# Scan Processing

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**Abstract**

This document presents several cases of geometry processing and rendering techniques on unstructured point clouds acquired with 3D scanners. In particular, fast appearence preserving of large data sets, surface-based hierarchical clustering and interactive out-of-core texturing are illustrated through several examples.

## 1 Introduction

Automatical modeling can help to obtain complexe objects in few seconds. But 3D acquisition devices have a lack of precision (noise [9]), and can only produce depth grids from various points of view, usually put together in a non-uniform point cloud. Surface reconstruction and Point-based graphics techniques have been developped to create tools that fit these constraints, with or without the help of the user.

## 2 The Acquisition-Processing-Rendering Pipeline

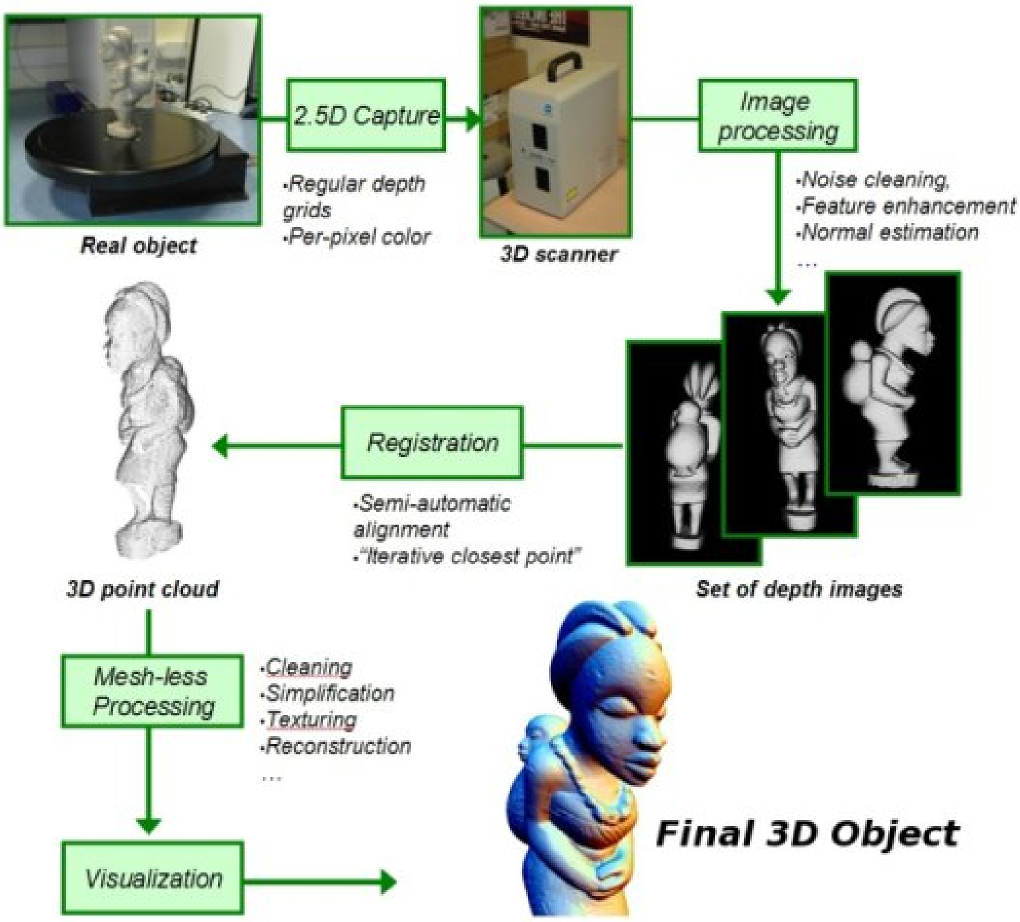
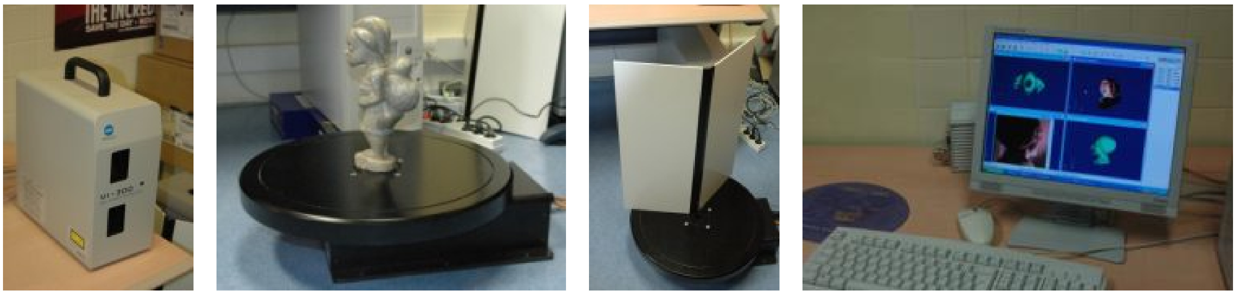



Figure 1: **The Acquisition-Processing-Rendering Pipeline**.



(a) Scanner (b) Rotating-Table (c) Chart (d) Workstation

Figure 2: **The Harware Pipeline**.

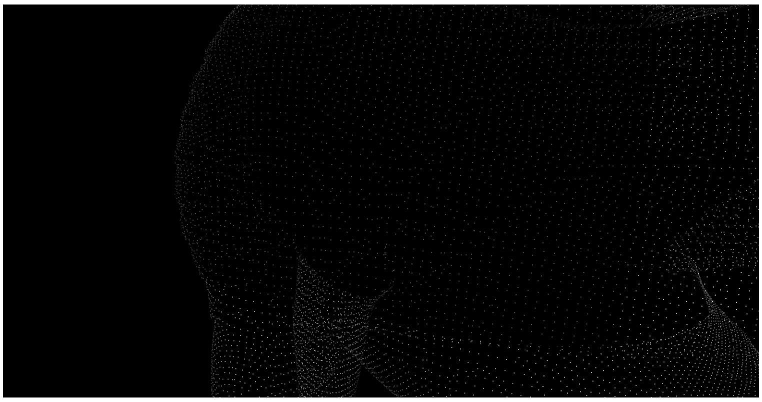
**Scanner**. Our 3D scanner is a Minolta Vivid VI 300. It is a Laser Range Scanner, which produces a 400x400 color resolution, and 200x200 depth resolution. Its main advantage is its mobility and its main drawback is its lack of precision (e.g., noise). Our approach is to directly work on point sets generated by aligning several scans (registerind scan sheets). In fact, the topology providen by the scanner is a simple view-dependant 4-connexity, wihch can induced many artefact when considered as valid. So, we discard any topology information, and just convert the scans toward a point set by changing the local frame of the scans (each pixel of the scan sheet can be considered as a 3D point with (x,y) its coordinates in the depth image and (z) the value of the pixel). Of course, a complete topology (a 2-manifold mesh) is necessary in a large variety of applications, but we try to maintain topology-free models during the whole processing pipeline, generating a surface only at the end, once the model is considered as valid. For this, we use different texturing/filtering tools, visualization systems and reconstruction algorithms that all work with generic unorganised point clouds.

**Rotating table**. We use a rotating table to obtain 360 scans (actually done with 6 (resp. 8) scans by 60 (reps. 45) degrees step). This table can support the weight of an adult, which makes easier the acquisition of human faces.

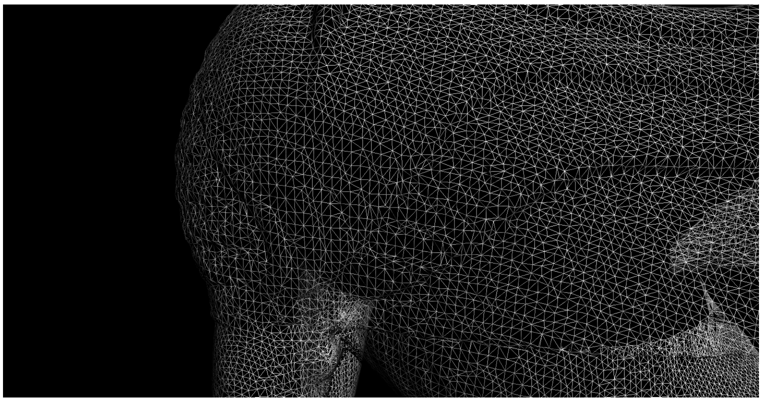
**Chart**. This simple chart is used after the last scan : this additionnal capture helps to estimate a rotation axis.

**Workstation**. The acquisition task is performed on an AMD Athlon XP2000+, with 1GB of main memory, an nVidia GeForce Ti 4600, 60 GO HD, and an SCSI card. Some interactive operations, such as manual alignement of scans, require a powerful workstation. We convert scans in point sets and export them toward Osiris and PointShop 3D for processing and visualization. We use to work on a per-scan basis, since the Polygon Editing Tool provided by Minolta is quiet unstable, and regulary crashes for too complexe objects (more than 8 scans).

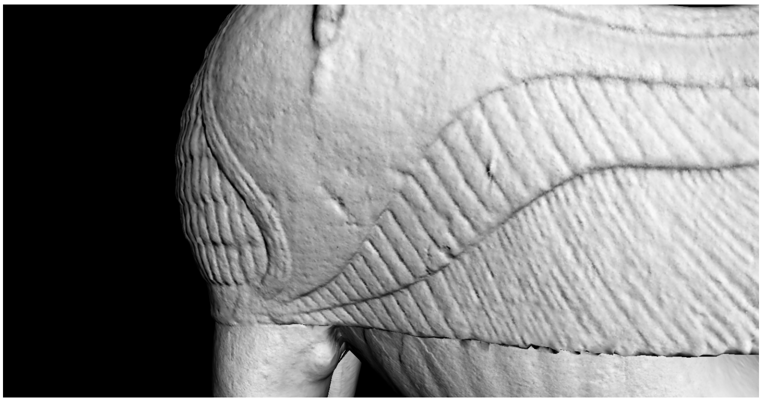
## 3 Efficient Visualization of Large Point-Based Surfaces



(a) 80k samples from 5M polygons



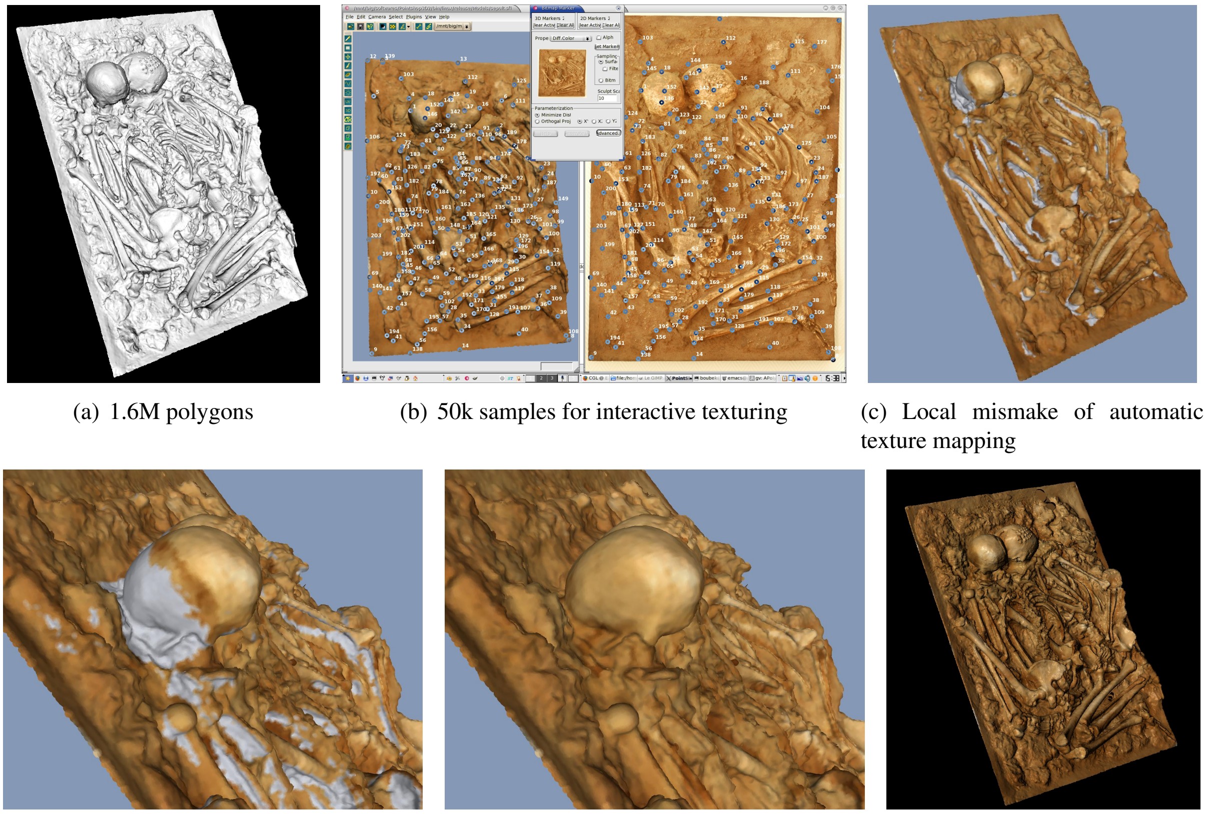
(b) Coarse Mesh Generation suing surfel stripping



(c) High-Resolustion Normal Map by localized push-pull (stream implementation)

Figure 3: **Large Data Visualization: the Sphinx of Naxiens**. The first system for direct "large point set" to "detail-preserving normal mapped meshes" conversion, without intermediate large mesh generation/storage/processing. [3, 5, 4, 1, 6]

# 4 Scanned Model Editing



(a) 1.6M polygons

(b) 50k samples for interactive texturing

(c) Local mismake of automatic texture mapping

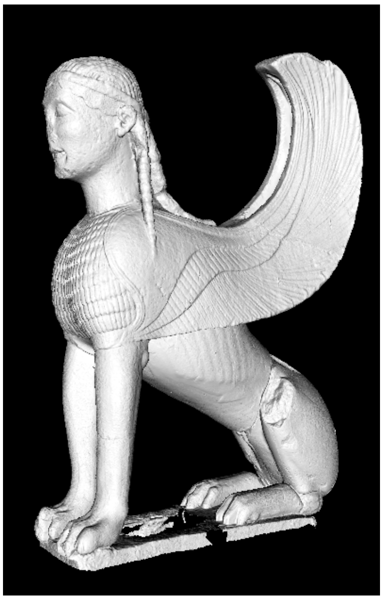
(d) Close-up

(e) Up-sampling and brush repairing by users

(f) 1.6M textured polygons

Figure 4: **Recoloring models for *Cultural Heritage*:the Sepulture example**. (a) Original scanned object. (b) Point-based texturing of a point-sampled version : bitmap integration, brush painting, smoothing, etc. (c) Fast texture projection on the point cloud, with distance minimisation (*markers* constraints). (d) Local Up-sampling. (e) The user paints missing parts and *repairs* the model texturation. (f) Application of the PST to the original large object and Out-Of -Core real-time rendering with QSplat.[7]

# 5 Large Data Processing



(a) 10M polygons

(b) partial texturation

(c) QSplat Rendering

Figure 5: **Large Data Processing: the Sphinx of Naxiens**. This model has been built by archaeologists from early scans. The resulting mesh is a 10 millions polygons set, too huge to be textured **interactively**. Now, our system allows to texture it using simple photos from the net and some original written descriptions.[8]

# 6 Scanning Natural Environnement

**Acknowledgements** Data sources are courtesy of Ausonius.

## References

[1] Tamy Boubekeur, Florent Duguet, and Christophe Schlick. Rapid visualization of large point-based surfaces. In *Proceedings of ACM Graphite 2005*, December 2005.

[2] Tamy Boubekeur, Wolfgang Heidrich, Xavier Granier, and Christophe Schlick. Volume-surface trees. *Computer Graphics Forum (Proceedings of EUROGRAPHICS 2006)*, 25(3), 2006.

[3] Tamy Boubekeur, Patrick Reuter, and Christophe Schlick. Reconstruction locale et visualisation de nuages de points par surfaces de subdivision. In *Actes des 17ièmes Journées de l'Association Française d'Informatique Graphique (AFIG)*, 2004. best paper award.

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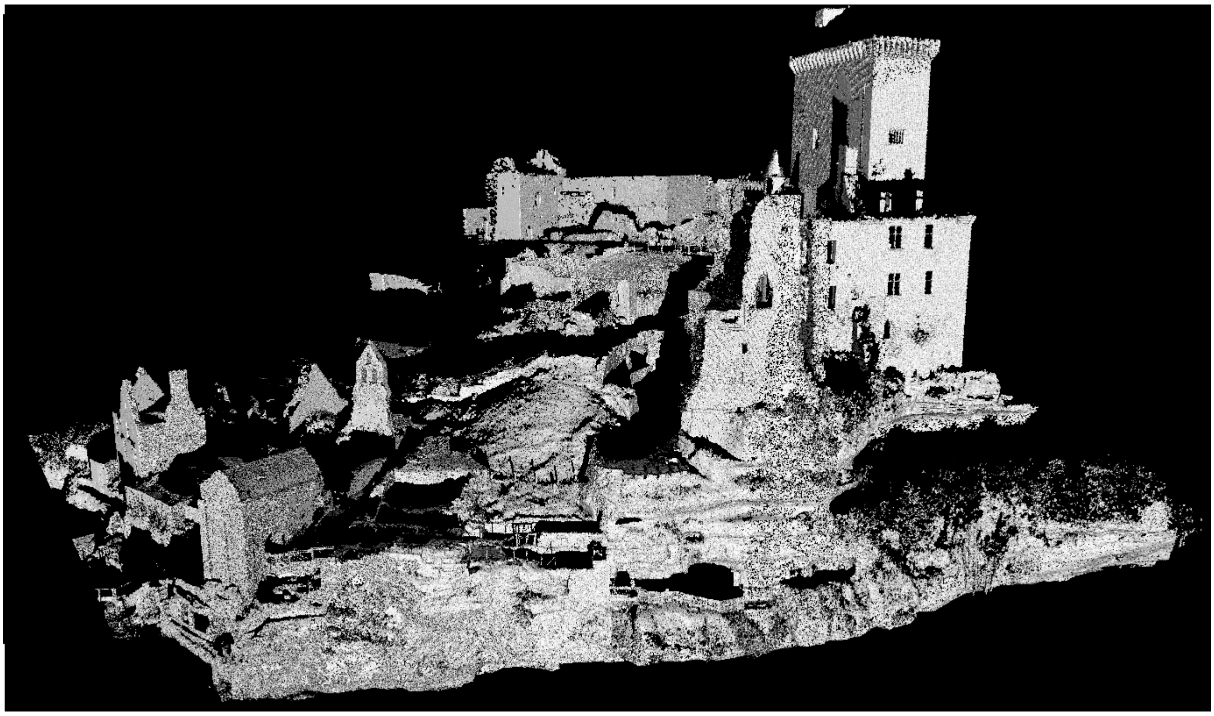
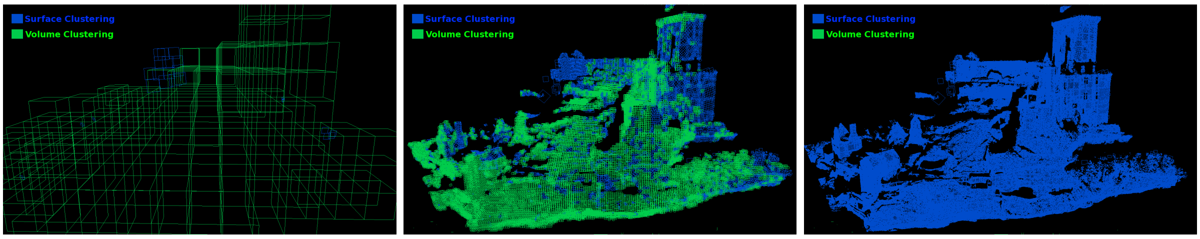
[7] Tamy Boubekeur and Christophe Schlick. Interactive out-of-core texturing. In *ACM SIGGRAPH 2006 - Sketch Program*. ACM, August 2006.

[8] Tamy Boubekeur and Christophe Schlick. Interactive out-of-core texturing using point-sampled textures. In *Proceedings of IEEE/Eurographics Point-Based Graphics 2006*. Eurographics/IEEE Computer Society, August 2006.

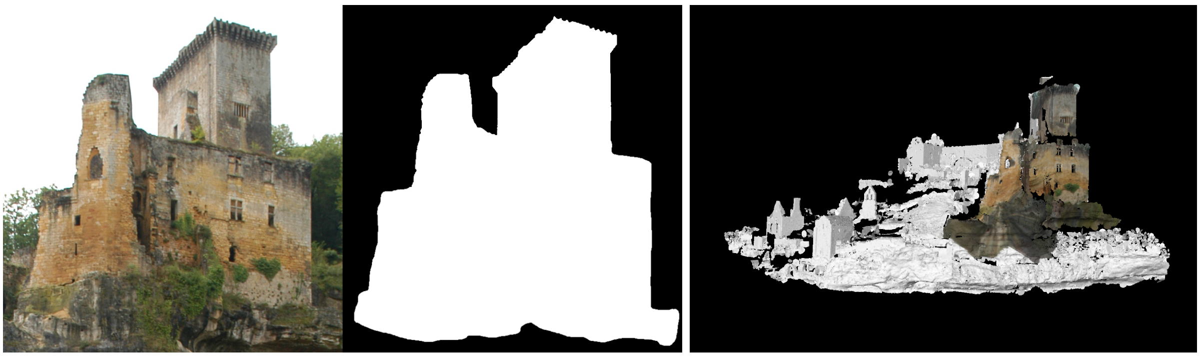
[9] Patrick Reuter, Pierre Joyot, Jean Trunzler, Tamy Boubekeur, and Christophe Schlick. Surface reconstruction with enriched reproducing kernel particle approximation. In *Proceedings of the IEEE/Eurographics Symposium on Point-Based Graphics*. Eurographics/IEEE Computer Society, 2005.



(a) Laser Range Scan of the Chateau




(b) Volume-Surface Clustering



(c) Interactive-Out-Of-Core Texturing

Figure 6: **Scanning Natural Environnement: the Castle example**. (a) 7 millions point-samples coming from the registration of 6 scans. Each scan has been obtained using a time-of-flight scanner, suitable for distant and large scale object scaning. (b) Hierarchical Volume-Surface clustering: man-made objects quickly appear during the clustering. (c) Interactive out-of-core texturing: using several photos and some texture pattern of stone, wood and grass, the environnement model is increased with color-information for each points in a full size-independent stream process.[2]