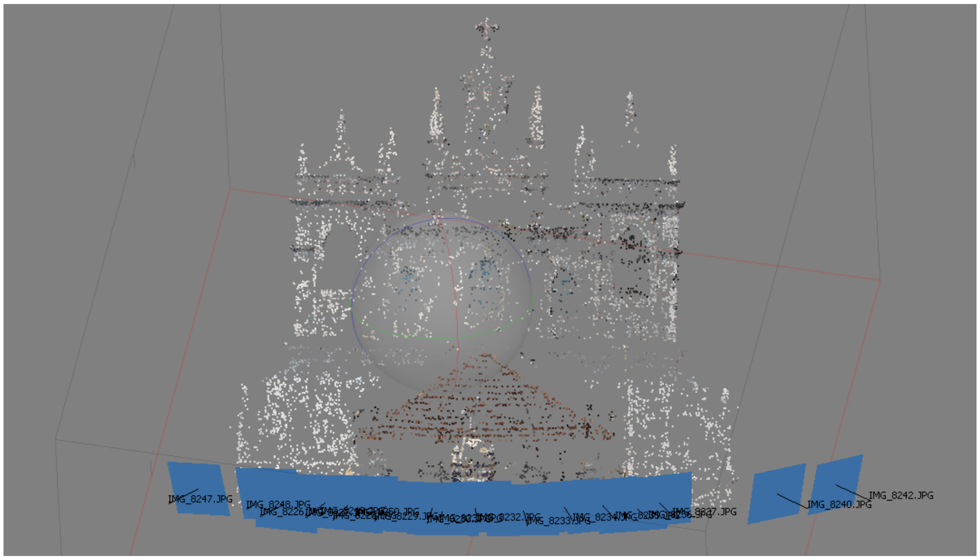

Figure 4: Generated sparse point cloud with camera positions

Building dense point cloud

PhotoScan allows us to generate and visualize a dense point cloud model. Based on the estimated camera positions the program calculates depth information for each camera to be combined into a single dense point cloud. At this stage, we can select the desired quality of the model from very low to very high. Program also offers depth filtering from mild to aggressive mode. For subject with more details on the surface mild is preferred. We used very high quality mode with moderate depth filtering. The resulting dense cloud will be very similar to sparse point cloud model.

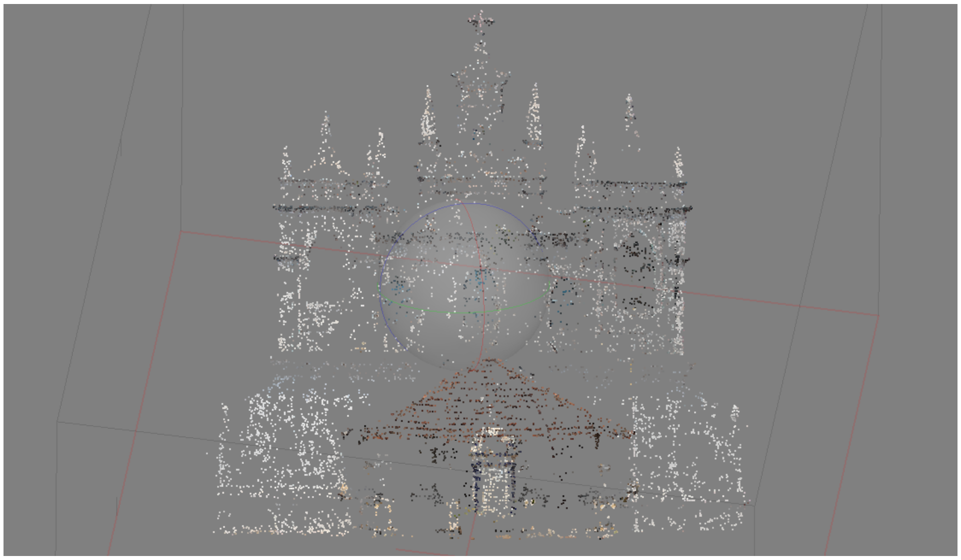

Figure 5: Generated dense point cloud model

Building mesh and texture

What we have obtained till now is a cloud of thousands or millions of points, 11,502 points in our case. To obtain the mesh each set of three adjacent points is connected into a triangular face, which combine seamlessly to produce a continuous mesh over the surface of your model. At last the original images are combined into a texture map and wrapped around the mesh, resulting in a photorealistic model of your original object.

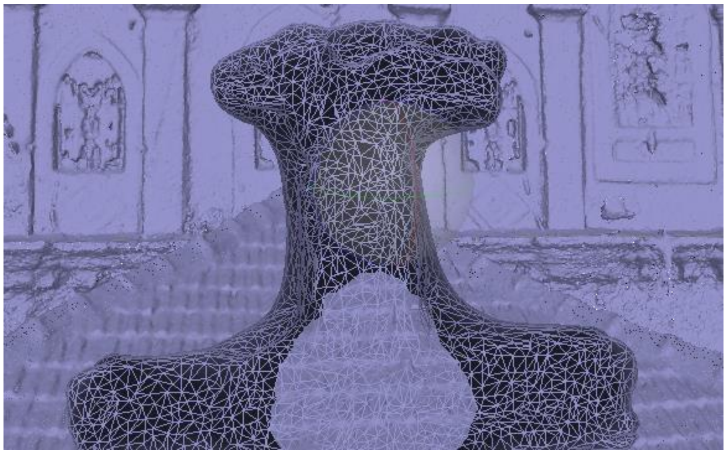

Figure 6: generated mesh model view

Analysis

We obtained the final model of the Sao Jacinto church from photos using photogrammetry technique.

Figure 7: Final textured model produced

Features of photogrammetry

- Photogrammetry is easy to use, and can be learned quickly.
- It gives very good results subject to only requirement, high quality pictures. In our project also, we got a very decent texture of the model.
- The cost of this method is very low, we only require good camera and computer. Though better the camera and hardware of the computer, better the quality of output and time efficiency will be.

Figure 8: zoomed view of the final model. With high quality images, the generated texture is decent.

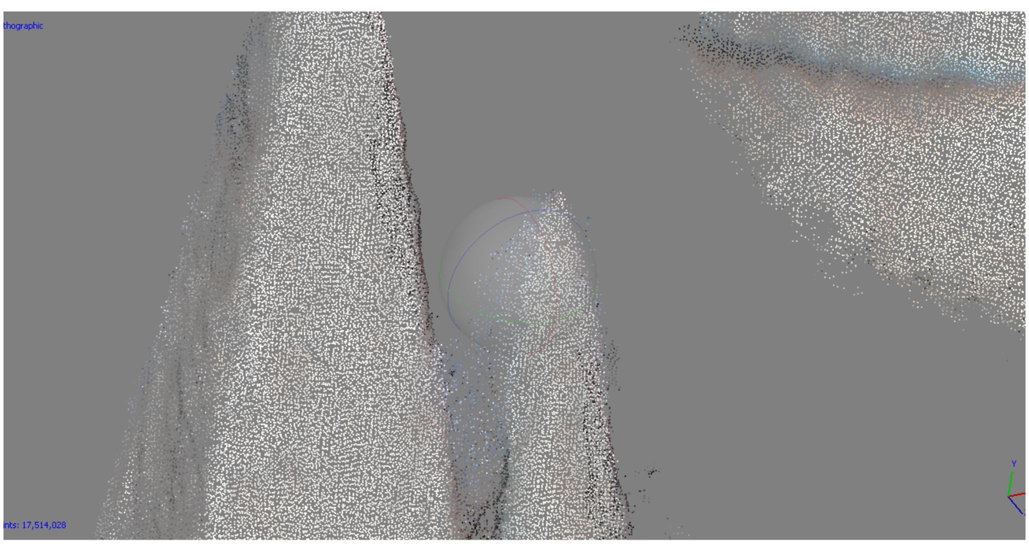

Figure 9: Close view of point cloud

Shortcomings of photogrammetry

- We can not get a very detailed model compared to hand-rendered model in some 3D modeling software like Maya or Blender. The edges may be blurred and there might be missing features.
- This method is very hardware intensive. If you reequire model of very detailed subject, it would requires a lot of memory and processing power for computer.
- As the generated mesh and textures are made up of very high number of points, any further changes in the model will require almost as much time as making a new model. The mesh is single object and it can be very intensive for softwares like maya or blender to edit it.
- The photogrammetry fails when there is recurring pattern of symmetry in the subject. As this process is based on superimposition of images, it may be difficult for software to identify which side view it is.

Figure 10: Missing part in the model. Photogrammetry tends to fail in case of symmetrical subjects.

Figure 11: jagged texture on edges. The texture on inside faces is very satisfactory

Conclusion

This paper presents an overview of our efforts in modeling-from-reality to create virtual models of cultural heritage items through observation of real heritage items and using photogrammetry method. We photographed the Sao Jacinto Church of Goa to obtain the exact structural information of the church for the purpose of preserving its cultural heritage. The photogrammetry software we used stiches multiple images taken by DSLR camera from different angle and positions.

This method can be used successfully to generate the models of cultural heritage sites at very low cost and great ease. All over the world, the world heritage sites need to be digitized and preserved. This method can be implemented by anyone to contribute to heritage preservation.

Here is comparison between the real church and model we produced.