# Bringing Regional Heritage Sites Into 3D Virtual Environments: Cost-Free Data Workflow and Multiple 3D Exhibition

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**Abstract**
*Today 3D laser scanning is a common technique for digital heritage preservation. We plan to widen the application of its usage to the preservation of regional heritage sites and in the same time, provide digitized 3D contents appealing to both local and general public, in order to enhance the sense of regional identity for the former and to promote tourism among the latter. Since there still remain cost and exhibition issues, we decided to use free, widely distributed software packages for all stages of data post-prcessing and 3D exhibitions. Meshlab and Google SketchUp with appropriate plug-ins are used for data post-processing and conversion. Google Earth and realXtend are employed as online exhibition platforms and Partiview for offline form. We checked and established the data workflow processes that employed above listed softwares starting with initial 5 million point cloud data of nearby 7th century ancient tomb, and succeeded in providing desired exhibition forms.*

**Key Words:** *Laser scanning, 3D Modelling, 3D Exhibition*

## Project Outline

### *Project aim*

The application of 3D laser scanning to digital preservation of heritage sites is now a popular and commonplace technique. Its results are proven to be of value for archaeological research and also for wider usage such as historical education[1].

Our plan is to apply this technique to local heritage sites in the region of Utsunomiya city and provide digitized 3D contents appealing to both local and general public. Today regional universities are encouraged to participate in and contribute to the local (not just academic) community. The distribution of public information to outer public is encouraged by the government[2].

### *Challenges*

The use of 3D laser scanning has been common for some time now. However, when we considered widening the range of its application, there were still problems remaining, namely:

- *Cost:* The cost of commercial laser scanning service including data post-processing is still

1 A pioneering example is "Cyark," http://archive.cyark.org/, accessed December 15, 2010.

2 Regional content production and tourism promotion is today a national concern in Japan. See Japan's Intellectual Property Strategic Program 2010. Accessed December 15, 2010, 14. http://www.kantei.go.jp/jp/singi/titeki2/2010keikaku.pdf

too high for ordinary academic use, such that basically only large-budget projects for major heritage sites can afford it.

• *Limited exhibition:* Many of the current virtual heritage software packages, either online or offline, are not widely distributed (Champion 2010, 17-18). This severely limits the possibilities of access for the general public.

To tackle these problems, we employed the following approach:

• Use only freely distributed software packages for all stages of data post-prcessing and 3D exhibitions.

• Provide 3D exhibition in widely distributed, multiple platforms.

This have become possible thanks to the recent trends such as the increased 3D rendering capability of consumer video cards, development of open source/free 3D softwares and development of point-based 3D graphics technologies (in the late 1990's). For the cost issue, the only cost left will be laser scanning itself, which we plan to eliminate by doing the scanning ourselves with a new generation cost-effective laser scanners[3].

## Methodology

### *Audience coverage plan and exhibition Software packages*

In previous section we proposed to employ multiple softwares for exhibition. The reason for this is that there is always a trade-off between the data quality that can be achieved and the ease of installation and/or popularity of an individual software package. Multiple exhibition schemes will allow us to cover different target audiences with different data resolution which will result in wider audience coverage. Figure 1 shows our audience coverage plan via 3 different exhibition softwares.

Three ellipsoids represent the range of audiences that can be reached. The innermost ellipsoid gives the smallest coverage but highest data fidelity. The target is the actual visitors of the institute or university. The middle ellipsoid mainly covers, but is not limited to, the local public. The service is online and data resolution is moderate. The outer ellipsoid has the widest coverage and this is for the general public that prefers casual access and fast data transfer.

To realize the above plan, we chose to use the following exhibition software packages: Partiview (www.dart.ncsa.uiuc.edu/partiview), realXtend (www.realxtend.org) and Google Earth (www.googleearth.com).

Partiview is a stereoscopic 3D or 4D (space 3D+time 1D) viewer for large-scale point datasets. It was primarily developed for use in astronomy in NCSA and is distributed freely with the source code. It can deal with datasets consisting of millions of points. For example, a raw 5 million point cloud can be displayed within an ordinary PC with a $300 video card. It is also capable of stereo rendering.

RealXtend is a variant of the Second Life clone software 'OpenSim', developed by several allied companies in Finland and is also distributed freely with its source. It is based on powerful OGRE (http://www.ogre3d.org) 3D graphics engine and thus gaining popularity for its aesthetic qualities. What is most important especially for our purpose is that the polygon mesh can be imported in the OGRE .mesh format, which means near free-form 3D objects can be put into their connected virtual world.

Lastly, Google Earth is the ever-so-popular 3D GIS software provided by Google. It is capable

3 A new generation laser scanner costs 1/3-1/4 of previous generation price. Early report is given at: http://sparllc.com/archiveviewer.php?vol=08&num=11&file=vol08no11-08. Accessed December 15, 2010.

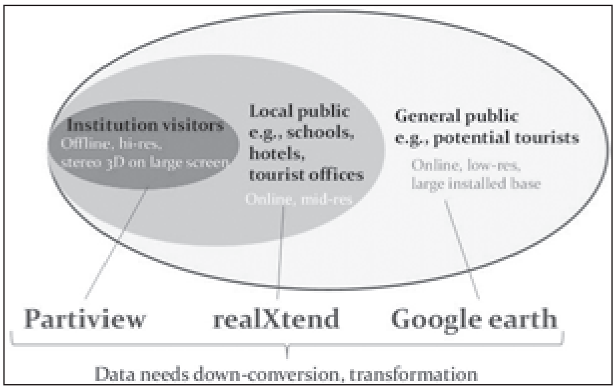


*Figure 1. Audience coverage plan via 3 different exhibition softwares.*

of displaying low resolution polygon meshes of buildings or other structures overlaid on satellite images of the Earth's surface.

*Data workflow and conversion/ transformation software*

Next, we have to think about data down-conversion and transformation.The raw laser-scanned data is in the form of point clouds which contain millions of points. Though each manufacturer has their proprietary data format, they can be converted into readable ASCII format, usually with minimal effort. It needs to be down-converted to more manageable data size and transformed into a polygon mesh for the exhibition softwares in which rendering is polygon-based. The actual workflow we established is depicted in figure 2.

The main software for data down-conversion and transformation is Meshlab (http:// meshlab.sourceforge.net). It provides the means to read, edit and down-convert (= reduce the point density of) raw point cloud data, generate a polygon mesh and write the results in various formats. We chose .ply ASCII format for preliminary output to Partiview since the data is compatible with the input format of Partiview (.speck) except for a few header lines which can be easily deleted with any text editor.

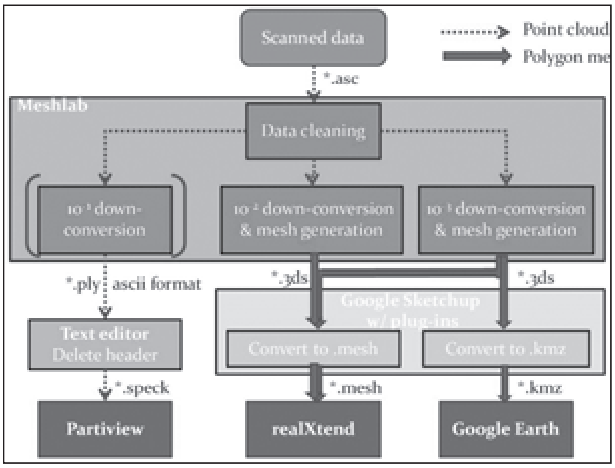


*Figure 2. Data conversion/transformation workflow.*

For realXtend and Google Earth, we needed a different conversion software since they can only read and display polygon mesh data in their proprietary format (.mesh, .kmz). We used Google SketchUp (http://sketchup.google.com) with appropriate plug-ins for .mesh output[4]. Note that 2 meshes with different resolution, each for rendering and collision detection, are necessary for realXtend. As we will show later, coarsening of the latter mesh is critical for the smooth frame rate due to the fact that calculation for collision detection deteriorates the video performance significantly when the mesh is kept unnecessary dense.

## Test Results

In this section we present the results of the test of the data workflow process applied to an ancient tomb near our campus. Figure 3 is a picture of the tomb.

The tomb is called Nagaoka hyaku-ana Kofun in Japanese, which means "Nagaoka 100-hole ancient tomb". It was built around the 7th century and has been selected as one of

4 "MakeFaces," http://www.smustard.com/script/MakeFaces

"realXtend Export Tools," http://www.realxtend.org/page.php?pg=downloads

"SketchUp to Ogre Exporter," http://www.di.unito.it/~nunnarif/sketchup_ogre_export


*Figure 3. The picture of Nagaoka hyaku-ana Kofun.*

*Figure 4, Stereo point cloud image rendered in Partiview on 170-inch passive stereo 3D system*

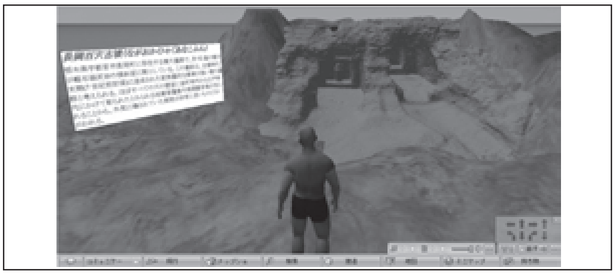

*Figure 5. Approximately 30k polygon mesh rendered in realXtend.*

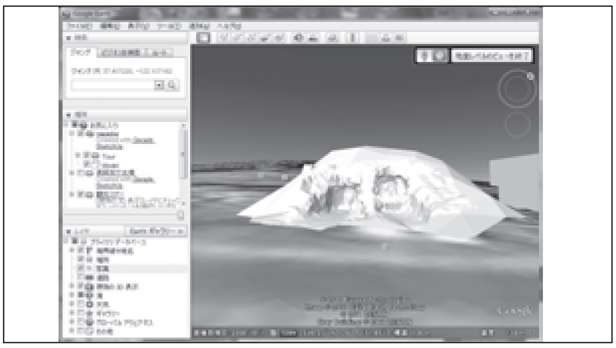

*Figure 6, Approximately 2k polygon mesh rendered in Google Earth.*

the acknowledged historical sites of Tochigi prefecture. Additional reliefs of Buddhas were carved in the front walls of the lateral holes in later centuries, which suggests that it remained respected by people as a religious, sacred place.

The 3D laser scanning measurement was done by engineers from Nikon Trimble and a laser scanning company 3D Survey Plus LLC. The scenner used was a Trimble CX. The data obtained was a point cloud of approximately 5 million points.

We first show the result with Partiview in figure 4. The image in the figure is that of 0.5 million data points, which is a reduction of 1/10 of the original 5 million points. The PC used for rendering was Dell precision T7500 equipped with 3.33GHz Intel Xeon 5590 and NVIDIA Quadro FX5800 video card.

We chose this resolution because, although original 5M data could be displayed within Partiview, the frame rate was only a few fps which was actually frustrating to watch. It seems that 1 million points (particles) is the threshold of 'comfort' in Partiview with our PC. Details like Buddhas in lateral holes were still visible with a smooth enough frame rate at this resolution.

The result with realXtend is shown in figure 5. The number of polygons is approximately 30,000. This is the upper limit of Meshlab for exporting data correctly in .3ds format. The rendering PC was equipped with 2.4GHz AMD Athlon 64X2 and NVIDIA Geforce 8600GT.

We can see a good rendered image even with the much reduced number of points (vertices) compared to the 0.5M point cloud in Partiview. The frame rate was satisfactory when the mesh for collision detection was made coarse enough, which was in this case around 2,000.

Finally, the results obtained with Google Earth are shown in figure 6. The reduced 3D model

| Software | Data type and scale | Characteristics |
|---|---|---|
| Partiview | $10^6$ hi-res point cloud | Hi-res stereo 3D. Minimum data processing necessary. |
| realXtend | $10^4$~ polygon mesh | Good rendering quality. Needs mesh generation, client installation. |
| Google Earth | $10^3$~ polygon mesh | Details are lost. Needs mesh generation. Huge intalled base, combined with geo-information. |

*Table 1. Comparison of 3 exhibition softwares*

of approximately 2,000 polygons is rendered in Google Earth. This number was chosen from our experience that a test with approximately 7,400 polygon data could be displayed but not comfortably manipulated. The rendering PC was the same as the one used for the realXtend. The .kmz file is uploaded to Google's 3D warehouse and can either be downloaded and viewed in Google Earth or directly viewed in a 3D map on the web page.

In figure 6, it can be seen that the details are lost e.g. Buddha reliefs are unrecognizable. However the data access is fast and the download time is negligible since the data file is only 115kB.

Table 1 summarizes and compares our experiences with the different exhibition software packages.

## Conclusions and Future Work

We have proposed the application of 3D laser scanning to regional heritage sites. To tackle cost and audience issues, schemes of cost-free data workflow and multiple exhibitions with existing free software packages have been proposed and tested.

The collection of 3D data of regional heritage sites via owned laser scanner and their exhibition to the public is now planned and will hopefully start next summer.

## Bibliography

Champion, E. 2010. *Playing with the Past*. New York/London: Springer.