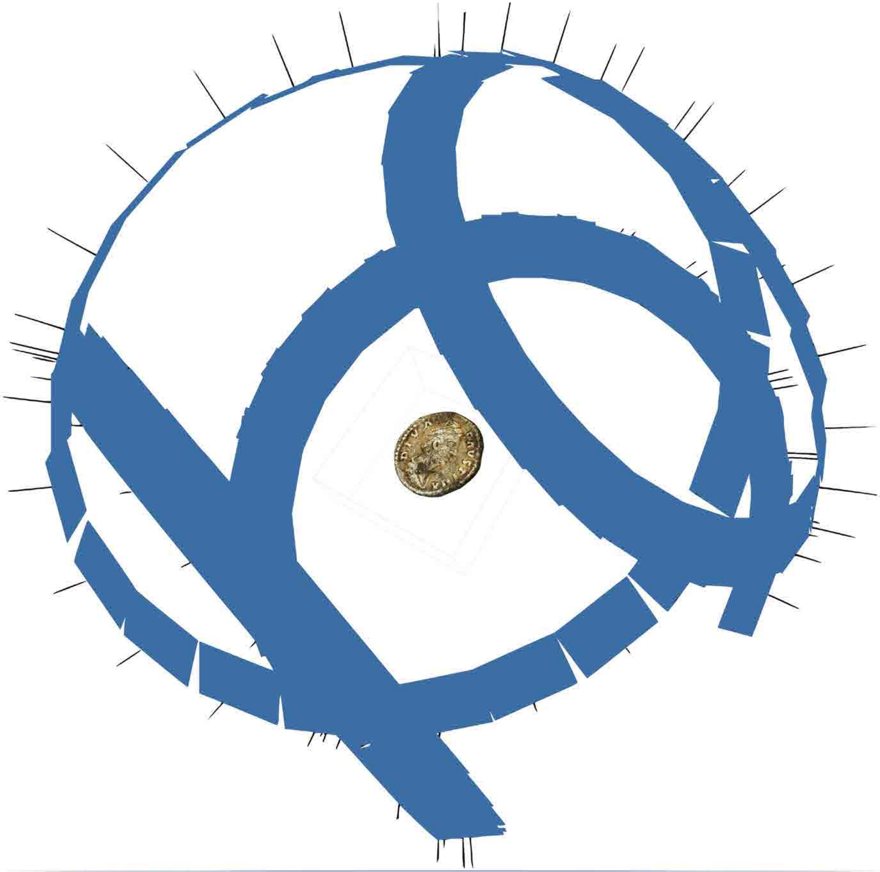

Collection Development, Cultural Heritage, and Digital Humanities

DIGITAL TECHNIQUES FOR DOCUMENTING AND PRESERVING CULTURAL HERITAGE

Edited by **ANNA BENTKOWSKA-KAFEL** and **LINDSAY MacDONALD**

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DIGITAL TECHNIQUES FOR DOCUMENTING AND PRESERVING CULTURAL HERITAGE

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Chapter 6

DIGITIZATION OF CULTURAL HERITAGE AT THE NATIONAL MUSEUM OF ROMANIAN HISTORY, BUCHAREST

IRINA MIHAELA CIORTAN

ABSTRACT

The National Museum of Romanian History in Bucharest holds a vast number of archaeological objects of both Romanian and European cultural significance: ceramics, objects made of marble, stone, copper, gold, and silver, as well as a collection of painted icons and manuscripts, dating from prehistoric periods to the Modern Age. The museum has been undergoing renovation for several years and the majority of the objects in its collection are not available to the public.

The main purpose of the case study described in this chapter is to grow the collection of digitized objects and their 3D visualizations, and to present these for viewing in a virtual gallery. Through this the general public, as well as scholars, will be able to access virtual surrogates of the objects that are at present not available on site. Another objective of this case study was to implement state-of-the-art non-invasive techniques for acquiring images of the artefacts, using both spectral and spatial object documentation. Finally, the case study aims to disseminate information about the digitization process and to provide specifications and guidelines of good practice that will serve both the scientific and arts and humanities communities involved in the field of cultural heritage. The objects used in this study were: three ceramic vases from the Cucuteni culture, three icons painted on wood, and a collection of medieval manuscripts. The techniques used for recording and analysis were photogrammetry and multispectral imaging.

Keywords: icons, medieval manuscripts, Cucuteni, photogrammetry, multispectral imaging, COSCH

Introduction

If one were to think of cultural heritage as a person, one would most probably describe this person as a wise, long-distance time-voyager, who survived and withstood centuries of history in order to be able now to share a self-defining life story; a person whose eyes sparkle with the desire of surviving twice as many centuries longer to keep the story mimetically close to its original: alive, intact, and unperturbed. For the story may be looked upon as one of the substantial means through which one can reach the true understanding of an instance. The time-voyager, the embodied cultural heritage, is aware that the greatest threat to his story is the loss of credibility, which may happen easily when change is waiting at the corner, year after year. Thus, the most urgent need of cultural heritage is its confrontation with time; the immediately triggered change is, first and foremost, the need for documentation as a stable proof against uncertainty. Once documentation has been secured, further needs such as conservation, preservation, and restoration are easier to pursue since the description of the original is archived, with as much detail and accuracy as possible. The more continuous the set of finite moments across the axis of history that the spotlight is shed onto a cultural heritage instance, the less darkness we (the curators, archaeologists, and conservation scientists) will have to fathom when later posed with the problem of gathering full knowledge about the history of the instance.

However, cultural heritage is not a stand-alone entity and there are many stakeholders involved, with many categories of end-users with both different and common needs. The best way to discover and tackle these needs is by the most ancient tool of research, that is, asking questions. Through an intensive questioning process and conversations with the stakeholders interested in cultural heritage, needs arise and can afterwards be collected and classified according

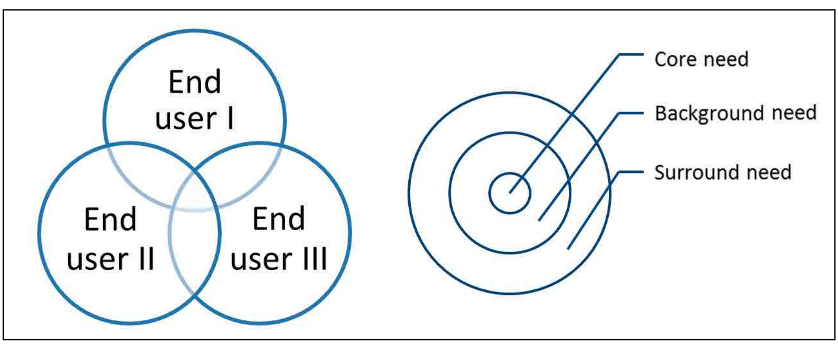


Figure 6.1. Pattern of end-user needs in the planning phase of a cultural heritage project. Left: Venn-like pattern, Right: Concentric pattern. © Irina Mihaela Ciortan, 2016.

to their similarity. From the experience of the current case study, the inquiring process that leads to the discovery of needs can follow two patterns: a Venn-like pattern or a concentric pattern (fig. 6.1). The former implies various groups of end-users, who in the diversity of their discourse have an underlying, intersecting common need, while the latter consists of needs depending on external factors, built around an essential core.

When starting a cultural heritage project, the first imagination exercise is to envision the large picture, that is, to see the starting point and the far end, to jump from A to Z, without drawing all the important letters in between. The rough sketch of the large picture helps in finding and then pursuing a common, holistic goal that will govern the subsequent, deterministic steps.

The Context of the Case Study (Problem Statement)

The National Museum of Romanian History (NMRH) holds vast collections of cultural heritage items relevant to the history and culture of Romania. They are housed in a nineteenth-century neoclassical palace, originally the central Post Office, on one of the oldest streets in the historic centre of Bucharest. The museum is currently (2016) undergoing renovation work, meaning that the objects are not accessible to visitors. Hence, this is how the first research questions were raised: How to support the general public interested in the museum during the renovation? How to give conservation scientists access to the objects? How to stimulate interest in the museum? How to enhance the virtual gallery of the museum?

Then, the question that followed naturally was: How to select representative objects for digitization? The choice of objects that would showcase the diversity of the NMRH's collections was deliberated in collaboration with the museum curators, followed by a conversation about the historic significance of objects, as well as their condition and conservation requirements that may impact on advanced documentation. Given these criteria, the artefacts chosen for the present case study were Orthodox icons, ceramic vases from Cucuteni culture (Ellis 1984), and medieval manuscripts. The chosen artefacts were documented in the museum archive as 2D images only (see Table 6.1 for details of the selected objects).

Having identified the core need—documentation—and having chosen representative cultural heritage objects, the next questions concerned the technologies, techniques, and tools that could be used to achieve accurate documentation, and subsequently the display of the visualization in a virtual gallery, so as to meet expectations of the remote visitors. Is 3D digitization necessary? Are we interested in gathering more information about the material or spectral characteristics? Should we confine our study to an already trodden path or should we explore novelty? It was also necessary to identify the goals of the virtual exhibition. Should it only inform? Or should it, perhaps, tangentially include education and learning objectives? All these topics will be covered below.

State-of-the-Art

Documentation is one of the most important and urgent tasks for cultural heritage (Yilmaz et al. 2007), especially if assuming hypothetical natural catastrophes that could provoke loss (Patias 2006), as was the case in the series of earthquakes in Italy in 2016 (ICCROM 2016). One way of classifying the plethora of documentation techniques in the literature is to divide them according to the appearance attributes that they are primarily intended to record. Thus, we will further use *spatial techniques* to refer to the collection of technologies that are optimally designed to capture the shape and geometry of an object, while *spectral techniques* designate the set of imaging systems that are developed to record accurate and precise information about the reflectance behaviour of an object as a function of wavelength.

Pavlidis et al. (2007) offer a comprehensive review of state-of-the-art technologies used to capture the 3D geometry for cultural heritage applications, that can be roughly divided between laser scanning techniques and a group of "shape recovered from ~" methods, where ~ may stand for structured light, motion, silhouette, texture, shading, stereo, etc. Remondino and El-Hakim (2006) classify the image-based 3D modelling techniques and highlight the advantages of close-range photogrammetry. They point out a series of guidelines for improving the photogrammetric acquisition and the quality of images acquired, so that the 3D reconstruction is less prone to errors and more precise.

Spectral imaging has already made a name for itself in cultural heritage projects (Stanco et al. 2011), as the spectral signature can be considered a definitive characteristic of the object. It has been used for pigment mapping (Deborah et al. 2014; Zhao 2008), crack detection in paintings (Deborah et al. 2015), and manuscript analysis (Ciortan et al. 2015). The greatest advantage of spectral imaging in comparison with alternative technologies for capturing reflectance information, as for example spectroscopic measurements, is that instead of sampling the recorded reflectance for a restricted contact area, it captures a 2D image array with a reflectance measurement at each pixel. However, the reflectance information may be more discrete or more continuous depending on the bandwidth of the system, which differentiates the multispectral imaging systems (up to 30 bands) from the hyperspectral systems (30 bands onwards). The equipment cost increases with resolution in either the spatial or spectral domain. Usually, a trade-off is the solution between extended accuracy in one of the two domains and the decision depends on the characteristics of the acquired object such as size, flatness and material composition.

Although when treated individually, the spectral and spatial domains have been well explored, it is difficult to locate previous experiments and technologies that approach a spectro-spatial setup. This is not surprising, given that the task is far from trivial. The field that opened the gates to a registered fusion between data with resolution in spectral and spatial domain is represented by spectral imaging systems, with their variants: multispectral and hyperspectral imaging systems. Spectral imaging systems output aligned images on the x and y dimensions along the sampled electromagnetic spectrum (the frequency of sampling determines the resolution in the spectral dimension). Limited even in the x and y dimensions, spectral imaging systems have a substantial lack of information in the z dimension, making depth information recovery and hence a so-called multi/hyperspectral 3D model a very difficult task to solve. Another serious limitation is the inter-band detail variation captured by the hyperspectral images and related to changing reflectance properties, where one detail might be visible for one wavelength and then disappear in another, which is challenging when aiming to reconstruct 3D information from the whole. Shy attempts have been made in this direction, culminating with an approach (Zia et al. 2015), where 3D information is extracted band-wise and is recomposed for the whole hyperspectral data set, based on a structural descriptor, used for the spatial registration between the single-wavelength point map and then registered with a complete three-dimensional model.

Considering the features of the objects involved in this case study, both spatial and spectral recording techniques were involved as follows: the defining intrinsic feature of the ceramic vases is their shape and geometry, so spatial documentation was performed. However, it is worth remarking that the Cucuteni ceramic vases are unique for their colour patterns, so precise and accurate colour information might also present relevant research material, which leads to exploring combined 3D multispectral reconstruction. For the icons and medieval manuscripts, where the geometry is rather flat above microscale, but the colour and reflectance properties carry more importance in documenting the appearance of the objects, multispectral techniques were considered as appropriate to explore.

Description of Work

The case study encapsulated both the spatial documentation with photogrammetry of the Cucuteni ceramic vases, and the spectral documentation with a filter-wheel digital camera of three Orthodox icons, together with a collection of medieval manuscripts. In this section, the acquisition campaign will be described and the pros and cons of each technique discussed.

Spatial Documentation

The technique chosen for spatial documentation was photogrammetry due to the versatility of the output data, the relative low-key requirements of the set-up (digital camera, light sources, rotating table, calibration target), and the ready availability of post-processing software. Recent technological advances in digital cameras, computer processors, and computational techniques make photogrammetry a portable and powerful technique. This enables a dense and precise 3D surface to be constructed from a limited number of photos, captured with standard digital photography equipment, in a relatively short period of time and with low-costs. One disadvantage is that the automation of the post-processing software gives little control over the final product. However, additional editing of the 3D photogrammetric data, such as smoothing or hole filling, can be performed by additional software

In the present case study, the setup used to acquire photogrammetry data consisted of a digital camera Sony NEX 6, with 16–50 mm f/3.5–5.6 lens, two Studioflash 1000 w lights, a white panel for diffusing the light, and a rotating table (fig. 6.2). For each object placed on the turntable, thirty-six images were taken, at intervals of ten degrees. The resulting image stack was post-processed in Photoshop (masking the region of interest corresponding to the object and discarding the remainder in order to decrease computation time) and afterwards, the 3D models were generated with the AgiSoft PhotoScan software, which implements the Structure from Motion algorithm.

Figure 6.2. Setup for photogrammetric acquisition of the ceramic vases. © National Museum of Romanian History, Bucharest, 2015.

Spectral Documentation

The spectral documentation was performed by a SpectroCam filter-wheel multispectral camera that allows for the capture of 8-band registered images. The camera incorporates an InGAas sensor for increased sensitivity with 15 μm pixel size, with a full-frame pixel resolution of 640 × 512 (width × height). The advantages of this setup are the relatively low costs compared to other multispectral setups, the possibility to attach additional filters with different spectral transmittance (for acquisition in the NIR and UV ranges) and the increased portability, making it appropriate for *in situ* acquisition. The disadvantage is that the change of a new set of filters might cause a misalignment from the images acquired with a previous set of filters. The SpectroCam camera comes with built-in software for real-time visualization, and the multispectral images are output in all common file formats (raw, jpg, bmp, png) enabling post-processing with tools such as Matlab (proprietary) or ImageJ (open source).

There is no constraint regarding the orientation of the setup, hence the cultural heritage object can be arranged either vertically or horizontally, depending on the space limits given by the acquisition site. In the campaign conducted for this study, the camera was positioned parallel to the horizontal acquisition scene and the light source at the same close distance as the camera distance, on the side (fig. 6.3). Apart from the object, the acquisition scene included a perfect white diffuser (Spectralon target), necessary to compensate in post-processing for the non-uniformity of the illumination. The set of filters used for the documentation of the Visible Spectra had peak wavelengths at: 425, 475, 525, 570, 615, 680, 708, and 784 nm.

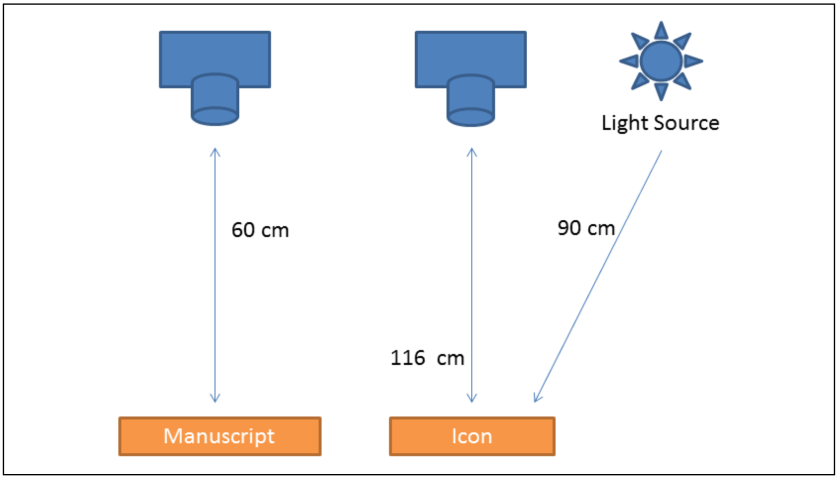


Figure 6.3. Setup for the multispectral acquisition with the filter-wheel camera of the manuscripts and icons. © Sony George, 2015.

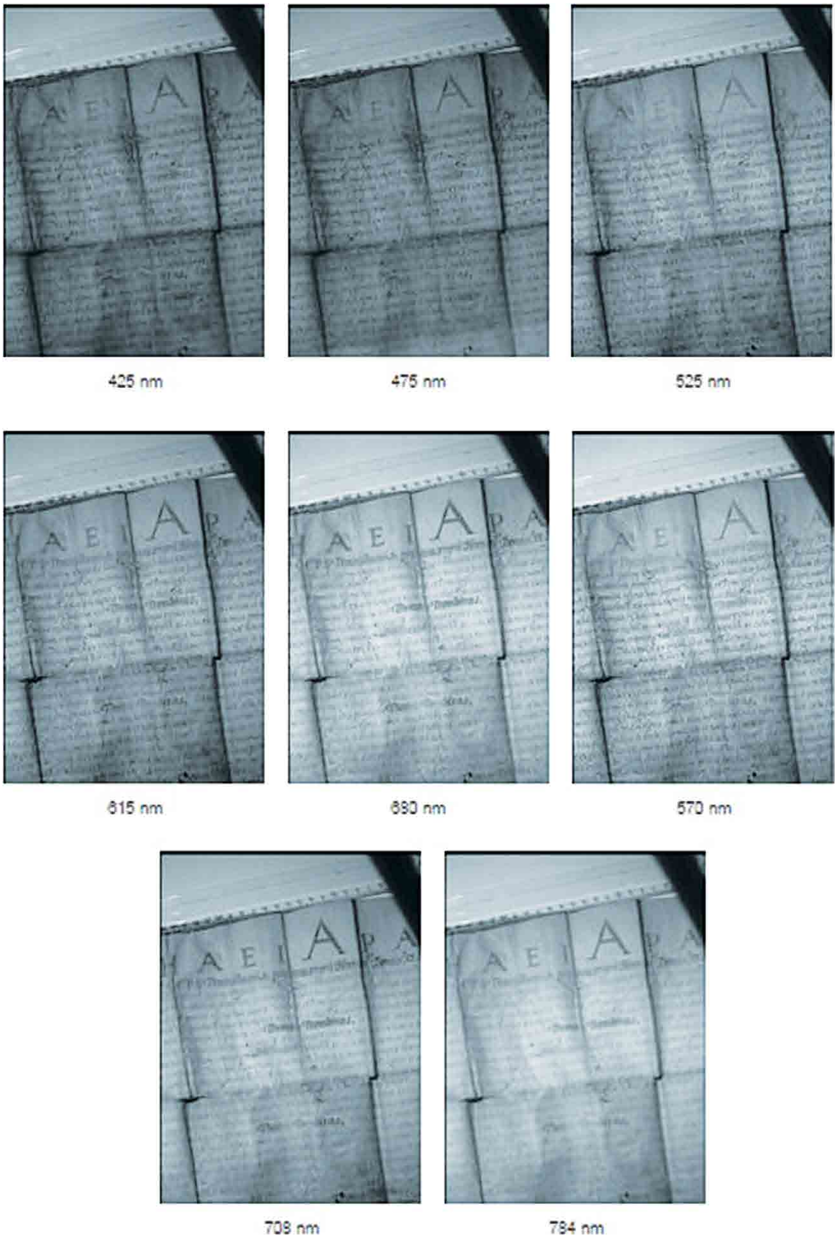


Figure 6.4. The single-band images corresponding to each of the eight filters. Note how some of the text begins to fade as the wavelength approaches the NIR. Photo: Irina Mihaela Ciortan.

Visualization and Virtual Gallery

The documentation process results were uploaded to a virtual gallery dedicated to this case study at http://romanianculturalheritage.omeka.net/about (work in progress). The virtual gallery was built on the Omeka.net Platform, which is especially designed for the archiving of cultural heritage items, including the metadata fields defined by the Dublin Core System.

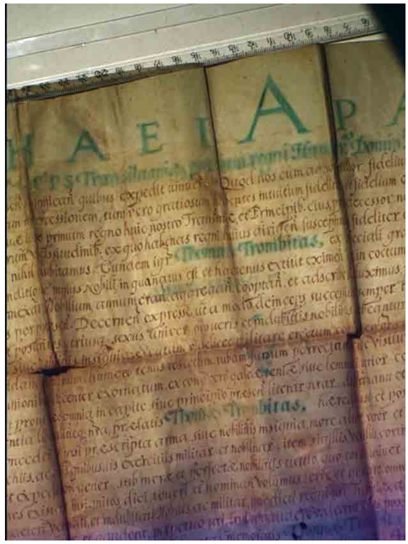
Multispectral data enable multiple visualizations. The display of single-band (Padoan et al. 2008) image series shows how the imaged artefact changes its reflectance with wavelength (fig. 6.4). A traditional RGB image can be simulated by merging three monochrome images that correspond to the spectral bands with the highest signal for RGB colours (fig. 6.5). From the current set of filters, the association was: R-680nm, G-570nm, B-475nm. If NIR have been used, false-colour visualization (Douma 2008) would also have been possible, by assigning the Red channel to the NIR information, Green to Red, and Blue to Green. Similarly, if UV filters had been used, the shift of the channels for generating a false-colour image would have been: Blue for the UV information, Green for the Blue information, and Red for the Green information.

Evaluation of Research

This case study enabled multispectral image documentation for museum objects, adding information and visual quality to the museum virtual gallery. While quantitative evaluation has always been a challenge in cultural heritage, either due to the lack of ground truth or to the difficulty of fair comparison between the data, qualitative evaluation and visual assessment offer a more immediate and spontaneous feedback. Out of the interdisciplinary discussion about carrying out the acquisition, a common criterion was agreed between the parties: novelty. It might be novelty regarding the perspective from which the cultural heritage artefact is seen, novelty of the acquisition technique and its implementation, or novelty triggered by new findings in the nature/material of the object that previous techniques have not revealed. In cultural heritage tasks, whether documentation, conservation, or restoration, a toolbox of complementary technologies is needed for viewing the object from multiple perspectives, as this is the path to reveal its full authenticity.

A case study, as any research experiment, uses one method to find its results and to assess the appropriateness of the results to the initial purpose. The method may provide novel results, the same results in comparison to previous techniques, or it may provide data that are difficult to interpret meaningfully for the given input. Nonetheless, by exploring the particular method, future research can be continued or not in that direction, depending on how encouraging the results are.

Figure 6.5. The RGB visualizations of the Orthodox icons and the medieval manuscripts in the National Museum of Romanian History, Bucharest. Photos: Irina Mihaela Ciortan.



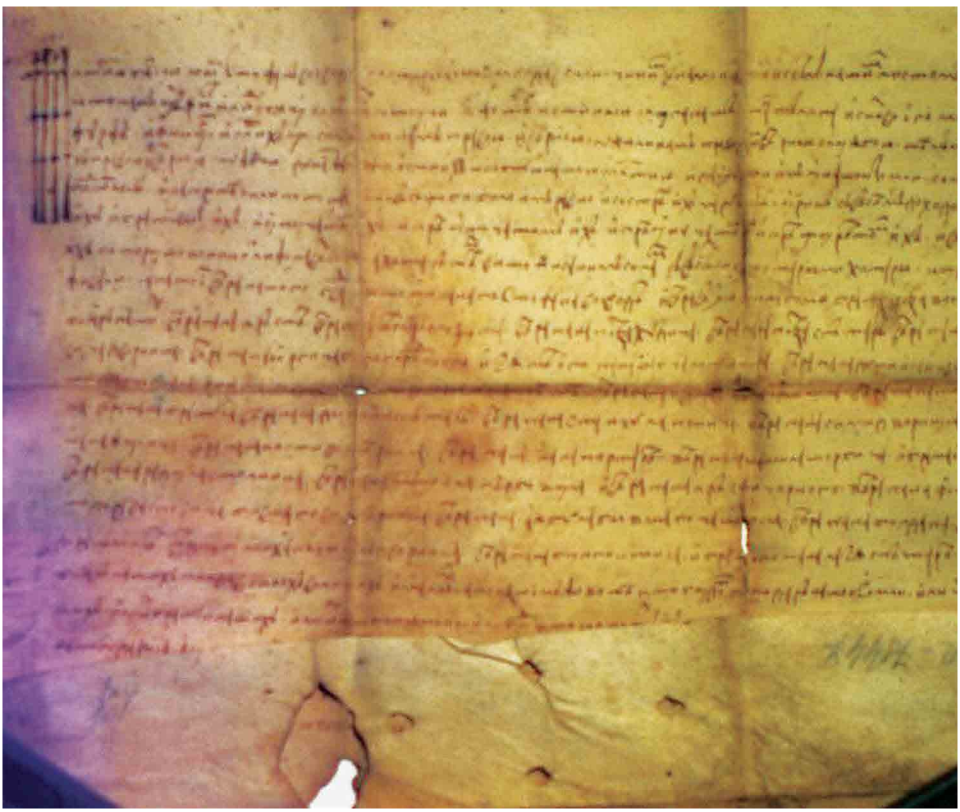


Table 6.1. Selected Cultural Heritage Objects, as Documented in the Database of the National Museum of Romanian History, Bucharest.

Inventory No.	Subject	Creator and dating
88220	Saint Michael and Saint Gabriel	Artist unknown, last quarter of the 18th century
88232	Virgin Mary and Child	Unknown Russian artist, nineteenth century
172399	Crucifixion	Unknown artist, eighteenth century
12143	n/a	Object belonging to the Neolithic Cucuteni culture; dating imprecise
12136	n/a	Object belonging to the Neolithic Cucuteni culture; dating imprecise
15894	n/a	Object belonging to the Neolithic Cucuteni culture, approx. 3800–3600 BC
MS 30414	n/a	Mihail Apafi, Prince of Transylvania, Sibiu, 1663
MS 107427	n/a	Stephen the Great, 1462
MS 108160	n/a	Voievod Ștefan Lupu, 11 May 1660
MS 108162	n/a	Radu Mihnea, 26 March 1618
MS 75447	n/a	Ștefan II, Voievod of Moldavia, 16 April 1443
MS 131443	*Pravila de la Govora* (Law book of Govora)	The first Romanian Code of Laws published in Wallachia, 1640, under the rule of the voivod Matei Basarab; in vernacular Romanian, in Cyrillic alphabet

In conclusion, this case study at the National Museum of Romanian History provided spectral and spatial documentation for a number of cultural heritage objects, recording one moment in their history and status, offering a new perspective for visualizing appearance features and setting a new benchmark for future research, as more and more technologies emerge to be used for the recording of cultural heritage.

Object type and main material	Details and dimensions
Icon on wood panel	Double-sided icon, 26.5 × 21.5 × 2.4 cm
Icon on wood panel	Portable icon, 39.5 × 31.5 cm × 2.5 cm
Icon on wood panel	The icon was restored in the 2010s. 38.0 × 31.2 × 2.5 cm
Ceramic vessel	The vessel was made of clay, decorated with painted circular and spiral designs, and fired
Ceramic vessel	The vessel was made of clay, decorated with painted circular and spiral designs and fired
Amphora with bitronconic decoration	The vessel was made of clay, decorated with intricate designs and fired. Height 36.0 cm; max. external diameter 38.0 cm; internal diameter 17.2 cm
Manuscript on parchment, written with sepia and green inks; red wax seal, silk threads, wood	Document issued by Prince Mihail Apafi bestowing a noble rank and coat of arms on Toma Trambitas of Betlean. 32 × 61cm; seal diameter 7cm
Manuscript with attached seal	31.0 × 52.5 cm
Manuscript charter with attached seal	49 × 64 cm
Document with attached seal	44.5 × 70.0 cm
Manuscript in ferrogalic ink on parchment	The document, 21 × 27 cm, is written in Slavonic.
Codex printed in typographic ink on paper. The cover is made of cardboard and is wrapped in leather	The codex, 19.7 × 14.0 × 3.5 cm, consists of 337 pages. It was restored in 2010 and subsequently scanned in 2D though the programme "Manuscriptum." The codex is being preserved wrapped in Japanese tissue, with neutral pH and cased in antistatic and fireproof polyethylene foam.