INSIDDE

Collaborative Project

FP7 – 600849

Publishable summary

First Reporting Period (RP1)

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INSIDDE ("Integration of technological solutions for imaging, detection, and digitisation of hidden elements in artworks") is a FP7 project – under the topic FP7-ICT-2011.8.2 ICT for access to cultural resources – that started in January 2013 and has a duration of three years. The consortium consists of eight partners assuming multidisciplinary roles – researchers, restorers or art advisors – in an international environment – universities, small-medium enterprises, research centres and museums from five European countries:

- Treelogic (coordinator, Spain), Dr Javier Gutiérrez Meana (javier.gutierrez@treelogic.com)
- Universidad de Oviedo (Spain), Dr Samuel ver Hoeye (sverhoeye@tsc.uniovi.es).
- ITMA Materials Technology (Spain), Dr David Gómez Plaza (d.gomez@itma.es).
- Technische Universiteit Delft (Netherlands), Dr Laurens van der Maaten (lvdmaaten@gmail.com).
- 3D Dynamic Bvba (Belgium), Ms Denis Grauzinis-Bartels (denise@3ddynamics.eu).
- Consiglio Nazionale delle Ricerche (Italy), Dr Raffaella Fontana (raffaella.fontana@ino.it).
- Regionalen Istoricheski Muzei Stara Zagora (Bulgaria), Ms Irina Yordanova (rim@museum.starazagora.net).
- Centro Regional de Bellas Artes de Oviedo (Spain), Dr Alfonso Palacio (direccion@museobbaa.com)

The main goal of INSIDDE is unveiling unknown elements – such as underdrawings, underpaintings, identification of pigments, contents or brushstrokes – in 2D and 3D artworks by means of a combination of a novel technology – terahertz (THz) waves – and advanced processing techniques. On the one hand, the results will be integrated into an augmented-reality based application for smartphones and tablets and, on the other hand, these digital surrogates will be shared through Europeana. Therefore, not only visitors but also art professionals and all European citizens in general will benefit from this work.

The objective pursued by the participant entities can be split into six more specific challenges. However, none of them exactly corresponds to one particular year. During the First Reporting Period (RP1) – from January 2013 to December 2013 – a THz scanner was being developed for the acquisition of images at different frequencies, making the best of its capabilities (penetration depth, spatial resolution). In addition to this, some experiments were performed to analyse and interpret the THz data. All along 2014, these tasks will be reinforced and will definitely produce the first results using ad-hoc or fake paintings.

According to the work plan, INSIDDE is divided into 6 work packages – 4 technical, one for dealing with management and administrative issues, and other for dissemination and exploitation. Besides, the achievements will be assessed through 7 milestones and 29 deliverables. Nonetheless, as planned, 5 deliverables were completed in RP1 – two of them release through the website (www.insidde-fp7.eu) – 2 milestones were reached and 4 work packages were running. The tasks and activities of work package 1, 2, 3 and 6 (WP1, WP2, WP3 and WP6) will be outlined in the subsequent sections.

1.1 Work package 1 "Project coordination"

The aim of WP1, as stated in the Description of Work (DoW), is ensuring a successful completion of the project goals on time, within budget, and with quality standards. To this end, two tasks were defined: T1.1 "Project management and coordination" and T1.2 "Quality requirements assurance". While the former is responsible for the development of activities regarding coordination, planning, management and administrative matters of non-technical matters, the latter is devoted to provide confidence that INSIDDE satisfies the quality standards, preserves the access rights and is performed as a continuous process in which the partners spend the minimum effort on ancillary aspects. During 2013, several actions were executed to comply with those obligations:

- Inviting the partners to and organising meetings (in person or via teleconference): kick-off (4-5 February 2013) and follow-up (15 July 2013). A picture is presented in Figure 1.
- Defining the different committees – Steering Board, Scientific Committee and Intellectual and Property Rights Committee – and appointing their members.
- Ensuring a good communication among the partners and with the European Commission (EC) by creating dedicated mailing lists and providing an online application for sharing all types of documentation – reports, dissemination material, meeting minutes, etc.
- Submitting the deliverables to the Project Officer in due time. Before, the process of writing, reviewing or making changes was agreed as part of the quality assurance.
- Initiating, leading and completing the amendment process that allowed Centro Regional de Bellas Artes de Oviedo to enter the consortium.
- Managing the funds – including day-to day or extraordinary operations such as the distribution of the pre-financing amount.
- Creating a set of templates – presentations, deliverables, deliverable review, meeting minutes, etc. – to facilitate the readability and the integration of contents and building a "project identity" through the attendance to workshops, conferences and meetings with third parties.

Figure 1: Kick-off meeting.

1.2 Work package 2 "Development of a cost-effective terahertz system for specialised digitisation of artworks"

Five different frequency bands within the terahertz range are expected to be implemented in the framework of INSIDDE. Graphene based frequency multipliers and mixers are the keystones to guarantee the successful prototyping of transmitters and receivers from 140 GHz to 1.1 THz. During RP1, the focus was on the development of the elements corresponding to the band between 220 and 325 GHz.

A Chemical Vapour Decomposition (CVD) procedure was followed to obtain the first samples of this material. After generating the films, a detailed study on how to transfer them onto substrates in which metallic contacts had been previously grown was completed.

Several designs and prototypes were designed and measured respectively before selecting the frequency multiplier and mixers – one for upconversion and other for downconversion – that will be integrated into

the transmitter and receiver subsystems. In this context, the antennas were also optimised in a 3D electromagnetic simulator to satisfy the requirements of the focusing system in terms of angular range of the main radiation lobe, size of the antenna aperture, length of the horn, etc.

Regarding the focusing system, it was decided to use a setup made of terahertz lenses to focus the terahertz signals on the surface of the canvas. The scanner position will be adjusted to maintain the focus on the correct position by measuring the distance from the canvas to the terahertz transmitter/receiver head using a high precision optical distance measurement device. The optical measurement dot will be aligned with the focus of the terahertz signal on the canvas. Similarly, a second setup will be used for the reception of the signal reflected by the canvas.

1.3 Work package 3 "Automatic analysis of painting terahertz images"

This work package (started in September 2013) concentrated on two activities: the application of image processing techniques to THz images and the automatic analysis of canvas structure of paintings.

Several methods were (and are being) contemplated and implemented to tackle the identification of materials with different constitutive parameters. At the same time, it was explored how to calculate the number of layers that can be found in a painting – glue, paint, varnish, etc. Moreover, this distinction is very important to extract and analyse the information acquired by the THz scanner.

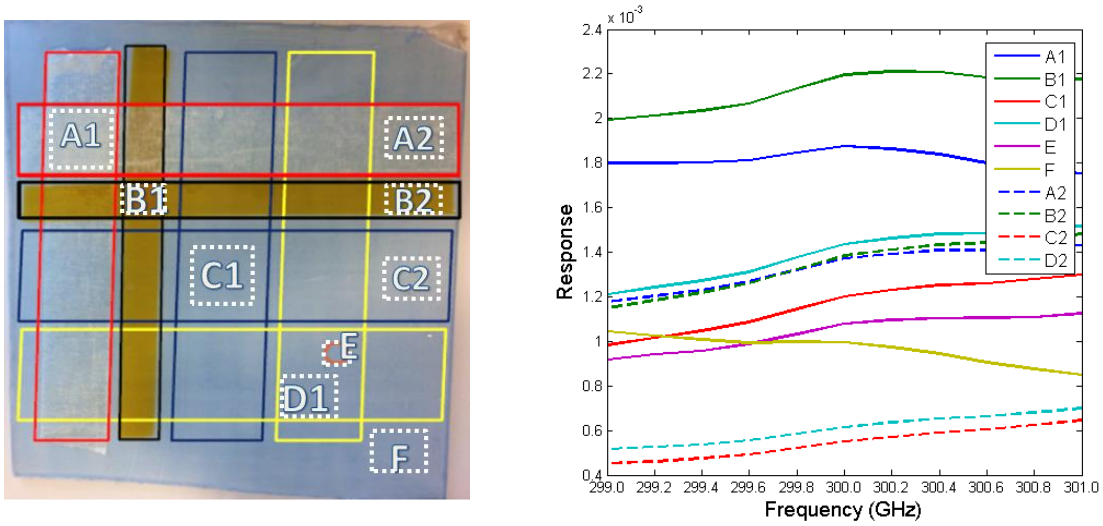

Figure 2: (a) Defined patches and (b) the mean spectra plots for these patches.

A setup consisting of overlapping tape strips on plexyglass – widths and lengths were not constant – was employed to carry out the initial tests (see Figure 2). De-noising techniques, e.g. Gaussian blurring/ deconvolution, were firstly implemented to enhance the data. Then, these were complemented by Independent Component Analysis (ICA) and Principal Component Analysis (PCA) or a division into patches among others. Promising results were achieved and more tests will be planned on real paintings.

In parallel, X-ray images were utilised to perform some experiments on the canvas structure of paintings. Detecting irregularities that persist on the whole bolt of canvas through an automatic analysis of thread crossings may lead to discern whether two artworks had a common origin – same period, workshop or even author – or not. The potential of this study was demonstrated on three paintings by Nicolas Poussin.

The algorithms that were implemented for radiography-like images will be adapted for terahertz images in 2014, once the transmitter and the receivers, together with the focusing system, are working.

1.4 Work package 6 “Dissemination and exploitation”

Dissemination deals with making known the objectives, strategies and results of INSIDDE. This can be accomplished in several ways, since it is not only restricted to technical advances. A list of quantitative indicators are in Table 1.

In particular the kick-off meeting produced high impact in the mass media in Spain and Bulgaria. Newspapers, radio and TV programmes or blogs talked about INSIDDE in the weeks that followed the event. As a result, the consortium was invited to participate in workshops, conferences and other international encounters. INSIDDE was present at the “European Microwave Week”, “Second European Conference on Conservation of the Natural and Cultural Heritage for Achieving a Stable Development: a GIS-Based Approach”, “Eurovision. Museums exhibiting Europe” or “ICT 2013” in Vilnus. Besides, Dr. Laurens van der Maaten (TU Delft) co-organised the workshop “New technologies for art conservation and history” at the Netherlands Institute for Advanced Study in the Humanities and Social Sciences (NIAS).

The project website (www.insidde-fp7.eu) was developed (and will be also supported) by the coordinator in January 2013. The design and contents were drafted in an initial phase and the final version was approved by the consortium after the kick-off meeting. Apart from the information about the objectives, the consortium, etc., perhaps the most interesting section is the one entitled “News and events”, in which the users can find information on the forthcoming activities in advance.

With regard to getting in touch with similar initiatives, INSIDDE signed agreements and collaborated with other projects in the field of cultural heritage in order to boost the technical and social impact, but also with the purpose of increasing the synergy between European funded actions. Maxiculture (www.maxiculture.eu), Europeana Photography (www.europeana-photography.eu/), Linked Heritage (www.linkedheritage.eu/) or In3DGuide (www.treelogic.com) are some examples.

Table 1 : Quantitative indicators for 2013.

Indicators	Number
Scientific publications in conferences and magazines	2
Events visited/ presentations made	3
Minutes on TV	16
Minutes on radio	41
Articles in newspapers and magazines	11
News in the Internet	18
Views in Slideshare	63

Finally, as part of the exploitation process, all the work packages and tasks were carefully examined to identify the outputs of the project. The aim is making a preliminary assessment in terms of innovation, IPR issues, competitors, financial viability to know whether one (or some) of the prototypes/techniques may be commercialised in the short-medium term. This task will continue in 2014 and 2015.


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