INSIDDE: Integration of Technological Solutions for Imaging, Detection, and Digitisation of hidden Elements in Artworks

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Abstract—until relatively recent years, the curators needed to do assays and tests on artworks, involving an aggression on materials and the integrity of the paintings. Today, thanks to the valuable work of experts in physics, chemistry and different non-invasive technologies, we are able to study and explore aspects of the artwork that provide us information of high relevance and high accuracy to develop our labor. This workshop is intended to give an overview about the capabilities of terahertz (THz) waves in the field of cultural heritage and make a comparison with other technologies such as infrared (IR) reflectography or optical coherence tomography (OCT). In this workshop, different cases dealing with 2D and 3D artworks will be presented.

Keywords—art, conservation, restoration, scientific studies, UV reflectance, IR reflectography, X-rays, optical coherence tomography, THz waves, INSIDDE.

I. INTRODUCTION

In the analysis of artworks, novel imaging technologies and techniques are becoming more and more common at research laboratories and museums as a result of the latest breakthroughs in other areas of knowledge. Based on the achieved resolution, interaction with materials or penetration depths, they are often deemed to be complementary to other approaches that have been traditionally employed by curators, such as IR reflectography, UV reflectance and X-rays.

Our investigation in the framework of the project INSIDDE [1] is focused on the use of terahertz technology on artworks. Terahertz radiation is usually defined as the region within the electromagnetic spectrum lying between 0.3 and 3 THz –

wavelength between 1 mm and 100 microns respectively. As a consequence, it can penetrate through dielectric materials up to 1 cm, allowing the expert to recover information about inner layers that cannot be seen by the human eye. In addition, this non-ionizing radiation guarantees that both professionals and artistic objects are not at risk when applying this technology. These features have paved the way to be introduced in different sectors, especially in the last decade: security applications (e.g. airport screening), health (e.g. skin cancer detection) or non-destructive tests (e.g. analysis of paints, composites, etc.).

Regarding cultural heritage, although other studies have been carried out using commercial equipment, this is the first time graphene-based transmitters and receivers have been designed and fabricated to build a THz scanner that works in reflection mode and can be configured to scan 2D and 3D artworks.

II. THE PROJECT

The main objective of INSIDDE can be stated as unveiling unknown features - hidden paint layers, overpainting, possibly underdrawing steps, brushstroke textures, sealed contents - of both 2D and 3D artworks for enhancing the knowledge-sharing of and the access to the digitised surrogates of the original cultural resources.

In order to achieve the goals, the project relies on combination of terahertz technology, image processing techniques, and 3D high-resolution scanning as the basis for the development of an innovative augmented reality application for smartphones to be used at museums and the

integration of the digital models into Europeana. Although the focus of the workshop will be on terahertz technology and processing techniques, references to how to exploit the results from different points of view will be commented.

Fig. 1. Photograph of the painting that is being used to test and validate the performance of the terahertz scanner.

The overall process to complete the study is split into different phases. The first one consists in preparing samples and reproductions with several pigments in diverse binders, so that this can be measured by the THz scanner. Therefore, information about the paintings and/or pieces of ceramics must be collected beforehand until a large database is available. This is a common procedure that is applied in the most emerging technologies to ensure the measurements are in agreement with the expected results.

Fig. 2. Measurement of samples made of different pigments to obtain reference signals with the purpose of calibrating the equipment.

This initial step is followed by 2D image processing techniques [2-3], which contemplate an automatic analysis of THz images – including brushstroke segmentation, pigment identification, etc. – in order to extract author's features and other aspects that dwell inside. Analogically, albedo reconstruction and content identification of sealed objects by means of spectroscopy is carried out to enhance the perception of 3D artworks through highly detailed and accurate digital surrogates.

As end-user scenarios AR-based application and the integration into Europeana is being carried out at the Museo de Bellas Artes de Asturias (Spain) and the Regional Historical Museum of Stara Zagora (Bulgaria) employing real artworks so, at the end, the results will be transferred to a wider range of users of cultural resources – not only cultural heritage experts but also citizens and visitors.

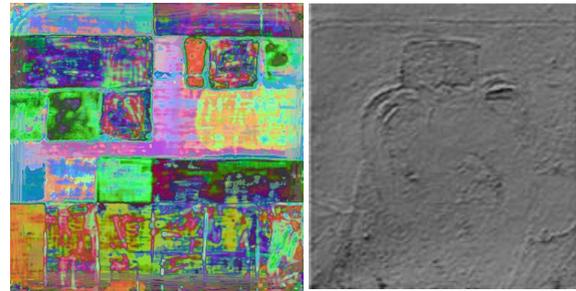Fig. 3. Different samples and a reproduction prepared by Marta Flórez Igual based on the still life.

Fig. 4. Results obtained after measuring the samples in Fig. 3. On the left, differentiation of pigments based on different image processing techniques. On the right, identification of brushstrokes.

III. STRUCTURE AND AGENDA

According to the preliminary program, this workshop is scheduled for Monday, September 28th. The sessions will start at 9:00 and will finish at 13:00. Five talks and two additional time slots for discussion between speakers and attendees are envisioned, apart from the opening, coffee break and closure. During the first part of the workshop, technologies and techniques will be analysed, paying special attention to their capabilities, pros and cons in the field of cultural heritage. The second part will concentrate on the application of terahertz technology to paintings and 3D objects, such as ceramics, sculptures, etc. This will be based on the results of INSIDDE.

- 9:00 – 9:15 "Presentation of the Workshop and Introduction to the Project INSIDDE" by Ms Marta Flórez Igual (Museo de Bellas Artes de Asturias). Welcome and overview of the project INSIDDE and terahertz technology (basis, the digitisation process, tests and validation, results).

- 9:15 – 9:45 "Automatic Analysis of Painting Terahertz Images" by Dr Hamdi Dibeklioğlu (TU Delft). Algorithms and techniques to analyse THz images but also other data obtained by different means. Focus on non-invasive pigment distinction and brushstroke identification.

- 9:45 – 10:15 "IR Reflectography and Multispectral IR Reflectography" by Dr Raffaella Fontana (centro Nazionale delle Ricerche). Description of the technology and equipment needed. Comparison between mono- and multispectral approaches. Underpaintings and underdrawings. Examples.

- 10:15 – 10:45 "Optical Coherence Tomography (OCT) applied to cultural heritage" by Dr Haida Liang (Nottingham Trent University). Summary of the latest advances and how these can be applied in the field of cultural heritage.

- 10:45 – 11:00 Discussion on the technologies and techniques.

- 11:00 – 11:30 Coffee break.

- 11:30 – 12:00 "Applications of Terahertz Imaging in Conservation of Paintings" by Ms Marta Flórez Igual (Museo de Bellas Artes de Asturias). Potential applications: underdrawings, pigment identification, etc. Preparation of samples, calibration and validation techniques. Examples.

- 12:00 – 12:30 "Applications of Terahertz Imaging in Conservation of 3D Artworks" by Ms Irina Yordanova (Regional Historical Museum Stara Zagora). 3D modelling of interiors, content identification and deposit removing. Structured light scanners. Combination of 3D models. Examples.

- 12:30 – 12:45 Discussion.

- 12:45 – 13:00 Closure.

IV. SPEAKERS

As described in the agenda, five speakers will participate in this workshop organized by Ms. Marta Flórez Igual. Their expertise is perfectly aligned with the topics addressed in this framework and they have wide experience in lecturing and giving talks in international events.

Each expert will, on the one hand, comment the latest advances in the specific area and, on the other hand, provide a more general view so that the audience can understand the context in which the described cutting-edge technologies are used. The final intention is to compare the different ways to study the works of art and bring new methodologies and resources to museums to complement existing techniques.

Dr Hamdi Dibeklioğlu (h.dibeklioglu@tudelft.nl). Post-Doctoral Researcher in Delft University of Technology. He received the B.Sc. degree in Computer Engineering from Yeditepe University, Istanbul, Turkey, in 2006, the M.Sc. degree in Computer Engineering from Boğaziçi University, Istanbul, Turkey, in 2008, and the Ph.D. degree in Computer Science from the University of Amsterdam, the Netherlands, in 2014. He is also a Guest Researcher with the Intelligent Systems Lab Amsterdam, University of Amsterdam. His research interests include computer vision and pattern recognition.

Dr Raffaella Fontana (raffaella.fontana@ino.it). Researcher in development and design of optical instrumentation for diagnostics on the cultural, multi-spectral analysis to image VIS-NIR, three-dimensional relief, coherent optical tomography for the evaluation of the thickness of the paint surface of paintings, processing and data analysis, image processing, in situ diagnostics.

Core expertise: spectrophotometry, colorimetry, 3D relief, optical interferometry, optical fibers, TDL spectrometry, neutron diffraction, data analysis, multivariate analysis of multidimensional arrays, programming environment.

Dr Haida Liang (haida.liang@ntu.ac.uk). She is a reader in Physics and Head of the Imaging Science for Archaeology & Art Conservation Research Group at Nottingham Trent University, UK. She gained a PhD in Astronomy & Astrophysics from the Australian National University. Prior to her current post, she worked at the Scientific Department of the National Gallery (London) on the development of non-invasive techniques for the examination of paintings, the Physics Department of the University of Bristol, Service d'Astrophysique of Commissariat a l'Energie Atomique (Saclay) and Australia Telescope National Facilities on various Astrophysics projects. Her main research interests are the development and application of advanced non-invasive imaging and spectroscopic techniques to art conservation, art history and archaeology. She is currently leading the Imaging Science for Archaeology & Art Conservation group within the School of Science & Technology at Nottingham Trent University.

Ms Marta Flórez Igual (martamuseoasturias@gmail.com). She works as a conservator at Museo de Bellas Artes de Asturias (Museum of Fine Arts of Asturias).

She received her Bachelor degree in Fine Arts from the University of Seville and specialized in Art Conservation. She has experience in multiple fields, such as conservation and restoration of paintings on canvas or wood and mural painting. She has also been also involved in teaching at the Art School of Oviedo. Being on the members of the INSIDDE project, she gives support to the technical partners as expert in cultural heritage and is currently responsible for the preparation of samples and reproductions as well as for the validation of results and critical assessment.

Ms. Irina Yordanova (rim@museum.starazagora.net) Graduated from University of Veliko Turnovo "St. Cyril and St. Methodius" in 2012 (BA degree in History). Her research interest is focused on Medieval European History and especially on History of the Albigensian Crusade and development of the Cathar heresy in Languedoc XI-XII c. She is currently working in the Public relation department of Regional museum of history – Stara Zagora. Her work is focused on the promotion of the cultural heritage of Stara Zagora region and the development of projects related to adaptation of the museums environment for children.

V. AUDIENCE AND BUDGET

The target audience of this workshop covers a wide range of profiles, from art experts to scientific researchers in different areas. Although an overview of the technologies will be given, speakers will mainly concentrate on the applications in the field of cultural heritage and the requirements to take advantage of the latest developments.

The workshop is also understood as a co-operative environment to foster collaborations between end-users and researchers. Therefore, a close interaction with the attendees is expected during the discussions but also during the presentations. This will limit the number of attendees to 20-25 people.

No special requirements for technical support will be requested to organize the workshop. In addition, speakers will provide some printed materials that will be funded by the INSIDDE project while a server will be enabled to share other digital contents.

REFERENCES

[1] INSIDDE project website. Available on line (17 April 2015): http://insidde-fp7.eu/

[2] Laurens Van der Maaten et al., "D3.2.1: Software for automatic analysis of terahertz images", *INSIDDE Public Report*, 2014. Available on line (17 April 2015): http://insidde-fp7.eu/sites/default/files/ INSIDDE_ D3_2_1_Dec14_0.pdf

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[4] INSIDDE leaflet, "Results. September 2014". Available on line (17 April 2015): http://insidde-fp7.eu/sites/default/files/INSIDDE_ September2014.pdf