Heritage textiles – an integrated approach for assessment and future conservation

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DORINA CAMELIA ILIEȘ
LILIANA INDRIE
TUDOR CACIORA
GRIGORE VASILE HERMAN
ANCA HUNIADI
MIRCEA SANDOR
ADINA ALBU
MONICA COSTEA
CĂLIN MOȘ
SAFAROV BAHODIRHON
EMILIAN TARCAU
EMILIA PANTEA

ABSTRACT – REZUMAT

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The digital revolution has been present in our lives more and more since the beginning of the third millennium and until now, has affected the way in which cultural heritage is valued, preserved and passed on. In this context, the present study aims to use digital technologies (digital radiography and Reflectance Transformation Imaging) to contribute to assessing the conservation status of a heritage textile fabric; a traditional women's shirt about 100 years old from Bihor County (ie). The investigations concerned both the fine details that are not visible to the naked eye, regarding the internal structure of the material and external (damaged areas, embroidery with traditional motifs, etc.). The results obtained show high suitability of the methods used for the analysis performed on historical textiles, having major importance in identifying the visual representation of the weave, the fibres and the surface of the fabric, the deterioration and also the current state of preservation and contributing to the identification of optimal restoration-conservation solutions.

Keywords: *digital radiography, Reflectance Transformation Imaging, digital techniques, cultural heritage textiles*

Patrimoniul textil – o abordare integrată pentru evaluare și conservare

Revoluția digitală a fost prezentă din ce în ce mai mult în viața noastră de la începutul mileniului al treilea și până în prezent, afectând modul în care patrimoniul cultural este valorificat, conservat și transmis. În acest context, studiul de față își propune să utilizeze tehnologiile digitale (radiografie digitală și tehnica RTI – Reflection Transformation Imaging) pentru a contribui la evaluarea stării de conservare a unui articol vestimentar de patrimoniu: o cămașă tradițională pentru femei, veche de aproximativ 100 de ani, din județul Bihor. Investigațiile au vizat atât detaliile fine care nu sunt vizibile cu ochiul liber, privind structura fibrelor, cât și externe (zone deteriorate, broderii cu motive tradiționale etc.). Rezultatele obținute arată o adaptare ridicată a metodelor utilizate pentru analizele efectuate pe textile istorice, având o importanță majoră în identificarea si reprezentarea vizuală a țesăturii, a fibrelor, a suprafeței materialului, deteriorarea, starea actuală de conservare și contribuie la identificarea soluțiilor optime de restaurare-conservare.

Cuvinte-cheie: *radiografie digitală, RTI (Reflection Transformation Imaging), tehnici digitale, patrimoniul cultural textil*

INTRODUCTION

The importance of the elements that make up the cultural heritage lies mainly in the significance they have for the community, representing a span between the past, present and future. Undoubtedly, through its diverse functionality, simplicity, beauty, sensitivity, the textile heritage is certified as one of the most valuable samples that make up the material cultural heritage of a nation [1–2]. Whether it is represented by textiles with aesthetic values (paintings on canvas, decorative elements, etc.) [3–5] or practical ones (traditional garments, etc.) [6–8], the textile heritage facilitates the connection of the traditional universe, especially the rural one [9], to the largely informational society that characterizes the present.

For Romanians, one of the most significant and defining objects of textile cultural heritage is undoubtedly the traditional shirt called "ie". This part of the traditional costume, both men's and women's, is an unofficial Romanian brand that embodies the very spirit of this nation, depicting continuity (through its origins in the characteristic garment of the Dacian tribes – ancestors of the Romanians) and unity (by sharing this garment in different varieties, throughout Romania) [10].

The passing on of this cultural heritage to future generations involves sustained efforts to evaluate-preserve the authentic elements, considering that by their formation, the production techniques and materials used, traditional shirts are movable objects. To

achieve this goal, both traditional methods of analysis and new ones, updated to the requirements of a constantly changing cultural heritage, must be taken into account. The study indicates some possibilities of application in the practice of methods for assessing the conservation and capitalization and evolution stages of the heritage materials. Another considerable importance for practice is to point out the risk of damage to the health of museum and archive staff coming into contact with the preserved historical artefacts.

Among the newest techniques for the analysis of the textile cultural heritage, digital radiography and Reflectance Transformation Imaging (RTI) stand out. Digital radiography in old and new valuable textiles is an important analytical technique because it is non-destructive and non-invasive, economical and very fast [11–14] which can provide morphological and physical information about the inner structure of the investigated samples [15–20]. This can be a good foundation for documentation in terms of fabric making technique, damage and repair, etc., successfully contributing to the designation of the state of conservation of materials, its evolution over time and finding optimal conservation solutions. Ultrasound images of higher resolution and contrast indicate fine details of the textile material under investigation, weaving techniques, embroidery, etc. and will be completed, when necessary, if possible, by means complementary to other three-dimensional images (e.g. those obtained with the help of a computer tomography etc.). However, it is noted that a series of radiographic exposures of historic fabrics show that excessive exposure to low energy X-rays produced no detectable changes in their mechanical integrity [21]. At the York Art Gallery, there was an exhibition with radiographic images of quilts that presented the general public not only the technical details of the fabric of the quilts, defects, possible repair techniques, but they were also valuable and appreciated for the beauty of the photographs [22].

As for Reflectance Transformation Imaging (RTI), this is an image capture and processing technique that uses multiple illumination angles to generate advanced topographic information. The most common way to implement RTI is through Polynomial Texture Mapping (PTM) [23], developed by Malzbender et al. [24], representing one of the techniques that make up the general term Reflectance Transformation Imaging (RTI) [25]. RTI allows the detailed examination of the surfaces of vulnerable objects, without direct contact with them, using light sources from different positions [26–27] and comparing luminance values of each pixel to approximate the inclination and relative depth of the analysed surface [28–29]. Interactive light control and the ability to change reflection properties increase the perception of surface structure, unlike ordinary photographs, which are static, thus enhancing the visibility of fine details and damaged areas [30–31]. In addition to the advantages offered by interactive visualization and analysis of the physical and morphological properties of different objects, RTI is a very easy to obtain and cheap technique at the same time [32].

In view of the above, the purpose of this study is to make an incursion into the application of digital radiography and Reflectance Transformation Imaging (RTI) in the analysis of old and rare textiles, for their preservation and popularization among the public. These two techniques are to be applied on a traditional Romanian shirt, about 100 years old, originating from Bihor County, Romania.

MATERIAL AND METHOD

To obtain ultrasound images, the ultrasonography technique was used, a Samsung RS 80 (Samsung Healthcare Ultrasound) device, equipped with high-resolution linear probes: L3-12A probes, with variable frequency up to 12MHz, respectively LA4-18B probes, with variable frequency up to 18MHz [8].

Applying the RTI method to the traditional shirt involved the use of a DSLR Canon EOS 90D camera with CMOS sensor, 22.3x14.8 mm in size and resolution of 32.5 mpx, fixed at the bottom of a stand, a continuous light source consisting of a 15W LED projector placed at a constant distance of two lengths from the centre of the object and two bright red balls (24 mm in diameter) located in the close proximity of the shirt. Thus, using an independent shutter, 75 raw images were captured with light sources varying in different positions (15 concentric positions containing 5 rows each, obtained between an angle of 15° and 65° formed by a straight line. perpendicular to the horizontal plane represented by the surface of the object in question). The photos obtained were introduced into the Digital Lab Notebook Inspector – RTI Version 1.0 Beta, open-source software created by Cultural Heritage Imaging [33], in order to test the accuracy of the images and correct or include those considered inappropriate in terms of quality to be further processed.

The corrected data were entered in RTIBuilder Version 2.0.2 [34] to obtain the final model. The processing pipeline is based on a semi-automatic approach in which after manually indicating the positioning of the two shiny balls, the software seeks to determine the incidence of light in each photo based on its specular reflection on the surface of the balls. Furthermore, after automatic detection of the light

Fig. 1. View of the RTI model of the traditional women's shirt in the Default mode of RTIWiever

source position and a manual redefinition required in some photos, all 75 captures were successfully interpolated in a single reference area. Interactive viewing of the created model was done in RTIWiever Version 1.1 [35] (figure 1).

RESULTS AND DISCUSSION

The internal structures of the textile materials made of natural fibres (cotton, linen, silk, etc.) are very fine; the fibres have low densities, which together with the retention of water molecules in the intermolecular cavities can attenuate X-rays, the images not always having very good contrast, have to be very good to allow examination under magnification and improve the contrast by applying specific software [22].
The heavily damaged areas in the traditional shirt were the subject of another study [8], where through digital ultrasound were highlighted the areas that have discontinuities (e.g., ruptures, thinning, etc.). In the ultrasound images (figure 2) made to capture some fine irregularities of the fabric, one can still observe a great homogeneity of the material, mostly free of ruptures or gaps in the fabric mass; a sign that it is in a good state of preservation regarding the internal properties of the material.

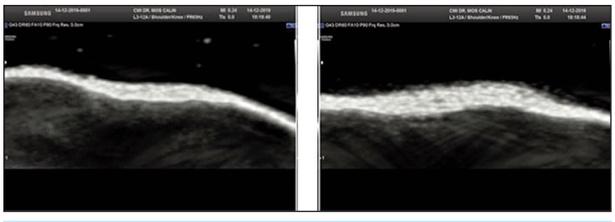

Fig. 2. Clinical Echography of the fabric of traditional shirt (ie)

The results obtained after performing the RTI on the traditional "ie" shirt were used to maximize the information transmitted and increase the volume of key details in order to determine more accurately the damaged surfaces within the cloth. The opportunity this technique offers is to separate the colour of the object from its texture and this aspect as a homogeneous surface in terms of hue favours the highlighting of degraded surfaces by observing them at different angles of light. Thus, in figure 3 can be seen multiple defects of the shirt with much higher accuracy than by the typical method of evaluation made with the naked eye, where many defects can go unnoticed due to the inappropriate incidence of light. In this respect, the image pairs A1-A2 and C1-C2 in figure 3 are edifying for the relevance of the method in terms of detecting damaged areas that stand out; here, the placement of the light source at a small angle in the upper part of the object and the modification of the specularity parameters have determined a certain shading of the two targeted areas, thus increasing the visibility of the defects. In B1-B2, the aim was to evaluate a group of small artificial damages, represented by holes in the depth of the material at the bottom of the shirt. And in this case, the interactive viewing allowed a better understanding of the degraded surfaces, the ruptures appearing more pronounced and with a greater extension than those observed with the naked eye or in default mode.

Fig. 3. Representation of the differences obtained in terms of detecting damaged areas between the default mode (A1, B1, C1) and interactive viewing through the spatial variability of light incidence and changing the parameters of specularity (A2, B2, C2)

At the same time, given the fact that the traditional motif is one of the most important and spectacular components of traditional Romanian shirts [36], the models themselves, the way they are made, the colour, etc., it is necessary to be kept and transmitted to future generations [37, 38]. In this context and considering that the qualitative photographic basis offered the possibility to generate an area of increased clarity, the traditional motif on the traditional shirt was evaluated in terms of conservation status and physical properties. The results of the analysis (figure 4) show that the motifs are in a very good state of preservation. They do not show abrasions, breaks, gaps or other discontinuities of natural or artificial origin, the models being homogeneous. The ability of RTI to arbitrarily represent geometric and diffuse shading effects, as well as to highlight details, when the light is positioned at a low angle, offers the possibility to analyse how it is made, shape, cloth, the material used and arrangement within the objects of these traditional motifs. This is fundamental for the preservation of motifs, the creation of physical and/or virtual prototypes and their application on new materials [39–41].

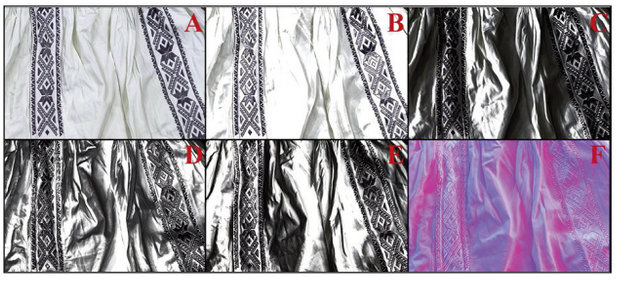

Fig. 4. Evaluation of the traditional motifs of the women's shirt under a spatially variable light source in RTIWiever: *A* – default view; *B* – specular enhancement with the light source positioned at the top; *C* – specular enhancement with the light source positioned at the left; *D* – specular enhancement with the light source positioned at the bottom; *E* – specular enhancement with the light source positioned at the right side; *F* – normal visualization

Interactive viewing from several angles of incidence of light (figure 4, *B*, *C*, *D* and *E*) and from different lighting positions, encourages an increased perception of the surface and the arrangement of the models from the overview (default mode) (figure 4, *A*). While the normal visualization mode (figure 4, *F*) creates a false-colour rendering at the pixel level, where X, Y and Z are represented by red, green and blue, thus highlighting the orientation and contour of the surfaces. This mode is very useful both in determining the contour of the traditional pattern on the shirt and the angle of inclination of the surface in question.

CONCLUSIONS

Radiographic technique and Reflectance Transformation Imaging are non-invasive evaluation methods that can be used successfully in the field of textile cultural heritage. Their aim was to highlight fine details of the fabric, which under normal conditions are not visible to the naked eye with the possibility of tracking the evolution of vulnerable areas over time and finding long-term conservation solutions. Following the application of the radiographic technique on the traditional women's shirt, a relative homogeneity was observed in terms of the internal particularities of the material, the degradations being mostly artificial and showing in separation. Using the free manipulation of the light source provided by the RTI models, the damaged surfaces were carefully examined in order to better understand the nature of the discontinuities for the future preservation of the piece of clothing. This integrated approach has proven to be very practical in identifying the degraded areas, with the great advantage of not being invasive. At the same time, the techniques involve minimal interaction with the original, they are fast both in terms of acquisition and processing, very easy to use even by non-experts, and in addition to the equipment needed to acquire data (even low-cost equipment performs well), the software dedicated to processing and visualization are open-source.

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Authors:

DORINA CAMELIA ILIEȘ[1], LILIANA INDRIE[2], TUDOR CACIORA[1], GRIGORE VASILE HERMAN[1], ANCA HUNIADI[3], MIRCEA SANDOR[3], ADINA ALBU[2], MONICA COSTEA[4], CĂLIN MOȘ[3], SAFAROV BAHODIRHON[5], EMILIAN TARCAU[6], EMILIA PANTEA[4]

[1]University of Oradea, Faculty of Geography, Tourism and Sport,
1st University Street, Oradea, 410087, Romania
e-mail: dilies@uoradea.ro, tudor.caciora@yahoo.com, gherman@uoradea.ro

[2]University of Oradea, Faculty of Energy Engineering and Industrial Management,
Department of Textile, Leather and Industrial Management,
B. St. Delavrancea Str. No. 4, 410058, Oradea, Romania
e-mail: lindrie@uoradea.ro, aalbu@uoradea.ro

[3]University of Oradea, Faculty of Medicine and Pharmacy,
St. Piața 1 Decembrie nr. 10, 410073 Oradea, Romania
e-mail: ancahuniadi@gmail.com, drims75@yahoo.com, drmoscalin@yahoo.com

[4]Faculty of Environmental Protection, University of Oradea,
26th Gen. Magheru Street, Oradea, 410048, Romania
e-amil: epantea@uoradea.ro

[5]Samarkand State Institute of Economics and Service, Uzbekistan
e-mail: safarovb@rambler.ru

[6]University of Oradea, Department of Physical Education and Kinetotherapy, Romania
e-mail: etarcau@uoradea.ro

Corresponding author:

MONICA COSTEA
e-mail: mcostea@uoradea.ro