Microcomputed X-ray tomography applied to bowed stringed instruments

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INTRODUCTION

This paper investigates some applications of Industrial Micro-Computed X-ray Tomography to bowed stringed instruments. When compared to clinical CT it is possible to appreciate that:

1. Diagnosis of damages and reparations can be performed at a higher degree of accuracy and reliability
2. 3D surfaces can be extracted, analysed and saved with a resolution better than 50 µm
3. Various part of the objects can be scanned at different resolutions (multiresolution)
4. Focal spot can be lowered down to few microns (microfocus), with great adwantages in terms of geometric unsharpness (Ug)
5. Exposure time can be increased to obtain adequate photon count, to compensate for the lower beam current
6. Relative position of specimen, source and detector can be varied, in order to obtain the best spatial resolution for a given specimen dimension

Industrial microCT, when applied in the particular field of bowed stringed instruments, allow to produce very detailed reports useful to value collections of museums, dealers and collectors.

METHODS

In this article we present the result of investigations carried out at TEC Eurolab (Modena, Italy), using a **North Star Imaging X5000** equipped with **XrayWorX** microfocus X-ray source.

This system can accomodate instruments of the dimension of a cello, and overcomes many of the limitations of clinical CT, which is devoted to the analysis of living tissues.

Images in this poster have been obtained at various working conditions.

The main picture on the right represents a combination of 3D volume rendering and thickness map on a "Workshop Rogeri" violin (courtesy of Atelier Lazzaro, Padova).
A picture of the experimental set-up and a list of the working parameters are listed below.

Working parameters for the other examples are reported in their picture captions.

Working parameters for the CT

Xray source: XRayWorX
Voltage: 150 kV
Current: 200 µA
focal spot size: 30 microns
focal spot mode: Microfocus

Detector: Varian
pixel pitch:[127 x 127] microns

Figure 1: experimental set-up, with the flat panel detector on the left of the violin

Figure 2: perspective view of the 3D rendering of Figure 3, showing the interior of the violin, with the back plate removed

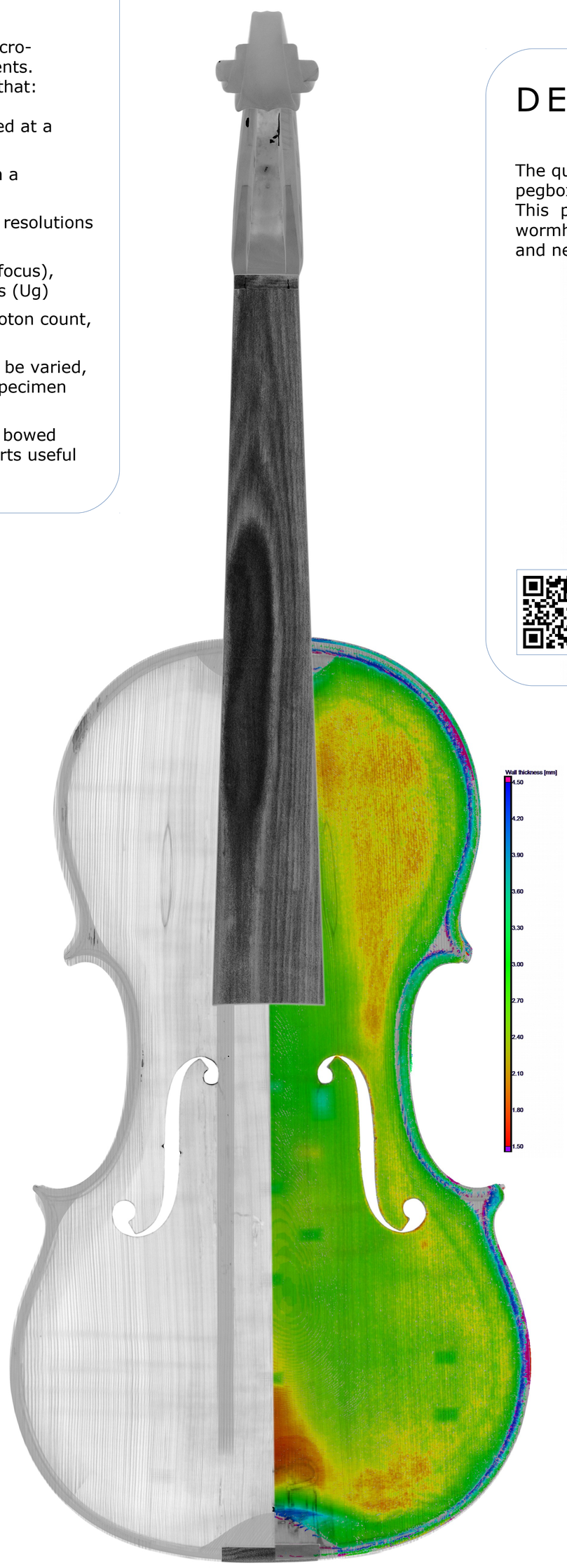
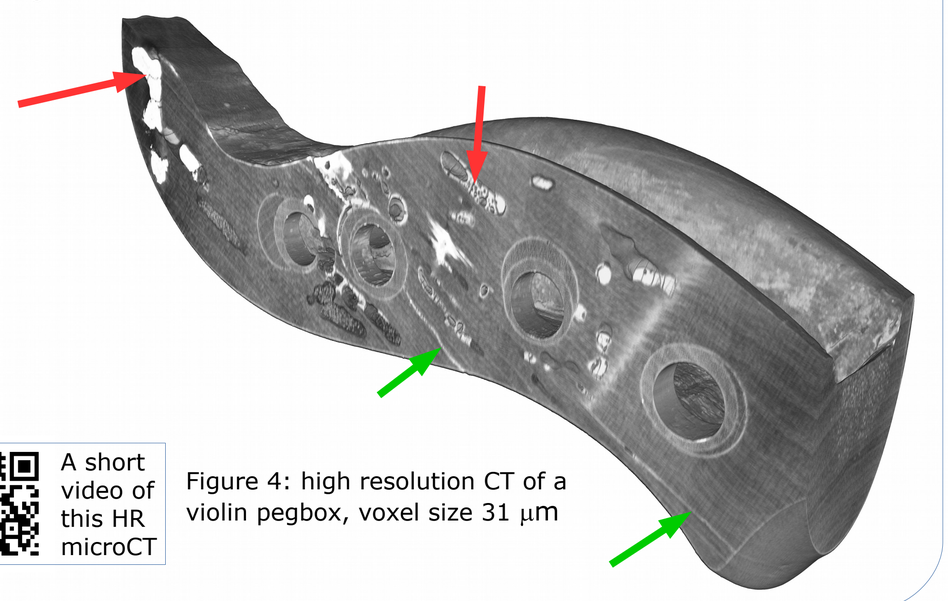


Figure 3: 3D volume rendering of a "workshop Rogeri" violin, restored at Atelier Lazzaro (Padova, Italy). For clarity the back has been removed from rendering (as shown in Figure 2).
On the right side the thickness map of the belly has been superposed.
Note the growth ring of the ebony in the fingerboard.

RESULTS

DEFECT DIAGNOSTICS

The quality of the 3D reconstruction can be appreciated in the image of a violin pegbox shown in figure 4.
This pegbox has been scanned at a resolution of 31 µm. Red arrows indicate wormholes filled with dense material, green arrows the hide glue lines of cracks and neckgraft.



A short video of this HR microCT

Figure 4: high resolution CT of a violin pegbox, voxel size 31 µm

METROLOGY & REV. ENGINEERING

The use of a micro-CT tube-based industrial system gives promising results regarding the geometric reconstruction of the instrument whole structure (both outside and inside surfaces) with the consequest applications:

- Accurate bi-dimensional projection and quote as a reference for violinmaking
- Plate thickness mapping
- 3D surface and surface texture determination
- polygon surfaces extraction (.stl)
- Comparison with a reference CAD surface

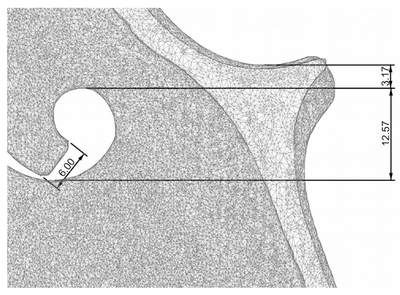


Figure 5: details of a .stl triangle mesh of the violin of figure 1, quoted in 2D

Figure 6: triangle mesh, perspective view of the scroll of the violin of figure 1

Dendrochronology

Another interesting application of microCT is wood dating by means of dendrochronology. In the figure 7 is represented a detail of an axial section of a violin.

Analysis carried out on this sections has proven to be comparable to traditional stereomicroscopy analysis.

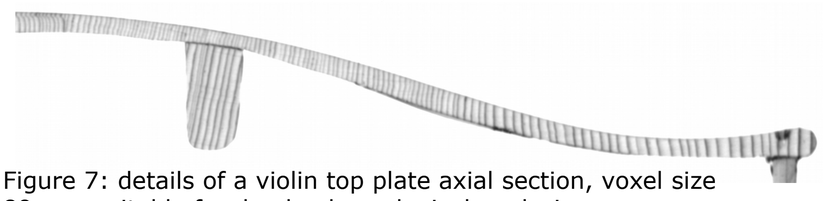


Figure 7: details of a violin top plate axial section, voxel size 89 µm, suitable for dendrochronological analysis

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