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**COSCH - TOWARDS A BETTER COMMON UNDERSTANDING  
IN CULTURAL HERITAGE DOCUMENTATION**

**Abstract:** True, precise and complete documentation of artefacts is essential for conservation and preservation of our cultural heritage (CH). Through access to the knowledge about best possible documentation of artefacts it's possible to support an enhanced understanding of material CH and its long-term preservation. Documentation of CH involves researchers, scientists and professionals from multiple disciplines and industries. All of them are contributing in different ways to a documentation process, have different background and correspondingly different views on this process. In order to end up with best possible digital representations supporting subsequent research questions and applications in an optimal way it's important to build a common base linking technical views with those from CH experts. COSCH aims to help building this common understanding through close cooperation on a concerted European level as typically provided through COST Actions. COSCH will address some key interdisciplinary questions concerning the development of optical measuring techniques and electronic imaging applied to documentation and presentation of artefacts, as identified through the work of Colour and Space in Cultural Heritage ([www.COSCH.info](http://www.COSCH.info)). More than 200 international researchers and professionals participate in COSCH activities which have been organised around six main subjects: (1) spectral object documentation, (2) spatial object documentation (3) algorithms and procedures (4) analysis and restoration of cultural heritage surfaces and objects, (5) visualisation of cultural heritage objects and its dissemination, (6) the semantic development of the COSCH Knowledge model. The latter one tries to provide the collected mutual knowledge in a structured way to the scientific community allowing to get necessary recommendations in order to select a most appropriate documentation process

**Keywords:** Cultural Heritage documentation, optical technologies, 3D scanning, multispectral imaging, colour

**1. Introduction**

Considering the importance of effective protection and preservation of CH it is paramount to scan, document, analyse, understand, model, virtually reconstruct and visualise/publish CH objects, in particular to

- accurately record artefacts at both micro and nano scales – to include material properties such as form, colour and texture – for today's use and future generations;
- make the resulting e-documentation accessible globally to specialists and the general public;
- monitor the condition of objects for enhanced preventive conservation;
- enhance the knowledge base for art-historical analysis and other scholarly activities;
- support routine applications with specialist know-how and state-of-the-art equipment.

While the level of European technical competence in the precise documentation of spatial or spectral characteristics of surfaces is high – mainly driven by industrial interests – no common standards concerning 3D shape and colour exist for precise documentation of CH objects. Despite a general understanding of spatial resolution and accuracy of such

documentation, and its potential, within the CH community, there is limited awareness that standards could be improved by direct cooperation within the technical sector. It is, therefore, difficult for CH professionals to use these technologies efficiently or even to define requirements.

This situation can be improved by an intensive information exchange between actors on both sides (CH professionals - technical specialists), which also may provide guidelines for using optical technologies for CH documentation. COST Actions provide an ideal base to realise such aims as they are dedicated to networking activities and to stimulate cooperation on a concerted European level. This is why COSCH has been proposed and will constitute an interdisciplinary forum for scientists and technicians and heritage specialists to facilitate the exchange of interests, needs, capabilities, constraints, limits and perspectives. Some COST means like conferences or work-shops will also allow to enter and to exchange ideas from scientifically adjacent or partly overlapping initiatives on European level.

In the following a brief description of this Action will be given, explaining the need to realize such an Action, its scientific focus, the objectives and the organisation of work planned for the 4 years of activity. At the present state more than 200 researchers from 25 European Countries are already willing to work in that Action.

## **2. Current state of knowledge**

CH studies employ many techniques. Some of them, like RAMAN [1] and chemical analysis, are destructive because of sample extraction that is needed from the object of study. Such techniques provide valuable information about material composition, but the analysis results are local and often invasive. In opposite to that are the advantages of non-destructive techniques (typically non-contact and imaging-based) that are becoming ever faster, precise, affordable and wide ranging.

The main state-of-the art techniques available for non-contact CH documentation can be summarized as follows [2, 3, 4, 5, 6, 7, 8, 9]:

- Digital photography provides valuable visible information, but is subjective and cannot be directly used in context of other acquisitions owing to the lack of unique and known scale.
- Infrared reflectography based on a higher transmission of infrared light is useful for detecting the underdrawing in paintings
- Traditional colorimetry and spectrophotometry provide accurate information on the optical properties (such as the reflectance) and colour coordinates of the samples analysed
- Imaging systems for specialist analyses, such as computer tomography, allow making use of various non-optical parts of the electromagnetic spectrum
- Multispectral colour imaging usually relies on three or more acquisition channels. Images are captured with spectral (or at least colour) information pixel by pixel, and relatively high precision
- Structured-light-based techniques for 3D visualisation of artefacts rely on the projection of highly contrasted patterns in order to map the 3D profile of the object. The resulting spatial models may be easily combined with colour images of the object to give a 3D rendering of real appearance of the object.
- Passive 3D imaging techniques are complementary techniques to structured light. They use the existing light to collect spatial and visual data which leads to lower quality of the spatial model.

- 3D laser scanning techniques use the triangulation principle and are able to scan the object of interest using different strategies. Outcome is generally a vast point cloud allowing accurate 3D rendering.
- Integrated multi-imaging systems are complex instruments and often a technological compromise. They need to support different technological concepts in order to respond to various wavelengths and to perform dimensional imaging.

However, there are still no well-established and commonly accepted standards for precise, non-contact documentation of CH objects that would implement and combine the above-mentioned techniques. Therefore COSCH will address these challenges and will try to work on general recommendations and to provide the CH community with guidelines for the most common applications. Participating CH partners will ensure the format of proposed guidelines suits the needs of their community.

Especially the problem to provide precise multi-sensoral data is not satisfyingly solved. Neither on the base of integrated hardware solutions, nor on base of automated software solutions this aspect is treated, why this COST Action tries to provide recommendations.

Finally, the design of adapted systems must address many issues including functionality, quality control and preservation of information, semantic multilingual indexing and access, and heterogeneity at various levels.

### **3. Arguments to run COSCH**

The major benefit of COSCH will be its work on technical standards for precise (in terms of spatial resolution and accuracy) documentation of cultural heritage objects. Such standards concerning 3D shape and colour are hitherto missing. Furthermore there is no common standard for art conservators and other users, how to make use of such data. The Action proposes the foundation of a structure that will become a reference for technical questions related to cultural heritage studies and 3D reproduction and will make all relevant information accessible to interested actors in that science field.

Technological advancements are needed in order to account, as fully as possible, for special characteristics of artefacts in terms of materials, ageing processes, sensitivity to physical, chemical or electromagnetic influences. Optical documentation technologies need to be adapted to those characteristics, which is only possible through interdisciplinary exchange of information, expertise and technology, which will be provided by the COST framework and its instruments. Therefore this Action not only addresses societal needs but also aims at technological advance in terms of three-dimensional and (multi) spectral documentation of CH objects. Within this COST Action, experts in information systems and databases will be important partners responsible for the efficiency of the processes of data storage and restitution.

Through this coordinated Action scientific progress will be expected, in particular concerning spatio-spectral acquisition, processing, rendering and quality evaluation for heritage documentation. Arts and Humanities researchers, museum professionals and educators will benefit from accurate records of artefacts, once access to these is made available to them, while scientists developing optical recording techniques will benefit from the guidance of standards and principles widely applied in the cultural sector.

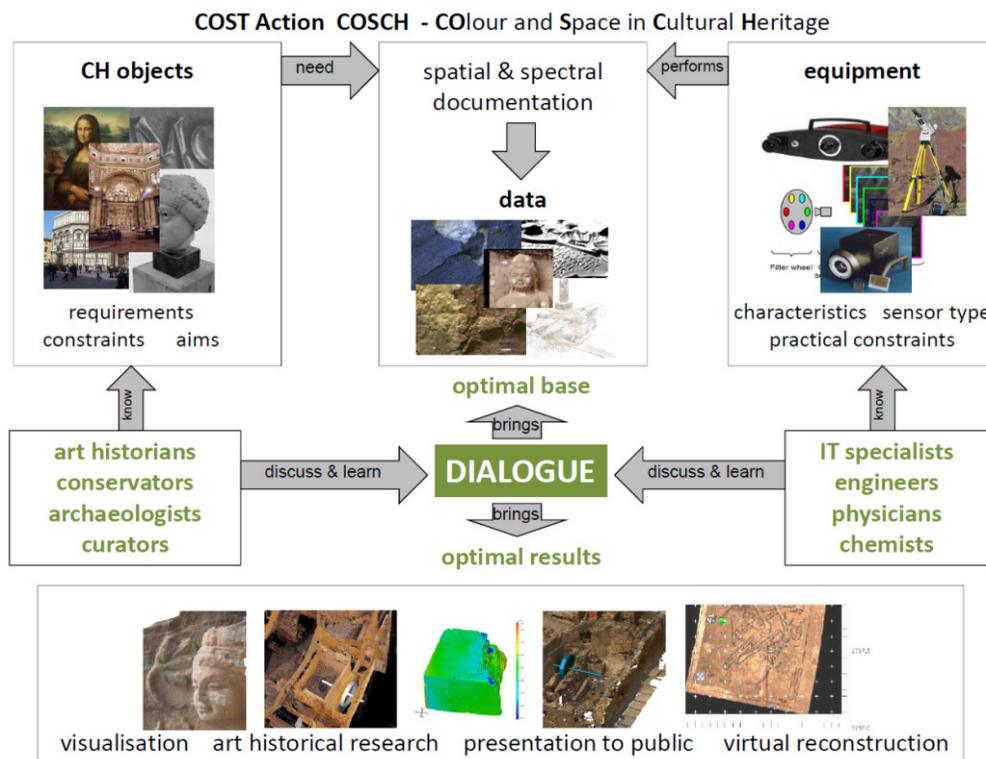


Figure 1: COSCH project overview

This interdisciplinary Action will bridge the humanities with the optical and information sciences (see Figure 1). Material sciences are also involved owing to a strong connection between the surface material of heritage objects, their visual appearance and techniques suitable for optical documentation. Also the involvement of chemists will be needed owing to the dependence of spectral reflectance on the chemical composition of an object; this will be of great interest when investigating ageing processes. Collaboration between the cultural sector and scientists is paramount to ensure mutual understanding of the requirements of CH documentation and how technology should develop to meet these requirements. Humanities specialists will benefit from learning about the state-of-the-art techniques for precision spectral and spatial documentation in order to explore the huge potential of non-contact methods in their fields. Scientists need to learn about the requirements for documentation and analysis of valuable heritage objects, such as paintings, sculptures, buildings, etc. in order to optimise current methods and ensure that future developments go in the right direction. Material scientists, physicists and chemists will provide the theoretical, scientific background in order to link optical data with material properties. This requires effective exchange of information and mutual understanding, which can only be achieved through exposure to and discussion of interdisciplinary research.

#### 4. Objectives of this COST Action

COST Actions are designed to build networks of researchers in order to facilitate cooperation on a European level, to promote knowledge exchange and to stimulate scientific progress in the addressed science field. Accordingly this Action will promote research, development and application of optical measurement techniques – adapted to the needs of heritage

documentation – based on an interdisciplinary cooperation, on a concerted European level and to offer a novel and reliable, independent and global knowledge base facilitating the use of today's and future optical measuring techniques to support the documentation of European heritage.

This includes, for example, the development of guidelines for CH authorities concerning the specification of minimal spatial resolution/uncertainty values for a selected set of materials (including its finishing techniques) depending on goal of documentation, e.g. visualisation and condition assessment.

But also knowledge of the potential, output, constraints, preconditions and practical aspects of precise spectral and spatial instruments will be collected and structured. This will be supported by case-studies in the application of the newest spectral and spatial technologies and critical reviews of current integration of state-of-the-art spectral and spatial optical technologies into documentation of CH objects. In that context also mutual benefits from spectral or spatial sensing techniques and the added value of combined usages will be analysed.

A central aspect has to be seen in the formation of a sustainable European network of researchers, solution providers, end-users and industrial partners in the field of optical measurement techniques for CH documentation, preservation and reconstruction. This network serves also as base to stimulate new and interdisciplinary research projects on a national, bilateral and European level, allows to identify knowledge centres hosting educational services and research support, what simplifies and promotes mobility among early-stage researchers.

Means to reach these objectives are typical COST instruments like Training Schools (TS), short term scientific missions (STSM), plenary workshops and exchange platforms like a dedicated website, the organisation of conferences or the initiation and realisation of new projects.

Main results are expected from an enhanced understanding of the benefits of optical documentation systems in CH, a wider adoption of optical technology customised to suit the needs of conservators and scientists in CH and a standardisation of methodologies resulting in simplification and enhanced spatio-spectral documentation. Furthermore the enhanced communication between CH and engineering communities will give a better mutual understanding and facilitate interdisciplinary cooperation providing better results for the documentation of CH objects.

A considerable impact is expected from an intensified usage and integration of multisensory optical acquisition techniques. This would greatly enhance the documentation and condition monitoring of heritage objects and is likely to reveal qualities that were not accessible to earlier techniques.

## **5. Scientific aims of this COST Action**

The technical program of COSCH focuses on the development, adaptation and standardized usage of optical non-contact technologies, suitable for recording the surfaces of heritage objects with high spatial and spectral precision and resolution. Especially, it is anticipated that the combined use of spatial and spectral data of the highest precision may open new possibilities for the documentation, presentation and analysis of heritage objects.

Multispectral imaging opens new doors to objective spectral documentation of objects. Observed data depend on geometrical relationships between sensor, surface and light source.

There is a need for connecting spatial and spectral data collection, which has not yet been fully explored.

The interaction of surfaces and sensing techniques will be studied in order to derive defined criteria for an optimal usage of documentation techniques depending on object characteristics.

Innovative aspects include knowledge exchange, for example, in:

- Acquisition: Combination and exact matching of 3D and spectral information, development of multi-sensor systems, methods for high-precision surface measurements of large objects without use of reference points or calibration patterns
- Processing (deblurring, enhancing, etc.): For a precise visualisation of CH objects, data (images and 3D) should be of high quality. This process needs establishing physical (spatial and spectral) models of the entire acquisition chain (light propagation, light integration, etc.)
- Analysis (feature extraction, fusion, etc.) is the process by which some features (measures, thematic maps, key points, pattern, regions, etc.) are extracted from images or 3D data with analysis algorithms. The challenge here is the integration and adaptation of such analyses within complex data (e.g. 3D+spectral)
- Standardised characterisation (optical, spatial description): Digital devices are involved in all stages of the acquisition (display, LCD-Projector, cameras, etc). Their correct calibration, characterisation and management provide faithful and repeatable measurements
- Definition of knowledge bases related to object characterisation: All the stages (acquisition, analysis, etc.) use and generate knowledge that needs to be managed in order to support objects description and characterisation
- Visualisation and reproduction (incl. object and colour rendering, Human-Computer interaction): The spectral data are not readily presented on standard monitors. Usually a dimensionality reduction is required. But the latter should balance informative content and Human Visual System properties while rendering these data. These processes should be integrated within the human - machine interaction.
- Data content: Improved use as such will add value to the content of acquired data and the potential for their further utilisation. Especially an integration of different data sources should considerably extend the content and value of the data possibly to their full potential.
- Quality evaluation (relevant to all previous steps): The quality of the process should be evaluated and validated by means of protocols and metrics (objective and subjective). This needs to be defined according to the goal of the process, the subsequent stages and user expectations.

In order to follow those aims, the interdisciplinary work will be organised in 5 different working groups, which are oriented at the science fields like spectral object documentation, spatial object documentation, Algorithms and procedures, Analysis and restoration of CH surfaces and objects, Visualisation of CH objects and its dissemination.

Inside these groups the respective state of the art has to be collected in a first project phase, giving the base for the subsequent interdisciplinary work going across the borders of the groups. Within this second phase a mutual exchange of knowledge and ideas among all groups will focus on tasks like:

- Identification, characterisation and testing of various techniques for use with CH objects (imaging, 3D)

- Identification and comparison of registration processes and integration of multi-sensor data
- Identification, structuring and implementation of typical use cases and development of guidelines
- Identification, planning, implementation and testing of typical applications of visualisation within CH domains

The results of these tasks will provide the major content of the knowledge base to be built in the course of the Action.

## 6. Conclusion

The introduced COST Action COSCH aims to promote research, development and application of optical measurement techniques with special emphasis on the needs of heritage documentation. The project relies on a wide network and realizes a deep interdisciplinary cooperation, on a concerted European level and aims to offer a novel and reliable, independent and global knowledge base facilitating the use of today's and future optical measuring techniques to support the documentation of European heritage.

This knowledge base will be developed by instruments provided in the framework of COST projects and will be accessible to the whole CH community. At the present state more than 200 researchers from 25 European Countries are supporting this Action, which is open until end 2015 to all interested actors in this science field, including possible cooperation with other initiatives, like EUROPEANA for example.

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## References

1. Josef Brandmüller, Heribert Moser *Einführung in die Ramanspektroskopie*, Steinkopff, Darmstadt, Wissenschaftliche Forschungsberichte, Naturwissenschaftliche Reihe 70, (1962), ISSN 0084-0920
2. Simon, C., Schütze, R., Boochs, F., Marzani F. *Asserting the Precise Position of 3D and Multispectral Acquisition Systems for Multisensor Registration Applied to Cultural Heritage Analysis*. 18th International Conference on MultiMedia Modeling, Salzburg, 2012
3. Maria-Lena Demetriou, Jon Yngve Hardeberg, Gabriel Adelman, *Computer-Aided Reclamation of Lost Art - A New Concept*, Proceedings of Gjøvik Color Imaging Symposium 2011, Gjøvik, Norway, September 2011

- 4 Alamin Mansouri, Tadeusz Sliwa, Jon Y. Hardeberg, Yvon Voisin, *Reflectance estimation using PCA and wavelet basis decomposition*, Color Research and Application, 33:6 (2008), 485–493
- 5 Ole Grøn, Susanna Palmer, Frans-Arne Stylegar, Kim Esbensen, Sergey Kucheryavski Sigurd Aase *Interpretation of archaeological small-scale features in spectral images*, Journal of Archaeological Science, 38:9 (2011), 2024–2030
- 6 C. Cucci, M. Picollo, M. Vervat, *Trans-illumination and trans-irradiation with digital cameras: potentials and limits of two imaging techniques used for the diagnostic investigation of paintings*, Journal of Cultural Heritage, in press.
- 7 M. de Lasarte, M. Arjona, M. Vilaseca, J. Pujol *Influence of the number of samples in a training set on the accuracy of color measurement and spectral reconstruction*, Journal of Imaging Science and Technology, 54:3 (2010), 030501-1-10
- 8 Bunsch E., Sitnik R., Michoński K. *Art documentation quality in function of 3D scanning resolution and precision*, Proc. SPIE, 2011, 7869, 78690D
- 9 A. Bentkowska-Kafel *Needs of the 3D Visualisation Community*, A report produced for the 3D Visualisation in the Arts Network commissioned by the UK Joint Information Systems Committee, London 2007

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