INSIDDE project: innovative imaging technologies and processing for unveiling and understanding artworks

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***Abstract*—The development of graphene-based transmitters and receivers working in different frequency bands within the submm-wave/terahertz range is the basis to build a scanner in the framework of the INSIDDE project. This is expected to allow, together with image processing techniques and a high-resolution structured light scanner – the identification of pigments, brush-strokes or underdrawing steps in paintings as well as to take a look inside sealed pottery.**

I. INTRODUCTION

INSIDDE "Integration of technological solutions for imaging, detection and digitisation of hidden elements in artworks" [1] is a FP7 project that brings together multiple disciplines to achieve a main goal: unveiling unknown features of both 2D and 3D artworks for enhancing the knowledge sharing of and the access to the digitised surrogates of the original cultural resources.

The adopted strategy (see **Fig. 1**) relies on the non-invasive and non-harmful terahertz technology because of its capability to penetrate non-metallic materials. This is complemented by image processing techniques and end-users integration with the purpose of understanding/interpreting the measurements and, thus, getting closer to art professionals and visitors.

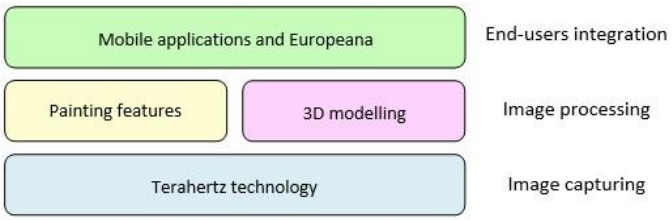

Fig. 1. INSIDDE is based on a hierarchical model that covers the whole process from acquisition to dissemination.

II. RESULTS

The THz scanner is being designed and developed from the scratch: taking advantage of the non-linear behaviour of the so called 'wonder material', graphene has been integrated into frequency multipliers and mixers [2] that are then incorporated into transmitters and receivers. The continuous-wave system [3], together with a focusing scheme and a laser sensor to improve spatial resolution and accuracy, is configured in reflection mode. An XYZ table allows a precise 3D positioning when digitising paintings and archaeological pottery (see examples in **Fig. 2**).

During the initial stages, samples resembling the original materials or pigments are being prepared by restorers. The resulting data are processed using several techniques such as filtering, image modelling, independent component analysis or classification (see **Fig. 3**) to reach the objectives outlined in the abstract. When completed, the algorithms will be available for free through a stand-alone graphical interface that will not be necessarily restricted to THz images.

Fig. 2. (Left) Still life and (Centre) sealed balsamarium for the validation process. (Right) The text was originally written with graphite and covered with layers of paint with different thickness. At the bottom, the resulting image using the THz scanner.

Regarding 3D acquisition, a structured light scanner is being used to generate realistic 3D digital models of pottery that will be merged with relevant information from the interior obtained by the THz scanner. Likewise, spectrum analyses are expected to facilitate the identification of substances in sealed elements by comparison with some references. Revealing carved or embossed decoration behind deposits of limestone is another potential application being tested.

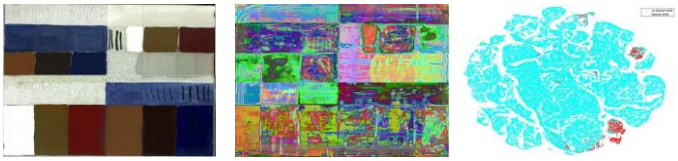

Fig. 3. (Left) Samples of pigments used in the original painting. (Centre) Terahertz spectra obtained via t-SNE analyses. (Right) Scatter plot of terahertz spectra in which the presence of titanium white is highlighted in red.

Results will be shared through the Europeana network [4] and will be integrated into an augmented reality based application for smartphones and tablets that will be available at the participating museums.

The consortium will continue working on these topics and collaborating with other institutions until December 2015.

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