Scan4Reco

Platform for Measuring, Simulating and Reconstructing Cultural Heritage

Our cultural heritage and the way we preserve and value it is a major factor in defining Europe's identity and attractiveness as a place to live, work and visit. It is powerful in creating a sense of belonging among European citizens. Therefore, the need to preserve, provide advanced access to and understanding of cultural heritage is obvious, especially when considering its wealth throughout Europe.

Scan4Reco Solution

The Scan4Reco project aims to deliver a user-friendly, modular and standardized platform that will be able to non-destructively scan cultural assets with a range of sensors, each of which delivering specific geometric, physical and chemical data. This will result in a hierarchical, multi-layered and multi-dimensional model of the object of interest. The data will allow detailed material analysis and prediction of decay and ageing processes, making the platform a valuable tool for conservation and restoration. For 3D printing of reconstructed copies of the original object at any stage of ageing, a process will be developed to yield realistic surface appearances based on the scanned data. A virtual museum is planned to share cultural heritage among professionals, students and the public alike.

The project is funded by the European Commission under grant agreement 665091 and by the Swiss State Secretariat for Education, Research and Innovation under contract number 15.0261 within the Horizon 2020 Framework Program.

benefits

for the scientific cultural heritage community

Various professionals responsible for cultural heritage objects can take advantage from Scan4Reco outputs, among them curators, restorers and conservation scientists.

In particular, 3D digitalization of cultural heritage objects can provide curators with a powerful tool that increases their capability to **visualize artwork surfaces** as well as their knowledge of the **material aspects** and of their **changes over time**.

A decision supporting system will provide aid to restorers by indicating the most suitable **treatment procedures**, selected by the system through the knowledge of the behaviour of a certain material upon exposing it in certain environmental conditions.

for companies active in cultural heritage analysis

The idea of an **integrated system** for measuring, analysing and reconstructing cultural heritage is attractive for professionals and institutions in charge of such objects. Therefore, any customer-oriented company manufacturing measurement equipment used in archaeology or arts should consider to support the Scan4Reco **platform**.

The **mechanical, electrical and informational standards** are not defined yet and will emerge as the project matures. This also means that the earlier input from equipment manufacturers is made, the better it can be incorporated into the concept. Apart from the chances, members of the Scan4Reco consortium also understand the concerns companies might have and look forward to exchange on ideas. So for companies, the best time to **get in touch** with the Scan4Reco consortium is now.

for European Citizens

The variety of individual goals of the Scan4Reco project may sound complicated and overwhelming. In simple words, Scan4Reco will be a platform consisting of hardware, software and data standards for measuring and processing 3D information on cultural heritage objects. It should be open to use with appropriate measuring equipment from different manufacturers. For a cultural heritage object, the measured 3D image data from different sensors will be stored in one standardized dataset, allowing its **reconstruction** on the computer screen or a 3D printer at different points in time – which makes the output 4D. The data can also be made available in a **virtual museum** to users connected to the internet.

Therefore, Scan4Reco will **make life easier for professionals** working with cultural heritage. It can speed up measurements, documentation and collaboration while reducing overall software training needs. The physical and virtual 3D reconstructions may help to **gain more insight into past epochs** and better **plan restoration efforts**. Via the virtual museum technology, cultural heritage objects can be presented to students, pupils and interested individuals anywhere in the world without adding stress to the originals.

This will allow an enhanced and also **new quality of experience** for everybody interested in history and arts. Furthermore, the public can profit from **cost savings** and **higher quality** in the cultural heritage sector in general.

measurement modalities

Sensors based on the following physical principles will be implemented an tested with the Scan4Reco platform:

time-of-flight 3D scanner

The depth sensor will allow the 3D modelling of a cultural heritage item capturing its **geometric structure** and **appearance**. The data collected allows to looking at and zooming into 3D replicas from different viewpoints and perspectives. At the same time the models will serve as starting point for users to select specific regions of an item for focusing into the more detailed data of other sensors.

optical micro-profilometry

The optical scanning micro-profilometer acquires small areas of the surface at micro-metric scale. In the cultural heritage field, analysis of **small-scale 3D features**, as **roughness** and **texture**, is an effective tool for material characterization and for documenting the conservation status, monitoring the decay, and controlling the treatments of an artwork's surface.

infrared imaging

For infrared imaging, the object is illuminated with a infrared broadband source. The reflection from the surface is imaged by an objective lens onto the focal plane array of a high speed camera. The resulting infrared reflectographic multispectral images reveal the **internal stratigraphic structure** of the object. The size of the imaging area depends on the lens used, and usually larger areas are composed by stitching adjacent areas.

Fourier transform infrared mapping spectroscopy

In Fourier transform infrared spectroscopy, infrared light reflected from the upper surface layers of an object is recorded while scanning the reference arm of a Michelson interferometer. From the resulting interferogram, the spectrum is calculated by Fourier transform. The spectrum holds information on the **chemical composition** of the upper surface layers. Scanning in two dimensions generates images which can reveal stratigraphic information.

infrared Raman mapping spectroscopy

For infrared Raman spectroscopy, a near-infrared laser beam is directed via an optical fiber cable to the object to excite vibrational modes of atoms and molecules within the upper surface layers. The beam may be focused for higher resolution. Emission light from the excited modes is captured and spectrally analysed to obtain information on the **chemical composition** of the object. Scanning in two dimensions generates images which can reveal stratigraphic information.

X-ray fluorescence spectroscopy

X-ray fluorescence spectroscopy uses a primary X-ray beam to excite the electrons in the atoms of the object under observation. The collected secondary X-ray emission contains the fluorescence spectrum of the elements. This allows the qualitative and quantitative analysis of the **elemental composition** of a cultural heritage object.

acoustic microscopy

Acoustic microscopy sends ultrasonic waves into the object and listens to the echoes to see below the surface and obtain the **3D sub-surface geometry**. The concept is similar to the well-known medical ultrasound, but reach within cultural heritage objects is usually very short. For example, hidden paint layers can be visualised without destroying the object.

ultraviolet or visible mapping spectroscopy

In ultraviolet or visible spectroscopy, the object is illuminated by an ultraviolet or visible light standard, respectively. Light from one point of the surface is collected and spectrally analysed to retrieve **colour properties** of the surface. Scanning in two dimensions generates a colour map.

multi-spectral reflectance transformation imaging

Device for measuring, through controlled lighting, the surface structure and visual characteristics of material samples and of flat areas of cultural heritage objects such as paintings or engravings. The application is in material characterization and **object surface** analysis.

visual camera

Except for the time-of-flight 3D scanner, the target areas of the different sensors on the cultural heritage object are very small. An (optional) camera can **visualize and locate the target area** of the other sensor modalities.

platform

control unit

The control unit will accommodate hardware and software needed to operate the system for measurements in situ. It holds a computer with user interface and controller devices for the sensors of the measurement modalities to be employed for the cultural heritage object under observation. The control unit links to the assisted positioning system.

assisted positioning

A multi-axis positioning system will allow sensor probes to be brought to the area of interest for measurement. Sensor probes will be mounted subsequently via mechanical adapters which support a high degree of repeatability.

analysis and simulation

Several software tools will be available for processing measurements. For example, it will be possible to simulate and visualize the ageing of surfaces, get information helpful for conservation by a decision support system or simply exhibit cultural heritage objects in a virtual museum.

reconstruction

Based on the physical properties recorded with multiple sensors, a parameter set can be derived to allow visual surface appearance to be reproduced in a 3D printing pipeline. This will allow to produce realistic copies of cultural heritage objects.

consortium

CERTH

CERTH is a research organization actively working on the fields of computer vision and virtual reality. Within Scan4Reco, CERTH is responsible for overall project management, while from a technical viewpoint CERTH will offer sensing technology to generate digital 3D replicas of cultural heritage items. In addition, CERTH will develop a software framework that will process measurements from multiple sensors in order to facilitate the conservation and restoration efforts of scholars.

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Ormylia Foundation

The Art Diagnosis Centre of Ormylia Foundation conducts interdisciplinary research on and provides services for the analysis, documentation and preservation of artwork and monuments of cultural heritage, with particular expertise on Byzantine iconography. It has already developed a multi-sensor system for cultural heritage analysis and will enrich the Scan4Reco project with engineering and application experience, existing sensor hardware and contacts to industrial partners.

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Fraunhofer IGD

The 3D Printing Department of Fraunhofer Institute for Computer Graphics Research develops models, algorithms and software to enable multi-material 3D printing which does not only accurately reproduce shape, but also visual perception based on optical material properties such as colour, texture, gloss and opacity. Within the Scan4Reco project, the department will create a device-independent parameter space to communicate visual properties, develop a workflow to reproduce anisotropic visual information and apply both for printing 3D reconstructions of pilot artworks.

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University of Verona

The Department of Computer Science University of Verona covers teaching and research activities in the fields of computer science, mathematics and physics. In Scan4Reco, its Applied Physics group will implement a device for multi-scale surface micro-profilometry and contribute to the physico-chemical characterization of cultural heritage materials. The Visual Computing group will collaborate on the development of reflectance transformation imaging setups and the analysis of multi-modal data for material characterization.

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Opificio delle Pietre Dure

Opificio delle Pietre Dure is a conservation institute which performs pilot restoration interventions, draws guidelines on conservation projects, tests new materials and procedures and trains conservators. The institute will contribute to Scan4Reco by defining experts' needs on material characterization, digital representation of art objects, analysis of paintings and metals and prediction of material behaviour. It will manufacture realistic material samples to extract ageing data for the predictive system, and identify pilot artworks to evaluate the Scan4Reco system.

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CRS4

CRS4 Visual Computing activities focus on the study, development, and application of scalable technology for acquiring, creating, distributing, exploring, and analysing complex objects and environments. In the context of Scan4Reco, it will develop solutions for multispectral reflectance transformation imaging acquisition and processing.

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B&W Tek Inc

B&W Tek Inc produces optical spectroscopy and laser instrumentation for laboratory, portable and handheld use targeting pharmaceutical, biomedical, physical, chemical, LED lighting and research communities. Its UV, VIS, NIR and Raman spectrometer modules allow small form factor accessories and customizable software control. In Scan4Reco, it will adapt the size and geometry of its Raman spectrometer to the needs of the system architecture in general and the probe positioning subsystem in particular.

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Avasha AG

Avasha AG designs and manufactures optical imaging and illumination systems according to customer specification. With expertise on the development of products and systems comprising optical, mechanical and electronic components, in the Scan4Reco project, Avasha AG will develop a solution for positioning the various sensors conveniently relative to cultural heritage objects and work and advise on overall system design and integration.

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RFSAT Ltd

RFSAT Ltd is a research-active SME focusing on research and development through national and international funding, industrial consultancy and commercial exploitation of research results. In the context of Scan4Reco, RFSAT Ltd will develop and implement advanced 3D scanning using stereoscopic vision and time-of-flight approaches as well as modelling algorithms showing object degradation in 3D, especially taking into account a multi-sensor nature of the cultural heritage data.

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meaning of project acronym

The acronym **Scan4Reco** stands for:

Multimodal Scanning of Cultural Heritage Assets for their Multilayered Digitization and Preventive Conservation via Spatio-Temporal 4D Reconstruction and 3D Printing

more information

For more information on the project, please make use of the following channels:

Project Website	www.scan4reco.eu
Project News Feed	www.scan4reco.eu/scan4reco/news.xml
Facebook	www.facebook.com/groups/982430741820987
Twitter	www.twitter.com/scan4reco
LinkedIn	www.linkedin.com/groups/8428972

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