# 3D imaging applications for ancient wooden stamps analysis

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## 1. ABSTRACT

This paper deals with the analysis of ancient wooden stamps. The aim is to provide tools for historians to ease the manipulation of very fragile and unique objects. By performing first a 3D imaging of stamps, data are then processed into three different methods: 1) an adaptive thresholding on the corresponding range image enables to obtain the unknown produced illustration of the stamp, 2) an interactive enhanced rendering provides a realistic real time visualization and finally, 3) a rapid prototyping production gives a perfect geometrical copy of the stamps enabling a real risk safe manipulation.

**Keywords:** Cultural Heritage Conservation, Wooden Stamps, 3D Imaging, 3D Rendering, Rapid Prototyping

## 2. INTRODUCTION

The Troyes's municipal library is rich in old documents and books series (years between 1500 to 1900) among the most important in French provincial libraries. The collection of 150 000 books includes 1700 medieval manuscripts, 700 incunabula, 2500 hawking booklets from "Bibliothèque bleue" serie and about 800 engraved wooden stamps used to illustrate those documents. This richness heritage led the Troyes's municipal library to join the Ancient Document Digitization national program of the French cultural department since 1998. One of the main problems involved in this program is to develop software and image processing systems to allow efficient access to the documents[1]. This is the ANITA project (ANalysis of ancient Images and sTAmps).

This article is focused on the analysis of ancient wooden stamps. A typical wooden stamp is presented on Figure 1.

Figure 1 - Ancient Wooden Stamp

The main goal is to provide digital tools for researchers in book history for a suitable access and manipulation of the stamps. For the moment, stamps access and manipulation is really

difficult because of the storage (stamps are stored in basements) and the fragility of the objects (wood degradation). Our work is to develop tools able to acquire, handle, compare and visualize ancient wooden stamps and illustrations produced by inking and using a printing press with the stamps.
A non-contact method is being used to perform three main applications for the stamp analysis: virtual stamping, visualization and duplication. In this article we first develop the used 3D imaging techniques based on a portable 3D scanner. Each application is then described by explaining how the 3D data are processed.

## 3. 3D DATA ACQUISITION

Two 3D scanners of the Le2i laboratory and Plateform3D have been used for this project. These two apparatuses function according to the method of laser triangulation by projection of a laser plane.

**Replica 500 Scanner from 3DScanners©**
This scanner is provided with a sensor head (made of a laser plane and two CCD cameras) mounted on a 3 axes translation system. This scanner provides only point clouds. Figure 2 presents the system. The precision is 50 µm on the X and Y axis and 20 µm on the Z axis. The useful working volume is about 500x500x500 mm.

**VI-910 Scanner from Konica-Minolta©**
This scanner is compact, portable and is able to function in an autonomous way (without any associated microcomputer). It enables to capture the geometry and the texture of 3D objects. The acquisition of the geometry is carried out by a rotary sweeping of the laser plane. The acquisition of color texture is carried out by the capture of 3 images through red, green and blue filters mounted on a wheel. Figure 3 and Figure 4 present this system.

Figure 2 - REPLICA 3D Scanner

Figure 3 - VI-910 Scanner Front View


Figure 4 - VI-910 Scanner Back View

The precision is of 100 µm on X, Y and Z axis. This system enables the digitization of 10 mm to 1 m width objects.

**Data acquisition**

Two digitalization campaigns have been realized. The first one, realized in the laboratory in May 2002 with the Replica scanner has validated the feasability of the virtual stamping on a small amount of stamps. The second one (Figure 5) was held in the TROYES' library in December 2003. 12 typical stamps from the XYL collection (the first wooden stamps classified collection of the library) were acquired with the MINOLTA scanner. These measures permitted to validate the three applications of 3d digitalization for the analysis of engraved wooden stamps.

Figure 5 - On site 3D Scanning campaign – TROYES - FRANCE

## 4. VIRTUAL PRINTING

From a real stamp, the produced illustration must be found. This (binary) image must be close to one produced by inking and using a printing press. Of course, inking the stamps is forbidden as they are ancient sole museum pieces. It is thus impossible to put any product on the stamp.

**Data pre-processing**

"Virtual" stamping is performed by first converting the 3D model to a range image. The starting data are the point cloud of digitized stamps. These sets of points co-ordinates are expressed in a three-dimensional space. These data can also be represented by a plane projection according to a point of view. This representation is called a range image. A range image is an image whose intensity is proportional to the altitude of the considered point. Figure 6 and Figure 7 respectively present the points cloud and the resulting range image of the "Le Vray Pêcheur" stamp.

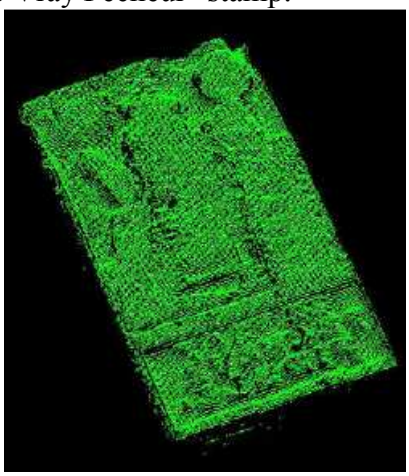

Figure 6 - Points cloud

Figure 7 - Range Image

**Virtual printing process**

The binarization is computed in order to simulate the printing process with black ink on white pages. As in a stamp, the printing zones are high elevation ones; the high gray level pixels in the range images have to be binarized as black (pixel = 0). The non-printing zones have therefore to be binarized as white (pixel = 1).
We use a modified Niblack's algorithm to binarize range images[2, 4]. The principle is to adapt the threshold over the image. The threshold is determined from the local mean and the local standard deviation, computed on a restricted neighbourhood for each pixel.
Let us define :

- m: the local mean computed on a [w x w] neighbourhood
- M: global mean computed on the complete range image
- s: the local standard deviation computed on a [w x w] neighbourhood
- t: the local threshold for each pixel
- k: a user defined parameter

The binarization is computed as follows :
For each pixel of the range image Do
    If m >M Then t = m + k.s  (the neighbourhood is in a high elevation zone)
        Else t = M + k s  (M>m and the neighbourhood is in a low zone)
    End if
    If pixel > t Then pixel = 0
        Else pixel = 1
    End if
End Do
We can summarize the local threshold computing with the formula:

$$t = \max ( M , m ) + k.s$$

By modifying the “k” parameter, it is possible to simulate the inking and printing process at various conditions (ink quantity, paper quality or humidity, ink fluidity, exerted pressure ...). Figure 8 shows the same range image as used in Figure 7, binarized for k= 0.1 to 0.5. We can notice the “inking” variations produced by the “k” value modification.

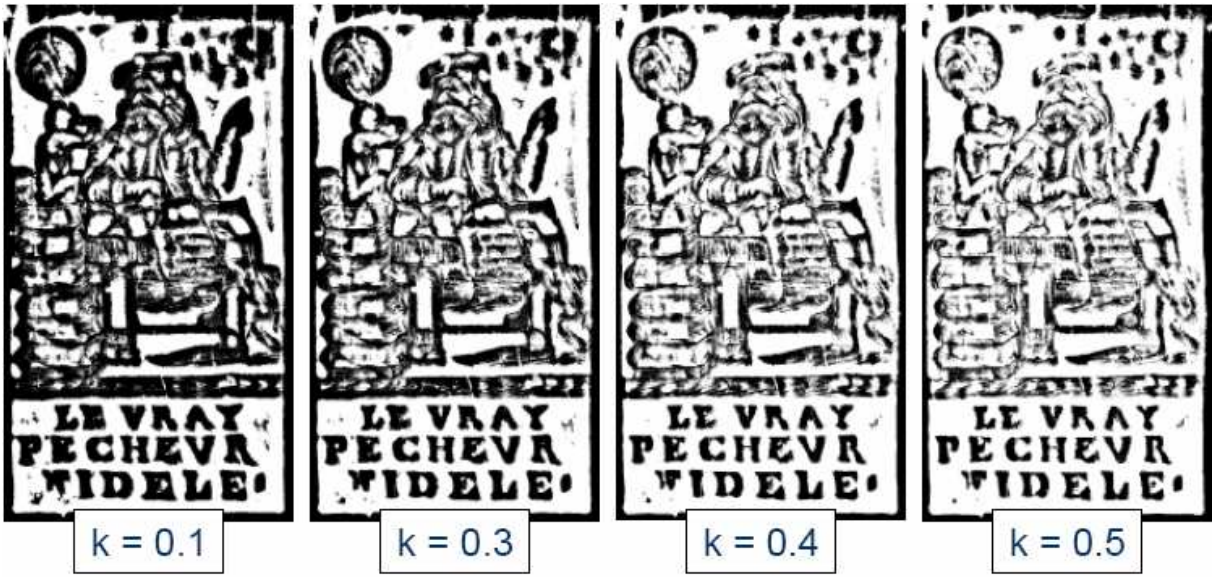


Figure 8 - Inking Variation Simulation

**Comparison between virtual and real stamping**

In order to test the proposed method we compared the results of virtual impressions with real impressions. For that, we used graven wooden stamps whose real impression is known. We present on Figure 9 to Figure 12 the results obtained for two stamps taken from the XYL collection.

Figure 9 - XYL 143 – Virtual Printing

Figure 10 - XYL 143 – Real Printing

Figure 11 - XYL 375 – Virtual Printing

Figure 12 - XYL 375 – Real Printing

**Results analysis**

We can notice that the images produced by virtual impression are visually similar to the real impressions. This validation enables an important confidence in the extraction method of the image produced by a wooden stamp.
The results are however of bad quality in the zones presenting fine details and particularly the zones which are striated to allow a dithering effect on the printed image. After detailed analysis of the results, the lack of details on the fine zones comes from the stage of digitalization. Indeed, the geometrical data obtained by 3D digitalization do not reveal the fine details which “are gummed” by a too weak resolution of the digitalization systems. The MINOLTA scanner clearly reveals this phenomenon. Work is to be carried out to improve quality of digitalization on wood presenting fine details.

## 5. VIZUALIZATION

The objective of this application is to enable a three-dimensional interactive visualization of the stamps.

**Data pre-processing**

The initial data are the points cloud and the numerical photographs of digitized stamps. These points cloud are first of all transformed into 3D models made up of faces. The aspect is then defined by the texture mapping. Two methods of texture mapping were tested:

- The first method consists in directly using the functionalities of acquisition and texture mapping offered by the MINOLTA scanner. This method is completely automated in the digitalization process and enables immediate results. On the other hand, it requires a very particular care of the lighting of the scene during digitalization.
- The second method consists in using the numerical high resolution photographs carried out by the library and available on its Internet site: http://www.mediatheque-agglo-troyes.fr. These photographs are manually mapped on the geometrical models by picking several matching points on the wooden stamps texture and the polygon representation respectively.

The 3D stamps models are processed to provide two visualization levels:

- high detail level for local exploitation to perform an accurate exploration of the stamp.
- low detail level to provide a web access to the models.

A non realistic rendering can also be performed to highlight the geometry details of the stamps[4].

Visualization must allow an interactive exploitation of the engraved wood models without any use of application softwares. We chose to carry out visualization via an Internet browser by handling the object using the mouse: rotation, translation of the object and zoom (see Figure 13).

Figure 13 - Web Browser Visualisation

Figure 14 - Non-photorealistic rendering

Light visualization requires a reduction of the quantity of information to be transmitted. For a local exploitation, the models can reach several ten megabytes. A simplification of the geometry (reduction of the number of faces) is thus practised to pass from models for a local exploitation to a remote exploitation. “Light” models of a few hundreds of kilobytes are thus generated.

Two visualization modes were tested:

- The first mode consists in directly using the export functionalities for visualization from the RapidForm software (http://www.rapidform.com). This method is completely automated in the software and enables to immediately obtain publishable results. On the other hand, it works only under the Microsoft Windows operating system and the offered functionalities are limited and fixed.
- The second mode of visualization is based on Sun MicroSystem JAVA3D software technology[5]. It consists in using the Java programming language enriched by the

Java3D software layer in order to develop interfaces of visualization in a completely original way. This method enables to obtain a personalized visualization of the 3D models and has the enormous advantage of functioning on a great number of operating systems. This solution has also the advantage of being based on free software solutions. This method has been validated on the following operating systems: Microsoft Windows, Linux, FreeBSD and Apple Mac OS X.

The visualization of models was also extended to non-photorealistic rendering. We set up different rendering modes allowing for example, by accentuating the brightness of the objects, to reveal in a more marked way the relief of the stamps[4] (see Figure 14). The studied wooden stamps models are presented on the Web3D site at the following address: http://vision.u-bourgogne.fr/Seulin/

Three-dimensional visualization enables to enrich Internet sites and shows and thus to improve the communication around the patrimonial objects. It also enables to interactively navigate close to stamps in order to study them in depth without any risk for the original parts. The digitalizations realized with the MINOLTA scanner on XYL collection have a low quality texture. These acquisitions were carried out with a lighting which appeared not adapted thereafter. Work is to be carried out to improve quality of digitalization of the texture and on an optimized exploitation of high resolution digital images.

## 6. DUPLICATION

A last application consists in carrying out stamps duplication.

**Data conditioning for duplication**

The initial data are the digitized points cloud. These groups of dots are first of all transformed into 3D models made up of facets. These models are then processed in order to reach manufacturing criteria: in our application, they should not present any hole and the object must be closed i.e. that its geometry must be represented by a closed volume (cubic for example) and not by an open surface (square for example). The obtained models are finally called CAD model (Computer Aided Design).

**Process of duplication**

Rapid prototyping is a process which uses the inkjet printing principle by successively depositing resins layers to directly manufacture a three-dimensional object. The system carries out a projection of resin then a polymerization in order to solidify the resin. When the manufacturing process is completed, the produced objects are immediately ready. The finished model can possibly be polished and sandpapered to be painted and/or to undergo other completions. Figure 15 and Figure 16 presents manufacturing results.

Figure 15 - XYL 143 Duplicata

Figure 16 - XYL 375 Duplicata

**Conclusions on duplication**

To be able to produce a copy of wooden stamps can avoid the complete stamp loss in the event of steeling or simply deterioration in the course of handling. There is here a need for cultural heritage conservation which becomes urgent for the oldest stamps. That also allows the provision of copies to distant researchers or visitors. This will also make possible to carry out operations of inking of copies and impression by the typographical process of press. That will thus make it possible to validate a new stage of analysis and comprehension of the use of stamps.

The obtained results in rapid prototyping are very satisfactory. The quality of the copies is largely validated for the concerned applications. On the other hand the geometrical models obtained have sometimes insufficient resolution involving no duplication of the details of certain wooden stamps.

## 7. CONCLUSIONS

After these two years of collaboration on the ANITA project, an important work on behalf of all the partners made it possible to build three families of numerical tools based on the exploitation of three-dimensional digitalization. These tools were validated by the potential users who are the researchers of the Written Cultural Heritage Laboratory (CEPLECA). Even if these tools are largely perfectible (the prospects for this work are only improvements of what exists), we are now guaranteed of the feasibility of the three applications.

Work to be carried out first of all relates to the improvement of the quality of digitalization on stamps presenting fine details. This work will focus on the following points:

- On a more effective exploitation of the existing means by implementing methods of improvement of the resolution. Existing technical solutions are proposed and will have to be implemented and to be tested.
- On the research for partners proposing higher performances digitalization means. Contacts are established with the Kestrel3D company which exploits a technology of three-dimensional digitalization of very high definition.

Future work also relates to the improvement of the texture digitalization. An optimized exploitation of digital images high resolution should make it possible to solve this problem by using equipment of professional photographic lighting recently acquired. The manual work which results from this for the texture mapping remains a barrier to this way of solution. Another search for solution relates to the technology of three-dimensional digitalization of very high definition suggested by the Kestrel3D company which also offers a completely remarkable quality of texture.


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