Gilt leather punch marks: preliminary evaluation of 3D technologies for documentation and punching tool reconstruction.

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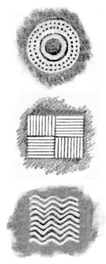
Introduction

The impression with metal punches had a significant role in the decoration of gilt and painted leather furnishings, from the first known specimens of the 16th century well through to the beginning of the 18th century. Data collection of punch marks' shapes and sizes is of great interest both for art historians and conservators as it supports a more rigorous geographical and chronological classification of the artefacts and workshops.



It is also relevant for conservation purposes.
To date, the documentation of punch marks has been carried out with graphic techniques, including rubbing, or photographic methods, mostly macrophotography with metric scale. Steel reproductions of the original tools can be manufactured manually and are used for reintegrating an artefact's missing parts or for creating replicas.

Objectives

This study presents a preliminary evaluation of the adoption of 3D technologies (3D scanning and printing) for the documentation and reconstruction of punches, as a potential alternative to traditional methods. In addition to the evaluation of the quality of the results, it also assesses this process' ease of accessibility and cost effectiveness.

Using as reference model a 16th century fragment of gilt painted and punched leather, the process has entailed the following steps:

- **acquisition** of the punch marks using 3D scanning and digital images in orthoplane with microscope and 2D scan;
- **elaboration** of a 3D graphic model with dedicated programs evaluating both geometric reconstruction and the elaboration of the 3D scans;
- **construction** of punching tool prototypes with 3D printing technique;
- **evaluation** of the prototypes efficiency in reproducing the original marks.

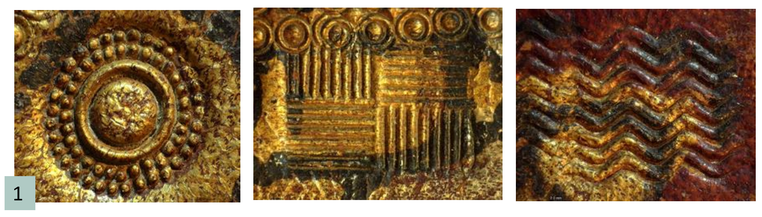
Fragment of the "Amorini" freize from Chigi Palace in Ariccia and details of the punch marks

Methods

Three punch marks, by different geometric elements, have been selected: **the bird's eye with double ring of dots** (9 mm), **the mat** (9,1x13,5 mm) and **the wavy parallel lines** (11,6x10,35 mm).

Acquisition using microscopy images and 2D scanning. Images geometrization with a CAD software.

1. The images of the different punch marks were collected both with digital microscopy DinoLite (AM4815ZTL) at 20x and a 2D scan using an Epson table scanner (Epson 1640XL).



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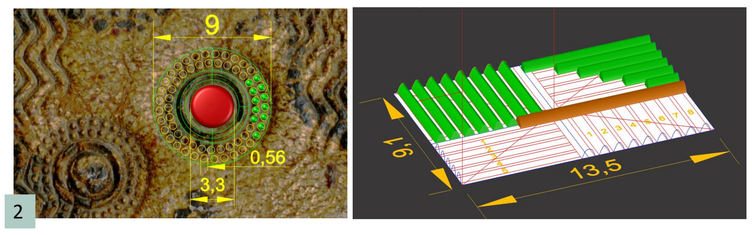
Optical magnification power 5x-140x; resolution up to 1280x1024 pixels - 2D scan resolution: 1200 dpi

2. Each image was paired with reference measures (segments and grids graded to the tenth of millimetre) and loaded within a CAD software (Autocad 2017 from Autodesk), which evaluated the sizes of each single decorative element, proceeding then to geometric restitution of the shapes first in a 2D and then in a 2D field.



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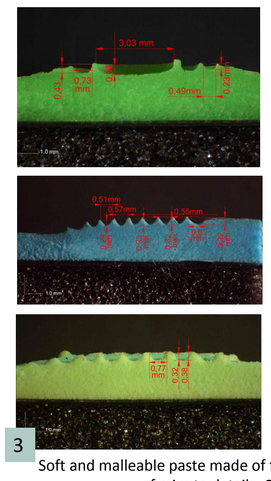

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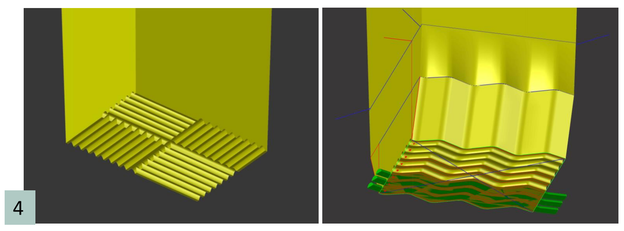
Didò by F.I.L.A. (Fabbrica Italiana Lapis ed Affini)
Soft and malleable paste made of flour salt and water suitable for the reproduction of minute details. Contact time on the surface 4'; no residues visible

3. In order to assess the depth and profile of the decorative elements, micro-moulds of the marks were obtained using coloured flour paste and were subsequently sectioned, photographed and measured with digital microscopy.

4. The shape of the tools' handles and tip was based on images from references textbooks and technical considerations concerning the effectiveness of blow transmission.



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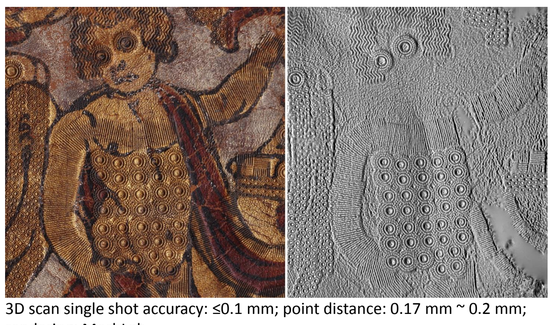
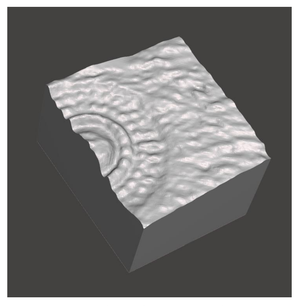
Acquisition using 3D scanning and elaboration



3D scan single shot accuracy: ≤0.1 mm; point distance: 0.17 mm ~ 0.2 mm; rendering: MeshLab



Execution and rendering: Meshmixer

3D scans of the whole gilt-leather fragment were performed using a structured light scanner Einscan SE from Shining C. and elaborated with MeshLab (Open source sw developed by the ISTI-CNR research center) and Meshmixer (Autodesk).

3D printing

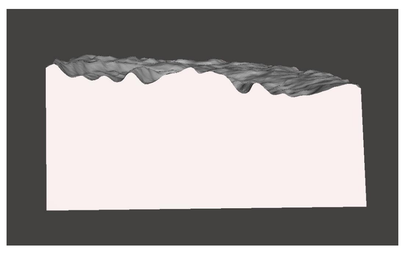
The realization of the 3 punch prototypes was performed with two different materials for a first comparison: standard resin 'Basic Red' using a Vat Polymerization LCD printer and high mechanical strength resin 'Durable' with a Vat Polymerization SL printer.

Evaluation and test

The prototypes' efficiency, in terms of hammer blow resistance and likeness to the original mark was evaluated by punching a silvered leather up to 1000 times.

Results and discussion

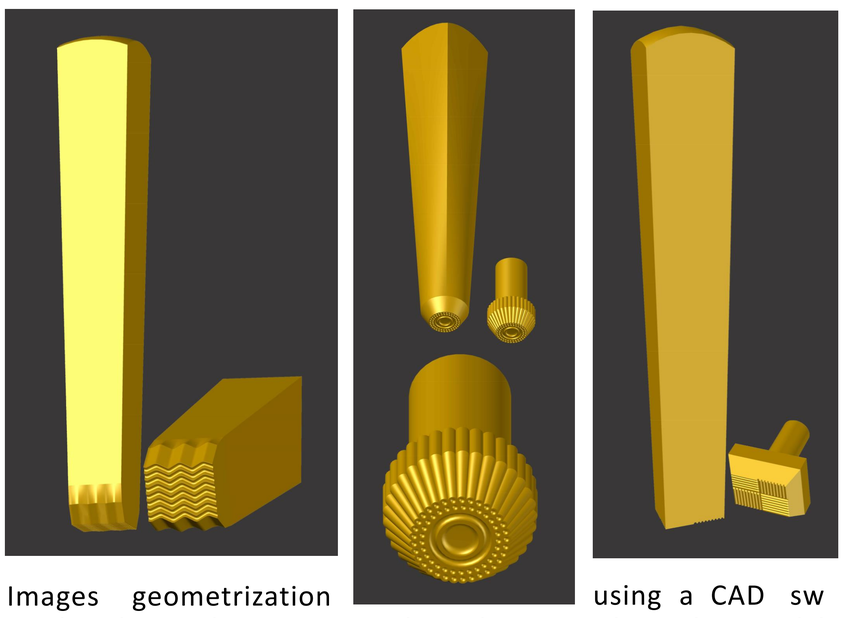
3D scanning



The 3D scan sections have been performed with MESHMIXER software from Autodesk

The 3D scans proved unfit, as the extremely small size of the details and the artefact's materials, particularly metallic layers and glossy and translucent varnishes, have strongly affected the scan quality, producing 3D models not sufficiently precise and detailed.

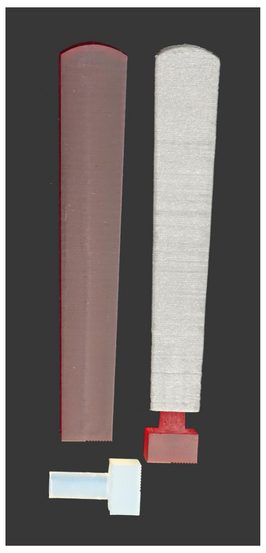
Geometrization using images loaded within a CAD software



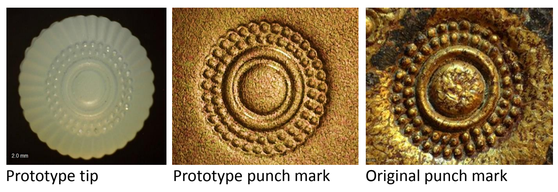
Images geometrization using a CAD sw produced a rather accurate three-dimensional graphic model, allowing the regularization of the punch elements shape and levelling of dimensional tolerances. Design software allows for the limitless implementation of this procedure, and many on-line downloadable programs are adequate for this purpose.

3D printing of punches and punching test

Printers using Vat Polymerization technology (SL and LCD) can achieve extremely accurate micrometric definition, together with smooth surfaces. The costs of the prototypes are generally contained. In order to reduce the printing expenses, the production of a prototype with the handle printed with the FDM technique and the tip in resin printed with Vat Polymerization technique is underway.



For both resins the punching process failed to demonstrate material loss neither in the tip, nor in the top of the tool handle receiving hammer blows.



Prototype tip | Prototype punch mark | Original punch mark

Quality and cost

The quality of the marks obtained with the prototypes was judged to be satisfactory. For the three punches, printed with the high mechanical strength 'Durable' resin, the cost was 15 euros each plus a fixed quota of 25 euros for the machine start-up.

Printing resins: 'Basic Red' resin produced by Harzlabs, printer Anycubic Photon; Durable resin produced by Formlabs, printer Formlabs Form2.
FDM printing: material PLA plus di Esun; printer CraftBot plus; slicing software Simplify 3D.

Conclusions

This study demonstrates that punching tools can be satisfactorily documented and reproduced with 3D technologies. Starting from images of punch marks acquired with digital microscopy or 2D scan, and precisely measured, it was possible to obtain an accurate three-dimensional graphic model which could be printed.

The adoption of 3D printers with Vat polymerization technology has allowed the production of punching tool prototypes which have been tested on leather, demonstrating good strength characteristics and producing marks similar to the originals. The process is presently in its early stage and it will be developed further.

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