

NEWSLETTER

Project iPhotoCult

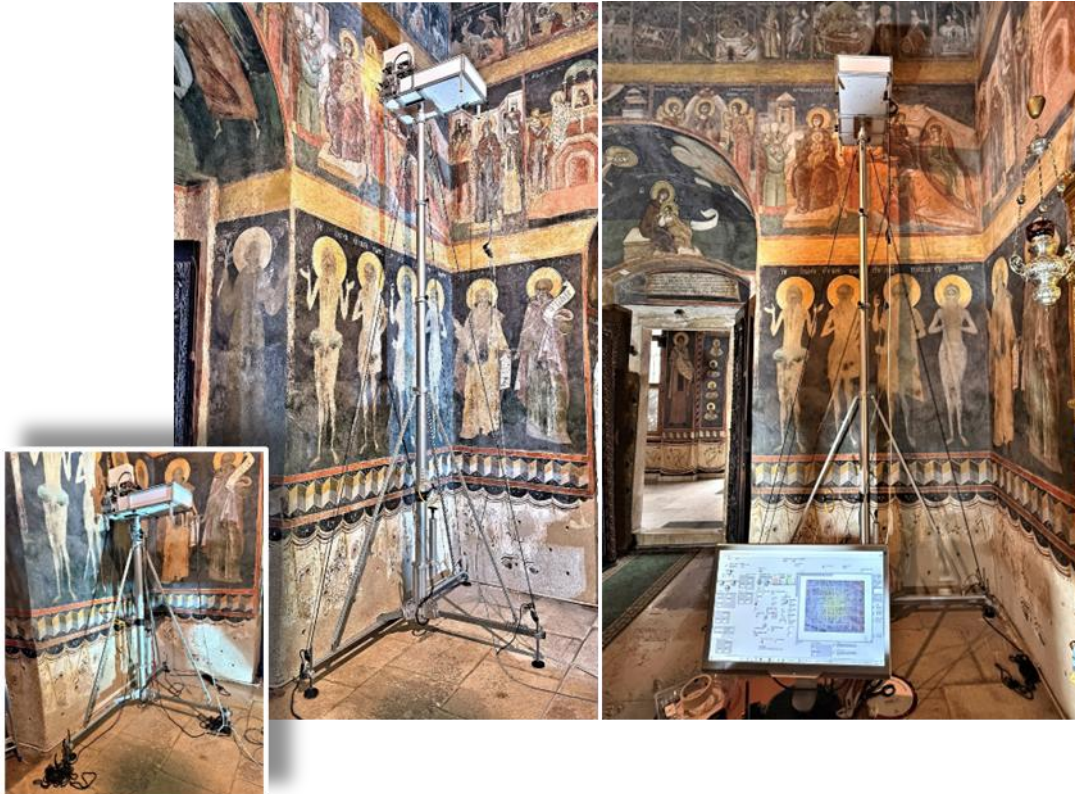
Intelligent advanced photonics tools for remote and/or on-site monitoring of cultural heritage monuments and artefacts



Funded by
the European Union



iPHOTOCULT



Bridging the Lab and the Field

At the Monastery of Tismana, Romania, CNR-IFAC in collaboration with INOE, successfully tested **Hybrid**, a cutting-edge tool combining five confocal analytical techniques and allowing to perform non-invasive compositional analyses at significant heights

At the National Gallery of Athens, FORTH tested **Optical Fiber Sensor (OFS)**, an innovative tool for remotely monitoring deformations of artworks during their exhibition or transportation

Digital Holographic Speckle Pattern Interferometry (DHSPI) successfully demonstrated at The Benaki Museum in Athens

THE PARTNERSHIP

Public and private subjects from 6 EU countries participate in the project iPhotoCult, which was approved within HORIZON-CL2-2023-HERITAGE-01-01 call

FORTH - Foundation for Research and Technology-Hellas (Coordinator)

CNR - National Research Council of Italy
CARTIF Foundation (ES)

INOE-National Institute for Research and Development in Optoelectronics (RO)

Tecreando B.V. (NL)

EAGLEprojects S.p.A. (IT)

UNIWA – University of West Attica (GR)

CCR Foundation - Centro Conservazione e Restauro "La Venaria Reale" (IT)

LSA GmbH – Laser Analytical Systems & Automation (DE)

Associated Partners

NGN - National Gallery – Museum of Alexandros Soutsos (EL)

CRRS-Consorzio delle Residenze Reali Sabaude,

AMTh-Archaeological Museum of Thessaloniki

HCYL - Consejería De Cultura y Turismo De La Junta De Castilla Y León

TECN - Technopolis, the Industrial Gas Museum of Athens

iPhotoCult at the European Researchers' Night 2025 in Heraklion, Crete

The event featured a public showcase and live demonstrations of the Optical Fiber Sensor (OFS).

iPhotoCult co-organized LACONA XIV, International Conference on Lasers in the Conservation of Artworks

R&D RESULTS

In the second half of 2025 (M12–18), **iPhotoCult** activities have progressed across multiple levels. These range from the identification of specific needs and user requirements for the nine **Cultural Heritage Pilots (CHPs)**, covering nineteen distinct Use Cases, to preliminary laboratory experiments and on-site applications of the seven analytical tools currently under development (see <https://iphotocult.eu/en/tools/> for more details). From a technical standpoint, advances achieved to date include:

- Development and optimization of the iPhotoCult prototypes
- Finalization of the design for transportable systems
- Identification of the material range of applications
- Testing of laboratory prototypes on model samples
- Demonstration of the proof of concept for iPhotoCult tools
- Development of the cloud-based Software Services Platform (iSSP) and integrated AI modules

Regarding technology development, iPhotoCult tools have reached an advanced level and they are on track with the scheduled finalization by a few months. The tools, specifically those dedicated to spectroscopic material analysis have undergone extensive laboratory implementation and testing phases. Concurrently, based on the examination of prior art, reference literature, and existing data from previous diagnostic campaigns, reference samples have been prepared and are currently under testing.

In view of the validation phase, developers have carried out dedicated laboratory investigations and evaluated instrumentation improvements to better address the specific diagnostic challenges as selected by CHP stakeholders. Preliminary campaigns have been conducted across various CHPs, which allowed preliminarily demonstrating the performance of iPhotoCult solutions and their suitability in addressing complex analytical problems in areas that are not directly accessible.

Testing the Hybrid system at Tismana's Monastery in Romania

In September 2025, the CNR-IFAC team conducted an on-site testing campaign at the Tismana Monastery (CHP5 site) in collaboration with the Romanian partner, INOE. The primary objective was to test whether the Hybrid system can provide accurate diagnostic data for the assessment and monitoring of mural paintings in harsh conditions.



Two complementary setups were tested for remotely controlled proximal analyses within height ranges up to 2 m and up to 5 m, respectively. Main aim was the validation of the overall stability in difficult operative conditions due to the significant heights to be reached, uneven limestone paving, and the many participants to the religious celebrations. The Hybrid system represents an innovative modular spectroscopic system, which was designed to address a variety of diagnostics problems characterized by harsh operative conditions. The integrated assembly combines Vis, NIR-SWIR, and LIF whisk broom hyperspectral imaging, pointwise Raman and LIBS spectroscopy, along with high-resolution snapshot Vis-SWIR imaging for comprehensive compositional mapping. It was specifically designed to operate either on a truss lift platform for works of art positioned at considerable heights or a tripod-based setup. The former allows to operate at heights of several meters without scaffolding. From an analytical standpoint, the Hybrid system enables the characterisation of a wide range of materials and conservation issues. At the Tismana site, the system was preliminarily tested for on-site diagnosis of interior frescoes suffering from the early formation of salt efflorescence and biodeterioration. This experimentation provided important information for further improvements of the mechanical and analytical performances of the tool.

Live demos of OFS at European Researchers' Night and Field Visit to the National Gallery of Athens



On September 26th, 2025, FORTH presented the iPhotoCult Project in Heraklion, Crete, during the European Researchers' Night. Through interactive demonstrations, multimedia presentations, and engaging discussions, the team (A. Giakoumaki, V. Sarakatsianos, E. Pirgianaki, S. Spyropoulou, S. Pissadakis, K. Melessanaki) showcased the project's key achievements and vision. The event offered an inspiring opportunity to share results, exchange ideas, and celebrate science, creativity, and collaboration with the public. On this occasion, visitors engaged with live demonstrations of the Optical Fiber Sensor (OFS). This compact, portable platform integrates Fiber Bragg Grating (FBG) strain sensing, which ensure high sensitivity and suitability for cultural heritage monitoring. During the live demos, the OFS system was attached to a canvas painting, showcasing its high sensitivity to environmental vibrations—detecting minute movements caused even by a clap of hands in the painting's vicinity. Following this successful outreach, the OFS system was used for field testing at the National Gallery - Alexandros Soutsos Museum in Athens (A. Terlix, E. Kouloumpi, P. Rompakis). Installed on a museum artifact for the first time, the sensor monitored stress and strain conditions. These trials confirmed the system's sensitivity, robustness, and usability while providing insights into installation constraints, noninvasive mounting, and operational workflows in conservation environments. The demonstrator represents a significant step toward deployable, real-time monitoring tools for preventive conservation and future large-scale cultural heritage applications.



Digital Holographic Speckle Pattern Interferometry (DHSPI) at The Benaki Museum in Athens

On the 12th and 13th of November, iPhotoCult Project and the Institute of Electronic Structure & Laser (IESL) - Foundation for Research and Technology - Hellas, together with The Benaki Museum and Holometrica B.V., hosted at The Benaki Museum, a live demonstration of the Digital Holographic Speckle Pattern Interferometry (DHSPI) structural diagnostics system based on a unique laser technology that detects hidden subsurface defects in artworks with unparalleled precision.

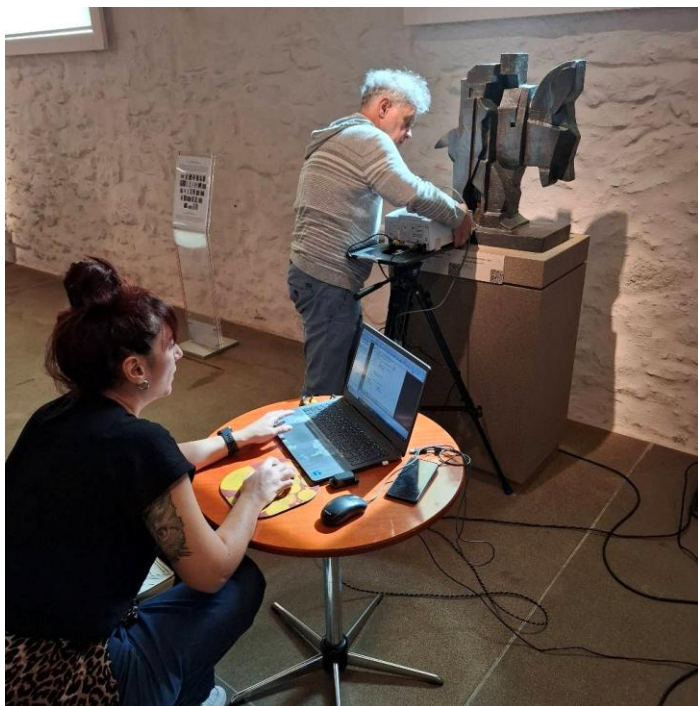


Moreover, conservators and heritage science professionals had the opportunity to delve more into this technology and its benefits, developed at IESL - FORTH and advanced within iPhotoCult Project through a series of talks from Vassilis Paschalis (Benaki Museum), Dr. Anastasia Giakoumaki (IESL-FORTH), Dr. Vivi Tornari (IESL-FORTH), Michalis Andrianakis (IESL-FORTH), Jenny Anagnostopoulou (Holometrica), and Dr. Michalis Doulgeridis (Athens School of Fine Arts). Visitors had the opportunity to observe real-time measurements on paintings from the Museum collection — with El Greco's Adoration of the Magi (ca. 1565–1567) being the most emblematic example — explore how invisible structural issues are transformed into detailed interferometric maps, and learn how this innovation is driving the shift toward preventive conservation.

Development of the cloud-based Software Services Platform (iSSP) and integrated AI modules

A significant collaborative effort focused on standardizing and processing complex data, organizing heterogeneous information from spectroscopy, imaging, and structural monitoring into a unified system. During this period, thanks to the continuous exchange between software developers, curators, and tool developers, the iSSP (Software Services Platform) has progressed through the architecture and requirement specification phase for all diagnostic tools it will host and a functional visualization demonstration. To date, the iSSP is able to provide: (a) data processing, management and visualization, (b) AI-supported data analysis (e.g., anomaly detection), data fusion from multiple Tools, and (c) analytical CH methodologies and protocols, in the form of digital "Workflows & Flowcharts & Process-Diagrams". These digital services are essential for documenting conservation interventions and leading to the standardization of risk assessments, conservation strategies, and the selection of suitable restoration materials. AI-supported prediction components demonstrate measurable progress, particularly in DHSPI optimization where machine learning algorithms have been trained using 10,000 synthetic data samples. The remote monitoring bridge is under active development, with established hardware and communication protocol specifications to ensure efficient data streaming on and off the field. A demonstration prototype based on currently available data has been created to serve as a reference for integrating all iPhotoCult tools as soon as their data become available. Simultaneously, AI components are under active development, initially focusing on the DHSPI-IRT system optimization through synthetic data generation and machine learning algorithms aimed at noise reduction and acquisition efficiency improvements. The remote monitoring bridge infrastructure has been designed with robust communication protocols and hardware specifications, incorporating miniSEED format and ringserver technology for efficient time-series data streaming. This architecture ensures seamless integration of diverse data outputs from all available tools.

Preparation for the Validation of iPhotoCult tools: Baseline Assessments



iPhotoCult at National Glyptothek in Athens, while performing in situ non-invasive FTIR analysis of coatings on bronze sculpture (UNIWA)

In view of the upcoming validation phase, preliminary condition assessments and data collection are advancing through macroscopic, photographic, and analytical techniques on both CHPs and reference mock-ups. During this period, multiple site visits were carried out across all CHPs to select specific objects of interest and establish baseline conditions. To cite a few key activities, on the 3rd of October, a team of experts from the University of West Attica (UNIWA) carried out at the National Glyptothek in situ non-invasive FTIR analysis of coatings on bronze. Coating evaluation, including degradation and the non-invasive identification of different compositions of metals and types of corrosion products on archaeological copper alloy and silver artefacts, is one of the key issues addressed in the project using iPhotoCult tools. Similarly, the mapping and monitoring of soluble salts and corrosion on surfaces, as well as structural defects in remote areas of Industrial Cultural Heritage items—such as the gas holders and the chimneys at the Industrial Gas Museum of Athens/Technopolis—were chosen as suitable use cases for the application and evaluation of the iPhotoCult methodology. These sites are ideal for testing as their condition assessment is notoriously laborious, difficult, and dangerous for the personnel responsible. On the 13th of October, students from the 1st High School of Metamorfoosi who visited the Industrial Gas Museum had the opportunity to experience the importance of maintaining industrial buildings closely and learn about an innovative methodology for monitoring and evaluating the state of large industrial structures, such as the gasometers and their chimneys. This educational session was led by Ms. Maria Giannoulaki, scientific associate of the Department of Preservation of Antiquities and Works of Art at the University of West Attica, within the framework of the HORIZON iPhotoCult program (iphotocult.eu). The Industrial Gas Museum participates in this initiative in cooperation with the Laboratory for the Study and Conservation of Ancient and Newer Cultural Items.



Paintings under assessment in the Hall of Diana at the Reggia di Venaria, Savoy Royal Residence, Turin, Italy.

Still in October 2025, CCR activities advanced in the Hall of Diana at the Reggia di Venaria, where the CCR team carried out technical-scientific monitoring on Dauphin's painting, Princess Ludovica Maria and Francesca Maria Cacherana, Countess of Bagnasco. In addition to drafting the condition report, valuable data were obtained through non-invasive diagnostic techniques including various imaging approaches (VIS raking light, IR, UV, and reflected UV), colorimetry, video microscopy, and X-ray fluorescence. These monitoring activities, periodically carried out as part of a preventive maintenance plan for the assessment of the artwork's conservation state, provide crucial information for supporting the next validation phase of iPhotoCult tools starting from M24.

Dissemination, Exploitation and Public Engagement

LACONA XIV conference in Bucharest

On 09–12 September 2025, the iPhotoCult consortium supported the Chair partner INOE to organize LACONA XIV (<https://lacona14.eu/>), the international conference on Lasers in the Conservation of Artworks dedicated to advances in photonic techniques for diagnostics and conservation-restoration of cultural heritage. The event, hosted took place in Bucharest. For nearly 30 years, the LACONA conference has brought together leading



scientists, conservators, and cultural heritage professionals to exchange knowledge and explore cutting-edge photonic solutions for preservation. At the conference, the photoacoustic laboratory of IESL-FORTH, within the framework of the iPhotoCult Project, presented a contribution titled “Non-invasive photoacoustic imaging for in-depth cultural heritage diagnostics.” This work highlighted a novel reflection-mode PA system integrating near-infrared pulsed excitation light and a spherically focused air-coupled ultrasonic transducer for the detection of generated PA waves. The system is specifically developed to detect in-depth ageing effects in painted mock-ups and to reveal hidden underdrawings, such as pencil sketches, beneath non-transparent paint layers. Overall, nine contributions supported by the iPhotoCult project were brought to LACONA XIV (see the list below for further details).



iPhotoCult's 1st Annual Consortium Meeting

On this occasion, Romania also hosted the 1st Annual Consortium Meeting, which was organized by CERTO-INOE 2000 on the 8th of September in Măgurele. The event brought together scientific representatives from all the partner institutions along with the members of the Scientific Advisory Board. This offered the opportunity for an overall examination of the status of the project objectives, milestones, and deliverables, in view of the oncoming 1st project Review Meeting, which was held online on October 14, 2025 and involved the Coordinator, WP leaders, the Project Officer and Reviewers.

Conference presentations

1. Iacopo Osticioli, Silvia Rita Amato, Aviva Burnstock, Francesco Carta, Daniela Comelli, Giada Magni, Lorenzo Marzini, Sonia Mugnaini, Salvatore Siano, Daniele Ciofini, Beyond the blue color of lapis lazuli: compositional mapping in cross-sections of painting masterpieces, Optics for Arts, Architecture, and Archaeology (O3A), Jun 23-25, 2025, Munich
2. M. Mari, E. Pirgianaki, K. Melessanaki, G. Filippidis, G. J. Tserevelakis, C. Fotakis Non-invasive Optoacoustic and Non-Linear Microscopy techniques reveal in-depth aging of CH objects, SPIE Optical Metrology, 23-26 June 2025, Munich, Germany.
3. V. Tornari, An. Chaban, M. Andrianakis, M. R. Lanfranchi, J. Striova, Optimising DHSPI-SIRT detection diagnostics through combined thermal and humidity excitation procedures on fresco mock-ups, SPIE Optical Metrology, Optics for Arts, Architecture, and Archaeology (O3A) X, 23-25 June 2025, Munich, Germany
4. V. Tornari, Y. Vezakis, M. Andrianakis, Subsurface defect classification based on deep learning-based fringe pattern analysis, SPIE Optical Metrology, Multimodal Sensing and Artificial Intelligence for Sustainable Future, 24-26 June 2025, Munich, Germany
5. Eleanna Pirgianaki, George J. Tserevelakis, Kristalia Melessanaki, Giannis Zacharakis and Costas Fotakis, Non-Invasive Optoacoustic Imaging for In-Depth Cultural Heritage Diagnostics, LACONA 14 conference, 9-12 September 2025, Romania
6. A.A.M. Pătrașcu, L.M. Angheluță, L.C. Ratoiu, Characterization of historical façades with multimodal imaging techniques, LACONA 14, 9-12 September 2025, Romania
7. (UNIWA) Poster presentation with partners involved at the international BIGSTUFF conference in 2025, 14-17th of October in Ghent, Belgium, entitled: Preserving Industrial Heritage using an innovative approach of iPhotoCult Solutions: A Case Study of the Athens Gasworks.
8. Iacopo Osticioli, Silvia Rita Amato, Aviva Burnstock, Francesco Carta, Alessia Di Benedetto, Daniela Comelli, Giada Magni, Lorenzo Marzini, Sonia Mugnaini, Salvatore Siano, Juri Agresti, Daniele Ciofini, Multi-analytical molecular mapping for assessing the quality of natural ultramarine blue pigment in painting cross-sections, LACONA 14 conference, 9-12 September 2025, Romania
9. Gianina Chiroșca, Octavian Filip, Matei Pop, Diana Dospinescu, Alecsandru Chiroșca, Computer vision machine learning tooling for cultural heritage, LACONA 14 conference, 9-12 September 2025, Romania
10. Gianina Chiroșca, Octavian Filip, Matei Pop, Diana Dospinescu, Alecsandru Chiroșca, Keeping knowledge in cultural heritage using large language models, LACONA 14 conference, 9-12 September 2025, Romania
11. L.C. Ratoiu, M. Dinu, L. Ghervase, I.M. Cortea, A. Ignața, revealing the original iconostasis of st. george wooden church from ionești (arad county-romania). a non-invasive study based on complementary spectroscopic techniques, LACONA 14 conference, 9-12 September 2025, Romania
12. L. Ghervase, M. Dinu, S. Oța, L.M. Angheluță, I.M. Cortea, The use of optoelectronic techniques for the investigation of medieval weapons, LACONA 14 conference, 9-12 September 2025, Romania
13. Laura Maestro-Guijarro, Paula María Carmona-Quiroga, Marta Castillejo, Mohamed Oujja, Verónica García, Almudena López, Salvatore Siano, Juri Agresti, Iacopo Osticioli, Daniele Ciofini, A laser-based bottom-up approach for the characterization and conservation of historical textiles, LACONA 14 conference, 9-12 September 2025, Romania
14. A.M. Pătrașcu, L.M. Angheluță, L.C. Ratoiu, Characterization of historical façades with multimodal imaging techniques, LACONA 14 conference, 9-12 September 2025, Romania
15. S. Siano, S. Mugnaini, I. Osticioli, D. Ciofini, A.A. Mencaglia, M. Giamello, J. Agresti, Interpreting the materials and execution processes of the arringatore from pila using advanced photonic techniques, LACONA 14 conference, 9-12 September 2025, Romania

Publications in peer-reviewed journals

Ketao Yan, Weizhi Jiang, Vivi Tornari, Ioannis Vezakis and Yingjie, **Electronic speckle fringe denoising using deep learning**, Measurement Science and Technology 2025. <https://10.1088/1361-6501/addf64>

Fringe denoising is a critical process for successful interferometry and a long standing issue in automated fringe processing. In this paper, deep learning fringe denoising methods are proposed and applied in electronic speckle pattern interferometry. This paper presents two denoising strategies. The U-Net model is adopted for supervised learning and trained from noisy and clean fringes. In addition, the Noise2Noise method is utilized to train the network from noisy fringe pairs, where the noise of fringe pairs has different distributions. Two datasets are established for training the parameters of two denoising networks. To verify the denoising performance, the fringes with different phase distributions and contrasts are simulated and analyzed. The average mean squared error (MSE) after supervised learning denoising and Noise2Noise denoising method is approximately 0.004 and 0.022, respectively. Different evaluation indicators are used to further evaluate the performance of the two methods.

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