Questionnaire for COSCH^{KR} App

Please note that you should use terms and vocabularies accepted inside your discipline. As the completed questionnaires will be read and analysed by COSCH members of different disciplines it is appreciated if you refer to accepted vocabularies when using specific terms.
Exemplary list of ambiguous and/or discipline inherent terms:
Feature (Archaeology, ICT), copy (conservation, archaeology, ICT), documentation, recording, artefact (Archaeology, ICT), reconstruction, etc.

Germolles' wall paintings

1. **Which spatial and spectral technique/s was/were chosen to document the Cultural Heritage object or site? If you used several techniques please answer the questions 4, 5, 12, and 13 referring to the individual techniques.**

Spatial Imaging techniques
- Structured Light Imaging (SLI);
- Reflectance Transformation Imaging (RTI);
- Photogrammetry

Spectral Imaging techniques
- VIS,
- UV and
- IR imaging;
- Spectrocolorimetry;
- Multi-spectral Imaging

The work is currently in progress. Other techniques planned: IR thermography…

2. **Name of the Cultural Heritage object or site (if possible please add a figure of the CH object)?**

Germolles was in the 14th c. one of the palace of the Dukes of Burgundy. Philip the Bold, brother of French kind Charles V, offered the site to his wife, Margaret of Flanders. Germolles wall paintings were made by Jean de Beaumetz's workshop. Accounting notes with the list of materials purchased to make the wall paintings are still surviving[1]. Some of Germolles wall paintings were restored in 1989-92 and are considered to be among the best preserved of their category. The wall paintings have not been documented when they were restored. We have only some information on the elementary composition of the green background (Pb and Cu based pigments on an ochre preparation layer) and some decorations (Pb for white, Hg-vermillion for red and ochre for yellow).

[1] Nash, S., *Pour couleurs et autres choses prise de lui …: The Supply, Acquisition, Cost and Employment of Painters' Materials at the Burgundian Court, c.1375–1419*, in Trade in Artists' Materials, (2010), pp. 97-182.

An example of Germolles wall paintings in the dressing-room of the Countess of Nevers, daughter-in-law of Margaret of Flanders. The P and M are the initials of the Duke and the Duchess while the thistles in between are a mark of fidelity between them (© F. Piqué).

The château is privately owned and was entirely classified as Historical Monument in 1989.

3. **What was the aim of documentation, multiple answers possible (visualization, condition survey, material analysis (using spectral techniques), reproduction (e.g. printout), dissemination)?)? Please clearly explain what information related to the CH object surface/appearance/geometry… is used how and why for your humanities question. Please explain terms which are inherent of your own discipline and might not be clearly understood by other domains.**

Objective 1: distinguishing original material from restoration work
A close observation with naked eyes enables to appreciate some original materials. But a more **global observation** was required to appreciate the extent of the restoration work (shadow effect on P letters). **UV radiation** has been particularly adapted when scanned on the large surfaces of Germolles wall paintings: the reintegration work and retouching became visible.

Approach: global observation

Method: UV imaging (Mobile hand-held high intensity ultraviolet lamp, UVAHAND 250 GS H1/BL. Emission centred at 365 nm. The emission spectrum shows that the light emitted contains 'parasitic light' in the visible region)

RAW-data produced by the instrument: quick visualisation of retouching work carried out in 1989-1992. The important outcomes of the imaging process was to appreciate the amount of conservation work: observation with naked eyes.

Which processing steps were realised on the RAW-data? Data were not collected in a professional way. Only low quality pictures showing the walls and the UV lamp were taken for documentation purposes (see p7 of the STSM report). How much time was needed?: a few seconds

Objective 2: rediscovery of the original materials

Technical photography using **VIS light and UV/IR radiations** applied on **macro** and **micro levels** has been used to document more precisely what is left of the original materials: extent of the conservation work on the P, M, floral decorations. First observation of the stratigraphy of paint layers, fluorescence of compounds (lead white, linseed oil)...

Approach: macro (few meters) and micro level (cm)

Method: VIS and UV/IR imaging (**Macro**: digital camera CANON EOS 5D Mark II. Halogen Lowel V (500W) lights (for VIS and IR light). UV light: Hg vapour lamps with DUG11 filters (to block parasitic light and **micro**: Dino-lite digital microscope pro AM413T-FVW with visible and UV light sources. Connected by USB to computer. Three images for each area: incident visible light: using microscope visible LEDs, raking visible light: turning microscope LEDs off and using a portable flash light to illuminate the surface from the side and UV light: using microscope UV LEDs)

RAW-data produced by the instrument: high resolution photographs fully calibrated

Which processing steps were realised on the RAW-data? None How much time was needed?

Produced data used for analyses by end-user: photographs (JPEG: 4 to 15Kko and Image bitmap 3Kko)

Link to other applied techniques/methods: photogrammetry (for geometric reference)

Objective 3: analysis of original materials

Beyond the stratigraphy of paint layers, original materials were investigated in a non-invasive way using **spectrocolorimetry combined with X-ray fluorescence** (elementary analysis). **Multi-spectral imaging** will be used as well in the near future. These are preliminary steps to **sampling**. Indeed a few samples will eventually be taken to analyse the whole stratigraphy of paint layers (pigments and binding media).

Approach: micro level (3mm for spectrophotometer and 4mm for the X-ray fluorescence)

Method: spectrocolorimetry combined with X-ray fluorescence, Multi-spectral imaging (soon)

RAW-data produced by the instruments: reference reflectance spectra + X-ray spectra

Which processing steps were realised on the RAW-data? **Spectrocolorimetry**: photography documentation of the measurement spot, collection of reflectance spectrum, La*b" space coordinates in formatted table. **X-ray fluorescence**: collection of data + photography documentation of the measurement spot. How much time was needed? Quick for a few spots and long for a complete survey. In our case around 100 measurements: 2 days for processing data.

Produced data used for analyses by end-user: tables with colorimetry measurements and elementary analyses.

Link to other applied techniques/methods: photogrammetry (for geometric reference)

Objective 4: understanding the painting technique used

The use of metallic decorations seems to have been rather common in princely palaces of the end of the Medieval times. We have sometimes written records providing technical information on the paintings but only a few examples like at Germolles where we have both the list of materials (pigments, metallic decorations, binders…) given in the accounting notes and existing remains conserved in-situ. The objective here is to observe the stratigraphy of the paint layers in a non invasive way (imaging techniques) before proceeding to sampling.

Additional spatial techniques such as SLI and RTI were tested to better visualize the stratigraphy of paint layers (still in progress).

Approach: Micro level (few cms)
Method: VIS (raking light), SLI and RTI (still in progress).
RAW-data produced by the instrument: high resolution photographs, PLY files (SLI) and PTM files (RTI)
Which processing steps were realised on the RAW-data? Not aware for SLI and PTM. How much time was needed? Rather immediate.
Produced data used for analyses by end-user: micro-photographs (JPEG and image bitmap, a few Kko), PLY files (100 to 300Kko) and PTM files (200Kko)
Link to other applied techniques/methods: photogrammetry (for geometric reference), sampling + cross-section and analytical work.

Objective 5: 3D virtual representation of the original decoration
At the end of the documentation work, it is planned to **reconstruct virtually and in 3D** the original decoration to offer the public visiting Germolles (currently 10 000 visitors per year) the possibility to appreciate the extent of original materials conserved.

Approach: global documentation
Method: not developed yet
RAW-data produced by the instrument: not developed yet
Which processing steps were realised on the RAW-data? How much time was needed?
Produced data used for analyses by end-user: XY (format XY)
Link to other applied techniques/methods: e.g. VIS/UV/IR imaging?

Objective 6: long-term preservation of the original materials
The original decoration is directly exposed without any specific protection. The owners are already applying preventive conservation policies (internal shutters are maintained closed, except during the guided tours). **Reference colorimetry data** have been collected in 2014. They should be compared to new data in future measurements campaigns to **monitor** the condition state of the paintings. Visitors can damage physically the wall paintings by accident. Therefore consolidation work on the wall paintings might be required to preserve them in the long-term.

Approach: monitoring at micro level (3mm for spectrophotometer)
Method: colorimetry data
RAW-data produced by the instrument: reference reflectance spectra
Which processing steps were realised on the RAW-data? photography
documentation of the measurement spot, collection of reflectance spectrum, La*b" space coordinates in formatted table. How much time was needed? In our case around 100 measurements: 2 days for processing data.
Produced data used for analyses by end-user: tables with colorimetry measurements
Link to other applied techniques/methods: photogrammetry (for geometric reference),

4. **Might only be answered by technicians: What is the level of resolution / uncertainty required?**

Please link the answer of these questions to the aims of your study mentioned under bullet point 3.

a. **Level of resolution (please add a relative and absolute value)**

Objective 1: UV radiation: low resolution (absolute value needed) to get an overview of the restoration work but photogrammetry pictures have a medium resolution (absolute value needed).

Objective 2: technical photography (VIS, UV and IR): high resolution (absolute value needed). RTI and SLI tested have a medium resolution (absolute value needed).

Objective 3: spectrocolorimetry: medium resolution (absolute value needed)

Objective 5: 3D virtual representation. High resolution if possible (absolute value needed).

b. **How do you use the produced data to answer your research questions? Do you need specific software? Which software? Is it freeware or payware?**

Under discussion: integration in a database?
Objective 1: visual analysis/evaluation of photographs…

c. **Please list all possible results which will be produced out of the digital data-sets.**

VIS, UV and IR pictures, reflectance spectra, 3D point clouds, 3D models, 3D reconstructions …

d. **How does the data of chosen resolution and uncertainty serve the needs of your humanities research question?**

Answered above.

5. **Please explain data collection:**
   a. **Spatial data**
      i. **Which instrument(s) and additional equipment were used?**

Photogrammetry: digital camera **(**Canon EOS 6D avec un objectif 16-35mm)
RTI: digital camera (no more information yet)
SLI: professional 3D Scanner (SMART SCAN). Acquisition with a precision of 1μm covering a surface of 120x100 mm

ii. **Were there any preparations needed before recording the CH object (e.g. covering of windows to protect from sunlight, add targets for referencing)? Were there any special considerations that had to be respected (e.g. object condition, preventive conservation rules)?**

The internal shutters of the room were closed. Work in darkness.
Photogrammetry: geometric reference

RTI: use of a target ball
SLI: colour chart

iii. What was the process of data capture? How much time was needed?

Photogrammetry: photography, aero-triangulation, reanalysis of data, interpolation, texture projection, orthophotography. The data capture is short. The data processing is long (a few hours).
RTI: photographs taken with different orientations of the flash light. Compilation of data to obtain a PTM file. The data capture is short as well as the compilation of data: a few minutes.
SLI: data capture is rather long for a large decor. Several photographs had to be done to cover P, M and floral decorations. Matching of photographs took some time. To record a letter a few hours was required.

b. Spectral data

i. Which wavelength range you chose?

UV radiation:

1. mobile hand-held high intensity ultraviolet lamp for quick scanning, UVAHAND 250 GS H1/BL by Honle UV technology (Munich, DE). Emission centred at 365 nm. The emission spectrum shows that the light emitted contains 'parasitic light' in the visible region.
2. mercury vapour lamps with black Wood's glass (emission max at 365 nm) provided with a Schott DUG11 interferential excitation filter to reduce the passage of 'parasitic' visible.
3. led UV light from Dino-lite digital microscope pro AM413T-FVW _ contains 'parasitic light' in the violet blue region.

IR radiation:
Lamps manufactured by the *Istituto di Fisica Applicata Nello Carrara* (IFAC), *Consiglio Nazionale delle Ricerche* (CNR) Italian National Council of Research, Florence provide radiation from 400 to 1000 nm.
Different filters were used: reflected visible light (filter idas) incident to the surface (vis) and raking to the surface (rak). In addition, using visible light (filter rg830) it was possible to record reflected infrared light (IRr). Using UV light (filters idas and kv418) it was possible to record the so called UV-induced visible fluorescence (UVf) while reflected ultraviolet light (UVr) is recorded with filter dug11.

The reflected infrared and ultraviolet images are single channel and combined with the visible image provided the so-called false colour images: Infrared false colour (IRfc) and ultraviolet false colour (UVfc). This combination can be done effectively only if the camera is perfectly still and the photograph perfectly overlapping.

Colorimetry measurements: 400 to 700nm.

ii. Which instrument(s) and additional equipment were used?

Recording device for VIS light, UV and IR radiation: Digital SLR camera: CANON EOS 5D Mark II, with a full frame (36mm x 24mm) CMOS sensor, professionally modified to make full use of the

bandwidth of the imaging sensor through the removal of the standard CANON IR blocker and replacement with IDAS/AR clear filter to allow focusing.

Portable microscope: Dino-lite digital microscope pro AM413T-FVW with VIS light and UV radiation sources.

Images are collected with camera software (EOS utilities) and microscope software (Dino Capture 2.0). Image manipulation to create false colours is carried out using Adobe photoshop.

iii. **Were there any preparations needed before recording the CH object (e.g. covering of windows to protect from sunlight, add targets for referencing)? Were there any special considerations that had to be respected (e.g. object condition, preventive conservation rules)?**

The internal shutters of the room were closed. Work in darkness. Colour charts are added for photographs under VIS light, UV and IR radiations. Photographs had to overlap perfectly well to obtain false colour photographs.

iv. **What was the process of data capture? How much time was needed?**
v. **Why did you choose this wavelength range?**

Observation under 366nm (UV) is appropriate to reveal the presence of linseed oil that was used in medieval times to fix metal decorations (Mounier 2010)[2].

For IR the range of wavelengths selected is a common practice in the conservation field. > IR radiation makes xyz visible.

For other pictures we counted on the expertise of the conservation professionals involved.

vi. **Did you focus on a specific wavelength range?**

For UV radiation, yes due to need to identify linseed oil in the paintings.

vii. **How does the data of chosen range of wavelengths serve the needs of your humanities research question?**

Answered above for UV radiation.

6. **What is the size of the documented Cultural Heritage object or site (length, width, height in mm, cm, m; choose the appropriate scale unit. If the documentation only for the part of object please describe the size of the documented fragment?**

[2] Mounier, A., *Aurum, argentum et aliae res innumerabiles, Les dorures dans les peintures murales médiévales du Sud-Ouest de la France*, Université Michel de Montaigne de Bordeaux, thèse de doctorat, 2010.

Had this parameter any impact on the selection of a specific documentation technique? If yes, please specify which.

The wall paintings are covering a few meters (5mx3m/ wall in the dressing room of the Countess of Nevers and 2mx1m in the rooms of the duke Philip the Bold and his wife Margaret of Flanders). Photogrammetry can be made easily on such artworks.

Scanned UV radiation was adapted to the large surfaces of wall paintings. In most cases (technical photography, SLI, RTI) we worked on smaller areas: 50cmx50cm max. Spectrocolorimetry, micro-technical photography was only applied on details (a few cms).

The SLI instrument used was adapted to small areas and several measurements were needed to get a full décor (P, M or flower decorations).

On the other hand. The RTI instrument used until now was not adapted to details (a few cms). New tests with a more appropriate instrument should be performed in the future.

7. **What is the shape of the Cultural Heritage object or site (e.g. round, flat, building with narrow parts etc.)?**
   Had this parameter any impact on the selection of a specific documentation technique? If yes, please specify which.

The paintings are more or less flat but with irregularities (few cms). Photogrammetry could reveal some of these irregularities.

Technical photography at macro or micro levels was not impacted by the lack of flatness, neither spectrocolorimetry, RTI and SLI tested.

8. **What is the appearance of the Cultural Heritage object surface (glossy, homogeneous or heterogeneous: same colour with various tints or multicolour, etc.)?**
   Had this parameter any impact on the selection of a specific documentation technique? If yes, please specify which.

Mat for most of the surface and shiny spots (metal decoration). The appearance is heterogeneous. None of the techniques tested and used was effected by the appearance of Germolles wall paintings.

9. **Is your Cultural Heritage object static or moving, can it be transported?**
   Had this parameter any impact on the selection of a specific documentation technique? If yes, please specify which.

The object cannot be moved.
Again, none of the techniques tested and used was effected by the non-moveable character of Germolles wall paintings.

10. What was the budget allocated to this documentation process?
Had this parameter any impact on the selection of a specific documentation technique? If yes, please specify which.

20 000€ grant provided by the Regional Direction of Cultural Affairs of Burgundy on a whole budget of 46 500€.
These limited funds led us to make a selection among the techniques to use on Germolles' wall paintings (technical photography, SLI, colorimetry). Other techniques were only tested for free (photogrammetry, RTI).

11. Reasons behind the selection of the technique/s?

- Techniques that can be used easily by conservation professionals (technical photography, colorimetry)
- Non invasive (most of the techniques tested until now),
- Offering different levels of precision (high for micro-technical photography), medium for photogrammetry, spectrocolorimetry, RTI and SLI).
- Portable (all techniques tested until now),
- Available within the COSCH project.

12. Did the spatial and spectral technique/s fulfilled the initial needs?

Definitely yes and more information than expected could be obtained. They should be used though in combination with other techniques such as analytical techniques (XRF…).
Photogrammetry: exact spatial recording of the wall paintings and possibility to reconstruct a 3D virtual representation of the walls.
Technical photography: UV radiation scanning is essential on restored wall paintings to get a global visualization of the level of the restoration work. Combination of both VIS light and UV/IR radiations should be used afterwards and on a lower scale to validate this first appreciation and determine what is left of the remaining decoration.
Colorimetry: should be used in combination with X-ray fluorescence to get reference data characterizing the colours of analysed painting materials and compare them with new data in order to monitor the wall paintings in the long term.
Structured Light Imaging and **Reflectance Transformation Imaging** were only tested. They are interesting techniques but the level of precision obtained until now is not high enough to make the data collected comparable to those obtained with micro-technical photography.

Evaluation question:

Did you face any problem/s related to the measurement process, storage of data, reuse by different actors, compatibility of data formats and software available.

Measurement process: it is essential that a conservation professional participates to the process to make sure that when moving instrumentation (lights, cameras, scanners), no physical damage on artworks is provoked by accident.
Storage of data: some data are rather huge and cannot be transferred easily using electronic forms.

Softwares: end-users have to be trained to use properly the softwares available. I am sceptical as well on the fact that end-users would use raw data to make their own interpretation.
Compatibility of data formats: not tested yet but it is planned that the raw data collected by one instrument might be used by another.