Towards a Virtual 3D Reconstruction of a Rood-Screen from its Archaeological Fragments

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Abstract

The micro-architecture in the Netherlands (XVth - XVIth centuries) is being studied with a comparative method. More than ten thousand exceptional fragments of stone sculpture have been excavated at the Brussels main collegiate church. The study reveals that the fragments are part of a rood-screen and a carved tabernacle.
The purpose of this project is to develop a method in order to help the art historians and archaeologists to reconstruct archaeological objects. A first manual classification divides the non painted remains into three main groups: architectural, floral and figurative motives. We first focus on the architectural remains.
At present, several automatic computerized methods exist, but most of them apply to particular kinds of objects like potteries, plates… which are not true 3D common objects.
We propose an approach that virtually manipulates the digitalized fragments through 3D geometric primitives. Up to now, these primitives are planes, lines and circles describing characteristics present on the architecture. The use of these primitives, by putting them in correspondence and by respecting their continuity, reduces and simplifies the range of possible associations between fragments. Then, the result of the association performed by the computer is proposed to an expert who can validate it.

Introduction

In 1991, archaeological excavation at the Brussels Saints-Michel-et-Gudule collegiate church has revealed amounts of carved stone remains. These finds open the way to new interpretation on the production of the Brussels and Brabantine Sculpture. The authors are working on remains of gothic and renaissance stone sculpture from Brussels.

Cédric Laugerotte and Nadine Warzée (SLN, ULB) are developing 3D reconstruction methods in order to virtually rebuild micro-architecture monuments and propose a computer aided assembling and visualization tool for the work of archaeologists.

Pierre Anagnostopoulos and Alain Dierkens (URHM, ULB) are studying stone micro-architecture in the Low Countries during the XVth and XVIth centuries.

This collaborative work will provide the old rood-screen that stood in the Brussels main collegiate church with a closest reconstitution.

Rood-Screen

Evolved from early forms of roman "cancello" and Byzantine "iconostasis", the medieval rood-screen is a larger structure with a doorway and an high arcade. It stands at the entrance of the choir, facing the principal nave of the church. Rood-screens were once found in many churches in the Low Countries and the oldest surviving example is that of the Sint-Pieter collegiate church at Leuven, which has recently been restored (Leyrens 2000) (Fig.1). This rood-screen stands as a reference in stone micro-architecture in the XVth century Netherlands since only a few other rood-screens still remain today (Steppe 1952).

Figure 1 Rood-screen. Leuven
Saint-Pieters collegiate church, 1450-1485

Figure 2 Rood-screen. Brou, Saint-Nicolas-de-Tolentin church, 1515-1530

Rood-screens have not only the physical function of dividing the ecclesiastical space; they also convey an emanation of the sacred (Jung 2000). Under the arcade, Brabantine rood-screens are open in the centre, flanked by solid walls in front of which stood altars. On the far side, facing the choir, it is connected to the choir stalls.

Above, rood-screens consist of openwork and an array of niches containing statues or religious scenes. Finally, they are crowned by a long openwork railing, as in the example from Brou (Fig.2). Steppe (1952) relates that during the mass or laic ceremonies the priest, the singers and also church officials could stand on the rood-screen. Rood-screens are good examples for demonstrating the evolution in micro-architecture in the Low Countries between 1450 and 1550, from the end of gothic period to the Renaissance (Kavaler 2000).

At Saints-Michel-et-Gudule church, Brussels, the rood-screen had probably been largely restored or partially remodelled around 1450 and was finally destroyed at the end of the XVIth century (Lefèvre 1942).

Archaeological Discovery at Brussels Main Collegiate Church

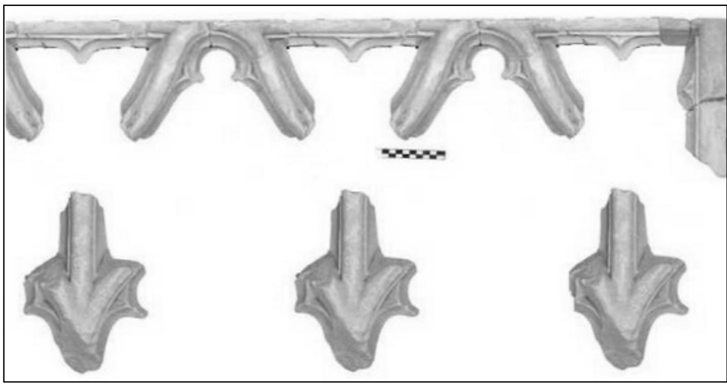
In the 1991 excavations under the floor of Saints-Michel-et-Gudule main collegiate church (Bonenfant 1998), 11600 stone sculpture fragments from the XVth and XVIth centuries were discovered. They represent the mixed remains of several monuments, most probably from around the choir, that were severely damaged by the Iconoclasts at the end of the XVIth century.

In dealing with these remains, we are faced with five major problems which have formed the starting point of an original method of classification.

Classification Method and Comparative Study: First Results

The classification method developed by one of the authors in a graduate thesis (Anagnostopoulos 2001) is currently used to enhance new results on the reconstitution of the rood-screen. The non-polychrome mouldings and floral elements are divided into 50 groups which are defined by their similarities in profile and size (Cabanot 1990). Combining together from two to six groups of mouldings can reveal the larger ornament of identifiable structures, such as the railing of the rood-screen (Fig.3) and a high pinnacle (Fig.4). The larger ornaments can be used to create new groups that can be matched together to form broader ensembles.

To facilitate this approach, digital photography was used, both to archive the fragments and to provide the means of creating a virtual 2D reconstitution of the rood-screen. With the help of a laser scanner, 3D reconstruction and 3D modelling is a key tool to virtually rebuild the rood-screen and other small scale monuments.



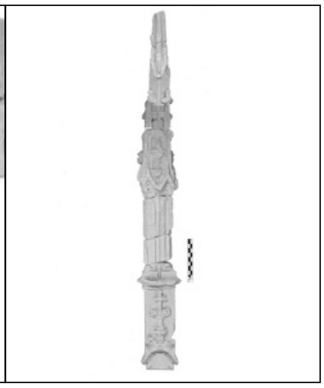


Figure 3 (left)Railing of the Rood-screen.
Brussels, Saints-Michel-et-Gudule, XVth century. Scale: 1cm
Figure 4 (right) Pinnacle. Brussels,
Saints-Michel-et-Gudule, XVth century. Scale: 1cm

A global overview and simple classification is not feasible due to the great number of fragments. Also, the relatively small size of the remains reveal little of any larger structural or thematic elements or any continuous motifs. And, as several monuments have been identified among the fragments which are similar in style and shape (including a gothic tabernacle, a gothic rood-screen and a renaissance niche) it becomes extremely difficult to work with such an intricate group of sculpture. Furthermore, this micro-architecture has been carved from a soft white stone from Avesnes-le-sec, northern France, raising conservation priorities to ensure that these richly ornate sculptures do not suffer further damage.

Finally, there exist no XVIth century pictures, drawings nor prints which illustrate this gothic monument in the choir of the church. In order to arrive at a model close to the XVth century rood-screen in Saints-Michel-et-Gudule church, a comparative method is used to firstly classify the fragments, to understand their characteristics and, thence, by combining different motifs, provide a reconstruction of the whole architectural ornament.

3D Tools

[1]Method

The approach we adopted to define a virtual environment for the manipulation of archaeological fragments consists in reproducing, on computer, the methodology already used by archaeologists. In essence, it consists in making successive steps of classification to isolate the sets of fragments displaying similar characteristics (size, colour, geometry, etc). Next, associations between fragments of the same set are attempted and tested on the basis of relations between these characteristics.

Most of the fragments used had already been classified by archaeologists according to their architectural form and/or floral ornamentation. Our technique of extracting characteristics and testing of assemblages by computer essentially replicates the manual method of the archaeologists.

[2] Set of validation

In order to validate the techniques of assemblage presented here, we first turned our attention to fragments from a niche which has been partially reconstructed and identified as a shell-like sculpture. The niche is "small architecture" (smaller than 1mx1m) and the number of available fragments is 24 (including fragments which may not belong to this niche). This limits the complexity of the tests while allowing us to focus on validation of the techniques. This choice was made for several reasons. First, details on these fragments are simple enough to identify points, lines, circles or planes. Secondly, the success of the technique can be judged by comparing our result against the manual assemblage of the fragments made by the archaeologists.

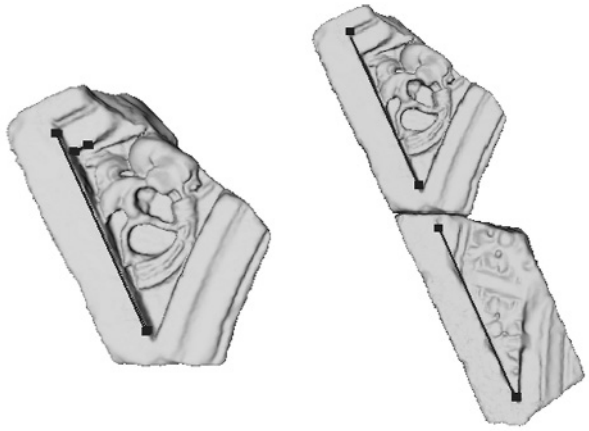


Figure 5 Extraction of features (left) and association between virtual fragments (right)

[3] Acquisition

It was felt that the technique demanded highly-accurate 3D models of the stone fragments since the level of detail on the fragments can be less than one millimetre. This, and the fragility of the fragments, suggested a non-contact acquisition technique and we chose a system based on the laser stripe triangulation. The device we used is the 3D scanner FastScanä commercialized by Polhemus.

[4] Extraction of features

The first step of our method consists in an interactive analysis of a fragment to select significant geometric features such as planar surfaces, ridges, valleys and axes of symmetry (Fig.5). The method used to isolate features are based on the analysis of differential parameters of the surface, such as normals (Thürmer 1998, Max 1999) and principal curvatures (Do Carmo 1976), deduced from the 3D mesh (Taubin 1995, Meyer 2002) and selected according the techniques of thresholding (Roessl 2000) and the analysis of local properties (Watanabe 2001). Then, for each feature, a simple geometric primitive (point, line, arc of circle) is associated. This primitive is obtained by approximation of the feature with classic methods of fitting and minimization (Eberly 2000, Thomas 1989).

[5] Assemblages

The association of different fragments of sculpture is possible through the manipulation of the geometric primitives which have previously been extracted. These primitives are selected manually and associated automatically by orienting and moving them in order to respect a continuity between them. For instance, two lines are oriented to be parallel and their extremities are identified (Fig.5). Concerning circles, they are oriented to make the tangents to the extremities parallel. Then, the extremities are identified. Moreover, the identification of the extremities can lead to situations where an overlap may occur between the fragments. To correct this effect, one of the fragments is moved in the direction of the geometric primitive used for the association till there is no more overlap. So, we get a configuration similar to a contact between the fragments.

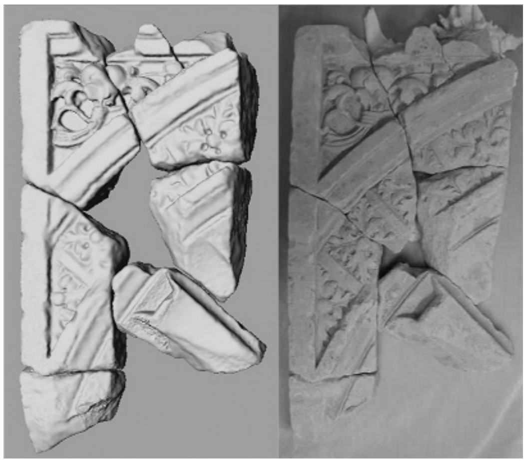


Figure 6 Reconstructed left top side of the niche.

Virtual reconstruction of the Niche

[1] Assemblage of the fragments

After several associations between the 24 initial fragments through planes, lines and circles, the result was compared to the real assemblage on Figure 6. We notice that the virtual reconstruction is valid although there is one missing fragment due to the lack of information for a correspondence with its neighbours.

[2] Dimensions of the niche

From the assemblage we have obtained, it is possible to estimate the dimensions of the original niche (Fig.7).

Since the assemblage contains fragments from the upper and lower borders, it is possible to calculate the height of the niche as being 70 centimetres. In a similar manner, the depth of the niche is calculated to be 8.5 centimetres.

To estimate the width of the niche, we exploit the symmetry of the ornamentation appearing on the fragments. By identifying the point of intersection of the arcs leaving the base of the niche and the centres of the arcs of circle used for the assemblage, it is possible to estimate a centre of symmetry by averaging the previous points. Once this centre-point is determined, it is easy to measure the distance between it and the left side of the niche and thence determine the total width. The niche was estimated to be 1 meter wide.

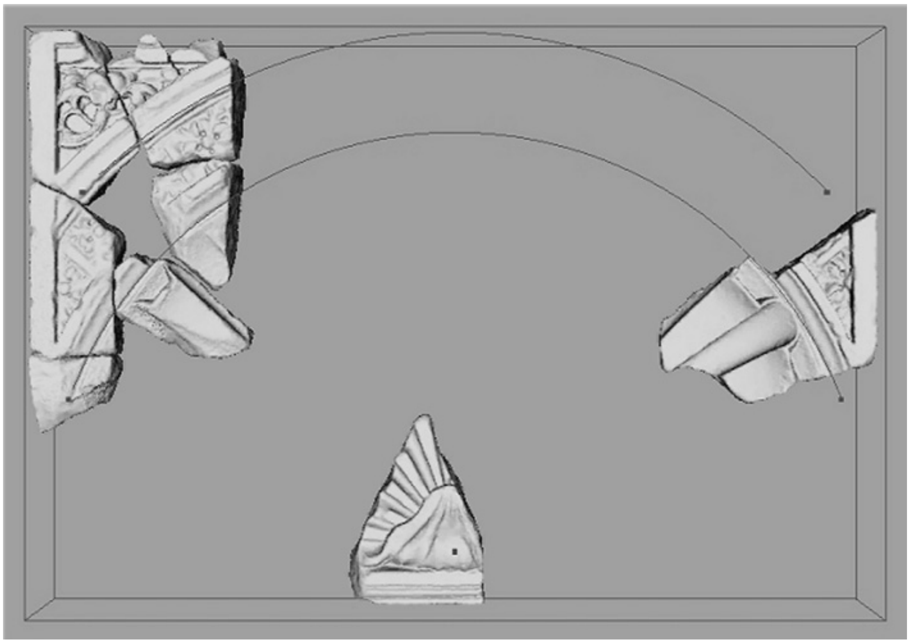


Figure 7 Dimensions of the niche. Virtually (left) and manually (right)

CONCLUSIONS AND FUTURE WORK

We have applied several techniques to develop a virtual environment to study, manipulate and assemble archaeological fragments into a virtual architectural reconstruction. The first method used photographs to archive and propose an initial 2D reconstitution. The second one is based on the analysis of 3D models of the fragments. These approaches were developed using "small architecture" as a study material for both simplicity and the ability to validate the approach by comparing "proposed" with "real" reconstructed assemblages. The results showed the efficiency of these tools to help us in the study of fragments and micro-architecture.

Thus far our work has focused on the reconstruction of a single niche. In the future, the tools and methods presented here will be used to further study the fragmentary micro-architecture of Brussels' main collegiate church, Saints-Michel-et-Gudule.

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