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X-ray radiographic analysis of the two wooden sculptures of 18th century

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Abstract: The X-ray radiography technique is highly efficient in investigating the manufacturing techniques employed by an artisan when creating a sculpture, as well as assessing the state of conservation and restoration processes. For instance, it allows the determination of whether the artist carved the sculpture from a single piece of massive wood or if it was sculpted in multiple parts, subsequently assembled using nails, hooks, or metal spikes. It also provides insights into whether the artwork underwent certain restoration processes and reveals its current state of preservation or degradation. This information can offer insights into the artist preferred creation technique, potentially the most popular technique of the time. It can also help estimate the period when the artwork underwent restoration and aid in choosing the appropriate restoration technique. In this study, we present the results of an investigative analysis of the internal structure, using digital X-ray radiography, of two wooden sacred sculptures representing biblical characters King David and his wife Bathsheba, dating back to the 18th century and housed in the Church of Our Lady of Pilar in Duque de Caxias, RJ, Brazil. Both sculptures are covered with layers of stain, with a prevailing golden hue on the garments. The obtained radiographic images show that the artist carved various parts of the sculptures and later assembled them using metal pegs. Additionally, recent nails were visible, indicating that the sculptures underwent a restoration process. All digital radiographic images were captured in high resolution using a flat-panel detector.

Keywords: digital radiography, wood sculptures, restoration process

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Análise radiográfica de duas esculturas em madeira do século XVIII

Resumo: A técnica de radiografia de raios X é muito eficiente para investigar o tipo de técnica de manufatura utilizada por um artesão ao criar uma escultura, o estado de conservação e processos de restauração. Por exemplo, é possível obter evidências se o artista lapidou a escultura em uma única de madeira maciça ou se esculpiu em várias partes e posteriormente realizou a montagem da obra através de pregos, ganchos ou cravos de metal; se a obra passou por alguns tipos de processos de restauração e o estado de conservação ou degradação. Essas informações podem fornecer para os estudiosos qual a preferência de técnica de criação escolhida pelo artesão e/ou a mais conhecida e utilizada na época; estimar o período em que a obra foi restaurada, também, auxiliar na escolha da técnica de restauração, no caso de um trabalho de restauro. Neste trabalho, nós apresentamos os resultados da análise investigativa da estrutura interna, usando a radiografia digital com raios X, de duas esculturas sacras, esculpidas em madeira, representando os personagens bíblicos *rei Davi* e sua mulher *Betsabá*, do século XVIII, pertencente à Igreja de Nossa Senhora do Pilar, na cidade de Duque de Caxias, RJ, Brasil. As duas esculturas são cobertas por camadas de tintura, prevalecendo nas vestimentas a coloração dourada. As imagens radiográficas obtidas mostram que nas duas esculturas o artista lapidou várias partes das esculturas e, posteriormente, as montou utilizado cravos metálicos, além disso, foram visíveis pregos de épocas mais recentes, indicando que as esculturas passaram por um processo de restauração. Todas as imagens radiográficas digitais foram obtidas em alta resolução, utilizando um detector *flat-panel*.

Palavras-chave: radiografia digital, esculturas em madeira, processo de restauração

1. INTRODUCTION

Portable object analysis systems, such as digital X-ray radiography, have proven highly satisfactory for the field of cultural heritage due to their practicality in analyzing works that cannot be removed from their locations, such as museums, ancient churches, institutions of historical, cultural, and artistic heritage, etc., or even due to the great difficulty of transporting them to laboratories for analytical techniques.

Studies of wooden sculptures using non-destructive imaging techniques, such as digital X-ray radiography, have been highly requested by historians, archaeologists, restorers, conservators, and specialists in historical and cultural heritage to obtain information about the internal structure, conservation status, restoration processes, deterioration of ancient and sacred works [1-4]. With the increasing application of imaging techniques for analyzing sacred wooden sculptures, recent studies have been conducted to improve X-Ray images of historical sculptures [5-12].

The technique used by the artist to produce the wooden work, the state of conservation, and the restoration process were the focus of this study. The analysis of the types of nails observed in the radiographic images could determine some of the previously mentioned information. In this study, two historical wooden sculptures, named "King David" and "Bathsheba," were analyzed using digital radiography with a portable system, representing biblical characters King David and his wife Bathsheba, dating back to the 18th century and housed in the Church of Our Lady of Pilar in Duque de Caxias, RJ, Brazil. Both sculptures are covered with layers of stain, with a prevailing golden hue on the garments. A study on the characterization of pigments in the two artworks was conducted by SANCHES *et al.* [13].

2. MATERIALS AND METHODS

Digital radiographic images were acquired for both the sculpture representing the figure of King David (Fig. 1-a) and Bathsheba (Fig. 1-b). Both sculptures, approximately 130 mm in height, are carved from wood and covered with layers of paint. The artist used beige paint for the skin areas, golden color for the clothing, brown for Bathsheba's hair, and white with brown to define her eyes. In contrast, King David's hair and beard remained untinted, leaving the exposed wood, while his eyes were painted dark to represent the eyeball.

2.1. X-Ray digital radiography

The radiographic system used for the acquisition of the radiographic images was the DXR250-U detector (GE), with a pixel size of 200 μm and a sensitive area of a-Si; the chosen X-ray source was the CP120B tube (ICM), operating at a voltage of 120 kV and a current of 1 mA. As the sensitive area of the flat-panel detector is limited to 410 x 410 mm, it was necessary to acquire multiple radiographs to capture images of as much information as possible from the entire structure of the two artworks. Since the harp in the sculpture of King David was removable, its radiographic images were obtained separately from the main artwork. In both sacred artworks, some nails and pegs were visible to the naked eye, indicating their use for supporting certain parts of the structures.

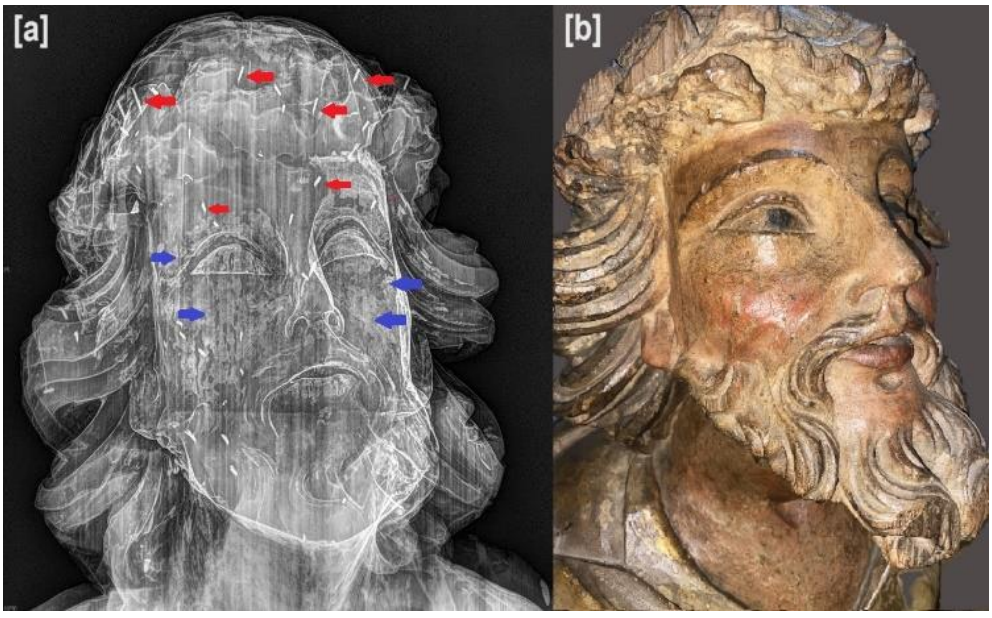
Figure 1: Sacred sculptures carved in wood referred to as [a] King David and [b] Bathsheba, both from the 18th century. Church of Our Lady of Pilar, in the city of Duque de Caxias, RJ, Brazil.

3. RESULTS AND DISCUSSIONS

The main focus of the radiographic analysis of the two sculptures was to identify evidence regarding the restoration process and the technique used by the artist in the structuring of the works. To achieve this, the analysis primarily concentrated on the types of nails identified in the radiographs: those used by restorers (more modern nails) and those used by the artist during the creation of the artworks (more rustic, termed as clavos) to join the separately carved pieces that make up the sculptures.

Figures 2-4 show results of the radiographic images analysis. In Figure 2-a, the radiographic image of the sculpture's head several denser areas are revealed (indicated by the red arrows). This suggests that, following the carving phase, the wood underwent a superficial filling using a denser material, possibly as part of the preparation for the painting of the artwork. It also shows the paint layer in the facial area, which is significantly deteriorated with some discontinuities in the paint.

Figure 2: [a] Radiographic image and [b] sculpture of the face of King David. The radiograph shows several points of higher density than the wood (red arrows) and the facial area where the deterioration of the paint layer is visible.



Figures 3-a and 3-b provide detailed radiographic images of the right arm (arrow 2 in Fig. 3-b). The radiographic image of this region shows that the artist used a metal nail for this joint (Fig. 3-a, arrow 1). In contrast, Fig. 3-c shows more modern nails, which were likely used during the restoration process to provide additional support to the right hand (indicated by arrows 5 and 6).

Figure 3: Radiographic analysis of the right arm of the King David sculpture. [a] image of a metal nail used by the author of the work to connect the forearm and image of restoration nails providing support to a part of the garment on the right side; [b] photograph of the right forearm of the sculpture; [c] radiograph showing restoration nails in the right hand of the work.

Figs. 4-a and 4-b show, respectively, metal nails used by the artist to connect a part of the clothing on the left side to the rest of the sculpture, indicating that the artist carved this part separately. Fig. 4-c presents the radiographic image of the lower part of the leg and clothing of the King David sculpture, indicating with arrow 1 an original support nail from the artwork and with arrow 2 a restoration nail. Fig. 4-d shows the photograph of the area where the nails are located, approximately (arrows 3 and 4).

Figure 4: [a] Radiographic image of the left side of the clothing of the King David sculpture, indicating the metal nails used by the artist; [b] photograph of the clothing area, showing the approximate location of these nails; [c] radiographic image of the right foot of the King David sculpture; and [d] photograph of the region of the sculpture corresponding to the radiograph shown on the right.

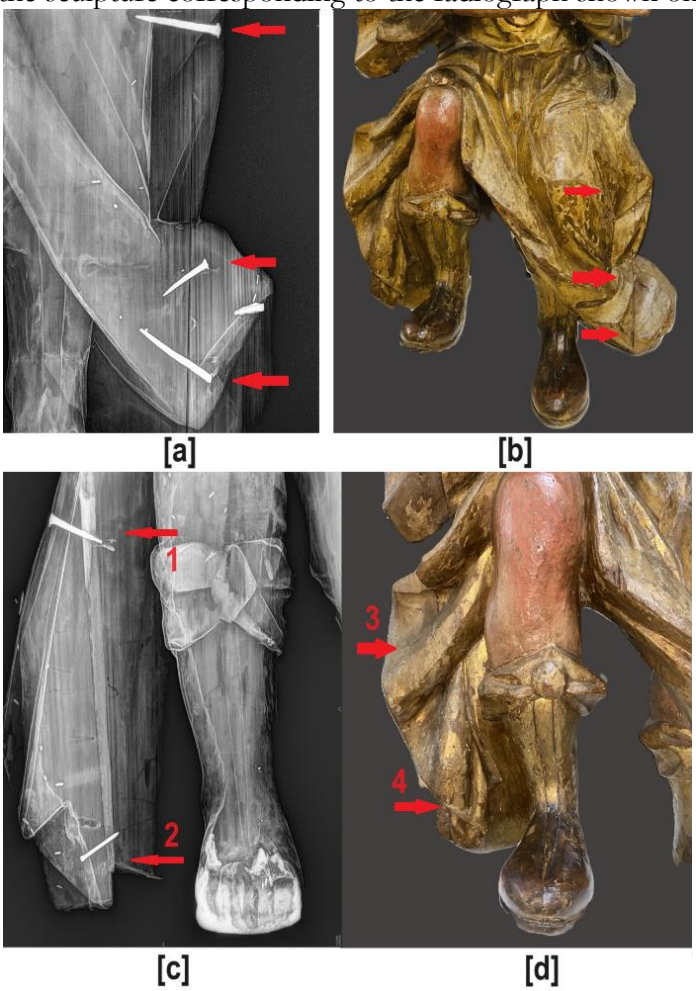


Fig. 5-a shows the radiograph identifying smaller restoration nails used by the restorers, indicating their concern for greater structural stability of the right hand, which might have been compromised due to probable wood deterioration. Fig. 5-b shows the approximate area where these nails are located. Radiographic images of the harp that forms part of the King David sculpture were also obtained, revealing restoration nails (Figs. 6-a to 6-c) and signs of paint coverage with some areas already deteriorated.

Figure 5: [a] Radiographic image of the left hand of the King David sculpture, indicating the nails used in the restoration of the artwork; and [b] photograph of the left hand area, showing the approximate location of the restoration nails.

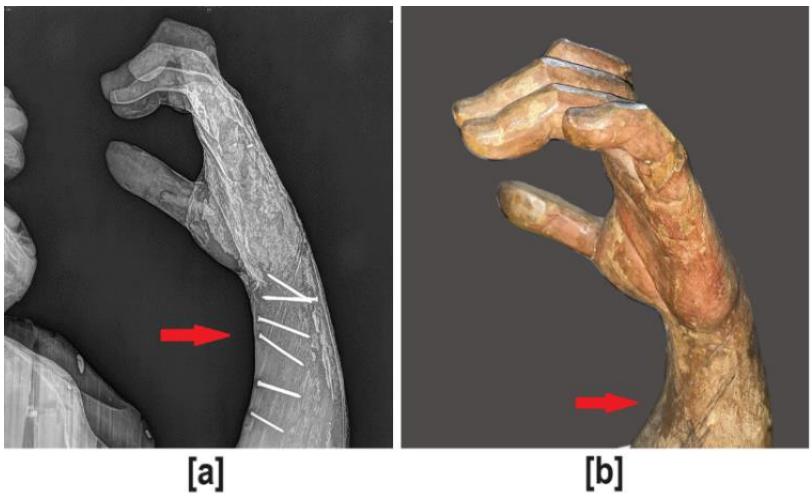
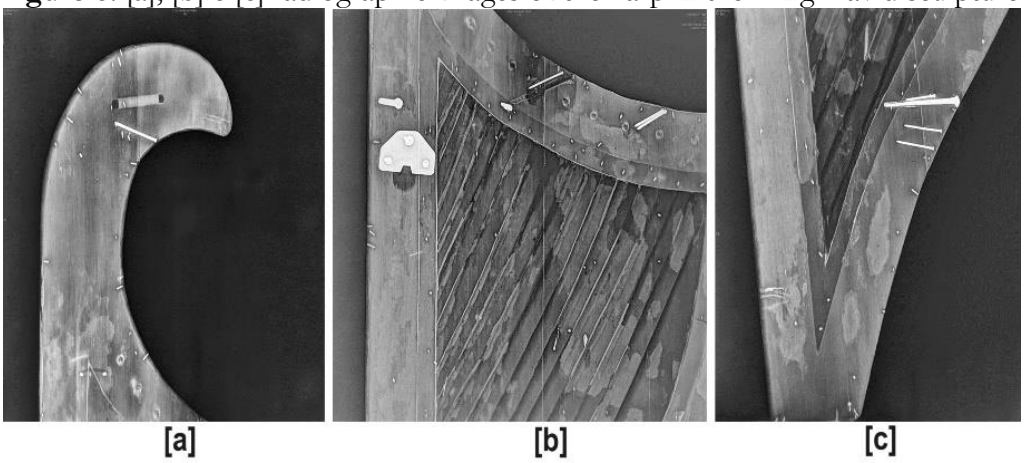


Figure 6: [a], [b] e [c] radiographic images of the harp in the King David sculpture.



The same technique of creating the artwork, carving some parts separately from the main structure, was observed in the sculpture of the Bathsheba. Figures 7-a show radiografic image of the head, indicating two large nails to secure the face to the main part of the head and in Fig. 7-b, a photo indicating the approximate location of these two fastening nails.

In Fig. 7-c, there is also an indication of a nail for attaching the left forearm to the main structure and, in the trunk region, an external support for fixing the sculpture to the church wall. In the shoulder region, restoration nails are visible, providing support for the arm (Figure 7-d).

Figure 7: [a] Radiographic image of the head of the Bathsheba sculpture showing two metal nails used to connect the face to the head; [b] photograph of the head of the sculpture indicating the location of the nails with arrows 3 and 4; [c] radiographic image showing nails placed by the artist to connect the forearm to the sculpture (arrow 1) and two restoration nails from a later restoration (arrow 2); [d] photograph indicating the approximate locations of the nails and restoration nails with arrows 3 and 4, respectively.

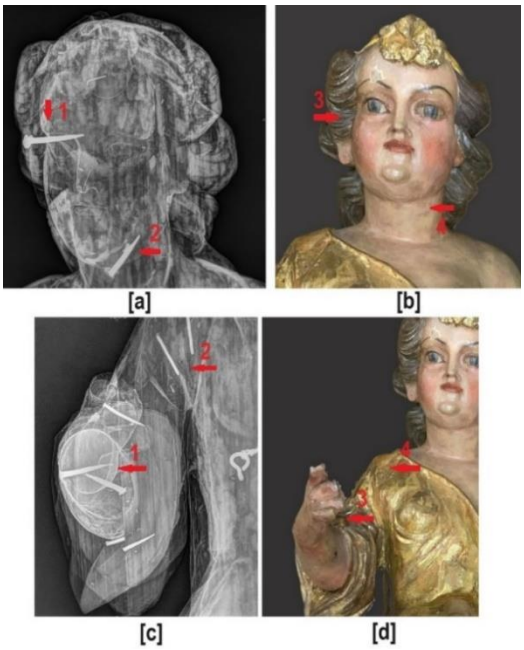
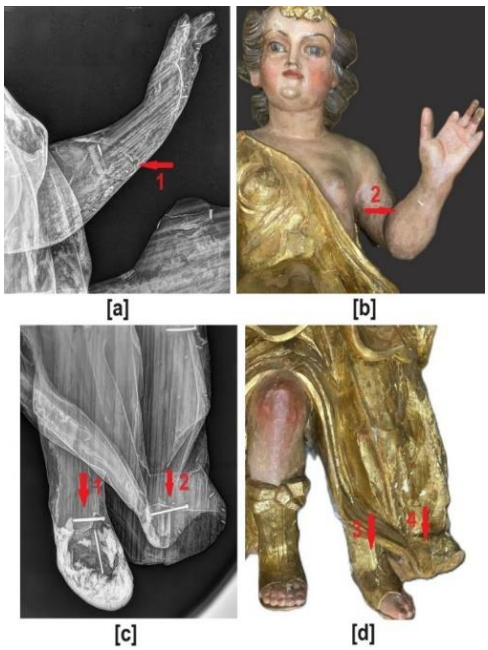


Figure 8: [a] Radiographic image indicating the location of the connection of the left hand of the Bathsheba sculpture; [b] photograph showing the approximate location of this connection; [c] radiographic image showing nails used in restoration techniques; and [d] photograph indicating the approximate locations of these restoration nails.



In Fig. 8-a, the radiographic image indicates the exact location of the connection of the forearm to the body of the sculpture (arrow 1), highlighting that the artist carved the hand separately and then fixed it to the sculpture (see Fig. 7-b). The radiographic image in Fig. 8-c shows nails used by restorers to provide additional support to the sculpture, aiming to preserve it despite some deterioration of the wood. Fig. 8-d presents a photograph with approximate indications of the locations of these restoration nails.

4. CONCLUSIONS

The radiographic images revealed details about the manufacturing process used by the artist during the historical period attributed to these sculptures. Based on the results, it was concluded that the artist carved certain parts of both sculptures separately and later affixed them using metal nails. Additionally, it was possible to determine that the sculptures underwent restoration processes at a later date, performed by restorers, as indicated by the presence of more modern nails providing additional support to some deteriorated areas of the two works. Thus, digital X-ray radiography, as a portable system, proved to be effective for analyzing the two sacred wooden sculptures.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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